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Foreword

Transportation is a vital element in local, regional, and national economic development. Transportation provides access to land and communication. Although there are many factors that determine whether specific lands will be developed, the ultimate foundation of any development is transportation. Transportation facilities provide the means for transporting raw materials to manufacturers and finished products to markets. They provide personal conveyance and communication and movement of the many service functions necessary within a society. That transportation is a vital element of any society has never been in question.

The primary difficulty for transportation planners is isolating the economic consequences of transportation investments and comparing them with the consequences of all other public and private investments. Another major problem is to establish causative relationships between specific transportation investments and subsequent economic events.

The impacts of introducing transportation where there was no previous access are relatively easy to establish. The impacts of marginal increases or decreases in transportation services are difficult to measure at the project, regional, or national level, because there are so many other factors simultaneously at work that affect economic development.

The United States is faced with an ever-increasing demand for use of transportation services. The transportation infrastructure is wearing out faster than it can be replaced or new facilities can be constructed. Those responsible for transportation development are concerned that the public is not aware of transportation needs or the effects of resources that are insufficient to maintain existing services or respond to increasing demand. They are, therefore, looking for a way to clearly establish a causative relationship between transportation and subsequent economic development. Transportation developers hope that establishing such a relationship will persuade the public and government decision makers to provide funds for maintaining and upgrading the transportation infrastructure.

The papers in this Record are the proceedings of an international conference on transportation and economic development that was held in Williamsburg, Virginia, in November 1989. The conference examined the interrelationships between investments in all modes of transportation and economic development. The conference examined the impacts of transportation on productivity and economic factors that improve the well-being of the community or region. The primary focus of the conference was on evaluating methods and modeling techniques and on examining economic impacts of modal transportation investments through a series of case studies.

The papers presented in this Record concern the following issues: (a) economic impact methodologies, (b) modeling impacts of transportation investments, (c) economic impacts of modal investments, (d) rural and agricultural impacts of transportation investments, (e) case studies of modal investment impacts, and (f) planning issues in transportation investments for economic enhancement. An overview of the methodology and a conference summary conclude these proceedings.

SECTION 1

Economic Impact Methodology

Putting Transportation and Economic Development into Perspective

DAVID J. FORKENBROCK

Economic development occurs when the income and product generated within an area increase. Government policies can promote economic development by helping an area increase the returns from using resources there. They do this by providing services that produce benefits in excess of their costs. Transportation services generate benefits by serving as an economic tool used in transporting goods and people. The benefits of transportation investments are strictly related to reductions in transportation costs. These investments foster economic development by increasing net local income through cost reductions that exceed the cost of such investments. A series of important issues should be taken into account when examining the extent to which a transportation investment contributes to economic development. The issues include the scale of the impact area to be considered because some activity will move from one location to another, because of uncertainties in future economic circumstances, and for social objectives. For example, policy trade-offs must be made between maximizing overall economic development with a state and assisting a less-promising but needy area. Six paradigms illustrate the types of trade-offs that decision makers face when using transportation investments to foster local economic development. Finally, a series of decision screens are presented to provide a practical basis for applying the principles discussed.

As the U.S. economy undergoes a significant restructuring and the fortunes of various locations within the country rise and fall, increased attention is being placed on local and regional economic development. Transportation infrastructure is one of the principal policy levers that state and local governments can use to increase their attractiveness to business investors. The reason is simple—better accessibility to materials and markets contributes to a competitive advantage.

In order to place the relationship between transportation investments and economic development in perspective, certain economic principles related to public investment are presented as a means for stimulating private-sector activity. These principles can apply a sound conceptual base to the problem of how transportation investments can best be used to foster economic development at state and local levels. Emphasis is placed on strategies for state governments because most highway investment decisions related to economic development are made at these levels. A series of points is provided for consideration during the examination of possible investments. Approaches are formulated that will help those faced with deciding whether and how much to invest in a transportation facility and who should pay what portion of the costs.

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EFFICIENT INVESTMENTS

Before considering the relationship between highway investment and economic development, establishing a working definition of economic development is useful. Economic development occurs when the income and products generated within an area increase. Increased production requires that either more resources (land, labor, materials, and capital) be used or that existing resources be used more productively.

Economic Development Process

As individuals and businesses decide where to use the resources they own, they also determine the pace of a state's economic development or growth. Resource owners base location decisions on their perceptions of the amount and certainty of the monetary income that their resources will earn in each location. They usually choose the location where they expect their resources to earn the highest income. But location decisions are not determined by monetary return alone. They also depend on environmental amenities or, more broadly, nonmonetary quality-of-life considerations. Because public-sector decisions and policies influence both the monetary and nonmonetary costs and benefits associated with each potential location, they also influence private-sector location decisions.

The question of where to use a resource does not arise unless the resource is mobile (not fixed in location). Owners of mobile resources can choose where such resources will be used. Land and most natural resources are immobile. Owners of farmland, for example, cannot move their resource to another state in response to a greater demand for land. Labor and capital are mobile, although location adjustments may take time, as demonstrated by the migration of people over the past few decades from the rust belt states to those in the sun belt. During the 1970s and early 1980s, the Mid-Atlantic and Great Lakes states lost 3.6 million people through migration. In contrast, the Southeast, excluding Florida, gained 2.9 million people.

Owners of mobile capital tend to locate where they expect the returns to their capital to be greatest, unless there are significant differences among potential locations in the certainty of returns. (The general economic and political environment in which businesses operate is likely to be similar in the various states. It is therefore plausible that differences in the certainty of returns to capital have little influence on where U.S. businesses choose to locate.) Owners of mobile capital tend to locate where the present value of the expected net return on their capital is greatest. In calculating this expected value, they consider wage rates, taxes, public services, and transportation costs. Quality of life may also be important because plant locations are often chosen by managers who will be living and working at the site.

Similarly, workers locate where they perceive the returns from employment to be greatest. These returns are both monetary and nonmonetary and include after-tax wages, public services, and environmental amenities. The wages that workers demand in a particular state depend in part on the taxes and public services in the area. Therefore, the factors that make an area an attractive place to live and work also make it attractive to prospective businesses, because these factors affect wages. An area's attractiveness to workers is an important dimension of its business climate.

It is often said that investment creates jobs and that private investment must be stimulated to provide jobs for a growing labor force. It is more correct to say that the nationwide demand for goods and services creates both jobs and investment opportunities. As the owners of mobile capital and labor respond to this demand, they create jobs in a particular area by deciding to use their resources in that location.

Government's Role in Economic Development

Government influences a state's economic development by affecting the state's attractiveness as a place for employment of mobile capital and labor resources and by affecting resource productivity. Government can promote development by increasing the perceived returns from employing mobile capital and labor in an area or by improving the certainty of those returns. Most commonly, a state government affects the state's business climate.

Among the key options for promoting development through public policy is increasing the value of public services, including transportation services, relative to taxes on mobile resources. A state or local government can try to accomplish this goal by conducting its activities in an efficient manner. There are two general conditions for efficiency. The first is that government provide only those services that generate benefits in excess of their costs (foregone private goods), in which case the area's residents would be willing to pay for the services if they could be sold by government. Meeting this condition requires that government eliminate services whose benefits fall short of their costs. Such action may well reduce the level of public services, but the service reduction would be more than compensated by reduced taxation. The second condition is that government minimize the costs of those services it chooses to provide, regardless of whether the services meet the first condition. Consolidation of county governments to reduce costs and taxes is an example of an action that might meet both conditions.

For a variety of reasons, an area is limited in its ability to increase employment and incomes. First, national and international market forces as well as public policies primarily determine the economic environment within which state and local governments and businesses operate; they can do relatively little to affect that environment. Second, businesses and individuals have strong incentives to make the best use of the resources under their control, and they tend to do so. For government to improve on these private decisions is difficult, yet that is exactly what it must attempt in its economic development activities. Government must identify instances in which the market activities of individuals and businesses fail to make the best possible use of scarce economic resources and then take actions that result in a net improvement. Third, identifying inefficiencies in the delivery of public services that can be eliminated to reduce the tax burden on mobile resources is difficult. Finally, fairness limits any redistribution of government costs from mobile to immobile resources.

Infrastructure Investment

Decisions to build a new infrastructure facility or replace an existing one should be guided by the efficiency criterion. In other words, an infrastructure investment should be made when those who will directly or indirectly use the services provided by the facility are willing to pay the cost of its construction, operation, and maintenance. If users are not willing to pay these costs, they are implying that the value of the services provided by the facility is less than its costs. Hence, resources used to provide the facility would generate more value in alternative uses.

The consequences of not following the efficiency criterion when making infrastructure decisions can be severe. Underbuilding infrastructure—that is, not providing services for which users would be willing to pay the full costs—can inhibit economic development. Problems arising from underbuilding include the costs associated with traffic congestion and longer-than-necessary travel times caused by substandard roads.

Overbuilt infrastructure can also deter growth. Facilities constructed at an earlier time often do not match current or future needs. Shifts in population and business activity, as well as changes in technology and demand, frequently render infrastructure economically or technologically obsolete. Maintaining facilities for which demand has fallen entails real costs that must be borne by infrastructure users (often, users of other facilities) or by taxpayers. The result is a loss of the fairness of cost-occasioned financing and an increase in the overall cost of doing business in the area. In fact, excess infrastructure costs function as a tax on economic activity and are therefore a barrier to economic development. To reduce this barrier, portions of overbuilt systems can be closed or allowed to decline to a lower level of service. With either action, the supply of infrastructure can be adjusted to meet the actual level of demand.

In summary, public policies intended to positively influence an area's economic development seek either to increase the perceived returns from mobile resources or to improve the certainty of these returns. For a government to markedly assist economic development, it must use its resources efficiently. Investing in transportation facilities only when the benefits would exceed the costs can improve the prospects for area development through public action. A trade-off of efficiency for other policy objectives, including equity, should only be made after an explicit public decision about whether and to what extent overall economic growth should be diminished to promote the other objectives.

TRANSPORTATION INVESTMENT AND ECONOMIC DEVELOPMENT

Transportation is best thought of as a tool used to transport goods and people from one place to another. Investments in highways or other facilities generate benefits only to the extent that they lower transportation costs. (Highways can be considered to be intermediate goods used in the production of final goods.) Reductions in transportation costs may be realized in numerous ways, including decreased travel time, increased safety, decreased fuel and other operating costs, and reduced noise or air pollution. But in the final analysis, all benefits of a road, and therefore the justification for building it, flow from using it for transportation. Road investments should be made only when they lower transportation costs (broadly defined to include safety and environmental impacts) enough to warrant their investment costs (including the present value of future maintenance and operation costs).

Basic Investment Principles

There are two fundamental types of transportation investments: new facilities and marginal improvements to existing facilities. Most future investments are likely to be of the latter variety because some level of transportation service exists almost everywhere. The underlying principles of transportation investment analysis are equally appropriate and valid in both circumstances. In practical terms, the difference is that in the case of investments to upgrade facilities, an incremental benefit-cost analysis is appropriate (the existing facility is a sunk cost). The key issue is whether the additional investment will lead to increases in benefits that exceed the relevant costs.

Highway benefits may accrue not only to individuals and businesses who use the highway. Lower transportation costs may be passed on to consumers as lower prices for consumer goods, to workers as higher wages, or to owners of businesses as higher net income. Thus, individuals may benefit from a highway without traveling on it, for example, when travel on the highway by others increases the income they derive from their resources or when such travel increases the purchasing power of that income (by reducing the prices paid for commodities).

Although all highway benefits are derived from lower transportation costs, they can also be represented as increases in the real incomes of individuals in their roles as consumers and producers. (Real income includes the value of environmental amenities, safety, and other goods that are not ordinarily traded in the marketplace. Therefore, real income is not simply the purchasing power of monetary income generated by transactions.) Highway benefits can be considered increases in real income regardless of how they are initially realized and regardless of the extent to which they are passed on to consumers and resource owners who do not directly use the highway. Furthermore, increases in real income may in some cases be capitalized into asset values; for example, the value of land at a particular location may increase when road transportation to the location is improved. It is important when estimating highway benefits not to double count by including both the transportation cost savings and the increases in real income and asset values that these cost savings induce.

The increases in income that individuals receive as producers and the increases in the purchasing power of that income that they enjoy as consumers are the basis of their willingness to pay the costs of highway investments. This use of the term "willingness to pay" presumes that a person would be willing to pay up to the full amount of the increase in real income that a highway investment would generate rather than have the investment not take place. Of course, the person would prefer to pay less than the full amount. If the costs of the highway improvement are lower than the real income gains that it generates, then the improvement has the potential for benefiting some or all of the population and is therefore said to be economically efficient.

Building or improving a stretch of road may reduce the benefits derived from existing highways. Therefore, a project's benefit to an entire state usually cannot be determined by looking only at how the project affects transportation costs for those using the highway and the value of property along it. For example, upgrading an existing highway to four lanes may lead some businesses to locate along the upgraded highway. But this relocation does not mean that the project increases business activity in the state as a whole if the businesses would have located at sites on an existing four-lane road. Instead, the project in this case simply diverts activity from already available sites to the new sites. That is, a project cannot be credited with bringing new economic activity to the state if the sites on the upgraded highway are essentially duplicates of unused sites on existing four-lane roads. In this case, there is no shortage of sites for commercial and industrial businesses, and there is no economic development justification for the project. Although the project increases income and property values for owners of property along the upgraded road, it does so at the expense of owners of property along existing roads. Furthermore, in addition to transferring income and wealth from one group of property owners to another, the project generates a net loss for the state unless its benefits exceed its cost. If the project's benefits, measured by people's willingness to pay for the safer and faster travel that it provides, exceed its costs, then the project satisfies the efficiency criterion and promotes development (broadly defined as increasing the real income generated within the state). Once again, there is no need to appeal to a separate economic development justification for the project.

Impact Area

A transportation investment contributes to economic development if it significantly reduces transportation costs, thereby improving the net return on mobile resources in the area. By helping to produce a better return than would be realized at competing locations, the investment helps attract mobile resources. If the impact area of interest is a rather narrow corridor along the facility, those benefiting significantly may be able to compensate those negatively affected and still enjoy net gains. From the perspective of the corridor, the project will then be efficient.

If state funds are used to finance the transportation improvement, the impact area of interest is the entire state. In this case the project will be efficient only if the state residents as a whole experience benefits that exceed their costs.

If any of the economic activity attracted to the corridor is shifted from other sites within the state, that activity cannot be viewed as new economic development but rather as a transfer from one place to another (more properly, from one group of people to another). This simple fact is widely appreciated, and states typically do not credit in-state relocations as benefits from a particular project.

However, many states attempt to recruit businesses from locations in other states. From the narrow perspective of the gaining state, this recruitment constitutes an increase in product generated and, hence, economic development. But from a national perspective, no new economic growth is likely to occur from the transfer. (It may be that the new location is conducive to increased productivity on the part of the business. In this case the net benefit of the transfer is this productivity increase minus the costs of the move.) Any public investments to encourage a move are a net loss to the nation as a whole unless other users of the new facilities benefit sufficiently to warrant the cost. From a national perspective, states working to draw industry away from one another do little, if anything, to foster national growth.

If transportation investments intended to foster economic development in a particular area do not promote national growth, the only rationale for federal funding is income redistribution. In this instance, two tests must be passed. First, income levels in the benefiting area should be comparatively low. Second, the project should be efficient. If it is not, the low-income area would be better off with a cash subsidy equal to the benefits of the transportation investment, as would the federal government, because the subsidy would be less than the cost of the investment.

If for political reasons transportation investments are made in the guise of promoting area economic development, the nation becomes less well off if these investments are not efficient. From a national viewpoint, then, inefficient investments have the opposite effect than their supposed intent.

Uncertain Future

Perhaps the most vexing issue in transportation investment analysis is uncertainty about future conditions, including demand for the facility. A thorough benefit-cost analysis depends on accurate estimates of future demand for the transportation facility. However, previous long-range forecasts have been inaccurate enough to raise doubts about the probability that great accuracy will be achieved in the future.

Given an uncertain future, should society err on the side of overbuilding transportation facilities or on the side of foregoing potentially valuable improvements when their efficiency cannot be absolutely ensured? This question is especially germane in less populated areas, where the long-term economic future is particularly unclear. One useful way of viewing the issue is to apply the analogy of portfolio management. In other words, there is room for a certain level of calculated risk as long as the overall strategy is sufficiently prudent.

A distinction must be drawn between highly speculative investments based on an assumption that mobile resources will follow a road, regardless of its placement, and more prudent investments. Analyzing the likelihood of attracting the other factors of production (capital, labor, and materials) necessary to enable growth is a good place to begin.

Competition and Duplication

As stated earlier, transportation investments can contribute to economic development only when they generate sufficient benefits to offset their costs. Truly duplicative facilities compete for traffic; they are less likely to be efficient unless the demand level for each is high. But are there conditions when competition between public facilities can actually contribute to cost-effective service?

Consider the example of competing ports along a coastline. The ports function much like private businesses in that the cost and quality of service greatly affect the choices made by the operators of vessels. Because of competition, the ports have an incentive to operate in a cost-effective manner. If a port cannot attract vessels because of poor management or a competitive disadvantage, it may not be able to continue operating. The more efficient ports will prevail and will strive to remain competitive.

In this example, some degree of duplication probably leads to a higher overall level of service than would exist without competition. A more difficult example might be two competing rail lines, each of which serves a series of businesses and receives a subsidy. Public decision makers could judge one line to be superior and end the subsidy to the other, creating hardship for those affected. Or, if both lines are efficient (benefits exceed costs), they could both be maintained. Maintaining only the most efficient facility is not always good policy; the costs and benefits of maintaining, downgrading, or closing other facilities deserve careful attention.

Efficient Investment Versus Other Objectives

An area can promote economic development by undertaking highway investments that are economically efficient. It is unclear whether the objective of economic development is also served by making investments that cannot be considered efficient but are intended to satisfy some other criterion. Such investments have opposing effects on the area's economic growth and development.

On the positive side, the investment probably would lower transportation costs involved in carrying out production in the area, which would favor economic growth. But the investment would also mean higher taxes and fees, which might increase the cost of doing business in the state and discourage growth. Owners of mobile resources (labor and capital) would have an incentive to find a more attractive post-tax return elsewhere. If an area fails to attract and retain mobile resources, economic development is impossible.

An alternative criterion to economic efficiency for guiding highway investments is that of income redistribution. Investments in highways and roads are used to influence the pattern of investment across regions or within a particular region. In other words, a redistributive policy would be aimed at place prosperity rather than people prosperity. Resources would be invested not to maximize the welfare of society as a whole but, rather, that of a designated place.

Some analysts are skeptical about using highway investments to foster economic development in lagging areas, contending that the relative lack of development in areas with weak or stagnant economies is much less likely to be due to inadequate transportation than to a shortage of factors such as labor, location, and agglomeration economies (lower costs caused by an aggregation of activities). If highway investment in a declining area would cost more than the value of the resulting benefits, it would be inefficient even if the objective were to aid the area. That is, deploying the resources to benefit residents of the declining area in other ways would be more cost effective. For example, a block grant cash transfer to these residents would benefit them more than the same dollar amount invested in an inefficient highway. If the highway does not carry particularly high traffic volumes or is not able to reduce costs significantly, the benefits to area residents, both users and nonusers, will not be great.

APPLYING THE PRINCIPLES: SIX PARADIGMS

The previous discussion defines the general conditions under which transportation investments may foster economic development in substate areas. To further clarify these conditions and to relate them to specific circumstances likely to be encountered by planners and policy makers, six paradigms were developed. The paradigms illustrate a variety of situations that frequently confront policy makers when assessing the potential effects of a highway project on an area's economic development. Similar reasoning applies to other modes.

Sixth City

Consider a circumstance in which a community aggressively pursues an out-of-state company that intends to build a new plant. In its negotiations with the company, the community finds that a major issue is the inadequacy of a road connected to an Interstate highway. The community requests funds from the state department of transportation (DOT) to build a connecting road.

The state DOT determines that five similar communities within the state also have the necessary attributes. However, these five communities would not require the connecting road because adequate access already exists to an Interstate highway. Should the state DOT fund the project even though the road would be duplicative with a number of existing roads?

New facilities that serve the same function as existing ones are inefficient because no additional incremental benefits to society result. However, a sizable capital cost must be defrayed. The example illustrates, of course, that local communities are usually the applicants in state highway programs related to economic development. It would be difficult politically to redirect the company from the community that is trying to recruit it to another that already has the needed connecting road. Programs that promote competition among communities within a state for economic activity are likely to fund projects that are duplicative and, from a state perspective, inefficient.

Gold Mine

A second paradigm relates to a situation in which a business owns a parcel of land with a unique potential for economic development. For example, the parcel could be adjacent to a beautiful lake, making it an opportune site for a tourist facility, or it could be endowed with a special natural resource (e.g., oil or ore). The business owning the parcel determines that the present value of the income stream of the parcel, net of taxes and expenses, is about $10 million.

To recover this $10 million, however, a road would need to be built—at a cost of $2 million. Few others than the business would use the road, although it could be built as a public road. Without government assistance, the rational choice would be for the business to build the road; a net income of $8 million is far better than earning nothing without the necessary access. Instead, however, the business requests that the state DOT build the road, arguing that jobs would be created, the local economy diversified, and taxes paid.

Several key points are at issue, one of which is whether government should subsidize the development of immobile resources. As previously discussed, immobile resources cannot be transferred to another location where demand might be greater; hence, incentives to develop them are unneeded. If developing a site is not economical for the private sector, public-sector subsidies are unlikely to be efficient. Conversely, if the site has a unique resource that is in demand, as in this example, no public subsidy is needed or warranted.

Devoting public funds to enhance the private return on the profitable site amounts to a transfer from taxpayers to the owners of the business. Unless a transfer can be defended on the grounds that the business produces a good that benefits society to a greater extent than is reflected by the market, the transfer is inefficient. As such, it increases the tax burden on other businesses and households, which is deleterious to economic development.

A highway investment program should not devote its resources to building a road whose benefits are mainly increased profits to owners of immobile resources, especially if the benefits would accrue to a small number of people.

Raise the Ante

The third paradigm relates to the practice that has emerged whereby state and local governments wage bidding wars with their counterparts elsewhere to attract desirable businesses. Consider a situation in which a community seeks to attract a light industrial plant that is nonpolluting and would employ several hundred workers. Such an activity would be coveted by nearly all communities.

In order to improve its prospects for attracting the plant, the community requests that the state DOT substantially upgrade a public highway serving the proposed plant site. The community also requests job training funds from another state agency and offers a local property tax abatement. Lacking a coordinated or single-point funding approach, the total value of these incentives could be sizable.

More important is that the incentive package could well be inefficient if its total value exceeds the present value of the wealth enhancement brought about by the plant. An assessment should be carried out that considers distributional impacts—the effects on area households and businesses. The assessment should take into account the extent to which jobs would be created by the plant, as opposed to shifted there from other locations. If jobs are merely shifted, society does not gain, and the incentives amount to a net cost that actually worsens overall economic development prospects regionally or nationally.

The total ante offered should not be whatever it takes to attract the business but, rather, only that which is not greater than the economic benefits of having the plant.

Spread It Out

The fourth paradigm pertains to a desire for state government to help spread out economic development. Specifically, the state DOT is asked to do what it can to build highways that better serve less prosperous areas. The hope is that improved accessibility will lead to the attraction of economic activity and will balance development across the state.

Most states have significant geographical variations in prosperity. One or a few urban areas often dominate the state's economy. Scale economies (larger plants, office complexes, and the like), agglomeration economies (shared capabilities, such as law firms and printing services), and superior locations (explaining the urban area's initial settlement and growth) give certain urban areas competitive advantages in attracting mobile resources.

The return on mobile resources such as labor and capital is superior in certain growing urban areas, so these resources congregate there. Because the greater density of economic activity already present in more viable urban areas and the growth taking place in them leads to escalating traffic volumes, road investments in these urban areas tend to be more efficient than typically is the case in more remote rural areas or urban areas experiencing decline. If other key factors of production do not exist and are unlikely to be attracted to depressed areas, building improved transportation facilities is unlikely to contribute much to economic development.

The state DOT faces a critical public-policy dilemma as an agency charged with promoting the public welfare. Through its highway investments, it can either work to maximize overall state economic growth and development through efficient investments or it can seek to spread out development. The latter often means foregoing more efficient investments, thereby reducing the aggregate economic development potential for the state. In simple terms, trying to spread out development will diminish statewide growth. The state's residents, overall, will be less well off if resources are spread out as a policy objective.

Open Up the Amazon

A paradigm somewhat related to the previous one pertains to a policy objective to make less-well-served parts of the state more accessible. Unlike the previous paradigm, however, the objective is not to raise the incomes of depressed areas, per se, but to foster growth in undeveloped areas. By its nature, the practice of providing access to these areas is speculative. It could bring about new opportunities, or it could result in serious inefficiencies.

The effects of railroads on opening up the West during the late 1800s are legendary. Can the same be true of highways today? Almost 30 years ago, analysts first argued that further major investments would not greatly influence the spatial pattern of private investment. Recent industrial location surveys have led to the conclusion that education, unionization, physical amenities, business climate, energy, and tax rates define a region's developmental prospects to a much greater extent than do highways.

Rarely will the high construction costs of adding new regional highways to the nation's highway system be justified on efficiency grounds, even in less-developed areas. Because a sufficient number of developable sites remain, providing highway access to others is unlikely to advance economic development. Arguments of place prosperity and geographic redistribution, and not efficiency, must form the basis for highway investments under these circumstances.

The Carnival

The final paradigm is concerned with "foot-loose businesses"—those for whom the transaction costs of relocating are low. Foot-loose businesses tend to make minimal investments in immobile facilities; they are more likely to lease buildings and less likely to purchase bulky machines. If only slightly more favorable economic circumstances avail themselves at another location, foot-loose businesses will likely depart. Over time, such businesses are analogous to a carnival; they move from place to place.

Care should be taken when making a permanent improvement in the area's road system to attract a foot-loose business. Reasonable certainty should exist that an equally beneficial activity will occupy the facility if the business leaves. Failing this, investments in fixed transportation facilities should be deferred until objective forecasts portend efficiency-ensuring traffic volumes.

One useful indicator of commitment by the business is the level of capital expenditures. If the ratio of private capital expenditures on a facility to be served by a road investment compares favorably with the cost of the road, a stronger argument can be made for a public-sector expenditure. Thus, private-sector capital expenditure should be an important element in analyses of potential local road investments, especially if the expenditure is long lived and fixed to the site.

Implications of the Paradigms

The six paradigms apply the central points presented earlier to a series of real-world circumstances likely to be encountered by planners and policy makers. The paradigms convey a stern message, that many pitfalls exist when seeking to stimulate state or local economic development by investing in highways. In the end, the wisdom of such investments depends on how they fare when the efficiency criterion is applied. In other words, will the investment lead to a net economic gain to society? The surest way to an efficient investment is to concentrate on the benefits for users of the highway and those who stand to gain through reduced transportation costs.

Is there room for speculative investments under any circumstances? The answer clearly depends on the certainty and size of the investment's potential payoff. Careful forecasts of future travel demand are a critical element in gauging the probable efficiency of an investment in a new or significantly upgraded facility.

STATE-LEVEL HIGHWAY INVESTMENT PROGRAMS

One of the more common elements in state and local government efforts to stimulate economic development is the investment in roads and highways. At present, 24 states have special programs to provide funds for such investments. A recent survey of the 50 states indicated that when specific criteria are applied to evaluate proposed projects, they tend to include the following: number of jobs projected to be created, cost per job, and the amount of capital investment per state program dollar. Several problems are examined using these measures, and an alternative strategy is offered on the basis of the efficiency-based concepts presented earlier.

Number of Jobs Projected

This criterion is based on the correct idea that a public investment in a road should facilitate the more effective use of resources, in this case labor. Presumably, additional jobs imply more aggregate spending and a generally stronger economy. The difficulty with this measure is that employment increases on the part of the business being assisted may not result in a net increase in total state employment. It is difficult to ascertain how many of the projected jobs will be new and how many will simply be transferred from another location within the same state. Moreover, if the jobs are low paying, they may not lead to increased income within the state, especially when the need for public assistance is considered. In short, using this measure as an investment criterion cannot ensure efficient projects.

Cost per Job

By itself, this measure reveals little about the effectiveness of a state highway investment program. Even if it is assumed that all of the jobs are new to the state, determining a reasonable amount to pay for a new job is difficult. Unfortunately, the data needed to make this determination are unattainable. The per-job average increase in income generated by the project could be estimated, but the associated costs cannot be accurately measured. Furthermore, to determine the extent of economic development (increases in state residents' wealth) per job would be nearly impossible. Finally, because jobs are not of equal value, it is difficult to scale the value of a particular job in a specific circumstance.

Private Investment

To gauge the efficacy of a road investment intended to foster economic development, this criterion uses the ratio of private capital invested at the site to the public cost of the road. On the one hand, a high ratio implies that the carnival paradigm is avoided because a commitment is being made. Yet, as in the paradigm of the gold mine, being sure that the private investment would not have occurred anyway is exceedingly difficult. Furthermore, like the number of jobs, this measure is an indicator of economic activity at the site, not of net gains in such activity within the state.

Decision Screens: An Alternative Approach

During the research, a series of evaluation screens was developed. As shown in Figure 1, these screens are an operational approach to applying the road investment concepts discussed earlier. As presented, the screens apply to the rather typical circumstance in which a firm requests assistance from the state DOT either directly or through the community in which it intends to locate. Proposed investment projects can be evaluated by applying the screens sequentially. A project passing through all five screens will likely be efficient and help foster economic development. A brief explanation of each screen follows:

1. Does the firm have to operate within this particular state because of the product or service it is selling? For example, a retail store responds to demand; if sufficient demand exists, retail stores will appear without government incentives. Thus, if the answer to this question is yes, no public investment is warranted.
2. Is there a cost advantage for the firm at this site compared with other sites within the state? If other sites within the state are equivalent to the improved site from the firm's perspective, the investment is not warranted on efficiency grounds.
3. Is the project cost-effective? In other words, are road improvements the least expensive way to give to the firm the level of benefits necessary to attract it to the state? For example, a cash subsidy well less than the cost of the road may be of equal value to the firm.
4. Is there an out-of-state site that provides a cost or profitability advantage over the best available site in the state if the road investment is not undertaken? The state can only benefit from funding a road investment project to help attract a firm if the project actually changes the firm's location decision. A firm could be asked to specify the location of the better site and explain why that location is preferred.
5. Are the benefits of the project concentrated? A project that benefits only a small number of people but whose costs are shouldered by many is not desirable unless aiding these particular beneficiaries is a distributional policy objective.

These five screens attempt to make the basic concepts discussed earlier operational. Certain data and measurement problems remain, but the evaluation screens suggested can help identify efficient projects, even if further simplification becomes necessary. The key point is that longer-term economic development is best served by systematically evaluating project costs and benefits, not by being caught up in arguments about the benefits of "image-building" roads, for example. If a project cannot be justified on the basis of efficiency, a careful assessment should be made of the extent to which it contributes to the attainment of other policy objectives.

CONCLUSIONS

The relationship between transportation investments and local economic development is subtle and difficult to measure accurately. Estimating the probable developmental impacts of a

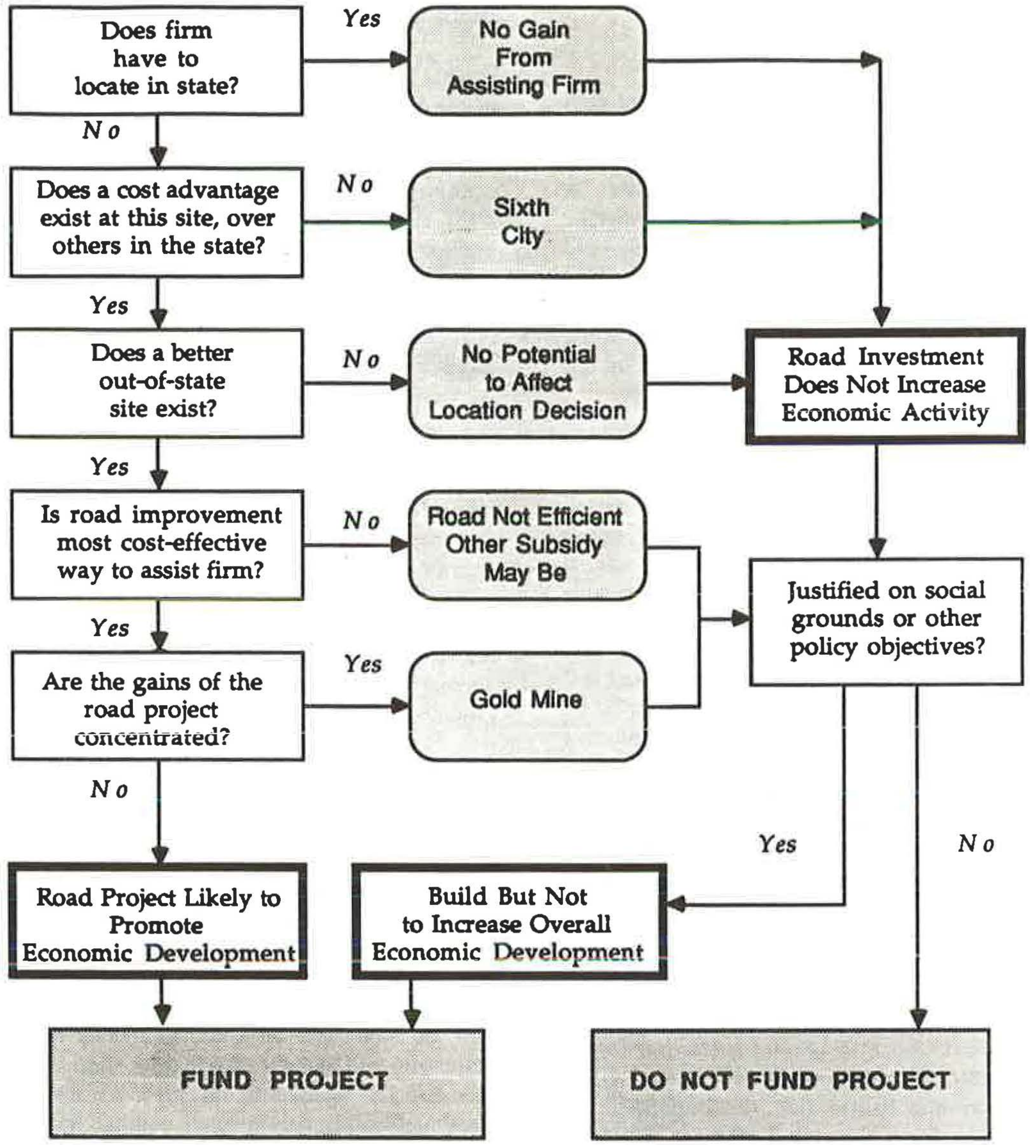

FIGURE 1 Application of decision screens.

proposed investment (a new facility or an upgrade) is as difficult as examining the actual effects of an existing facility. In part, the complexity stems from the significant effects on the economic fortunes of cities and regions by external forces beyond the control of state and local policy makers.

Despite great uncertainty about future conditions, and hence the value of transportation facilities, certain guiding principles can be applied. Fundamentally, the ability of a transportation facility to contribute to economic development is solely dependent on the traffic it carries. Reduced transportation costs help make the area served by the facility attractive to businesses.

Good transportation facilities are not enough to ensure that economic development will occur. The area must be able to attract the necessary factors of production, labor, capital, and materials. Without such factors, even a good transportation facility will accomplish little, as evidenced by the miles of Interstate highways that run through many rural areas.

Investing in transportation facilities whose benefits exceed their costs is critical to make an area attractive for development. Failing to invest in what could be efficient facilities will retard growth as surely as investing in those that are not efficient. However, estimating the long-term benefits of a facility is not an easy task. Neither is determining when facilities are likely to compete in an efficiency-enhancing manner rather than robbing each other of their reason for existence.

Particularly vexing are the competing roles of efficiency and other social objectives. Specifically, a state could invest in (or continue to operate) facilities that are not efficient, according to the traffic carried. Although doing so may improve an area's accessibility and even its development potential, it will also require a subsidy from other, more efficient facilities or from taxpayers in general. The result is higher user fees or taxes than otherwise would be the case, which is deleterious to economic development. The policy trade-offs are complex but should be treated explicitly.

The six paradigms are intended to illustrate variations of these policy trade-offs. They show the attention to developmental objectives that must underlie investment decisions. To help guide the evaluation of projects, a series of five decision screens was submitted (see Figure 1). The screens shed further light on considerations that can guide state-level transportation investment decisions and transform the principles discussed into investment guidelines.

The relationship between transportation investments and economic development is complex. The surest way to foster economic development through transportation investments is to focus on cost savings to users and consumers. Improvements that yield transportation cost savings in excess of the costs they impose lead to real increases in income—the essence of economic development.

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Role of Transportation in Manufacturers' Satisfaction with Locations

DAVID T. HARTGEN, ALFRED W. STUART, WAYNE A. WALCOTT, AND JAMES W. CLAY

A study is currently under way in North Carolina to examine the complex relationship between transportation investments and satisfaction of manufacturing firms with location. The study is part of a continuing analysis by the University of North Carolina at Charlotte to develop the linkage between transportation and economic development. The 100 counties of North Carolina were classified according to transportation access, economic structure, manufacturing composition, and socioeconomic characteristics. A data set consisting of more than 400 variables was analyzed using factor analysis and cluster analysis to develop the classifications. The counties were then grouped into six clusters. Using this cluster structure, a survey of about 1,000 manufacturing firms in North Carolina is being conducted using an extensive mail questionnaire. Manufacturers have been asked to describe their perceptions of the importance of transportation systems and other factors in bringing in materials, shipping out products, and providing access to labor markets. These data will be correlated with information on highway investments, location of the firm with respect to the highway system, and other transportation access measures. Models such as factor analysis, discriminant analysis, and canonical modeling will be used to determine the relative importance of transportation against other socioeconomic and fiscal variables in determining manufacturer satisfaction. Then, policy analysis of various transportation funding strategies will be used to determine the effects of investment. Findings will be used to help rank transportation system investments intended to strengthen the state's industrial base.

The approaching completion of the Interstate system marks the end of an era in U.S. economic development and transportation investment. After approximately 35 years and more than $100 billion, the 44,000-mi system is largely complete. During its development, the system has contributed to a transformation of the U.S. economy from one based largely on separate regions with significant intraregional economies to one based on highly interdependent regions connected by a vast network of transportation services. At this megascale, the Interstate system has not only facilitated the transformation of the U.S. economy but has propelled it forward in many positive ways. The Interstate system has returned its investment manyfold through economic growth, greater national interconnectedness, and higher quality of life. Perhaps no other governmental investment in U.S. history has had so great a relative effect on the nation's economy.

What else can be done? How should future transportation dollars be spent? These are simple questions with complex answers. In spite of a general understanding of the impact of the Interstate system, knowledge of the relative effects of specific transportation investments on economic development is surprisingly limited. Current transportation economic analysis focuses almost entirely on the quantification of user benefits, that is, benefits derived from savings in travel time, reductions in operating costs and accidents, and other quantifiable effects on users of transportation systems. Modern transportation economics is based on the evaluation of such benefits. Nonuser benefits (including second-order positive and negative effects on adjacent land owners, increases in land values, additional increases in economic activity that result in greater tax dollar flows, improvements in competitive position, and improvements in the quality of life) are not only generally not quantified but are often ignored as inconsequential or dismissed as irrelevant to transportation decisions. Methodology for determining such effects is not extensively developed.

More recently, broader views of transportation evaluation have included assessments of the effects on economic development, but in an essentially nonquantifiable or quasiquantifiable way. That is, estimates of the number of units affected or the resulting change in accessibility (for example, the number of jobs within 30 min of a downtown area) have often been added to the users' dimension. Because of the difficulties of incorporating such elements in a dollar-based fashion, they have usually been treated separate from more easily quantifiable measures such as travel time, operating costs, and accidents.

Economic development reacts to transportation investments, but the reaction varies by industry type, preexisting local conditions, geography, site characteristics, demographics, and previous investments in transportation and other elements of the infrastructure. This study was intended to provide an understanding of these complex relationships, including issues such as the following:

1. For a given transportation proposal, what are its first- and second-order economic benefits or effects?
2. How important is transportation, relative to other factors, in determining the price of goods, in making siting decisions, in acceleration or deceleration of urban growth, in providing labor accessibility, and in moving materials or products?
3. If a given amount of money is spent on a statewide or regional transportation program, what will be the economic effect?
4. How can current companies be retained, and new ones attracted, through additional transportation investments?

Transportation analysts have found it difficult to answer such questions in satisfactory terms. Often, specific first-order

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effects on construction jobs cannot be estimated, and second- and third-order effects become impossible to assess without using high-level assumptions such as regional economic multipliers. The result is a less-than-satisfactory state-of-the-art in an area that is continuing to generate considerable interest.

LITERATURE REVIEW

Economic development has long been recognized as an important rationale for transportation investment, but the nature of the relationship remains unclear. At the national level, TRB (*1*) identified the following as critical research needs: (a) transportation and the U.S. competitive position worldwide and (b) transportation and economic development. NCHRP recently issued a request for proposal to determine the nature of this linkage. The Eno Foundation (*2*) assessed the relative importance of transportation to a healthy economy. The recent call for a system of Highways of National Significance (*3*) is one effort to propose a national corridor-level system of about 150,000 mi.

At the regional level, Toft and Stough (*4*) developed a shift-share model of the U.S. economy that showed economic shifts in transportation sector employment from the Old North to the Old South and West. Sullivan (*5*) analyzed the effects of transportation investments in the Pacific Northwest Coastal region. The Appalachian Regional Commission (*6*) justified the Appalachian Development Highway System on improvements in access leading to better delivery of services and attractiveness to industry.

At the state and local level, recent strategic plans for transportation (*7–10*) have recognized the importance of transportation access to economic growth. Many states have developed and are implementing corridor plans for upgrading selected highways to four-lane or Interstate standards. Wilson et al. (*11*) surveyed industrial firms in the maritime region of Canada to examine the relationship between transportation public expenditures and economic development stimulation. They used a local factor preference index model to analyze the importance of transportation and other factors in attracting industry to siting locations. Larson (*12*) found that the Interstate system is critical to Pennsylvania's economic growth. Lebo and Adams (*13*) developed an industrial- and commercial-access transportation network to accelerate Pennsylvania's economic development. Moon (*14*) found that the effect of 65 nonmetropolitan interchanges in Kentucky on local economics was large, even creating interchange villages on isolated land. Sinha et al. (*15*) reviewed the role of transportation on the northwest Indiana economy. Poole and Cribbins (*16*) developed a benefits matrix model for evaluating transportation proposals in North Carolina. Also in North Carolina, Clay et al. (*17*) developed a straightforward linear relationship between job growth and highway investment, by county type. Although the study found that each $5,796 in investments was correlated with one job increase, the authors recognized the inherent complexity of the relationship being studied. In nearby Georgia, Floyd and Melvin (unpublished data) found that the most important factor in giving a region a competitive edge in economic development is a superior transportation system. They projected that over half of all the growth in Georgia up to the year 2000 will occur in and close to Atlanta, because the state's current non-Interstate multilane system is inadequate compared with those of other southeastern states and considering desired growth rates. Also in Georgia, Maggied (unpublished data) investigated the relationship between mobility and poverty and concluded that Georgia counties could be clustered by different levels of mobility and economic deprivation.

Not all the studies show positive results. In a review of Interstate system effects on minority communities, Steptoe and Thornton (*18*) found that the presence of an Interstate system did not attract new businesses in minority communities. Eagle and Stephanedes (*19*) concluded that the effects of highway investment on the economy do not lead to long-term jobs, except in counties that are already economic centers. Even more pessimistically, Briggs (*20*) concluded that the presence of an Interstate system alone did not ensure development, particularly for manufacturing and wholesaling industries. He concluded that the Interstate's role seems to have been to increase accessibility levels throughout the country.

The importance of transportation to advanced-technology firms was reviewed by Hummon et al. (*21*). They found that Standard Industrial Classification (SIC) code variables representing industry type did not predict transportation preference, which was better predicted by type of firm, age of technology, and firm size. The study focused on advanced technology firms in Pennsylvania. It was concluded that transportation access is a necessary, but not sufficient, condition for locating and generating successful business at a given site. Paaswell (*22*) surveyed Illinois companies to identify the strengths and weaknesses for growth industries. In various input-output models, e.g., Liew and Liew (*23*), transportation investments affect the economy but in different ways for different sectors. Toft and Mahmassani (*24*) concluded that high-technology industries possess spatial and production attributes that require different transportation services.

The methodology of these studies varies widely. Constantin (*25*) suggested a functional logistics-based method, noting that the functional approach gives a better overall perspective on the role of transportation in small towns and rural areas. Varaprasad and Cordey-Hayes (*26*) developed an integrated set of 10 differential equations to describe London's population dispersal into two concentric rings. Twark et al. (*27*) used a system of simultaneous equations calibrated by two-stage least squares to predict economic development at 93 Pennsylvania Interstate interchanges. The model system used 15 exogenous and 25 endogenous variables. Maggied used factor analysis of county-level variables. Clay et al. (*17*), on the other hand, used straightforward trend statistics and simple correlation ratios.

MODEL STRUCTURE

To facilitate this study, the University of North Carolina at Charlotte (UNCC) team is working under the general guidance of several conceptual models of firm location and investment. These include a county-level economic model, a firm performance model, and a location life-cycle model.

Figure 1 shows how county-level economic structure influences firm activities. Firms are viewed as the decision-making

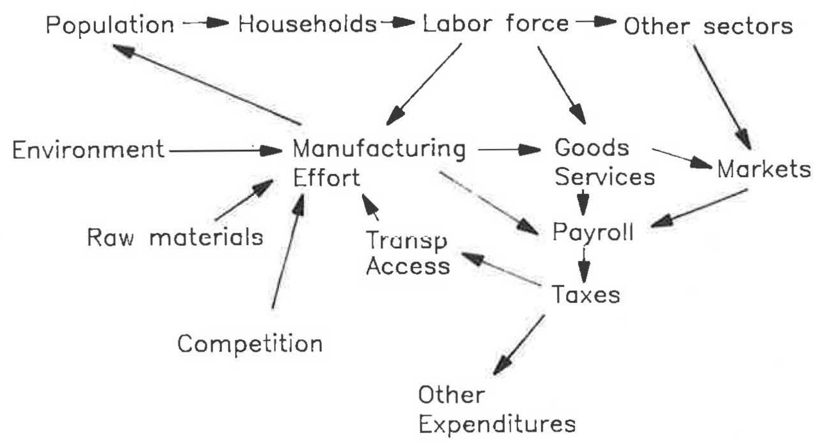

FIGURE 1 County-level manufacturing model.

unit embedded in a physical and socioeconomic county environment. Using labor, land, money, and other resources and raw materials shipped in from outside, firms generate wages and payrolls through the production of useful products and services. The transportation system provides the accessibility by which firms attract and hold employees and move the factors of production from the site to the marketplace through the manufacturer. This high-level view follows traditional economic thinking and relates the key elements of the firm's environment to its output products.

Firm performance (Figure 2) is viewed as the product of interactions among the firm's internal activities, wages, taxes, labor, the transportation system, characteristics of the firm's specific location, and actions of its competition. In this model, transportation access operates as a lens that mollifies or accentuates the effectiveness of the firm's ability to interact with its labor force, its markets, and its production system.

The firm's siting-decision process is viewed as a temporal series approximating a long-term life cycle (Figure 3). The firm's satisfaction with its current location and situation is

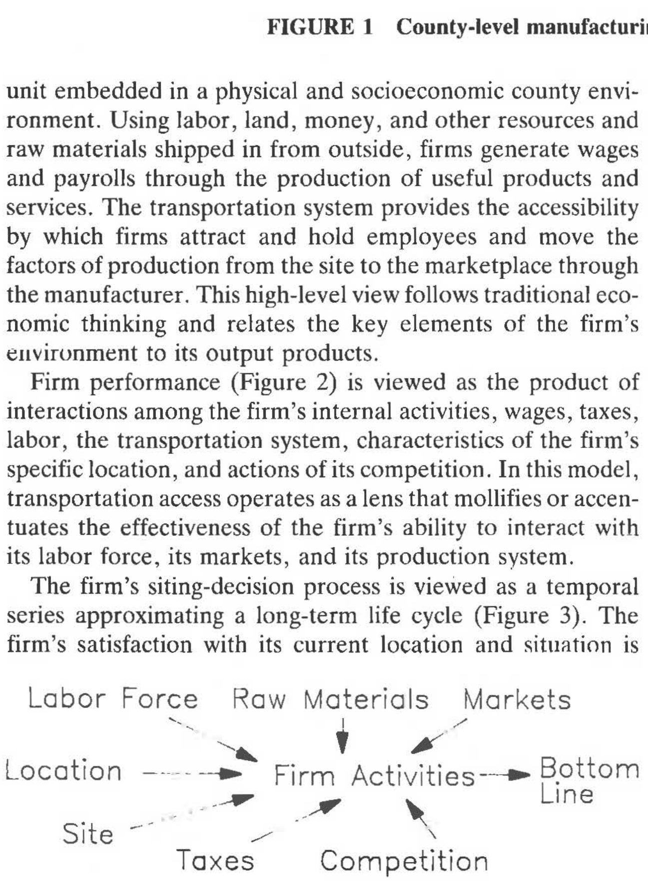

FIGURE 2 Firm performance.

hypothesized to be highest immediately after a move. After an interim honeymoon period, factors such as competition, aging facilities, price changes, labor, and supply problems generate a number of difficulties associated with the location, which deteriorates the satisfaction level. Eventually, these problems initiate a reevaluation process in which the firm consciously decides to assess its location in some formal way. A review of alternatives then generates a decision to stay put, move, or otherwise change its locational situation. In North Carolina, many firms have been operating at the same locations for up to 100 years; nevertheless, changes in labor, raw materials, markets, and competition can render the location less competitive now than when the siting decision was made. It might be expected therefore that companies expressing various levels of satisfaction with their current locations could be expected to be in various stages of their siting-decision life cycle. The issue is how firms currently view their location in light of changed circumstances.

The location of a factory is a major capital allocation decision. Once made, the factory is immobile until the investment can be amortized (in 20 to 30 years), unless it is sold. Thus location decisions take on geographic inertia—a resistance to relocation. A company may be unhappy with a location but financially unable to relocate for some time. The study survey will reveal this latent relocation potential, along with reasons for dissatisfaction that might be addressed by state policy changes. This emphasis on location satisfaction of existing manufacturers—as opposed to original location decision making—makes this study unique.

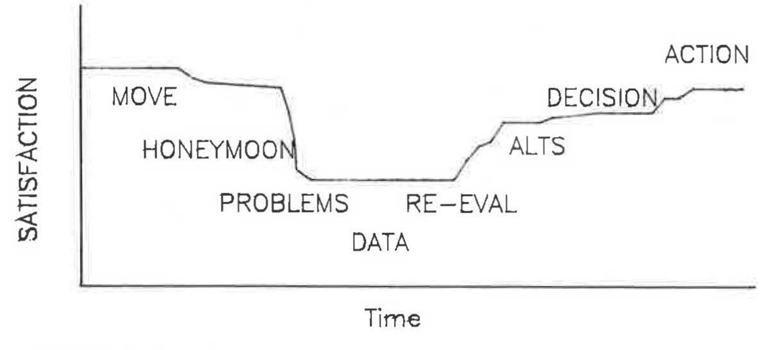

FIGURE 3 Location decision life-cycle.

STUDY STRUCTURE

A particularly interesting aspect of the relationship between economic development and transportation is the relationship between transportation access and the location satisfaction of manufacturers. Several aspects related to this process are addressed:

- What perceptions do manufacturers have of transportation access, and how are these current perceptions related to their previous siting decisions?
- What policies could be suggested to improve satisfaction with transportation systems, and how would such policies attract new firms or hold current ones?
- What other factors influence manufacturing firm satisfaction with location, and how are these factors different in rural and urban areas and rapidly growing versus slowly growing communities?

Earlier assessments found that North Carolina's crucial manufacturing base was undergoing change that threatened the viability of rural economies in particular. With about 30 percent of its workforce still in factories, the state is heavily industrialized. More uniquely, this industry is concentrated not just in cities; a large part is dispersed throughout small towns and rural areas. The more dispersed factories are largely in labor-intensive industries, especially textiles and apparel, which are vulnerable to offshore competition. Urban areas have experienced dramatic growth in nonmanufacturing, but the more specialized rural economies have not shared proportionately in these gains. Thus, North Carolina is seeking ways to retain and strengthen its manufacturing base, particularly in rural counties. Because manufacturing is viewed as the key to economic stability in these areas, the manufacturing sector of the economy is emphasized.

The study is divided into the following analytical tasks.

Classification of Counties

An economic and transportation-access classification of counties, necessary for survey sampling and analytical work, was developed. Previous works have shown that groupings such as rural or urban and metropolitan or nonmetropolitan are too simplistic for analytical purposes. Further, some terms, such as "rural," engender emotional responses that interfere with objective analysis. The 100 counties in North Carolina are being classified along socioeconomic, employment mix, manufacturing structure, and transportation dimensions. A large data set consisting of over 414 variables has been developed describing characteristics of the labor force, transportation access by various modes, and socioeconomic indicators. Sources of this information include census publications, materials from state and federal agencies, and private organizations. For many data items, information is available for several points in time, which will enable trend statistics to be developed. Table 1 presents the variables used in the classification. At the completion of this step, the four separate classifications will be merged into one that reflects the characteristics of each scheme.

Survey of Manufacturers

A representative sample of about 2,000 North Carolina manufacturing establishments will be drawn from the total of about 6,800 manufacturers in the state, in anticipation of receiving about 1,000 returns. The survey sample will be a stratified random sample using county classification structure and manufacturing industry type. Manufacturers will receive a six-page questionnaire focusing on their perceptions of transportation and other factors relating to their satisfaction with their current location.

TABLE 1 OVERVIEW OF COUNTY-LEVEL DATA

Group	Number of Variables	Description
Classification	19	State, regional, FIPS groups
Labor force	14	Labor/force 1980-1987
Unemployment	8	Unemployment rates 1980-1987
Employment	99	Employment by sector/year
Manufacturing Employment	92	Wages, Employment & Establishments in SIC codes 20-39
Education	18	Population at educational levels and institutions
Crime	4	Crime and prisons
Health	8	Doctors, nurses, beds, rates
Income	13	Per-capita income
Population	50	Population by age group 1970-2000
Population density	6	Density 1980-2000
County size	4	Area measure
Poverty	10	AFDC etc. statistics
Misc.	11	Tourism, sales, companies
Transportation-mileage	43	Miles by system, yr., width
-financing	17	Expenditures by system 1973-1985
-intercity	27	Access to train, bus, air, port, interstate

Analysis

Analytical work will involve a number of straightforward methodologies. Descriptive statistics will be prepared both for manufacturers and counties, describing their current economic structure and overall linkages with respect to transportation. Clustering methods are being used to classify counties and develop profiles matching county characteristics with industry characteristics. Correlations will be developed between transportation investment and perceptions of the quality of transportation service. Classification procedures such as Automatic Interaction Detector (AID), CLUSTER, and discriminant analysis are being used to identify the characteristics of firms that express very high and very low satisfaction levels with transportation facilities and network investment.

Policy Model

The study team will develop a policy model relating transportation investments to firm employment and siting-decision satisfaction. It is expected that the model will contain a number of simultaneous equations that will be embedded in a spreadsheet for forecasting purposes. Numerous policies, such as those being considered by the North Carolina legislature involving transportation investments for a proposed $8.6 billion highway program, could be evaluated for their effect on employment and economic development.

PRELIMINARY RESULTS

As of July 1989, study results were available only for county classification. The following results relate primarily to the classification structure.

County Classifications

The county classifications effort has focused on three major activities:

1. Descriptive statistics,
2. Factor analysis to identify key variables describing the differences in county structure, and
3. Cluster analysis of counties on the basis of these key variables.

Preliminary results of the assessment are as follows.

Trends and Statistics

North Carolina's economic development patterns are not uniform. Rather, overall economic growth has been concentrated primarily in major metropolitan counties, with additional strong growth concentrated in surrounding fringe counties. Overall employment trends in North Carolina (Figure 4) show essentially flat employment in manufacturing and a decline in agriculture, with a significant increase in nonmanufacturing employment. Changes in population have been most rapid in urban core counties and their surrounding environment, as well as in recreation and retirement counties (Figure 5).

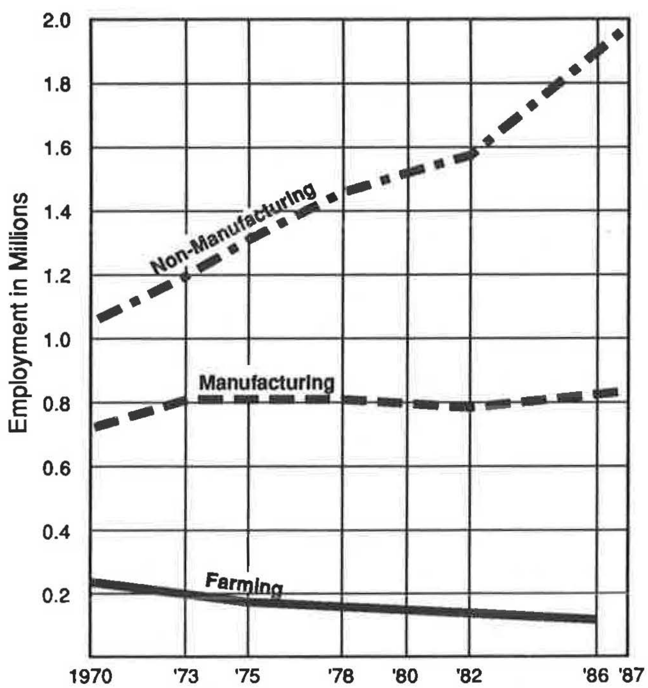

FIGURE 4 Employment trends in North Carolina.

Employment

Initial review of the employment portion of the data set suggested that employment in North Carolina can be represented by 11 variables, which were collected from data supplied by the Bureau of Economic Analysis (BEA) for 1986. After factor analysis was performed on this set of variables, seven were chosen as explaining the most variation between the counties. The 11 variables initially chosen are listed below.

- CVILEMP (STALOC + FEDCIV): state, local, and federal employees, excluding military.
- FIRE: finance, insurance, and real estate employees.
- BMFG: manufacturing employees.
- AGSMIN: agriculture and mining employees.
- CONST: construction employees.
- FARM: farming employees.
- HSLETRD: employees in wholesale trade.
- MILITARY: military employment.
- SERV86: services employment.
- TRAVEX86: travel expenditures, in thousands of dollars.
- BTOTEM86: total employment.

After the clusters were formed, a classification scheme of six groups of counties was chosen. The results of this classification are shown in Figure 6. The six groups include manufacturing, services, mixed manufacturing, farm, government, and military. Although the model developed for the employment section was fairly decisive, it did not explain much of the variation among the 100 counties in North Carolina. Of the total variation in these seven variables, 25 percent was explained by the six-cluster model. Forty-three percent of the counties had enough of a manufacturing emphasis to be clustered around the manufacturing dimension. Only the large urban counties and those with a large military pop-

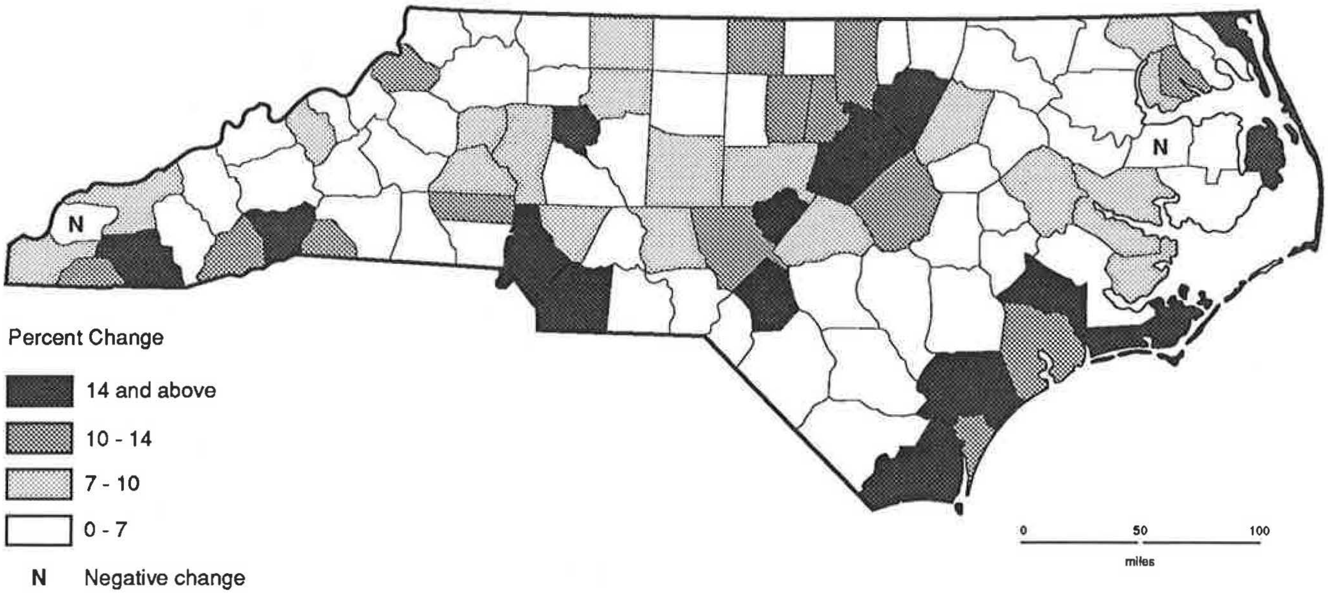

FIGURE 5 Percent change in population by county, 1980–1987.

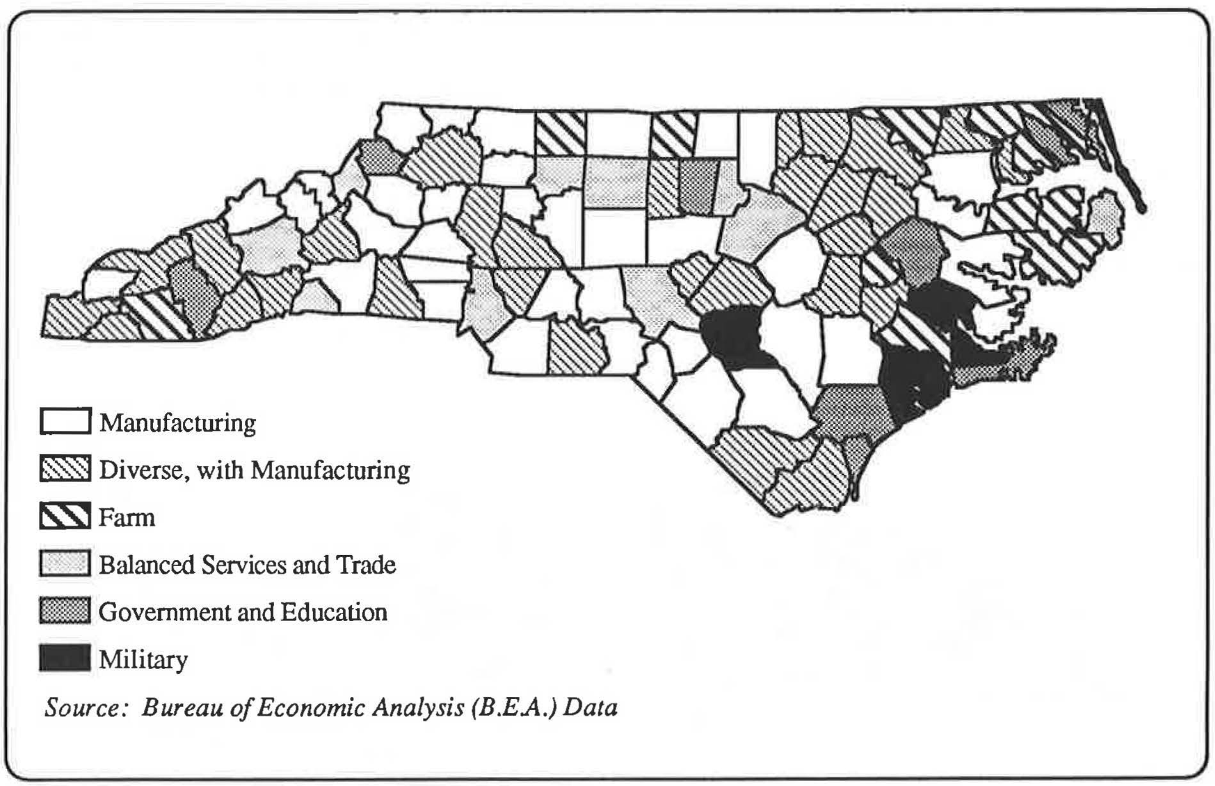

FIGURE 6 Employment focus by county, 1986.

ulation were well-defined groups, the remainder having a variety of employment types.

Several variables had little impact on defining the clusters. Among these are agriculture and mining, construction, transportation and utility, and wholesale trade employment. The factor loadings were rather weak: any variable that had a coefficient above 0.50 was considered acceptable for inclusion in the cluster analysis. Therefore, it would be incorrect to say that wholesale trade does not have an impact on the employment structure of the state; rather, these activities are spread thinly throughout the state.

Manufacturing

The manufacturing portion of the data consisted of 25 variables, each representing a part of the manufacturing employment in North Carolina. These data were compiled by the Employment Security Commission. Each variable represents one, or a portion of one, complete two-digit SIC category. In some instances, the SIC category was subdivided to sharpen differences within the category. For example, SIC 21 was broken into two categories, with cigarettes and tobacco in one and tobacco stemming in the other. Several sites were made at the three-digit level.

In the case of manufacturing, simply choosing variables that ranked high and running them through a cluster analysis was not feasible because this method was not able to break apart a large, diversified cluster of counties. Instead, a cluster model was performed on the basis of six factors, with each factor having special characteristics. For example, one factor was labeled "Office, Computing, and Accounting Machines," and another was called "Agricultural Chemicals/Apparel." When these six factors were used as a basis for a clustering algorithm, the pattern of clusters shown in Figure 7 resulted.

Fifty-five counties were left as a diversified cluster; that is, they did not cluster strongly around any single variable. Some tendencies toward the Tobacco Stemming/Miscellaneous Plastics group are evident, but the associations are weak. A plot of the factors showed that the clustering was weakly organized, with the diversified cluster (Cluster 1) mixed in with the remaining clusters (Clusters 2 through 5). This plot indicates the lack of strength of the model for forming clusters, especially for this group. The counties in the Diversified Products category are spread throughout the state, with the majority lying in the middle of North Carolina and two arcs extending through the coastal plains region all the way to the coast.

The cluster model developed for manufacturing is weak. The total amount of variance explained by the model is only 12 percent. Any plot of these clusters shows a high degree of intermixing. The categories should be interpreted as a general classification, or a focus, of the manufacturing employment structure of the counties in North Carolina.

Socioeconomic

From the data base, 24 variables were chosen to represent the socioeconomic characteristics of the counties. These variables include county population, population characteristics, and health aspects. Many of them were calculated from the more general variables found in the data base.

These variables were used in a factor analysis to determine which were the most important in determining the overall socioeconomic status of the counties. The factor analyses were performed with four, five, and six factors. The analysis that used four factors was found to be inconclusive; however, the analyses using five and six factors found 12 and 14 variables, respectively, to be pertinent for further analysis. These variables were then used in a cluster analysis to group the similar counties. Four major clusters of counties were identified as follows:

- *Cluster 1 (Distressed Rural) (very low)*—These 34 counties have generally low-level health variables, percentage of persons age 16 to 64, and size variables (population, density, and employment), as well as low employment figures and low personal incomes. They also tend to have a high percentage of nonwhites, a high percentage of families receiving aid for dependent children (AFDC), and a high unemployment rate. They are located primarily in the eastern part of the state (see Figure 8).
- *Cluster 2 (Mountain and Coastal Fringes) (low)*—These 39 counties have the lowest percentage of nonwhites and the lowest percentage of families receiving AFDC. They also have

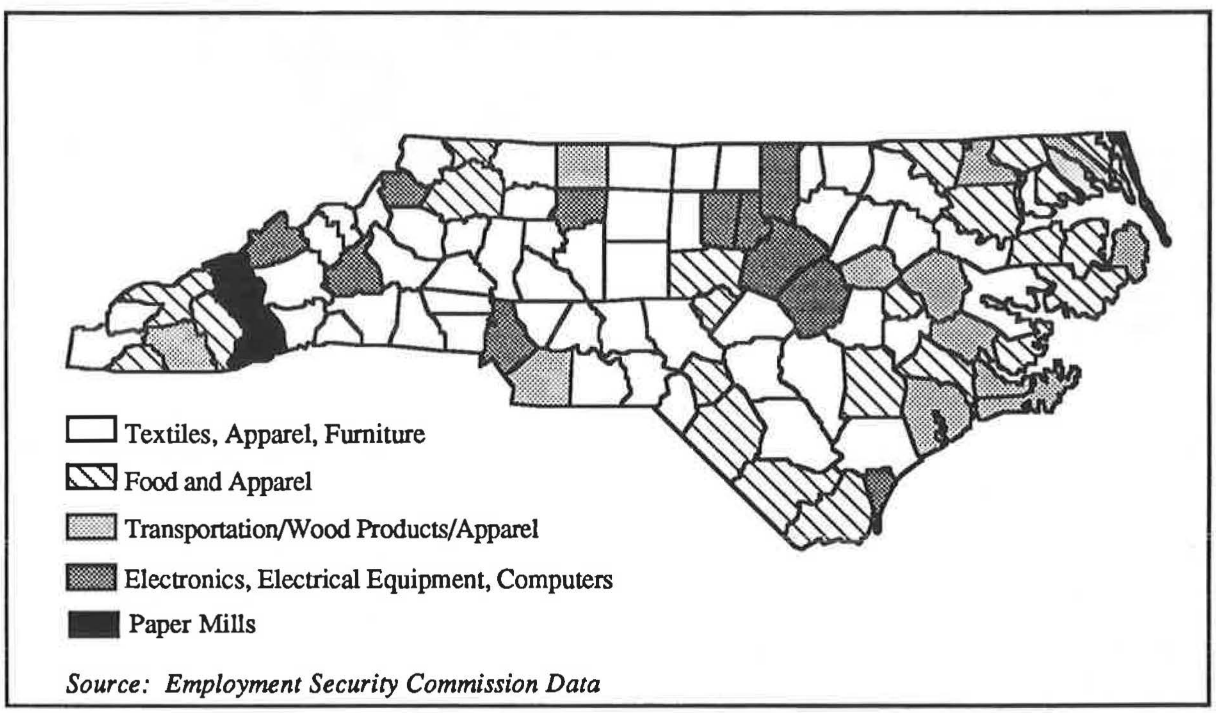

FIGURE 7 Manufacturing types of counties, 1987.

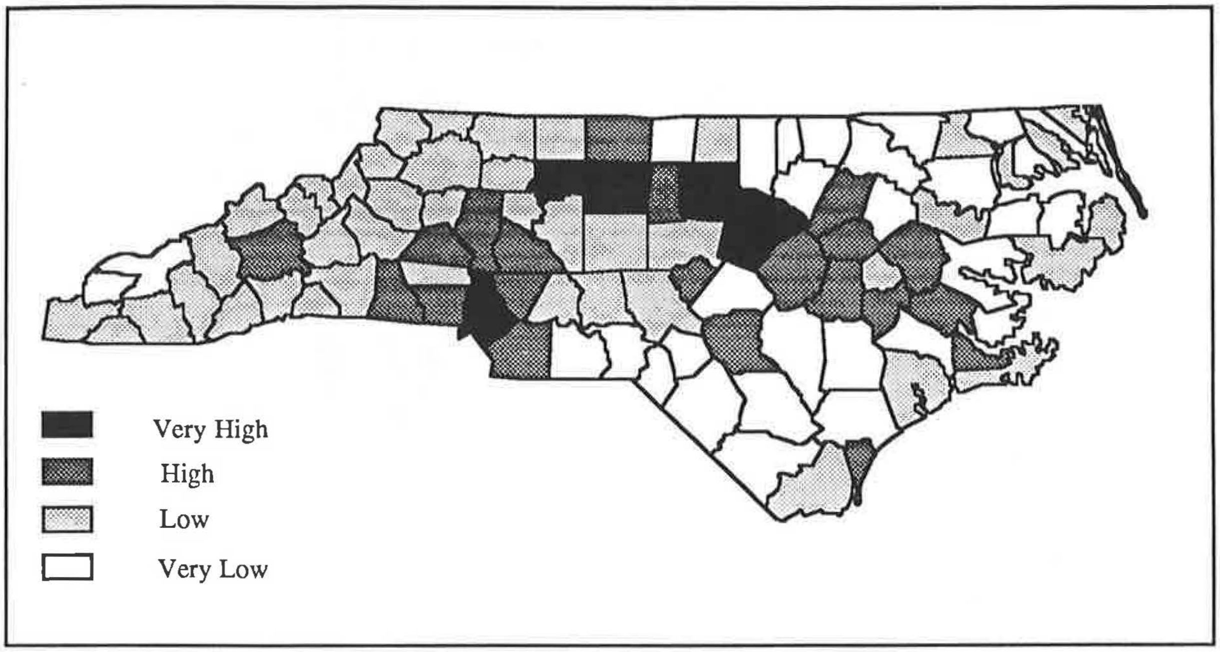

FIGURE 8 Socioeconomic status of counties.

the highest percentage of older persons and a fairly high unemployment rate. They have low health figures, size variables, and personal income, but not as low as Cluster 1.

- *Cluster 3 (Small Metropolitan and Suburban) (high)*—This cluster of 21 counties does not have any highest or lowest variables. These counties have fairly low numbers of persons aged 65 and over and a low unemployment rate. The rest of the variables are moderately high.
- *Cluster 4 (Affluent Metropolitan) (very high)*—This cluster is comprised of six counties: Mecklenburg, Guilford, Forsyth, Orange, Durham, and Wake. These counties have the highest health figures, percentage of population age 16 to 64, size variables, and personal income. They also have a fairly high percentage of nonwhites and families receiving AFDC. They have the lowest percentage of persons age 65 and over and the lowest unemployment rate.

Clusters 2 and 3 are much more similar to each other than are Clusters 1 and 2 or Clusters 3 and 4. Clusters 1 and 4 are the extremes of the variables and are very heterogeneous. Clusters 2 and 3 are in the middle statistically and are more homogeneous than the other clusters.

Transportation Variables

To develop a classification of counties on the basis of transportation variables, a list of about 90 transportation-related items was developed for each county. These include transportation access (distance and service levels) for each mode of travel; transportation expenditures by highway type; accessibility to Interstates, four-lane roads, and other roads; paved road miles; and roadway widths. This information was divided into three types, which were analyzed separately. The three types included the following:

- Internal (within-county) access,
- External (outside-county) access, and
- Fiscal (in-county) investment.

Internal Access Factor analysis of the internal access data set yielded a group of eight variables found to be important in county clustering. These variables described system size and urban-ness, system condition and quality, and traffic and system density. The eight variables include the following:

- Percentage of secondary roads;
- Percentage of urban roads;
- Percentage of primary roads;
- Total miles of road with more than four lanes;
- Interstate status (number of Interstates, number of Interstate exits);
- Percentage of narrow roads (lane widths <12 ft);
- Percentage of paved roads; and
- Total miles on the state highway system.

Cluster structuring of the counties on these eight variables yielded the five-cluster grouping shown in Figure 9. These clusters can be characterized as follows:

- Poor internal access, 26 counties (Cluster 1)
  - —Small system (approximately 570 mi)
  - —Very few four-lane roads, no Interstate
  - —High percentage of rural and secondary roads (72 percent)
  - —Medium percentage of narrow roads (57 percent) but high percentage of paved roads (78 percent)
  - —Prototype counties: Martin, Pamlico, and Jones
- Fair internal access, 25 counties (Cluster 4)
  - —Medium-small system (approximately 580 mi)

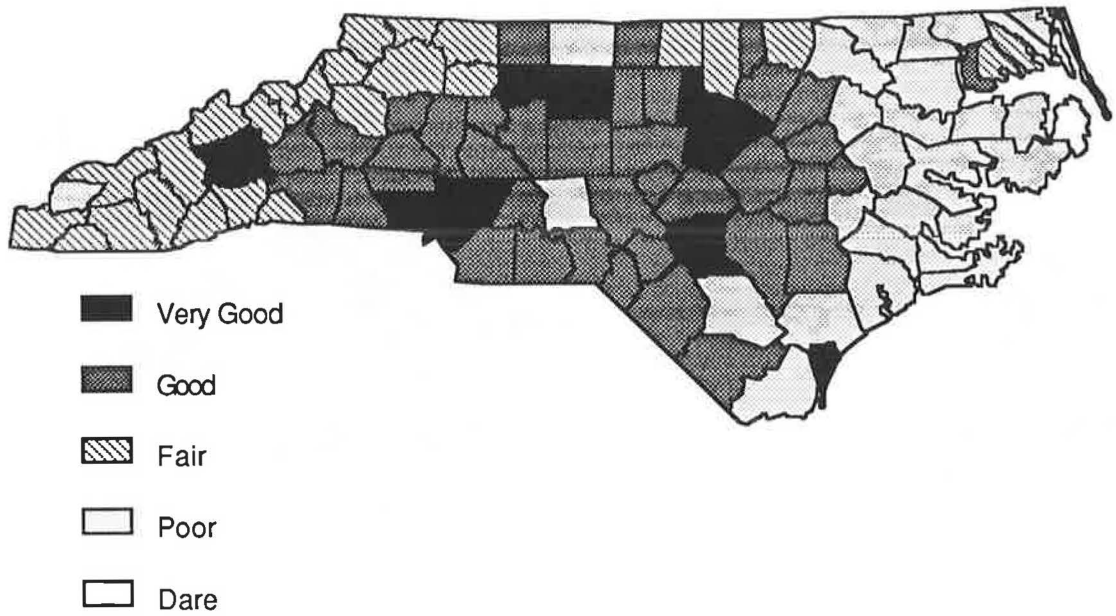

FIGURE 9 Internal access by county clusters.

—Contains at least one Interstate and some four-lane mileage
—High percentage of rural and secondary roads (80 percent)
—Low percentage of narrow roads (44 percent) and medium percentage of paved roads (62 percent)
—Prototype counties: Cherokee, Watauga, and Macon
- Good internal access, 38 counties (Cluster 2)
—Large system (approximately 930 mi)
—Contains at least one Interstate and some four-lanc mileage
—High percentage of urban roads (5 percent) and high percentage of paved roads (82 percent)
—Prototype counties: Wayne, Stanly, and Duplin
- Excellent internal access, 10 counties (Cluster 3)
—Very large system (approximately 1,120 mi)
—Large number of four-lane miles and Interstates
—Very high percentage of urban roads (15 percent) and high percentage of paved roads (85 percent)
—Prototype counties: Guilford, Durham, and Mecklenburg
- Special case—Dare County has a small spinal system, but a high percentage of urban roads through Manteo and Kitty Hawk.

Ten counties in North Carolina have excellent internal accessibility, and 38 have good systems. As Figure 9 shows, the counties with good systems are generally located in the Piedmont region, where the four major Interstates in North Carolina are located. The groups with fair or poor systems are located in the mountains and coastal regions.

External Access External access to a county is considered to be important in attracting manufacturing and other businesses because adequate access to production needs and markets is critical to a firm's viability. Straightforward definitions of access were used:

- Highways
—Number of Interstate miles, number of exits, and closeness to town center
—Number of four-lane miles of road
—Number of federal-aid Interstate miles
- Air
—Distance to major and minor hub airports
—Number of annual operations at hubs
—Number of enplanements at hubs
—Distance to general aviation airports
—Travel time to major hub
- Train
—Distance to passenger train station
—Number of train arrivals and departures
- Bus
—Distance to bus station
—County with rural or city bus system
- Port
—Distance to port city

Unfortunately, data on rail freight access were not readily available.

Extensive factor and cluster analysis of these variables yielded a highly separated set of clusters based on six variables:

- Miles of Interstate open to the public,
- Total four-lane miles of road,
- Travel time to Interstate,
- Travel time to major airport,
- Distance to bus station, and
- Distance to train station.

Figure 10 shows the cluster structure. The 100 counties are grouped as follows:

- Very low external access, 9 counties
  - —No Interstate, average 1½ hr to nearest Interstate,
  - —Average 7 mi of four-lane road,
  - —Average 2¼ hr to major hub airport,
  - —Average 94 mi to train, and
  - —Average 36 mi to bus.
- Low external access, 30 counties
  - —Little or no Interstate, average 74 min to an Interstate;
  - —Average 16 mi of four-lane road;
  - —Average 2 hr to major hub airport;
  - —Average 55 mi to train; and
  - —Contains or close to bus service.
- Moderate external access, 29 counties
  - —Little or no Interstate, average 30 min to an Interstate;
  - —Average 20 mi of four-lane road;
  - —Average 60 min to major hub airport;
  - —Average 41 mi to train; and
  - —Contains or close to bus service.
- High external access, 26 counties
  - —Average 23 mi of Interstate,
  - —Average 48 mi of four-lane road,
  - —Average 48 min to major hub airport,
  - —Average 35 mi to train, and
  - —Contains bus service.
- Very high external access, 6 counties
  - —Average 30 mi of federal-aid Interstate open,
  - —Contains average 153 mi of four-lane road, and
  - —Contains train station and bus service.

The analytical structure of the data shows that the top two groups, containing 32 counties, are more similar to each other than to the other three groups.

Transportation Investment Fiscal investment is a vital part of the transportation overview of each county. The more money a county receives in highway aid, the better the county's transportation system. The fiscal picture for each county was developed from North Carolina Department of Transportation (NCDOT) statistics and investments from the period 1973–1985. Data included the following:

- Secondary expenditures per mile,
- Urban expenditures per mile,
- Primary expenditures per mile,
- Total expenditures per mile,
- Interstate expenditures,
- Secondary expenditures per capita,
- Urban expenditures per capita,
- Primary expenditures per capita,
- Total expenditures per capita, and
- Total expenditures from 1973 to 1985.

Of the 25 variables analyzed, a surprisingly small number (four) were sufficient to explain county expenditure patterns. These are as follows:

- Total Interstate expenditures, 1973–1985;
- Urban system expenditures per mile, 1973–1985;
- Primary system expenditures per capita, 1973–1985; and
- Secondary system expenditures per capita, 1973–1985.

The resulting five-cluster structure is described as follows:

- Low urban mileage and high urban expense rate, 6 counties (Cluster 5)
  - —No Interstate expenditures;
  - —$216,000/mi urban expenditures;
  - —$400/capita, primary expenditures;
  - —$300/capita, secondary expenditures; and
  - —Prototype counties Watauga and Pasquotank.
- Primary system focus, 6 counties (Cluster 4)
  - —No Interstate expenditures;
  - —$48,000/mi urban expenditures;
  - —$2,400/capita, primary expenditures;
  - —$380/capita, secondary expenditures; and
  - —Prototype counties Madison and Dare.

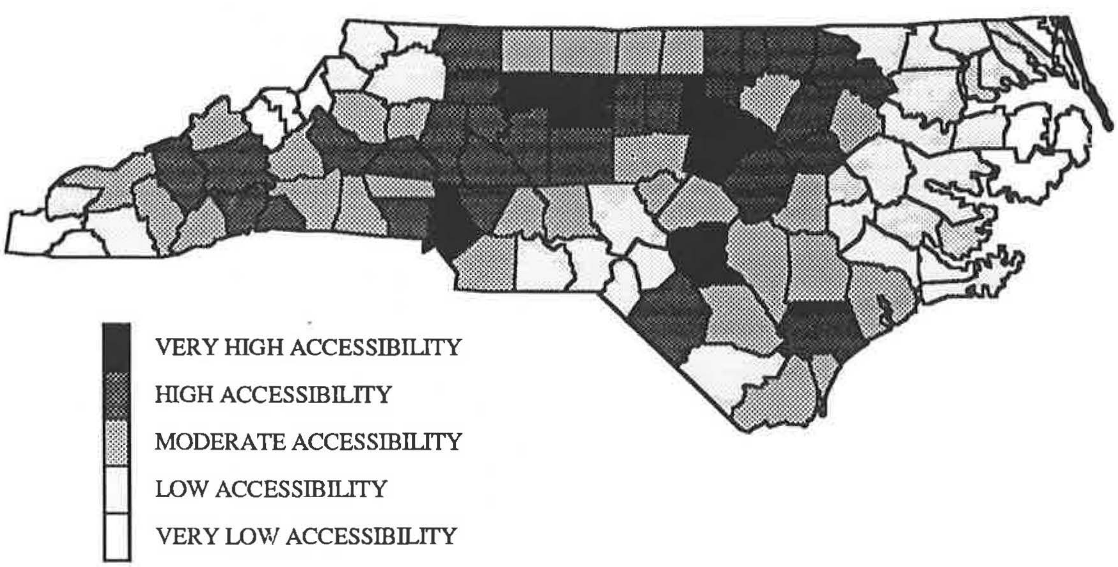

FIGURE 10 External accessibility of counties.

- Various needs, 59 counties (Cluster 1)
  - —$6 million Interstate expenditures;
  - —$36,000/mi urban expenditures;
  - —$250/capita, primary expenditures;
  - —$130/capita, secondary expenditures; and
  - —Prototype counties Chatham, Lee, and Catawba.
- Primary and secondary focus, 20 counties (Cluster 2)
  - —$1.5 million Interstate expenditures;
  - —$13,000/mi urban expenditures;
  - —$630/capita, primary expenditures;
  - —$325/capita, secondary expenditures; and
  - —Prototype counties Gates, Carteret, and Caswell.
- Interstate focus, 6 counties (Cluster 3)
  - —$84 million average for Interstate expenditures;
  - —$55,000/mi urban expenditures;
  - —$360/capita, primary expenditures;
  - —$125/capita, secondary expenditures; and
  - —Prototype counties Mecklenburg and Wake.

Survey of Manufacturers

The survey of manufacturers is currently being piloted. The sampling plan for manufacturing firms will be based on county and industry group (see Table 2). In each of the cells of the table, the universe of firms (N_f) with a universe of employers (E) will be developed from the North Carolina Department of Industry and Commerce data tapes. From each cell, a sample size ($\hat{n}_f$) with an associated employment ($\hat{e}$) will be estimated to ensure statistical reliability and balance. Samples will then be inflated by a factor of 2.5 to account for non-response. The actual returns in each cell (n_f) with employment e will then be factored to represent North Carolina manufacturing employment and total firms. That is,

$$\text{Factor}_{\text{firm}} = \frac{N_f}{n_f}$$

$$\text{Factor}_{\text{employment}} = \frac{E}{e}$$

for each cell. About 800 to 1,000 returns are anticipated.

Policy Analysis

Key items related to policies the state might undertake to improve access to counties or to increase manufacturers' satisfaction with sites are identified. As an example, consider a proposal to build a 150-mi loop around Charlotte, about 30 to 40 mi out. Such a loop would make several of the counties more accessible by increasing their four-lane road mileage. A preliminary estimate of changes in mileage, and resulting changes in cluster grouping, are presented in Table 3.

The outer-outer belt would radically increase the accessibility of Lincoln County (moving it from Spot 3 up to Spot 19 in Cluster 1), Cabarrus County (moving it from the bottom in Cluster 2 to Spot 45 in Cluster 1), and Stanly County (moving it from Spot 15 to Spot 25 in Cluster 1). Iredell County would jump from Cluster 2 to Cluster 5, joining five other metropolitan counties as the most accessible in the state.

TABLE 2 SAMPLING PLAN FOR MANUFACTURERS SURVEY

County		Industry Group 1	2	3	4
1					
2	Universe		$N_f\ E$		
	Sample		$\hat{n}_f\ \hat{e}$		
3	Actual		$n_f\ e$		
4					
5					

POLICY IMPLICATIONS AND CONCLUSIONS

The study has already yielded a number of important policy findings, which may be of use in other efforts.

First, except perhaps in the smallest of states, a homogeneous state economic structure or transportation-access structure does not exist. Therefore, policies related to these factors should be capable of being targeted at the county, subcounty, and perhaps the corridor level. States must recognize that individual counties will have different needs for transportation access. Different transportation investments in various regions of the state will yield different results. The conclusion argues for a county or regional approach to transportation-investment assessment. In such a context, regional economic models at the state level are not likely to be particularly successful.

Second, although it is possible to develop and manipulate extensive analytical tools during the analysis of transportation and economic development, these tools are not necessary for most studies. The authors' analytical work in recent studies has been relatively straightforward and has focused almost entirely on the use of aggregate relative trend statistics by county. The use of analytical tools such as factor and cluster analysis may aid the investigation but are certainly not essential. Thorough study planning and straightforward, descriptive analysis results can yield a great deal of valuable information.

Third, perhaps not surprisingly, transportation access was found to be a nonprimary variable in overall siting decisions. An affirmative location decision will not occur in the absence of good accessibility, but, conversely, the presence of a good highway is not apt to be a decisive factor. The transportation systems in many states are extensively developed and provide good access to distant markets by high-level Interstate systems. As noted earlier, the virtual completion of the Interstate

TABLE 3 EFFECT OF CHARLOTTE LOOP ON COUNTY ACCESSIBILITY

	Without Outer-Outer Belt			With Outer-Outer Belt		
County	Four-Lane Roads (mi)	Cluster	Position	Four-Lane Roads (mi)	Cluster	Position
Cleveland	48.20	1	38	63.20	1	40
Lincoln	20.58	1	3	30.58	1	19
Iredell	66.94	2	23	77.94	5	5
Cabarrus	39.81	2	1	52.81	1	45
Stanly	14.31	1	15	26.31	1	25
Union	28.40	1	26	59.40		35
Gaston	68.43	2	9	75.43	2	4

system has made good highway accessibility a reality for many previously less well served areas. Although the most rapid economic growth is likely to continue in those regions that are the most accessible, increasing the accessibility of other regions will not necessarily accelerate their growth. Furthermore, the most accessible regions also have infrastructure, markets, labor supply, and other assets to attract economic growth. At the site scale, transportation access is critical to a firm's success; in the aggregate, at a county or state level, it has a less discernible impact.

ACKNOWLEDGMENT

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Comprehensive Framework for Highway Economic Impact Assessment: Methods and Results

SAMUEL N. SESKIN

A framework for assessing economic impacts of highway improvements that is comprehensive in scope, diverse in methodology, and useful both for ranking needed improvements and in making investment decisions is presented. Current user benefit assessment techniques are expanded by adding an assessment of regional economic benefits. These benefits are measured in terms of changes in business costs, both in absolute terms, and in relation to costs experienced by areas or regions not affected by the proposed improvement. Changes in business costs increase the productivity of affected businesses, allowing them to expand markets and market share, increase profits, or otherwise enhance their competitive position. Regional economic benefits include opportunities for business expansion, business attraction, and tourism development. Business expansion benefits include the indirect and induced effects of user benefits (travel time savings, operating cost changes, and safety benefits). Business attraction benefits include the effects of the highway investment on the types and quantity of new economic activity that may occur in the affected region as a result of the highway. This assessment typically includes the development of several scenarios, on the basis of varying levels of effort and initiative by local economic developers. Tourism benefits include changes in expenditures resulting from new tourist travel patterns. Three case studies are presented, illustrating the application of the framework to inter- and intraurban highway projects in Wisconsin, Massachusetts, and Indiana. The case studies suggest that the framework captures regional benefits the value of which is equal to 50 to 150 percent of user benefits alone. Regional benefits are sensitive to the level of improvement of the affected links, and to the implementation of related public policies.

The scarcity of funds at the federal, state, and local levels in the United States for the construction or improvement of highways has led to the need to improve techniques to measure the benefits of improvements to highway infrastructure and to apply these techniques more systematically and more rigorously. Although techniques of benefit-cost assessment for infrastructure have been refined systematically for decades by economists in this country and abroad, they have been applied more typically to investment decisions in less-developed countries than they have in the United States.

Three imperatives exist in today's world of highway investment decision making. The first imperative is for an accurate and comprehensive framework for benefit assessments. Traditional user benefits, as described in the 1977 AASHTO Red Book (*1*), do not account for the full set of economic benefits associated with highway improvement. At the same time, some attempts to correct for this underestimation have generated benefit assessments that are too generous. Overestimation has occurred both because of overestimation of values of certain benefits and because of double counting of others. The challenge to the academic and professional communities has been to expand the framework for measuring benefits of highway investments in a legitimate and responsible manner.

The second challenge has been to integrate several benefit assessment methods into a single framework. Each of the methods currently used to measure one or another aspect of benefits has its advantages and disadvantages. Through selective application of these methods to the benefit types most well suited to them, a benefit assessment system has been created, the value of which is symbolically greater than the sum of its parts.

The third imperative is for a benefit assessment system the results of which are both understandable and useful. In order for such results to occur, the benefit system must be intuitively as well as theoretically correct. It must sort out investment alternatives and rank them unambiguously on both an absolute and a relative basis.

A benefit assessment framework, which passes these three tests, will be presented in detail in the sections that follow. The proposed benefit assessment framework integrates the traditional user benefit framework together with a second series of techniques measuring benefits received by the larger economic region through which a highway passes and whose economy it affects (Figure 1).

The current user benefit framework, shown in Figure 1, is well understood. Benefits to the larger region(s) served by the highway have received less attention, but are equally important. It is this set of regional economic benefits which is the principal subject of this paper.

The methods used to measure these benefits are still evolving, in response to client comments and other research findings. The accounting framework presented, however, has remained in place in all the studies discussed. Application of this framework is illustrated by three case studies. Last, the principal findings are highlighted.

USER BENEFITS

Travel Time

Following the traditional framework, user benefits are assessed in the form of travel time savings, changes in operating costs, and reductions in accidents and fatalities. Travel time savings

Cambridge Systematics, Inc., 222 Third Street, Cambridge, Mass. 02142.

FIGURE 1 Highway benefit assessment framework.

are measured by the use of a travel demand forecasting model that estimates future demand not only for the facility proposed for construction or improvement, but also for all other links in the regional highway network of which it is a part.

A transportation network model (TRANPLAN) forecasts traffic demand and trip distribution. Because the TRANPLAN model assigns each trip to a route that minimizes travel time and produces estimates of both vehicle-hours and vehicle-miles traveled on each link in the highway system, its output can easily be used to calculate the value of travel time savings from highway improvements.

In two of the three studies, a value of time of $7.00/hr for a passenger vehicle was used. In the third study, value of time was based on 60 percent of the average hourly earnings of the driver of the vehicle and 40 percent of the hourly earnings of each passenger. Use of this method would result in the effective value of time per vehicle of $10.41/hr (*2*).

These studies depart from the traditional methods for travel time savings calculations in the treatment of benefits for commercial vehicles. Rather than follow the traditional approach of valuing commercial vehicle time at a fixed rate, it was recognized that savings in travel times for commercial vehicles change the cost of doing business for the owners of those vehicles relative to other businesses not making use of the highway improvements. If the driver of a truck saves 1 hr by making use of the highway improvement, then the value of that travel time saved is an actual savings of dollars for the business involved, rather than an imputed savings as is the case with passenger vehicles. In recognition of this fact, the direct benefits for business vehicles were segregated and their impacts examined more comprehensively.

Operating Costs

The second component of the traditional user benefit analysis is a calculation of changes in vehicle operating costs associated with changes either in travel speeds or operating conditions. To measure how increased highway travel speeds, reductions in stops and stop lights, and traffic congestion affect the operating speed of today's vehicle fleet, several methods were used.

The first method used information developed by FHWA on vehicle operating costs as a function of average travel speed. These statistics, shown in Figures 2 and 3, make clear that higher automobile and truck operating speeds in excess of approximately 30 to 40 mph result in reduced vehicle efficiency and increased operating costs.

On the other hand, there is ample literature documenting the savings that result from a reduction in acceleration and deceleration at signalized intersections. The methods also make use of these data by calculating the dollar value of savings in vehicle operating costs. These savings include a reduction in waiting or idling time at stops as well. For convenience, all of these savings are identified as savings in vehicle operating costs, rather than travel time savings, although idling time at signalized intersections clearly can be measured in the form of travel time savings.

Depending on the characteristics of the proposed highway improvements, benefits of reduced acceleration, deceleration, and idling time may offset the disbenefits associated with higher vehicle operating speeds and generate a net benefit under this heading. Alternatively, on roads principally free of signalized intersections, changes in vehicle operating costs as a result of improving a given link may result in higher operating speeds, which generate net disbenefits to highway users.

In this context, the benefit assessment model responded to conflicting forces that affected vehicle operating costs and generated results that estimated the dollar value of the benefits or disbenefits associated with those changes.

Safety

The third category of user benefits is safety benefits. The benefit assessment framework included a determination of the effects of highway improvements on accidents, injuries, and fatalities not only on the link improved but also on the entire regional network. This calculation was a result of the application of a matrix of accident rates used for the forecast of vehicle-miles traveled generated by the traffic model. Each link in the model was assigned a series accident rate that was a function of the link's characteristics. These characteristics included the number of lanes, whether the link was urban or rural, the range of volumes forecast for it, and the degree of access control.

Thus, if a given link was improved from uncontrolled to fully controlled access, widened from two to four lanes, and experienced a 25 percent increase in traffic volumes, the model identified the appropriate accident rate on the basis of empirical data developed by the FHWA and then calculated the number of accidents, injuries, and fatalities that could be expected on that particular link in any particular year. If the link itself was not subject to any improvements, but merely experienced a change in traffic volume as a result of an improvement made elsewhere, the associated effect on traffic safety was still calculated and included in the benefit assessment.

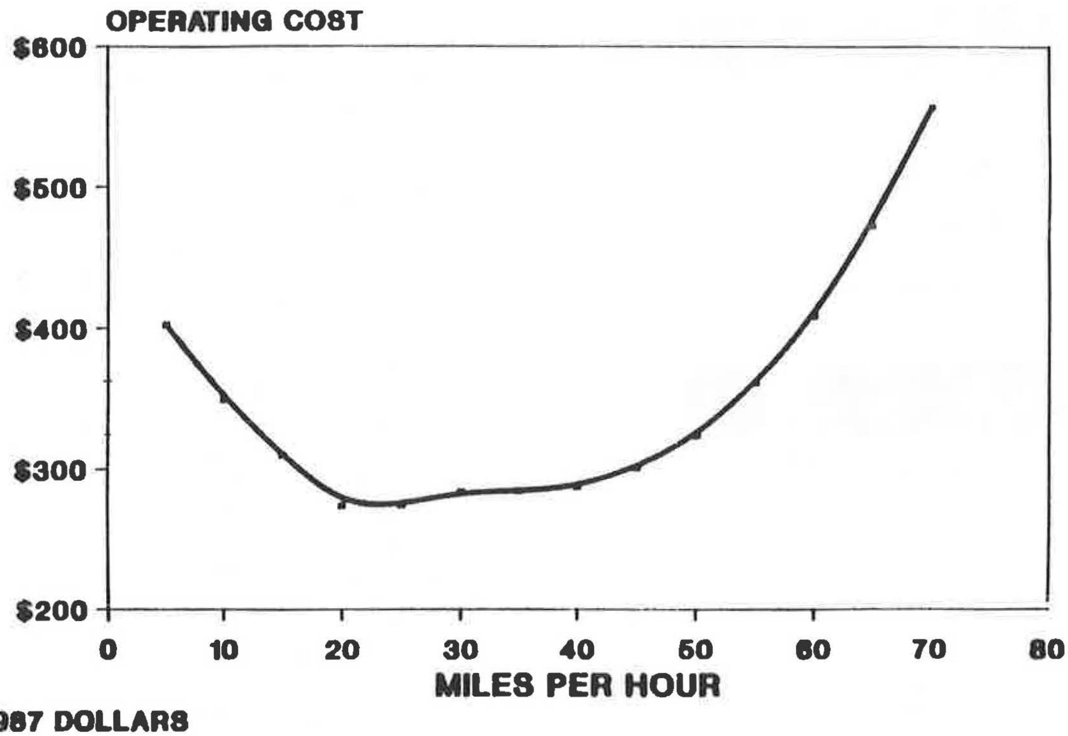

FIGURE 2 Truck operating costs per 1,000 mi of travel: four-lane highways for 1988.

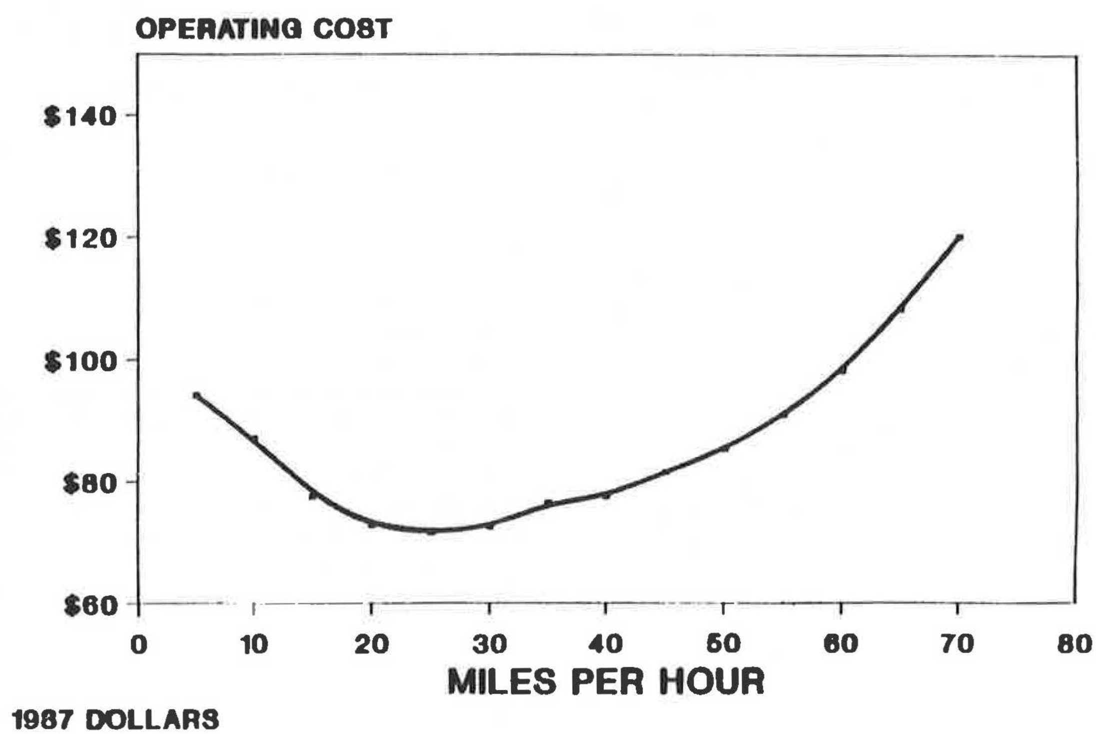

FIGURE 3 Automobile operating costs per 1,000 mi of travel: four-lane highways for 1988.

Safety benefit assessment methods are well developed today, but the approach just described has several unique aspects, one of which is its ability to model the effects of a transportation improvement on traffic safety in an entire region, rather than merely on the affected link. This results from integrating the transportation network model into the overall benefit assessment framework.

The framework also used willingness-to-pay studies completed in recent years by researchers at the Urban Institute. This research, underwritten by the FHWA, is a substantial advance in benefit assessment methods associated with the valuation of accidents, injuries, and fatalities. The effect of its use is to increase the dollar value of benefits associated with reductions in traffic incidents. This increased dollar value reflects broader measures of the true societal benefits associated with accident and injury reductions. Whatever the merit of the willingness-to-pay concept, the framework uses both these higher values for accidents, injuries, and fatalities, and the more traditional values calculated annually by the National Safety Council in different studies.

REGIONAL ECONOMIC BENEFITS

Today, concern is growing in the United States about economic competitiveness and the ways in which U.S. businesses are not competitive with other businesses globally. When transportation improvements result in reduced costs to businesses, businesses can be said to receive a competitive advantage that equates with increased profits, access to new markets, and generally a more competitive new product than was previously the case. A benefit assessment model that does not take into account the effects of these changes in relative and absolute costs ignores an important component of the complex and dynamic society and economy.

The rapidly growing interest in the issue of highway benefit-cost analysis is evidence of a widespread belief that improvements to transportation infrastructure have benefits that go beyond those attributable to highway users for the brief period of time in which they are actually traveling on the proposed highway improvement. There are two reasons to believe that this widespread belief is valid and correct.

First, that changes in transportation infrastructure can affect the cost of doing business has been amply documented. These effects are both absolute and relative. In the absolute sense, they can be measured in the form of dollar benefits to businesses resulting from reduced vehicle travel time, changes in operating costs, and safety benefits. In a relative sense, these same benefits can be measured in the form of advantages conferred on users of the new highway relative to those businesses or business regions beyond the reach of the highway improvement.

The second reason for believing that traditional benefit assessment techniques are imperfect and incomplete is their failure to recognize the way in which a change in transportation infrastructure changes not only the actual highway map, but also the perceptual map that plays such an important role in personal as well as business decisions. Research on business development and business attraction programs nationally has disclosed substantial anecdotal evidence of the ways in which a new highway can change or affect business locational decisions. In addition, published survey results of locational decision makers have confirmed this conclusion.

Although this point can be overstated, the upgrading in the functional classification of an interurban highway can change the prospects for business attraction in the affected metropolitan areas in a way that may not be directly related to changes in travel time. The effects of these changes in a region's perceptual map will be more fully discussed in terms of their effects both on business attraction and on tourism activities.

Together, issues of relative cost and local or regional perceptions necessitate the development of methods to assess impacts of highway improvements on the larger economic regions through which the improvements pass and whose features they affect. Such progress would require the development of new benefit categories, which are called regional economic benefits and include three types: business expansion, business attraction, and tourism benefits (Figure 4).

Business Expansion

The first category of regional economic benefits is an assessment of the full economic benefits associated with business expansion resulting from highway improvements. Business expansion impact assessment quantifies not only the direct, but also the indirect and induced effects of all types of user benefit savings to area businesses.

Determining the full value of business user benefits for a region's economy requires familiarity not only with national

Benefit Type	Transp. Network Model	Economic Based Analysis	Regional Economic Model	Input/ Output Matrix	Gravity Model
User Benefit					
Travel Time	●		●		
Operating Costs	●		●		
Safety	●		●		
Regional Economic Benefits					
Business Expansion	●		●	●	
Business Attraction		●	●	●	
Tourism		●	●		●

FIGURE 4 Principal analytic techniques.

statistics on transportation demand elasticity and modal preference by industry groups but also with the web of origins and destinations of goods shipped to and from businesses within the region affected by the transportation improvement. In order to obtain origin and destination data, surveying area businesses and industry groups and inquiring directly about the travel patterns of their fleets is usually necessary. This information includes the travel patterns of vehicles not only owned or leased by the companies interviewed, but also of vehicles paid to pick up and deliver products.

Several techniques that have been used to gather these data typically involve responses to a written questionnaire asking businesses to record the movement of all vehicles to and from their loading docks for 1 week. Exact origins and destinations are coded and entered into a data base that is used to generate an origin and destination matrix for the region as a whole for each of its key industries. Use of this matrix enables the refinement of a traffic forecast for commercial vehicles and the calculation of commercial travel time savings in the most precise manner possible.

With a calculation of business vehicle miles of travel (VMT) and vehicle hours of travel (VHT) in hand, a regional economic model was used to determine their value more comprehensively. The model takes as inputs the values of all user benefits attributable to the highway improvement and calculates their indirect and induced impacts on the regional economy by modeling the effects of recapturing the dollars that otherwise would be lost to longer trips, more accidents and injuries, and changes in vehicle operating costs. The model quantifies the value of the direct, indirect, and induced effects of business user benefits.

Thus, for example, if a business saves $1,000 per year in travel time, calculated at a value of $15.00/hr for each vehicle-hour saved, those dollars are assumed to reenter the regional economy as lower costs of doing business and in turn may result in increased profits for businesses, increased wages for employees, increased employment, and increased market share. Savings for businesses represent real dollars saved by the region's residents and entrepreneurs, rather than a reduction in opportunity cost experienced by motorists traveling in passenger vehicles. Furthermore, these dollar savings for area businesses have multiplier effects.

Regional Economic Models, Inc. (REMI) developed the economic simulation model used in the studies and is specifically designed for individual counties or aggregations of counties. The model goes beyond input-output accounting by including information on a large number of economic factors and their relationship to regional or industry-specific growth and decline. These factors include relative wage rates and labor productivity, utility costs, tax rates, capital costs, occupational mix, input costs, and transportation costs. Altogether, 1,312 variables can be adjusted in the model.

The model includes historic data from 1967 to the present that is used to determine how a county's or region's growth has and will compare with national forecasts developed by the U.S. Bureau of Economic Analysis. Another advantage of the REMI model is its full personal computer compatibility and also its ideal design for policy simulations. Other regional economic models may be available with these same advantages.

In summary, business expansion benefit assessment consists, first, of a determination of the magnitude of a marginal change in commercial vehicle hours and miles traveled. This information is the output from a transport network model from which changes in travel time for commercial vehicles are determined on the basis of the distribution of actual origins and destinations of area business travel. A regional economic model is then used to determine the indirect and induced effects of business travel time savings. In addition, the model is used to quantify the indirect and induced effect of changes in operating costs and of direct safety benefits to commercial vehicles (Figure 5). The result is a more comprehensive assessment of the value of user benefits to businesses than has been possible with traditional user benefit assessment techniques.

Business Attraction

A second set of broad regional economic benefits that result from transportation improvements is changes in the types of businesses and rates at which they are attracted to the region. Business attraction is defined as the selection of a location for new investment and employment by a company not previously represented within the region. It is a classification for the role that regional relative cost factors play in the growth of employment and income.

Transportation access is widely acknowledged as being an important influence in site selection. Transportation access along with the following factors influence the site selection process:

- Labor,
- Sites,
- Utilities,
- Quality of life,
- Business climate,
- Capital, and
- Transportation.

The role of these factors in site selection decisions varies not only by industry but also by facility type. These factors would be weighted differently for the location of a headquarters facility than for a branch plant.

Although factors affecting business location decisions are complex, sufficient empirical work has been done both to document the importance of transportation as a contributor to location decisions and to make possible the development of a framework and process for assessing effects of a specific transportation improvement on the prospects for business attraction. Failure to include and quantify the value of these business attraction benefits as part of a highway impact assessment would result in an unnecessary underestimation of the benefits associated with a project.

An assessment of potential business attraction benefits involves weighing qualitative and quantitative data. The first step in the assessment process is the identification of appropriate target industries and sectors. A diverse series of data collection techniques are used for this purpose. Quantitative techniques include a review of the measures of concentration of industries, such as shift-share analysis, and an assessment of relative cost faced by industries within the region, including wage rates, utility rates, and capital costs. A review of historic patterns and rates of employment growth provides an important perspective. Finally, a review of available data on recent

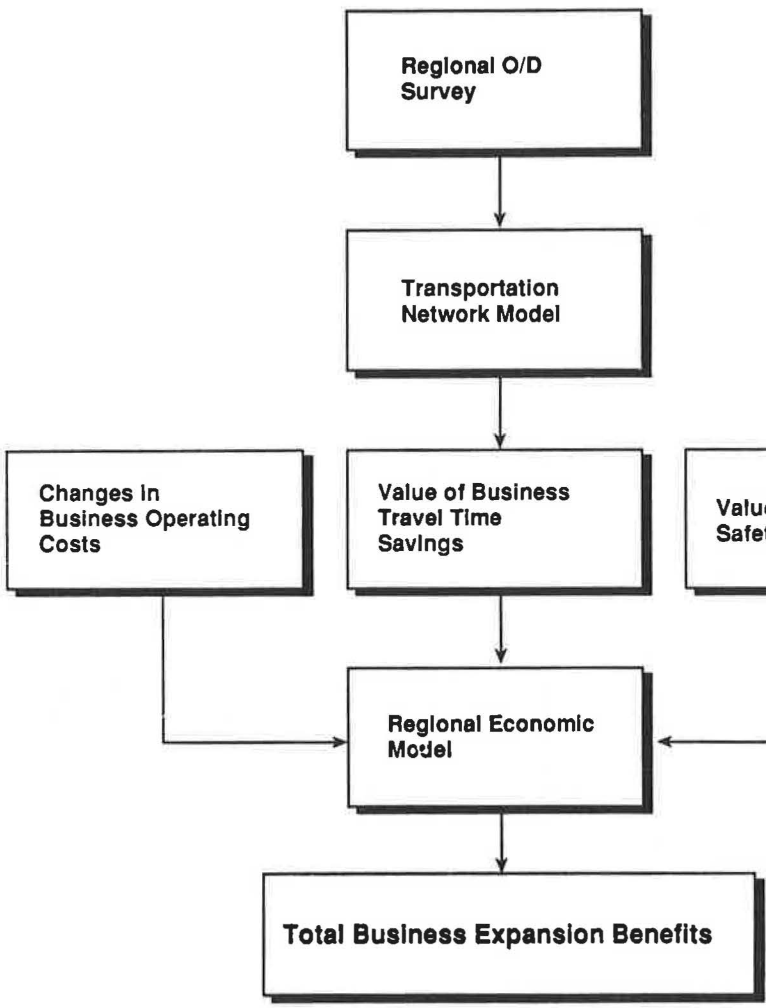

FIGURE 5 Business expansion analytic framework.

plant expansions and relocations would suggest which industries are sensitive to local and regional advantages.

Familiarity with national data on industry growth and location is also necessary. Interviews with local economic development practitioners are an important source of information and feedback about preliminary conclusions concerning appropriate target industries. Local practitioners are also a source of existing studies on the region and its economy, including target industry studies prepared for local economic development groups and Chambers of Commerce.

An assessment of potential business attraction benefits would also include a review of the strengths and weaknesses of individual communities and counties within the regional economy to determine the degree to which changes in transportation infrastructure and costs could induce economic growth.

These diverse activities all play a role in the business attraction assessment, which is essentially a four-step process. As shown in Figure 6, the process consists first of the development of an appropriate target industry list followed by a determination of the transportation sensitivity of those sectors on the target list. This review includes hard, quantitative data, such as transportation elasticity measures, as well as more qualitative data, such as the degree to which non-transportation-related problems are likely to act as constraints in economic growth.

In fact, to emphasize the role that non-transportation-related factors play in the prospects for economic growth and business attraction, several scenarios are usually developed for business attraction benefits. These business attraction scenarios are the third step in the assessment process. One scenario is developed assuming a continuation of existing economic development activities. Another scenario is developed assuming implementation of some set of policies, programs, or activities that are felt necessary to induce a higher level of economic growth. These activities may include job training programs, marketing or planning efforts, special community loan funds, or other political and economic activities that are part of a comprehensive economic development strategy.

Having estimated one or more levels of potential business attraction, the final step of the business attraction assessment is modeling the indirect and induced effects of a certain number of direct new jobs using the regional economic model previously discussed.

Tourism

The third component of a regional benefit assessment is assessing the potential growth in tourism as a result of the transportation improvement. Although the composition of the

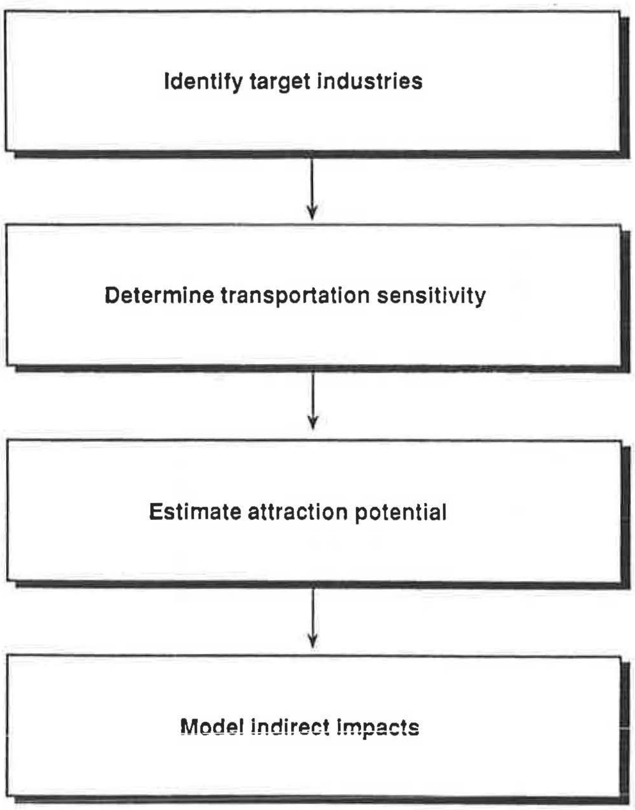

FIGURE 6 Business attraction analytic framework.

tourism industry is well known, and its relationships to other sectors of a regional economy are clearly established, the prospects for tourism growth must be assessed only by reviewing the specific local mix of tourism activities and the potential for growth in tourism from the highway improvement in question.

Because tourism has become such an important part of many local economic strategies and demand for its product is a unique result of the relationship between local attractions and characteristics and those of competing areas and attractions, distinctive methods for assessing tourism potential have been developed.

This assessment begins with a collection of existing tourism visitor origins and destinations. Patterns of origination are evaluated on a county-by-county basis whenever possible. The object of the assessment is to determine existing and historic patterns of tourism and business travel to identify those directions of origin that have traditionally provided the largest number of visitors to the study area.

In addition, the potential for development of new destinations and tourism attractions within the study area is assessed, focusing principally on potential for new destinations for personal or family, rather than business, travel.

A final component of the data collection process is obtaining tourism expenditure data. These data typically are available through regional or state tourism promotion groups. With information on visitor origins and destinations, visitor expenditures, and an assessment of the potential for growth and local attractions, a demand forecast is prepared for local tourism activities.

This forecast can be driven by a gravity model that predicts the potential for growth in personal travel from a specific direction as a function of changes in travel time. Thus, given that City A, 100 mi north of the study area, yields 10 visitors per 1,000 population, whereas City B, 50 mi away, yields 30 visitors per 1,000, the degree to which transportation improvements in a northward direction would increase the likely level of visitation from City A was measured as the decrease in travel time from that city to the study area. These calculations are refined to reflect knowledge of the pull of competing attractions elsewhere to the north.

The tourism demand forecast, coupled with the available data on tourism expenditures, allows for the calculation of the economic impact of increases in tourism activities and visitation as a result of transportation improvements. This economic impact is expressed in terms of direct expenditures and indirect and induced expenditures, again through the use of the regional economic model (see Figure 7).

Tourism impact assessment includes an explicit assessment of the degree to which increases in tourism activity in the study area would be at the expense of tourism activity elsewhere. The object of this assessment is to ensure that increases in tourism activity being measured are, in fact, net rather than gross increases. The regional economic model can be designed with a zone corresponding to the balance of state or balance of region, and changes in employment in this zone can be quantified and deducted from the effects otherwise attributable to the improvement being studied.

CASE STUDIES

Of the several studies and reports that have made use of all or part of the economic impact framework just discussed, three projects merit special attention. One study, completed for the Wisconsin Department of Transportation between 1987 and 1989, involved the economic development benefits of a combination of east-west highway corridors between Green Bay, Wis., and the Minneapolis-St. Paul, Minn., metropolitan area. A second study was completed in 1989 for the Massachusetts Executive Office of Transportation and Construction on the economic effects of the reconstruction of the central artery in Boston, Mass., and the construction of a third harbor tunnel between Boston and Logan International Airport. The third case study, conducted between 1988 and 1989, assessed the benefits of four alternative highway improvement packages in southwest Indiana, principally between Indianapolis and the city of Evansville.

Northern Wisconsin

In Wisconsin, the costs and benefits of constructing a four-lane, 200-mi highway between Green Bay and the Minneapolis-St. Paul area were examined. The study evaluated four alternative levels of improvements for State Highway 29 (SH-29) and US-45; a follow-on report evaluated similar alternatives for SH-29 and US-10.

This project was distinguished by a number of features. First was an emphasis on ways of attracting tourism development from the Minneapolis area to northern Wisconsin.

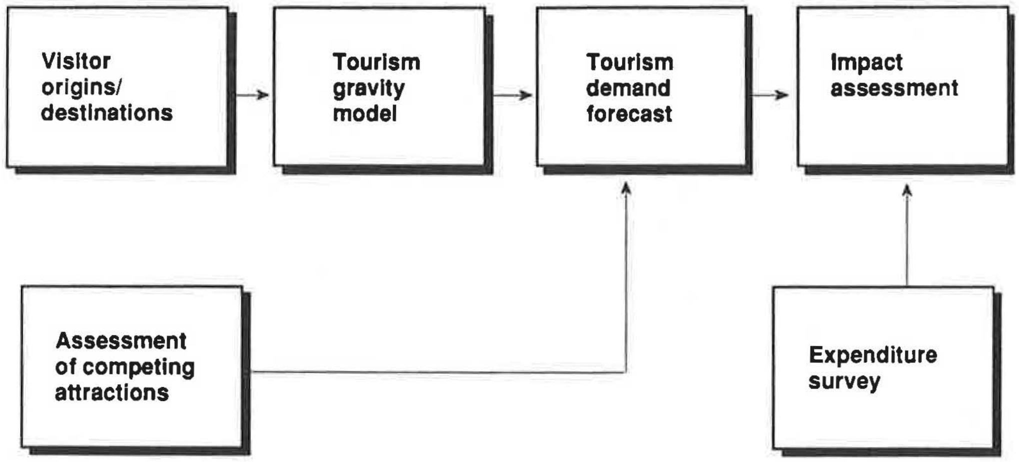

FIGURE 7 Tourism analytic framework.

Second was an emphasis on examining benefits and costs associated with different levels of highway improvements, ranging from a mixture of two- and four-lane at-grade highway segments to a full freeway configuration.

The Wisconsin Department of Transportation was committed to constructing improvements in the corridor and funds were available for the project. The question for the consultants was to assess the magnitude of the benefits associated with the alternatives and to determine the appropriate level of improvements.

For this project, nonuser benefits were roughly equal in magnitude to traditional user benefits (Figure 8). Of particular significance was the potential for attracting new businesses in food products, wood products, trucking and distribution, and health care in addition to substantially enhancing tourism development.

A combination of freeway and expressway improvements on SH-29 and US-10 emerged as the most beneficial improvement package. Benefits from this package were greater than those using SH-29 and US-45 (the alternative route). Furthermore, benefits from the freeway and expressway combination exceeded those that could be obtained from all-freeway construction. Although benefits were associated with a freeway route, the return on the incremental investment required for constructing the freeway was less than the return available from the construction of a combination of freeway and expressway improvements. Accordingly, the all-freeway alternative was not selected.

Eastern Massachusetts

In Massachusetts, economic effects were assessed for the planned construction of an underground central artery freeway (I-93) to downtown Boston and a new tunnel under Boston Harbor extending the Massachusetts Turnpike (I-90) to

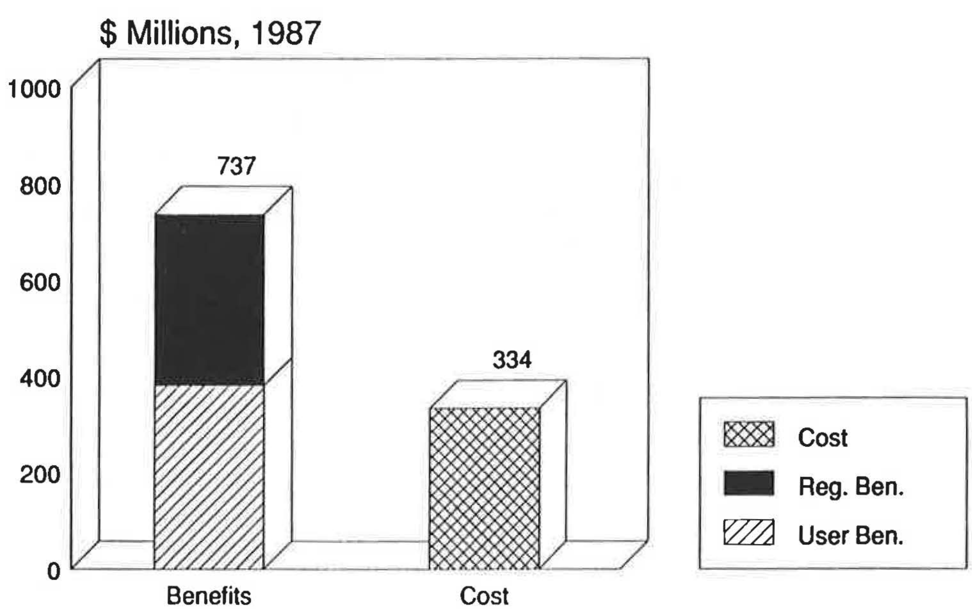

FIGURE 8 Ratio of benefits to costs for SH-29 and US-45 in Wisconsin.

Logan International Airport. The cost of the improvement package was estimated at $4.4 billion. As part of the environmental impact analysis, the economic effects of the project on the City of Boston and the broader five-county metropolitan area were evaluated.

Long-term effects of building versus not building the project were evaluated by using a transportation network model to estimate differences in commuter and commercial travel time savings. In addition, the effects of the project on tourism, conventioneering, and retail activities were also evaluated.

The study examined effects during and after construction. During construction, a modest decrease in economic activity was forecast along with a shift of retailing activity away from downtown Boston. In addition, the loss of some convention business was seen for the downtown area. After construction, the benefits included a reduction in commuting time and trucking costs thereby encouraging the expansion of existing regional businesses. Reduced congestion to downtown was measured in terms of its effects on labor market access and labor costs, particularly for white collar employment. The study concluded that constructing the project would help achieve the forecast level of growth for the regional economy by removing a key barrier limiting the prospects for downtown employment growth. Similarly, the existence of the new freeway and toll tunnel would encourage continued growth of tourism and convention business that would have otherwise been constrained by downtown congestion.

A formal benefit-cost analysis was not conducted as a part of this study. The results indicate, however, that the project would yield a net present-value benefit-cost ratio in excess of three to one. User benefits (excluding safety benefits) for the year 2010 were estimated to be $500 million out of a total of $2 billion in user and regional economic benefits for that year.

Thus, for this major intraurban highway reconstruction program a substantial stream of benefits were identified that would not occur without the proposed improvements. Long-term growth prospects for downtown Boston depend on providing travel access for all modes of transportation, including highways. This study quantified the amount of growth in the forms of jobs and income that were at risk for this project if it were not completed.

Southwest Indiana

In Indiana, economic benefits were studied for highway improvements between the state capital, Indianapolis, and major cities in the southwestern part of the state. Two alternatives were studied for highway improvements between Indianapolis and Evansville, the southwest region's largest city. One was the construction of a new controlled-access highway about 135 mi long. The other consisted of a package of improvements to existing two-lane roads that included upgrading to a mixture of controlled-access and expressway segments. In two parallel corridors, the economic effects of selective improvements were also studied. These improvements included upgrading existing two-lane roads to super two-lane and four-lane facilities.

For each corridor, four to six alternatives were initially examined, from which one alternative was proposed for a full-scale analysis. A screening process was developed to sort out the relative advantages of these numerous alternatives in a cost-effective manner. The screening process involved a qualitative assessment of several dozen economic development and engineering criteria and a weighing of the relative ranking of each preliminary alternative for each of the criteria.

Despite the emphasis given to economic development considerations in this study, the results were surprising. Although all four alternatives generated substantial economic benefits and in one case the present value of the benefit stream exceeded the present value of project costs, resulting in a benefit-cost ratio of 1.23, levels of overall benefits relative to cost were, as a group, considered too low to warrant a recommendation to construct.

The magnitude of the regional economic benefits for all four alternatives equaled or exceeded the magnitude of the traditional user benefits. Forecast levels of business attraction benefits were substantial for all of the alignments. The benefits for existing business were also substantial, though when measured in terms of contributions to regional employment they constituted a smaller share of overall benefits than their dollar value would suggest. This effect occurs because the benefits for existing businesses of improvements in transportation accrue principally in the form of increased profits rather than in expanded sales and employment. Last, tourism benefits, although of relatively small importance in the context of the 18 counties studied, were a dominant source of potential benefit to several counties within the study area. These counties ranged from urban, with a large regional convention center, to rural, with a variety of scenic and recreational attractions.

KEY FINDINGS

Viewed together, the three case studies suggested several conclusions.

1. In each case described, the application of a more comprehensive framework for the assessment of benefits generated a stream of benefits whose value was approximately 50 to 150 percent of what would have been identified solely by reference to traditional user benefits. For Massachusetts, user benefits were of such substantial value that the project warranted construction on the basis of them alone. For Wisconsin, an analysis of user benefits alone was not sufficient to justify construction, but when combined with regional economic benefits, they made a compelling case for the proposed improvement package. For Indiana, although the inclusion of economic benefits clearly increased the value of the overall benefit stream, the ratios of benefits to cost were still not sufficiently large to warrant a recommendation for construction.

In all cases, the enhanced benefit stream was measured without any double counting through adherence to a rigorous framework for both regional benefits and highway user benefits. The fundamental principle behind the development of this framework was that highways change the underlying set of economic conditions that affect the prospects for economic growth and business development. These changes include changes in relative business costs, which result from more efficient transportation systems, and changes in the perceived attractiveness of a particular location or region as a business address. These perceptual changes, though a less important contributor to economic growth and a less tangible one, contribute greatly to the potential for economic growth in an economy driven by a highly competitive site selection process in which communities and states vie with one another to attract expanding companies.

More significant, changes in the relative cost of doing business in a region fundamentally change the prospects for business growth, tourism attraction, and overall business attraction. These changes in relative costs reflect an improvement in the overall efficiency not only for the regional economy, but also for the national economy, because of national sales of the region's products and services.

The system described here for the measurement of regional economic benefits was designed explicitly to avoid any double counting. For example, the economic value of travel time savings for passenger automobiles was carefully segregated from the economic impacts of travel time savings for businesses and their vehicle fleet. Business travel time savings have different effects and were accounted for in a separate manner.

2. A second conclusion drawn from the research was that both user benefits and regional economic benefits are sensitive to the levels of improvement that might occur on the region's highway system. Just as user benefits increase when a highway is improved from two to four lanes, or when travel speeds are improved from 50 to 55 or 65 mph, regional economic benefits increase as well.

Research in Indiana disclosed the existence of a set of regional economic benefits that can accrue to a medium-sized metropolitan area solely from the construction of an interregional highway to Interstate standards. There is clear evidence that corporations considering a multistate or national environment for an expansion site can and will overlook a city or region that lacks an Interstate highway connection, or a controlled-access road of similar quality leading to or from the markets of interest to them. Interviews with site location decision makers and local economic developers suggest that certain facilities will be sited not only on the basis of a quantitative transportation factor, such as travel time to or from other points, but also on the basis of a more qualitative assessment of the characteristics of highways leading to and from the region in question.

For someone responsible for siting a major distribution facility, that St. Louis or Indianapolis is 3 hr away may not matter as much as that those 3 hr would be consumed traveling on an Interstate rather than a state or U.S. highway. Similarly, managers of convention facilities and major resorts affirm that the absence of Interstate access precludes bookings from certain companies and tour operators.

Every city may not need, deserve, or be able to benefit sufficiently from an Interstate highway. However, the economic development benefits of transportation improvements are not solely a function of changes in travel time as traditionally included in a user benefit assessment.

3. Regardless of whether the particular highways studied were recommended for construction, the levels of benefits projected to occur seem to fall within a somewhat narrow range. In Wisconsin, Massachusetts, and Indiana, the research showed that significant inter- or intraregional improvements can increase regional income and employment by amounts in the range of 0 to 3 percent (in present-value terms) for about 20 years following completion of construction.

This finding has both technical merit and intuitive appeal. Although the benefits to a particular community or portion of a region may be greater than this 0 to 3 percent range, the overall level of regional benefits seems consistently to fall into this range.

The regions analyzed have populations ranging from 500,000 to 3 million. They are, in other words, medium-to-large economic regions. That a strategic highway improvement generates benefits of this magnitude suggests not only that wild claims of proponents are exaggerated and should be discounted but also that claims by pessimists that highway improvements have no value should receive the same treatment.

Although the change of 0 to 3 percent seems like a small number, the dollar value of such changes is not at all trivial. The benefits from the improvements previously described ranged in constant, discounted dollars from several hundred million to over 2 billion over a 20-year period. In two of the three cases studied, this benefit stream was sufficient to recommend spending large sums on improvements to a region's highway infrastructure. Given the vast scale of trade that occurs in major metropolitan areas, small changes can mean substantial improvements in the standard of living of thousands of its residents.

4. In order to measure benefits reliably and objectively, quantitative and qualitative data must be gathered. Quantitative data include information from input-output models, tables on regional economies across the nation, and those from full use of structural econometric models and econometric forecasts. These data also include using results from econometric models as input to traffic forecasting models.

In addition, qualitative data play an important role in the benefit assessment process. This role includes making full use of local expert knowledge of economic development practitioners, bankers, business owners, and others. Their knowledge of markets, labor conditions, recent business location and expansion decisions, perceptions about the local business climate, and insights into the trends or problems facing key local employers or industries are indispensable for determining the prospects for business attraction or expansion that might result from a transportation improvement.

5. Because the prospects for business growth resulting from highway improvements are a function of changes in relative costs and perceptions about locational advantage, any economic model that cannot determine the magnitude of these cost changes or the meaning of these changed perceptions will be insufficient to assess the prospects for economic growth and change.

For example, a static input-output model such as the Regional Industrial Multiplier System (RIMS), which presents a static understanding of a region's economy expressed in the form of regional purchase coefficients, will be of little use by itself in determining how any particular business, industry, or set of industries will become more or less profitable, more or less competitive, or larger or smaller in size as a result of changes in transportation costs. Those transportation costs have to be quantified in other ways and explicitly included in the modeling process.

Furthermore, a static input-output model cannot simulate alone the ways in which economic changes unfold over time. The substitutions of capital for labor and the changes in the cost of labor that result from economic growth in a particular labor market are beyond the reach of an input-output modeling system. Only a model that explicitly includes recent wages and unemployment rates can take these changes into consideration.

In calculating regional economic benefits from highway improvements, choosing a set of techniques that can identify all economic benefits is essential. A static input-output model such as RIMS theoretically and empirically appears to underestimate the magnitude of the economic benefits associated with highway improvements because by itself the model fails to take into account the effects of changes in relative costs.

From experience, the REMI modeling system avoids these serious pitfalls. When used with other techniques including input-output analysis, REMI produces a more realistic and comprehensive economic benefit assessment.

6. Economic benefits in general and regional economic benefits in particular resulting from highway improvements are not part of a zero-sum game.

Numerous criticisms of economic impact studies focus on their frequent overstatement of benefits. Overstatements are a result of many judgments and factors, one being a tendency to define and measure economic effects only within a narrow geographic area while ignoring possible adverse economic effects in adjacent jurisdictions. Thus, a highway in Indiana might attract business to that state at the expense of development in Kentucky or Illinois.

All economic studies define the boundaries of the economic impact assessment area. Beyond the boundaries of this impact area are impacts that are not being measured that may be positive or negative in nature.

The conclusion that highways can and frequently do generate substantial net economic benefits is based not on an arbitrary or self-serving geographic boundary, but rather on the fact that highways are inherently a productivity tool both for businesses and for citizens. Reductions in travel time, easier and safer access to new markets, and new locations for business activity all represent ways in which businesses and individuals can be more productive in deployment of their time, vehicles, products, and services.

Thus, highway investments clearly represent a means to increase the size of the economic pie rather than redistribute tiny slices of it. Obviously, there remain questions about the distribution of the pie, regardless of its size. But there can be little doubt that highways can make the pie bigger.

7. Last, although the economic framework presented is universally applicable to highway economic impact studies, the methods used to quantify the value of key variables must continue to be refined. The use of other modeling systems, such as variable or dynamic input-output models, should be examined. Techniques to better estimate the more qualitative dimensions of business attraction estimation should be developed. Through these and other means, the task of measuring highway economic effects can continue to be refined, with benefits to public officials, taxpayers, and businesses.

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Methodology for Assessing Local Land Use Impacts of Highways

IRA HIRSCHMAN AND MICHAEL HENDERSON

A methodology to project and evaluate the potential land use impacts of a proposed limited-access highway extension in the Rochester, New York, metropolitan area is described. The analysis, the result of a 1-year consultant study for the New York State Urban Development Corporation and local sponsors, examined the potential impacts of linking the towns of Brockport and Albion, west of Rochester, to the Rochester central business district (CBD) via an extension of Route 531. An important constraint that affected the selection of assessment methodologies was the relatively modest amount of time and resources available for the study. This type of resource constraint, which was probably the norm for planning studies, precluded the development of a grand land use/transportation modeling effort in the style of the National Bureau of Economic Research Study, Puget Sound, or Bay Area Simulation pioneered several decades ealier. It required instead the use of methodologies or models that would not require enormous amounts of data, time, or effort to calibrate. The approach used to project potential residential location decisions was to develop a gravity model of residential location. In general, gravity models, when applied to residential location, require calculation of accessibility index scores for subareas that are then used to reallocate a region-wide growth projection to the subareas. The key advantage of this approach was that it was sensitive to changes in travel times between residential zones and major employment nodes. A qualitative approach was used to evaluate business impacts. The basic methodology involved a review of the competitive advantages of the area with and without the highway extension that included surveys of businesses inside and outside the Brockport-Albion corridor. A separate region-wide marketing analysis was performed to assess retail development possibilities in the Brockport-Albion corridor.

Western Monroe County and eastern Orleans County in upstate New York are economically linked to the city of Rochester, but lack adequate highway access to that urban center. Route 31, which is the main roadway connecting Spencerport, Brockport, and Albion to Rochester (Figure 1), is a two-lane road that is used heavily and is often congested. In addition to commuters working in Rochester, students and employees at the State University of New York at Brockport are also major users of Route 31. Trucks headed to and from industries in western Monroe and eastern Orleans counties also add to the roadway congestion.

The need for a new roadway in this area was recognized as long ago as the late 1960s and an expressway was included in transportation plans prepared in the 1960s and 1970s. In 1978, the Western Monroe County Transportation Study examined the expressway issue once again. A total of 26 transportation alternatives were evaluated for the area and a new expressway was recommended to connect I-490 with Washington Street in the town of Ogden. However, an extension further west as far as Brockport could not be justified by the New York State Department of Transportation (NYSDOT), primarily because of projected traffic volumes.

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The first extension of Route 531 (as the new expressway was designated) was completed in 1986 for the 1-mi stretch between Elmgrove and Manitou Roads. The remainder of the state-approved Route 531 extension, from Manitou Road to Washington Street, is a high-priority project for the NYSDOT. In July 1988, money was appropriated in the state budget for final design of this extension. Construction of the roadway could begin as early as 1990.

Extension of Route 531 beyond Washington Street may take several more years to be built, if it is built at all, because of the NYSDOT recommendation that the road could not be justified on the basis of projected traffic levels. Many local legislators, business people, interest groups, and individuals believe, however, that such a policy does not recognize the development situation in the Brockport-Albion corridor and ignores current and future economic conditions. At local urging, the state legislature appropriated funds to the New York State Urban Development Corporation for a study to evaluate further westward extension of the highway—to the town of Brockport and possibly to Albion—from an economic development perspective.

The Brockport-Albion Highway Economic Impacts Study was commissioned because, despite the NYSDOT's conclusion that the full roadway could not be justified by potential traffic levels on the basis of current conditions, the economic development that might occur once the roadway was constructed might generate enough traffic to make the road necessary. Recent closings of two major manufacturing plants in Brockport added to the concern about local growth, job creation, and increased local tax base.

RESIDENTIAL IMPACTS

With the construction of the highway, the Brockport-Albion area would become, at least in one dimension, a more attractive residential location because of improved access, i.e., reduced travel times to places of employment, recreation, and educational facilities.

Several possible formal methodologies, identified in the planning literature, might have been used to identify and define this effect. One approach was to calibrate a statistical model, such as a multiple regression model, which relates changes in residential densities to changes in travel time, while holding other neighborhood characteristics constant. Calibra-

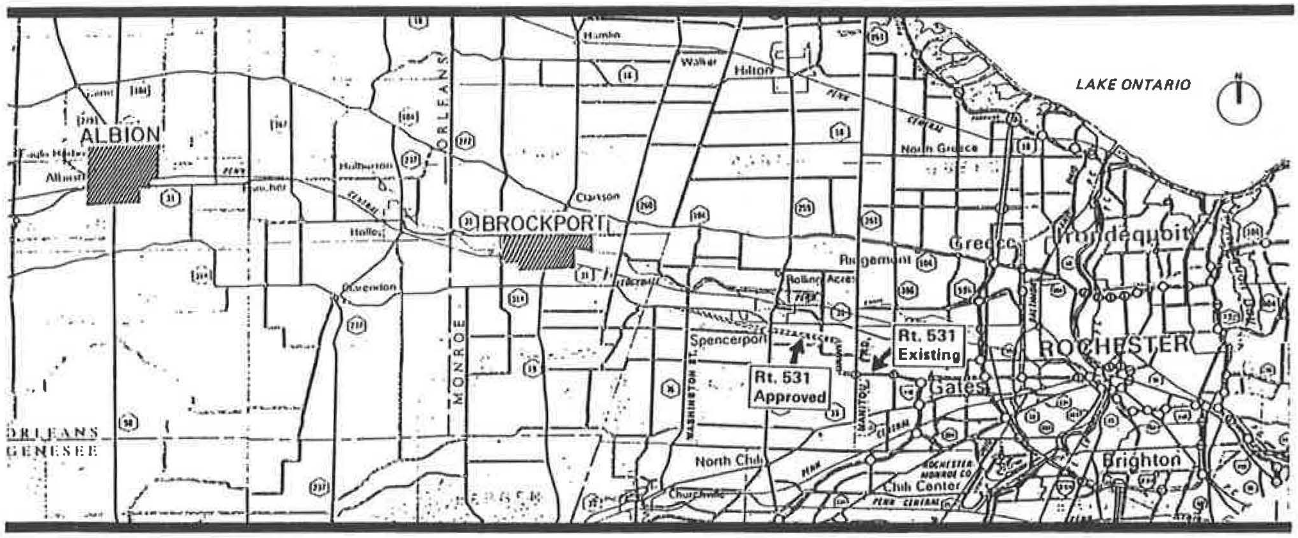

FIGURE 1 Brockport-Albion highway economic impact study area.

tion is made using an analog corridor within the same region that experienced a similar highway improvement at an earlier date. This approach requires compilation of a substantial data base and time-consuming calibration of a prediction equation, including the appropriate model specification.

A second and far simpler approach was to use one of several possible formulations of a gravity model. In general, gravity models, when applied to residential location in a region, require calculations of accessibility index scores for subregions, that are then used to reallocate projected region-wide growth to the subregions. Accessibility index scores are a function of composite-weighted travel times to the downtown core and to other major employment centers in the region. Other factors that affect residential expansion and density, such as availability of developable land, are also taken into account. From a formal demographic standpoint, the gravity model seeks to gauge the impacts of transportation access on the migration component of population change.

In studies of this nature, where serious time and resource constraints prevail, the gravity model approach offered two major advantages. First, it did not require calibration of a statistical model but instead required only one empirical parameter with a typical value that has been established by previous studies. Second, it allowed the analyst to relate changes in travel time in a highway corridor to changes in population. Therefore, it was the approach used in the study.

A review of the literature pointed to the Hansen formulation of the gravity model as the basic form to be used for the study (*1*,*2*). The basic form of this model states that

$$G_j = G_t \frac{L_j A_j}{\sum_{i=1}^{n} L_i A_i} \qquad (1)$$

where

G_j = population growth increment allocated to subregion j;
G_t = total growth projected for the region;
L_j = developable land in subregion; and
A_j = travel time to employment centers from subregion j.

A basic assumption of the gravity model is that the overall regional population projection, generally an official county-level forecast, would remain constant. In effect, the overall regional projection is treated as a stable control total within which small area projections are allowed to vary.

The value A_j is a composite weighted (inverse of) travel time between the subregion j and all subregions, where the weights are the number of jobs (employees) in each subregion. A typical formulation would be

$$A_j = \sum_{i=1}^{n} \frac{E_i}{T_{ij}^a} \qquad (2)$$

where

E_i = employment in each subregion,
T_{ij} = the travel time between subregion j and the other subregion, and
a = exponential time-impedance parameter, usually equal to about 2.0 in most applications of this technique.

The A_j value can be referred to as an accessibility index score.

Of course, other factors in addition to accessibility and developable land capacity can influence the growth share, such as net natural increase, anticipated economic growth, land use controls, infrastructure, tax rates, and local public services. Thus, the basic gravity formulation of Equation 1 can be extended by substituting a product of causal factors that interacts with accessibility for the single vacant land (L_j) factor:

$$V_j = (V_a \times V_b \times V_c \times \ldots) \qquad (3)$$

Therefore, the baseline growth share for each subregion can be reformulated as follows:

$$G_j = G_t \frac{V_j A_j}{\sum_{i=1}^{n} V_i A_i} \qquad (4)$$

where V_j represents a product of attributes that interacts with accessibility and affects residential population.

As a practical matter, application of the gravity model technique, as formulated in Equation 4, requires that municipalities be regarded as the subareas. The analyst must then compute changes in each town's A_j score so that revised growth shares for each town can be derived and applied to the regional population projections.

To apply the gravity model, it was not necessary to measure the individual elements of V_j explicitly for each town in the study area. Instead, it was reasoned that the V_j values could be computed on the basis of existing official town population projections because these projections could be assumed to already take into account the various factors of V_j that affect local population change. In particular, once baseline A_j values are calculated, it becomes possible to derive implicit values for V_j. Further, by separating out these V_j values it becomes possible to empirically compute changes in the A_j scores with the highway extension while holding the V_j values constant. In effect, the procedure allows the analyst to run the gravity model by varying the accessibility scores while holding all other influences constant.

For the study, a no-highway-improvement baseline was first established. This baseline was calibrated to correspond to the latest set of town population projections for the Rochester region prepared by the New York State Department of Environmental Conservation (NYSDEC) in 1985 for its Water Quality Management Plan.

For the model, the Rochester region was defined as Monroe County plus a ring of surrounding towns in Orleans, Livingston, Ontario, and Wayne counties. These towns were included because they are approximately the same distance (or less) from the Rochester CBD as the town of Albion. The modeling area was delineated in this way to fairly reflect the competition between suburban towns, which, under a highway-build scenario, would have roughly the same travel times to the CBD as does Albion.

Because each town's baseline projected growth share was known from the NYSDEC town population projections (i.e., the ratio of the town's projected growth divided by total regional population growth), the implicit value of V_j was computed for each town as a simple residual value after deriving the baseline A_j accessibility index values. A_j values were derived for each town using employment data from the 1980-Census Urban Transportation Planning Package and zone-to-zone highway travel time data from the Rochester regional transportation model.

To simplify the analysis, the measurement of travel times was limited to six selected employment concentrations thought to be the most important home-based work trip destinations in the metropolitan region, including the CBD.

Next, the gravity model was rerun using revised A_j accessibility index scores for each town while holding the residual V_j values constant. The revised A_j scores reflected expected reductions in travel times between towns in the Brockport-Albion corridor and the major employment zones because of the extension of Route 531. To the extent that growth shares for towns in the corridor increased as a result of the extension of the highway (and decreased elsewhere in the region), the model reallocated population from other areas within the region to the corridor. Differences in the baseline population projection and the with-highway projection represented the changes in each town's population attributable to the highway extension.

The results of the gravity model analysis presented in Table 1 indicate the magnitude of the potential impacts of the highway extension on population in the Brockport-Albion corridor. The table shows differences in projected populations with and without the highway in those towns in Monroe and Orleans counties that would enjoy significant improvements in travel access. Population projections are shown for the year 2010. These impacts are also translated into changes in the number of households using an average household size factor of 2.86 for the Rochester area. Also shown in the table are changes in the A_j accessibility index scores.

In total, the corridor was projected to experience a population gain of about 3,870 residents as a result of the extension of Route 531 from Spencerport west to Brockport and then to Albion, or about 1,350 households. This increase is over and above the officially projected increase in corridor population of 7,950 residents between the years 1980 and 2010.

Several caveats regarding the results and application of the technique are warranted. First, increases in accessibility scores are not, in all cases, correlated with significant population increases. The town of Gaines, for example, would experience a 21 percent increase in its accessibility score indicating significant travel time improvements to key employment zones. However, the gravity model projected no increase in population as a result of these highway-related accessibility improvements. The gravity model assumes an interaction between accessibility and all other factors influencing population (as reflected in the residual V_j values). Therefore, towns such as Gaines and Clarkson, which are under the baseline, are projected to undergo slow or zero population growth and would remain slow-growth or no-growth towns even with the accessibility improvements. In effect, the gravity model assumes that locales with constrained residential growth would continue to be constrained even with the highway extension. This characteristic of the gravity model may mean that the population increases projected in these communities are too conservative, particularly for communities such as Clarkson, and appear to be growing faster than official projections.

Second, in reallocating population growth, the model assumes that only the residential choices of new households, either in-migrants to the Rochester region or newly formed households, would be affected by the highway. In the short run, this assumption was reasonable. However, over the long run, the highway's impacts could be expected to also extend to long-time residents in the region. Over time, established residents are also likely to move from one place to another within the region, with the number of intraregional migrants increasing over a longer period of time. Thus, a number of long-term area residents may also move to the Brockport-Albion corridor from other locales as a result of improved accessibility in the corridor. In the short run, however, this level of migration within the region should be somewhat small because most residents now living in the region are probably firmly established in their communities.

Taken together, these caveats suggest that the residential impacts forecast by the gravity model may be understated, particularly in the long run.

TABLE 1 BROCKPORT-ALBION CORRIDOR RESIDENTIAL IMPACTS SUMMARY FOR YEAR 2010

Town	County*	1985 Population	2010 Baseline Population	2010 Baseline A sub j Score	2010 With-highway A sub j Scores	Pct Change A sub j Scores	2010 With-Highway Population	Population Change (vs. Baseline)	Household Change (vs. Baseline)
Ogden	1	15400	16500	670.470	701.537	1.046	16482	0	0
Clarkson	1	4150	4200	195.203	234.806	1.203	4207	7	2
Hamlin	1	8400	8550	180.957	221.181	1.222	8572	22	8
Sweden	1	14750	16850	467.371	606.190	1.297	17310	460	161
Murray	2	4800	5400	125.910	217.728	1.729	5775	375	131
Albion	2	6550	7550	104.640	209.116	1.998	8428	878	307
Carlton	2	2950	3900	74.156	129.981	1.753	4515	615	215
Barre	2	2150	2400	100.036	201.320	2.012	2623	223	78
Kendall	2	2500	3250	100.140	164.653	1.644	3659	409	143
Clarendon	2	2250	3250	205.353	410.070	1.997	4127	877	307
Gaines	2	2650	2650	76.913	139.397	1.812	2650	0	0
Corridor Total:		66550	74500				78348	3866	1352

* 1=Monroe County
2=Orleans County

BUSINESS IMPACTS

A literature review, conducted as part of this study, revealed virtually no methodologies available that could have predicted changes in industrial activity and employment for a small area such as the Brockport-Albion corridor as a result of improvements in the performance of the transportation system. Although there were input-output (I/O) models, which may have been adapted for purposes of projecting these changes for a region, they were not very useful for specific subareas such as that examined in this study. In addition, it was difficult to make I/O models sensitive to changes in travel times. As a result, a primarily qualitative approach was used in the Brockport-Albion study.

The basic methodology selected involved a survey of businesses inside and outside the corridor and a review of the competitive advantages of the area with and without the highway extension. This methodology included a detailed evaluation of such factors as developable industrial land, zoning regulations, transportation facilities, infrastructure expansions, and available financial incentive programs.

The objective was to determine the importance of the highway extension to businesses and to determine what other factors would influence the decisions of companies to locate facilities in the corridor. Although the highway extension itself might have generated substantial economic development, there might have been other characteristics of the corridor that could have positively or negatively impacted such decisions.

The business survey included personal interviews with local business persons, elected officials, industrial development officials, and planning agency personnel. This survey was supplemented by questionnaires mailed to businesses in the Brockport-Albion corridor and to businesses outside the corridor but within the Genesee-Finger Lakes region.

The purpose of this survey was to determine expansion plans for companies inside and outside the corridor, the importance of the highway extension to local businesses, the factors that companies considered important in facility location decisions, and the possibilities that companies outside the corridor would consider locating facilities in the corridor if the highway were built.

The surveys and interviews provided some valuable insights into the need for, and the probable effects of, a Route 531 expansion. A few conclusions were drawn from the results, although they were mostly general in nature. Most were sufficiently verifiable to be used as the basic assumptions for the impact analysis, however:

- The Brockport-Albion area had several advantages for businesses, including lower land and building prices, and availability of low-cost utilities. Improved access to the east was another major factor that could have attracted new businesses to the area.
- Businesses in the corridor generated approximately 500 truck trips per day. The capacity of the existing road system was believed by most of these companies to be adequate, but there were problems caused by traffic delays, weight and trailer size restrictions, and lower speed limits.
- Over 80 percent of the firms surveyed in the corridor had plans to expand in the next 5 years, either at their existing location or at another site in the same general area.

- Almost half of the local companies rated the Route 531 extension vital or very important to their business. One-third of these firms indicated the possibility of moving from the area if the road were not extended.
- Only about one-third of the firms outside of the Brockport-Albion area, but still within the region, had plans to expand in the next 5 to 10 years.
- Only 11 percent of these region-wide firms had ever considered locating a facility in Brockport-Albion.
- Only 12 percent of the regional firms would explore the possibility of locating a facility in Brockport-Albion if Route 531 were extended there.

On the basis of the interviews and surveys, the primary industrial benefit from the new highway would have been a strengthening of companies already in the corridor. These businesses would have been able to cut costs and compete more effectively, thereby permitting them to expand their local facilities. The highway would have also helped retain those firms that indicated the possibility of moving from the area if the highway were not built.

Although the surveys suggested the possibility that firms outside the immediate area could have been attracted to the Brockport-Albion corridor because of the highway extension, it was considered a lesser probability. In fact, there were some indications from the interviews that executives of firms already in the region may have had a bias against the corridor, with few willing to even consider locating facilities there. One reason for this bias was the impression that the more desirable locations for executive homes were east and south of Rochester, which was a long commute to Brockport-Albion. Another reason was that the area was perceived as being industrial and blue collar.

An additional finding was that although there may have been interest in the corridor by firms outside the region, the addition of the new highway alone was not enough to attract their attention. To affect their location decisions, firms from outside of the region would have had to perceive the Brockport-Albion corridor as having significant competitive advantages at the local level, including such elements as local financial incentives such as industrial development bonds and revolving loan funds, availability of relatively inexpensive space in well-situated industrial parks, cooperative zoning and planning boards, and adequate support services, especially basic utilities and sewerage. These local competitive advantages were necessary to differentiate an area from its surrounding neighbors and became even more important when an area had an image problem to overcome.

An evaluation of these business location factors was done to determine the potential attractiveness of the Brockport-Albion corridor for industry. Although it was found that the area had advantages for business development, it also had disadvantages or deficiencies that should be rectified before the completion of the highway extension. In addition, there were other improvements that should be implemented to complement the beneficial impacts of the highway. Some of the improvements found to be needed were additional local financial incentives, zoning of industrial land near the highway, extension of water and sewer service to that property, improvements to north-south routes leading to the New York State Thruway, and upgrading of the local general aviation airport. A local program to provide these additional amenities before the highway's opening would stimulate much more interest in the area from firms seeking to site new facilities.

RETAIL DEVELOPMENT

During the study, it became evident that the Brockport-Albion corridor contained relatively little major retail development (i.e., shopping centers serving a regional market area) when compared to other suburban parts of the Rochester metropolitan area. Because lack of adequate highway access to local retail centers could have been one factor contributing to this deficiency, a separate analysis was done to estimate the amount of new regionally oriented retail space that could be supported by the area and might be developed if a new highway were built.

Firm predictions could not be reliably made regarding the amount or whether regionally oriented shopping centers would develop as a result of the highway extension. However, it was possible to make an order-of-magnitude estimate of the amount of such retail development that could occur.

One reasonable approach of doing this, which was ultimately used in the study, was to use an analog corridor as a benchmark by relating the total amount of regional retail development to the population in the analog corridor and applying this information to the Brockport-Albion area.

The Route 104 Webster Highway corridor northeast of Rochester was chosen for this comparison because it had many of the same characteristics that the Brockport-Albion corridor would have had with the Route 531 extension. Data from the 1987 *Shopping Center Directory* (*3*) indicate that the Webster Highway corridor contained at least 2 million ft^2 gross of regionally oriented retail shopping center space, compared to only about 0.4 million ft^2 gross in the Brockport-Albion corridor.

Further, the total resident population in the Webster Corridor was about 72,500 people, which supported about 28 ft^2 gross of regionally oriented retail space per capita. In contrast, the Brockport-Albion market area would contain, in the year 2010, a total population of about 78,000 (with the full highway extension to Albion). Thus, assuming that no additional regional shopping centers were developed in the Brockport-Albion corridor, its regional-retail space per capita ratio would be only 5.1.

Although the Brockport-Albion corridor extended over a larger geographic area than the Webster Highway corridor, it was not unreasonable to assume that the Brockport-Albion corridor could support a substantial amount of new regional shopping center development. A modest doubling of the gross square feet per capita multiplier in the Brockport-Albion corridor (from 5.1 to 10.2), for example, would have resulted in the development of an additional 400,000 ft^2 gross of regional retail shopping center space in the study corridor.

Although an untapped market was found to exist in the Brockport-Albion corridor, a highway interchange providing access from all parts of the area was a virtual necessity to realize the market potential. If the highway were built, an area near one of the interchanges would become an ideal site for a new shopping center.

SUMMARY AND CONCLUSION

In this paper, methodologies were described that were used to forecast local economic impacts of a highway extension in the Rochester metropolitan area. In part, these methodologies were selected because of relatively limited time and resources available to perform the study and because the analysis was concerned with impacts on a small geographic scale. These requirements made data-intensive and time-consuming methodologies, such as econometric modeling of regional location decisions, impractical. In addition, input-output analysis was also rejected for use in this study because I/O models measure economic impacts at the regional rather than local level and are not directly responsive to changes in a travel time variable.

Impacts on residential location decisions were forecast using a gravity model. This approach was selected for two reasons. First, this approach did not require new statistical calibration but instead relied on a previously calibrated mathematical parameter expressing the relationship between travel time and population change. Second, the gravity model is sensitive to travel time changes on a small-area scale.

The gravity model projected population impacts that appeared reasonable in terms of the magnitude of the corridor-wide impacts. In particular, the travel time saving that would have resulted from extending Route 531 was relatively small—about 4 min, on average, or a 12 percent travel time saving. Correspondingly, the overall increase in corridor population was also projected by the gravity model to be modest, about 5 percent. However, the model as applied had several limitations.

First, the model may have understated the potential for growth resulting from improved highway access in areas that were otherwise projected to experience little or no growth without the highway improvement. This understatement resulted from the model's assuming an interaction between accessibility and other factors influencing population. When other factors were expected to fully constrain growth, the model effectively assumed that these constraints would override the impact of improved accessibility, and the population would remain constant.

Second, the model may have also underpredicted population growth in the corridor because it considered only the location decisions of newly formed households and in-migrants to the region. However, over the long run, the location decisions of long-time residents could also have been affected.

Third, the application of the model relied on an exponential travel time parameter, assumed to equal 2.0, that was derived in the late 1950s. This parameter may, in fact, be outdated because the dynamics of metropolitan population change in the United States has changed considerably since that time. Metropolitan areas were then experiencing greater levels of inter- and intraregional migration than is presently occurring in most U.S. cities. Indeed, the dynamism of metropolitan growth during the 1950s and early 1960s was partly fueled by the rapid development of the Interstate highway system as well as highway construction within metropolitan areas. Because metropolitan populations are less mobile now, it is possible that the travel time parameter used in the study may have overstated the current impact of highway accessibility on household location decisions.

In order to evaluate the highway's impacts on business location decisions, a qualitative approach had to be used. The review of literature did not reveal any formal methodologies that could have been used to predict these impacts on a subregional level. Even if a quantitative approach could have been developed, however, surveys and interviews of business leaders should have been a complementary task, because other, non-travel-related issues could have had major impacts on such business decisions. As was shown in this study, such factors as financial incentives, additional infrastructure improvements, and, perhaps most important, a bias against the area could have considerable positive or negative impacts on industrial development even if transportation access were improved.

In order to overcome or at least minimize the problems, a program of basic research is recommended on the relationship between location decisions and transportation access. Perhaps the most valuable research would be to recalibrate the exponential travel time parameter under contemporary conditions. Validation of new travel time parameters against a variety of actual highway developments would also improve the reliability of gravity model technique. Although to predict what these newer results might be is impossible, the hypothesis is that the travel time parameter would be less than 2.0.

With greater commitment of research effort, more complete models of urban structure, including the impact of transportation system changes on long-term locational behavior of residences and business, could be developed under contemporary conditions. By explicitly isolating the impacts of factors besides accessibility, a more fully specified multiple regression model would reduce the underprediction biases that are now present in the model.

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Framework for Classifying and Evaluating Economic Impacts Caused by a Transportation Improvement

MAX H. PERERA

Economic principles involved in conducting benefit-cost analysis of a transportation investment have been discussed at length in the literature, but there are few articles that provide a synthesis of the main components of the analysis and evaluation process. First, an attempt will be made to distinguish between transportation user benefits and economic impacts from a transportation improvement. Although some of the economic impacts are intuitively recognized, they have not been clearly identified or completely recognized. As a result, the evaluation process has been less than complete. A system for classifying the economic impacts and methods of measuring these impacts are suggested for discussion. Second, a framework for the evaluation of the improvement costs, transportation user benefits, and economic impacts from a transportation improvement is presented.

Consideration of social, economic, and environmental factors has traditionally been part of the transportation plan evaluation and the environmental impact assessment process. Although the environmental and social impacts of a transportation improvement have been well recognized and classified, not all the economic impacts have been identified in any systematic manner by their relative significance or magnitude. Often, transportation user benefits result from savings in travel time, in avoiding delays at railway crossings, in operating a vehicle, and in avoiding accidents. These savings are mistakenly attributed as economic impacts. An array of methods for determining user benefits of transportation projects is available, but how the different types of economic impacts are measured and evaluated in an integrated manner has not been demonstrated adequately in the literature. As background information, a brief description of techniques currently used is provided, and comments are offered on the limitations and problems generally associated with these techniques.

Within a region, transportation is closely linked to economic activity. Consequently, economic development is linked with the transportation system and at times this relationship is almost symbiotic under a scenario of economic renewal. Continued development of these economic corridors is vital for maintaining the economic health of the state or province, but also poses special problems. The growth in employment and activity centers, housing, and associated traffic places a heavy burden on the transportation infrastructure. This growth creates demands for system expansion, degrades Provincial highway mobility (i.e., the through movement of traffic), and imposes constraints on future developments. These burdens often cannot be met with existing or anticipated resources because traditional funding mechanisms for the much-needed transportation improvements appear to be inadequate.

An assessment of the expected change in economic activity or its potential for growth within a selected economic corridor then becomes an important consideration in improving and expanding transportation services. Administrators, engineers, and planners are continually called on to make decisions relating to investment choices for developing corridors. However, now, more than ever, they find themselves subjected to increasing pressure for justification of capital expenditures. These increasing demands come from the ever-growing lobby and interest groups who often hold conflicting objectives, from the public who feel the effects of inadequate infrastructure needs, and from central agencies who must determine the priority of major capital expenditures on infrastructure needs (including transportation systems). As a result, decisions concerning capital investments for transportation corridors are becoming increasingly complex as planners attempt to assess, weigh, and evaluate social, cultural, and environmental factors in addition to economic factors in determining a preferred investment strategy. On the basis of an analysis of total primary user benefits and costs, the traditional method by itself is considered inadequate when negotiating for funding of transportation improvements.

OBJECTIVES

The objectives are (a) to distinguish between transportation user benefits and economic impacts, (b) to present a system for the classification of the economic impacts caused by a transportation improvement, and (c) to suggest a simple framework for evaluating the transportation benefits, costs, and economic impacts resulting from a transportation improvement, from the dual standpoint of relevancy and feasibility. Furthermore, some aspects of the reality and problems of economic evaluation are emphasized.

For ease of discussion and treatment, the subject is confined to the roadway mode. However, the analysis framework is equally applicable to other transportation modes as well. For purposes of discussion, the term "impact" is treated synonymously with "effect" and the term "improvement" refers to a transportation improvement.

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TRANSPORTATION BENEFITS AND ECONOMIC IMPACTS

Discussion of Benefits and Impacts

A regional highway network basically serves a number of population centers, industries, and markets and consists of a number of roadway links providing both mobility and access. The addition of a single link to the existing highway network or an improvement to the network generates transportation user benefits (and disbenefits) from the day the improvement is first used, whereas economic impacts occur almost from the day construction begins. The total benefits and impacts that result from improving a single link of the network are never realized immediately. In other words, a stream of benefits flows over time, with the economic effects not fully felt in the region until production and marketing economies and cost savings resulting from the improvement are incorporated into freight rates, pricing structures, and production levels. A subtle distinction therefore exists between transportation user benefits and economic impacts of a transportation improvement.

Transportation User Benefits

The primary purpose of transportation capital expenditures is to provide new and improved transportation services to maintain quality of service. Transportation user benefits measured in terms of time savings, savings from avoidance of delays at bridge or river crossings, vehicle operating cost savings, and savings from accident reduction on transportation improvements are the primary effects of transportation improvements. These transportation user benefits are the main components of benefit-cost analysis, which provides a quantitative assessment of the relative benefits of different alternatives in terms of a common measure—namely, dollars. However, other benefits to users such as ride comfort, convenience, and availability of emergency services cannot readily be reduced to dollar terms. Measures of effectiveness have been used to deal with benefits that are not easily quantified or reduced to dollar values. But, such usage is not common in highway engineering economic analysis. Procedures to measure the value of user benefits are discussed under benefit-cost analysis.

Economic Impacts

Economic impacts measure the secondary effects of capital expenditures on the regional economy. They affect income, employment, and production and generate tax revenues and consume resources. In order to assess the overall economic impact, it is important to first identify and classify the individual impacts. They are broadly categorized into the following three types:

- Direct impacts are consequences of economic activities carried out on site in the construction and operation of an improvement. Employment of labor, purchasing of goods and services, and taxes paid are examples of activities that generate direct impacts. The use of the improvement by vehicles is also a source of direct impacts.
- Indirect impacts derive primarily from offsite economic activities associated with production of intermediate goods and services required for the construction and operation of the improvement. Some of these activities include services provided by aggregate, asphalt, steel, and concrete suppliers. These enterprises employ labor, purchase goods and services, and consume resources. The indirect impacts differ from direct impacts in that they originate entirely offsite.
- Induced impacts are the multiplier effects of the direct and indirect impacts. As income expands because of direct and indirect effects, households increase their purchases of goods and services, thereby giving rise to still further changes in production and corresponding changes in the other impact variables. For example, most of the wages earned by the construction workers is spent in the region. Some of this spending becomes income to individuals who provide goods and services to the construction crews and also for local businesses and their employees. As successive rounds of spending occur, additional income is generated.

However, if the goods and services are imported to the region, the benefits to the region are reduced proportionately. An excellent discussion of caveats regarding the regional import component and other examples of the application of economic impacts is found in Butler and Kiernan (*1*).

Therefore, total economic impacts are the sum of the direct, indirect, and induced impacts.

In a study of economic development in smaller cities, Malizia (*2*) suggests that economic benefits might be distinguished between economic growth benefits (purely quantitative increases) and economic development benefits (qualitative increases, such as increases in the diversity of employment, which contributes to the stability of a local economy). This concept appears to have some relevance in the understanding of economic impacts.

At this point, before the introduction to the classification and evaluation framework, the major tools and techniques available to the analyst for estimation of transportation benefits and economic impacts are reviewed. They are in no way exhaustive; NCHRP Synthesis of Highway Practice 142 (*3*) contains an overview of highway economic analysis procedures.

Analytical Techniques

Some techniques available for determining the transportation benefits and economic impacts follow.

Benefit-Cost Analysis

The best known technique for measuring the efficient use of available resources is benefit-cost analysis, in which the benefit-cost ratio (B/C ratio) is examined. Benefit-cost analysis, techniques for which have been comprehensively covered in the literature (*4*), is an accounting of all benefits and costs for each alternative plan and a selecting of the alternative that yields the most benefits per unit of cost. In practice, complications arise because many of the effects of a transportation improvement cannot be measured easily.

There are three principal methods of evaluating the efficiency of transportation investments. The first method examines the ratio of the total benefits to total costs. In this method, the investment alternative with the highest *B/C* ratio provides the largest return per investment dollar. The second method examines the net benefits (or net present value) produced by each alternative. Total costs are subtracted from total benefits and the option with the largest net benefits is chosen as the best investment option. A third method is the incremental benefit-cost ratio, in which the costs and benefits of each alternative are compared with the cost and benefits of the next alternative, beginning with the least expensive option. As long as the resulting incremental benefits exceed the added cost, it is best to invest in the next higher cost option (*5*).

Associated with the benefit-cost analysis is present-value or present-worth analysis. A stream of benefits and costs occurs at different times during the life of the improvement. Because these yearly benefits change, discount rates must be applied to convert all benefits and costs to a present value. As is the practice in many jurisdictions, the appropriate discount rate to be applied is the average rate of return that can be expected on private investment before taxes and after inflation. This choice of discount rate is based on the fact that funds expended for a transportation improvement are not funds that would otherwise stand idle. The government obtains these funds from the private sector, either by taxation or borrowing, and if left in the private sector the funds would be used to generate a return as do other investments. When the funds are diverted to public use, the cost of the diversion is the return that otherwise would have been earned. This cost is considered to be the opportunity cost of capital. The results of the benefit-cost analysis may be sensitive to the discount rates used. Some of the computerized program packages available for the determination of user benefits and costs are described in the following paragraphs.

• Priority Planning System (PPS). In 1974, the Ontario Ministry of Transportation developed a computerized method for the systematic assessment of highway improvement priorities so that improvements could be implemented in such a way as to optimize benefits to the general public (*6*). This method was considered state-of-the-art for a long time and was the subject of NCHRP Project 8–18, conducted by the Maryland Department of Transportation. NCHRP Report 199 describes the PPS in detail (*7*). The first two stages of this computerized program can be used independently to estimate road user cost and hence the benefits to the users. PPS calculates three user benefits for each improvement alternative as follows:

1. Travel time savings—change in user's travel time cost because of the improvements;
2. Vehicle operating savings—change in road users' vehicle operating costs because of the improvement; and
3. Accident savings—change in costs because of the improvement. They are divided into three types: fatal, personal injury, and property damage accidents.

Positive savings occurring because of the improvement (i.e., a reduced user cost after the improvement) are called benefits, whereas negative savings are called disbenefits.

• The Highway User Benefit Assessment Model (HUBAM). HUBAM is a computer model similar to PPS, but unlike PPS, this model can include rehabilitation and upgrading projects (*8*). Now operational at Transport Canada, the model is currently being used in the evaluation of new highway agreements with some of the provinces.

Input-Output Analysis

Input-output (I/O) analysis provides a framework within which industrial linkages and the feedbacks between consumers and the producing sector of the economy can be simulated. The approach involves modeling the economy in a set of linear equations that can be solved mathematically. The cost of the new construction or improvement is obtained from the preconstruction cost estimates or from costs incurred on a comparable project adjusted suitably to reflect the conditions of the project evaluated. The construction cost estimate and other project parameters form the input to an I/O model, which in turn generates the impacts of the construction activity.

The Ontario Ministry of Transportation has developed an interactive computer model known as the Transportation Impact Model (TRIM) to calculate the economic impact of capital investments in transportation infrastructure (*9*). TRIM is based on the I/O model of the Ontario economy.

The identification and classification of economic impacts are discussed in the following paragraphs.

CLASSIFICATION OF ECONOMIC IMPACTS

An efficient transportation network connecting business and industry with markets and suppliers is important to a region's continuing economic vitality. Improvements to the network help existing firms become more competitive and make the region more attractive for new business as well.

The most important step in assessing the economic impact of an improvement is to ensure that all the issues have been identified for examination. The economic impacts of an improvement may be broken down as affecting the following areas (*10*):

- Business and industry,
- Residential,
- Tax revenues,
- Regional and community, and
- Resources.

Other important aspects of impacts are that they vary in the degree of permanence (i.e., the effects can be temporary or permanent) and that they are considered either beneficial or detrimental. For this paper, temporary impacts are those that are short lived on a site-specific basis, often lasting only for the duration of construction. Impacts of a more lasting nature would then be categorized as being permanent. Using this definition, the relative importance of the different classes can be established. Those impacts considered to be permanent and classified as producing direct, indirect, and induced effects would rank higher against an impact classed as temporary and having only indirect effects.

The following analysis attempts to understand and limit the boundaries for the categories within these five classes. This restriction is necessary to avoid the double counting of impacts in the assessment stage.

Business and Industry

Economic activity in a corridor is the sum total of the activities occurring in each sector of the economy. All categories of business activity may be affected by a transportation improvement through changes in the levels of employment and income resulting from changes in accessibility, economic stimulus from construction, and acquisition of land for the right-of-way. Negative effects from pollution and indirect effects in the economy can also result from an improvement. An improvement could also influence locational decisions of firms. The preponderance of industry impacts will vary depending on an industry's dependence on transportation.

In order to develop a process of assessing the potential impacts, they may be grouped under the following subheadings:

Effects of Facility Construction on Business

Improvements in a corridor generally yield three types of economic impacts:

1. Direct expenditures on labor and materials used on site for construction and recurring expenditures on labor and materials required for maintenance;
2. Secondary effects induced by direct expenditures (i.e., they affect income, employment, and production inside and outside the state or province; generate tax revenues; and consume energy sources); and
3. Possible temporary losses to firms in the vicinity of the construction area because of decreased accessibility.

Right-of-way acquisition costs will be excluded from actual construction expenditures as they are handled as a separate item in the next subsection. Also, the economic activity induced by wages and sales is assumed to be contained within the region, and no leakage is considered. In practice, construction workers may come from outside the region and sales income may accrue to companies located outside the region as well.

Effects of Right-of-Way Acquisition

Expansion of the existing right-of-way by acquisition of additional land could lead to the displacement of business establishments in the corridor and have the following effects:

1. Net loss of jobs and services should displaced businesses choose to relocate outside the region or even to cease operations.
2. Redistribution of jobs and services within the corridor or the region.
3. Loss of land required for the right-of-way.

Further, businesses outside the right-of-way may suffer loss of customers if the right-of-way creates a barrier, such as in the case of a divided highway, that hinders access to and from them (*11*). This type of impact is more permanent in nature than the disruption caused by construction discussed previously.

The number of jobs and income losses can be estimated for a route alignment. Estimates may be provided on the basis of employment and sales of establishments in the affected corridor.

Effects on Business Growth

Transportation investments often provide an impetus for business growth. This growth may occur in manufacturing, service, wholesale, or retail sectors of the economy and may include the following:

1. Expanding existing businesses;
2. Attracting new business or labor to the corridor;
3. Deterring growth of other businesses and those that depend on remoteness (e.g., wilderness recreation amenities);
4. Reducing the cost of moving goods and raw materials, which may enhance the competitive position of existing businesses and thus encourage regional development and expansion (see 1);
5. Servicing interregional traffic flows, which can encourage the development of travel-related businesses (see 1 and 2); and
6. Redistributing traffic patterns, which may depress economic development of areas where traffic is reduced (see 3).

The direct impacts lead to indirect effects on the economy such as additional orders for materials and equipment from other businesses. For example, expansion of the hospitality industry leads to additional orders for linen, fresh and frozen foods, and a host of other supplies. Also, there are induced effects that result when new businesses hire more workers who then spend money on consumer products and services. The resulting overall impact on business will be reflected in terms of sales, income, employment, or other economic indicators, and these impacts are normally induced, after completion of the facility.

Although there are several ways to evaluate these economic impacts (i.e., increase in income or wages) the simplest measure is the additional disposable income resulting from the new jobs created by all the direct, indirect, and induced effects.

Effects on Tourism and Recreation

Where tourism or recreational activity is regarded as an important sector in the region's economy, a transportation improvement can have positive or negative effects on the industry and requires inclusion in any accounting of impacts.

Improved accessibility stimulates tourism and recreation in much the same manner that it stimulates business growth. Highway improvements, especially expansion from two to four lanes, save travel time, reduce safety hazards, and make travel more predictable to various tourist and recreational centers. Industry experts believe that the stimulus is proportional to the degree of change in accessibility that the improvement creates. Where improved accessibility makes travel safer, faster, and more enjoyable (especially to lake areas), the waterfront lots increase in value.

An improvement can also have negative effects on the tourist industry of a region when a certain measure of remoteness is desired, such as for the operation of fly-in tourist resorts. Also, if accessibility to a tourist area is increased without regard to the supply of sufficient facilities, competition for limited tourist and recreational facilities could discourage tourists. Furthermore, a new alignment, which bypasses a recreation or tourist area, can divert potential users away from existing facilities, resulting in a reduction in facility usage.

Increase in tourist spending will impact certain sectors of the economy directly whereas other sectors are unaffected. Visitors spending money in hotels, lodging facilities, gas stations, restaurants, and grocery stores generate demand for agricultural products, petroleum, etc. The retail and service sectors generally experience the highest increase in sales and employment. Money spent by tourists circulates through the economy, creating indirect and induced economic impacts. Additional sales and employment result in other industries such as manufacturing, services, and transportation that supply goods and services to the hospitality and recreation industries because of direct spending.

Techniques for assessing the incremental demand and the corresponding impacts of improved accessibility from an improvement should be undertaken by a recreational or tourism planner. Essentially, the assessment involves estimating highway use for greater visitation and spending patterns by trip categories, such as hotel or motel trips, camping, seasonal home visits, visits to friends and relatives, and day trips. Interviews with owners and managers of hospitality, recreation, and tourism businesses would help to assess the potential future visitor spending. An important factor to be considered is the potential negative impacts of improvements increasing the attractiveness of other regions for study area residents.

Effects on Agriculture

In many rural or suburban areas, through which highways are located, agriculture is the dominant economic activity. Improvements from a two- to a four-lane facility, particularly, would enhance accessibility and mobility.

A transportation improvement may affect agricultural activity as follows:

1. Improved Accessibility to Markets to Increase Profitability. Improving accessibility may result in lower transportation costs for moving produce and farm supplies, thus leaving more money in the hands of the farmers. Also, farmers may be able to shift to more valuable crops as a result of improved access. This conversion to higher-value crops can result in increased productivity. Furthermore, an entirely new corridor of travel could open new markets, thus enabling farmers to produce more agricultural commodities or more profitable ones.
2. Encouraged Conversion of Agricultural Land to Other Uses. Improved accessibility in a corridor may increase employment opportunities and the increased activity may result in pressures for conversion of agricultural lands to other "highest and best" uses such as residential, commercial, or industrial. The permanent loss of valuable farm land to urban development is of concern to most people, hence, the assessment of this impact is sufficiently important to warrant special attention. It has been noted that interchange points are more susceptible to early development or zoning conversions.
3. Change in Agricultural Productivity. Agricultural productivity of a region is estimated by the output of the region measured in terms of the quantity of commodities produced and the income generated. Shifts to more valuable crops increase productivity. However, transportation facility construction could also affect farm operations adversely because of siltation and altered drainage patterns and severance of farms by the right-of-way, not to mention the reduction of farmland from right-of-way acquisition.

An assessment of the incremental productivity and the economic impacts of a transportation improvement on farm land can be made in consultation with an agricultural economist.

Effects on Mining and Forestry

In other rural or remote areas, highways provide access to mining and forest resources. Improvements result in lowering of transportation costs, thus enabling operators to remain competitive. An assessment of the incremental productivity and the economic impacts of an improvement on mining and forest resource industries is similar to that of agriculture.

Residential

Residential development (i.e., the construction of new dwelling units) is a function of economic growth and housing market variables such as immigration, employment, population growth, income changes, rate of household formation, decreased housing inventory through aging or demolition, and availability of building sites. The effects of a transportation improvement in this impact category may be as follows:

- Induced or secondary effects of employment growth in the regional economy may also attract additional workers and families to a region, thus creating an additional demand for housing.
- Reduced housing stock from right-of-way acquisition may cause relocation and replacement housing needs.

Although the impacts are linked closely, the scope of the assessment here can be confined to the following effects.

1. Replacement and Relocation Housing Needs. The right-of-way requirements and the associated residential relocation implications can be determined for each option considered. The reasonableness of the estimate should be discussed with realtors and others knowledgeable about housing and socio-economic conditions. At times, according to U.S. experience, families from minority groups experience difficulty in securing alternative accommodation. As a last resort, relocation hous-

ing may have to be acquired or constructed to carry out any relocation program.

2. Induced or Secondary Effect on Residential Construction. In addition to causing residential relocation, a highway improvement may also affect residential construction by inducing the construction of new housing units. At the local level, lower-cost lands are made more attractive to developers and home buyers because of improved accessibility. However, at the regional level increased business activity generates additional employment and population in the region, requiring additional housing.

It is important to distinguish between induced residential construction from improved accessibility to some areas, and induced construction from positive overall growth in the economy. The former mainly causes a redistribution of construction activity within the region, whereas the latter results in a net increase, not necessarily limited to the local impact corridor.

Tax Revenues

Any expenditure, such as for a transportation improvement, generates tax revenues for the different levels of government. In Ontario, more than 35 percent of the total cost of an improvement is recovered by government from personal taxes, indirect business tax, tariffs, and local property and business tax. From the TRIM model, the federal government collects the largest portion, about 18 percent of the investment cost, whereas the provincial government recovers about 12 percent and the local governments about 5 percent of the project cost. The magnitude of the capital returned to government has not been stressed sufficiently.

Although the magnitude of the federal and provincial taxes recovered is much larger, their impacts are not location-specific. The impact on the improvement area can be attributed mainly to property and business taxes, which determine the level of public services and facilities provided to the community.

Property Taxes

Property taxes are the primary source of revenue for local governments, and their impacts can be divided into two areas:

1. Loss of Tax Revenues from Acquisition of Private Property. Using local tax rolls, the assessed value and the annual tax for each parcel of land affected by acquisition can be determined. A computation to account for the extent of losses from the acquisition can then be made.

2. Changes in Property Values and Tax Revenues. An improved highway may increase accessibility to an area and boost property values, by making properties more attractive for commercial, industrial, or high-density uses. On the other hand, undesirable environmental and safety effects may depress property values. These market value changes for the land may be reflected in assessed values and, hence, the property taxes. The effect of these changes is long lasting.

Experience shows that the level of development induced by a new or reconstructed corridor is often greater than anticipated. Commercial and industrial growth yielding positive tax benefits is desired by local municipalities.

In conducting the analysis, the changes in property value can be considered as follows:

1. Changes in Value from Accessibility. In general, the increase in property value resulting from improved accessibility can be further subdivided into two types: (a) increase in value from making the property more attractive or useful from reduced travel time, etc., and (b) increase in value from making the property attractive for a more intensive purpose such as a shopping center or plaza.

2. Decrease in Value from Environmental Effects. Estimates of the degree to which property values will decline from environmental effects are highly subjective. The important factor is people's perception of the situation. A study of a large subdivision in Toledo showed that lots adjoining a freeway sold at comparable prices to interior lots but more slowly. This occurred at a time when a majority of realtors in the area felt that property near the freeway would be of lower value (*12*).

3. Changes in Value from Other Positive Effects. Occasionally, a highway improvement will provide benefits to adjacent properties other than from improved accessibility. An example of this type of impact could involve a reduction in air pollution by providing for public transportation and by eliminating congested locations.

The effect of a transportation improvement on property values should be estimated in consultation with realtors and appraisers who are knowledgeable about property values.

Public Service Changes

Impacts in the area of public services can be attributed to the following:

- Changes in net public expenditures (i.e., new tax revenues less the cost of providing additional public facilities and services to accommodate the new growth).
- Public expenditures for replacement of displaced public facilities.

The analytical procedure of estimating public service requirements associated with induced residential development could follow a three-step approach:

1. Estimate public service requirements in relation to the estimate of the households and residential units resulting from induced development.

2. Review capacities in existing facilities because they may have excess capacity and be capable of accommodating additional demand.

3. Compare anticipated public service requirements and the capacities of present and planned facilities to reveal the additional public services required to service the incremental growth.

Estimating the scale, timing, and location of induced development in an improvement corridor is no simple task.

Regional and Community Activity

Transportation facilities, together with water, sewer, and other public utilities, are major determinants of urban development and economic growth. Transportation facilities also reinforce land use planning and economic development objectives in rural areas by providing access to agricultural lands, tourist attractions, and natural resources. An improvement can be expected to encourage economic growth of a region as well.

Occasionally, an improvement that is required to provide mobility for regional travel could conflict with plans for a housing project or a public facility, such as a hospital or school. A highway agency could also be unaware that a building in the demolition zone has been designated as a historic structure. Liaison with other planning agencies and early identification of such situations is required to avoid conflict.

An improvement may affect a community

- In terms of the general pattern of community growth;
- In terms of public revenues and expenditure;
- In terms of direct income; and
- In terms of environmental conditions.

These effects are somewhat interrelated and the assessment of impacts in this area can generally be reduced to two categories by asking the following questions:

1. How does the improvement relate to adjacent land uses?
2. How will the induced development relate to the existing uses?

In attempting to answer these questions, one realizes that the impacts under this activity relate to a broader context of economic and land use planning at the regional or province-wide scale. Unless the project has system-wide repercussions, consideration of impacts under this activity may not be warranted in the case of area-specific projects.

Resources

The construction and operation of a transportation improvement require the direct consumption of resources, thus creating potential economic impacts on four broad resource types (i.e., land, labor, materials, and energy).

The assessment of impacts on resources involves the determination of energy consumption associated with direct, indirect, and induced effects of the project. Standardized impact values available from I/O models of energy consumption for standard-unit projects can be used to estimate the effect of direct impacts.

Appreciation of Land Values

Transportation improvements enhance the desirability of locations within the catchment area of the improvement corridor. This increased desirability stimulates the demand for land at those locations. Because the supply of land is fixed, increased demand leads to escalation of land rents, which in turn results in higher land values. The increase in land values results from the reduction in transportation costs to users. Inclusion of this as an economic benefit leads to double counting the effects of transportation improvements (*13*). An aggregation of the estimated increase in land values of all parcels of land within the catchment area would yield an overall measure of the value of an improvement to the community or society at large.

Note of Caution

When funds normally allocated for a capital construction program are involved that would generate economic benefits to the province or state as a whole, then it is inappropriate to attribute the economic impacts to the transportation improvement.

Classification Summary

A summary of the different categories of economic impacts is presented in Table 1. The foregoing discussion has indicated that the consequences of an improvement can be broadly categorized as direct, indirect, and induced, and that they vary in the degree of permanence.

BASIC EVALUATION FRAMEWORK

A basic framework integrating the different components of the evaluation process is shown in Figure 1. The framework consists of the following components.

Set of Goals and Objectives

The framework requires a clear statement of goals and objectives. Goals are generalized statements indicating the direction in which society is to move. An objective, on the other hand, is a specific statement that is the outgrowth of a goal. Objectives are attainable and stated so that it is possible to measure the extent to which they have been attained. Some simplified examples of desirable state or provincial objectives for transportation in general could be

- To provide transportation services for the mobility of people and goods;
- To preserve the transportation system now and for the future;
- To ensure safety, effectiveness, and environmental acceptability;
- To ensure that the expectations of various stakeholders are reconciled; and
- To promote economic growth.

Associated with these objectives is the implicit understanding that they be achieved at reasonable cost.

The degree to which the objectives are attained is defined by criteria. One particular type of criterion, known as a stan-

TABLE 1 CLASSIFICATION SUMMARY—ECONOMIC IMPACTS

Class	Category	Effects	Direct	Indirect	Induced	Temporary/ Permanent
Business & Industry	Facility Construction	Expenditure on labour and materials for construction	x			T
		Secondary effects induced by direct expenditures		x	x	T
		Losses to firms in the vicinity		x		T/P
	R-O-W Acquisition	Loss of jobs and services due to relocation	x			T
		Redistribution of jobs and services within the corridor		x		T
		Loss of land	x			P
	Business Growth	Expansion of existing businesses	x	x	x	P
		Attract new businesses or labour	x	x	x	P
		Deter businesses that depend on remoteness	x	x	x	P
	Tourism & Recreation	Expansion of existing businesses	x	x	x	P
		Deter businesses that depend on remoteness	x	x	x	P
		Divert potential business	x			P
	Agriculture	Increase or decrease in productivity and profit	x			T
		Encourage conversion of land to other use		x		P
	Mining & Forestry	Improved accessibility to markets	x			P
Residential	Regional Economy	Replacement & Relocation housing needs		x	x	T
		Attracts additional workers and families		x	x	P
Tax Revenues	Property Taxes	Loss of tax revenues due to acquisition	x			P
		Property value changes and associated tax revenues		x	x	P
	Public Service Needs	Require additional expenditure			x	P
Regional & Community	Community Region	Changes to pattern of community growth				?
		Changes to public revenues and expenditure		x		?
		Gain or loss in direct incomes	x			?
		Environmental changes				T
Resources	Land	Covered under R-O-W acquisition	-	-	-	-
	Materials & Labour	Covered in effects of facility construction	-	-	-	-
	Energy	Consumption associated with direct, indirect and induced effects	x	x	x	P

dard, defines the cutoff point above or beyond which performance is rejected (*14*). Irwin (*15*) classified criteria into social, economic, physical, fiscal, and aesthetic types. Absolute criteria could be applied to meet minimum standards in social, physical, and aesthetic areas to which dollar values may not be readily applied. Having eliminated alternatives that do not meet the minimum level, relative criteria could be applied in the economic and fiscal areas to provide a basis for selecting the preferred improvement that produces the most benefits in relation to cost. Therefore, physical and aesthetic areas will be combined as environmental considerations.

If need be, a relative ordering of the objectives could signify the importance attached to each objective. For example, a highway improvement necessary for the revitalization or stabilization of a disadvantaged or declining area could be selected even if the improvement is only marginally viable in terms of system productivity.

Goals, objectives, and criteria will be highlighted for the purpose of assisting the decision makers to focus on the task when making the ultimate choice between feasible alternative improvements and are to be used more as reference devices. In the context of current knowledge pertaining to consensus

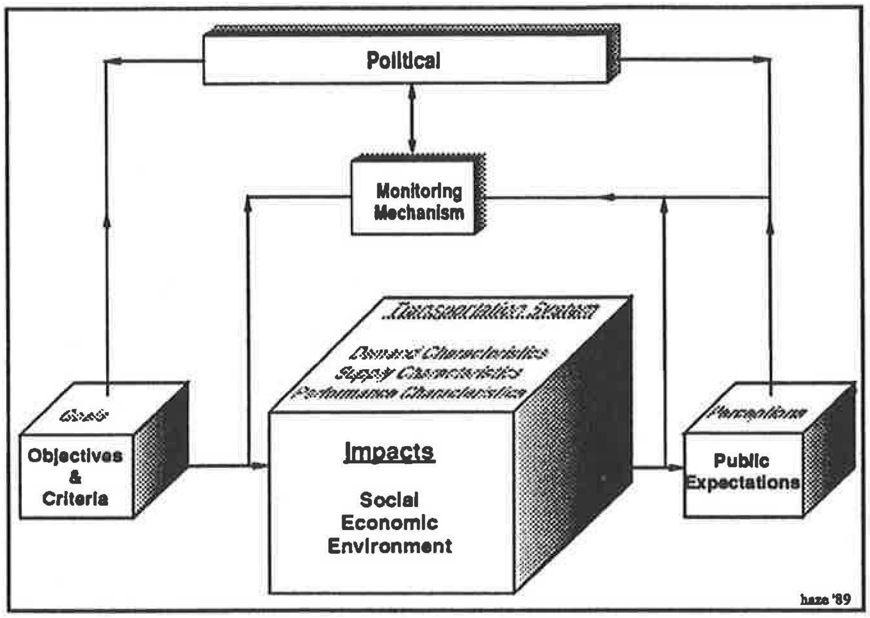

FIGURE 1 Evaluation framework.

building, it is desirable that the objectives be agreed on as being the most relevant to decisions. Without consensus, a strategy is weakened from dissension among the stakeholders. The political process thus provides the forum for discussion and reconciliation of conflicting stakeholder interests.

Transportation System

The transportation system can be characterized in terms of its

- Supply characteristics (capacity, operating costs, level-of-service, etc.);
- Demand characteristics (land use, demand for travel, etc.); and
- Performance characteristics (accident rate, vehicle-km of travel, etc.).

The consequences that occur as a result of the activity associated with a transportation system can be categorized into three main impact areas, namely social, environmental, and economic.

Public Perceptions

Public perceptions involve stakeholder interest and participation by the public with their perceptions of the transportation system. Information for a public perceptions study can be collected from newspaper clippings or articles relating to transportation issues in the corridor of interest and by interviewing business persons and community leaders. Review of correspondence from the public might also provide useful insights.

The Ministry of Transportation Ontario recently carried out a public opinion survey to determine the perceptions of Ontario residents regarding the adequacy of highway transportation services from a general standpoint, but included an analysis of a few specific corridors as well.

Monitoring Agencies

Departments of transportation normally act as the monitoring agencies. The planning and control elements in these organizations review the status of the existing system, assess system performance against the program objectives, consider public concerns, project future needs, and plan measures to correct existing or anticipated system deficiencies.

Any major deviation between the system's performance and expectations would necessarily activate a response from the institutional component of the monitoring system.

Political Process

This is the most important component of the framework. However, its linkage with the other components of the system tends to be tenuous. An important consideration for planners and administrators to recognize is that the mechanics of the political process call for more emphasis on short-term issues at the expense of longer-term considerations.

APPLICATION OF THE FRAMEWORK

The selection of objectives and criteria applied to judge relative priorities of the project or preferred improvements form the initial stage of the framework. As suggested by Irwin (*15*), absolute criteria satisfying minimum standards in the social and environmental impact areas are applied to select those projects to be tested for economic viability. The selection and definition of criteria form an important part of the public participation process.

Planners and analysts guided by the objectives and criteria set and review the supply, demand, and performance characteristics of the system within the study area. The application of economic analysis and the evaluation of viable options is the outcome of this stage.

The results of the preceding evaluatory stage are then made public, and feedback obtained regarding public perceptions and satisfaction is used to improve the project selection process further. Where possible and feasible, conflicting stakeholder interests are resolved.

The final stage of the entire process is the reconciliation of any residual conflicting stakeholder interests and the selection of the project for implementation, which is a political decision.

The following subsections outline briefly the methodology involved in evaluating the economic impacts from a highway transportation improvement.

Improvement Alternatives

The typical highway improvement involves the expansion of an existing two-lane highway to four lanes. Generally, four improvement alternatives can be considered as follows:

1. Status Quo, No-Build, or Do-Nothing Alternative. This alternative is not an improvement in the strictest sense, but rather provides a benchmark against which to measure changes in costs and benefits of the other three basic improvement alternatives in the following discussion. This alternative represents the costs incurred to provide normal maintenance to keep the improvement in a satisfactory condition.
2. Combination 2-Lane–4-Lane Alternative. Four-lane sections are proposed only where required to accommodate increased traffic volumes. This capacity improvement would be effective throughout the life cycle of the facility according to the transportation agency's normal highway improvement plans.
3. Freeway-Expressway Alternative. This alternative expands the existing two-lane highway by adding two additional lanes to provide for a four-lane divided highway basically on the existing alignment. The expressway design allows some at-grade intersections (i.e., direct access only at major arterial urban roads) rather than requiring access to the highway through expensive interchanges.
4. Freeway Alternative. This alternative consists of a full four-lane divided highway designed to the highest standard. A higher speed limit than the freeway-expressway alternative is allowed. In order to maintain a constant speed limit, much of the facility may be required to be built on a new alignment with bypasses around communities and access to the highway via interchanges.

Variations of these basic alternatives can be considered as well. The evaluation process consists of the estimation and comparative assessment of improvement costs, user benefits, and economic impacts for each of the preceding options considered within the transportation system for the entire study period.

Improvement Costs

Improvement costs relating to each study alternative can be determined by using unit cost estimates. Such cost would include construction, rehabilitation, and maintenance expenditures. Because some of these costs vary from one-time costs (construction) to costs incurred more than once (rehabilitation) to annual costs (maintenance), the cost stream over the study period for each alternative is discounted to current dollars. This allows a comparison of relative costs for each alternative.

Potential User Benefits and Economic Impacts

In order to select the best investment strategy, comparing the improvement costs of each alternative with its potential benefits and impacts is necessary.

Using models of travel behavior, the existing and future traffic (for the system as is) in the study corridor can be estimated. Computer assignment programs are then used to simulate new traffic and travel patterns for each of the improvement alternatives. With each successive level of improvement, the corridor may attract more users from other routes. These traffic volumes become the basis for the estimation of user benefits and economic impacts over the entire study period.

The transportation user benefits for the three improvement alternatives, in relation to the do-nothing alternative, can then be determined using existing computer packages such as PPS, HUBAM, etc. In this context, the current NCHRP Project 7-12, Microcomputer Evaluation of Highway User Benefit, should prove to be an invaluable tool for the analyst.

The estimation of the economic impacts for the three improvement alternatives form an integral part of the total benefit package. In a previous section, an attempt was made to identify and classify the different economic impacts, and methods of estimating the magnitude of these impacts were suggested. The future user benefit and economic impact stream is discounted to their equivalent present value as is the improvement cost. The freeway alternative would provide the greatest economic impact because the expressway and combination alternatives are less attractive for industry because of increased travel times, reduced travel ranges, and a general perception that any highway with less than freeway standards provides a less safe and relaxing travel environment.

The suggested methodology for some impacts is not entirely satisfactory because of the interaction between impact categories. It is suspected that there is some leakage and the author perceives that this could be an area for further research. As indicated by Table 1, business growth, recreation and tourism, facility construction, and property tax, in that order, appear to be important impact categories. Estimation of impacts in these areas would account for the greater part of all economic impacts.

A matrix of improvement costs, user benefits, and economic impacts for the improvement alternatives considered for a hypothetical case are presented in Table 2.

Evaluation of Improvement Alternatives

A benefit-cost analysis may then be carried out to determine if the benefits (both user benefits and economic impacts) resulting from an accelerated construction program exceed costs, and if so, which improvement alternative can be expected

TABLE 2 PRESENT VALUE OF COSTS, BENEFITS, AND IMPACTS (1988 DOLLARS IN MILLIONS)

	Combination Two-lane - Four-lane		Freeway - Expressway		Freeway	
Improvement Cost:						
Construction	300		450		550	
Maintenance	20		50		70	
Total Cost		320		500		620
User Benefits:						
Travel Time Savings	500		750		900	
Vehicle Operating Savings	10		-35		-125	
Accident Savings	150		200		300	
Sub-total		660		915		1075
Economic Impacts:						
Facility Construction	420		630		770	
Business Growth*	500		1200		1500	
Tourism & Recreation*	100		250		350	
Sub-total		1020		2080		2620
Total Benefits & Impacts		1680		2995		3695
Tax Revenues	90		135		165	

** Note: Figures shown above are hypothetical for purposes of illustration*

to provide the best return. Table 3 presents a summary of results. Some aspects of the benefit-cost analysis process were discussed under analytical techniques.

The array of improvement costs, transportation user benefits, and economic impacts for improvement alternatives, together with the results of the benefit-cost analysis, may then be presented to the political decision makers and even to the public. Final decisions should, quite properly, be made at the political level, which involves debate and trade-offs between individuals and groups who hold conflicting views.

The planners should ensure that all facts are made available and presented in a manner that is understandable in order that an informed political decision can be made. It would be a mistake to avoid the scrutiny of the political decision-making process by reducing the evaluation of alternatives to a numerical exercise.

CONCLUSION

The distinction between transportation user benefits and economic impacts has been explained. An understanding of the three types of impacts (i.e., direct, indirect, and induced) would assist in identifying economic impacts. Some economic impacts from a transportation improvement have been identified in previous studies. Additional economic impacts, some of which appear to be significant, have been identified and arranged into generic groups.

As an integral part of the classification of impacts, the effects of such impacts have been recognized. Some impacts can be placed in more than one class type, illustrating the complex nature of the impacts and their interrelationships. Also identified in the classification is the degree of permanence of the impacts. Naturally, impacts classed as permanent are considered more significant than temporary impacts.

A ranking of the impact categories has not been assigned. However, from the tabulation of impact categories, business growth, recreation and tourism, and property tax appear to be significant categories on the basis of the degree of permanence and incidence of impact types.

Methods of measuring the magnitude of some of the economic impacts are suggested. In view of the interrelationship between the different impact categories, further research is suggested in the area of assessment of their magnitude and method of aggregation.

TABLE 3 BENEFIT-COST ANALYSIS (1988 DOLLARS IN MILLIONS)

	Combination Two-lane - Four-lane	Freeway - Expressway	Freeway
Present Value of Benefits & Impacts (B)	1680	2995	3695
Present Value of Costs (C)	320	500	620
Net Present Value (B - C)	1360	2495	3075
Benefit - Cost Ratio (B/C)	4.25	4.99	4.95

A simple framework for the evaluation of the improvement costs, transportation user benefits, and economic impacts associated with improvement alternatives is presented for discussion. This framework requires that minimum standards be satisfied in the social and environmental impact areas before an alternative routing is included in the evaluation process.

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Bottlenecks and Flexibility: Key Concepts for Identifying Economic Development Impacts of Transportation Services

MICHAEL BELL AND ERAN FEITELSON

Today, because of economic activity restructuring by function rather than sector, there is a need to reconsider the relationship between transportation and economic development. Most current analyses are static and do not consider capital stock in place, level and quality of service, and demand for transportation. Transportation services can be viewed as intermediate goods in the private production and consumption processes of firms and individuals. As is the case with other intermediate goods, different industries will demand different types, levels, and qualities. When adequate services are not available in a timely manner, bottlenecks arise. Bottlenecks are not limited to congestion on urban highways during peak hours; therefore, policy responses to them are not limited to simply building more highways. From this perspective, the transportation system can either aid or hinder public and private firms' production functions either directly or by complementing private inputs. Transportation networks also contribute to the attractiveness of a region. An analysis of linkages between transportation and economic development under such circumstances would begin by identifying the role and potential of various sectors and functions in the economy. Next, the importance of transportation services for the most important sectors and functions in the economy would have to be identified. This method would require a highly disaggregated analysis of the role of transportation services in the location of relevant industries and services that are now differentiated by function rather than by sector. Such an analysis can help identify situations where the lack of specific transportation services becomes a bottleneck to economic development. However, this analysis is a necessary first step toward a cost-effective policy for economic development, but is not sufficient for formulating or evaluating a transportation policy's contribution to economic development. To make this additional step, analyzing the attributes of both transportation services and prospective users is necessary. Specifically, the concentration ratios of users and operators need to be considered, as well as their footlooseness. These flexibility considerations are important to reduce the risk of long-term public investments being made on the basis of an ephemeral conjunction of circumstances in the rapidly changing economic scene.

In fiscal year 1987, federal, state, and local governments spent $66.2 billion on transportation investment, operation, and maintenance—about $272 for every man, woman, and child in the United States. (Transportation includes highways, streets, roads, bridges, waterways, airports, and airways.) Eighty percent of these funds were spent on the nation's network of highways, streets, roads, and bridges. However, spending for system improvement has fallen short of the need in high-growth urban and suburban areas and, as a result, congestion was a problem on nearly half of the nation's Interstate urban highway system. This concern led the National Council on Public Works Improvement to conclude that the nation's infrastructure is insufficient to meet the demand of future economic growth and development (*1*).

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Several studies suggest using standard or determined needs-based approaches or comprehensive planning approaches for addressing perceived transportation shortfalls (*2,3*). More recently, the National Council on Public Works Improvement (*1*) noted that the focus of such analysis should be on transportation services rather than engineering standards. Still, these approaches do not answer questions regarding ways to determine which transportation policies have the most effect on economic development and how transportation policies should be related to different types of economic development.

In the current environment of limited fiscal resources, the important policy question is how federal, state, and local government officials can use such limited resources effectively to provide the highest level and quality of transportation services. One element to consider in setting spending priorities to obtain maximum benefits from limited resources is the linkages between transportation and economic development.

Historically, transportation has been a necessary ingredient in almost every aspect of economic development. Transportation made possible ready access to resources, specialization of industry, commercialization of agriculture, and the rise of trade centers (*4,5*). The increasing ubiquity of transportation systems (particularly highways) in the United States led several influential analysts to suggest that the importance of transportation for economic development was declining (*6,7*). Because the U.S. economy was based on industrial production at the time of these analyses, most focused on the relationships between transportation systems and industry.

In recent years, the U.S. economy went through a series of crises and restructuring from such forces as technological change (sometimes termed the "information revolution") and increasing international competition and, as a result, many industries changed their production processes by substituting capital for labor as well as changing the location of their activities (*8,9*). Most of the job growth since 1970 has been in advanced services (primarily production services), education, and health (*10,11*). Both the service and industrial sectors of the economy were also affected by the shift in federal expenditures from welfare to defense (*12*). The outcome was a restructuring to a new service-oriented, postindustrial economy and, thus, to a new economic geography (*13,14*).

Economic restructuring affects the demand and usage patterns of the transportation infrastructure (*15*). These effects, combined with the aging of transportation facilities, lead to increased maintenance costs. Along with changes in the financing and administration of transportation services, they have led to growing concern regarding the ability to maintain the existing infrastructure and to finance needed capital improvements (*1,15*). Because changes in economic structure and geography affect both the demand for transportation services and the ability to maintain and to improve transportation infrastructure, there is a need today to reconsider the relationship between transportation and economic development in the United States in the context of the emerging economic geography.

Traditionally, analyses of linkages between transportation and economic development focus on the multiplier effect of transportation investments and the impact of such investments on accessibility and land values. Most of these analyses are static and do not consider capital stock in place, the level and quality of services being provided, and the demand for transportation services. Thus, existing empirical evidence quantifying the linkages between transportation and economic development is mostly derived from cross-sectional analyses, and results in findings that are mixed and inconclusive. Such inconclusive findings reflect, in part, a lack of consideration of differences between places and across sectors in the economic development effects of transportation (*16*). As a result, current knowledge does not provide sufficient guidance for policy makers as to the type and location for transportation services needed to enhance their region's economic position. Today, there is no generally accepted framework for explaining why, where, and how various transportation services are linked to economic development in the context of the new postindustrial economy.

First, some initial steps toward developing a framework will be discussed that would enable researchers and policy makers to analyze the possible roles and potential of various transportation services for economic development in different settings within the new economy. Next, the importance of the private-goods nature of transportation services will be explored from the perspective of the individual firm. Last, a first step will be taken toward the formulation of a conceptual framework for analyzing linkages between the demand for transportation services and economic development from a policy maker's (federal, state, or local) perspective by reviewing economic restructuring and identifying its implication for transportation demand. In this context, two central concepts will be introduced for such a framework: bottlenecks and flexibility.

THE CHANGING FACE OF THE ECONOMY—A REVIEW

The economic restructuring taking place in the United States in recent years can be described by four transformations occurring concurrently, as follows:

1. Changes in intrafirm production processes;
2. Changes in the structure of the industrial sector (including both institutional structure and types of products being produced);
3. Shifts in the location of various economic activities; and
4. The increasing importance of the service sector in the economy.

All of these transformations are driven to some extent by the revolution in information technology and each has implications for the future demand for transportation services (*13,17,18*).

Changes in Nature of Production Processes

Since the industrial revolution, the primary direction of change in production processes has been toward mass production. Underlying this trend was a stable demand for undifferentiated products, resulting in the epitome of standardized production processes, the Ford-type assembly line.

However, in recent years there has been increasing economic uncertainty because of volatile energy prices and flexible exchange and interest rates combined with increasing international competition, much of it from countries with lower wages but high technological capabilities. This uncertainty has led to a need for differentiated production that would allow differences in products in response to changing preferences of various market segments (*19*). Many firms have adopted new techniques that allow rapid adaptation of production to changes in demand through the production of various goods on the same production line. These new techniques require, in addition to multiuse machines, complex task programming, higher skills, ability to receive diverse inputs just in time, and close relationships with markets.

In a recent study of the changing economy and its implications for future infrastructure use, the U.S. Department of Commerce observed that (*20*, p. 3.7)

> The computer integrated flexible manufacturing system will break the hold that the search for economies of scale has had on manufacturing up to now. Big scale, single purpose, long production run plants will be a thing of the past.

The Commerce report continues by arguing that because of these new computer-integrated flexible manufacturing systems, production would become much more of a local matter with plants being able to make a batch of differentiated products almost on demand. These manufacturing centers would have the capability of manufacturing nearly an infinite variety of classes of products. Major cities would tend to become ringed by companies operating these computer-integrated flexible manufacturing systems.

Changes in Industrial Structure

The economic dislocations of the 1970s and early 1980s that were characterized by large layoffs of workers in basic industries can be viewed, in part, as the manifestation of a double transformation of the industrial sector (*8*). First, the institutional structure of the sector evolved from industrial firms to multinational corporations that often control a large number of spatially dispersed manufacturing and nonmanufacturing operations.

The emergence of these multinational corporations has contributed to the growing integration of the U.S. and world economies, resulting in increased interdependence. Over the last 30 years, real merchandise imports into the United States have increased from about 3 percent of gross national product to over 11 percent, whereas merchandise exports have increased from about 3.5 to 6.5 percent. In such an interdependent world, international trade would influence the structure of U.S. industry through the remainder of this century as domestic firms respond to the challenges of the international marketplace. Thus, international trade would influence the future demand for domestic infrastructure services, including transportation.

Second, the composition of the industrial sector changed. New industries emerged as a result of the development of new information technologies at the same time that many basic industries in the United States declined. In contrast to the basic industries on which the U.S. economy was based for the last century, the new industries are characterized by the knowledge-intensity of their products and have research and development (R&D) as a major input in their production processes.

These industries, best characterized by the semiconductor, biotechnology, and computer industries, often have a bifurcated labor force that includes a large percentage of highly skilled engineers and researchers, as well as unskilled assembly workers (*21,22*). Firm location decisions for these industries must be sensitive to the availability of housing for both segments of the labor force. Any mismatch between the location of housing and employment would add stress on the demand for transportation services, as has been evident in Silicon Valley (*22*).

In many cases, the physical inputs and outputs of these sectors are small, yet highly valuable. As documented by the U.S. Department of Commerce (*20*), contracting sectors in the nation's economy tend to be relatively material-intensive and require large amounts of physical inputs to produce large amounts of physical outputs. On the other hand, the expanding industries tend to be less material-intensive. The report concludes that as a result of these differences, ". . . there is evidence supporting the notion that future economic growth will require less in the way of transportation of heavy industrial raw materials per unit of output" (*20*, p. 127). This shift from heavier inputs and outputs to lighter, high-value products has important implications for the relative use of competing transportation modes in the future.

Changes in Location of Economic Activities

Because of advances in telecommunications and computers, firms have been able to spatially separate different parts of their production processes (*9,13,18*). Thus, management, R&D, and various production phases can each be located at the best places for that function. For example, specialized production services could be located near management headquarters, whereas other services could be located elsewhere. This differentiation is increasingly taking on international dimensions and is not limited to industry but is just as pertinent for services as well. The result of the intrasectoral spatial differentiation of functions has been that places increasingly specialize in function, rather than in sector (*10,23*).

Before restructuring, regions were differentiated by the dominant sector driving their growth. For example, Detroit was dominated by the automobile industry whereas Pittsburgh was the center of steel production. In each region, the most important source of jobs was the production within the dominant sector. Today, certain areas specialize and compete over production, whereas others specialize in management or R&D. Molotch and Logan (*24*), for example, identify five types of U.S. cities that are today differentiated by their role in the nation's economy—headquarter cities, innovation centers, module production places, migration entreports, and retirement centers.

Because of this trend toward multilocational and multinational firms, the amount of economic activity involving intrafirm transactions has increased. Market mechanisms are thus supplanted by intrafirm bureaucracies located in a few metropolitan centers, the headquarter cities. These bureaucracies require a large number of specialized producer services that agglomerate around them (*10*). One activity that increases the attraction of major financial centers for the location of corporate headquarters is the manipulation of corporate stock, sometimes to merge firms (whether in a friendly or unfriendly manner). This increasing paper entrepreneurialism identified by Reich (*25*) requires much face-to-face interaction.

R&D has a number of geographic patterns (*26*). Some R&D activity is directly related to corporate decision making and tends to locate near other production services in the headquarter city, whereas in other cases R&D may be linked directly to plant operations. The pure type of R&D, at the top of the product cycle, is often footloose so that agglomeration benefits from universities, public research institutions (military as well as civilian), and other private R&D units may be very important in its location (*21,22*).

Most places lack special qualities that would make them attractive for headquarters, R&D, or retirement centers so they compete for routine production tasks. These tasks are not limited to manufacturing because government and private services have many routinized functions requiring information processing.

Yet, as Saxenian (*22*) shows for the semiconductor industry, there is also a hierarchy of routine production tasks. Some require higher levels of skill than others and have different impacts on their environments. Thus, better-suited places may attract more desirable production activities, whereas less-endowed places may attract functions not desired elsewhere (such as waste handling). Generally, the lower the production function in terms of skills, the greater the importance of cost in determining locational desirability. For this reason, many of the most routinized low-skill functions have been shifted to low-cost developing countries.

In addition to the changes in national location patterns of economic activities, the intraregional location patterns of various activities have shifted. In particular, many activities not requiring extensive face-to-face contacts shifted to the suburbs or ex-urban locations. Thus, much of the differentiation of functions described at the national level is also reflected at the regional level. Although management functions remain in the central business district as well as associated services (such as financial and legal services), R&D and production functions, as well as routinized services (such as data processing) decentralize. Furthermore, some processes decentralize to the employee's home, resulting in so-called "telecommuting."

The demand for transportation services will be affected by these shifts, as different production activities would require a different type, level, and quality of transportation service. Also, as economic activities become less tied to central cities, traditional transportation networks that serve downtown areas become less adequate.

Rise of the Service Economy

Most of the jobs created since 1970 have been in the service sector (*10,11*). Two reasons for the increase in producer services previously discussed were the need to manipulate corporate stock and the growing complexity of managing multilocational and multinational firms. A third reason is the increasing importance of functions such as marketing, product development, and finance in the new international competitive environment.

Services changed not only in terms of employment levels but also in terms of the nature of the services and the ways they are provided. For example, many routinized functions have been automated such as many routine bank transactions and most data processing. Services also became more specialized by focusing on the needs of specific market segments, much like the industrial sector. These changes in the nature of the service sector had important implications for the labor and locational requirements of various service functions. The exact nature of these implications, however, is highly sensitive to the exact type, or combination, of services provided (*27*).

From a national perspective, other types of services, such as retailing and distributive services (transportation, communication, wholesaling, and utilities) did not grow as fast as the rest of the economy. In certain areas, however, where tourism or retirements have become a major component of the local economic base, such services have grown dramatically. The locational and labor needs of these services are naturally different from those of producer or nonprofit (education, health, and government) services. Specifically, these services require a large unskilled or semiskilled labor force at the place of service provision.

TRANSPORTATION IMPLICATIONS OF ECONOMIC RESTRUCTURING

Because of the spatial differentiation of economic activity by function rather than sector and other structural changes taking place within the U.S. economy, locational considerations have become increasingly important in understanding economic development patterns. Thus, the transportation implications of economic restructuring also have to be analyzed within the context of locational considerations by economic functions rather than by sectors.

In this view, public and private transportation investments, including expenditures on operation and maintenance, interact to produce transportation services, i.e., mobility. The level and quality of service is a function of both the condition and use of the capital stock in place and the flow of new investment and operation and maintenance expenditures. These transportation services become intermediate goods in the private production and consumption processes of firms and individuals.

As is the case with other intermediate goods, different industries will demand different types, levels, and qualities of transportation services (*28*). When adequate services for any particular industry or firm are not available in a timely manner, bottlenecks arise. Bottlenecks are not limited to congestion on urban highways during peak hours; therefore, policy responses to them are not limited to simply building more highways.

From this perspective, transportation systems relate to economic development in two ways. First, they serve as an input in public and private firms' production functions either aiding production directly or complementing private inputs, thereby making them more productive. Similarly, transportation systems provide services that are inputs into private consumption and recreation activities. Second, transportation networks contribute to making a region relatively more attractive, thereby encouraging the location of firms and families.

The major concern for location of production activities, especially in the latter parts of the product cycle, is cost minimization. Cost minimization has two implications for transportation demand. First, the system has to provide good accessibility for the labor force. A congested transportation system may drive some production activities away by increasing labor cost as was demonstrated in the case of the semiconductor industry in Silicon Valley. As housing prices in the northern part of the valley soared, workers in production processes had to commute longer distances, resulting in traffic congestion. Eventually, most production functions left the area to reduce labor costs (*22*), a portion of which can be accounted for by commuting time.

Second, a transportation system has to provide low-cost movement of inputs and outputs. Because of changes in production processes that eliminated most inventories, deliveries are required on a timely basis. That is, all inputs and outputs have to move in and out of a production facility just at the time they are needed or completed. The total cost of transportation for production is thus a function of both the direct pecuniary cost and the timeliness of shipments.

At a time of intermodal freight transportation and overnight deliveries, small differences in transportation services may have important implications for the relative attractiveness of a place for the location of a particular type of production facility. For example, many high-technology industries have small, high-value products that make air freight transportation increasingly important (*29*). As a result, over time, there may need to be a reallocation of resources away from highways, which currently receive about 80 percent of governmental expenditures on transportation, to airports and airways.

Many studies indicate that a major consideration in the location of R&D facilities is the availability of a highly skilled, research-oriented labor force (*17*). The location of R&D facilities would thus be a function of the locational preferences of such a labor force (*21*). Although there is still much to be learned about their locational preferences, several studies indicate that access to other researchers and research centers, as well as quality-of-life considerations, play an important role in the preferences of this group. The transportation system must make a region attractive for such manpower by permitting access to other research institutions, primarily by air (*29*). In addition, the transportation system has to allow a high level of living usually through good access to services in an environmentally sensitive manner. This characteristic accounts for the somewhat peculiar transportation preferences of high-technology industries reported in the literature (*28*).

A headquarter city functions as a locus of control over widespread operations and a center for interaction between firms (both face-to-face and remote). These cities require good air transportation and telecommunication for both control purposes and interactions between top executives (*18*). For headquarter cities, employee access appears to be a minor consideration in central management locational decisions resulting in highly congested cities' retaining their national and world economic position (*30*).

So far, the previous discussion focused on production activities associated with industrial firms; however, much of the current economy is oriented toward the service sectors. Most growing firms in the service sectors, including finance, real estate, business, and professional services, are relatively concentrated in central cities with many of their employees commuting from the suburbs (*11*). The main pull of central cities for such firms seems to be agglomeration economies (*31*). Yet, there is little empirical research regarding locational considerations of various service activities (both sectors and functions within sectors) and until such research is undertaken, the role of transportation in this increasingly important sector cannot be analyzed systematically.

In addition, the previous discussion outlining an approach for analyzing the implications of economic restructuring on the role of transportation in economic development was focused on the local or regional level. Clearly, the accumulation of these implications has ramifications at the national level. For example, the increase in demand for air transportation from production R&D and headquarter functions, noted by Toft and Mahmassani (*29*), may partly explain differences between the problems facing the air transportation system (congestion) and the maritime system (excess supply).

A highly differentiated analysis of the demand for transportation services by various agents and functions in the economy is needed. Such an analysis must consider the role of transportation services in the private production and consumption process. However, because of the large number of existing and potential functions and economic agents in a region, there is a need for a framework identifying which analyses should be undertaken and which of the possible improvements may be most beneficial.

BOTTLENECKS AND FLEXIBILITY

In order to identify situations where transportation services are important from an economic development perspective, a determination is made on when and where transportation services impinge on the location of economic activities. One condition impinging on economic activity occurs when the demand for a certain transportation service outstrips the supply of that service for a specific place or region, type of activity, or time period. This condition is a bottleneck and would be evident by the transportation service having a high shadow price in the location considerations of a specific economic activity.

The concept of bottlenecks is not new. Transportation has long been an enabling, but insufficient, factor for economic development (*4,7*). The historical contribution of transportation to economic development essentially has been the removal of bottlenecks by providing access and alleviating congestion, thus allowing the economy to maximize its comparative advantages. In the past, however, such bottlenecks were seen as static and solely in the context of industrial development or resource utilization. Thus, once accessibility for freight had been assured and improved the bottleneck was seen as alleviated.

Today, in the context of economic restructuring such a view is untenable because bottlenecks are constantly emerging and changing as a function of changes in the economy. Furthermore, different places competing for different types of economic development face different types of bottlenecks. Thus, the notion of bottlenecks changes when they are viewed in the context of different types of transportation services being provided at different levels and qualities to different sectors.

The nature of bottlenecks would be a function of the economic activity in question. For example, in the case of production processes, relatively low levels of road congestion, freight backups, or unreliability of deliveries (in terms of timeliness) may prove to be important bottlenecks. In areas competing for R&D facilities, the lack of appropriate air travel services or the presence of high levels of transportation-related pollution or environmentally insensitive development may prove to be bottlenecks. Similar factors may be bottlenecks also for the development of tourist services.

Identifying bottlenecks would require detailed surveys of the locational considerations of various activities (both industrial and services) such as those conducted by Hummon et al. (*28*) for high-technology industries. However, such surveys would also have to be differentiated by functions within sectors because the major problem in bottlenecks identification may be which activities (sectors and functions) to survey. Addressing this problem may require a preliminary analysis identifying the potential sectors and functions that may locate in the area. Such an analysis would have to take into account the larger regional, national, and global restructuring processes. The relationships leading to the identification of bottlenecks are shown in Figure 1.

The realization that the economy is constantly changing, in what seems to be an accelerating pace, leads to a second concept that should be an integral part of any framework for analyzing the role of transportation services in the emerging highly dynamic economy. That concept of flexibility has two facets.

First, because demand for transportation services changes continually, but in manners sometimes difficult to predict, transportation services have to adapt. Thus, the first facet of flexibility is the ability of an element in a transportation system to adapt to changing types and levels of demand. The lower the cost of changing the attributes of service provided (in terms of volume, schedule, commodities, and needed inputs) the more flexible is that element in the system. In an evaluation of various policy options, the ability of investments to adapt to changing economic conditions should be included.

One element affecting the fluctuations in demand for a service is the diversity of its users and operators. If the type and number of users or operators are highly concentrated, changes in demand patterns of users or operation decisions by operators may have major effects on demand for the trans-

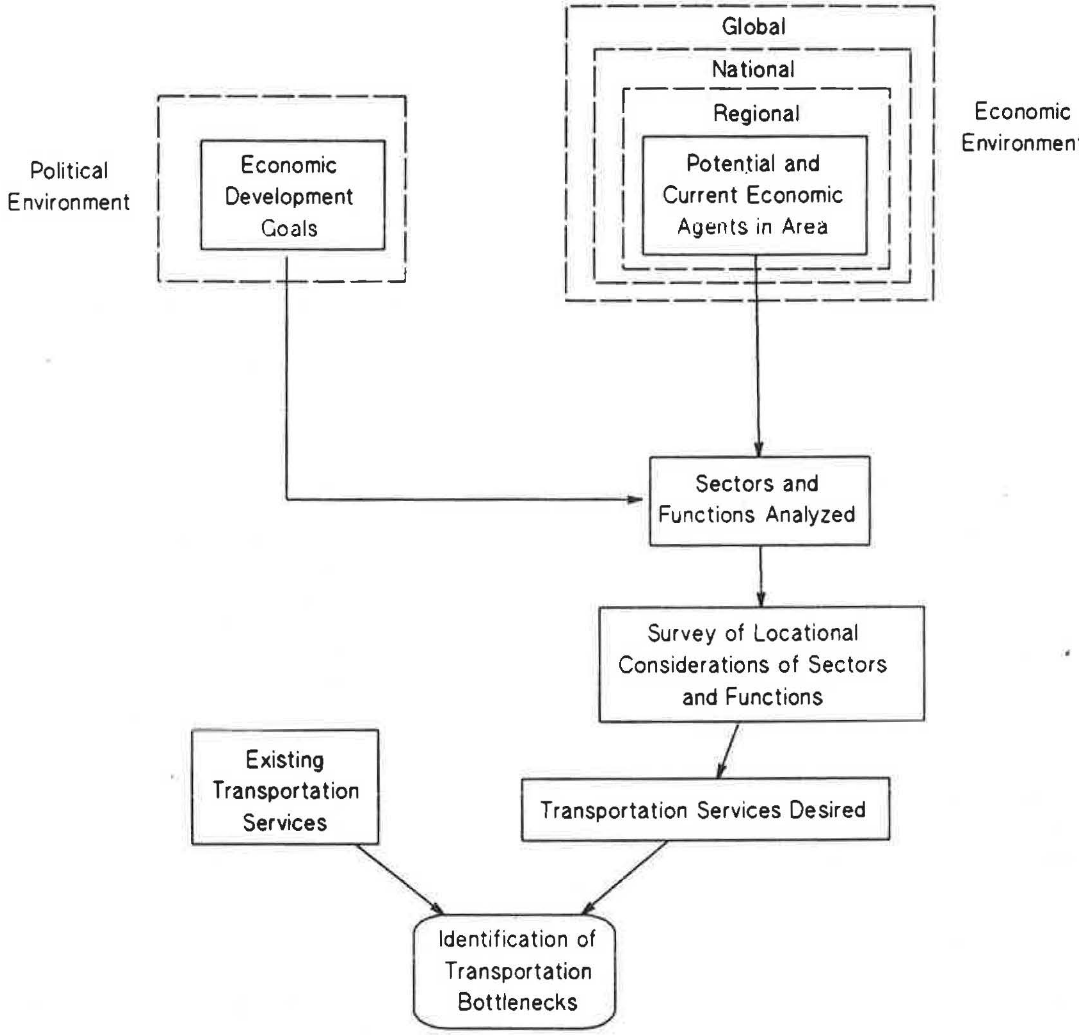

FIGURE 1 Identification of bottlenecks.

portation service. Thus, the lower the concentration ratio of users and operators of a transportation service the greater its flexibility.

Second, different economic actors have different levels of freedom in their locational decisions. Therefore, the second facet of flexibility is the ability of an economic activity to relocate (its locational elasticity of substitution). The lower the relocation cost for an economic activity, or the smaller the cost differential between alternative sites, the more flexible the activity is. This type of flexibility may have two different implications for transportation policy formulation. If an economic activity is inflexible it may sustain high transportation shadow prices before deciding to relocate. Even if the transportation services for the activity are not optimal, it may be reluctant to relocate, because of high relocation costs. In such cases, the use of public funds for transportation investments to retain the economic activity may be unwarranted because the activity would remain in the area without the investment, or may be willing to participate in financing the transportation services it wants.

On the other hand, when an economic activity is footloose, it has alternative sites at similar cost with low relocation costs, and therefore long-term, single-purpose transportation investments for retaining or attracting such a footloose activity may be risky. By the time the investment is operational, the desired activity may have located elsewhere. However, short-term, multipurpose, publicly financed transportation services may prove important for attracting or retaining such firms.

This facet of the flexibility concept reemphasizes the importance of careful analysis of the various sectors and functions that are considered desirable for economic development before committing public resources for transportation services intended to attract them.

CONCLUSION

Most studies of linkages between transportation and economic development focus on the effects of transportation facilities on employment, or on some indicators of economic productivity. A first step toward an alternative approach would focus on transportation services as intermediary goods in production and consumption processes. Because of economic restructuring in the U.S. and global economies, production and consumption processes are constantly changing over space and time. Thus, the role of various transportation services in the economy and their effect on economic development are constantly in flux.

An analysis of the linkages between transportation services and economic development under such circumstances would begin by identifying the role and potential of various sectors and functions in the economy (local, regional, or national). Next, the importance of transportation services for the most important sectors and functions in the economy would need to be identified. This method would require a highly disaggregate analysis of the role of transportation services in the location of relevant industries and services, differentiated by function rather than by sector.

Such an analysis can help identify situations where the lack of specific transportation services becomes a bottleneck to economic development. However, this analysis is a necessary first step toward a cost-effective policy for economic development but is not sufficient for formulating or evaluating transportation policy contributions to economic development.

To make this additional step, analyzing the attributes of both transportation services and prospective users is necessary. Specifically, the concentration ratio of users and operators needs to be considered, as well as their footlooseness. These flexibility considerations are important to reduce the risk of long-term public investments being made on the basis of an ephemeral conjunction of circumstances in the rapidly changing economic scene. The importance of such considerations is increasing because of the lower predictability of future economic forecasts for most specific sectors or agents caused by economic restructuring.

Much work must be done before these ideas can be coalesced into a coherent operational framework. It is hoped that they may stimulate enough interest to begin the work needed to formulate and apply such a framework.

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SECTION 2

Modeling Impacts of Transportation Investments

System Dynamics Modeling of Development Induced by Transportation Investment

DONALD R. DREW

A modeling paradigm for analyzing transportation-development interactions is described. The new approach is based on isolating underlying causes of development deficiencies in a systematic way, identifying policies and infrastructure investments to deal with the causes, and then assessing the impacts of alternatives against specified goals. The system dynamics methodology uses three alternative forms of the model: verbal (narrative description), visual (causal diagram), and mathematical (set of equations derived from the causal diagram). The methodology is illustrated using three examples: (a) modeling urban systems, (b) modeling regional and national economics, and (c) evaluating user and nonuser benefits.

Reducing the true cost of transport increases the total amount of goods and services available, ultimately increasing the total real income of any society. Tools for estimating the effects of different transportation improvements within these contexts are only now being developed. These tools tend to fall into two classes: (a) models of national and regional economies with a component being the transportation system; and (b) traditional models of various aspects of the development process such as land use models, population models, location models, economic base models and input-output models that are linked either explicitly or implicitly to transportation.

NEED FOR MODELING PARADIGM

Although there are well-established professional activities associated with transportation problems (transportation planning, transportation operations, and transportation economics) and well-established professional activities associated with development problems (development planning, development economics, and development administration), the two classes of activities are usually linked subjectively. Moreover, the actual decision-making processes in each proceeds with nearly total isolation from ongoing planning activities. A new approach is needed for isolating underlying causes of development deficiencies in a systematic way, identifying policies and infrastructure investments to deal with the causes, and then assessing the impacts of alternatives against specified goals.

The whole process starts with a basic restatement of values and goals. Values are those irreducible qualities on which individual and group preferences are based. The groups are defined as the users of transportation, the providers of transportation, and the society. Goals are desirable end-states toward which planning might be expected to lead. A problem exists when a goal is not being achieved. There may be two possible reasons for this failure: (a) the goal is unachievable and (b) the problem results from conflicting goals. There is not much that can be done in the first case except to lower aspirations. In the second case, the problem may be described as an issue—a matter that is in dispute between two or more of the three groups involved (*1*).

In all, there are three ways in which causality from a policy-controlled variable acts on a goal or uncontrolled variable: (a) the sign of the interaction (positive or negative), (b) the strength of the interaction (strong or weak), and (c) the time lag of the influence. Moreover, because policy variables may act indirectly on several different goals through causal sequences of intermediate variables, cross-impact analysis is best accomplished using a digital computer. The ultimate result is one of creating scenarios—determining future impacts of contemplated policies by setting logical sequences of events in step-by-step relationships (*2*).

A systems perspective of transportation development analysis requires consideration of software (policies) as well as hardware (technologies), time as well as space, and strategic as well as tactical methods. The principal requirement for viable strategic approaches to solving transportation-development problems is that the approaches be system-wide, causally based, and policy-oriented, and permit the specification of alternative transportation-development concepts in sufficient detail to allow their implications and impacts to be examined.

SYSTEM DYNAMICS APPROACH

Transportation systems—particularly highways, ports, and airports—are essential to the efficient functioning of national economies throughout the world, but experts say that these systems will be increasingly burdened by ever-growing demand, limited supply, and increased congestion. Although transportation systems are particularly vital to national and regional economic productivity, no organized or well-developed body of knowledge exists regarding the effects of transportation infrastructure on development. Indeed, engineers and planners dealing with transportation problems rarely work closely with their counterparts in economic development.

The transportation-development relationship is essentially a two-way interactive process with results of the interaction

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depending on the type of economy involved and on the level of development at which transport improvements are effected. At a given level of development an area requires a certain level of transportation to maximize its potential. Thus, an optimum transportation capacity corresponds to any development level. Existence of unsatisfied demand for transportation may, over time, have serious adverse effects on the economy; conversely, the results of overcapitalization may be unpleasant if too much money is spent on transportation in anticipation of demand that never materializes (*3,4*).

A model of this process can be complex and can consist of hundreds of variables. Because of the necessary feedbacks, determining the optimal transport system consistent with a specific spatial structure of an area is, to say the least, elusive (*5*).

Research is needed to develop a methodology for constructing regional transportation-development models. Such a methodology would start with verbal descriptions of perceptions of the process. From these verbal descriptions, key variables and their interactions would be identified and displayed graphically in the form of causal diagrams. Using the causal diagrams, mathematical models would be developed. Verbal description is important in explaining the reasoning leading to a proposed policy and the consequences of that policy. Graphical display provides a gestalt for synthesizing the contributions of experts and specialists. Mathematical models provide an instrumentality that can be subject to manipulation and sensitivity analysis. By examining the sensitivities of hypothesized relationships, priorities for data collection for model calibration can be established (*6*).

Although experts may understand portions of the transportation-economic development process, to synthesize these portions in a consistent manner without a formal technique is impossible. The transportation-development process is composed of large numbers of variables spanning many disciplines. These variables are causally related and close on themselves to form higher-order feedback loops. Inputs are stochastic, relationships are nonlinear, and delays and noise are present in the information channels. All of these characteristics preclude predicting systems behavior by partitioning the problem along disciplinary lines and then assembling the component solutions (*7*).

THE MODELING PROCESS

Policy makers, to guide national development effectively, must bring together a variety of mental models, translate them into a common language, and then determine simultaneously all their important implications. Therefore, formal models with assumptions stated explicitly are required. Formal models are best expressed in mathematical equations for three reasons: (a) mathematics is precise and interdisciplinary, (b) equations can be manipulated in response to changing inputs, and (c) the mathematical notation permits processing by computer.

For system dynamics methodology, three alternative forms of the model of a system are used: verbal, visual, and mathematical (*8*). The verbal description is a mental model of the system expressed in words. Visual descriptions are diagrammatic and show cause-and-effect relationships between many variables in a simple, concise manner. The visual model, or causal diagram, is then translated into a mathematical model of system equations. All forms are equivalent, with any one form merely serving as an aid to understanding for someone who does not comprehend the other forms. However, the verbal description does not lend itself to formal analysis and the visual causal diagram can only be analyzed qualitatively. Mathematical models are by far the most precise and are the only representations of the system that permit quantitative analysis and the evaluation of alternative solutions to a problem.

Modeling procedure is sequential and iterative and starts with the verbal description of the major elements necessary to represent relevant aspects of the system. Next is the postulation of the model's structure and conceptualization of causal relationships between model parameters in the form of a causal diagram. From the causal diagram, system equations may be written. In order to complete the mathematical model, the model's parameters must be estimated. This step includes placing numerical values on constants and the quantification of causal assumptions. The accuracy of the model can be evaluated through simulation. At each step, the model is exposed to criticism, revision, reexposure, etc., in an iterative process that continues as long as it proves useful (*9*).

The proposed methodology uses all of the relevant parameter classes in system dynamics—level variables, rate variables, auxiliary variables, supplementary variables, and constants. However, the methodology is different because the geometric shapes—rectangles, valves, circles, etc.—used in system dynamic diagrams are unnecessary. For example, a level variable is always at the head and a rate variable is always at the tail of a solid arrow. Signs on the solid arrow indicate if the rate is added to or subtracted from the level of the state variable. Whereas solid arrows denote physical flows, dashed arrows in the causal diagram define information flows from level variables to rates, or action, variables. Any intermediate variable on the path from a level variable, or from an exogenous input, to a rate variable is called an auxiliary variable. Signs on dashed arrows have the following interpretation: a plus sign (+) means that an increase in the parameter at the tail of the arrow will cause an increase in the variable at the head of the arrow; a minus sign (−) means that an increase in the parameter at the tail of the arrow will cause a decrease in the parameter at the head of the arrow. Exogenous inputs are easily identified on a causal diagram because they have no arrows leading to them, but have one or more dashed arrows emanating from them. Supplementary variables, in contrast, do not form part of the system itself but merely indicate its performance and, therefore, are always identified by being at the head of a dashed arrow and having no arrows emanating from them. In summarizing the causal diagramming convention: (a) arrows describe the direction of causality between pairs of variables, (b) lines (solid or dashed) denote (physical or information) flows, and (c) signs indicate the nature (direct or inverse) of the relationship between dependent-independent variable pairs.

The methodology uses the DYNAMO computer language associated with system dynamics. In difference equation terminology, any level variable L_i is expressed as a function of rate variables R_j and the previous value of the level.

$$L_i(t + dt) = L_i(t) + (dt) \sum_{j=1}^{n} R_j(t) \qquad i = 1, \ldots, m \qquad (1)$$

with R_j values assumed constant over the time interval from t to $t + dt$. The rate variables are in the form

$$R_j(t) = F[L_i(t), E_k(t), A_{ij}(t), A_{kj}(t)] \qquad (2)$$

where E_k are the set of exogenous inputs that affect variables R_j directly, and A_{ij} and A_{kj} are the impacts of auxiliary variables in the causal streams from the ith variable and kth exogenous input, respectively. Because exogenous inputs are known time functions or constants, if initial values of the level variables are known, all other variables can be computed from them for that time. Then, new values of the level variables for the next point in time can be found from Equation 1. DYNAMO uses a postscript notation for subscripts in which $.K$ stands for the present time t, $.J$ stands for past time $t - dt$, and $.L$ stands for future time $t + dt$. As in all computer programming, upper-case letters are used. DT (dt) is called the solution interval, the time between successive computations in the simulation. Because rate variables are assumed to be constant over DT, the double postscript is used, $.JK$ for rates on the right side of an equation and $.KL$ for rates on the left side.

MODELING URBAN SYSTEMS

Impacts of transportation on national development are usually focused on urban areas. Transportation is the bloodstream of the urban community because spatial interdependence is the rationale of the urban area. A given transportation system both influences the location of activities within the city and is itself influenced by the location of these activities, because each location pattern constitutes a set of trip demands that is responded to by investment and operating decisions within the transportation system. Unfortunately, despite this strategic importance, the system may diverge from efficient resource use on a number of grounds—economies of scale, mixed public and private sector decision making, and lack of coordinated decision making for the affected metropolitan area and across different transportation modes. Before modeling the impact of transportation on regional or urban development, a model needs to be developed for the region or the urban area, whichever applies.

Urban systems can be arbitrarily divided into two categories: (a) those that are related to the urban socioeconomic structure such as social, industrial, and residential systems; and (b) those that serve the urban community (the urban technological systems) such as water supply, energy, transportation, and the environment. Basic knowledge of how the urban systems are formed and interact with each other provides a basis for a better learning process and, thus, a better decision-making process. Because of interrelationships between urban systems, a sound solution to an urban problem can hardly be attained without knowing the possible effects on other systems. Lack of understanding of this causality in forecasting usually leads to treatment of symptoms rather than causes.

In a system as complex as a city, intuition has proven most unreliable in forecasting the probable consequences of well-meaning policies, simply because the human mind is incapable of dealing with a system containing so many variables. No wonder that urban policies, laws, and decisions have produced results different from those intended, ranging from partial success to tragic failure. Predicting with confidence the long-term consequences of costly programs has been impossible. One of the main causes leading to the failure of many urban development programs is the inability to experiment with the designed policies. Usually, a policy is implemented on the basis of some informally estimated consequences and a few decades later the policy turns out wrong. Therefore, in a decision-making process, facts must be included, but facts about future events cannot be obtained.

With present technology, one means of studying future events is through computer simulation, which is not only economical, but also is a powerful conceptual device that can increase the role of reason at the expense of rhetoric in determining effective policies. Unlike intuition and common sense of informal mental models, computer simulation is comprehensive, unambiguous, flexible, and subject to logical manipulation and testing. Flexibility of a system dynamics model is its least appreciated virtue. If there is disagreement about some aspect of causal structure or the strength of effects between variables of a problem, in a short time the model can be rerun and observations made of its behavior under each set of assumptions. Often, the argument is trifling because the phenomenon of interest may be unchanged by the factor in disagreement.

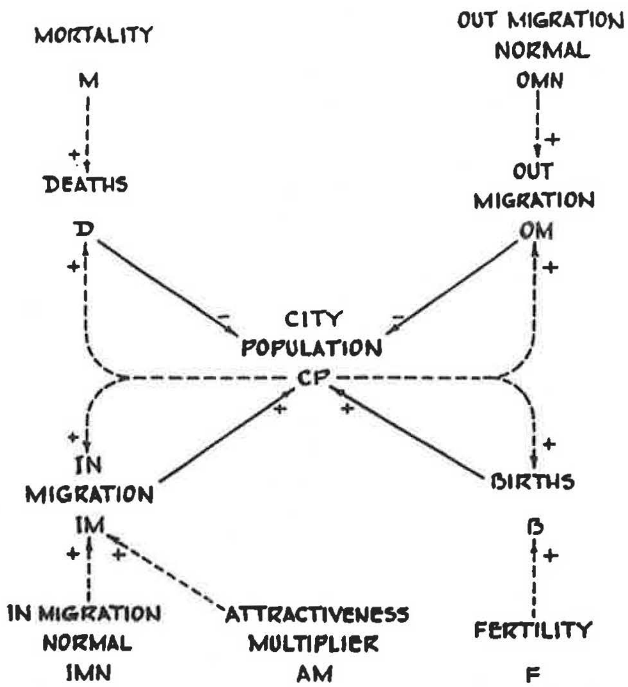
To illustrate the system dynamics approach to modeling transportation-development interactions, three examples will be presented. The first, METRO, is a model of a metropolitan area consisting of a central city and its suburbs. The model comprises seven sectors (city population, industry, housing, employment, land, suburban carrying capacities, and transportation) that will be described in the traditional system dynamics format: verbally, by causal diagrams, and by DYNAMO equations.

First, the population sector of the central city is displayed in causal diagram form and in equation form (Figure 1). The level variable CP, for city population, is controlled by two types of rates: natural increase (births and deaths) and migration in and out. Each of these four rates depends on the population and constant fractional rates of increase. However, in-migration is also assumed to be influenced by an attractiveness multiplier.

Next, Figure 2 shows the industry sector. Although many ways of measuring economic activity are available, industry is chosen as the level variable for this sector. Industries create more industries through industry construction. Amounts of additional economic activity are proportional to the present rate of economic activity. So, at every point in time, industry construction equals the number of industrial structures multiplied by industry construction normal with the word "normal" denoting the conditions under which construction occurs. Conditions within the urban area such as labor availability and land availability that encourage or discourage construction (above or below the normal fraction, respectively) are handled by an industry construction multiplier.

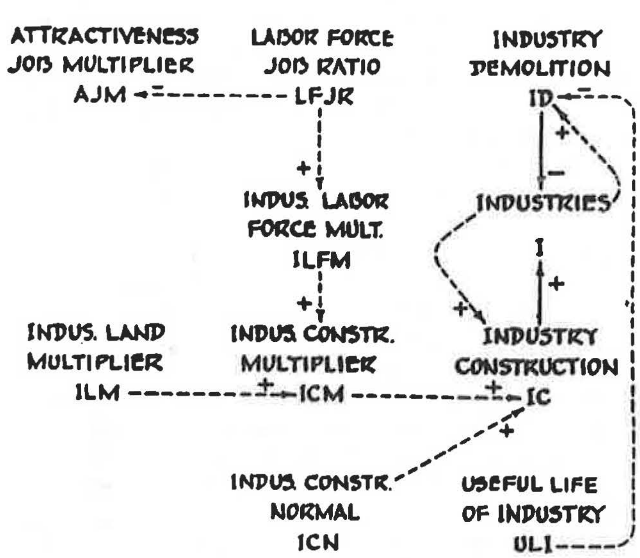
The housing sector, which is shown graphically and mathematically in Figure 3, is handled in a manner similar to the industry sector, except that the basic structural unit is the dwelling instead of the industry.

The employment sector relates the demographic (population) and economic (industry) sectors. Population determines the size of the labor force, that is, the demand for jobs. Industry creates jobs—the supply side of the interaction (see Figure 4).




```
L CP.K=CP.J+(DT)(B.JK+IM.JK-D.JK-OM.JK)        1
N CP=CPN                                      1.1
NOTE CP-CITY POPULATION (PERSONS)
C CPN=290000                                  1.2
NOTE CPN-CITY POP INITIALLY (PERSONS)
R B.KL=CP.K*F                                 2
NOTE B-BIRTHS (PERSONS/YR)
C F=0.03                                      2.1
NOTE F-FERTILITY (FRACT/YR)
R D.KL=CP.K*M                                 3
NOTE D-DEATHS (PERSONS/YR)
C M=0.015                                     3.1
NOTE M-MORTALITY (FRACT/YR)
R OM.KL=CP.K*OMN                              4
NOTE OM-OUT MIGRATION (PERSONS/YR)
C OMN=0.07                                    4.1
NOTE OMN-OUT MIGRATION NORMAL (FRACT/YR)
R IM.KL=CP.K*IMN*AM.K                         5
NOTE IM-IN MIGRATION (PERSONS/YR)
C IMN=0.1                                     5.1
NOTE IMN-IN MIGRATION NORMAL (FRACT/YR)
A AM.K=AJM.K*AHM.K                            6
NOTE AM-ATTRACTIVENESS MULTIPLIER (DIM)
```

FIGURE 1 Population sector: *left*, causal diagram; *right*, mathematical form (METRO model).



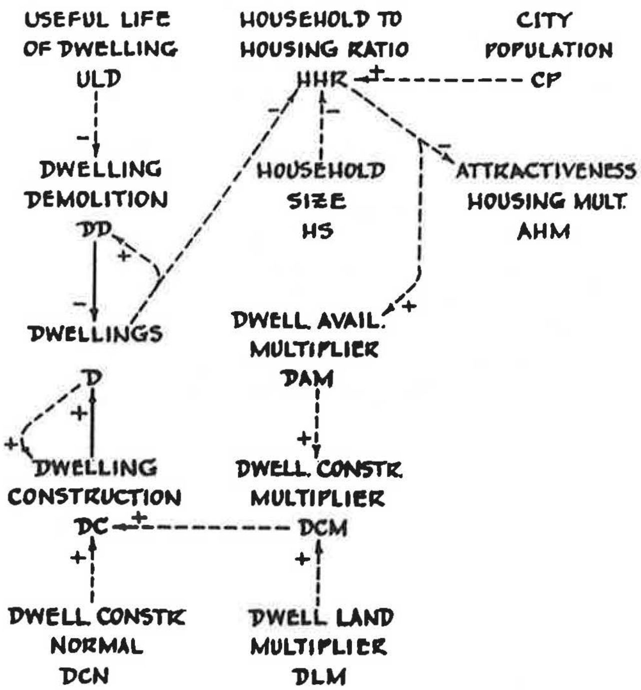

```
L I.K=I.J+(DT)(IC.JK-ID.JK)                    7
N I=IN                                        7.1
NOTE I-INDUSTRIES (STRUCTURES)
C IN=4000                                     7.2
NOTE IN-INDUSTRIES INITIALLY (STRUCTURES)
R IC.KL=I.K*ICN*ICM.K                         8
NOTE IC-INDUSTRY CONSTRUCTION (STRUCT/YR)
C ICN=0.10                                    8.1
NOTE ICN-INDUS CONSTR NORMAL (FRACT/YR)
A ICM.K=ILM.K*ILFM.K                          9
NOTE ICM-INDUS CONSTR MULTIPLIER (DIM)
R ID.KL=I.K/ULI                               10
NOTE ID-INDUSTRY DEMOLITION (STRUCT/YR)
C ULI=40                                      10.1
NOTE ULI-USEFUL LIFE INDUSTRY (YR)
A AJM.K=TABLE(AJMT,LFJR.K,0,2,0.2)            11
T AJMT=2/1.95/1.8/1.6/1.35/1/.5/.3/.2/.15/.1  11.1
NOTE AJM-ATTRACTIVENESS JOBS MULT (DIM)
```

FIGURE 2 Industry sector: *left*, causal diagram; *right*, mathematical form.

Figure 5 shows the land sector and the ways that industry and housing compete for land. Availability of land influences the expansion of industry and housing through the industry land multiplier (ILM) and dwelling land multiplier (DLM), respectively.

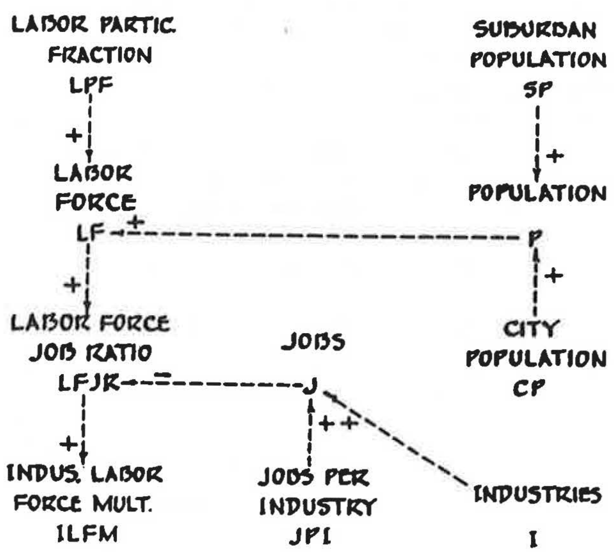
These five sectors will be considered as a system with interactions within and between the sectors. Job availability modulates migration into and out of the area through an attractiveness multiplier. Availability of housing also influences housing construction because builders and developers cannot make a profit by building and marketing houses for which there is no demand. Population and industry structures are coupled through the ratio of labor force to jobs, population and housing through the ratio of households to housing, and industry structures and housing through values of the land fraction occupied.

A city is not self-sufficient. The hypothetical city must reach out into the hinterland for water, food, clean air, energy, and raw materials. Physical systems that help an urban population eat, drink, breathe, sleep, work, and move about are engineering systems. These systems are lifelines; without them, modern cities could not exist. Transportation is a life support system that can be superimposed on previously modeled socioeconomic systems.




```
L  D.K=D.J+(DT)(DC.JK-DD.JK)                          12
N  D=DN                                               12.1
NOTE  D-DWELLINGS (STRUCTURES)
C  DN=56000                                           12.2
NOTE  DN-DWELLINGS INITIALLY (STRUCTURES)
R  DC.KL=D.K*DCN*DCM.K                                13
NOTE  DC-DWELLING CONSTRUCTION (STRUCT/YR)
C  DCN=0.07                                           13.1
NOTE  DCN-DWELL CONSTR NORMAL (FRACT/YR)
A  DCM.K=DLM.K*DAM.K                                  14
NOTE  DCM-DWELL CONSTR MULT (DIM)
R  DD.KL=D.K/ULD                                      15
NOTE  DD-DWELLING DEMOLITION (STRUCT/YR)
C  ULD=66.67                                          15.1
NOTE  ULD-USEFUL LIFE DWELLING (YR)
A  DAM.K=TABLE(DAMT,HHR.K,0,2,0.2)                    16
T  DAMT=.2/.25/.35/.5/.7/1/1.35/1.6/1.8/1.95/2        16.1
NOTE  DAM-DWELLING AVAILABILITY MULT (DIM)
A  HHR.K=CP.K/(D.K*HS)                                17
NOTE  HHR-HOUSEHOLD TO HOUSING RATIO (DIM)
C  HS=4                                               17.1
NOTE  HS-HOUSEHOLD SIZE (PERSONS/STRUCT)
A  AHM.K=TABLE(AHMT,HHR.K,0,2,0.2)                    18
T  AHMT=1.4/1.4/1.35/1.3/1.15/1/.8/.65/.5/.45/.4      18.1
NOTE  AHM-ATTRACTIVENESS HOUSING MULT (DIM)
```

FIGURE 3 Housing sector: *left*, causal diagram; *right*, mathematical form.

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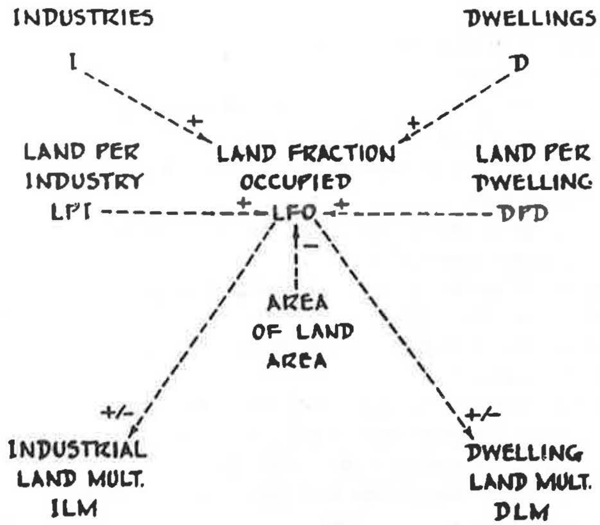
A  ILFM.K=TABLE(ILFMT,LFJR.K,0,2,0.2)                 19
T  ILFMT=.2/.25/.35/.5/.7/1/1.35/1.6/1.8/1.95/2       19.1
NOTE  ILFM-INDUS LABOR FORCE MULT (DIM)
A  LFJR.K=LF.K/J.K                                    20
NOTE  LFJR-LABOR FORCE JOB RATIO (DIM)
A  LF.K=P.K*LPF                                       21
NOTE  LF-LABOR FORCE (PERSONS)
C  LPF=0.50                                           21.1
NOTE  LPF-LABOR PARTICIPATION FRACT (DIM)
A  P.K=CP.K+SP.K                                      22
NOTE  P-POPULATION (PERSONS)
A  J.K=I.K*JPI                                        23
NOTE  J-JOBS (PERSONS)
C  JPI=38                                             23.1
NOTE  JPI-JOBS PER INDUS (PERSONS/INDUS)
S  UR.K=(LF.K-J.K)/LF.K                               24
NOTE  UR-UNEMPLOYMENT RATE (DIM)
```

FIGURE 4 Employment sector: *left*, causal diagram; *right*, mathematical form.

If the availability of employment and housing is the principal determinant of in-migration to the hypothetical urban area, accessibility of suburban residences to central city work places (achieved through suburban expressways) accounts for the movement of people from the central city to the suburbs. The causal diagram and mathematical model for the suburban sector are shown in Figure 6 and for the transportation sector in Figure 7.

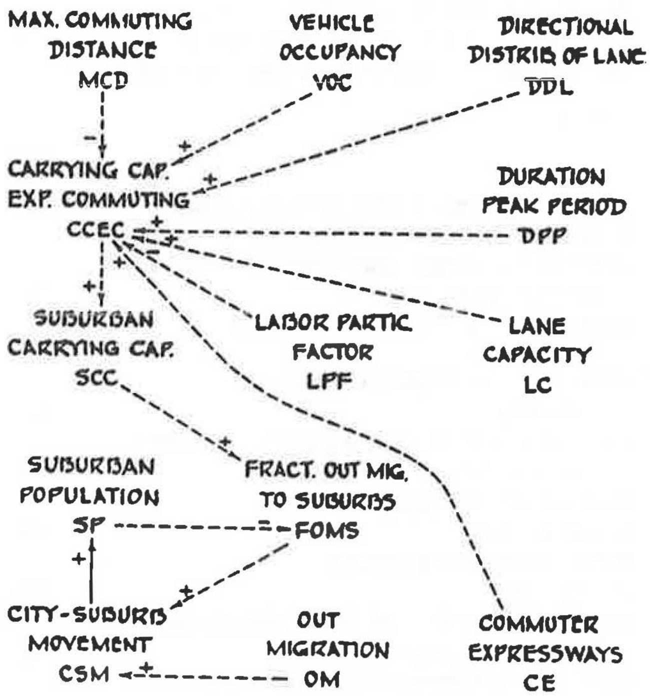
The causal diagram for the entire METRO model is shown in Figure 8. Streams of causality can be followed from variable to variable through the sectors. The suburban population SP depends on the lane-miles of commuter expressways CE. Figure 8 also gives the control statements for the model outputs, which are presented in Figures 9–12.

Figures 9 and 10 show the standard or base run outputs of the model. Figures 11 and 12 are outputs of alternative scenarios based on parameter changes made to represent various development strategies. In these four figures, the abscissas are time corresponding to 100 years in the lifetime of the hypothetical metropolis. In Figure 10, the ordinate *E* expressed




```
A LFO.K=(LPI*I.K+LPD*D.K)/AREA                          25
NOTE LFO-LAND FRACT OCCUPIED (DIM)
C LPI=1.0                                              25.1
NOTE LPI-LAND PER INDUSTRY (ACRES/STRUCT)
C LPD=0.5                                              25.2
NOTE LPD-LAND PER DWELLING (ACRES/STRUCT)
C AREA=200000                                          25.3
NOTE AREA-AREA OF LAND (ACRES)
A ILM.K=TABLE(ILMT,LFO.K,0,1,0.1)                        26
T ILMT=1/1.15/1.3/1.4/1.45/1.4/1.3/0.9/0.5/.25/0       26.1
NOTE ILM-INDUSTRIAL LAND MULT (DIM)
A DLM.K=TABLE(DLMT,LFO.K,0,1,0.1)                        27
T DLMT=.4/.7/1/1.25/1.45/1.5/1.5/1.4/1/.5/0            27.1
NOTE DLM-DWELLING LAND MULTIPLIER(DIM)
```

FIGURE 5 Land sector: ***left*****, causal diagram;** ***right*****, mathematical form.**

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L SP.K=SP.J+(DTXCSM.JK)                                 28
N SP=SPN                                               28.1
NOTE SP-SUBURBAN POPULATION (PERSONS)
C SPN=14000                                            28.2
NOTE SPN-SUBURBAN POP INITIALLY (PERSONS)
R CSM.KL=OM.JK*FOMS.K                                   29
NOTE CSM-CITY SUBURB MOVEMENT (PERSONS/YR)
A FOMS.K=TABLE(FOMST,(SCC.K-SP.K)/SCC.K,0,1,.2)         30
T FOMST=0/.8/.9/.9/.8/0                                30.1
NOTE FOMS-FRACT OUT MIG TO SUBURBS (DIM)
A SCC.K=CCEC.K                                          31
NOTE SCC-SUBURBAN CARRYING CAP (PERSONS)
A CCEC.K=(CE.K*DDL*LC*DPP*VOC)/(MCD*LPF)                32
NOTE CCEC-CARRYING CAP EXP COMMUTING (PERSONS)
C LC=2000                                              32.1
NOTE LC-LANE CAPACITY (VEH/HR-LANE)
C VOC=1.35                                             32.2
NOTE VOC-VEHICLE OCCUPANCY (PERSONS/VEH)
C MCD=30                                               32.3
NOTE MCD-MAX COMMUTING DISTANCE (MI)
C DDL=0.5                                              32.4
NOTE DDL-DIRECTIONAL DISTRIBUTION OF LANES (DIM)
C DPP=3                                                32.5
NOTE DPP-DURATION PEAK PERIOD (HR)
```

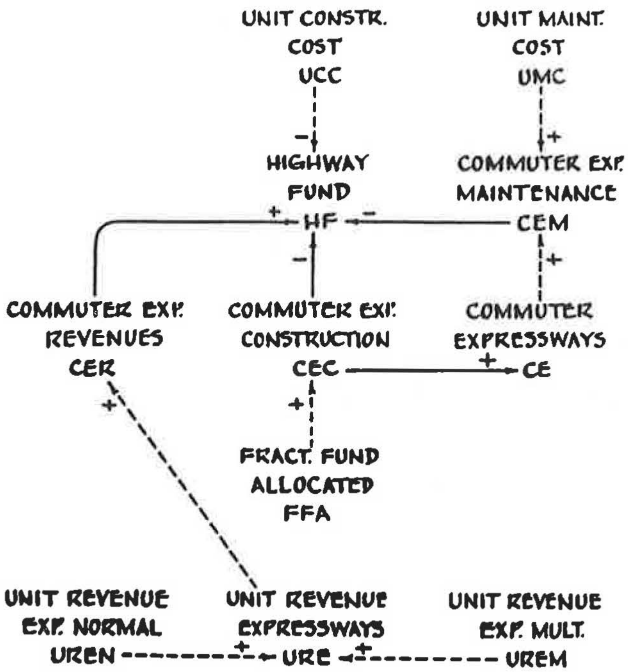
FIGURE 6 Suburban sector: ***left*****, causal diagram;** ***right*****, mathematical form.**

in lane-miles stands for commuter expressways, and ranges from 0 to 1,000. In the other figures, there are two ordinate scales: one for city population (C) and suburban population (S) and the other for the unemployment rate (U). The scales for C and S run from 0 to 2,000 T (2 million) persons and the scale for U from -0.05 to $+0.25$. Unemployment rate is defined in Equation 24 in Figure 4.

By examining the computer outputs, the various strategies for reducing unemployment can be compared and the effects on population distribution between city and suburbs can be observed. Table 1 presents the effects of the strategies at 30 years and Table 2 at 100 years. The pattern of behavior is similar in the five cases. The first 30 years are marked by rapid growth whereas the next 30 years are marked by a transition phase followed by an equilibrium phase. This pattern of growth is typical of the dynamics of the American metropolitan area over the past century.

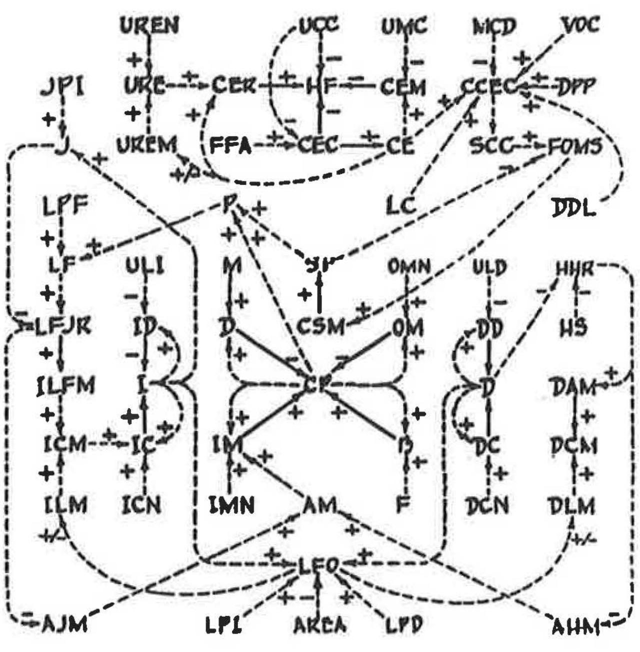
The four policies tested and reported in Figures 11 and 12 can be described as follows:

1. Industrial Development Policy—aims at reducing the shortage of jobs as unemployment increases by attracting new




```
L  CE.K=CE.J+(DT)(CEC.JK)                                33
N  CE=CEN                                                33.1
NOTE  CE-COMMUTER EXPRESSWAYS (LANE MI)
C  CEN=100                                               33.2
NOTE  CEN-COM EXPRESSWAYS INITIALLY (LANE MI)
R  CEC.KL=(HF.K/UCC)*FFA                                 34
NOTE  CEC-COM EXP CONSTRUCTION (LANE MI/YR)
C  UCC=2000000                                           34.1
NOTE  UCC-UNIT CONSTRUCTION COST ($/LANE MI)
C  FFA=1.0                                               34.2
NOTE  FFA-FRACT FUND ALLOCATED (FRACT/YR)
L  HF.K=HF.J+(DT)(CER.JK-CEM.JK-CEC.JK*UCC/FFA)          35
C  HF=0                                                  35.1
NOTE  HF-HIGHWAY FUND ($)
R  CEM.KL=CE.K*UMC                                       36
NOTE  CEM-COM EXP MAINTENANCE ($/YR)
C  UMC=200000                                            36.1
NOTE  UMC-UNIT MAINTENANCE COST ($/YR-LANE MI)
R  CER.KL=CE.K*URE.K                                     37
NOTE  CER-COM EXP REVENUES ($/YR)
A  URE.K=UREN*UREM.K                                     38
NOTE  URE-UNIT REV EXPRESSWAYS ($/YR-LANE MI)
C  UREN=400000                                           38.1
NOTE  UREN-UNIT REV EXP NORMAL ($/YR-LANE MI)
A  UREM.K=TABLE(UREMT,CE.K,0,1000,100)                   39
T  UREMT=0/1/1.2/1.3/1.2/1/.8/.6/.5/.4/.3/.2             39.1
NOTE  UREM-UNIT REV EXP MULTIPLIER (DIM)
```

FIGURE 7 Transportation sector: *left*, causal diagram; *right*, mathematical form.




```
PLOT  CP=C,SP=S(0,2000000)/UR=U(-.05,.20)        FIG. 9
NOTE  C-CITY POPULATION
NOTE  S-SUBURBAN POPULATION
NOTE  U-UNEMPLOYMENT RATE
PLOT  CE=E(0,1000)                               FIG. 10
NOTE  E-COMMUTER EXPRESSWAYS
C  DT=0.5
NOTE  DT-SOLUTION INTERVAL (YR)
C  LENGTH=50
NOTE  LENGTH-LENGTH OF SIMULATION (YR)
C  PLTPER=1
NOTE  PLTPER-PLOT PERIOD
C  ICN=0.15
NOTE  INCREASE IN ICN FROM 0.10 TO 0.15
RUN  INDUSTRIAL DEVELOPMENT SCENARIO             FIG. 11
C  DCN=0.10
NOTE  INCREASE IN DCN FROM 0.07 TO 0.10
RUN  HOUSING DEVELOPMENT SCENARIO                FIG. 11
C  ICN=0.15
C  ULD=33.3
NOTE  CHANGES IN ICN AND ULD
RUN  MIXED DEVELOPMENT SCENARIO                  FIG. 12
C  FFA=0.5
NOTE  CHANGE IN FFA FROM 1.0 TO 0.5
RUN  GENERAL FUND SCENARIO                       FIG. 12
QUIT
```

FIGURE 8 METRO model: *left*, causal diagram; *right*, control statements.

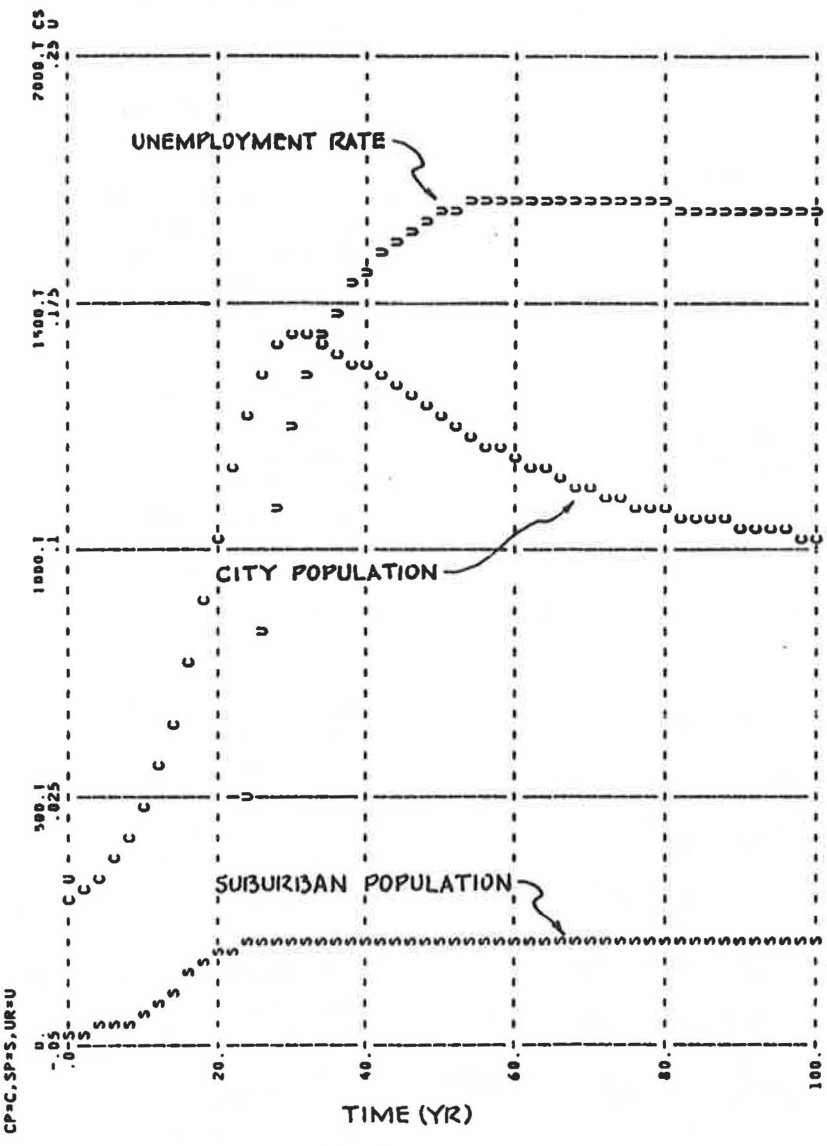


FIGURE 9 Base Scenario 1.

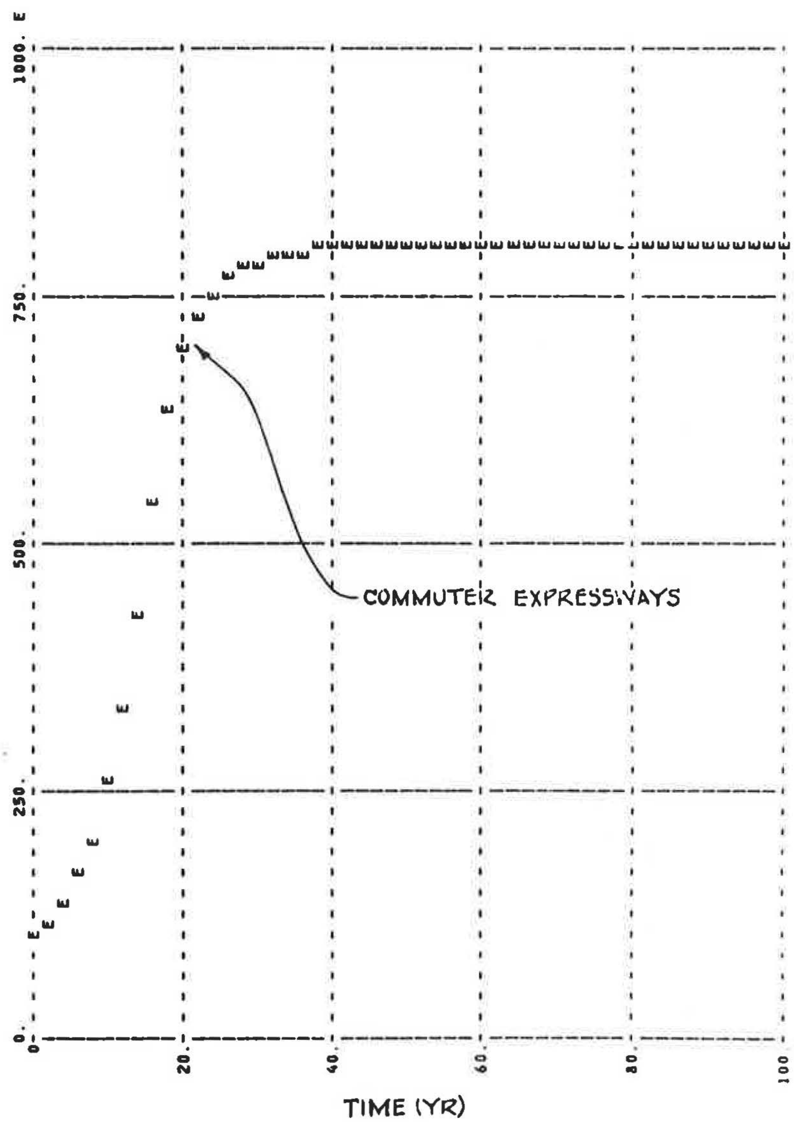


FIGURE 10 Base Scenario 2.

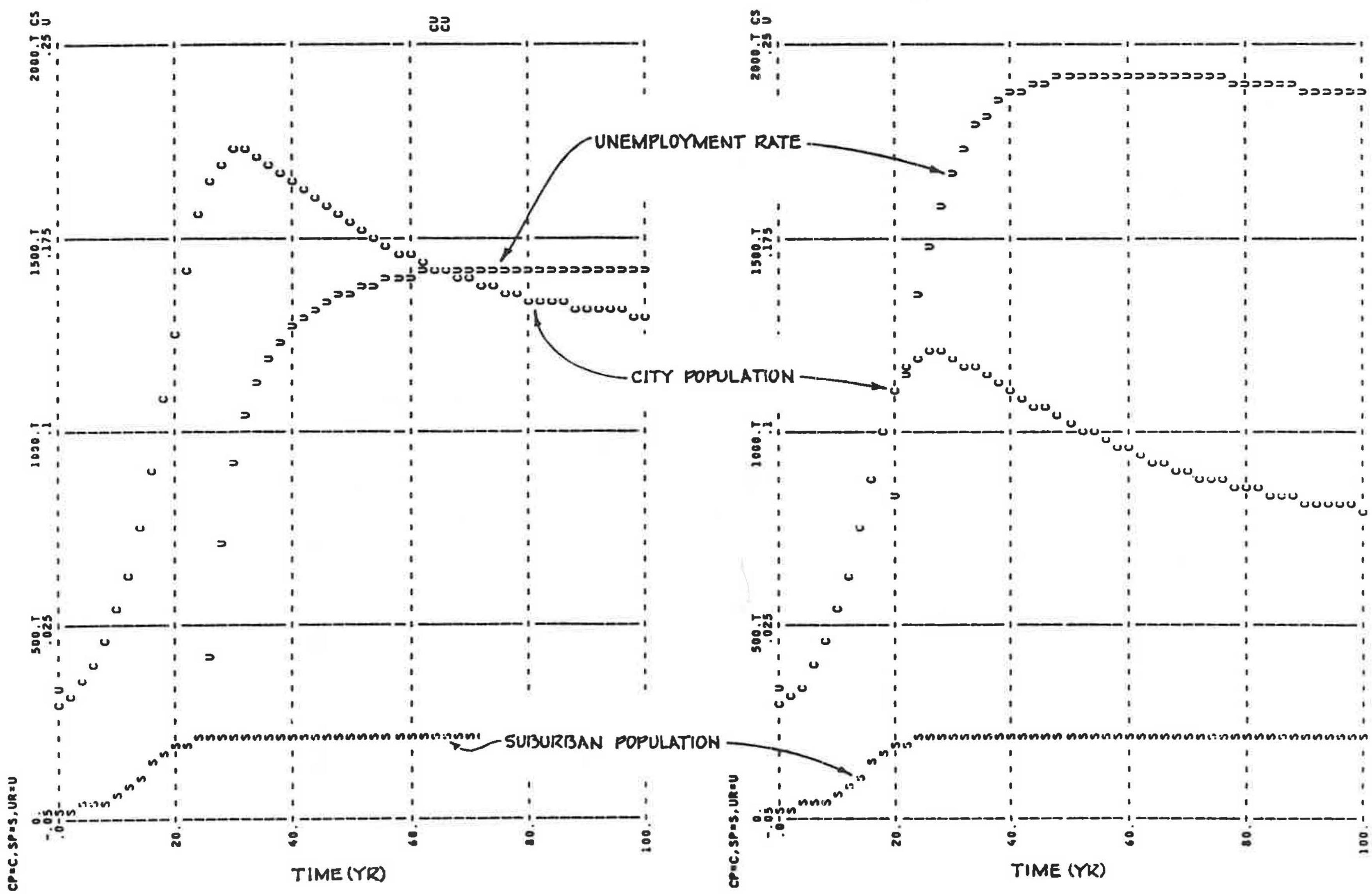


FIGURE 11 Industrial and housing development scenarios.

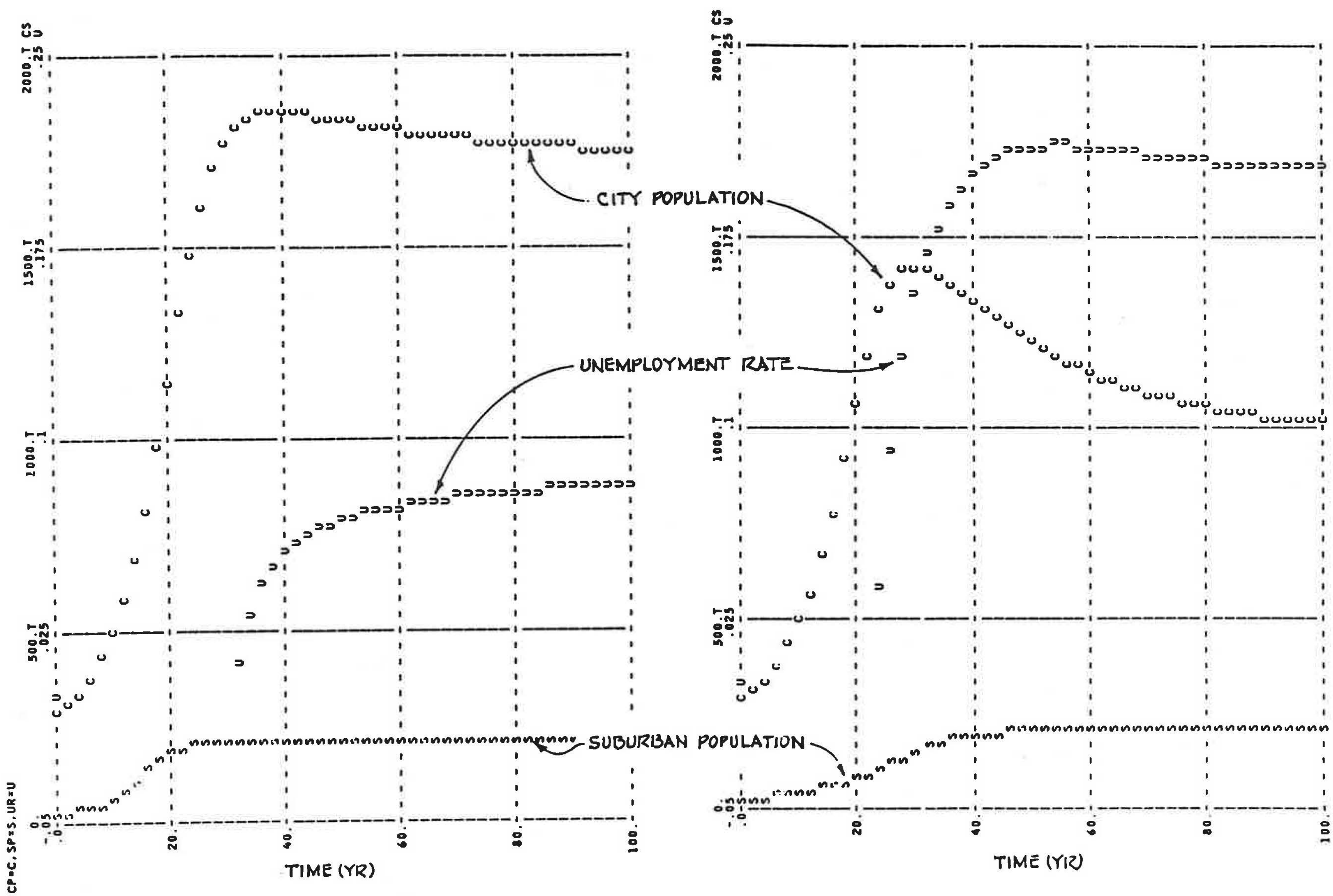


FIGURE 12 Mixed development and general fund scenarios.

TABLE 1 COMPARISON OF SCENARIOS AT TIME T = 30 YEARS

Parameters	Base Run	Policy 1	Policy 2	Policy 3	Policy 4
ICN	.10	.15	.10	.15	.10
DCN	.07	.07	.10	.07	.07
ULD	66.7	66.7	66.7	33.3	66.7
FFA	1.0	1.0	1.0	1.0	0.5
CP	1430T	1719T	1190T	1766T	1424T
SP	212T	212T	212T	212T	147T
UR	0.14	0.09	0.20	-.02	0.15

TABLE 2 COMPARISON OF SCENARIOS AT TIME T = 100 YEARS

Parameters	Base Run	Policy 1	Policy 2	Policy 3	Policy 4
ICN	.10	.15	.10	.15	.10
DCN	.07	.07	.10	.07	.07
ULD	66.7	66.7	66.7	33.3	66.7
FFA	1.0	1.0	1.0	1.0	0.5
CP	1026T	1295T	798T	1754T	1013T
SP	216T	216T	216T	216T	216T
UR	0.20	0.16	0.23	0.08	0.20

industries, accomplished in the model by increasing industrial capacity initial value (ICN).

2. Housing Development Policy—represents a strategy (i.e., low-income housing programs of the 1960s) encouraging the construction of more housing, accomplished in the model by increasing dwelling construction initial value (DCN) (Figure 3, Equation 13.1).

3. Mixed Development Policy—represents a combination of increasing ICN as in the industrial development scenario while reducing useful lifetime of dwellings (ULD) to remove slum housing.

4. General Fund Policy—corresponds to using the highway fund for nonhighway purposes, a proposal that surfaces from time to time. Indeed, it has become commonplace to divert highway earning to transit subsidies. This policy is implemented through the parameter FFA in the model (Figure 7, Equation 34.2).

On the basis of the unemployment rate as a measure of effectiveness, development alternatives can be ranked from best to worst in this hypothetical case as follows: Policy 3, Policy 1, base policy, Policy 4, and Policy 2 (see Tables 1 and 2).

MODELING REGIONAL AND NATIONAL ECONOMIES

National development models should, ideally, be structured to accommodate three development orientations: (a) resource development, (b) regional development, and (c) sectoral development. Resource components include natural resources, land resources, water resources, and human resources (manpower). Regional development is organized on the basis of rural and urban. Sectors represented in the model are agriculture, manufacturing, business, infrastructure, and government. Obviously, the three orientations overlap and are also tied together by two quantities most responsible for material growth: (a) population, including the effects of all economic and environmental factors that influence human birth, death, and migration rates; and (b) capital, including the means of producing industrial, service, and agricultural outputs.

Many of the sectors of a national or regional model can be thought of as elements in a national account that is concerned with measuring aggregate product originating within some geographical area to provide a picture of economic performance.

End results of economic activity are the production of goods and services and the distribution of those goods and services to members of society. The most comprehensive measure of national output is the gross national product (GNP), which is the value of all goods and services produced annually in the nation. Estimating GNP, however, is not merely adding up the value of all output because that would result in double counting. The value of any product is created by a large number of different industries with each firm buying materials or supplies from other firms, processing or transporting them, and thus adding to their value.

Four major components of GNP, each representing a final use of GNP, are consumption, investment, government purchases, and net exports. Investment refers to that portion of the final output that takes the form of additions to or replacements of capital. Government purchases of goods and services are a second component of GNP. In addition, government makes other expenditures in the form of transfer payments, which do not represent the purchase of output and consequently are excluded from GNP. Consumption refers to the portion of national output that is devoted to meeting consumer wants. Net exports (exports minus imports of goods and services) are a final use of GNP and must be included in the total. Three of the four major components (consumption, investment, and government purchases) can be grouped under the heading of gross domestic product (GDP). The GNP, then, is the sum of the GDP plus net exports.

For purposes of national income analysis, GNP statistics are subdivided into mutually exclusive, collectively exhaustive categories. The most commonly used scheme for subdivision is based on the International Standard Industrial Classification (ISIC). The nine major ISIC categories are as follows:

Code	*Classification and Description*
1	Agriculture, hunting, forestry, and fishing
2	Mining and quarrying
3	Manufacturing
4	Electricity, gas, and water
5	Construction
6	Wholesale and retail trade, restaurants, and hotels
7	Transport, storage, and communication
8	Financing, insurance, real estate, and business services
9	Community, social, and personal services

Each of the nine ISIC economic output divisions is associated with a particular capital stock. In a typical model, the agriculture sector provides most of the output in the first ISIC division. Manufacturing capital stock provides the output in ISIC Divisions 2 and 3. Business capital in the model is associated with the activities listed under ISIC Divisions 6 and 8. The infrastructure sector, including transportation in the model, corresponds to ISIC Divisions 4 and 7, and the government services sector to ISIC Division 9.

Transportation-development interactions in a regional and national context are shown in causal diagram form in Figure 13. The causal processes tend to close on themselves forming feedback loops. Polarity of a feedback loop can be determined by counting the number of negative causal relationships—if odd, the loop is negative; if even, the loop is positive. Loop 1 is the economic growth loop and, being positive, would generate exponential growth if unchecked. Loop 2 provides this check and is the constraint on economic growth that is supplied by the environment. Loop 3 (GNP–FB–TII–TI–FIOT–FIOI–GNP) is the development loop induced by transportation investment and is positive.

Economic development and developments induced by transportation investments have been combined into a single second-order (having two state variables, IC and TI) loop (Figure 13, and simplified in Figure 14). This idealization of the transportation-development interaction is the transportation-development model. Analytical treatment of this model to obtain a solution is shown in Figure 15 with the following steps: (a) steady state analysis, (b) formation of the two first-order differential equations representing the two sectors, (c) formation of the second-order differential equation from the two first-order equations, (d) determination of the general solution to the second-order differential equations, and (e) evaluation of the constants in the general solution to obtain the final solutions of the two state variables IC and TI (Figure 15). Because GNP can be found from IC,

$$GNP_t = IC_t(1 - FIOI)/COR \tag{3}$$

and because GNP and TI are both functions of time t, it follows that GNP and TI are functions of each other. In Figure 16, normalized versions of GNP and TI are plotted for various initial values of GNP_0 and TI_0 and for $t = 10$ years. Four cases are shown. Because the ratio GNP_0/GNP_e is the same for the four cases, the effect of transportation infrastructure on economic growth can be seen.

EVALUATION OF USER AND NONUSER BENEFITS

Until recently, the long chain of impacts of infrastructure improvements on socioeconomic systems could not be estimated except by contemplation, discussion, argument, and guesswork.

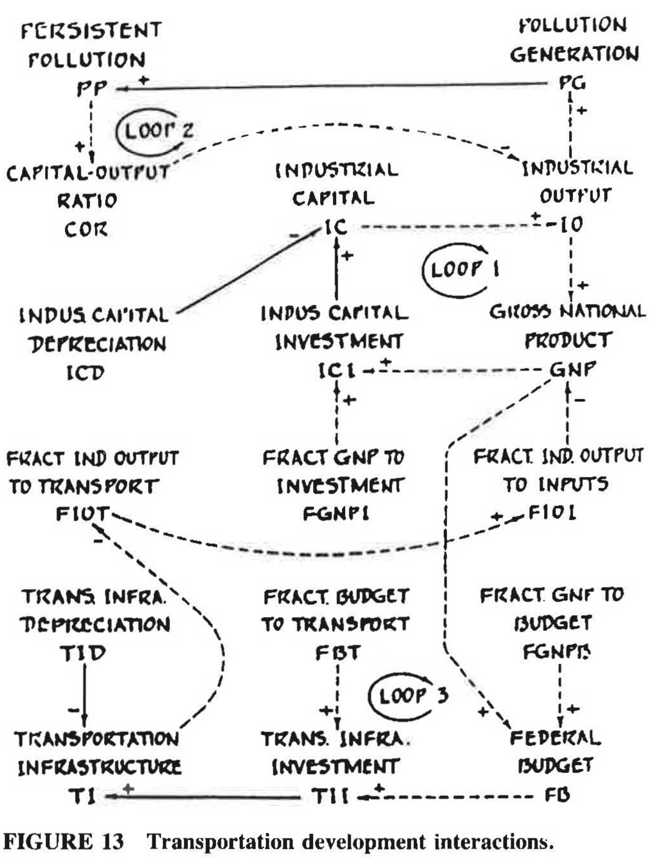


FIGURE 13 Transportation development interactions.

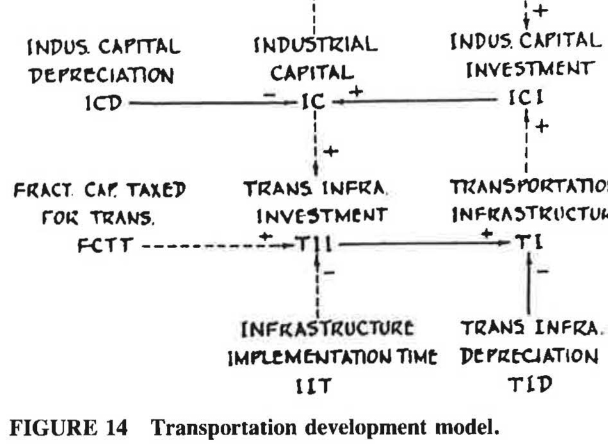


FIGURE 14 Transportation development model.

AT STEADY STATE EQUILIBRIUM, INVESTMENT IS EQUAL TO DEPRECIATION IN BOTH SECTORS:

INDUSTRIAL SECTOR	TRANSPORTATION SECTOR
$ICI_e = ICD_e$	$TII_e = TID_e$
$TI_e \cdot TDM = ICD$	$IC_e \cdot FCTT/IIT = TID$
$TI_e = ICD/TDM$	$IC_e = (TID \cdot IIT)/FCTT$

THE DIFFERENTIAL EQUATIONS IN THE TWO SECTORS CAN BE EXPRESSED AS FOLLOWS:

INDUSTRIAL SECTOR	TRANSPORTATION SECTOR
$\frac{dIC_t}{dt} = ICI_t - ICD_t$	$\frac{dTI_t}{dt} = TII_t - TID_t$
$= (TI_t - TI_e)(TDM)$	$= (IC_t - IC_e)(FCTT/IIT)$

THE SECOND ORDER SYSTEM CAN BE REPRESENTED BY A SECOND ORDER DIFFERENTIAL EQUATION

$$\frac{d^2 IC_t}{dt^2} = (IC_t - IC_e)\left(\frac{TDM \cdot FCTT}{IIT}\right)$$

WITH GENERAL SOLUTION

$$(IC_t - IC_e) = C_1 e^{\omega t} + C_2 e^{-\omega t} \qquad (3)$$

WHERE

$$\omega = \sqrt{\frac{TDM \cdot FCTT}{IIT}}$$

$$C_1 = ((IC_0 - IC_e) + (TI_0 - TI_e)(TDM/\omega))/2$$

$$C_2 = ((IC_0 - IC_e) - (TI_0 - TI_e)(TDM/\omega))/2$$

THE SOLUTION TO THE OTHER STATE VARIABLE IS

$$(TI_t - TI_e) = (\omega/TDM)(C_1 e^{\omega t} - C_2 e^{-\omega t}) \qquad (4)$$

FIGURE 15 Analytical solution of transportation development model.

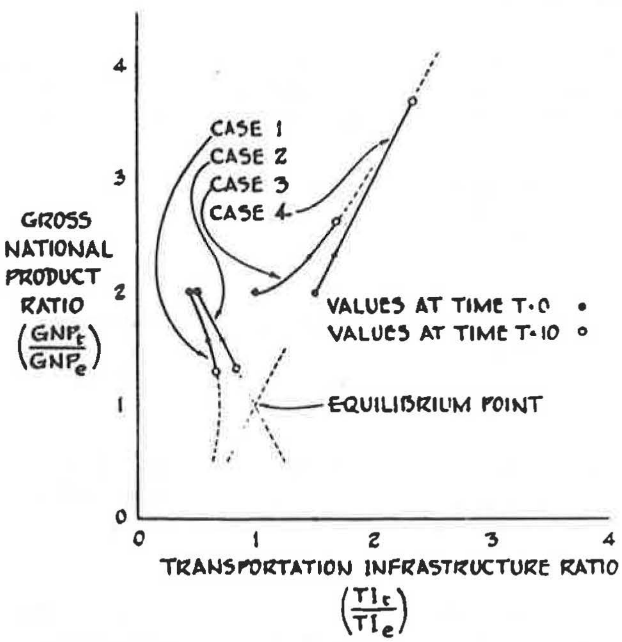
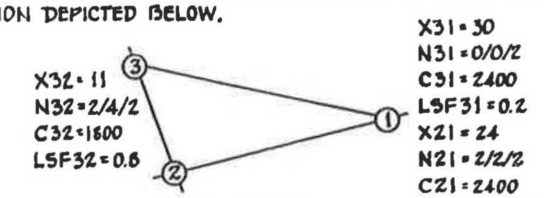


FIGURE 16 Transportation-induced development.

One way out of this present dilemma about transportation-development problems is to sketch an approach that combines the strengths of the human mind and the strengths of today's computers. For example, in Figure 17, Link 32 is a congested expressway, Link 21 is part of the Interstate system, and Node 3 is an urban area with high unemployment. The solution being contemplated is to improve accessibility from Node 3 to the regional hub, Node 1. Three alternatives have been identified. The decision will be based on the evaluation of user and nonuser benefits for the two improvement alternatives. However, existing methodologies do not permit objective evaluation because they cannot measure socioeconomic impacts (such as a reduction in the unemployment rate in this example) that are the key to finding nonuser benefits. One approach is to use system dynamics (shown in Figures 18–20). Steps in finding user benefits for all traffic, including induced and diverted traffic as well as through-traffic, include the following:

A CLASSIC PROBLEM FACING STATE HIGHWAY DEPARTMENTS IS WHETHER TO ADD LANES TO AN EXISTING CONGESTED HIGHWAY SERVING TWO CITIES OR BUILD A NEW, MORE DIRECT HIGHWAY FACILITY BETWEEN THE TWO LOCATIONS. THE DECISION TURNS ON THE EVALUATION OF USER & NON-USER BENEFITS FOR THE TWO ALTERNATIVES. CONSIDER THE HYPOTHETICAL APPLICATION OF THIS GENERIC SITUATION DEPICTED BELOW.



XKL = DISTANCE FROM K TO L (MILES)
NKL = NO. OF LANES FROM K TO L (EA. WAY)
CKL = LANE CAPACITY FROM K TO L (VPH)
LSFKL = LEVEL OF SERVICE FACTOR OVER KL ($0 \le LSF \le 1$)

URBAN AREA 3 HAS A POPULATION P & AN UNEMPLOYMENT RATE UR. IT IS LINKED TO THE REGIONAL HUB, NODE 1, BY AN EXPRESSWAY FROM 3 TO 2 & A SECTION OF INTERSTATE HIGHWAY FROM 2 TO 1. THREE ALTERNATIVES ARE BEING CONSIDERED:

(1) DO NOTHING
(2) EXPANSION OF LINK 32 BY INCREASING N32
(3) CONSTRUCTION OF AN EXPRESSWAY FROM 3 TO 1

USING THE BENEFIT-COST RATIO CRITERION TO EVALUATE HIGHWAY USER BENEFITS & USING THE MODEL THAT YOU WILL HAVE DEVELOPED TO RELATE HIGHWAY VARIABLES TO URBAN AREA 3 SOCIO-ECONOMIC VARIABLES TO EVALUATE NON-USER BENEFITS, RANK THE 3 ALTERNATIVES.

FIGURE 17 Example: application of system dynamics to evaluate the effect of transportation on development.

1. Plot the demand function and the supply functions for the three alternatives (see Figure 18).
2. Find the changes in annual user costs by finding the areas under the curves shown in Figure 18.
3. Calculate the benefit-cost ratios for Alternatives 2 and 3 using the well-known benefit-cost expression

$$BC = \frac{R - E}{cr}(1 - e^{-rt}) \qquad (4)$$

where R is obtained from Step 2.

Steps in finding nonuser benefits (in this case the unemployment rate for the urban area designated Node 3) includes the following:

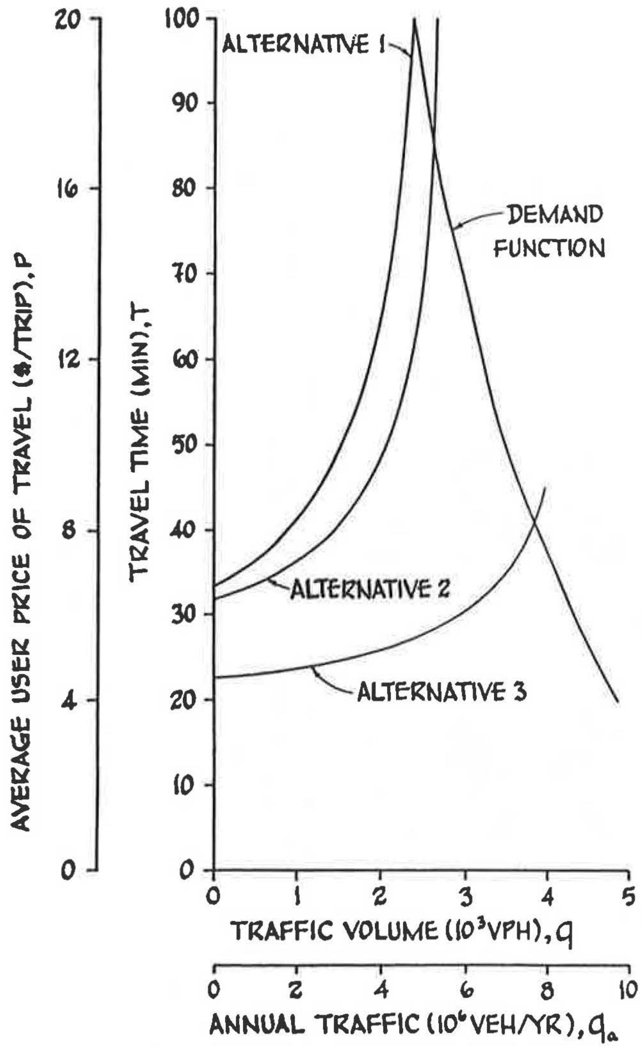


FIGURE 18 Highway user cost-benefit relationships.

1. Extend the chain of causality from the decision variable NUMBER OF LANES (NKL) to the measure of effectiveness UNEMPLOYMENT RATE (UR) (see Figure 19).
2. Develop the mathematical model expressed in the DYNAMO language corresponding to the causal diagram in Step 1 (see Figure 20).

For the initial conditions given in this hypothetical example, a population in Urban Area 3 of 240,000, and basic industrial capital of $10 billion (see Figure 20 for PN = 240000 and BICN = 1.0.E 10), the results for a 25-year horizon or planning year are presented in Table 3. Although the cost-benefit ratio for Alternative 2 is greater than that for Alternative 3, the unemployment rate has been reduced more for Alternative 3. Thus, both user and nonuser benefits have been quantified as a first step to trading them off in reaching the final decision.

In system dynamics, it must be understood that development systems contain causally related variables; every variable depends on every other variable. The causal diagram in Figure 19 shows that the system dynamics model for this example problem contains four sectors: a population sector, an economic sector, an employment sector, and a transportation sector. Arrows and signs on the arrows describe causal hypotheses regarding pairs of variables. In the population sector, the state or level variable POPULATION (P) is affected by three rate variables: NET POPULATION GROWTH (NGP), IN MIGRATION (IM), and OUT MIGRATION (OM). The first two variables increase the state variable, whereas the third decreases it, explaining the signs on the arrows. Arrows are solid to denote accumulation or integration, as opposed to information or feedback, flows, which use dashed arrows. The relationship for POPULATION can be expressed in the following integral equation:

$$P_t = P_{t-1} + \int_{t-1}^{t} (NPG_t + IM_t - OM_t)dt \qquad (5)$$

As a difference equation in DYNAMO language (as in Figure 30),

$$P.K = P.J + (DT)(NPG.JK + IM.JK - OM.JK) \qquad (6)$$

A body of dynamic behavior and principles of structure is emerging that allows organizing and understanding the development process of a region or a whole nation. The basic building block is the feedback loop formed when two or more variables close on themselves. For example, a feedback loop is formed by POPULATION and NET POPULATION GROWTH because the latter also depends on the former. System dynamics is a methodology especially conceived to deal with feedback.

The entire transportation-induced development process is dominated by feedback because it features the synthesis of demand and supply functions. For the demand function, the transportation improvement required to accommodate a certain socioeconomic load is sought. For the supply function, the level of service obtained for a certain transportation improvement must be known. Because higher levels of service attract socioeconomic activity, the feedback loop is closed.

Within and between the development subsystems—population, economic, employment, and transportation in the example—the feedback continues. For example, in the economic sector in Figure 19 an increase in BASIC INDUSTRY CAPITAL increases BASIC INDUSTRY OUTPUT, which increases BASIC INDUSTRY PRODUCT, which increases BASIC INDUSTRY CAPITAL INVESTMENT, which adds to BASIC INDUSTRY CAPITAL, which increases BASIC INDUSTRY JOBS (in the employment sector), which adds to TOTAL NUMBER OF JOBS, which decreases UNEMPLOYMENT RATE. An improved level of service, as measured by decreased TRAVEL TIME, reduces the FRACTION OF INDUSTRIAL OUTPUT TO INPUTS, which increases BASIC INDUSTRY PRODUCT, which eventually reduces UNEMPLOYMENT RATE. But an improved level of service leads to increases in LAND ZONED FOR RESIDENTIAL in the suburbs, which increases urban area POPULATION, which increases LABOR FORCE and, therefore, UNEMPLOYMENT RATE. Although simple, the example shows why transportation-induced development is not a panacea. There are two causal streams from the decision variable TRAVEL TIME to the measure of effectiveness, UNEMPLOYMENT RATE, that tend to cancel each other.

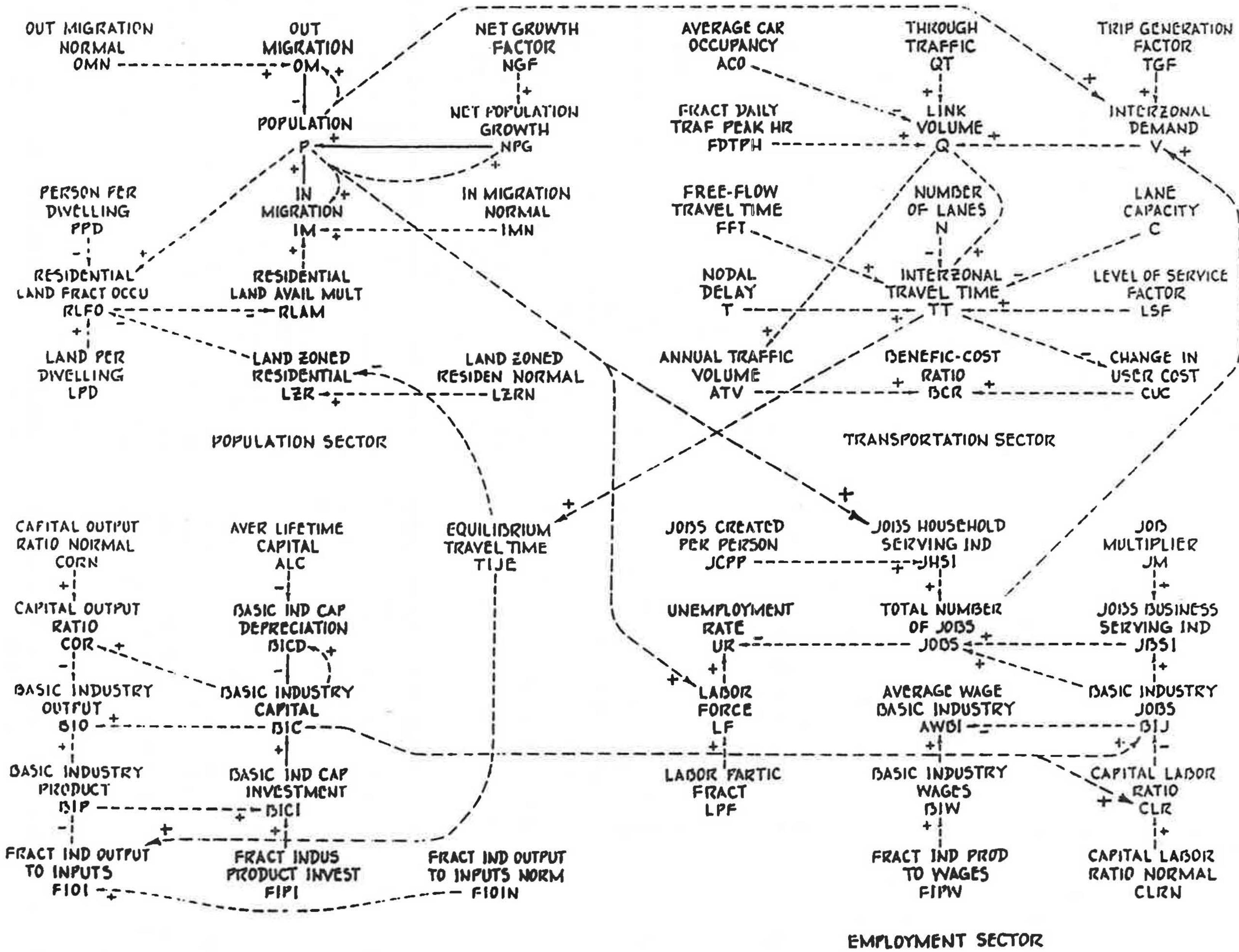


FIGURE 19 Model of highway user and nonuser benefits.

```
                         POPULATION SECTOR
                         ****************
L P.K=P.J+(DT)(NPG.JK+IM.JK-OM.JK)
N P=PN
NOTE P-POPULATION(PERSON)
C PN=240000
NOTE PN-POPULATION AT TIME 0 (PERSONS)
R NPG.KL=P.K*NGF
NOTE NPG-NET POPULATION GROWTH (PERSONS/YR)
C NGF=.02
NOTE NGF-NET GROWTH FACTOR (1/YR)
R OM.KL=P.K*OMN
NOTE OM-OUT-MIGRATION (PERSONS/YR)
C OMN=0.08
NOTE OMN-OUT-MIGRATION NORMAL(1/YR)
R IM.KL=P.K*IMN*RLAM.K
NOTE IM-IN-MIGRATION (PERSONS/YR)
C IMN=0.10
NOTE IMN-IN-MIGRATION NORMAL (1/YR)
A RLAM.K=1-RLFO.K
NOTE RLAM-RESIDENTIAL LAND AVAILABILITY MULT (DIM)
A RLFO.K=P.K*LPD/(PPD*LZR.K)
NOTE RLFO-RESIDENTIAL LAND FRACTION OCCUPIED (DIM)
C LPD=0.5
NOTE LPD-LAND PER DWELLING (ACRES/UNIT)
C PPD=3
NOTE PPD-PERSONS PER DWELLING (PERSONS/UNIT)
A LZR.K=LZRN*(TN31/T31E)
NOTE LZR-LAND ZONED RESIDENTIAL (ACRES)
C LZRN=100000
NOTE LZRN-LAND ZONED RESIDENTIAL NORMAL (ACRES)
C TN31=100
NOTE TN31-TRAVEL TIME NORMAL(MIN)
NOTE
NOTE                      ECONOMIC SECTOR
NOTE                      ***************
L BIC.K=BIC.J+(DT)(BICI.JK-BICD.JK)
N BIC=BICN
NOTE BIC=BASIC INDUSTRY CAPITAL($)
C BICN=1.0E10
NOTE BICN-BASIC INDUS CAPITAL AT TIME 0 ($)
R BICI.KL=BIP.K*FIBI
NOTE BICI-BASIC INDUS CAPITAL INVESTMENT ($?YR)
C FIPI=0.2
NOTE FIPI-FRACT INDUS PRODUCT INVESTED (DIM)
A BIP.K=BIO.K*(1-FIOI.K)
NOTE BIP-BASIC INDUS PRODUCT ($/YR)
A FIOI.K=FIOIN*EXP(-(1.0-T31E/TN31))
C FIOIN=.7
NOTE FIOIN-FRACT INDUS OUTPUT TO INPUTS NORM (DIM)
C T31E=
NOTE T31E-TRAVEL TIME AT EQUILIBRIUM (MIN)
A BIO.K=BIC.K/COR.K
NOTE BIO-BASIC INDUSTRY OUTPUT ($/YR)
A COR.K=CORN*BIC.K/BICN


NOTE COR-CAPITAL OUTPUT RATIO(YR)
C CORN=1.8
NOTE CORN-CAPITAL OUTPUT RATIO NORMAL (YR)
R BICD.KL=BIC.K/ALC
NOTE BICD-BASIC INDUS CAPITAL DEPRECIATION ($/YR)
C ALC=30
NOTE ALC-AVERAGE LIFETIME CAPITAL (YR)
NOTE
NOTE                        EMPLOYMENT SECTOR
NOTE                        *****************
A BIJ.K=BIC.K/CLR.K
NOTE BIJ-BASIC INDUS JOBS (PERSONS)
A CLR.K=CLRN*SQRT(BICN/BIC.K)
NOTE CLR-CAPITAL LABOR RATIO ($/PERSON)
C CLRN=250000
NOTE CLRN-CAPITAL LABOR RATIO NORMAL ($/PERSON)
A BIW.K=BIP.K*FIPW
NOTE BIW-BASIC INDUS WAGES
C FIPW=0.6
NOTE FIPW-FRACT INDUS PROD TO WAGES (DIM)
```

FIGURE 20 *(continued on next page)*

```
A AWBI.K=BIW.K/BIJ.K
NOTE AWBI-AVER WAGE BASIC INDUS ($/PERSON)
A JBSI.K=BIJ.K*JM
NOTE JBSI-JOBS BUSIN SERVING IND (PERSONS)
C JM=0.7
NOTE JM-JOB MULTIPLIER (DIM)
A JHSI.K=P.K*JCPP
NOTE JHSI-JOBS HOUSEHOLD SERV IND (PERSON)
C JCPP=0.05
NOTE JCPP-JOBS CREATED PER PERSON (DIM)
A JOBS.K=BIJ.K+JBSI.K+JHSI.K
NOTE JOBS-TOTAL NO OF JOBS (PERSONS)
A UR.K=(LF.K-JOBS.K)/LF.K
NOTE UR-UNEMPLOYMENT RATE (DIM)
A LF.K=P.K*LPF
NOTE LF-LABOR FORCE (PERSONS)
C LPF=0.4
NOTE LPF-LABOR PARTICIPATION FRACTION (PERSONS/PERSON)
NOTE
NOTE                          TRANSPORTATION SECTOR
NOTE                          ********************
A TERM1.K=(ALT1+ALT2)*(((FFT32*(1-((1-LSF32)
X    *Q32.K)/(N32*C32)))/(1-Q32.K/(N32*C32)))
X    +(FFT21*(1-((1-LSF21)*Q21.K)/(N21*C21)))
X    /(1-Q21.K/(N21*C21)))
A TERM2.K=T2
A TERM3.K=(ALT3*FFT31*(1-((1-LSF31)*Q31.K)/(N31*C31)))/(1-Q31.K/
X    (N31*C31))
A TERM4.K=T1
A TERM5.K=T3
A T31.K=TERM1.K+TERM2.K+TERM3.K+TERM4.K+TERM5.K
NOTE T31-TRAVEL TIME FROM AREA 3 TO AREA 1 (MIN)
C ALT1=1
C ALT2=0
C ALT3=0
NOTE ALTX-ALTERNATIVE X
N FFT32=60*X32/60
N FFT21=60*X21/80

N FFT31=60*X31/80
NOTE FFTKL-FREE FLOW TRAVEL TIME ON LINE KL (MIN)
C LSF32=0.8
C LSF21=0.167
C LSF31=0.2
NOTE LSFKL-LEVEL OF SERVICE FACTOR ON LINK KL (DIM)
C N32=2
C N21=2
C N31=1E-50
NOTE NKL-NO. OF LANES PER DIRECTION ON LINK KL
C C32=1800
C C21=2400
C C31=2400
NOTE CKL-LANE CAPACITY ON LINK KL (VEH/HR)
A Q32.K=(FDTPH/ACO)*V31.K+Q32T
A Q21.K=(FDTPH/ACO)*V31.K+Q21T
A Q31.K=(FDTPH/ACO)*V31.K+Q31T
NOTE QKL-VOLUME ON LINK KL(VEH/HR)
C Q32T=600
C Q21T=1920
C Q31T=0
NOTE QKLT-THRU TRAFFIC ON LINK KL (VEH/HR)
C FDTPH=0.10
NOTE FDTPH-FRACT DAILY TRAFFIC IN PEAR HOUR (DIM)
C ACO=2
NOTE ACO-AVER. CAR OCCUPANCY (PERSONS/HR)
A V31.K=P.K*TGF

NOTE V31-DEMAND FROM AREA 3 TO AREA 1 (PERSONS/HR)
C T1=0
C T2=0
C T3=0
C TGF=0.2
NOTE TGF-TRIP GENERATION FACTOR
NOTE TK-COLLECTION,DISTRIBUTION,TRANSFER TIME AT NODE K (MIN)
C X32=11
C X21=24
C X31=30
NOTE XKL-DIST BETWEEN NODES K AND L (MILES)
```

FIGURE 20 *(continued)* **Estimation of population, transportation needs, and socioeconomic impact.**

TABLE 3 TRANSPORTATION DEVELOPMENT EVALUATION METHODOLOGY RESULTS

USER BENEFIT ANALYSIS					NONUSER BENEFIT ANALYSIS (t=25)				
ALTER.	R	E	C	BC	P_t	LF_t	BIC_t	$JOBS_t$	UR_t
2	15 150 000	9 200 000	25 000 000	2.38	265 000	107 000	1.19×10^{10}	101 000	6%
3	73 455 000	18 000 000	250 000 000	2.22	383 000	154 000	1.59×10^{10}	155 000	0%

$$R_2 = \frac{(P_1 - P_2)(q_{a1} + q_{a2})}{2} = \frac{(20-17)(4\,800\,000 + 5\,300\,000)}{2} = 15\,150\,000$$

$$R_3 = \frac{(P_1 - P_3)(q_{a1} + q_{a3})}{2} = \frac{(20-8.2)(4\,800\,000 + 7\,650\,000)}{2} = 73\,455\,000$$

(SEE FIG 16)

$$BC_2 = \frac{R_2 - E_2}{C_2 r}(1 - e^{-rL}) = \frac{15\,150\,000 - 9\,200\,000}{25\,000\,000 \times .10}(1-0) = 2.38$$

$$BC_3 = \frac{R_3 - E_3}{C_3 r}(1 - e^{-rL}) = \frac{73\,455\,000 - 18\,000\,000}{250\,000\,000 \times .10}(1-0) = 2.22$$

$$UR_t = \frac{LF_t - JOBS_t}{LF_t} \times 100 \quad \text{WHERE } LF_t = P_t \times LPF$$

$$JOBS_t = BIJ_t + JBSI_t + JHSI_t$$

$$BIJ_t = BIC_t / CLR\ ;\ JBSI_t = BIJ_t \times JM\ ;\ JHSI_t = P_t \times JCPP$$

(SEE FIG 30)

IT CAN ALSO BE SHOWN THAT

$$P_t = \frac{P_e}{1 + (\frac{P_e}{P_0} - 1)e^{-(IMN + NGF - OMN)t}} \quad \text{AND}$$

$$BIC_t = BIC_e - (BIC_e - BICN)e^{-t/ALC} \quad \text{WHERE}$$

$$P_e = (\frac{PPD}{LPD})(1 - \frac{OMN - NGF}{IMN})(LZRN \frac{TN31}{T31E})$$

$$BIC_e = ALC \times FIPI \times (\frac{BICN}{CORN})(1 - FIOIN \times e^{-(1 - \frac{T31E}{TN31})t}$$

In the mathematical model, parameter values have been chosen that support transport improvement to reduce unemployment (see Figure 20). Obviously, the modeling of transportation-induced development in the real world is serious business. The advantage of the system dynamics approach is the absence of the restrictions inherent in the many methodologies. Thus, the dichotomy that exists in a strategy of transport movement becomes explicit and must not be obscured by modeling limitations.

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Economic Development Impact of Airports: A Cross-Sectional Analysis of Consumer Surplus

BAHAR B. NORRIS AND RICHARD GOLASZEWSKI

Attributing the entire impact of an airport's operations to economic development would be overestimating the net economic benefits of an airport. A methodology is developed for using consumer surplus as a proxy measure of the net economic development benefits from the construction of a regional airport. This methodology involves partitioning the impact of an airport into two parts: (a) the impact from the purchases of air transportation services; and (b) the consumer surplus from a decline in air transportation prices subsequent to the construction of the facility. Using a combination of input-output analysis and airport-user surveys, a cross-sectional study was conducted on two airports, one in an island economy—with few alternate means of transportation and no other airports—and the other in the Dallas-Fort Worth (DFW) area with an abundant supply of alternate airports and other modes of transportation. The transportation purchase impact was larger in the DFW area than in the island economy ($5.26 billion compared to the island's $3.73 billion—or $1,571 and $612 per capita, respectively). The size of the consumer surplus for the DFW airport was much smaller because of the proliferation of other transportation modes and competing airports ($1.3 billion). In the island economy, the consumer surplus was much larger ($11.03 billion), suggesting the importance of the availability of substitute modes and airports. The study emphasizes the importance of the industry mix, the diversity of the economy, the regional transportation infrastructure, and the full-employment status of the economy in determining the size of the impact. It also provides caveats on using stated preference methods in determining the value to the consumers of products that could be enjoyed as a free rider.

Many economists and policy makers have applauded the benefits of government investments in large-scale public projects on the grounds that such projects generate public benefits over and above the costs of constructing them. The opportunity cost of constructing such projects, the argument goes, would be lower for the public sector than if private-sector cost accounting were used.

A methodology will be outlined for using consumer surplus as a proxy measure of the net economic development benefits from the construction of a regional airport. This measure avoids double counting that would result if the entire upper and lower areas under the demand curve were attributed to the economic development impact. This methodology involves dividing the impact of an airport into two parts: (a) the impact from purchasing air transportation services, and (b) the consumer surplus accruing from a decline in air transportation prices following construction of the facility.

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To identify factors determining the size of the impact, a cross-sectional comparison will be made of the economic impact of two airports, one in an island economy (with few alternative means of transportation and no other airports) and the other in the Dallas-Ft. Worth (DFW) metroplex (with an abundant supply of alternative airports and other modes of transportation).

Although the size of the purchase impact closely relates to diversity of the economy, the size of the consumer surplus is a function of the accessibility of the region, its industrial mix, and the importance consumers attach to continuing operations of the airport. In the DFW metroplex where demand for air transportation was elastic and there were extensive input-output linkages within the economy, there were substantial output multipliers indicating the number of times each dollar spent rolls over within the region. Here, both the absolute and relative sizes of the transportation purchase impact were larger when compared with the island economy ($5.26 billion compared to the island's $3.73 billion for total impact; and $1,571 per capita compared to the island's $612 for per capita impact). In the same economies, because of differences in accessibility and industrial mix characteristics, the relative magnitudes of the consumer surplus were reversed. The DFW region showed a relatively small economic development impact ($1.3 billion, or one-fourth of the purchase impact), whereas the island economy showed a relatively large impact ($11.03 billion) that was three times larger than the purchase impact.

BACKGROUND

Although the idea of using government investment as a tool of promoting economic development by no means started with Keynes, his treatment of the role of government in combating high unemployment gave the notion of benefits from government expenditures vivid urgency that is still present:

> Public works even of doubtful utility may pay for themselves over and over again at a time of severe unemployment, if only from the diminished cost of relief expenditure, provided that we can assume that a smaller proportion of income is saved where unemployment is greater; but they may become a more doubtful proposition as a state of full employment is approached (*1*).

In the postdepression period when high unemployment was prevalent, development benefits from investments in infrastructure projects (e.g., roads, public utilities, and mass transportation) were often used as the rationale for increasing the role of government in the construction of public projects. The first 25 years following World War II was a period of unprecedented federal government involvement in funding public works projects (infrastructure). Several new mass transit systems and the Interstate highway system were the most visible of these commitments.

Beginning in the early 1970s, economic difficulties faced by all levels of government in the United States resulted in rethinking the role of government in the economic development of a region. With the increasing practice of privatization, the question of the economic development impact of infrastructure investment has not lost its relevance, but rather has reemerged with renewed force in the form of benefit fees, assessment districts, and joint ventures.

The common thread running through the postwar activism of the federal government and the privatization trend of the past two decades has been the effort of quantifying the net external benefits that accrue from infrastructure investments. Developing a methodology for estimating net development benefits from these investment projects will gain increasing significance as state and local governments continue to juggle their increasingly scarce funds to complete as many projects as possible.

STUDY OBJECTIVES

The objective is to offer a methodology for dividing the economic impact of an airport so that the entire impact is not attributed to economic development. By dividing the total impact into purchase of air transportation service and consumer surplus, the latter can more appropriately be interpreted as a measure of development impact. Much of the activity generated as part of the purchase impact is a transfer of resources within the economy and would not constitute a net gain to the region.

The rationale behind attributing both development and purchase of service impacts is the notion of external economies. An airport, the argument goes, enhances the accessibility of a region and stimulates further economic development by opening up its consumer and labor markets and improving passenger and goods movement. The forces behind this surge of economic development are the agglomeration (or external) economies that generate cost savings for businesses located in proximity of the airport and also increase their productivity. Local governments, therefore, have an incentive to invest in projects such as airports because they can stimulate economic growth.

Separating the impact of the purchase of air transportation services from the external benefits of the investments would

- Avoid overestimating the development impact by refraining from using a label for an array of resource transfers, and
- Include only incremental benefits to the consumer.

These benefits are measured as the consumers' willingness to pay for the nonmarket benefits of a more accessible region.

Consumer surplus in this context was used instead of the amount business consumers of air transportation would be willing to pay over and above the market rates rather than go without air transportation. In this sense, a measurement was made of the increment to the regional welfare function that is not reflected in the market value of goods and services purchased for airport operations.

A second factor is the derived-demand nature of consumer demand for air transportation. Although the size of the transportation purchase impact is a function of the complexity of the economy and the region's size, the size of the development impact is a function of the derived demand for air transportation in the region and the prevailing level of unemployment. Construction of an airport would lower the price of an input rather than the price of a final product. As the price of air transportation declines, the production levels for firms locating in commuting range of the airport increase and the economy of the region grows because of the following factors:

- More firms substitute the now cheaper air transportation for other modes;
- Firms producing products with a higher income elastic demand grow at a more rapid rate now that the price of one of their inputs has declined; and
- Regions with abundant supplies of labor—either from unemployment or high levels of immigration—and capital, enjoy a further boost in the growth that was earlier fueled by the drop in the price of air transportation.

The interplay of these three factors ultimately determines the size of the development impact of an airport.

THEORETICAL UNDERPINNINGS

Regional economics has assessed the role of transportation improvements in economic development by integrating spatial and gravity models of geographers with the theory of least-cost production. Isard's (*2*) formulations, for instance, maintain that transportation improvements, by removing barriers to the efficient movement of goods and people, maximize the profits for firms and thereby stimulate further growth.

A related and somewhat supply-oriented school of thought, represented by central place theory, focuses on the interrelationships between a firm's location within a system of cities and its production costs. In higher-order cities, the array of services and amenities available to firms reduces production costs, thereby stimulating growth. These cost savings accrue from the establishment of an efficient system of market areas that minimizes transport costs and maximizes profits by providing easy access to inputs, abundant labor supply, and a smooth movement of the final output.

Much of these cost savings (or agglomeration economies) are not internal to the firm or its production technology, but rather are external and a result of more efficient movements of input and output between intermediate and end users. Hoover (*3*) distinguished between two types of agglomeration economies: (a) localization economies that depend on the size of an industry that is centralized in a single location; and (b) urbanization economies that depend on the size of the city and the amenities it offers in terms of more efficient input and output linkages. According to Hoover, economic development gains result from the firms' comparative advantage in market access, adequate supply of labor and materials, and low costs of transportation and production. The interplay of these market and supply forces

- Attracts new firms to the region;
- Increases demand for the products of existing firms; and
- Increases production in general as firms substitute the now cheaper air transportation as an input in their production process and produces more of the now cheaper final product as well.

EMPIRICAL EVIDENCE

Empirical quantification of the relationship between investing in public infrastructure and economic development has been sparse. Eberts (*4*) tried to quantify gains in regional productivity from a given increase in investment by establishing a moderate and positive link between specific infrastructure investments and gains in productivity. Eberts considered public infrastructure an input, together with labor and private capital, in a citywide manufacturing production function and estimated that a doubling of public infrastructure would lead to a 4 percent increase in manufacturing output in a sample of 38 metropolitan areas. This increase translates to an elasticity of 0.04, i.e., for each 1 percent additional investment in infrastructure, regional productivity grows by 0.04 percent. This rise in productivity is analogous to a slight shift in the regional supply curve subsequent to a lowering of the price of an input.

The overwhelming empirical evidence on the size of the development impact relates to the industrial mix of the region. Numerous studies have indicated that the location of high-technology and research and development (R&D) firms shows a strong and positive association with the presence of airports. In a survey of firms' locational decisions, proximity to an airport was cited as one of the top five factors for high-technology firms. A similar panel study found access to air transportation as one of the top six factors in the locational choice of R&D firms (*5*).

Additional evidence of the positive correlation between the presence of an airport and the growth of high-technology firms is provided by a study of biotechnology firms that found proximity to airports and major research centers to be of major significance (*6*). On the other hand, Anjomani et al. (*7*) suggested that although the presence of an airport in a county showed a positive and significant correlation with manufacturing growth for some four-digit Standard Industrial Code (SIC) sectors, airports showed negative and significant relationships with growth in other sectors.

Although the overall relationship between transportation improvements and economic development is not strong, sector-specific relationships are pronounced. For instance, in a study of metropolitan areas with a high level of air service, only when the type of the industry sector is controlled is employment growth positively affected by a high level of air service (*8*). A study of new airports in Ohio similarly illustrated that when all industry sectors were combined and the overall employment growth was observed, no positive correlation was found between the presence of an airport and employment growth (*9*).

In addition to these findings on the influence of industrial mix, a survey of firms in Pennsylvania showed that advanced-technology firms were more likely than other manufacturing firms to cite proximity to an airport as a locational factor (*10*). The survey further showed that an average of 8.5 percent of the products and services of advanced-technology firms were transported by air, whereas only 1.1 percent of the products and services of all other firms were shipped by this mode.

DATA COLLECTION AND METHODOLOGY

Two types of surveys were conducted to ascertain and divide the economic impacts of two regional airports, one the Dallas-Ft. Worth International Airport and the other a major international airport in an island economy. The first type of survey measured the transportation purchase impact of the airports by measuring the final demand impact of the airport generated as a result of the purchase of air transportation services; whereas the second type measured the economic development impact by estimating the consumer surplus of the nonaviation firms in the region.

FINAL DEMAND IMPACT OF AIR TRANSPORTATION PURCHASE

The air transportation purchase impact of the two airports was measured by estimating the final demand—net of intermediate inputs—of the firms directly connected with airport operations. To estimate final demand, data were collected from all on-airport firms and a sample of off-airport firms. On-airport firms included

- Passenger airlines,
- Cargo airlines,
- Airline suppliers,
- Airport concessions, and
- Airport board and government agencies.

Off-airport firms that were sampled and their impact extrapolated included

- Hotels,
- Travel agencies,
- Airline headquarters and ticket offices,
- Car rentals, and
- Ground transportation agencies.

Expenditures, budgets, revenues, and employment generated in each airport in 1987 were thoroughly inventoried and entered into a data base. Capital budgets were not included in the expenditures to ensure that only the flow of expenditures in the study year were included in the impact.

The transportation purchase impact of an airport can be illustrated as the rectangle under the demand curve that is the product of P (unit price of air transportation service) and Q (quantity of final air transportation-related goods and services produced net of intermediate goods). Figures 1 and 2 show the position of the transportation purchase impact relative to the consumer surplus impact. For the DFW airport, the size of the rectangle was \$5.2 billion, whereas for the island economy airport the impact was \$3.73 billion. In per

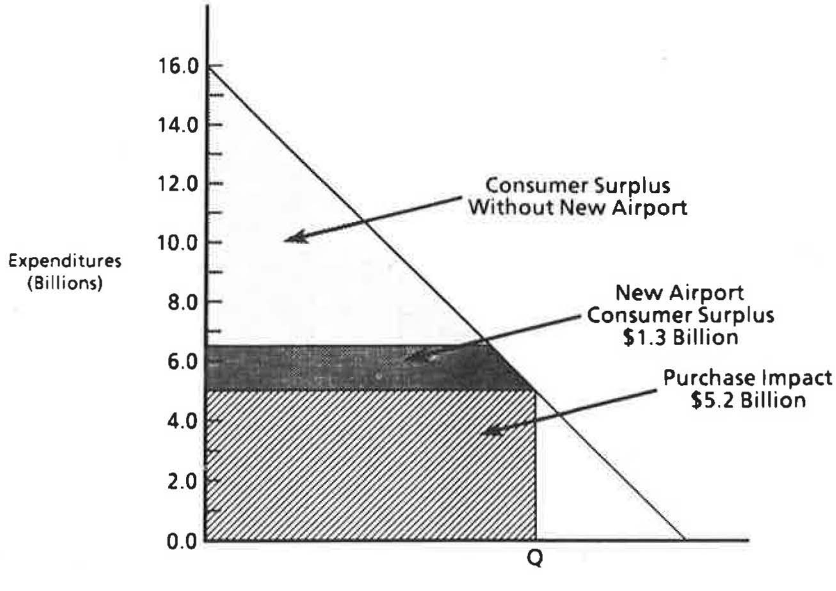

FIGURE 1 Air transportation impact for DFW airport.

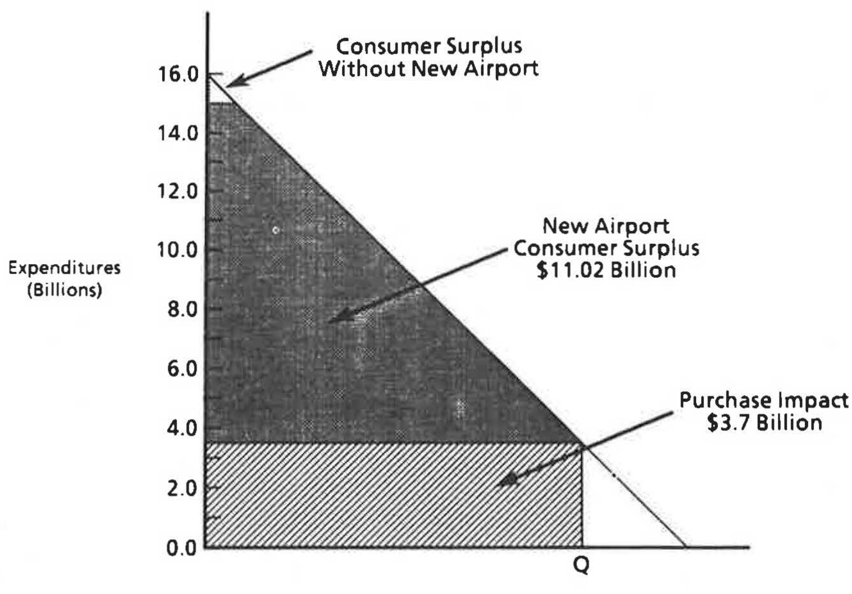

FIGURE 2 Air transportation impact for island airport.

capita terms, this amounted to $1,570 for each resident of the DFW region and $612 for each resident of the island. The overall purchase impact consisted of the primary (direct, first round of air transportation-related expenditures) and secondary (induced-multiplier effect) impacts as follows:

1. Primary Impact. The primary final demand impact for each airport was estimated using the method of National Income Accounting. All airport-related (direct on-airport and off-airport) expenditure flows (net of intermediate purchases) were measured as the primary impact in the sense that they included only the first round of expenditures attributed to the airport (Figure 3 shows the two economies in their primary impact).

2. Secondary Impact. Input-output multipliers (using the RIMS II model generated by the Bureau of Economic Analysis) were used to estimate the induced and indirect impacts. Induced impacts result from the rippling effect through the economy of the first round of expenditures (multiplier effect), whereas indirect impacts result from increased expenditures in all other nonaviation sectors of the economy (Figure 3 shows the sizes of the secondary impact in the two economies).

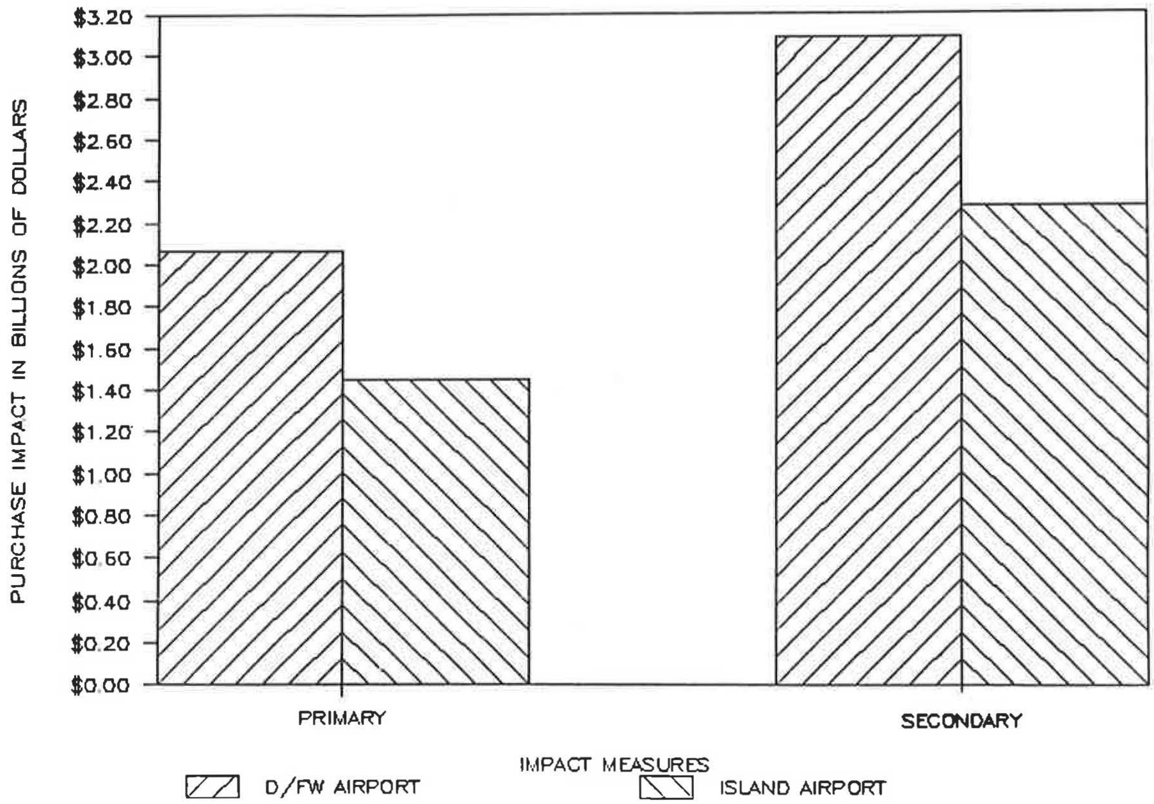

FIGURE 3 Transportation purchase impact: primary and secondary impacts.

CONSUMER SURPLUS MEASURE OF ECONOMIC DEVELOPMENT IMPACT

As a proxy for the economic development impact, a measure of consumer surplus was estimated. A combination of survey methods and econometric modeling was used to measure the value that nonaviation firms in the region received from each airport net of the value generated from the production of air transportation services.

In the sample survey of nonaviation firms (with sampling ratios ranging between 12 and 17 percent), the firms were asked to estimate the percentage of their airport dependency (i.e., revenues that would be foregone without the airport in question). In order to ascertain the magnitude of the dependency, a composite dependency index was developed that consisted of the following responses to hypothetical questions about what the firms would do in the event the airport ceased to exist:

- Whether or not the firm would relocate;
- Whether or not the firm's operating costs would increase; and
- Whether or not any percentage of the firm's revenues would be lost.

Figure 4 shows the percentage distribution of the responses of the firms in the two economies for these questions. The magnitude of the development impact and the firms' degree of airport dependency were estimated by using regression models. The models estimated final demand and the extent of airport dependency by assuming a linear or logarithmic relationship between the dependent variables and responses to such explanatory variables as employment size, the firm's industry category, the firm's product mix, and the probabilities of relocation or financial losses.

Figures 1 and 2 show the size of development impact for the two airports under study. For the DFW region, the development impact was estimated at $1.3 billion, approximately one-fourth the size of the purchase impact. For the island economy, the development impact was $11.03 billion, or three times as large as the purchase impact. In per capita terms, each resident of the DFW region was willing to pay an additional $371 rather than go without the airport. In the island, each resident was willing to pay as much as $1,807 rather than go without the airport.

ANALYSIS AND CONCLUSION

To summarize, the findings of the two surveys corroborated the hypotheses as follows:

- The size of the consumer surplus for the DFW airport was small relative to the overall economic impact, whereas for the island economy the economic development impact was three times as large as the overall impact. Transportation supply characteristics thus strongly influenced the degree of airport dependency of firms, suggesting that the greater the

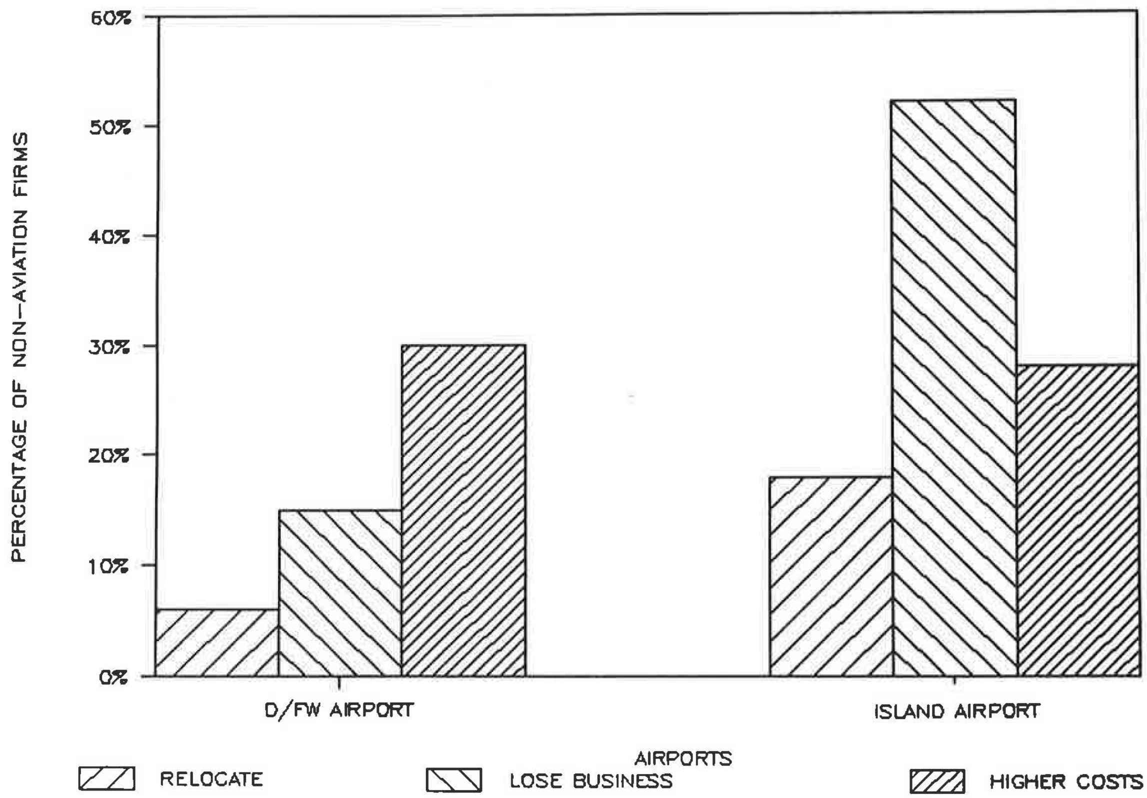

FIGURE 4 Consumer surplus impact: DFW and island airport comparisons.

threat of supply constraints (as in the case of the island) the larger the degree of airport dependency and consumer benefit.

• Substitution of air transportation as an input in production function was done freely by a large number of firms in both study areas. In both regions, the operations of the airport contributed to the overall economic growth.

• Availability of substitute transportation modes and competing airports both emerged as a significant factor in the degree of airport dependency and therefore the size of the consumer surplus. The size of the consumer surplus for the DFW airport, both in absolute terms and relative to the size of the transportation purchase impact, was small because of the proliferation of other transportation modes (especially trucking and rail) and competing airports.

• The size of the consumer surplus for the island airport was larger both in absolute terms and relative to the purchase impact. The strong $11.03 billion impact resulted from the dearth of surface and rail transportation facilities, as well as the monopolistic control of air transportation services by the single airport on the island.

• Firms producing products with a large price elasticity of demand (e.g., high value-added, advanced technology products, or financing and professional services) were more likely to expand production in response to a decline in the price of air transportation. Both in DFW and on the island, firms in these business categories expressed the highest degree of dependency on the airport.

• Elastic supplies of labor, capital, and other inputs allowed the expansion of production prompted by the lowering of prices.

• Transportation supply constraints contributed to the degree of airport dependency and the size of the consumer surplus. For the island, where prospects of capacity constraints were greater, the consumer surplus was proportionately larger.

• The net benefit measure of the consumer surplus should be interpreted as an incremental value rather than a total. In this sense, the larger the range of transportation services available in the region, the less the incremental benefits that consumers perceive. Furthermore, including only the incremental gains in the consumer surplus rather than the total triangle avoids inflating the benefits attributed to the airport.

• The relatively small size of the consumer surplus for Dallas is consistent with the public goods nature of the project and the free rider dilemma. For the island economy, however, the fears of capacity constraint prompted many firms surveyed to move toward the upper bounds of their estimated dependency.

A multitude of factors influence the size of net external benefits from an airport. A naive view, which attributes the entire impact to economic development, ignores that much of the impact often consists of transferred resources, and that such an attribution is justified only in the presence of high unemployment rates. The consumer surplus measurement shows that this component of the impact is rather small partly because of the flaws in the method of stated preferences used in consumer surveys. Consumers tend not to reveal their true preferences because they have the option to be a free rider and enjoy the external benefits of an airport without attaching a dollar value to it. More important, however, the small size of the impact for the DFW area resulted from the saturation of metropolitan economies with transportation services and the near full-employment status of many urban labor markets in the past decade.

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Hybrid Approach to Estimating Economic Impacts Using the Regional Input-Output Modeling System (RIMS II)

RICHARD M. BEEMILLER

A hybrid approach for estimating economic inpacts uses survey information on the direct output effects in conjunction with Regional Input-Output Modeling System (RIMS II) multipliers. The approach is demonstrated using hypothetical direct coefficients and multipliers. The increased accuracy of the approach is then assessed by comparing survey and nonsurvey impacts estimated for two states. As an example, the hybrid RIMS II approach is applied to the impacts of a General Electric plant in the Charlottesville, Virginia, Metropolitan Statistical Area.

Effective planning for public- and private-sector projects at the state and local levels requires systematic analysis of the economic impacts of these projects on affected regions. This analysis, in turn, must take into account interindustry relationships within regions because these relationships largely determine regional responses to project changes. Regional input-output (I-O) models, which reflect such relationships, are a useful tool for regional economic impact analysis.

Most regional I-O models use an accounting framework called an I-O table, which shows inputs purchased and outputs sold for each industry. Direct requirements coefficients, which show the inputs of goods and services required to produce \$1.00 of output, can be estimated from an I-O table and are the basis for deriving I-O multipliers. I-O multipliers show the regional economic impact that would result from a \$1.00 change in the output delivered to final demand (i.e., to ultimate purchasers, such as consumers outside the region) by a given industry. Comprehensive discussions of I-O multipliers are provided by Miernyk (*1*), Miller and Blair (*2*), Richardson (*3*), and Schaffer (*4*).

I-O tables have previously been constructed by surveying regional firms to determine their inputs and outputs. However, time and cost are major obstacles. For example, Glickman (*5*) notes that approximately \$250,000 was expended over a 5-year period for the collection and processing of data in a 1958 I-O study of 500 industries conducted in Philadelphia.

The time and cost disadvantages of survey-based models have been largely overcome by nonsurvey models, which typically use direct requirements coefficients for the nation as a basis for estimating industry relationships in a region. However, comparisons of nonsurvey and survey models have generally indicated that the advantages of nonsurvey models are gained at the expense of a loss in multiplier accuracy. This result has spawned a well-documented debate over the relative costs and benefits of the two approaches. A discussion of selected nonsurvey models is provided by Brucker et al. (*6*).

In the mid-1970s, the Bureau of Economic Analysis (BEA) developed a nonsurvey method known as RIMS (Regional Industrial Multiplier System) for estimating regional I-O multipliers, that was based on the work of Garnick (*7*) and Drake (*8*). More recently, BEA completed an enhancement of RIMS known as RIMS II (Regional Input-Output Modeling System) (*9,10*). In RIMS II, direct requirements coefficients are derived mainly from two data sources: (a) BEA's national I-O table, which shows the input and output structure of more than 500 U.S. industries, and (b) BEA's four-digit Standard Industrial Classification (SIC) county wage-and-salary data, which can be used to adjust the national direct requirements coefficients to show a region's industrial structure and trading patterns (*11,12*). Regional multipliers for industrial output, earnings, and employment are then estimated on the basis of the adjusted coefficients.

Comparisons of RIMS II multipliers with those derived from survey I-O tables have shown that the multipliers are similar for a number of industries, whereas for others there are differences that may be considered unacceptable. (The accuracy of a nonsurvey technique is typically judged by comparing the estimated I-O relationships with those in a survey table. However, the survey data are themselves estimates of the true I-O relationships in the economy. Because measurement errors may be associated both with survey and nonsurvey estimates, to ascribe the entire difference to nonsurvey estimation errors is incorrect.)

Stevens (*13*) and others have found that the effect of a multiplier error on an estimated impact can be mitigated by gathering primary data on the direct (first-round) effects associated with the initial impact. These data are then used with I-O multipliers to estimate the additional, or indirect, effects.

A hybrid RIMS II approach is evaluated. Primary data on the direct effects are used in conjunction with RIMS II multipliers to estimate economic impacts. [A discussion of several hybrid approaches is provided by Richardson (*14*).] The hybrid approach is demonstrated using hypothetical direct coefficients and multipliers. The increased accuracy of the hybrid approach is then assessed by comparing survey and nonsurvey impacts estimated for Texas and Washington. Finally, an application of the hybrid RIMS II approach is described.

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HYBRID APPROACH FOR ESTIMATING ECONOMIC IMPACTS

As previously explained, regional I-O multipliers are derived from direct requirements coefficients, which show the inputs of goods and services required from the region's industries to produce $1.00 of output. The coefficients do not necessarily reflect the total input requirements; rather, they reflect the inputs supplied by industries in the region. Input requirements not supplied locally are imported from outside the region. Table 1 presents direct requirements coefficients for a hypothetical region having three industries, including households. [Regional I-O multipliers account more fully for the regional economic repercussions of project expenditures if households are included as an industry (*1–4*).] As shown in Table 1, to produce $1.00 of output, Industry 1 requires 6 cents of inputs from regional firms in the same industry, 12 cents from regional firms in Industry 2, and 18 cents from regional households.

Gross output multipliers for a region are derived on the basis of direct coefficients. [In technical terms, gross output multipliers are calculated by taking the difference between an identity matrix and the direct requirements matrix, and from this computing a transposed inverse matrix (*1*).] Compared with direct requirements coefficients, gross output multipliers account more fully for the regional economic repercussions of producing $1.00 of output. For example, they reflect (a) the initial $1.00 of final demand for the output of a given industry, (b) direct requirements coefficients, and (c) indirect requirements coefficients. Indirect requirements coefficients for a given industry in a region reflect the regional production required both to produce the industry's direct requirements and to meet the increased consumer demand generated by payments to households for their labor inputs. Earnings and employment multipliers, in turn, can be derived from gross output multipliers. Respectively, they reflect the household earnings paid and the number of jobs provided, both directly and indirectly, to deliver $1.00's worth of output to final demand.

Table 2 presents earnings multipliers for the industries from Table 1. The earnings multipliers are calculated by multiplying gross output multipliers by industry-specific ratios of earnings to gross output (*9*). As shown in Table 2, for Industry 1 to deliver $1.00 of output to final demand, regional firms must pay 20 cents of earnings to households employed in the same industry, 3.7 cents to households employed in Industry 2, and 1.5 cents of earnings to household employees. For Industry 1, the total earnings impact is 25.2 cents per $1.00 of output delivered to final demand. Therefore, the total earnings impact (direct plus indirect impact) associated with a final demand change in Industry 1 can be estimated by multiplying the change in final demand by 25.2 cents.

Alternatively, the indirect portion of the total earnings impact for the industries in Table 1 can be estimated by treating the direct requirements as final demand changes and applying

TABLE 1 INDUSTRY-BY-INDUSTRY DIRECT REQUIREMENTS FOR A HYPOTHETICAL REGION

	Purchasing industry		
	1	2	Households
1.............	0.06	0.15	0.08
2.............	.12	.02	.10
Households.....	.18	.23	.06

NOTE.--Each entry represents the input required directly from the row industry for each dollar of output of the column industry.

TABLE 2 INDUSTRY-BY-INDUSTRY EARNINGS MULTIPLIERS FOR A HYPOTHETICAL REGION

	Purchasing industry		
	1	2	Households
1..................	0.200	0.035	0.021
2..................	.037	.247	.029
Households.........	.015	.018	.067
Total...........	.252	.300	.117

NOTE.-- Each entry represents the earnings paid, directly and indirectly, to the households employed by the row industry for each dollar of output delivered to final demand by the column industry.

them to the appropriate earnings multipliers. Similarly, the indirect impact on output (employment) of an additional $1.00 of output delivered to final demand can be estimated by treating the direct requirements as final demand changes and applying them to the appropriate output (employment) multipliers.

As previously noted, Table 1 indicates that the direct requirements of Industry 1 per $1.00 of output are 6 cents from other firms in Industry 1, 12 cents from Industry 2, and 18 cents from households. The indirect earnings impact that results from these output changes is estimated by multiplying the direct requirements by the respective column of earnings multipliers presented in Table 2. For example, entries in the first column of Table 2 are multiplied by the element in the first row and first column of Table 1 (6 cents). Entries in the second column of Table 2 are multiplied by the element in the second row and first column of Table 1 (12 cents), and entries in the third column of Table 2 are multiplied by the element in the third row and first column of Table 1 (18 cents). The results of these multiplications are presented in Table 3.

The total earnings impact is the total indirect impact of 7.2 cents from Table 3 (the sum of entries in Column 4) plus the direct earnings impact in Industry 1 of 18 cents (from the household row of Table 1). Again, this sum is 25.2 cents.

As described, the two approaches yield the same result; either can be used to estimate the total impact that results from a final demand change. [A generalized proof that the two approaches yield the same result is provided by Miller and Blair (*2*).] Using the first approach, the total impact is estimated by multiplying the change in final demand by the appropriate column of multipliers. In the second approach, the indirect impact is estimated by multiplying the direct impacts that result from the final demand change by the appropriate column of multipliers. The indirect impact is then added to the direct impact to obtain the total impact. In effect, the multipliers are used to estimate the indirect impact of secondary, or derived, final demand. The direct impacts can often be obtained through a survey of the initially affected industry, requiring only that the indirect impact be estimated using nonsurvey techniques.

As discussed in the following section, a combination of survey and nonsurvey techniques is likely to reduce error in estimating impacts because a large share of the total impact is the direct impact; as mentioned, these data are obtainable through surveys and are presumably more reliable than nonsurvey data.

A COMPARISON OF THE RIMS II HYBRID AND NONSURVEY APPROACHES

The accuracy of the two approaches is evaluated here by using each to estimate the earnings impacts for the states of Texas and Washington. The estimated impacts are compared with the earnings impacts estimated by the respective survey-based state models (*15,16*).

The total earnings impacts are estimated for each state using the RIMS II nonsurvey approach to measure the direct and indirect impacts; these results are then expressed as ratios of the total earnings impacts derived from the survey-based state models. Figure 1 shows the distribution of the ratios estimated for 52 industrial sectors in Washington State. As shown, 34 percent of the RIMS II estimates differ by 10 percent or less from the survey-based estimates, and 44 percent differ by more than 20 percent. Similar results for Texas are shown in Figure 2, in which the distribution of ratios calculated for 139 industrial sectors is shown. Figure 2 shows that 38 percent of the RIMS II estimates differ by 10 percent or less from the survey-based estimates, and 32 percent differ by more than 20 percent.

For both states, the industries with the largest differences are quite dissimilar, making it difficult to characterize them. For example, the four Washington industries with differences greater than 50 percent are forestry; petroleum refining; motor vehicles; and finance, insurance, and real estate. In addition, a comparison of differences, by industry, between states is complicated by the different levels of industry aggregation used for each state.

Figures 3 and 4 show the distribution of ratios using the RIMS II hybrid approach. Information on the direct requirements is simulated using the direct requirements coefficients from survey I-O tables for the two states. The coefficients are used as final demand changes and multiplied by RIMS II earnings multipliers to estimate the indirect impacts. These ratios cluster around 1.00, with 88 percent of the multiplier estimates differing by 10 percent or less from the survey-based estimates for Washington (see Figure 3) and 68 percent differing by 10 percent or less from the estimates for Texas (see Figure 4).

TABLE 3 INDUSTRY-BY-INDUSTRY INDIRECT EARNINGS IMPACTS FOR A HYPOTHETICAL REGION

	Purchasing industry			
	1	2	Households	Total
1..................	0.012	0.004	0.004	0.020
2..................	.002	.030	.005	.037
Households..........	.001	.002	.012	.015
Total...........	.015	.036	.021	.072

NOTE.-- Each entry represents the earnings paid, indirectly, to the households employed by the row industry for each dollar of output delivered to final demand by industry 1.

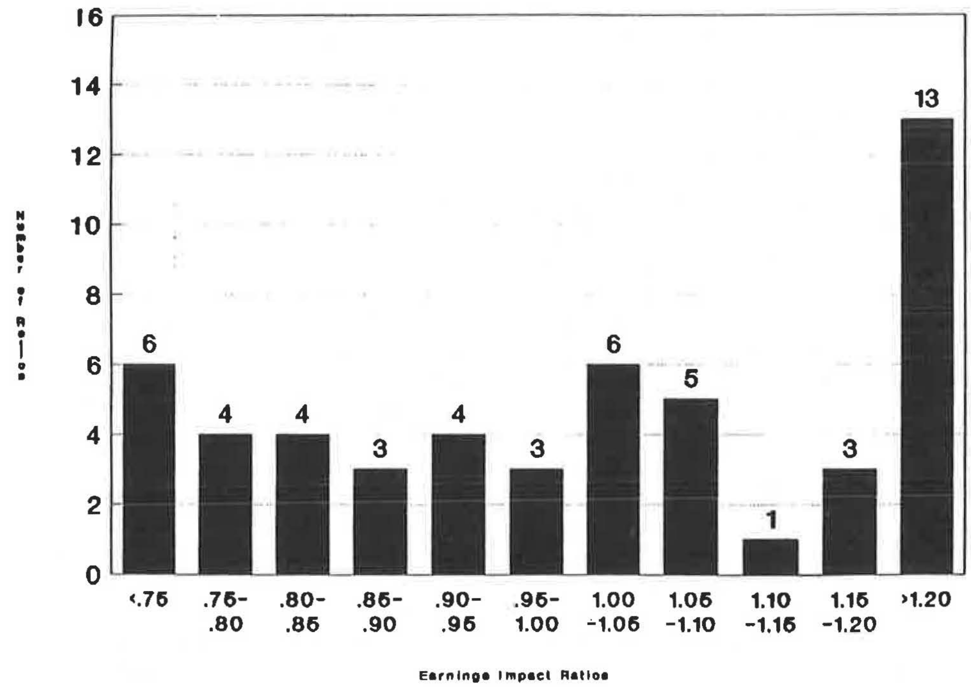

FIGURE 1 Distribution of ratios of estimated earnings impacts for nonsurvey RIMS II approach and survey approach: Washington.

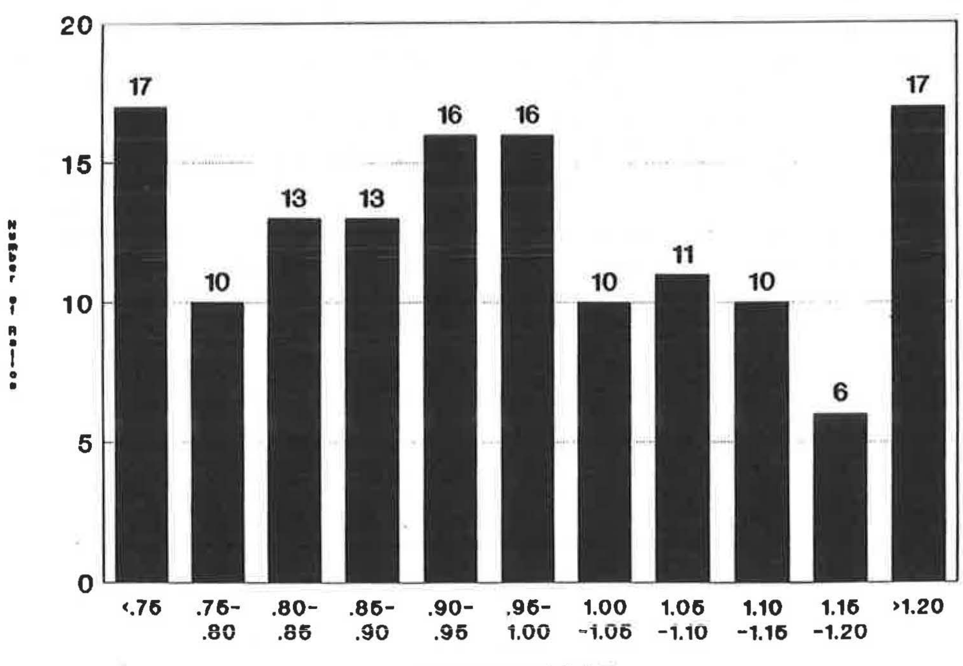

FIGURE 2 Distribution of ratios of estimated earnings impacts for nonsurvey RIMS II approach and survey approach: Texas.

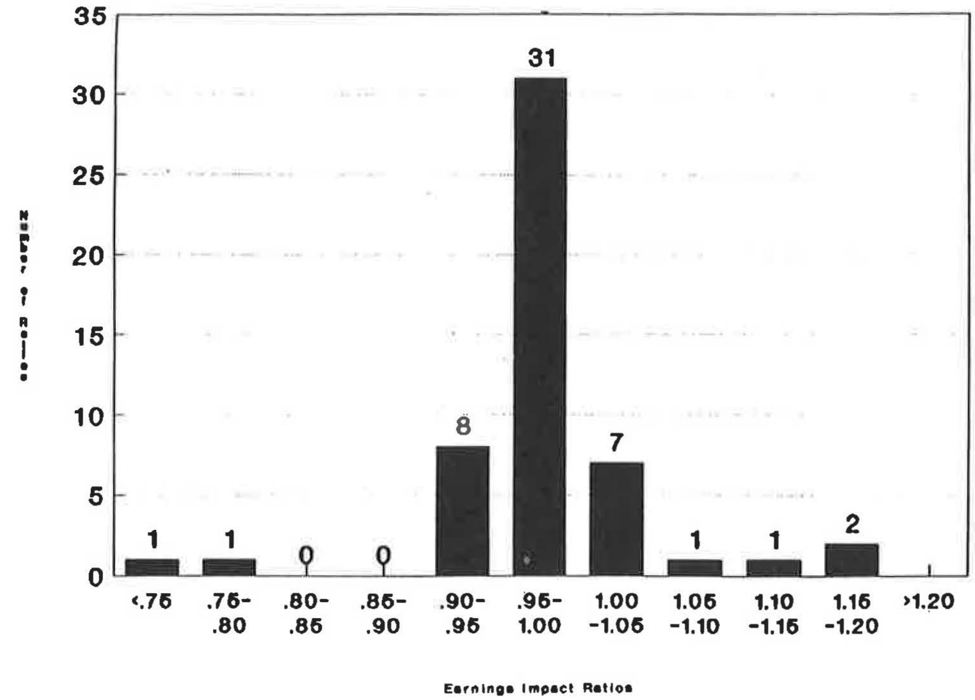

FIGURE 3 Distribution of ratios of estimated earnings impacts for hybrid RIMS II approach and survey approach: Washington.

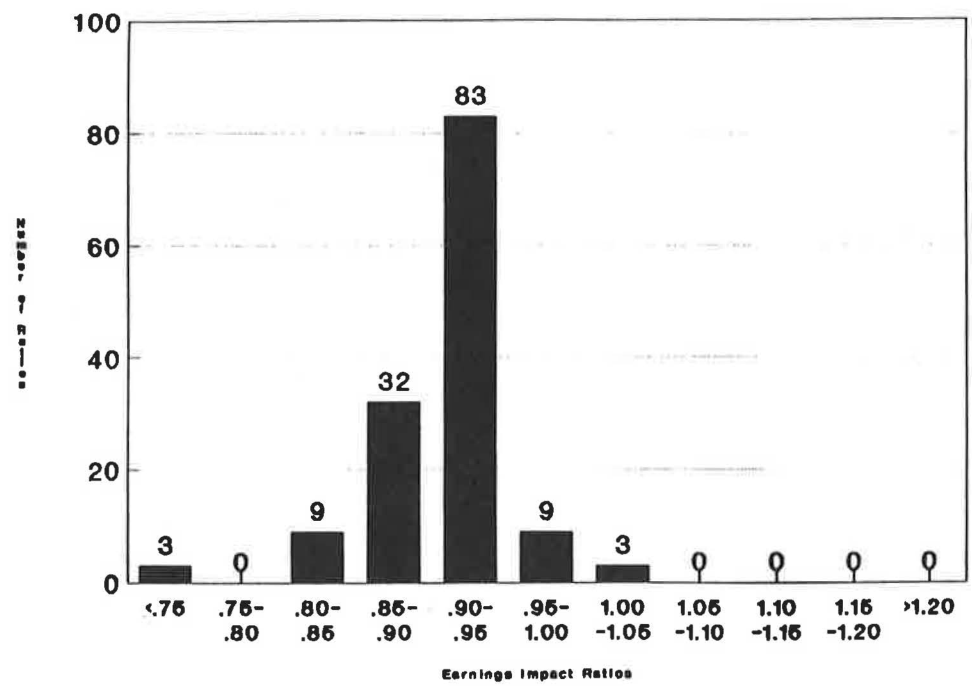

FIGURE 4 Distribution of ratios of estimated earnings impacts for hybrid RIMS II approach and survey approach: Texas.

This comparison indicates that the accuracy of impact estimates can be significantly improved by surveying the initially impacted industry for direct impacts. However, the distributions shown in Figures 3 and 4 are based on detailed knowledge of the direct impacts. For Washington, the inputs from 52 industrial sectors are known, and, for Texas, 139 are known.

Because such extensive surveys are costly, whether the same level of accuracy can be achieved with less information and, consequently, at a reduced cost is of interest. This possibility is examined for each industry by a cumulative replacement of RIMS II direct coefficients, in descending order beginning with the industry's largest input coefficient, with the corresponding survey-based coefficients. [Research indicates that the largest coefficients have the largest effects on multipliers (17).] Following each replacement, the new combination of RIMS II and survey-based coefficients is used as a final demand column and multiplied by the RIMS II earnings multipliers. The resulting earnings impacts are then compared with the survey-based estimates. The change in the mean and standard deviation of the ratios as the number of replaced RIMS II coefficients increases is shown for Washington and Texas in Figures 5 and 6, respectively. Figure 5 shows that, for Washington, the mean approaches unity as the number of replaced coefficients increases from 0 to 15 and remains relatively constant thereafter. Figure 6 shows that, for Texas, the mean is slightly closer to unity when there is no replacement than when all RIMS II coefficients are replaced. For both states, as indicated by the standard deviation, the ratio for any given industry at a low level of replacement is likely to be considerably above or below the mean; however, the individual

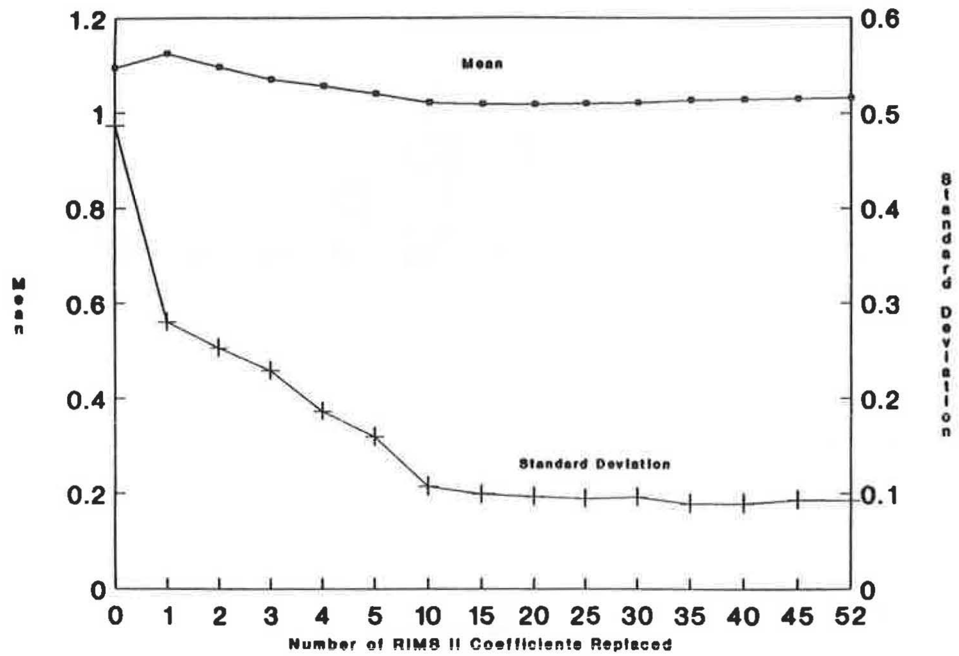

FIGURE 5 Mean and standard deviation of ratios of estimated earnings impacts with cumulative replacement of RIMS II direct coefficients: Washington.

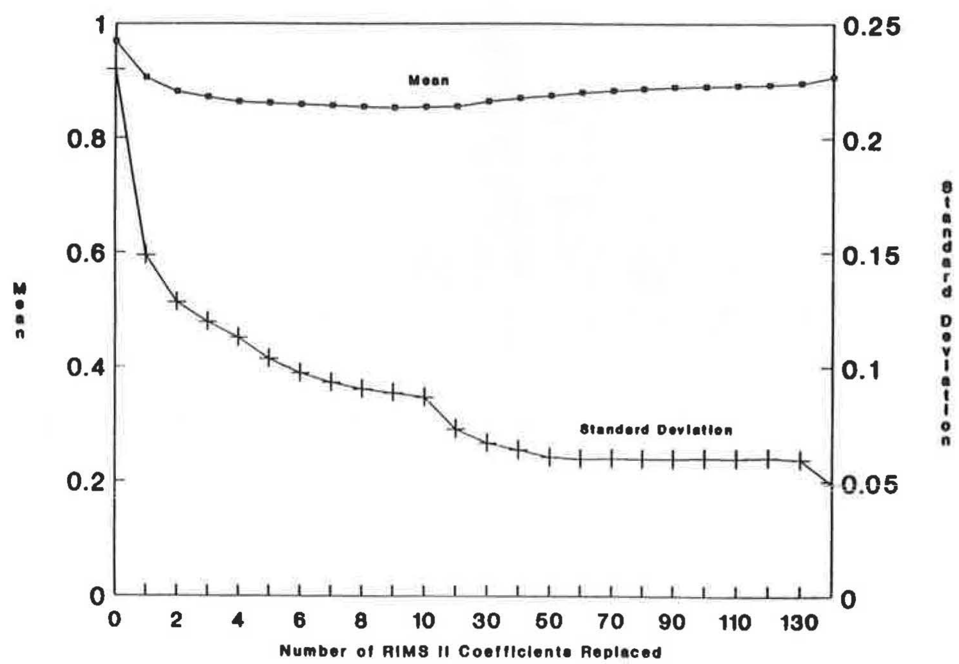

FIGURE 6 Mean and standard deviation of ratios of estimated earnings impacts with cumulative replacement of RIMS II direct coefficients: Texas.

observations become more clustered about the mean as the number of replaced coefficients increases. The largest decline in the standard deviation occurs for both states when the largest RIMS II coefficient—for most industries, the household row coefficient—is replaced. This result is analogous to surveying the industry in which the initial final demand change occurs to determine the change in payrolls (the direct earnings impact) and using RIMS II to estimate the indirect earnings impact. Figures 5 and 6 show that the standard deviation of the ratios remains relatively constant after an average of 20 to 30 percent of the coefficients in each industry have been replaced.

The preceding analysis indicates that the accuracy of impact estimates is likely to be significantly improved by surveying the initially impacted industry to determine the direct requirements and using RIMS II (or other nonsurvey approaches) to estimate the indirect requirements. When estimating earnings impacts, survey information should at least be collected on payrolls; accuracy is likely to be further improved if information is also collected on the most important material and service inputs. (The employment data associated with the payrolls should be collected if employment impacts are being estimated.)

AN APPLICATION OF THE RIMS II HYBRID APPROACH

The hybrid RIMS II approach was used by the Center for Public Service (formerly Tayloe Murphy Institute) at the University of Virginia to analyze the impacts of a General Electric (GE) plant on the Charlottesville, Virginia, Metropolitan Statistical Area. A portion of that study's results is reproduced to demonstrate the estimation of earnings impacts using survey data on the direct requirements and RIMS II multipliers. The same procedure can be used to estimate the impacts of constructing and operating transportation facilities.

GE provided information on the direct requirements purchased locally for 22 of the 39 industrial sectors presented in Table 4 (*18*). (RIMS II can provide two series of tables of

TABLE 4 EARNINGS IMPACTS IN THE CHARLOTTESVILLE, VIRGINIA, MSA (*18*)

Industry	Local direct expenditures (thousands)	RIMS II earnings multipliers	Earnings impacts (thousands)
Agriculture	$ 90.0	0.2581	$ 23.2
Forestry and fishery products	0	.2013	0
Coal mining	0	0	0
Crude petroleum and natural gas	0	.1651	0
Miscellaneous mining	.1	.3712	0
New construction	0	.4743	0
Maintenance and repair construction	213.8	.5721	122.3
Food and kindred products and tobacco	0	.2424	0
Textile mill products	0	.2544	0
Apparel	0	.4168	0
Paper and allied products	25.1	.2512	6.3
Printing and publishing	4.6	.3804	1.7
Chemicals and petroleum refining	66.8	.2167	14.5
Rubber and leather products	0	0	0
Lumber and wood products and furniture	128.2	.3839	49.2
Stone, clay, and glass products	1.4	.3068	.4
Primary metal industries	.2	0	0
Fabricated metal products	4.3	.3121	1.3
Machinery, except electrical	23.6	.3134	7.4
Electric and electronic equipment	731.8	.4888	357.7
Motor vehicles and equipment	0	0	0
Transportation equipment, except motor vehicles	0	0	0
Instruments and related products	0	.4515	0
Miscellaneous manufacturing industries	59.1	.3882	22.9
Transportation	187.0	.6215	116.2
Communication	546.4	.3473	189.8
Electric, gas, water, and sanitary services	129.1	.1637	21.1
Wholesale trade	0	.5062	0
Retail trade	0	.5980	0
Finance	0	.4226	0
Insurance	0	.4310	0
Real estate	68.4	.1007	6.9
Hotels and lodging places and amusements	26.9	.4472	12.0
Personal services	0	.5717	0
Business services	832.5	.6706	558.3
Eating and drinking places	0	.4045	0
Health services	2397.6	.6689	1603.8
Miscellaneous services	117.4	.6123	71.9
Households	38800.0	1.2116	47010.1
Total	44454.3		50197.1

I-O multipliers: one for the 39 industry aggregates presented in Table 4 and the other for 531 industries.) Local expenditures of $44.5 million are approximately 28.5 percent of GE's total expenditures (not shown), whereas the direct coefficients estimated with RIMS II indicate that 53 percent of the total expenditures are local. Because RIMS II overestimates purchases from within the region (and, consequently, underestimates purchases from outside the region), the impacts will be overestimated if a change in the output delivered to final demand by GE is multiplied by RIMS II multipliers using the nonsurvey approach. For example, when an estimate of such a change is multiplied by the RIMS II earnings multiplier for the industry that includes GE, the total earnings impact is estimated to be $82.7 million. (The gross output associated with the expenditures in Table 4 is estimated to be $171.6 million, which is then multiplied by 0.4821—the RIMS II earnings multiplier for the electric and electronic equipment industry—to estimate the earnings impact of $82.7 million.) However, the impact error is reduced by treating the GE expenditures as changes in final demand and multiplying them by the appropriate industry-specific RIMS II multipliers (see Table 4). In this case, the total earnings impact is $50.2 million. Essentially, the same impact would have been estimated if information were collected on only five industrial sectors (households, health services, business services, electric and electronic equipment, and communications), supporting the contention that information need be collected only on the most important inputs.

SUMMARY

A hybrid approach to estimating economic impacts was described. This approach uses survey information on the direct output effects in conjunction with RIMS II multipliers. It was demonstrated that impacts can be estimated when the direct output effects of a change in final demand are themselves used as changes in final demand and applied to I-O multipliers to estimate the indirect effects. A comparison was made between the impact estimates that result when the direct output effects applied to RIMS II earnings multipliers are (a) based on survey information or (b) estimated by RIMS II. The comparison indicated that the accuracy of the impact estimates can be significantly improved when the hybrid approach is used and, further, that survey information need only be collected on the most important inputs. The hybrid approach was demonstrated by estimating the earnings impacts associated with the operation of a GE plant in Charlottesville, Virginia.

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Using Risk Assessment for Aviation Demand and Economic Impact Forecasting in the Minneapolis-St. Paul Region

MATTHEW F. HARDISON, RICHARD R. MUDGE, AND DAVID LEWIS

The process of risk assessment was applied to airport strategic planning for analysis of the adequacy of the Minneapolis-St. Paul International Airport. Three steps were used to forecast demand: (a) development of a structure and logic model; (b) development of initial input assumptions; and (c) forecasting, risk analysis, and public exposure. The findings are presented in terms of operational results that define the probability of meeting unconstrained demand under each of three proposed development scenarios. The operational data are translated into implied economic benefits to the region.

Apogee Research and its partner, James F. Hickling Management Consultants, were asked to develop a proposed approach to evaluating the adequacy of the Minneapolis-St. Paul (MSP) International Airport. The existing forecasts, developed for the airport master plan, were correct enough, but the implications were unclear. The planners for the Metropolitan Council of the Twin Cities were faced with the real risk that the forecasts might be wrong. Consequently, the planners needed a process that, in addition to projecting growth in demand, could interpret the forecasts in light of the economic consequences of alternative airport development scenarios.

A request came to Apogee Research, Inc., in the form of a series of questions, the most fundamental being, Are the forecast results correct? Related questions included (a) What are the sensitivities of the forecast to changes in the underlying assumptions? and (b) What do each of the development alternatives imply for long-term development in the region? As a practical matter, any technical evaluation also had to bring together the diverse and divisive groups involved in airport planning if the process were to prove successful.

Simply reviewing the existing forecast would add no new information and was unlikely to create the consensus that would be necessary for long-term investment decision making. Thus, Apogee began by asking a new question: What is the risk that the forecast will be wrong?

If the forecast were framed in terms of the probabilities of meeting demand under selected airport development (i.e., capacity) scenarios, the impact (economic or financial) of different decisions on the region could be evaluated. However, to do so would imply the simulation of a wide variety of inputs for the entire planning horizon—in this case through the year 2018.

The process selected to carry out the simulation was risk assessment. The risk assessment framework, customized for use in aviation strategic planning, would simultaneously evaluate the potential variability in the forecast inputs and therefore the potential variability in the outputs.

RISK ASSESSMENT

Forecasts are often used to make major long-term investment decisions, as they should be. However, forecasts are generally wrong. Although a forecast may, for example, correctly pick the direction of change (i.e., growth or decline), the magnitude of the actual change is often far different from that forecast.

For example, two key parts of the technical portion of an airport analysis—the expected amount of air traffic and the future capacity of the airport—require long-term forecasts of economic, social, technical, and political factors. In most long-term planning efforts, these forces are rolled into a single discrete forecast or a set of discrete forecasts. Each of these forecasts results from a series of explicit and implicit decisions about the many variables that influence the forecast. Some may be highly unlikely, such as explosive traffic growth with no capacity improvements. Although this traditional methodology of probable or expected outcome helps focus the decision-making process, it provides no guidance regarding the likelihood of a given outcome, thereby leaving the community and its elected decision makers with an incomplete view of the future.

Hence, forecasts themselves often become a major focus of local debate. Those in favor of a given solution will, of necessity, rely on projections in justifying their proposed approach. However, those in disagreement with the forecasts will offer resistance, leading to a protracted debate among experts. Moreover, those opposed to the approach for other reasons (such as its implications for the pattern of economic development) will also focus on the projections, knowing full well that virtually every important assumption underlying a projection will, to some extent, be wrong. In this way, opponents of a given investment can pose a serious and effective threat to the planning process by creating plausible scenarios that differ from those underlying official projections.

Should decision makers and planners ignore forecasts? Of course not. Public participation and debate over forecasts is

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natural and productive, and should be encouraged. But how can forecasts be developed and presented in a way that defuses the unproductive acrimony and manipulation that so often plague forecast-related planning efforts? Reliance on high and low cases has proven to be of little value in this regard because they, like the point-estimate forecasts, indicate nothing about the relative likelihood of any given outcome. Perhaps even worse, they are usually developed by assuming all variables change in the same direction—an outcome that is just as unlikely as all assumptions being accurate.

Probability provides a way around the limitations of the discrete point-estimate forecasts by describing the confidence, or odds, that an expected outcome will actually materialize. To understand how probability aids decision making, consider a simple example. Before the advent of powerful computers, weather forecasters would simply assert their mean expectations: "We do not expect rain today." The decision on whether or not to hold a picnic would be easy. Now, the same forecast incorporates the probability for each causal factor in the determination of rain, and the forecaster announces, "There is a 25 percent chance of rain by midafternoon." A more reasoned decision regarding the picnic is now possible. If the event involves costly logistics for hundreds of people, a rain date might well be announced. In the past, provision for risk was not possible, and many dollars—not to mention goodwill and tempers—were lost.

A similar process—one that would integrate probability with the existing forecasting methodology—would clearly assist in resolving many of the key questions posed by Minneapolis in particular, and those raised during airport strategic planning in general. The approach adopted for the Minneapolis-St. Paul analysis, termed "risk assessment," is based on risk analysis techniques strongly grounded in statistical theory. By quantifying the risks of each of the key inputs to a forecast, risk assessment allows explicit recognition of those factors that are only implied in traditional estimates. Instead of the point-estimate results generated by most air traffic forecasts, for example, the process yields a probability distribution around each key output that more accurately portrays potential variability over time. As such, this tool allows flexibility in policy development by documenting the trade-offs of different levels of service and the ability to plan for a full range of outcomes.

DEVELOPING THE FORECAST

Forecasting demand is the critical first step in the strategic planning process because forecasts serve as the basis for all strategic planning decisions: determining the expected adequacy and longevity of the current facilities, the cost of development alternatives, the implicit quality of service the region provides, and the potential economic benefits of the alternatives. MSP International Airport already had point-estimate demand forecasts in place. These forecasts were used as the basis for modeling, both to provide consistency with existing results (the expected values of the forecasts would approximate the point-estimate forecasts of the existing forecasts) and to ensure that the underlying demand model did not itself become the point of debate. This was accomplished in three steps:

- Development of a structure and logic model;
- Development of initial input assumptions; and
- Forecasting, risk analysis, and public exposure.

Development of Structure and Logic Model

The first step was to become thoroughly familiar with the methodology of the existing analyses, including forecast demand and capacity estimates. This step was not merely a review, but involved the development of detailed structure and logic diagrams for the entire forecasting process and for each category of traffic (such as air carrier, air freight, and general aviation). In this effort, maximum use was made of the forecast framework developed for the region's master plan to ensure direct comparability of results.

Figure 1 shows a structure and logic diagram of the forecasting process for air carrier traffic that was developed for MSP International Airport. Similar diagrams were developed for the remaining categories of traffic. The purpose of these diagrams was threefold:

- To document precisely how the different assumptions of the existing forecast are combined to produce forecasts of each of the key input variables (annual and for various times of day and year) for each category of traffic;
- To obtain agreement from the client and interest groups that the process was properly understood and specified (the structure and logic diagrams then became the basis for algorithms programmed into the risk analysis software); and
- To present the forecasting procedure in a way that the public and interested parties could understand.

The process shown in Figure 1 identifies both the econometric and the accounting (or nonstochastic) and judgmental aspects of the forecasting process. The econometric relationships were fully exposed, along with ancillary assumptions, in the subsequent step.

Development of Initial Input Assumptions

Once the essential data requirements were in place, all input assumptions to the risk assessment process had to be developed. In the case of forecasts of demand and financial feasibility, these assumptions included specific demographic and economic variables for the region that were in turn used to develop the activity forecasts.

Baseline input assumptions (e.g., population, employment, fare elasticity, and various aircraft variables) were established by drawing from the airport master plan (for consistency). The risk analysis approach requires that a probability distribution be attached to each input assumption. Statistical analysis and judgmental factors were used to assign the initial probability distributions. However, to facilitate community and outside expert involvement, expert panels were assembled that were responsible—after a briefing on the technical approach and participant responsibilities—for confirming or adjusting the initial distributions, as necessary. The process had two key benefits:

- Those groups or individuals with a special interest (such as airline, business, or community leaders) were part of the

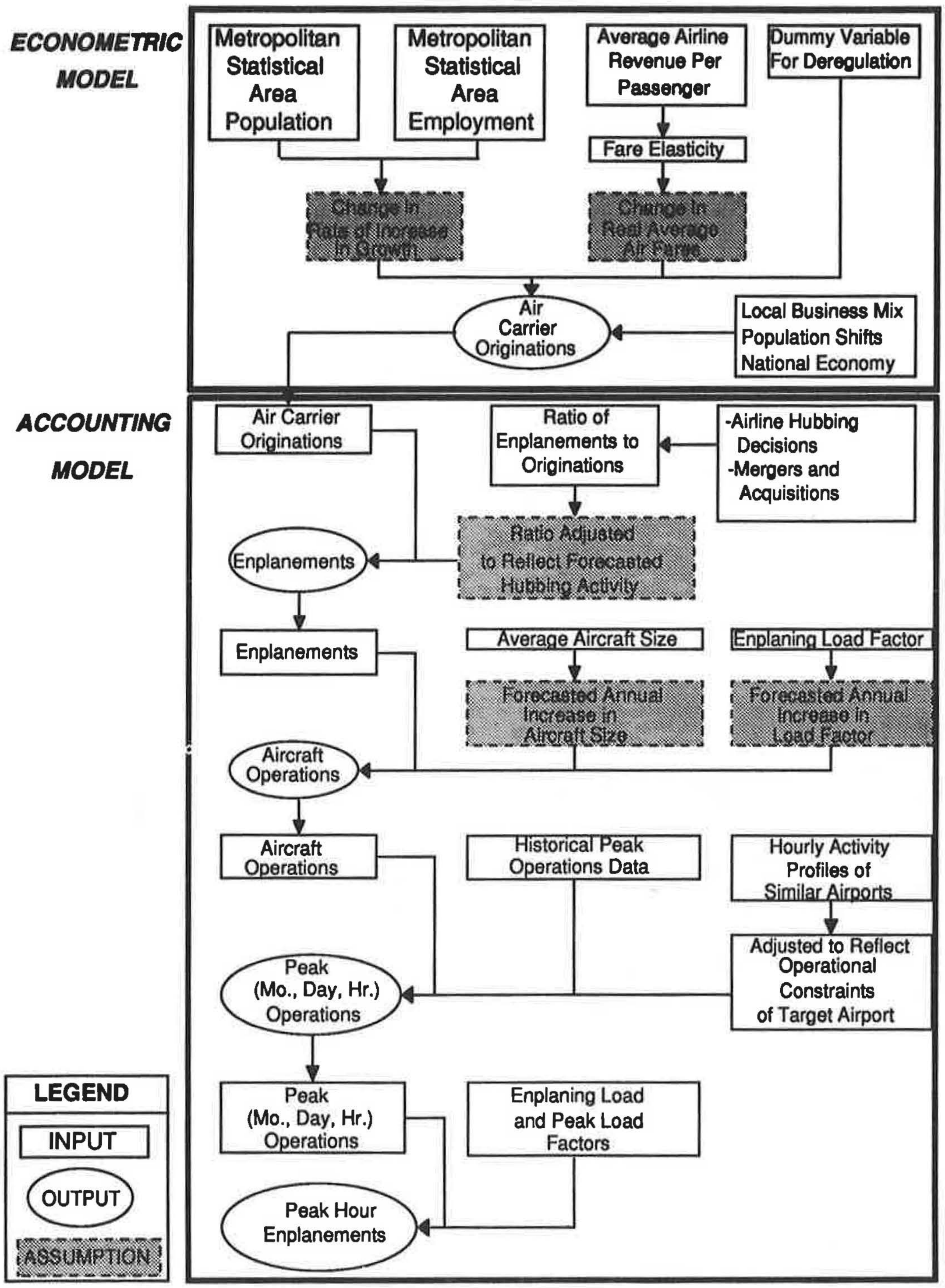

FIGURE 1 Logic diagram for forecasting model (domestic air carrier activity).

process of developing assumptions and thus were involved before actual traffic forecasts were developed (thereby eliminating a great deal of unrest over the results later on); and

- The process facilitated the application of full-scale risk analysis by identifying the estimated probabilities associated with all inputs.

Forecasting, Risk Analysis, and Public Exposure

Once the input assumptions and ranges were developed, computer software translated the ranges into formal probability distributions (called probability density functions). With these in place, the computer software used the forecasting methodology (based on the structure and logic flows programmed into the software) to generate traffic forecasts. The forecasts were developed using Monte Carlo simulation, in which the computer calculates each forecast an unlimited number of times (generally 1,000) by sampling randomly from the various probability distributions. Thus, instead of a point estimate of traffic for each forecast year, this process generated a probability distribution (see Figure 2).

The mean of the distribution often corresponds closely to the point estimate that the traditional process would yield. This relationship is important to understanding the interaction between the traditional forecasting technique and risk analysis.

Once this point in the analysis was reached, changes in the underlying assumptions had little effect on fundamental results.

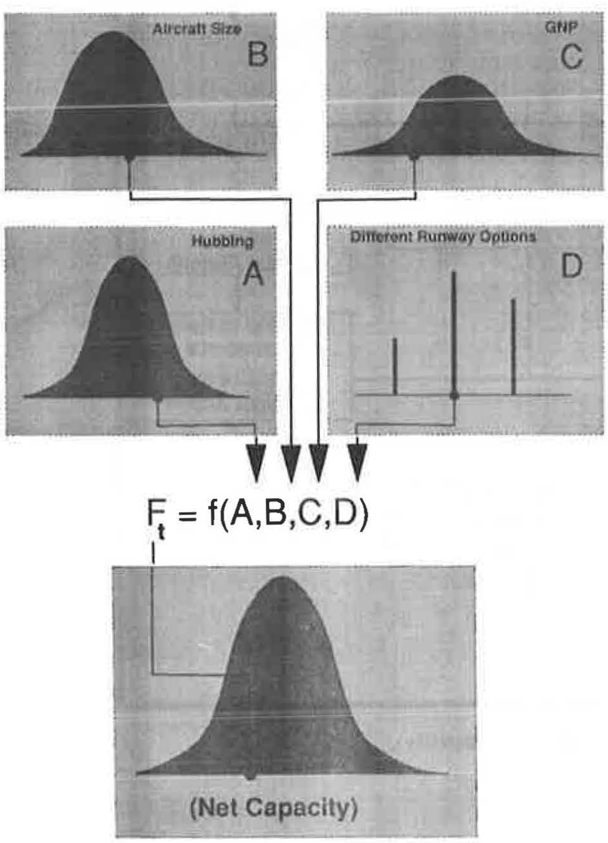

FIGURE 2 Monte Carlo simulation: a way to combine probabilities.

For example, an 85 percent probability of exceeding a given number of operations might change to an 80 percent probability with a fairly large change in key assumptions. This approach allows those parties with a special interest in the results (such as a community or regional planning agency) to quickly put into context the significance of debate over the effect of changes in the model inputs. In this way, special panels or workshops held to discuss the findings defused potentially unproductive debate and gave the forecasts the credibility needed to support the subsequent planning process.

FINDINGS

Forecast results are presented in two ways. First, operational results are provided that define the probability of meeting unconstrained demand under each of three proposed development scenarios. Second, the operational data are translated into implied economic benefits to the region.

Operational Analysis

Although there are different ways to measure the level of service, the approach used in this study was based on the probability of being able to meet expected future demand. A low probability will result in a low quality of service. A high probability, however, runs the risk of overinvesting or building too soon if demand does not materialize.

Traditional planning efforts implicitly assume only a 50 percent chance of meeting expected demand (or, conversely, a 50 percent chance of having adequate capacity). Providing a higher level of assurance would imply a higher quality service to air travelers (fewer delays and shorter delays) but would also require higher costs (financial as well as political) and be likely to increase environmental and other negative effects on the surrounding community.

Figure 3 combines the baseline forecasts with three capacity options contemplated at MSP International Airport: Strategy A, Strategy B, and Strategy C. The base case included only those capacity options already programmed. Strategy A included base case improvements plus a new north-south runway. Strategy C comprised Strategy A and a third parallel.

The results reflect not only each of the alternative runway layouts, but also the likelihood of future air traffic control improvements and the full range of variables that affect future demand. Figure 3 uses expected instrument flight rules (IFR) capacity estimates for each option because the focus is on the year 2008; however, the difference between these estimates and the visual flight rules (VFR) was small.

Net capacity is shown along the bottom of the figure. Negative numbers indicate a shortfall in capacity, whereas positive numbers show capacity in excess of the expected demand. The vertical scale indicates the probability that expected demand will be less than the capacity shown, that is, that the airport will be large enough. For example, there is only about a 5 percent chance that the base case will provide adequate capacity in 2008. However, there is a 23 percent chance that Strategy A will be adequate and a more than 85 percent chance

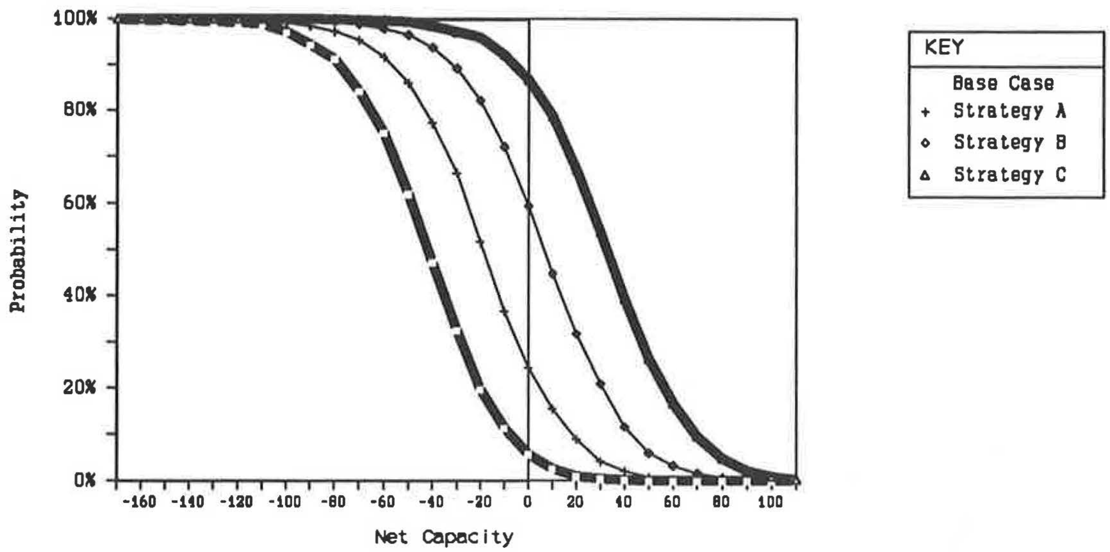

FIGURE 3 Net capacity probabilities for MSP International Airport in year 2008.

for Strategy B. By 2018, as presented in Table 1, the choices are more limited. In that year, Strategy A offers little chance of being able to meet expected demand, although Strategy B shows an almost 45 percent probability of meeting demand. The analysis further indicates that Strategy B represents close to the maximum operating capacity for the current site.

These findings make clear the operational implications of each of three airport development strategies, and, as was suggested earlier, the question of the accuracy of the forecasts now needs no answer. However, from the planner's perspective, a new question is raised: What are the costs and benefits of each of the alternatives?

The technical analysis evaluated both engineering costs and direct, quantifiable benefits (such as fuel savings to the airlines as a result of improved capacity). Financially, this analysis demonstrated that all capacity improvements would realize a high rate of return.

Economic Benefits

Airports often play a key role in attracting new business and in encouraging existing businesses to expand. Economic development was a motivating factor in the decision to build a new Dallas Airport in the early 1970s and in the current plans to build a new airport in Denver. However, strategic planners often make key investment decisions in the absence of any understanding of the potential economic benefits (or costs) of each alternative. Consequently, an analysis of the range of potential economic benefits associated with the development scenarios was prepared on the basis of the risk assessment results. The findings of the MSP International Airport analysis provided information on the range of benefits attributable to aviation under each growth or development scenario and made clear the value of committing to continued growth.

Airport economic impacts are of two types: (a) direct impacts related to handling and servicing aircraft, passengers, and cargo, and (b) indirect impacts as these streams of activity move through the economy. The summary numbers presented in this section combine both types of impacts to emphasize the general findings—the range of potential impacts associated with airport development scenarios.

The potential regional economic gains (direct and indirect) that could be achieved from increasing capacity to meet expected demand are quite large (see Figure 4). It is estimated that MSP International Airport currently contributes more than $2 billion a year to the region's economy. On the basis of the airport economic impact model developed for the Minneapolis Chamber of Commerce, the unconstrained forecast of enplanements and aircraft operations suggests that this impact could increase to about $3.5 billion over the next two decades.

However, if a significant increase in capacity is not realized, the severe capacity constraints forecast for the base case development scenario imply annual losses of $1 billion or more by 2008—a loss of one-third. This estimate assumes that the overall level of activity through MSP International Airport will drop in line with the expected higher delays. In other words, rather than impose huge delays on air travelers, the airlines will shift activity to other airports by early in the next century. Clearly, even without significant capacity improvements at MSP International Airport, activity would still increase regional income and add new jobs. However, although the regional economy would not shrink if significant capacity additions were not made, future growth would be limited.

In addition to the value of economic activity, an airport also brings new jobs. One that is capacity constrained, on the other hand, will limit growth below its potential. As dem-

TABLE 1 PROBABILITY OF ADEQUATE CAPACITY IN MEETING PEAK-LOAD DEMAND

	Year		
	1998	2008	2018
Option	Percent		
Base case	10	5	1
Strategy A	67	18	9
Strategy B	92	87	40

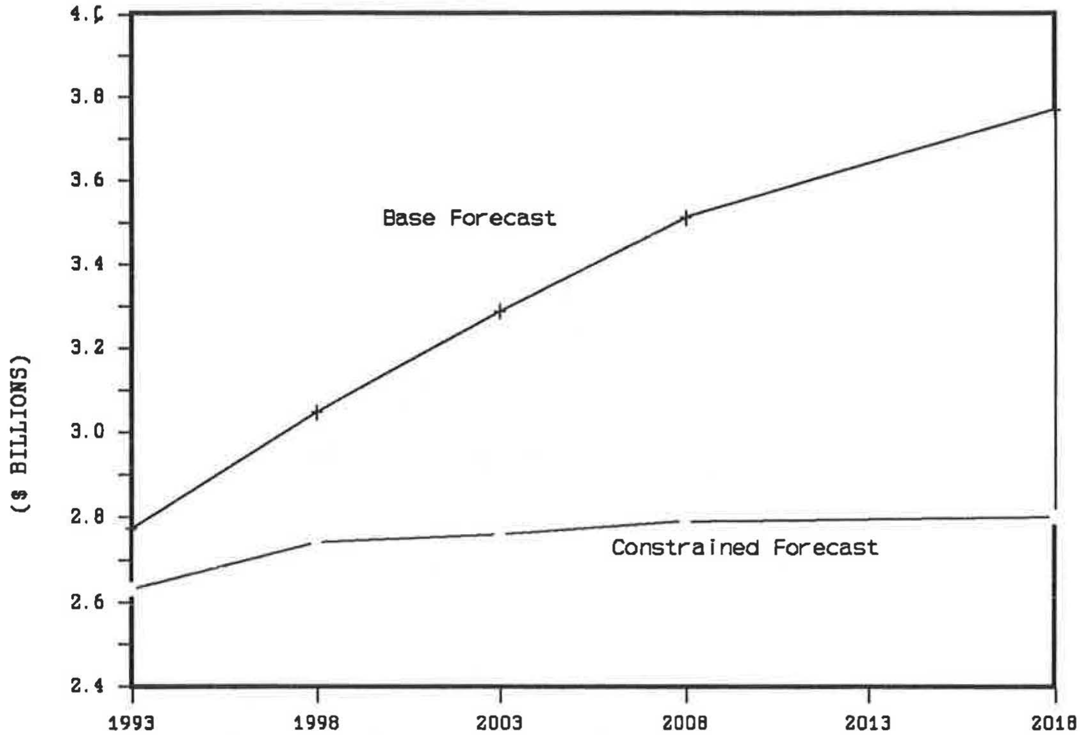

FIGURE 4 Range of potential economic impacts attributable to alternative airport demand scenarios at MSP International Airport.

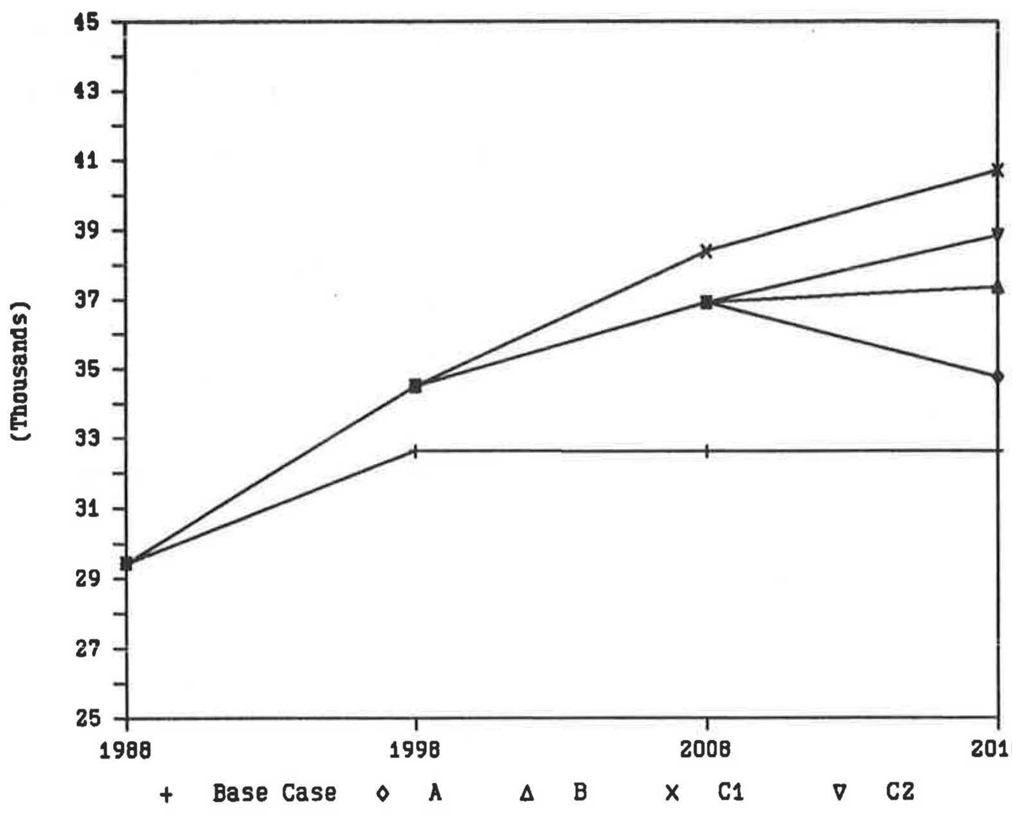

FIGURE 5 Range of potential employment impacts by airport development scenario.

onstrated in Figure 5, for example, the change in service implied by increased delays can only result in lost opportunities for growth. Here, the greater delays and diverted flights under the base case result in a loss of thousands of jobs in the region.

These estimates are based on changes that either restrict capacity to well below current demand or allow capacity to grow roughly in line with expected demand. Yet even the high end of the range of potential impacts may understate the potential growth; by offering a higher level of service, an airport with excess capacity could act as a "growth pole."

CONCLUSION

The risk assessment process has been applied successfully in a variety of analyses. Until the Minneapolis analysis, however, the only related application was an evaluation of the costs and benefits of the nation's air traffic control system. Since its introduction to airport strategic planning, the process has become accepted not simply as a means of identifying the implications of operational, financial, and economic forecasts, but also as a particularly useful tool for redirecting the debate away from the forecasts and toward a decision.

Did the process work in Minneapolis? Before the analysis began, the general decision taken from the airport master plan had been that no decision was necessary—capacity was adequate. And it would have been for the next 5 to 10 years. However, on release of the analysis, the Minnesota state legislature mandated that a large tract of land being considered for sale be held until a decision could be made on how to meet the capacity needs of the region. At the same time, the Metropolitan Council of the Twin Cities began to explore extensive capacity additions at the existing site as well as the possibility of a new airport. The analysis had taken the original forecasts and explicitly identified their strategic, long-term implications. As a result, the regional planning agency and special interest groups together decided to pursue additional economic opportunities rather than face regional opportunity costs. The process had worked.

Beyond these results, the process of preparing the analysis led to the identification of new opportunities for the application of risk assessment. For example, the economic impact of each development scenario depends on the baseline used and assumptions pertaining to the redistribution of aircraft demand at capacity-constrained airports. The analysis presented here focused on comparisons with what would happen under the base case with a predefined set of changes in aircraft mix. However, the base case is itself a moving target, with the practical capacity of the airport continually changing. In addition, faced with severe capacity constraints, the aircraft mix will likely either change as a result of fees (as was proposed at Boston recently), through restrictions, or naturally (as often happens when pilots of general aviation aircraft find capacity-constrained airports less attractive). Recent work with Martin O'Connell Associates, a firm specializing in aviation economics, points to the ability to define direct employment implications even to the level of aircraft mix scenarios. Such results would prove invaluable documentation for an informed and defensible decision on the priority to give different types of aircraft operations.

The process has proven to be a practical, politically sensitive approach to strategic planning and analysis. Its degree of precision can be tuned to meet specific strategic planning needs because the focus is no longer on the forecasts, but instead on the risks.

Transport in the Input-Output System

ESRA BENNATHAN AND MARK JOHNSON

The links between the transport industry and other economic sectors of production or demand are examined for Côte d'Ivoire, India, Mexico, Philippines, and the United States, on the basis of recent input-output (I-O) tables of those countries. The extent to which the cost of transport services is affected by the prices of other goods and services that are required as inputs in the production of transport is indicated. The extent of the effects of prices and productivity of the labor and capital employed directly by the industry are also indicated. Effects of different tax systems on the cost of transport services are examined. Dependence of transport on industrial (intermediate) demand and on demand generated by private and government consumption, investment, and exports (final demand) and the extent to which the demand for transport reacts to changes in aggregate output are discussed. Further, realistic examples are used to demonstrate the ways in which I-O tables can be used to predict input requirements of the transport industry and of the demand for its output. The precautions necessary in such exercises and in international comparisons and the meaning of different concepts of the relative total size of a country's transport industry are discussed. In addition, the main features of I-O accounting and its relation to national income accounting are reviewed. Usually, national accounts are constructed with the help of relations discovered in I-O accounts so that the same qualifications apply to inferences drawn from either. Input-output accounts rarely attempt to credit transport with the output of own-account (i.e., self-operated) transport operations. Therefore, value added in transport and total output of transport are typically understatements of the true value of a country's total transport activity. Further, the transport cost component of a transaction between two industries could be debited to either the buyer or the seller as a purchase from transport. Different conventions are followed in this matter and the differences affect the apparent transport requirements of various industries.

Structural analysis of industries in terms of their input-output (I-O) relations may seem rather an old-fashioned pursuit but so far it has not been done for the transport industries of developing countries. Input-output tables are used essentially for descriptive purposes and the small number of countries covered make this study a modest attempt in this direction. The links between transport and other sectors of the economy are described as they appear from the I-O tables of five countries: Côte d'Ivoire, India, Philippines, Mexico, and the United States. Figure 1 presents the underlying accounting framework of I-O analysis. Essentials of the method become clear by thinking of a closed economy without foreign trade and, moreover, one in which the output of an industry can be unambiguously identified with one well-defined commodity or service.

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TRANSPORT AS A USER OF RESOURCES

Differences between the five countries in the share of intermediate inputs within the total value of transport output are partly explained by differences in prices, including the cost of labor per unit of output.

As a broad generalization, the gross output of the transport industry is about 1.8 times the value added by transport. The share of value added (the value of labor and capital services employed directly by the industry) in the cost of total output is typically greater for the transport industry than for the average of all industries. A relatively light share of intermediate inputs in the cost of producing transport services tends to insulate transport from movements in the prices of traded goods in the economy and thus from the effect of competitive forces or of technical progress acting on those prices.

Transport is less sensitive than other industries to the cascading effect of turnover taxes. Users and the transport industry should therefore be less affected and benefit less than other industries from the trend towards value-added taxation.

DEMAND FOR TRANSPORT

The average share of transport cost in the total output value of industries is found to be close to 2 percent in all countries. Although the average direct transport input coefficients of industries is similar, this is not true of the total coefficient, which represents the shares of different inputs required per unit dollar increase, in each industry's sales to the final demand sector. In the case of the required transport inputs the total demand coefficients are significantly higher than the direct coefficients that measure input requirements for the prevailing output levels.

In order to sustain a unit increase of each industry's sales to final demand, transport has to increase its output by more than the average industry. Demand for transport is thus more sensitive to a general increase (or decrease) in general production than the average industry.

INDICATORS OF THE RELATIVE SIZE OF TRANSPORT ACTIVITY

Different measures of the relative size or importance of transport in the national economy are value added, gross output, final demand, and the index of sensitivity to general output changes. Each measure provides an answer to a different question.

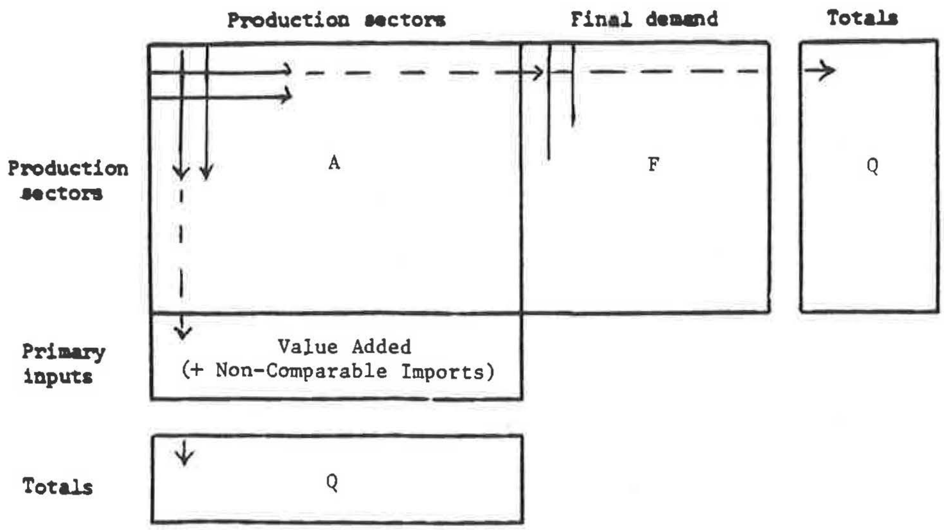

FIGURE 1 Accounting framework of I-O analysis.

Matrix **A** at the upper left corner of the scheme (Figure 1) records the flows of intermediate goods and services traded between different production units, called industries. The scheme can be a commodity-by-commodity matrix (commodity *i* as an input into commodity *j*), a commodity-by-industry matrix (commodity *i* into the production of industry *j*), an industry by commodity matrix, or an industry-by-industry matrix. Concentration here is on this last type in which each industry has a row and a column arrayed in either direction in the same sequence. The crucial convention on dimension is that each industry distributes its output along its row to other producers within matrix **A**, and to final demand sectors **F**. In the absence of foreign trade, final demand consists essentially of private and government consumption and investment.

Industry sales are elements in the rows and columns record inputs for each industry. Inputs consist of intermediate goods and services (recorded in **A**) and of primary inputs. Primary inputs consist of the industry's own resources which contribute its value added (wages and gross profits) and of indirect taxes that make up the difference between value to the producer and value to the buyer.

In the absence of imports, row totals must equal column totals for each industry (in **Q**)—the value of an industry's sales (rows) equals the total value of its output (columns).

The simplicity of this rudimentary scheme is destroyed by the existence of foreign trade and by the heterogeneity of most industries' output. Different I-O tables deal with imports in different ways and this affects the comparability of different tables across countries. The problem of heterogeneous output is relevant because many industries besides transport produce transport services for their own account.

Exports do not present a problem because they are usually and simply treated as a final demand sector with a separate column into which each industry (in an industry by industry scheme) contributes the value of its exports. However, imports infiltrate both the interindustry exchanges in matrix **A** (as intermediate goods and services) and the final demand sectors. Imports are subject to very different treatment in different I-O tables. A widely, but by no means universally adopted, procedure is to split imports between (a) comparable (or competitive) imports—goods or services similar in nature to domestic production and (b) noncomparable (or noncompetitive) imports. Noncomparable imports are then treated as a special industry with its own row (distributing to intermediate uses and final demand) but not corresponding column. On the other hand, comparable imports are merged with the outputs of similar (comparable) domestic industries, which distribute their product, domestic or foreign, along their rows. However, this method is not generally used. In some tables noncomparable imports are classified as a primary input, whereas in others they are treated as an industry (i.e., left in matrix **A** of Figure 1). In still others, the distinction between the two classes of imports is not drawn or drawn on principles unlike those followed elsewhere. These differences limit the comparability of tables because it is sometimes not clear what method was followed.

One further aspect of the treatment of imports in I-O tables is relevant to the connection between I-O and national accounting. In the method previously described, imports are treated as a sector (i.e., a column) of final demand with negative entries. Thus, imports are deducted from each industry's sale of its product and row totals are clear of imports. In the columns of the interindustry exchanges of matrix **A**, however, no deduction is made for imported inputs because column totals represent the total value of industry output, including the value of all inputs, imported or otherwise. Not all tables follow this scheme—some have no imports column in final demand (see Figure 2). Whether imports are deducted from total sales value, the presence of imports breaks the equality between row and column totals. Some industries buy more imports than they sell along with their own comparable product, whereas others distribute more imports than they absorb.

I-O ACCOUNTS AND NATIONAL ACCOUNTING

In most national accounts the analysis of gross domestic product (GDP) is done according to its industrial origin. This

Gross National Product

In the National Income and Product Accounts

CHARGES AGAINST GNP	GNP
Compensation of Employees	Personal Consumption Expenditures
Proprietors' Income	Gross Private Domestic Investment
Rental Income of Persons	Net Exports
Corporate Profits	Government Purchases
Net Interest	
Business Transfer Payments	
Indirect Business Taxes	
Less: Subsidies Less Current Surplus of Government Enterprises	
Capital Consumption Allowances	

In an Input-Output Format

	PRODUCERS	FINAL DEMAND				
PRODUCERS		Personal Consumption Expenditures	Gross Private Domestic Investment	Net Exports	Government Purchases	GNP
VALUE ADDED	Compensation of Employees					
	Profit-Type Income*, Net Interest, & Capital Consumption Allowances					
	Indirect Business Taxes					
	Charges Against GNP					

* Consists of proprietors' income, rental income of persons, corporate profits, and business transfer payments, less: subsidies less current surplus of government enterprises.

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Input-Output Use Table

		INDUSTRIES									FINAL DEMAND (GNP)				TOTAL COMMODITY OUTPUT
		Agriculture	Mining	Construction	Manufacturing	Transportation	Trade	Finance	Services	Other	Personal Consumption Expenditures	Gross Private Domestic Investment	Net Exports	Government Purchases	
COMMODITIES	Agricultural Products														
	Minerals														
	Construction														
	Manufactured Commodities														
	Transportation														
	Trade														
	Finance														
	Services														
	Other														
VALUE ADDED (Charges against GNP)	Compensation of Employees														
	Profit-Type Income*, Net Interest, & Capital Consumption Allowances														
	Indirect Business Taxes														
TOTAL INDUSTRY OUTPUT															

* Consists of proprietors' income, rental income of persons, corporate profits, and business transfer payments, less: subsidies less current surplus of government enterprises.

U.S. Department of Commerce, Bureau of Economic Analysis

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FIGURE 2 Relationship between gross national product and the I-O account.

method uses a readily available statistic and the simplest measure of the relative contribution of a sector to national product (though not a measure of total resources devoted to the production of that sector's output). In terms of accuracy or completeness, however, this measure is subject to the same qualifications that are attached to I-O totals of industry output or value added—industrial origin analysis in the national accounts is typically based on the results of I-O accounts.

In broadest terms, the relationship between I-O accounts and national accounts is

$$\text{GDP} = \text{value added by industries}$$
$$= \text{final demand} - \text{imports}$$

The GDP of the national accounts is identical (in principle) to the total of value added in the I-O account. The industrial origin analysis is the same in each. Figure 2, which reflects U.S. methodology, demonstrates this relationship (*1*).

THREE BASIC TABLES IN I-O ACCOUNTING

I-O accounting subjects data to essentially three different treatments, each giving rise to a basic table.

Transactions Matrix

This matrix of interindustry exchanges records the absolute values of goods and services flowing between industries in the accounting period (one year). It is bordered by the blocks for final demand, primary input, and the two totals (Figure 1). Sources of these data are censuses of production, the less common censuses of distribution, special studies, fiscal records, and special estimating efforts.

Several major decisions have been made when constructing this table. First, the way in which industries, commodities, or producing units are aggregated affects the results and meaning of any analysis based on the table. In an industry by industry scheme, changing the method of aggregation will change the gross output of industry just as would vertical integration of industries (e.g., sugar refineries integrating with sugar plantations). It is quite common for transport to be aggregated (in I-O as well as national accounting) with warehousing and frequently also with communications. The result is a loss of information on transport throughout the (output) rows and the (input) columns of the aggregate industry. A nuisance of special significance arises at the crossing of a row and column in the cell (the diagonal element) that records intraindustry transactions. The size of the entry in this cell is particularly sensitive to purely organizational features of an industry. For example, whether a railway contracts with independent road haulers or merges with them, payments arise in the former case and vanish in the latter. Because such features of an industry, and changes in them, do not have any necessary technological or economic meaning these entries may be removed at the row-and-column crossing from the table for purposes of analysis. This method was used for the empirical part of this study. If warehousing and communications are combined with transport, however, the contents of the diagonal cell refer partly to the result of otherwise irrelevant organizational peculiarities of the transport industry and partly to relevant exchanges between essentially different activities (e.g., road haulage under contract for the post office).

Second, a decision has to be made on the treatment of an industry's secondary products. Industries are normally defined by their products but many firms produce a variety, including some that are the principal products of other industries. Coke from gasworks is the usual textbook example. But an equally important example is the production of transport services by firms outside the transport industry for their own-account transport. The general treatment of secondary production varies between I-O accounts of different countries. The recommended method is to define principal products for an industry then split off secondary products and redefine them together with the corresponding inputs for the industry that has them for its principal product. But the principle differs between countries and the practice is likely to differ even more. Comparability between different tables is especially affected in the case of transport because the principle adopted in a country for the treatment of secondary production is not necessarily extended to own-account transport. United Kingdom statisticians seek to transfer own-account transport operations to the transport industry, whereas the U.S. Commerce Department does not. In the empirical part of this study, the U.S. method prevails in the various tables. An immediate consequence of this omission is that the value added in transport and its gross output as recorded in the tables underestimate the total value of transport activities in the natural (not the organizational) sense of the word. Furthermore, the use of transport service by different industries will be underestimated whenever they operate own-account transport.

Third, a decision has to be made about the prices at which transactions are valued: net indirect taxes (basic prices), producer prices (including tax), or at purchaser's prices (including taxes, trade, and transport profits). Most of the tables examined use producer prices.

Fourth, the treatment of transport costs in the sale or purchase price requires yet another decision. The principle most widely adopted and followed so far as feasible is to debit the cost of transport to the buyer of the product as a separate purchase made from transport (the f.o.b. method). Thus, it is assumed that the costs transferred are solely those of transport purchased from the transport industry as defined in the I-O classification.

Direct Coefficient Matrix

This matrix, derived from the transactions matrix, records in its columns the inputs that the industry receives from other industries, each expressed as a proportion of the receiving industry's gross output. These figures are the industry's direct input coefficients—its direct intermediate requirements per unit of its own gross production, in practice, per dollar of its gross output.

Total Coefficient Matrix

This matrix is constructed from the direct coefficient matrix by matrix inversion through solution of the simultaneous equations underlying the I-O account. The coefficients that result in any one industry column express the inputs from each sector per dollar of that industry's gross output for given final demands and account for direct as well as indirect inputs (the fuel absorbed by transport to carry the fuel, etc.).

USES AND BASIC ASSUMPTIONS

I-O analysis has developed significantly since Leontief (*2,3*) and has become a central tool in planning, forecasting, and many types of policy analysis. Its use in international comparisons of the structure of production and the study of development was largely pioneered by Chenery (*4,5*).

Use of I-O accounting for any of these purposes, and even for the descriptive purpose of this study, is conditional on certain assumptions. Without these assumptions the coefficients in the tables cannot be thought of as requirements and as requirements of specific inputs. The first, homogeneity of industry output, has to be accepted if the entries in I-O tables are to be treated as technical coefficients rather than as coefficients thrown up by mere commercial arrangements or industrial organization. Second, the proportion of inputs to outputs is assumed to be linear. Each input into a particular sector is assumed to vary in direct proportion with that sector's output. It is known that such strict proportionality characterizes only a limited class of production processes. The more usual assumption in economics is that inputs are substitutable (so that the unit cost of an output is a strictly concave function of the price of any one input). In addition, constant returns cannot be accepted as an empirically valid condition of production in general. It follows that the expected error in projections of input requirements for a specified level of output, based on a given set of I-O coefficients, will be greater the larger the specified change in final demands or the greater the possible change in relative prices. Major abuses of I-O analysis become possible when this caveat is ignored or forgotten. For example, a study in the 1970s using fixed I-O coefficients obtained results with truly alarming consequences for U.S. production and employment from a 15 percent reduction of the output of the U.S. maritime industry.

RELEVANT QUESTIONS FOR TRANSPORT IN THE ECONOMY

In order to throw light on the role of transport in the economy input-output data will be used to answer the following questions:

1. What are the input requirements of transport, the sources of inputs, and the balance between intermediate inputs and primary inputs? The answers should point to some of the major determinants of the cost and efficiency of the activity and the impact of different tax systems on transport; and
2. What are the destinations of transport services, the sources of demand for transport, and the balance between intermediate and final demand? The answers are relevant to the relative degree of sensitivity of the demand for transport to variations in national output.

The establishment of these requirements will be attempted with the help of relatively simple tools of industrial structure analysis formulated mainly by Chenery (*4,5*) some 30 years ago. More sophisticated and complex experiments would be needed to explore the consequences for transport of technological change or general economic growth. For this study, more data would be needed than are available in the tables for the five different countries. The countries are heterogeneous and although one strives to find reasons for differences among data of the different countries, such rationalizations have to be viewed with caution.

CASE STUDIES

Five sets of input-output tables were reviewed, one table for each country in the study. Information obtained from each I-O table was based on the following: the year of reference, the definition of the sector, the share of transport in GDP (gross national product) from the national accounts, the number of sectors distinguished in the interindustry matrix, the definition of the prices used for valuing the flows of inputs or outputs, and special features of the tables. For each case study country the I-O table information was based on

- United States (*6–8*)
  - —Year: 1977.
  - —Sector definition: transport and warehousing.
  - —GDP share of transport and communications: 6.4 percent at market prices.
  - —Number of sectors distinguished: 85.
  - —Valuation: at market prices (including tax on inputs).
  - —Value added: includes taxes on sector output.
- Philippines (*9*)
  - —Year: 1974, updated to 1981.
  - —Sector definition: distinguishes five transport subsectors (busline, other public passenger transport, land freight, water, and air).
  - —GDP share of transport and communications: 5.4 percent at market prices.
  - —Number of sectors distinguished: 31.
  - —Valuation: at market prices including tax on inputs.
  - —Value added: includes taxes on sector output.
  - —Special feature: the object of the table was the analysis of energy requirements. Energy (and fuels) and transport sectors were therefore analyzed in considerable detail.
- India (*10,11*)
  - —Year: 1968-1969, updated to 1979-1980 prices.
  - —Sector definition: distinguishes subsectors: rail, other.
  - —GDP share of transport and communications: 6.1 percent at factor cost.
  - —Number of sectors distinguished: 89.
  - —Valuation: at factor cost; indirect taxes included in primary inputs (with value added).
  - —Special features: high level of disaggregation of agricultural sector.
- Côte d'Ivoire (*12*)
  - —Year: 1987.
  - —Sector definition: transport and communications.
  - —GDP share of transport and communications: 7.5 percent at market prices.

—Number of sectors distinguished: 33.
—Valuation: market prices, including taxes on inputs.
—Value added: includes taxes on output.

- Mexico (*13*)
  - —Year: 1975, transaction matrix updated to 1978 prices.
  - —Sector definition: transport.
  - —GDP share of transport and communications: 6.3 percent at market prices.
  - —Number of sectors distinguished: 72.
  - —Valuation: basic prices (exclude taxes); indirect taxes included in primary inputs.

For each case study country, the data used were noted for that country's heterogeneity in

- Definition of the sector that included transport,
- Relation of the time to which the underlying production data refer and the date of the prices applied to them,
- Extent of disaggregation of the economy, and
- Rule for valuing goods and services.

In addition to these differences are the highly probable differences in the treatment of imports in the different tables.

To improve comparability, the data were subjected to uniform treatment in two respects:

1. Intrasectoral transactions (the diagonal cells of the interindustry exchange table, at the crossing of the rows and columns for transport) were eliminated from the tables.
2. When tables were identified noncomparable imports they were included in primary inputs with value added by the industry receiving these imports because two of the tables merged this class of imports with value added. In the case of Côte d'Ivoire, this procedure could not be followed because imports were not separated into comparable and noncomparable. Total imports, by industry, are given separately and when added into primary inputs were found to form an improbably large proportion of the sum. The alternative is to assign imports wholly to intermediate inputs and this was the course adopted.

TRANSPORT AS USER OF RESOURCES

Two simple measures indicate the dependence of transport on intermediate inputs (and thus, by implication on primary inputs measured by the complement of the percentage share of intermediates). For convenience, intermediate inputs were named *U* and *D*:

1. The proportion of direct intermediate inputs in the gross value of output by transport (*U*) is computed from the direct input coefficients and was formulated by Chenery and Watanabe (*3*) for purposes of comparative structural analysis of industry. It is known also as the backward linkage coefficient because it reflects the extent to which activity is a source of demand for the outputs of other activities (*14*).
2. The index of the power of dispersion (*D*) is computed from the total coefficient matrix as the ratio of the average of total input coefficients in the transport column (the production function of transport) to the average of all total input coefficients in the matrix. Therefore, it measures the relative input-dependence of transport allowing for all the circles of interindustry exchanges. If $D > 1$, transport is a relatively intensive user of intermediate inputs. If $D = 0.5$, a dollar increase in the country's final demand generates only half as much additional demand for intermediate inputs for transport as for the country's average industry.

Table 1 shows the *U* and *D* indexes for the transport sectors or subsectors identified in the tables. It also shows the index for each country's total industry (Column 2) and the weights (Column 1) signifying the relative importance of transport subsectors in the two countries (Philippines and India) for which no sector aggregate is available.

THE LEVEL OF INTERMEDIATE INPUT SHARES

If the average share of intermediate inputs in gross output value across all industries is considered first, a notable degree

TABLE 1 INTERMEDIATE INPUT REQUIREMENTS FOR ALL INDUSTRY AND FOR TRANSPORT

Country and Sector	Weights: % of Value Added by Specified Sector (1)	*U*-Share of Intermediate Inputs in Gross Output: All Industry (2)	Transport: Sector (3)	Transport: Subsector (4)	*D*-Relative Total Dependence on Intermediate Inputs (5)
United States, 1977		.4896			
Transport and warehousing	100		.3229		.8438
Philippines, 1981		.5125			
Land freight	51			.4523	.9514
Public transport	13			.5063	.9912
Water	17			.5403	1.0612
Air	13			.5084	1.0794
India, 1979–1980		.4948			
Other than rail	77			.4650	1.0112
Rail	23			.3602	.9245
Côte d'Ivoire, 1978		.4426[a]			
Transport and communications	100		.4525[a]		1.0406
Mexico, 1978		.3733			
Transport	100		.2773		.9183

[a]Imports are not separated into comparable and noncomparable (left wholly with intermediate inputs).

of similarity exists between countries with the exception of Mexico. Intermediate input shares in the first four countries are between 44 and 51 percent, about the level found in most industrial or industrializing economies.

However, there is much less agreement between the shares of intermediate input in the transport sectors because the values for the United States and Mexico are well below those of the Philippines, India, and Côte d'Ivoire.

ROLE OF RELATIVE PRICES

Some part of the contrast noted previously can be explained by differences in relative prices and, specifically, the relative prices of fuels and labor. Table 2 presents the fuel input coefficients of transport as recorded in the five countries with the prevailing prices for the main fuels. Two petroleum-rich countries stand out in terms of both low fuel input coefficients (per unit of transport output) and low domestic fuel prices, kept at the time of the I-O table below world prices. If the fuel input coefficient for Mexico (0.06063) is doubled, bringing it closer to the corresponding coefficients for the Philippines, India, or the Côte d'Ivoire, the share of intermediate inputs for the transport sector would increase from the 0.2773 in Table 2, to 0.3373. Mexico thus underestimates gross output from transport.

The relative price of labor is more of a structural fact than the relative price of diesel fuel and the low share of intermediate inputs in the gross output of U.S. transport (Table 1, Column 3) may be explained in part by relatively high U.S. labor costs. A low share of intermediate inputs implies a high share of primary inputs within which labor accounted for 67 percent in the United States. Average share of labor in primary inputs across all industries was only 59 percent. The labor cost element in the cost of U.S. transport is higher than in U.S. industry in general and this should raise the share of primary inputs and depress that of intermediate inputs in gross transport output. Thus, relatively high labor cost and low fuel prices should explain some (unknown) part of the comparatively low shares of intermediate inputs in U.S. and Mexican transport products. The 1979 I-O accounts of the United Kingdom, a country with relatively high labor cost but with much higher relative fuel prices, have a *U*-index value for transport of 0.53, close to values found for the Philippines, India, and Côte d'Ivoire (Table 1, Columns 3 and 4). On the other hand, the United Kingdom's *U*-index for all industry is practically the same as that of the United States: 0.48 versus 0.49, respectively.

A NUMERICAL CONCLUSION: THE TYPICAL VALUE OF *U*

On the basis of the previous discussion it can be concluded that the average share of intermediate inputs in the gross output of transport in developing countries is about 45 percent. It then follows that the gross output of transport is about 1.8 times the value of the primary inputs into transport. If the noncomparable imports component of primary inputs is ignored (see Table 3), transport gross output would be about 1.8 times the value added in transport, as ascertainable from national accounts.

INTERMEDIATE INPUTS VERSUS PRIMARY INPUTS INTO TRANSPORT

For the United States, the main transport subsectors of the Philippines, India, and Mexico the share of intermediate inputs in the gross output value of transport is below the national average of this share (Table 2, Columns 2–4). In these countries, transport is intensive in primary inputs. The exception is Côte d'Ivoire where the *U*-index of transport lies close to the average for all industries.

Transport is largely classed as a nontraded good or service. In most countries, transport services are not in competition (actually or potentially) with imported services of the same kind. Except in countries that serve as important transit routes to others, international trade in transport services is confined to air and some shipping services. Therefore, in general world levels of costs (or efficiency in production of transport services) exercise little constraint on the costs and efficiency of national transport industries. Although direct competitive pressure from the outside is negligible there could still be

TABLE 2 FUEL INPUT COEFFICIENTS FOR TRANSPORT AND FUEL PRICES (*15*)

Country and Sector	Fuels	Fuel Input as Proportion of Sector Gross Output Value	Price per Gallon in U.S. Cents	
			Diesel	Premium Gasoline
Philippines, 1981				
Land freight	Diesel, gasoline	.19915	120.4	225.8
Public transport	Diesel, gasoline, and other	.2591		
India, 1979–1980				
Other than rail	Petroleum products	.14111	72.0–111.0	205–257
Rail	Coal, petrol products	.09111		
Côte d'Ivoire, 1978				
Transport and communications	Petroleum	.12156	N.A.	N.A.
United States, 1977				
Transport and warehousing	Diesel, petroleum refining, electricity	.09014	54.3	71.9
Mexico, 1978				
Transportation	Petroleum refining	.06063	11.0	67.0

TABLE 3 COMPOSITION OF PRIMARY INPUTS

Country and Sector	Payment to Labor (%)	Property-Type Income (%)	Noncomparable Imports (%)
United States, 1977			
Transport and warehousing	67	23	4
All industry	59		
Philippines, 1981			
Transport and communications	40		
All industry	33		
Côte d'Ivoire, 1978			
Transport and communications	57	41	[a]
All industry	33		
Mexico, 1978			
Transport	37	60	2

NOTE: India's I-O accounts do not distinguish labor and property-type income in gross value added by industry.
[a]Noncomparable imports cannot be distinguished for Côte d'Ivoire. Total imports were assigned as intermediate inputs.

indirect external effects on domestic transport cost levels transmitted through the prices of traded goods required in the production of transport service. The relatively low share of such intermediate inputs (including imported intermediate goods) in the gross output value of transport reinforces the effect of an absence of importable substitutes for transport. The lack of importable substitutes helps to shelter the cost of domestic transport from international costs, prices, and changes in them that follow from technical progress and other productivity improvements. Even in open economies, therefore, the lower the value of the *U*-index the more will the relative cost of transport be governed by the levels of competition and efficiency within the industry and not least by wage costs per unit of output (Table 3).

EFFECTS OF THE TAX SYSTEM

Two classes of taxes on the production of goods and services are the cascading type—turnover taxes and value-added taxes. The distorting effect of the turnover tax is a major argument in favor of the value-added tax. Transport, however, tends to have a relatively gross output. Other things being equal, transport may be relatively favored by a cascading system and should in any case benefit less than other industry from the institution of a value-added tax system (*16*).

TOTAL INPUT REQUIREMENT OF TRANSPORT

Total input coefficients represent the input requirements in response to a unit change in final demand calculated through the sequence of rounds of inputs into inputs. Coefficients in any one column thus depend on all other coefficients in the table. Averaging these total coefficients in the transport column and comparing the average with that of all total coefficients in the matrix results in the *D*-index. Its values (Table 1, Column 5) confirm what appeared from comparisons between the direct input coefficients for transport and all industry except in the case of India. For Côte d'Ivoire, India (nonrail transport), and the two lesser transport subsectors of the Philippines, the demand response of transport to a unit increase in general output is more intensive for intermediate inputs than for industry in general. In all other cases, the demand generated by transport for the output of other activities is less than for industry as a whole in India. Therefore, the direct input coefficients are a less reliable base for predicting requirements than in the remaining four countries.

TRANSPORT AS SUPPLIER OF SERVICES: TRANSPORT DEMAND

Once again two summary measures are used to indicate the sectoral destination of transport output or sectoral sources of demand for transport services and the sensitivity of transport demand to changes in general output:

1. The proportion of gross transport output going to other industries as intermediate services (*W*). This ratio is computed from the direct input coefficients and, like the index, was defined by Chenery and Watanabe (*4*). It is also known as the forward linkage coefficient because it expresses the support that transport (or any given sector) supplies to other industries. A relatively high ratio denotes relative predominance of intermediate uses of transport services.
2. The index of sensitivity (*S*) is the ratio of the average of the transport row entries to the average of all coefficients in the matrix. It indicates the relative importance of a sector as a supplier of intermediate inputs to other sectors, the comparison being with the average of all industries. Therefore, it measures the dependence of transport on industrial demand for its output relative to that kind of dependence for the country's industry as a whole. When this index exceeds unity transport has to increase output relatively more than other sectors for a unit increase in final demand in every sector.

TRANSPORT REQUIREMENTS: DEMAND FOR TRANSPORT

The presumed omission of own-account transport from the transport account in the I-O tables is likely to have more of a distorting effect on the reported structure of demand for transport than on its input composition. Totals for transport services sold (row totals) and for resource requirements for transport (column totals) will be affected to an equal degree. But there is less reason to expect differences in input structures between professional and own-account transport than in the structure of demand (or destination of output) for the two modes of operation. Own-account transport tends to be used to a greater extent than professional transport for industrial purposes as intermediate service. The true *W*-index is thus likely to be underestimated in Table 4 (Columns 3 and 4). The size of the necessary correction remains unknown.

The demand structure of transport seems less likely to be a structural fact of the industry than its input structure. Transport in the United States and Mexico is presented in Table 4 as depending more on final demand than does the industrial sector as a whole. In the transport sector of Côte d'Ivoire and the main transport subsectors of India and the Philippines transport services are intermediate goods to a greater extent than industrial output in general. This does not hold for rail in India or for public transport, water, or air transport. In addition, water and air transport in the Philippines depend more than the average industry on sales to final demand.

DIRECT AND TOTAL TRANSPORT REQUIREMENTS

Although the distribution of total transport output between intermediate use and final demand differs a good deal between the countries there is striking similarity in the average direct transport input coefficients of their industries (Table 5). These coefficients are sensitive to the varying degrees of aggregation in the different tables with the means of the direct coefficients clustering around 2 percent. In four of the five countries, the dispersion of coefficients around the mean is also quite similar. Therefore, the average impact of changes in transport prices on industrial costs seems to be broadly similar in these different countries. Less uniformity exists in the total transport coefficients, which are highly sensitive to aggregation differences. Predictions of future demand for transport on the basis of direct input coefficients will be biased downwards. Table 5 indicates that the errors will be significant. When all repercussions have been taken into account, the average transport input coefficient is doubled in three of the five countries and raised by one-third in the other two.

Table 5 also presents the average of direct transport input coefficients for the groups of most intensive users—producers most sensitive to changes in productivity and prices of the transport industry. Identifying this group of main users may be difficult, but in terms more readily known they are the industries on whose activity and development transport operators depend most heavily. In principle, the two groups need not overlap, either fully or partially. Main users may be industries with transport input coefficients well below the national average, but have a high total output value relative for the total interindustry sales of the transport industry. A main user who is not also a most intensive user will have a larger total output value than the least intensive among the most intensive users. This relationship is illustrated by comparing the five most intensive users of land freight transport in the Philippines with the top five main users (Table 6). Using commodity producing sectors, three of five Philippine industries figure in either group. If trade is included in the 5 main users—an industry for which forecasts may be more difficult than for commodity sectors—the overlap shrinks to two in five. Excluding trade the two most important users of this major branch of Philippines transport, with a combined share of 40 percent of transport services provided to intermediate users, are not among the most intensive users. However, in a comparison with all industry all of the top 5 main users (whether trade is included or not) have transport coefficients above the general average. This result is the norm in the 4 I-O tables that permit the comparison of average direct transport coefficients for all industry and for the group of main users. For the practical purpose of determining required volumes of transport service, the average of industry coefficients is not usually relevant because coefficients for individual industries are expected to increase or decrease more than the average.

TABLE 4 SHARE AND INTENSITY OF INTERMEDIATE DEMAND FOR THE OUTPUT OF ALL INDUSTRY AND OF TRANSPORT

County and Sector	Weights: Value Added by Specified Sector (%)	Proportion of Gross Output for Intermediate Use (*W*): All Industry	Transport: Sector	Transport: Subsector	Relative Total Dependence on Demand for Intermediate Use (*S*)
United States, 1977		.5619			
Transport and warehousing	100		.5268		2.3029
Philippines, 1981		.5969			
Land freight	51			.7280	1.1531
Public transport	13			.0657	.5383
Water	17			.6930	.7732
Air	13			.0958	.5427
India, 1979–1980		.5539			
Other than rail	77			.5833	2.7900
Rail	23			.4648	1.1235
Cote d'Ivoire, 1978		.4048			
Transport and communications	100		.4495		1.4035
Mexico, 1978		.4276			
Transportation	100		.3263		2.0088

TABLE 5 AVERAGE TRANSPORT REQUIREMENT PER UNIT DOLLARS OF OUTPUT

Country and Sector	Total in I-O Table	Direct Requirements: Mean Coefficient (%)	Direct Requirements: SD (%)	Direct Requirements: CV	Total Requirement: Mean Coefficient (%)	Total Requirement: SD (%)	Total Requirement: CV
United States, 1977							
Transport and warehousing							
Sectors	78	2.04	1.43	0.7	4.3	1.7	0.4
Most intensive users	10	5.1	1.51	0.3	7.3	1.3	0.2
Philippines, 1981							
Land freight transport							
Sectors	29	2.1	1.2	0.6	4.0	1.6	0.4
Most intensive users	5	3.8	0.8	0.2	5.3	1.2	0.2
India, 1979–1980							
Rail							
Sectors	88	0.6	1.2	2.0	1.2	1.3	1.04
Other than rail							
Sectors	88	2.5	1.8	0.73	4.7	2.6	0.56
Most intensive users	10	5.7	0.7	0.13	9.0	1.5	0.16
Côte d'Ivoire, 1978							
Transport and communications							
Sectors	30	2.0	3.4	1.7	3.3	3.5	1.06
Most intensive users	5	7.0	5.6	0.8	7.7	6.4	0.83
Mexico, 1978							
Transportation							
Sectors	71	2.0	1.2	0.6	2.9	1.4	0.5
Most intensive users	10	3.8	1.8	0.5	4.8	1.7	0.35

NOTE: SD – Standard Deviation
CV – Coefficient of Variation

TABLE 6 COMPARISON OF USERS OF PHILIPPINES LAND FREIGHT TRANSPORT

	A	A′	B
Five most intensive users			
Basic metals	5.2	7.3	4.8
Paper, publishing	3.6	5.1	2.0
Chemicals	3.6	5.1	5.0
Forest, wood production	3.5	4.7	5.0
Textiles	3.2	4.4	5.3
Subtotal			22.1
Top five main users			
Food products (1)	2.7	3.8	23
Construction (2)	2.5	4.5	12
Textiles (3)	3.2	4.4	5.3
Forest, wood production (4)	3.6	4.7	5.0
Basic metals (5)	5.2	7.3	4.8
Subtotal (1–5)			50.1
[Trade] (6)	[2.4]	[2.9]	[17]
Total (1–4, 6)			[62.3]

NOTE: **A** – Direct transport input coefficient.
A′ – Total transport input coefficient.
B – Share of total transport services delivered to industries.

TABLE 7 RELATIVE INTENSITY OF TRANSPORT USE BY DIFFERENT PRODUCER GROUPS

Country	A (%)	B (%)
United States		
All industry	2.04	
10 main users	4.01	40
Omitting Trade	3.96	32
India (excluding rail transport)		
All industry	2.5	
10 main users	4.0	47
Omitting Trade	3.0	34
Philippines (land freight)		
All industry	2.1	
5 main users	2.9	62.3
Omitting Trade	3.4	50.1
Côte d'Ivoire		
All industry	2.0	
5 main users	7.0	57
Omitting Trade	5.2	18

Averages are used for a quick characterization of the relative intensity of transport use by different producer groups (Table 7). For this table, *A* and *B* have the same meaning as in Table 6. The comparisons suggest that the main users of transport are transport-intensive industries relative to the average of the producing sector. Other things being equal, changes in the efficiency and unit price of transport (cost of the service to its user) should affect their costs and profits more than the effect on industry at large. Because transport-intensive industries are the main source of demand for transport their reaction will, in turn, have a relatively strong effect on transport. Trade and construction are in all cases among the main users of transport.

Sensitivity of Transport Demand to Changes in Production

The index of sensitivity *S* shown in the final column of Table 4 is computed using the rows of the total requirements table. Entries in the transport row of those tables show the production of transport services required, directly and indirectly, per dollar of output delivered to final demand by the respective column industries. The index then compares the average of these required transport inputs to other industries (per dollar of additional final demand for their products) with the average of total input coefficients in the table. Therefore, it measures the average effect on transport of equal increases in sales to final demand by all sectors relative to the corresponding average demand effect on all sectors. (Because of the use of total coefficients, all intermediate demands for inputs to support such a final demand expansion are, of course, brought into consideration.

The sensitivity index for the transport sectors of the United States, India, Côte d'Ivoire, and Mexico, and for the land-freight subsector of the Philippines, is always well above unity (Table 4). Therefore, in terms of the index, transport is distinctly more sensitive to general output expansion than the average industry because it has to expand output by more than the average industry to support this type of output expansion. It is unlikely that final demand will ever expand in this particular fashion, by equal amounts for each industry's output. When the entire pattern of incremental demands is specified (a standard step in planning exercises) in sensitivity planning exercises, the index seems as good a measure as any other for determining the relative effect of general marginal output expansion on the demand for the output of specific sectors. The magnitudes of the transport sensitivity index reported in Table 4 are such that it may be concluded that relatively high output sensitivity of transport demand will hold even for moderately uneven distributions of increments to final demand.

Size of the Transport Sector

Different summary indicators of the total size of an industry are usually answers to different questions. Therefore, in considering alternatives it is essential to be clear about the meaning of the indicator and the use to which it is to be put. Most uses require that the indicator permit logically valid comparisons with other aggregates.

Value added by transport is usually the most available indicator because it is part of the standard presentation of national accounts. Value added is the sector's contribution to GDP or gross national product and can be expressed as a percentage of them. Like other indicators drawn from national statistics, value added is safer to use for comparisons over time in the same country than for international comparisons. Interpreting the difference between the percentages of value added from transport in Côte d'Ivoire (9.6 percent in 1978) and the United States (6.4 percent in 1977) is difficult because the sector definitions are different. For example, in Côte d'Ivoire the definition includes communications with transport whereas in the United States warehousing is included. Furthermore, in the former, value added is at factor cost and in the latter, at market prices. In addition, U.S. national accounts include the value added by trade or public administration and defense whereas these are omitted in Côte d'Ivoire (or so it appears), yielding a smaller result. A more general objection to the value added measure is that in most countries it excludes the value added in own-account transport operations. This objection is no less valid for any other measure that does not include a deliberate correction for this omission. Although the computation of value added by transport will be done with different degrees of perfection in different countries, the concept is clear—the value (at local prices) of the annual product is the gross of capital consumption but net of all intermediate inputs (labor and capital) employed in what is defined as the transport industry.

Because the industry's labor and capital do not produce transport services unaided by supplies from other industries, value added is not a measure of the total resources devoted to the production of transport services. Gross output may seem to be the right answer to this question because it is the sum of value added plus intermediate inputs in transport. For a given technology, industrial organization, and differential productivity gross output in transport is not quite twice value added. Unfortunately, gross output is useless as a measure of the relative size of the transport sector because it cannot be related to the other aggregates such as GDP, which is net of intermediate inputs, nor to a grand total of gross outputs, which involves double-counting (the gross output of petroleum refining also being partly counted in the gross output of transport, and so forth). Therefore, the concept has limited uses. Planners may use it as the base from which to project or plan changes in the supply of transport to all uses. Because gross output measures industry turnover, it can be used in estimating the return to changes in turnover taxes. Also, the comparative movement over time of value added and gross output (the time path of the index) can serve as an indicator of differential productivity change. This use is safest done in the course of projecting because in ex post facto studies the problem of having to control for irrelevant changes in industrial organization or statistical aggregation must be faced. For example, India's seventh 5-year plan expects gross value added in transport to rise annually at 7.1 percent and gross output value at 8 percent, between 1984-1985 and 1989-1990 (*17*).

None of these indices of the total size of the transport sector cover the country's transport activity exhaustively. The gap consists of own-account, industrial, and personal transport. Most input-output accounts known do not attempt to reclassify the outputs and the corresponding inputs of industrial own-account transport operation to the transport industry. The overall importance of this omission (in terms of the proportion of the country's total freight transport cost excluded from the account of the transport industry) should be the larger. The smaller is the share of rail, water, and air in freight transport. A rough calculation for the United States suggests that the value added by personal consumption expenditure (and government consumption) accounts for final demand. In developed countries, the category of own-account transport operations constitutes a sizeable component of the transport output in the broadest sense. In the United States, personal consumption absorbs 26 percent of the total output of transport industry services. Even without government consumption (partly also personal transport) personal consumption is thus more than half of that consumed by intermediate uses of transport (Table 8). But personal consumption expenditure on petroleum refinery products (used partly for other household purposes) and automobile repairs amounts to almost twice as much as personal expenditure on services bought from the transport industry. In 1977, personal expenditure on

TABLE 8 PERSONAL CONSUMPTION OF TRANSPORT OUTPUT

From Industry	Delivered to Intermediate Users[a] (all industry)	Personal Consumption	Government Consumption
United States (1977)			
Transport and Warehousing			
$ millions	58,805	33,210	7,194
Percent	100	56	12
Percent		100	
Petroleum Refining			
$ millions	49,561	38,595	5,831
Percent	100	78	12
Percent		116	
Automobile Repair and Services			
$ millions	16,997	25,437	775
Percent	100	150	8
Percent		77	
Motor Vehicles and Equipment			
$ millions	38,896[b]	46,124	3,026
Percent	100	119	8
India			
Railways			
Rs millions	9,247	6,751	2,629
Percent	100	73	28
Other Transport			
Rs millions	45,513	23,527	5,390
Percent	100	52	12
Petroleum Products			
Rs millions	25,933	10,852	1,525
Percent	100	42	6
Motor Vehicles and Repair			
Rs millions	8,611[b]	1,614	3,672
Percent	100	19	43
Motorcycles, Bicycles, and Repair			
Rs millions	2,890[b]	1,706	334
Percent	100	59	12

[a]Intra-industry transactions excluded.
[b]Value of output delivered to industries plus delivery to Gross Fixed Investment.

motor vehicles and equipment exceeded that of industry by almost one-fifth. For developing countries, ownership of the means of transport is less relevant. For example, in India (Table 8) the share of personal consumption in the total output of the transport industry (30 percent) and its share relative to that of intermediate industrial use are quite close to those in the United States. Personal expenditure on motor vehicles, motorcycles, bicycles, and repairs was only 28 percent of such purchases by classified industries. (Motorcycles and bicycles for intermediate use went to the other transport industry, which includes services by rickshaws of all kinds.) If government purchases are added the percentage rises but only to 64 percent of the purchases by industries. These quantities, besides confirming who are the passengers, are a better representation of the total personal transport output in developing rather than in developed countries, but are in no sense a full representation.

TRANSPORT AND ECONOMIC DEVELOPMENT: HYPOTHESES

Data for only five countries, each representing just 1 year, are not a sufficient basis for generalizations, but some hypotheses nevertheless emerge from even this small sample that are relevant to transport in the development process and also have a bearing on policy formation.

A Sheltered Industry

Inland transport is normally sheltered from foreign competition because professional transport depends less than the average industry upon intermediate inputs. Value added in transport accounts for a larger percentage of the value of transport services than is the case for other industries (Table 1). Therefore, technical progress in other parts of the economy will have a smaller effect on the cost of transport than it should have for the cost of the average industry. Sheltered by space and technology, transport efficiency and the control of costs and the level of prices depend critically on competition within the transport sector itself.

Growth-Sensitive Industry

Demand for transport as an intermediate input into production is sensitive, above the average for all industry, to variations in national output (Table 4). Because this conclusion is derived from I-O data, it is more likely to hold for small rather than for large changes in national output (I-O analysis generally assumes that industries have an infinite elasticity of supply). Nevertheless, it points to a relatively high risk of transport acting as a bottleneck and a brake on growth.

A Wage-Intensive Industry

If gross domestic product per capita serves as a proxy for the national wage level, the data tell us that the share of value added in the value of national production tends to fall with the wage levels presented in Table 9. The corresponding share in the value of transport output in the sample is greater than the share for all industry and declines much more regularly with GDP per capita. The relatively high share of labor payments in value added (Table 3) hints that the transport industry, in national terms, is labor-intensive. More cautiously, transport is relatively wage-intensive and therefore sensitive above average to wage increases in the course of development.

In Poor Countries, A Producer's Good

Data in Tables 4 and 8 suggest that transport in poor countries is more of an intermediate product for use by other producers than is the output of the average national industry. Going down the income scale, the share of intermediate use of transport output tends to grow relative to the corresponding share for all industry. Taxes that fall on all transport (such as fuel tax rather than license fees that can distinguish trucks from cars) are therefore likely to interfere with the desirable object of productive efficiency, that is, the choices that producers would make in the absence of taxation. This interference seems to be stronger, the poorer the country.

TABLE 9 SHARE OF VALUE ADDED IN GROSS OUTPUT FOR ALL INDUSTRY AND FOR TRANSPORT PER CAPITA GROSS DOMESTIC PRODUCT

Country	1987 GDP ($U.S.)	Share of Value Added in Gross Output	
		All Industry	Transport
United States	18,530	.51	.68
Mexico	1,830	.63	.66
Côte d'Ivoire	740	.56	.55
Philippines	590	.49	.53
India	300	.50	.54

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SECTION 3

Economic Impacts of Modal Investments

Highway Stock and Private-Sector Productivity

KAZEM ATTARAN AND PHILIPPE AUCLAIR

The availability of a good transportation system is essential to a growing, healthy economy. For this reason, in developing economies transportation improvements are usually among the first projects undertaken to start the path toward economic development and prosperity. Transportation facilities connect markets and facilitate production and trade. Although the relationship between transportation facilities and the well-being of the economy of a country is intuitively obvious, little research has been undertaken to measure this relationship quantitatively. An attempt was made to demonstrate that variations in the existing stock of public highways have, to a large extent, explained variations in the productivity of labor and capital in the private sector of the economy. For this purpose, two econometric regression models were constructed to separately measure the association between the stock of highways and the productivities of (a) private-sector capital and (b) combined labor and capital. The regression models not only support the contention that the highway stock has contributed to improved private-sector productivity, but also that it has had a proportionately greater effect than that of the nonhighway infrastructure. A third regression model in which the infrastructure was further disaggregated also supports the same conclusions.

The availability of transportation facilities plays an essential role in the process of a nation's economic development from a state of underdevelopment. Usually, one of the first steps taken in the path of development is to link markets together by creating transportation facilities. Unfortunately, once markets are linked, transportation facilities often are taken for granted—until severe inadequacies begin to emerge. As competing social needs bid for limited resources, nations tend to forget that, although factor supplies determine the initial level of economic output, their growth (or growth in their productivity) determines later economic growth. The stimulation of such growth has been generally neglected in the United States, including California.

The problem stems from the *long-term* nature of providing transportation infrastructure. Facilities are usually planned and constructed with a 20- to 30-year time horizon. The planned excess capacity often creates the illusion of indefinite adequacy. When this capacity is eventually exceeded by demand, realization of the finite nature of capacity occurs, sometimes at the considerable cost of stalled economic growth.

Although the significance of the contribution of transportation facilities (as well as other infrastructure) to the U.S. economy is intuitively obvious, it has neither been easy to quantify nor has there been any urgency for researchers to do so. Until recently, no systematic research had been conducted to quantitatively link transportation facilities to the well-being of the economy. However, with national concern for the competitive position of the nation's economy and productivity, this linkage has become of increasing interest. Aschauer (*1*) has successfully modeled and quantified the contribution of public investment in infrastructure to economic productivity. (Productivity is defined as the value of goods and services, in constant dollars, produced per unit of input—e.g., labor or capital. Total factor productivity refers to output per unit of combined labor and capital.)

Aschauer (*1*) associated the stock of the nation's total infrastructure with private-sector productivity. As a variation of that study, this analysis focused on the highway component of public infrastructure and attempted to isolate the effect of a slowdown in the growth rate of federal, state, and local highway stock on private-sector productivity. Cursory examination of the data between 1950 and 1985 (compiled by the Bureau of Labor Statistics) revealed a striking correlation between the rate of growth in the stock of highway infrastructure and the rate of growth in productivity. After normalizing the data to remove effects of time trends and business cycles, this close association became quite apparent (see Figure 1).

In order to test the hypothesis that productivity in the private sector of the economy is strongly associated with the availability of highway stock, three econometric regression models were constructed. The purpose of the capital productivity regression model was to examine the empirical relationship between private-sector capital productivity and the total stock of state and federal highways. (Highway stock is defined here as the present value of the existing stock of highways, net of depreciation, and measured in constant 1982 dollars.)

The total factor productivity regression model was formulated to analyze the relationship between private-sector total input productivity and the total stock of highways. It was hypothesized that the growth rates in both productivity measures could be explained to a large extent by variations in the existing stock of highways. In other words, the hypothesis contends that the stock of public highways has greatly influenced the growth in productivity of the private sector, which in turn has influenced the growth of the U.S. economy and the competitiveness of U.S. commodities in the international markets.

The third regression model further disaggregated the stock of public infrastructure in order to evaluate the conclusions obtained from the first two models.

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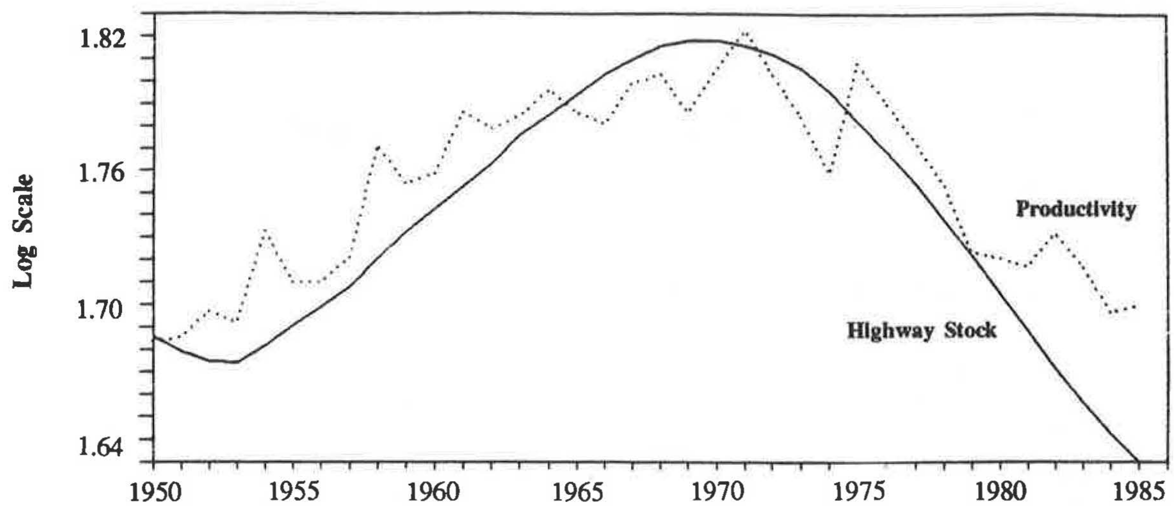

Note: After the effects of technological gains have been removed, the decline in productivity in the private sector (broken line) since the early 1970's has gone hand-in-hand with the decline in the real value (net of depreciation) of the total highway stock. The slope of the two curves (expressed in log form) indicates the percentage change in the two variables over time.

FIGURE 1 Productivity and highway stocks (growth trends).

ECONOMETRIC MODELS

The general form of the economy-wide production function is

$$Y = Y(T, C, K, L, G, \dots) \quad (1)$$

where

- Y = private-sector output variable,
- T = physical time variable running on a discrete annual basis from 1950 through 1985,
- C = capacity utilization rate,
- K = private-sector capital input variable,
- L = labor input variable, and
- G = total stock of public infrastructure variable.

In Equation 1, all the variables have explicit cumulative time dependence although the independent time variable is omitted for simplicity in terminology.

The discussion that follows is based on several sources (*1–5*).

In order to analyze the relationship between the growth rate in the stock of highway infrastructure and private-sector capital productivity, a Cobb-Douglas production function was used. This functional form precludes explicit modeling of the substitutability or complementarity of the inputs. That is, the elasticity of substitution is assumed to be unity. Future research on this topic will attempt to capture and quantify the interrelationship among all inputs by directly estimating the elasticities of substitution. To this end, more general production functions such as the constant elasticity of substitution production function and the translog production function could be used.

In the analysis, a working hypothesis of constant returns to scale was used, meaning that total private output is generated by labor, private capital, and the total stock of public infrastructure in such a way that a doubling of output is achieved by doubling all three inputs simultaneously. Similarly, a simultaneous increase of 1 percent in each of the inputs would lead to a 1 percent increase in private-sector output.

The Cobb-Douglas production function over K, L, G is as follows:

$$Y = BK^kL^lG^g \quad (2)$$

where

- B = a constant;
- k = elasticity of private capital, i.e., the percent increase in output per unit percent increase in private capital;
- l = elasticity of labor, i.e., the percent increase in output per unit percent increase in labor; and
- g = elasticity of public infrastructure stock, i.e., the percent increase in output per unit percent increase in public infrastructure stock.

As a result of the assumption of constant returns to scale,

$$k + l + g = 1 \quad (3)$$

A statistical test performed to support the assumption of constant returns to scale indicated that, during the sample period, the sum of the estimated coefficients was not significantly different from 1. That is, the empirical evidence strongly suggested that a simultaneous increase of 1 percent in each of the inputs K, L, and G resulted, on the average, in a 1 percent increase in real private-sector output Y.

For this study, the stock of public infrastructure (G) and its respective elasticity (g) were disaggregated. The various components were then directly incorporated in the economy-wide production function and analyzed to reach a conclusion about the role that the stock of highways and streets has played in the growth of U.S. productivity.

The total stock of public infrastructure was disaggregated into a highway component and a nonhighway component, as follows:

$$G = H + N \tag{4}$$

where

H = total stock of highways and streets, and
N = stock of nonhighway infrastructure.

The Cobb-Douglas production function therefore assumed the form

$$Y = BK^kL^lH^hN^n \tag{5}$$

where h and n are the elasticities of highway and nonhighway stock, respectively. Because during the 36-year sample period the relative amount of highway and nonhighway stock remained almost constant (the ratio of highway to nonhighway stock ranged between 0.53 and 0.60), the elasticity for total public infrastructure could be decomposed into the sum of elasticities for highway and nonhighway infrastructure, i.e.,

$$g = h + n \tag{6}$$

Again, as a result of the assumption of constant returns to scale,

$$k + l + h + n = 1 \tag{7}$$

This relationship avoids direct estimation of all possible production function coefficients, which would lead to a problem of multicollinearity. That is, because movements in each input (private capital, public capital, and labor) are themselves strongly correlated over time, direct estimation would be unjustifiable. The technique of using the constant returns to scale assumption reduces the problem of multicollinearity, because one less parameter needs to be estimated.

Adoption of a working hypothesis of constant returns to scale allowed the following log-linear variants of the production function to be deduced.

Capital Productivity Regression Model

Rewriting the specified Cobb-Douglas production function,

$$Y = BK^kL^lH^hN^n$$

Then

$$Y = BK^{(1-l-h-n)}\,L^lH^hN^n$$
$$= BKK^{-l}K^{-h}K^{-n}L^lH^hN^n$$

Dividing by K and collecting terms yields

$$Y/K = B(L/K)^l\,(H/K)^h\,(N/K)^n \tag{8}$$

Taking the natural logarithm yields

$$\ln (Y/K) = \ln B + l \ln (L/K) + h \ln (H/K) + n \ln (N/K) \tag{9}$$

This form of the private-sector productivity equation contained the functional dependence of the productivity function most suitable for estimating the parameters l, h, and n directly using the method of ordinary least squares (OLS).

Before estimating the parameters l, h, and n, the remaining factors considered include the capacity utilization rate C of the manufacturing sector used to control for output data fluctuations caused by the influence of the business cycle. In addition at this point, because time series data were used (for 1950 to 1985), the time variable T for changes not otherwise accounted for is included in the general specification of the model.

These adjustments yield the following equation:

$$\ln (Y/K) = b + rT + l \ln (L/K) + h \ln (H/K) + n \ln (N/K) + c \ln (C) + E \tag{10}$$

where

b = ln B;
r = average growth rate of ratio of output to capital (capital productivity) unexplained by other specified variables during the period of study [$r = \delta \ln (Y/K)/\delta T$];
c = percentage change in the ratio of output to capital resulting from a 1 percent change in C; and
E = error measure that is a surrogate for all other omitted variables, the joint influence of which is random and negligible in explaining the variation in the output.

The parameters r, l, h, n, and c were numerically estimated by the OLS method.

For the 36 years of historical data analyzed by the OLS procedure, this model yielded the following estimated log-linear private-sector capital productivity regression equation:

$$\ln (Y/K) = -10.9 + 0.0092T + 0.444 \ln (L/K) + 0.226 \ln (H/K) + 0.163 \ln (N/K) + 0.37 \ln (C) \tag{11}$$

where

$\bar{R}^2 = 0.9819$

Standard error of the regression = 0.008674

Durbin-Watson statistics = 1.547942

The t-values corresponding to the six coefficients of Equation 16 were −10.6, 3.78, 4.44, 3.85, 1.65, and 7.95.

All but one of the t-statistics were statistically significant at the 1 percent level. The t-statistic for the nonhighway stock was significant at the 10 percent level but was close to the critical value of 1.69 for the 5 percent level. Therefore, each explanatory variable was significant in helping explain the variation in capital productivity.

Additionally, as the $\bar{R}^2$ measure indicates, 98 percent of the variation in private-sector productivity could be explained by the combined effects of time, labor, private-sector capital, stock of highways, stock of nonhighway infrastructure, and capacity utilization rate.

The Durbin-Watson (D–W) test for serial correlation was employed to address the concern that the effect of omitted variables E was significant or anything other than purely random. The sum of the effects of all omitted variables had to be purely random to preserve a meaningful interpretation of the specified model. Because 36 observations were made using five explanatory variables, the critical values for the D–W d-statistics at the 5 percent significance level were $d_l = 1.175$ and $d_u = 1.799$. Because the calculated sample D–W statistic was 1.559, it lay in the zone of indecision. That is, at the 5 percent significance level the question of whether any correlation existed among the residuals was inconclusive. On the other hand, it was relatively safe to reject the null hypothesis of autocorrelation at the 1 percent significance level because the critical values in this case were $d_l = 0.988$ and $d_u = 1.588$. In summary, the specified functional form (see Equation 10) was close to explaining much of the variation of private-sector capital productivity.

Its relatively high t-statistic showed the significance of the stock of highways and streets in explaining movements in private-sector output.

As expected, the sum of the estimated highway and nonhighway elasticities of 0.389 was close to the estimated elasticity of the total public infrastructure stock of 0.42 (a value derived using a separate model that did not disaggregate the components of total infrastructure).

In addition, even though the average ratio of the real value of highway stock to nonhighway stock was only 0.561 during the sample period, the ratio of elasticities of 0.226 for the highway component and 0.163 for the nonhighway component was 1.39. This comparison indicates that the nation's highway and street system has had a disproportionate effect on U.S. economic growth. In other words, for every 10 percent increase in the stock of highway and streets, private-sector output has grown by 2.26 percent; for every 10 percent increase in all other nonhighway public infrastructure stock, real private-sector output has grown by 1.63 percent. Within the model assumptions, these results indicated that the stock of highways and streets has had on the average 39 percent more influence on private-sector output than the stock of all other infrastructure combined.

Total Factor Productivity Regression Model

In developing the extent to which the stock of highway infrastructure influences total factor productivity growth, the assumption of constant returns to scale in the economywide production function was again used.

Further assuming that each factor is paid according to its marginal product, the elasticities l, k, h, and n also represent the relative shares of total output from labor, capital, and highway and nonhighway public inputs. According to Euler's theorem, the production function of Equation 5 can be written

$$Y = L\frac{\delta Y}{\delta L} + K\frac{\delta Y}{\delta K} + H\frac{\delta Y}{\delta H} + N\frac{\delta Y}{\delta N} \qquad (12)$$

where

$$\frac{L}{Y} \cdot \frac{\delta Y}{\delta L} = l$$

$$\frac{K}{Y} \cdot \frac{\delta Y}{\delta K} = k$$

$$\frac{H}{Y} \cdot \frac{\delta Y}{\delta H} = h$$

$$\frac{N}{Y} \cdot \frac{\delta Y}{\delta N} = n$$

Again, the general Cobb-Douglas form for Y yields the following equation in which the variables are accumulated functions of time:

$$Y = BP^zH^hN^n \qquad (13)$$

where P is the combined total accumulated unit of private capital and labor and z is the corresponding elasticity with respect to the output.

In constructing an expression for P it was assumed that the rents from public service were appropriated by the private factors of production. In particular, it was assumed that the private-sector input shares were proportional to their true marginal productivities. Thus, the labor share of real output was

$$\frac{L}{Y}\left(w\frac{\delta Y}{\delta L}\right) = wl$$

and the private capital share of real output was

$$\frac{K}{Y}\left(w\frac{\delta Y}{\delta K}\right) = wk$$

where w is the constant of proportionality.

Because of the appropriation process,

$$l + k + g = wk + wl$$

and because of the assumption of constant returns to scale,

$$wk + wl = 1$$

As a result, the combined input variable can be written

$$P = K^{wk}L^{wl} \qquad (14)$$

and the production function becomes

$$\begin{aligned} Y &= B(K^{wk}L^{wl})^{(k+l)}H^hN^n \\ &= B(K^{wk}L^{wl})^{1-h-n}H^hN^n \\ &= B(K^{wk}L^{wl})(K^{wk}L^{wl})^{-h}H^h(K^{wk}L^{wl})^{-n}N^n \end{aligned} \qquad (15)$$

Dividing by $K^{wk}L^{wl}$ and rearranging terms yields

$$Y/(K^{wk}L^{wl}) = B(H/K^{wk}L^{wl})^h(N/K^{wk}L^{wl})^n$$

Substituting,

$$Y/P = B(H/P)^h(N/P)^n$$

Taking logarithms,

$$\ln (Y/P) = \ln B + h \ln (H/P) + n \ln (N/P) \tag{16}$$

This functional form is again useful for estimating the parameters h and n using the OLS method. Again introducing the capacity utilization rate C and time T for the same reasons as before, the productivity function for combined labor and capital inputs becomes

$$\ln (Y/P) = b + rT + h \ln (H/P) + n \ln (N/P) + c \ln (C) + E \tag{17}$$

When Equation 17 was estimated using the OLS method employing data obtained elsewhere (*6–8*), the following sample regression equation was obtained:

$$\ln (Y/P) = -10.52 + 0.008T + 0.238 \ln (H/P) + 0.134 \ln (N/P) + 0.386 \ln (C) \tag{18}$$

$\bar{R}^2 = 0.996$

D-W statistic = 1.535

The t-values corresponding to the five coefficients of Equation 18 were −13.45, 16.1, 4.34, 1.6, and 14.2.

Again, review of the t-statistics indicated that all specified explanatory variables, except the stock of nonhighways, were significant at the 1 percent level in explaining variations in total factor productivity. (The stock of nonhighways was again significant at a 10 percent level.) Furthermore, the combined effect of these variables explained about 99 percent of the variation observed in total factor productivity (i.e., the variation in private-sector output per combined unit of labor and private-sector capital) during the sample period.

The test for the possible existence of autocorrelation was again inconclusive at the 5 percent significance level. But, with four regressors and 36 observations, the critical values of the D–W d-statistics were $d_l = 1.043$ and $d_u = 1.513$ at the 1 percent level of significance. With a calculated D–W statistic of 1.535, the result indicated no autocorrelation at this significance level.

As expected, the results supported those obtained with the capital productivity model. Because this procedure involved estimating one less parameter, the estimated coefficients were more dependable. That is, as observed from the higher t-statistics, the possible problem of multicollinearity was ameliorated somewhat.

Of particular significance, the estimated elasticity of the stock of highways and streets of 0.238 was consistent with the previous estimate. Also, the estimated elasticity for nonhighway stock was 0.134, which again was close to the result obtained with the capital productivity model.

Further Disaggregated Regression Model

To further support the results obtained so far, the total public infrastructure stock was disaggregated in various ways to analyze the stability of the estimated coefficient of highways and streets.

For example, public infrastructure stock was disaggregated in the following way:

$$G = H + M + S + O \tag{19}$$

where

- M = stock of mass transit and airport facilities as well as that of gas and electric facilities (the data for the four components of M are not separately available);
- S = stock of sewers and water systems; and
- O = all other infrastructure stock.

The same methodology used in the capital productivity model was used to estimate all appropriate parameters of the economy-wide production function. Only one method of disaggregation yielded a significant model specification result:

$$\ln (Y/P) = B + rT + h \ln (H/P) + m \ln (M/P) + q \ln (Q/P) + c \ln (C) + E \tag{20}$$

where m is the elasticity of M with respect to output and q is the elasticity of a combination unit Q of O and S.

When Equation 20 was estimated using the OLS method, the following results were obtained:

$$\ln (Y/P) = -10.17 + 0.009 * T + 0.242 * \ln (H/P) - 0.0221 * \ln (M/P) + 0.13477 * \ln (Q/P) + 0.386 \ln (C) \tag{21}$$

$\bar{R}^2 = 0.996$

D-W statistic = 1.626

The statistical t-values corresponding to the six coefficients of Equation 21 were 13.1, 13.7, 4.45, −0.848, 1.77, and 14.4.

Again, the D-W test was used as a measure of specification error to determine whether the model construction was correctly specified. With five regressors and 36 observations, the lower bound (level of significance of 1 percent) was 0.988 and the upper bound was 1.588. The value obtained of 1.626 indicated that no autocorrelation or specification error existed at a 1 percent level of significance.

The stock of highways and streets again revealed a large t-statistic. Also, the estimated elasticity for the stock of highways and streets of 0.242 did not deviate significantly from the previous estimates.

From the results obtained in the three estimated regression equations (Equations 11, 18, and 21), it could be reasonably concluded that the stock of highways and streets was significant in explaining variations in private-sector productivity. In addition, the estimated elasticity using the three model specifications proved to be stable (ranging between 0.226 and 0.242).

SUMMARY AND FINDINGS

This study was conducted to test the hypothesis that productivity in the private sector of the economy is strongly associated with the availability of highway stock. For this purpose, two separate econometric models were constructed to try to explain this association in terms of the productivity both of capital inputs and of combined labor and capital inputs in the private sector.

The results provide a preliminary support to the proposed hypothesis—i.e., variations in the availability of highway stock can, to a large extent, explain variations in the productivity of private-sector capital investments, as well as in the productivity of capital and labor combined. In other words, full economic benefits of investments in capital and labor in the private sector can be achieved when an adequate supply of public infrastructure in general, and highways in this particular case, exists to go along with the private investment. Conversely, a decline in the availability of highways would lead to a decline in the productivity of both labor and capital in the private sector. These findings were supported by significant statistical results of the models (over 98 percent explanatory power). Some specific findings of the two sets of models included the following:

- On average, for every 10 percent increase in the stock of highway infrastructure (adjusted for inflation), a corresponding increase of between 2.26 and 2.42 percent in real private-sector output was realized.
- The results demonstrate that the stock of U.S. highways has had a proportionally greater effect on private-sector productivity than all other components of public infrastructure combined. In other words, as observed from the data in the sample period, highways comprising only about one-third of the value of total public infrastructure in the United States have been responsible for well over one-half (between 57 and 60 percent) of the gain in private-sector output attributable to public infrastructure.
- Considering the strong association between the level of highway stock and productivity in the private sector, it might be argued that, within the model assumptions, inadequacies of highway facilities could lead to loss of economic production and productivity.

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Airports and Economic Development: An Overview

RONALD COOPER

Airports and aviation make an important contribution to local, state, and regional economies. A review of literature on the links between airports and economic development indicates that air transport is usually associated with significant portions of local business. The influence on local and regional economic activity extends well beyond the airport site. The location of airports influences the geographic distribution of industries and can be a significant factor in the decisions of certain industries to locate in a specific state or region. Data indicate that access to air transport plays an increasingly important role in the ability of some high-technology industries, such as computers and electronics, to compete, and that the location of airport facilities influences the location of these industries. Tourism industries have also been shown to be sensitive to air travel access.

That airport development acts as a catalyst for economic development, drawing industry and economic activity to an area like a magnet, is often claimed. Some examples seem to confirm this, others contradict it. Although some industries appear to require access to air transportation, airport development in itself does not guarantee the growth of such industries. The impact an airport development project has on an area depends, to a large degree, on the particular economic conditions and characteristics of that area. Therefore, generalizations about whether airports tend to lead economic development, limit it (when not constructed or expanded), or merely follow it, are difficult to make. Better data and more comprehensive analysis of the issue are needed. The information currently available indicates that the impacts of airports on local and regional economies are significant but are not yet fully understood.

Governors recognize that airports and aviation are an integral part of economic development and that there is a need for more comprehensive research on their impacts. Comprehensive analyses of airport development should be integrated into state economic development planning. An expanded state role could result in integrating the planning and development of airports and aviation with state economic development goals, to include responses to such airport and aviation problems as (a) the potential capacity problem at many airports, (b) the discontinuation of air service to less populated areas, and (c) the loss of public use general aviation airports.

The following is an overview of the literature on the link between airports and their local, regional, or state economies.

INTRODUCTION

The literature that analyzes the relationship between airports and economic development covers a wide range of approaches and concerns. The literature was reviewed by National Governors' Association (NGA) Center of Policy Research staff as part of the States and Air Transportation project funded by FAA. The library and computer search resources of public and private groups, such as the American Association of Airport Executives and the FAA, were used in the review, which was completed in the last 4 months of 1988.

Most studies of the link between airports and economic development focus on the effects of a particular airport on its local economic or natural environment. Some are more broadly focused, analyzing the link between aviation in general and economic growth at the regional, state, or national levels. Although some aviation studies assess the effects on an area's income and employment, others consider the impacts on particular industries only. Also, some studies focus on the total impact of an airport or of aviation in general, whereas others consider the effects of a change in airport capacity.

Not all of this literature is relevant to states' concerns. It is most useful to governors for understanding the impact of a change in airport capacity on the state as a whole or on the economic regions of the state. Unfortunately, relatively little of the existing literature is aimed explicitly at the state level. As noted, most studies analyze the impacts of individual airports on their local economies, making generalizations difficult. Each airport or airport expansion project involves a unique set of characteristics and circumstances because of its role in the regional aviation system, location, physical features, and other factors. Nevertheless, there appears to be a general consensus that an economic link does exist between airport development and economic development. How this link is conceived and analyzed depends on the particular focus and purpose of a study as well as the methodology it uses.

This paper identifies the scope and limitations of the standard literature, reviews several studies that go somewhat beyond the conventional approaches, and cites data that may be useful to further research. Information is reviewed that is, or could be, used to address state economic development issues, such as whether airport development draws industry into a state, or whether there tends to be a bias to the type of economic development encouraged by increased airport and aviation development.

CONVENTIONAL APPROACHES

Most of the literature that directly analyzes the effects of airports follows at least one of three general analytic approaches: (a) economic impact, (b) financial feasibility, or (c) cost-benefit. Following is a summary of these approaches describing their methodology, principal users, common findings, and

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limitations. Selected examples are presented to illustrate each approach.

Economic Impact

In terms of sheer volume, economic impact studies on airports and economic development dominate the literature. Impact studies typically measure the economic benefits to a locality or region that accrue as a result of the continued or expanded operation of an airport. These studies follow a fairly standard format, viewing the total economic impact of an airport as the sum of three components: direct, indirect, and induced effects.

Direct impacts are the consequences of the economic activities occurring at the airport site. The suppliers of aviation-related services at the airport itself, such as the airlines, airport concessions, airport management, ground transportation services, fixed-base operators, and other tenants, spend their revenues to employ labor, purchase locally produced goods and services, contract for airport construction and capital improvements, and pay taxes. Data for direct impact estimates are generally collected through direct surveys. Questionnaires or personal interviews are used to collect data on payroll, local purchases, tax revenues, and expenditures by those businesses using the airport.

Indirect impacts are the consequences of economic activities that are directly attributable to, but occur away from, the airport site. These impacts include services provided by travel agencies, taxi cabs, hotels, restaurants, and retail businesses to the users of the airport services (travelers). Data for indirect impact estimates are collected through surveys or estimated from data on direct expenditures. An example of indirect effects estimated from direct data was the use of a rule of thumb per capita estimate, replacing passenger surveys, to gauge visitors' shopping, dining, and lodging patterns. The Aircraft Owners and Pilots Association and U.S. Chamber of Commerce used such a method, on the basis of estimates of average length of stay, daily expenditure, aircraft occupancy rate, and number of planes arriving daily at an airport (*1*).

Induced impacts, or multiplier effects, are the changes in employment and income generated as the initial direct and indirect expenditures trigger a chain reaction of spending through the local economy. The sum of direct and indirect impacts is called the primary impact. Induced effects, or respending effects, are calculated by applying economic multipliers to the primary expenditures. Multipliers measure the total increase in expenditures, within a defined area, per dollar of initial spending.

Most economic impact studies now use multipliers estimated with input-output models. Many use multipliers produced by the Regional Input-Output Modeling Systems (RIMS II) model of the U.S. Department of Commerce's Bureau of Economic Analysis (BEA) (*2*). RIMS II provides multipliers for specific counties or groups of counties and for 496 industrial sectors. BEA derives RIMS II multipliers from its National Input-Output Table of Industries, and its County Wage and Salary Data. From these sources, an input-output table reflecting the industrial structure and interdependence of a county, region, or state can be developed. In general, the larger the study area, the higher the multiplier. This relationship follows because the larger the study area, the more self-sufficient the economy tends to be and the more likely that each dollar of income is spent on goods or services produced within the region.

Therefore, the economic impact of an airport is measured by the cumulative flow of spending that originates at the airport and eventually works its way throughout the local and regional economy. Studies using this methodology usually arrive at a single dollar figure representing the total impact (or economic significance) of the airport. It is also common to impute the total employment impact on the basis of the flow of expenditures.

Impact studies vary widely with regard to the detail and sophistication of the analysis. They also differ as to which of the primary effects are classified as direct and which are indirect. However, they generally share the view that the activity at an airport (i.e., passenger activity and the handling of air cargo) generates four types of impacts:

1. Business revenue,
2. Jobs,
3. Personal income, and
4. Taxes.

These impacts are felt throughout five basic sectors of the economy (*3*):

1. Airline and airport services,
2. Freight transportation,
3. Passenger ground transportation,
4. Contract construction and consulting, and
5. Visitor industries.

Finally, income multipliers are used to estimate the eventual total effect (direct, indirect, and induced) on these five sectors, and the economy as a whole.

Economic impact analyses tend to produce large impact figures, often in billions of dollars. For example, in recent years the total annual impacts of the Los Angeles LAX and New York Kennedy airports have been estimated to be $28.6 billion and $13.6 billion, respectively (*4,5*). These estimates are for the total economic significance of airports, rather than the impact of a particular change in capacity or activity. Table 1 presents examples of airport and aviation impact estimates for several metropolitan areas and states.

As can be seen from the data, the multipliers range from a high of almost 3 (LAX) to just under 2 (Omaha and Philadelphia). The total impact for LAX, for example, is about three times the sum of direct and indirect impacts. To put these figures in perspective, the total impact estimates for the New York-New Jersey metropolitan area and Vancouver, British Columbia, for example, accounted for over 3 percent of the economic activity of the impact area (3.5 percent for N.Y.-N.J. and 3.1 percent for Vancouver) (*6*).

Although these studies (particularly those that rely on extensive surveys) provide useful information on the types of jobs and industries that benefit from airport operations and give an indication of the income-generating effects, they say little about how airports influence the type of economic development that takes place around them. By assigning a total

TABLE 1 SAMPLE ECONOMIC IMPACT ESTIMATES

(Note: Figures within direct and indirect columns may not be comparable due to differences in estimation methodologies.)

Airport/ Area	Economic Impact ($ millions) Direct[a]	Indirect[b]	Induced[c]	Total[d]
LAX	2,491	7,343	18,770	28,604
NY/NJ Metro Area	n.a.	n.a.	n.a.	18,900
Baltimore/ Washington (BWI)	324	237	755	1,315
Phila.	320	623	874	1,817
Virginia[e]	818	947	2,635	4,400
Omaha	56	58	78	191
Stockton CA	13	13	26	52
Illinois[e]	1,600	1,000	4,700	7,400
Vancouver, B.C.	800	n.a.	n.a.	1,400

[a]Direct impact created by provision of airport services (on-site airport income).
[b]Indirect impact created by use of air transportation services (off-site income).
[c]Induced: Multiplier effect resulting from direct and indirect.
[d]Totals may not add due to rounding.
[e]G.A. airports only.

value to an airport, impact studies are measuring the total value (income) that would be lost if the airport were to disappear, everything else remaining the same. Perhaps a more useful approach would be to ask how the area would have developed had the airport never been constructed. In this case, other things would not, of course, have remained the same—alternative forms of transportation and land use might have developed and consequently other economic activities as well.

Even more useful is the comparison of continual airport expansion or maintenance with alternative uses of revenues and resources. Public officials have sometimes argued that the impact of developing specific airport land for retail, industrial, or residential use outweighs the economic benefit of continuing the operation of an airport. For example, in Crestwood, Illinois, where Howell Airport was put up for sale, Frank Gassmere, the director of village services, claimed that the prospect of $500 million worth of new building development plus some 4,000 corresponding new jobs "so far outweighs the argument in favor of the airport as to be one-sided."

Some impact studies have recognized the unrealistic nature of figures for total impact. A 1986 assessment of Vancouver International Airport (VIA), for example, calculated the total annual impact figure of $2.4 billion, but noted that "it is unrealistic to assume VIA will disappear. . . . As such, it would not be [of] any value to quantify the total economic impact" (*6*). The VIA study, therefore, offered several more plausible hypothetical alternatives and asked its survey respondents to describe the effects of a change in the airport's role on their operations. The alternative scenarios included the sudden elimination of all transborder (Canada-United States) service, the sudden elimination of all international service, and an immediate 20 percent overall increase in activity at VIA. The estimated impacts of the first two scenarios on economic output were $669 million and $1.2 billion, respectively. These figures were interpreted as the economic contribution of the two services. The third scenario was not calculated because of inadequate survey responses.

Analyzing such changes in airport and aviation activity, rather than the overall level of activity, can produce impact measures of events that may be more realistic, but the underlying methodology is the same. There are a number of limitations of this methodology that lessen the credibility of some impact studies and may restrict its usefulness in analyzing the airport-economic development relationship. Most of these limitations involve the partial failure to measure the net impact of airport activity. As mentioned, these studies should include those activities that would not have occurred in the absence of the airport activity being assessed. They should also account for (net out) those activities that would have occurred without the airport activity but did not, as well as economic activities that may have been forced to discontinue their operations or leave the area because of the airport. That is, the methodology tends to measure the airport's benefits only (income and employment gains), ignoring the potential displacement effects of airport activity (jobs and income lost). The expansion of an airport's air cargo services, for example, might compete with and displace activities associated with the preexisting ground transport services.

A common limitation of economic impact studies is the problem of double counting, which occurs in different ways. The most common way is the calculation of the impact in terms of total expenditures or total output rather than in terms of value added to the economy by the airport activity. Total output figures include the costs of goods and services purchased from other firms. Value-added figures are net of these intermediate purchases. The difference between the two approaches can be significant. The 1986 VIA study (*6*) estimated both. It reported a total output impact of $2.4 billion and a value-added impact of $1.4 billion.

Another form of double counting is sometimes found in the calculations of traveler (visitor) spending. Visitor spending by airport users is generally a large portion of the total primary expenditures. The multiplier is applied to total visitor spending to arrive at the total impact. However, a more accurate estimate of the spending impact of air travelers would be based on total visitor spending minus the spending effects of those airport users who left the area (*7*). This double counting was evidently present in an economic impact study of the Philadelphia International Airport by Philadelphia (*8*).

The estimation of induced impacts is often criticized as involving double counting. Using inappropriate or arbitrary multipliers, some studies have exaggerated the total impact. Many do not cite their sources for the multiplier used. A multiplier of two is often regarded as a standard rule of thumb, but this is generally true only for large regions where most of the respending effects are played out. Smaller areas must rely more on imports from other areas and consequently have smaller multiplier effects (*7*).

The use of multipliers that are developed at the national level (reflecting the interindustry relations at that level) and then disaggregated to the specific region, often do not accurately reflect the particular characteristics of that region.

Socioeconomic and environmental effects (such as aircraft noise, air pollution, air safety, ground traffic congestion, land use mix, and locational advantages), which often have economic effects, are typically ignored in economic impact studies.

Perhaps one reason economic impact studies involve such limitations is that their purpose is often more political than analytical. The approach has often been used by proponents of aviation and airport development for promotional and public relations purposes. These studies became widespread when airport noise and forced residential and business relocation created public opposition to airport expansion. One expert notes that without strong economic arguments in favor of airport expansions, a potentially hostile public will not be convinced that the benefits may outweigh the adverse impacts (*9*). The purposes of the economic impact studies are threefold:

1. To provide a tool that enables airport management to assess the economic benefits accrued by the community it serves,
2. To provide a document that can be used by local, elected officials and others to justify requests for financial and political support, and
3. To furnish an educational instrument with which to inform the public and decision makers in both government and the private sector about the tangible and intangible benefits of general aviation.

Financial Feasibility

One way for state and local governments to decide whether construction of a new airport or expansion of an existing one is warranted is to determine whether the airport (or a cost center within an airport such as a terminal or cargo area) will be self-financing. The financial feasibility approach uses a benefit-cost methodology but focuses on the costs of operation and revenues of the airport as a business concern. The aim of the analysis is to determine whether the investment is financially sound, given expectations about the airport's revenues and costs and the cost of the initial investment. From the government's point of view, the pragmatic focus on cost recovery is justified, because the net income generated by an airport is one measure of the value users place on airport services.

The major components of airport revenues are airline and concession fees, cargo, and government transfers, primarily from the federal government. A recent study showed that federal aid is a major component in the budgets of all public airports and concluded that such aid is "essential to the preservation and expansion of the airport system" (*10*). The portion of airport revenues that is derived from federal aid decreases with the size of the airport. At large hubs (defined as airports where commercial carriers enplane 1 percent or more of total U.S. enplanements), federal aid accounts for only 10.6 percent of revenues. At nonhub reliever and general aviation airports, the federal government contributes over 50 percent of revenues.

Government expenditures on air transportation are largely covered by tax revenues and other fees. At the federal level, the largest revenue element is the passenger ticket tax, which accounted for about 70 percent of air transport-related revenues in 1987. A recent Department of Transportation study showed that the ratio of air transportation budget receipts to outlays has been increasing over the past 10 years, at federal, state, and local levels (*11*). In fact, of all the transportation modes in the United States, air is the most user-financed. In 1986, approximately 79 percent of the total government expenditures were covered by user revenues. This compares with 72 percent coverage for highways, 30 percent for transit, and 32 percent for water. At the state and local level alone, direct user revenues covered 77 percent of government expenditures related to air transportation (as compared with 47 percent for highways and 30 percent for transit). These coverage ratios for air transportation are expected to increase in the future, given recent increases in user charges at the federal and state levels, and federal budget proposals for increased user fees and decreased federal subsidies (*11*).

Revenues from airline fees, which were 16.7 percent of revenues at large hubs in 1985 (*10*), were determined by the airport operator's rate-setting methodology for rentals and landing fees and its debt financing structure. The financial feasibility approach is used as a tool on an ongoing basis to set a rate structure that will cover airport costs (*12*).

The financial feasibility of the project is calculated using the standard benefit-cost ratio formula:

$$\left[\frac{R_1 - E_1}{(1 + r)^1} + \frac{R_2 - E_2}{(1 + r)^2} + \ldots + \frac{R_n - E_n}{(1 + r)^n}\right] \div C$$

where the expected revenues from the airport (R) minus the costs of operating and maintaining the airport (E) in each year are discounted by a factor of (r), generally set equal to the current market rate of interest. The sum of discounted net revenues is then divided by the initial costs of constructing the airport (C). The discount rate used in this analysis should reflect the cost of capital faced by the airport operator under current market conditions. The advantage of using the market rate, which incorporates real interest, inflation, and risk, is that it affords comparison with any other potential investment.

If this exercise yields a benefit-cost ratio less than 1, it usually indicates that the investment is not warranted, because the net income generated would fail to cover the initial construction costs and the cost of capital. However, before rejecting the investment outright, a sensitivity analysis should be attempted to see if changes in the estimates of costs and revenues (e.g., assuming a different fee structure or a greater volume of air traffic) or the discount rate would make the ratio larger than 1.

Even if the benefit-cost ratio remains below 1, the construction of the facility may still be undertaken if the indirect benefits it offers the community warrant its subsidization from government funds. In fact, the indirect economic benefits of the airport might generate revenues to cover the subsidy. For example, if the location of the new airport in a state results in a net increase in economic growth, the state may capture part of the costs of construction indirectly through increases in its general tax revenues.

On the other hand, a project with a benefit-cost ratio greater than 1 might still be ruled out if other costs not measured by the financial feasibility approach are deemed to be too great.

The major weakness of this analysis is that it does not consider the full range of costs and benefits of the airport project. It does not consider job creation or displacement and the broader economic impact associated with airport development. As noted previously, these spread effects have a direct bearing on indirect costs and revenues associated with the airport, and therefore have budgetary implications for the governments financing the investment.

In addition, the analysis does not include intangible effects of airports, or costs and benefits that are difficult to quantify. Many economic activities provide incidental benefits to others for whom they are not specifically intended. Such benefits might include the value of time saved by airport users or the effects on property values close to the airport. Similarly, there are airport activities that indiscriminately impose costs on others. An example might be the air and noise pollution that an airport brings. An activity generates externalities if it causes incidental benefits or costs to others, and those who generate the externalities do not provide or are not provided corresponding compensation. In the context of airport construction, those who benefit from positive externalities are generally dispersed throughout the community, whereas those who suffer from negative externalities consist primarily of people who live near the airport.

Benefit-Cost

The traditional benefit-cost procedure involves measuring all the costs of providing a service (economic, social, and environmental) and all the benefits derived from the service, then valuing each of these in monetary terms discounted to a common point in time. The difference in the value of costs and benefits, usually expressed as a ratio, is then used for policy decisions. If the ratio of benefits to costs is greater than 1, the proposed project is warranted.

Benefit-cost analysis has not generally been used to evaluate the economic ramifications of airport development. It appears to have been used primarily at the federal level to establish funding criteria. Benefit-cost analysis has been used regularly, for example, by the FAA to look at proposed airport site improvements involving potential navigational aids (instrument landing systems) in relatively low-activity areas. According to FAA and others, in these cases the analysis was used to determine the minimum level of activity that warranted the expenditure necessary to install the system.

Perhaps the most extensive benefit-cost analysis of airport development was performed by the U.K. Commission of the Third London Airport. The study compared four proposed sites for the location of a third London airport, attempting to measure and compare the economic and social costs and benefits of each location. However, the study's recommendation was not followed. The study determined that Cublington, a site close to London, would be the best site, but the Parliament preferred Foulness, which was the site furthest from London with the worst benefit-cost ratio (*13*).

The limitations of the benefit-cost approach for analyzing multifaceted socioeconomic issues are well known. The methodology requires that the costs and benefits be quantifiable and comparable in monetary terms. In many cases, this valuation is difficult to justify and appears arbitrary—such as placing a dollar value on passenger time or passenger life when estimating risk factors.

IMPACTS OF AIRPORTS ON REGIONAL SOCIOECONOMIC DEVELOPMENT

As states become more involved in aviation, it is important that the relationship between airports and economic development be well understood, and that the longer-term effects and dynamics be assessed. The issues from the states' perspective are the following: Do airports help foster economic development? And if so, what kind of development is typically encouraged, how does this occur, and at what cost? These questions can be phrased more specifically. Do airports draw industry into a state or region, leading economic growth, or do they tend to follow development? Do they act as constraints to growth (if they are not built or expanded)? Is there a bias to the type of economic development encouraged, attracted, or supported by airport and aviation development?

As states consider increased involvement in aviation, the financing issues need to be addressed. What are the available sources and required levels of financing and, what additional (associated) expenditures and activities are required to exploit the full economic potential of airport development?

Although few studies address these questions directly, there are areas of the literature that can offer insights into these issues. Following is a review of some of this literature and data that could, in further research, be applied more directly to the previous questions.

Determinants of Business Location

In order to address the question of whether or not airports attract industry, it is useful to ask first what determines business location decisions generally and how important access to air travel and transport is to those decisions.

The part of industrial location literature that is most relevant is the body of empirical case studies of location factors. These studies attempt to explain industrial location shifts by identifying the factors that influence business decisions to locate or relocate (*14–16*). Studies generally show plant and industry location decisions on the basis of a variety of criteria including

1. Economic factors such as accessibility of markets, raw materials, utilities, transportation, and labor;
2. Institutional factors such as government characteristics and tax rates;
3. Community factors such as amenities (cultural facilities, natural environment), attitudes, and population size;
4. Personal preferences on the part of the management and owners; and
5. Site factors such as land and buildings (*17*).

Access to Air Transportation as a Location Factor

Access to transportation, as well as the speed, convenience, dependability, and frequency of service, is an important location criteria. For example, a research memorandum by the Kansas Department of Economic Development found that a cross match between two industrial location surveys showed "efficient transportation facilities" to be among the nine most important locational factors for more than 50 percent of the survey respondents. The other factors included

- Availability of energy and fuel,
- Tax abatement and incentives,
- Ample area for future expansion,
- Availability of labor,
- Accessibility to markets,
- Proximity to materials,
- Financing inducements, and
- Availability of technical and professional workers (*18*).

Studies directly addressing the link between airports and economic development vary in their conclusions. Some studies suggest that airports act as magnets, attracting industry and business, or that they are a necessary condition for growth. The Aviation Advisory Commission, for example, has argued that "it has been factually established that few businesses are willing to build plants and other facilities in a community that has no airport" (*19*). The FAA has claimed that documented cases show the existence of an airport to be a controlling factor in the decisions of industries to move in or out of a community.

Other studies, however, argue that unless there are other factors such as access to materials, an adequate labor supply, and the proper tax structure, air service will not induce new industry to an area (Vittek, M.I.T. Flight Transportation Laboratory). One study of three small airports in California (Bakersfield, Monterey, and Redding) suggested that economic development tends to drive airport development, rather than vice versa. This study concludes that local air service in many small cities is economically precarious—that "it depends on the presence of strong local demand which, in turn, requires a vigorous local economy." It notes further that this demand for local air service is less likely to develop if the locality is near a major hub airport (*20*).

A report prepared for the Appalachian Regional Commission (*21*) notes that the information concerning the airport's influence on industrial plant location decisions generally takes two forms: individual airport case studies and industrial surveys. According to the report, industrial surveys show that airports were listed as important by 20 to 30 percent of those involved in the location decision-making process.

In a survey of 330 Nebraska industrial plants, the most important factors determining industrial location decisions included quality, availability, cost of labor, and the existence of a right-to-work law in the state; highway transportation and proximity of markets; reliability of electrical service and availability of natural gas; availability of sites; and the fact that the people who started the plant lived in the area (*22*). Aviation services were not rated especially important. The study found that air freight transportation and air passenger transportation were, respectively, 33rd and 36th in importance among 43 factors. According to the study, some firms wanted airport facilities nearby for fast shipment of raw materials and finished products.

Air Travel and Transport Are More Important for Some Industries

Although airport access does not tend to rank near the top of the list as a determining factor in the location decisions of business in general, it is more important for some industries than for others. An important question for states to consider is whether there is a bias to the type of economic development encouraged, attracted, or supported by airport and aviation development. Such a bias might be discernable from data showing which industries depend most on air travel and transport. These data could identify those industries most influenced by access to air in their location decisions.

An analysis of industry location by the Kansas Department of Economic Development (*18*) attempted to identify aviation-oriented industries that would be attractive and attracted to Kansas. The report cites data from another study that classified 83 of 143 industries as "aviation oriented" (*23*). The report then groups these 83 industries according to their locational goals and state preferences. The report identified several industries that (a) do not require urban orientation, (b) are not primarily seeking cheap labor, and (c) would consider relocating to Kansas. These were grain mill products, beverages, household appliances, and electric lighting and wiring equipment.

This study reflects the types of efforts some states have made to assess the development effects of greater airport and aviation development. It also reflects the lack of adequate data. The list of industries identified as aviation-oriented refers to industries economically associated with aviation. But this does not necessarily mean that these industries need or prefer to locate near airports. Survey data directly addressing this question are needed.

A forthcoming study of the air cargo-air express service industry identifies the industries most dependent on this service (*24*). Ranked by shipment value, the top six industries are

- Computers and computer equipment,
- Radio and TV communications equipment,
- Semiconductors and related devices,
- Aerospace—vehicle equipment,
- Aerospace—engines and parts, and
- Electronic components.

The study notes that "because of market requirements, competitive pressures, and highly interrelated production/distribution process, manufacturers are shipping greater proportions of their output by air at a continuing rate. The speed, reliability, and security of air cargo services are sufficient to command premium rates" (*24*). Small, high-technology manufacturing plants are the major users of air cargo and air express services. The study also found that the average size of shipment, by weight and value, had dropped between 1983 and 1987. It concluded that air cargo and air express services have been instrumental in facilitating new industrial distribution systems (such as just-in-time inventory management) that require more frequent shipments of smaller average size.

In 1984, a 64,000-ft^2 cargo terminal was opened at the Norfolk, Virginia, airport. In 1985, it was reported that economic agencies there indicate that "bringing in Federal Express will boost many businesses in the region" (*25*).

A survey of firms in suburban Philadelphia found that access to Philadelphia International Airport is much more important to high-technology firms than non-high-technology firms (*26*).

In some cases, the tourism industry has been closely tied to airport development. A recent example of the importance of an airport development project to this industry is the expansion and initiation of commercial jet service to the Yampa Valley Regional Airport in Colorado. These changes, financed by both public and private sources, have been responsible for turning the local economy, which had been depressed and suffering from the collapse of the coal industry, toward growth based on the expanded use of the local ski resort.

As is the case with high-technology industries, the available studies on tourism industries suggest a strong link between the development of these industries and access to air transportation. But most of the information tends to be anecdotal and generalizations are difficult. There is a clear need, therefore, for improved data systems and broader analysis of the issue if state development policy makers are to be able to understand and anticipate the effects of airport development on state and local economies.

CONCLUSIONS

The literature that analyzes the relationship between airports and economic development covers a wide range of approaches and concerns. Although the literature is voluminous, little of it directly analyzes the airport and economic development relationship in a comprehensive way. Few studies look at the issue from the state perspective. Most agree, however, on one point—that airports do contribute significantly to, or at least influence, the economic activity beyond the airport site itself.

Some general findings of the literature are as follows:

- The location of airports influences the location and geographic distribution of some industries, and can be a significant factor in the decisions of certain industries to locate in a given state or region. (Data indicate that access to air transport plays an increasingly important role in the competitiveness of some high-technology industries).
- The impact that an airport development project has on an area depends on the particular economic conditions and characteristics of that area.
- There is a need for more comprehensive studies of the issue. Several data sources could be more fully explored, which could shed added light on the complex relationship between airports and economic development.

How can this literature be used to address state economic development issues? As noted, little of the existing literature speaks directly to the analytical needs of governors' offices as they budget their states' resources for economic development purposes. Nevertheless, many studies contain useful information and methodologies, and others identify sources of information that could be helpful.

For example, even though the final dollar figure arrived at by most conventional economic impact studies may not be appropriate or useful to a comprehensive view of the airport–economic development linkage, these studies contain detailed information on the specific industries and enterprises directly and indirectly associated with airports. This type of information is a necessary ingredient in any comprehensive analysis of this issue.

Similarly, the methodologies used and classifications developed in the financial analyses of airports should be used by governors' offices when contrasting airport development with other potential development investments.

Finally, detailed information on the industries that rely most heavily on air transport (i.e., those most likely to be attracted by improved air transportation) and those that are apt to be displaced in the event of airport development should be developed as the basis for predicting the type of economic development that is likely to occur as a result of enhanced air transport facilities and capacities. This kind of information currently exists in a few specialized studies, but has not yet been collected and analyzed on a broad enough basis to yield reliable generalizations.

Although little of the existing literature directly answers the questions governors are asking about the relationship between air transportation and economic development, it does contain information, analytic approaches, and data bases that can be effectively used by state and regional analysts to address the issue within the broader framework of statewide and regional development goals.

APPENDIX

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Economic Impacts of Improving General Aviation Airports

GLEN WEISBROD

Every state and many communities face the issue of setting priorities for investments in airport facilities. This issue has received the most public attention regarding the regional economic importance of investments in major new commercial airport facilities but relatively little attention has been given to the role of general aviation (GA) facilities. As a result, the issue of investment priorities is particularly problematic for GA airport facilities because their contribution to local and state economies is not well understood. The state and local economic impacts of GA airports are defined and measured, and the benefits of improvements to those airports are assessed. General aviation today is briefly summarized, and the measurement of airport benefits is examined with particular attention to the different approaches for economic impact analysis. Results are presented from a survey of businesses that use GA, which focused on the relative importance of GA for those businesses. A basic model system for evaluating GA benefits, developed for the Massachusetts Aeronautics Commission, is presented.

General Aviation (GA) refers to private aircraft that are not used for scheduled air services (passenger or cargo) or for military uses. Typically GA aircraft are small, propeller- or jet-powered airplanes or helicopters that may be owned by individuals or by corporations. Aircraft available for charter services (air taxi) or flight training are included in the GA category as well.

Contrary to the popular view, flying private planes is far from just a recreational activity. Nationally, according to a survey by the Aircraft Owners and Pilots Association, it is estimated that at least 26 percent of the GA fleet is operated exclusively for business and that 60 percent is used at least partly for business purposes. Other key findings from prior studies are as follows:

- Nationally, an estimated 34,000 firms operate 68,000 private aircraft.
- Of the Fortune 500 list of largest publicly held U.S. corporations, 363 operate their own business aircraft (*1*).
- Business turboprops and business jets in North America now number over 10,000, and are growing at a pace of over 3 percent annually (*2*).
- More than two-thirds of all business aircraft trips make use of GA airports rather than commercial air terminals (*3*).

Nationally, the importance of corporate access to GA airports is increasing as manufacturing and other corporations decentralize. As noted by one executive:

Cambridge Systematics, Inc., 222 Third Street, Cambridge, Mass. 02142.

> In this day and age, if you don't have a good all-weather airport, you're substantially jeopardizing your ability to grow and attract business. The more we grow, the more of a problem it becomes to us. The more reason we have to travel around (*4*).

MEASUREMENT OF AVIATION BENEFITS

GA facilities (and improvements to those facilities) can provide a range of potential benefits:

- User Benefits. Provide travel time and operating cost savings, as well as safety improvements, for travelers.
- Economic Benefits. Promote business expansion and attraction by generating jobs and business income and by providing necessary facilities to attract new businesses.

User benefits of an airport or airport improvement result in subsequent economic benefits for business expansion and attraction.

User Benefits

Transportation system efficiency impacts from transportation projects are evaluated through user benefits. For any given transportation improvement, the aggregate economic value of time savings, out-of-pocket cost savings, and safety improvements for all travelers can be compared to current or base case conditions. User benefits associated with a project can then be compared to the costs involved and can also be used to compare the net benefits of alternative projects and for ordering projects by priority in statewide airport system plans. Such a process is actively used by the state of Wisconsin in its statewide Airport Benefit Cost computer system and also in FAA's Airport Data Analysis microcomputer program.

Application of benefit-cost analysis on the basis of transportation efficiency (user) impacts is a respected approach used in project evaluation for highways and seaports, as well as aviation facilities. However, it is increasingly being recognized that user benefits can understate the full economic benefits of a project, particularly when the proposal is a new facility or expansion of an existing facility that is motivated by its potential role as a catalyst for local economic development.

Economic Benefits

Much confusion exists about how to measure economic impacts of GA airport facilities. In fact, different measures are appropriate depending on the policy questions, which may include the following:

- What is the value of an airport to the economy of its surrounding community or county area?
- What are the economic benefits of improving an airport, compared to the costs involved?

Role in the Economy

Airport promotional literature often describes the airport's economic importance in terms of its involvement in many aspects of the local economy. Economic roles of an airport are determined by counting the value of sales, employment, and payroll of fixed-base operators, airport-related services, and all businesses that depend on or use the airport in some way or another. Thus, this method essentially gives credit by association and overstates the economic value of an airport by giving credit for all the business activity that ever uses the airport. Local airport proponents like this method because it can generate big numbers favoring airport improvements.

Economic Contribution

Economic contributions of an airport are measured by accounting for revenue received by businesses in the community as a result of the airport activity and is generally a more sophisticated measurement. Included are not only spending at the airport for landing and storage fees, fuel, and maintenance, but also spending at hotels, restaurants, and retail stores by travelers visiting the community because of the airport. Economic contribution further includes indirect and induced spending flowing to other businesses in the community as a result of the additional worker income and business orders. Economic contribution may be measured in terms of business sales, employment, and business activity generated by construction of airport improvements. One adjustment that should be (but is not always) made is to distinguish the actual share of revenue that stays as income for residents of the community from the share of revenue that flows out to suppliers or manufacturers located elsewhere.

Economic contribution does not count benefits for local businesses that depend on or use the airport except insofar as they spend money at the airport. If an airport improvement saves time and lowers cost for businesses or attracts new industry or tourism, no further benefit is recognized unless reflected in projections of local spending. However, this measure also counts local spending generated by an airport project regardless of whether it is newly generated air travel or merely travel shifted from a neighboring airport. For this reason, economic contribution may be used for summarizing the local economic impacts of an airport, but is not appropriate for ordering of statewide projects by priority.

Net Economic Benefit

Net economic benefits are measured as income to residents generated as a result of maintaining or improving an airport compared to a base case of not maintaining or improving that airport. This benefit measure has three components:

- Local income generated as a result of business expansion from increased direct user spending at the airport and in the community, as well as from indirect and induced business growth;
- Local income generated as a result of additional jobs because of new business attraction made possible by the airport improvements; and
- Additional value of user benefits (time and cost savings) associated with nonbusiness travel by local residents and existing visitors, who do not generate any increase in their spending because of those additional user benefits.

For statewide evaluation, any local income benefits associated with trips shifted from other airports in the state are rightfully excluded as merely intrastate distributional shifts. An input-output model would be used to identify and exclude that portion of spending that flows to out-of-state suppliers.

ANALYSIS MODELS

Measuring economic benefits of GA airport projects is a major accounting process but a variety of microcomputer analysis tools are now emerging to aid the process. California's Economic Impact Model (*5*) provides a framework for assessing local impacts by measuring economic contribution and potential business attraction and includes a suggested survey of local airport users to provide additional data. Wisconsin's Airport Benefit-Cost Model (*6*) provides parallel accounting both of user benefits and of net economic benefits (compared to costs) from local and statewide points of view and also includes default statewide averages for valuation of user and local spending benefits. The Massachusetts Airport Impact Model (*7*) provides a method for estimating changes in airport business usage, economic contribution, and business attraction on the basis of characteristics of the airport improvements, its service area population, and the area's economic profile. Results from a Massachusetts survey and an impact model built on the results will be the focus of the following discussion.

SURVEY OF BUSINESS USERS OF GENERAL AVIATION FACILITIES

The hardest part of evaluating economic impacts of airport projects is not estimating the local spending that is generated, but rather, assessing the additional impact of airport facilities on attracting new businesses or keeping existing businesses from leaving. Although many local and regional economic factors come into play, a basic understanding is needed of how different kinds of businesses currently depend on GA airport facilities for their existence, location, and expansion decision making. Such considerations can be addressed by the following questions:

- What kinds of businesses use GA? In what ways? How important is access to GA for those various types of businesses?

- What alternative options would be feasible for these businesses if the GA access were not maintained? To what extent would businesses shrink, relocate, or close?
- What role does current GA access play in business location and expansion plans? What role would future changes in GA access play in affecting future business location and expansion plans?
- What types of improvements can be made to airport facilities to enhance business use of GA? How can that support the economies of communities and the state?

These questions help to address the fundamental question of the regional economic consequences of changes in the availability and quality of GA airport facilities and services.

In order to better understand these matters, a survey was conducted by Cambridge Systematics for the Massachusetts Aeronautics Commission (*8*) of businesses owning or operating GA aircraft. Mailback surveys (Figure 1) were sent to all aircraft owners that were businesses or who voluntarily reported use of their aircraft for business purposes on their Massachusetts registration. Out of 3,000 registered owners in the state, approximately 1,000 aircraft owners fit these criteria and received the survey. Exactly 250 completed surveys were returned. Key findings are summarized in the following sections.

Breadth of Business Use of General Aviation

A wide variety of businesses own or use GA in Massachusetts, as shown in Figure 2. Services, including consultants, lawyers, doctors, and advertising firms, made up the largest group and represented over 35 percent of survey respondents. Manufacturing contributed another 19 percent of all business users and was dominated by computer, electronics, and machinery manufacturers. An additional 32 percent of the survey respondents were engaged in diverse industries such as wholesaling, retailing, construction, utilities, agriculture, and fishing. Finally, 14 percent were engaged in educational services or transportation services (primarily flight training or aircraft charter services).

Firms using GA in Massachusetts were found to be of all sizes. Although 60 percent had under 25 employees, many manufacturing firms surveyed employ over 2,000 workers.

The survey showed that GA is used by businesses in many different ways. Roughly 67 percent of the firms said they use GA to transport staff, visitors, or clients. Receiving supplies and shipping products accounted for 6 percent of the use, whereas aerial surveying accounted for 4 percent. Other uses were flight training (3 percent), other miscellaneous business uses (4 percent), and nonbusiness use (16 percent).

Not surprisingly, the way businesses used GA differed significantly by the type of business (see Table 1). For utilities, aerial surveying and delivering of products were the major uses of GA. Delivering products and receiving supplies were also particularly important uses for high-technology electronic equipment manufacturers, and for businesses engaged in wholesale trade. Aerial surveying was found to be an important use for businesses engaged in agriculture, real estate sales, and spotting schools of fish.

Importance of GA for Business

Many methods exist to assess benefits businesses receive from GA but one method uses a minimum estimate of the productivity and cost-saving benefits for businesses. Such benefits are measured in terms of what firms are willing to spend on GA in terms of capital and operating costs. If the premise is accepted that businesses typically decide to spend money on aircraft only when the value for the firm exceeds the cost of acquisition and operation, then the annual level of spending on GA represents a minimum estimate of its true economic benefit to business.

From the survey, average annual expenditures for GA aircraft was $11,000 of operating expenses plus another $13,000 of annual capital costs. Given an average business fleet of 1.7 aircraft, total spending on GA averaged $40,000 per business.

Businesses were asked how they would respond if their base airport were no longer available for their use (see Figure 3 and Table 2). Overall, 66 percent of the firms reported that they would use the next closest airport or make fewer trips. Another 8 percent reported they would substitute another mode of transportation. Of particular concern, however, was the finding that 19 percent of the businesses reported they would relocate and 7 percent reported they would go out of business. Although the latter response may be an exaggeration of the true impact, it nevertheless highlighted the seriousness with which some businesses view their access to GA airport facilities. Also notable was that the incidence of reporting these impacts was highest (over 20 percent) for businesses engaged in agriculture, fishing, utilities, retail trade, finance, and real estate. Surveyed businesses that reported they would relocate or go out of business accounted for 8,050 employees and $2.2 billion in sales. If these survey results are taken at face value, then the total statewide impact of GA access is even higher because the survey accounted for just 25 percent of all businesses using GA in the state.

Interestingly, these results are consistent with other survey questions that asked businesses about the relative importance of proximity to a GA airport in their original site selection decision. Approximately 23 percent of the businesses considered it an essential factor.

These survey findings are of interest because they highlighted the importance of GA airport facilities for the location decisions of some businesses. However, the findings also left many questions unanswered:

- Are stated intentions to relocate or close in response to such a hypothetical situation a good prediction of actual behavior?
- To what extent would businesses actually close or relocate in cases where GA airports were downgraded or closed?
- If businesses were to relocate, would it be to another community within the same state?

Businesses reporting they would not go out of business or move out of state were asked to estimate how much their sales volume would change and how much their transportation costs would change. Of the businesses that would not relocate or close, 40 percent reported they expected their sales volume to decrease with an estimated average loss in sales (including businesses that expected no decrease) of $1 million (15 per-

1. **What is your firm's primary product or service?**

____

2. **What size is your firm?**

_______ Number of people

$_______ Annual sales

3. **Do you ever use general aviation aircraft for your business?**

☐ yes ☐ no

If YES, skip to Question 4 and complete remainder of the survey.

If NO, answer question 3a and do not complete the survey.

Please be sure to return the survey form. Thank you.

3a. **Have you ever considered using general aviation for your business?**

☐ yes ☐ no If YES, why haven't you used it?

____

4. **Is your firm's aircraft** (Check as many as apply.)

○ business owned
○ owned personally
○ leased
○ chartered

If business owned, is the aircraft

○ used exclusively by the business
○ leased back to a FBO from a charter or rental
○ used jointly with an other business

5. **What type(s) of aircraft do you use?**

Make/Model	# of Aircraft

Total in fleet _______

6. **How much does your firm spend for**

aircraft operating expenses per year . . . . $ _______
(fuel, maintenance & servicing)

aircraft capital costs per year . . $ _______
(lease payments, equipment purchases, depreciation, etc.)

7. **What percent of your firm's total transportation costs are spent on general aviation?**

_______ %

8. **In the future, does your firm plan to** (Check as many as apply)

○ increase the number of aircraft owned
○ decrease the number of aircraft owned
○ make no changes to the fleet
○ upgrade the fleet

9. **Estimate the TOTAL number of HOURS PER YEAR that your aircraft is used for BUSINESS purposes?**

_______ hours

10. **What percent do these business trips represent of your aircraft's TOTAL tripmaking?**

_______ %

11. **Estimate the PERCENT of total aircraft use attributable to transporting**

___ % staff/executive transport
___ % visitors/clients
___ % suppliers/contractors
___ % receiving supplies (incoming)
___ % delivery of products (outgoing)
___ % aerial surveying
___ % non-business use
___ % other (specify) _______

100% Total

12. **Where is your firm's aircraft based?**

[ ] Massachusetts: → → Please specify airport name or code:

____

[ ] Connecticut
[ ] New Hampshire
[ ] Vermont
[ ] Maine
[ ] other state (please specify)

____

13. **What are the five primary airports that you fly to in MASSACHUSETTS, and approximately how often do you go to each?**

Airport Name or Code	# of Times Per Year
1.	
2.	
3.	
4.	
5.	

14. **When you were selecting a site for your business, how important was proximity to a general aviation airport?**

[ ] not a consideration
[ ] moderately important
[ ] very important
[ ] essential

15a. **What would be your response IF your BASE AIRPORT were no longer available for your use?** (Check as many as apply.)

○ substitute other modes, e.g., bus, truck, rail
○ use next closest airport (specify)

____

○ make fewer trips
○ relocate business
○ go out of business
○ other (specify) _______

15b. **How much do you think your business/ sales would change? (Estimate PERCENT CHANGE.)**

[ ] remain the same
_______ % higher
_______ % lower

15c. **What would you expect your firm's transportation costs to be?**

☐ remain the same
_______ % higher
_______ % lower

16a. **What would be your response IF your most frequently used DESTINATION AIRPORT were no longer available for your use?** (Check as many as apply.)

○ substitute other modes, e.g., bus, truck, rail
○ use next closest airport (specify)

____

○ make fewer trips
○ relocate business
○ go out of business
○ other (specify) _______

16b. **How much do you think your business/ sales would change? Estimate PERCENT CHANGE.**

☐ remain the same
_______ % higher
_______ % lower

16c. **What would you expect your firm's transportation costs to be?**

☐ remain the same
_______ % higher
_______ % lower

17a. **What is the most important improvement that needs to be made to general aviation airports? (e.g., runway, navaids, services provided, etc.)**

Kind of improvement: _______________

____

____

Airport: _______________

17b. **How would this affect your business?**

_______ % increase in sales
_______ % decrease in business costs

Please use the space below to elaborate on any of your answers or to describe an occasion on which your aircraft played a major role in your business.

____

____

____

____

____

____

_______________ ☐

If we have any further questions, may we give you a call? All responses will be strictly confidential.

Contact Person: _______________
Firm: _______________
Telephone: _______________ ☐

Thank you very much for your time and effort.

FIGURE 1 Survey instrument.

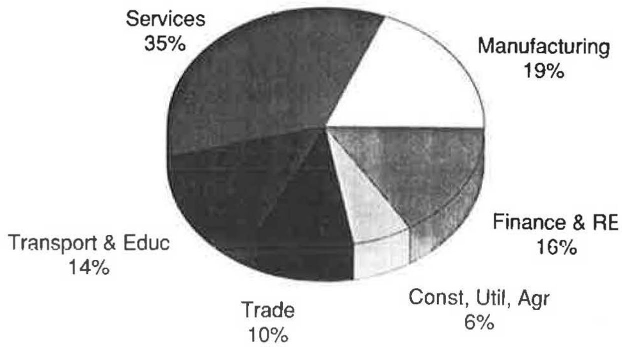

FIGURE 2 Business type of general aviation users.

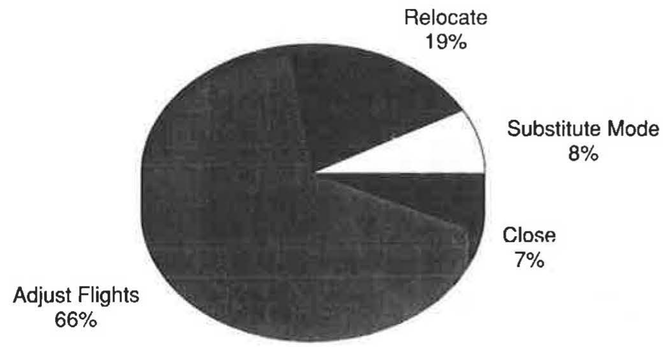

FIGURE 3 Responses to closing base airport.

TABLE 1 PERCENT OF EACH TRIP PURPOSE BY INDUSTRY (*8*)

Industry	Transporting Staff	Transporting Clients	Transporting Suppliers Contractors	Receiving Supplies	Delivering Products	Aerial Surveying	Other Than Business	Flight Training	Other
Agriculture	20	2	0	2	3	23	17	0	33
Construction	58	11	4	1	6	8	7	4	1
Miscellaneous manufacturing	70	16	4	0	3	0	8	0	0
Machinery manufacturing	60	8	2	1	6	1	21	1	0
Electronic equipment manufacturing	55	7	2	5	13	0	12	2	6
Transportation services	34	30	8	0	1	6	9	1	10
Utilities	23	8	7	2	17	24	9	0	10
Wholesale trade	54	10	1	12	11	0	13	0	0
Retail trade	71	4	0	2	0	0	13	0	9
Finance	71	15	2	0	2	2	7	0	0
Real estate	53	12	5	1	1	9	20	0	0
Services	53	10	1	2	2	4	22	2	5
Education	24	1	1	3	0	2	27	41	0
Average	53	12	2	2	4	4	17	3	4

TABLE 2 EXPECTED RESPONSE OF BUSINESSES LOSING BASE AIRPORT BY BUSINESS TYPE (*8*)

	RESPONSES TO LOSING DESTINATION AIRPORT				
BUSINESS TYPE	SUBSTITUTE OTHER MODES OF TRANSPORTATION	USE NEXT CLOSEST AIRPORT	MAKE FEWER TRIPS	RELOCATE BUSINESS	GO OUT OF BUSINESS
AGRICULTURE	0%	33%	0%	67%	0%
CONSTRUCTION	0	86	0	14	0
MISC. MANUFACTURING	7	79	7	0	7
MACHINERY MFG.	10	80	0	10	0
ELECTRONIC EQUIP. MFG.	7	64	14	14	0
TRANSPORTATION SERVICES	6	44	0	19	31
UTILITIES	20	60	0	20	0
WHOLESALE TRADE	8	67	8	8	8
RETAIL TRADE	22	44	0	22	11
FINANCE	0	73	0	27	0
REAL ESTATE	10	58	0	32	0
SERVICES	9	63	2	20	6
EDUCATION	0	50	10	20	20

cent). When asked about the effects on their transportation costs, over half reported that they expected their costs to increase with the average increase being 18 percent ($30,000).

If these survey results are indicative of true impacts, then the results allow estimation of both the resulting change in business costs and the change in local business employment and sales. Alternatively, an economic simulation model of business competition (such as the REMI model) could be used to estimate how increases in GA-related transportation costs (compared to areas elsewhere) are likely to lead to decreases in local business activity.

Both quality and availability of GA airport facilities also affect nonlocal businesses that use those facilities. In the survey, businesses were also asked to report their expected response if their base airport were still available, but their most frequently used destination airport were no longer available for use. Responses to this question differed from those of the previous question about the loss of base airport access. Fewer businesses reported they would relocate, close, or use the next closest airport. However, a significantly greater proportion of the businesses reported that they would substitute other modes of transportation or make fewer trips. Of those businesses that reported they would not go out of business, the expected impacts on sales and transportation costs were similar to the expected impact of the base airport closing.

By combining the portion of business sales at risk of being lost because of a business closing, relocating, or sales contracting, a measure can be constructed for overall business sales vulnerability associated with the loss of base or primary destination airports. Results, presented in Table 3, show a wide variation in the portion of sales at risk. Overall, the average level of sales at risk of being lost was found to be approximately 40 percent of total business activity for the surveyed businesses. For a median-sized business, this is equivalent to roughly $1 million of sales at risk although the average (mean) sales at risk is $30 million per business because of the existence of some large businesses in the survey. Either way, these figures for potentially lost sales dwarf the $40,000 average annual spending per business on general aviation costs.

In any case, care must be taken to avoid double counting benefits. Benefits can be measured either in terms of the firm's estimate of its savings in cost of doing business (average of $1 million per business), or in terms of the firm's estimate of local business sales at stake (average of $1 to $30 million per business), or in terms of the business expenditures associated with aircraft use (average of $40,000 per business). Business expenditures for fuel, repair, storage, and fees in turn provide a major portion of the revenue of local fixed-base operators. To include this activity as an additional element of business benefit would, however, be double counting.

PROCESS FRAMEWORK FOR ESTIMATING BUSINESS BENEFITS

One process framework for estimating benefits is the Massachusetts Airport Impact Model, which measures the economic benefit of GA airport projects as being the local worker income associated with that portion of business sales activity that depends on the continuation or improvement of a particular airport. For example, airport projects that may affect business use of an airport (and hence business sales activity) include

- Whether or not a runway is extended to accommodate corporate jets;

TABLE 3 PORTION OF BUSINESS SALES AT RISK (*8*)

SIC	INDUSTRY	
1-9	AGRICULTURE	67%
10-14	MINING	0%
15-19	CONSTRUCTION	21%
20-34,37-39	MANUFACTURING	13%
35	MACHINERY MFG.	12%
36	ELECTRICAL MFG.	19%
40-47	TRANSPORTATION SERVICES	57%
48-49	UTILITIES	20%
50-51	WHOLESALE	18%
52-59	RETAIL	36%
60-64,67	FINANCE	31%
65-66	REAL ESTATE	34%
70-81,83-89	SERVICES	33%
821-823	OTHER EDUCATION	0%
824-829	FLIGHT TRAINING/EDUC.	98%
90-99	GOVERNMENT	0%
AVERAGE WEIGHTED BY NUMBER OF AIRCRAFT		40.80%

Note: These figures represent the percentage of total business sales accounted by companies that claim they would relocate or go out of business if their base or primary/destination airport were to close, plus the reported loss to other companies that would not relocate or go out of business.

- Whether or not operating hours are extended and lighting is installed to allow night flying;
- Whether or not instrument landing systems or a crosswind runway is installed to allow operation in adverse weather conditions;
- Whether or not jet fuel and full maintenance services are provided; and
- Nature of user facilities and amenities.

Each of these considerations has the potential to encourage or prevent future business use of an airport.

The process of estimating business use of an airport, with and without improvements, is a multistep process. The key steps are discussed in the following paragraphs.

Characteristics of Business Aircraft Ownership

From the survey, aircraft ownership, average fleet size, and mix of aircraft types all differed by the type of business. Table 4 presents these data in terms of the number and types of aircraft owned by businesses in each industry, expressed as a ratio per total statewide employment in that industry. As the economy of the state changes over time, employment in some industries will grow faster than in other industries and, as a result, the number of business aircraft and the mix of aircraft types will also change over time.

Employment Profile and Forecast

State and federal sources provide forecasts of statewide employment growth (and decline) by industry (standard industrial classification groups) over the next decade and beyond. These forecasts reflect expectations of growth and decline in various industries as a result of shifts in the national economy, shifts to foreign manufacturing in some industries, and changing technology.

Potential Based Aircraft

Using the previous two steps together will allow estimates of the projected future number and mix of aircraft based in the state. The estimated potential for each airport depends on the specific employer profile forecast for its service area.

Limitations on Aircraft Use and Additional Achievable Use

Business growth benefits from investments in GA airport facilities depend upon the adequacy of facilities provided and can be defined in terms of criteria such as

- Critical Aircraft Type—limitations on the type of aircraft that can use the airport (related to runway length and pavement);
- Lighting—limitations on use of the airport at night;
- Instrument Navigational Aids—limitations on use of the airport during low-visibility or inclement weather conditions; and
- Other Factors—availability of hangars and tie-downs, weather services, fuel, plowing in winter, restaurant, etc.

Any airport project that increases the types of aircraft that can use the airport, or the time that the airport can be used, or the reliability for its usage, will encourage greater use of the airport and, hence, attract additional businesses and promote economic growth. Existing characteristics of an airport (with respect to these criteria) can be used to identify the existence of factors now limiting its use by business. Actual

TABLE 4 AIRCRAFT OWNED PER 1,000 TOTAL EMPLOYEES (*8*)

SIC	INDUSTRY	SINGLE	MULTI	JET	HELI	TOTAL
1-9	AGRICULTURE	0.80	0.00	0.00	0.00	0.00
10-14	MINING	0.00	0.00	0.00	0.00	0.00
15-19	CONSTRUCTION	0.18	0.09	0.00	0.05	0.32
20-34,37-39	MANUFACTURING	0.10	0.02	0.01	0.00	0.13
35	MACHINERY MFG.	0.35	0.16	0.08	0.04	0.63
36	ELECTRICAL MFG.	0.41	0.17	0.03	0.00	0.61
40-47	TRANSPORTATION SERVICES	1.87	0.62	0.05	0.10	2.64
48-49	UTILITIES	0.16	0.16	0.00	0.08	0.41
50-51	WHOLESALE	0.35	0.06	0.00	0.00	0.41
52-59	RETAIL	0.08	0.01	0.00	0.00	0.09
60-64,67	FINANCE	0.32	0.09	0.00	0.03	0.44
65-66	REAL ESTATE	2.31	1.08	0.15	0.00	3.55
70-81,83-89	SERVICES	0.47	0.10	0.01	0.03	0.61
821-823	OTHER EDUCATION	0.00	0.00	0.00	0.00	0.00
824-829	FLIGHT TRAINING/EDUC.	34.02	1.79	0.00	0.00	35.81
90-99	GOVERNMENT	0.00	0.00	0.00	0.00	0.00
	TOTAL	0.36	0.09	0.01	0.02	0.48

Estimated 1987 employment by industry from Massachusetts Division of Employment Security: Massachusetts Industrial Employment Projected Changes 1984-1995.

Aircraft Owned per 1000 Total Employees is the ratio of the two above sets of figures.

or hypothetical airport improvement projects can then be defined in terms of whether they address some or all of the factors now limiting that business use.

Business User Growth Impacts

It would be a clear oversimplification to credit a business startup, relocation, or expansion solely to the improvement of a nearby airport. Likewise, it would also be a clear oversimplification to blame a business failure, relocation, or contraction solely to the reduction in facilities or services of a nearby airport. Although access to GA is certainly an important factor in business location decisions and business sales, it is not the only factor. Usually, a combination of airport facilities with other business costs and competitive factors (such as availability and cost of labor and raw materials, and the nature of market competition) work together to encourage or discourage business growth. Therefore, the most appropriate ways to assess the effect of airports or changes in airports on business activity are in terms of the following measures:

- Associated Business Activity—additional business employment, payroll, and business sales generated by direct and indirect spending associated with the forecast of additional aircraft using the airport.
- At-Risk Business—portion of current employment, payroll, and sales volume of businesses using the airport that is at risk of being lost when their GA needs are not met, or gained when their GA needs are met.

CONCLUSION: USE OF THE FRAMEWORK FOR ESTIMATING BUSINESS BENEFITS

In setting priorities for airport projects, a great many benefit and cost factors must be considered. Transportation efficiency benefits to users are one measurable factor. Additional impacts on the economy because of potential business expansion and business attraction are other factors. There are, of course, other financial, environmental, and community impacts to be considered.

In addition to the specific economic benefits of airports to businesses, there are the less quantifiable benefits of the provision of access to the more remote regions of the state, the enhancement of mobility, and the ability to locate businesses where factors such as labor supply and resources are located. These quality-of-life aspects of GA airports make a more subtle, but nevertheless real, contribution to the quality of the business climate.

Not all benefits of airport improvements can yet be quantified. Further work is necessary to establish the transferability of results from the Massachusetts survey to other states. Further work is also needed to better understand the process of business relocations and business transportation changes resulting from changes in GA airport facilities and services. Nevertheless, the framework outlined was designed to demonstrate how impacts on the economy could be addressed.

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Economic Impacts of Transit on Cities

ROANNE NEUWIRTH

Justifications for transit investments have included stimulating community revitalization, creating jobs, spurring economic development along a specific transit corridor, and maintaining and sustaining dense urban centers that are becoming paralyzed by automobile congestion. However, opponents of transit investments argue that the actual economic effects of transit do not meet these claims and do not warrant the expenditure of public funds. Transit studies have provided mixed evidence of whether or not the objectives are actually met by transit. A review of the transit literature was conducted to examine the existing economic impact reports for rapid transit systems in the United States and Canada. Sample cities were chosen for case studies to test the varying opinions of policy makers, planners, business people, and developers on the objectives of transit investments and to determine the extent the objectives were achieved in each city. Four types of cities were sampled: older, established rail cities (Boston, Massachusetts); newer rail cities (Atlanta, Georgia); newer cities proposing rail transit (Dallas, Texas); and smaller, bus-oriented cities (Hartford, Connecticut). For each city, the transit system's characteristics, goals and objectives, and impact on economic development were discussed. Findings indicate that transit assists other factors in creating and directing new development projects, provides crucial access into highly congested downtowns, contributes to quality of life that makes a city more attractive for economic development, and provides economic opportunity for transit-dependent populations in urban areas.

One justification for transit investment has been its potential to provide a positive impact on the economic growth of cities. Claims for transit investment have included stimulating community revitalization, job creation, economic development along a specific corridor, and maintaining and sustaining dense urban centers that are becoming paralyzed by automobile congestion. Other benefits attributed to transit include helping to reduce urban pollution levels and increasing accessibility for the disadvantaged and elderly populations in the cities. In this context, transit generally refers to rail transit, which requires major capital investment.

Opponents of transit investment argue that the actual economic effects of transit do not meet these claims and are, in fact, less significant and therefore do not justify major expenditures of public funds. Opponents suggest that although transit may shift patterns of development within a region, it does not by itself bring additional economic benefits to the area economy in which it serves.

In fact, studies done on the subject have presented mixed evidence of whether or not these objectives are actually met by transit. The following discussion is the outcome of a 1988 study conducted for UMTA and results will be presented of new case studies on this issue to better clarify the objectives guiding transit planning and the implications for transit investment.

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In order to obtain a fresh and in-depth look at the economic impacts of transit development, the UMTA study called for a two-pronged approach: a set of case studies and a literature review. This approach was chosen to best qualify potential economic impacts of transit by comparing published findings with actual experience in four different cities. The results provide conclusions on what transit can and cannot accomplish for a city's economy that can then be used by decision makers and transit planners to make choices about their city's transit future.

The literature review examined existing impact reports for rapid transit systems built in the United States and Canada. Methodologies were examined to determine the actual economic impacts that have resulted in cities with new rapid transit facilities. In addition, the literature review examined the impact transit has had on achieving the major economic development objectives that are often presented as justification for transit investments.

To complement the findings of existing literature, a sample of cities with differing levels of transit investment was chosen to test the varying opinions of policy makers, planners, business people, and developers on the objectives of transit and to determine the extent the objectives were achieved in each city. Four types of cities were sampled: older, established rail cities (Boston, Massachusetts); newer rail cities (Atlanta, Georgia); newer cities proposing rail transit (Dallas, Texas); and smaller, bus-oriented cities (Hartford, Connecticut). In each city, a sample of policy makers, business leaders, transit planners, and academic observers was interviewed to determine the current state of opinion on the value of public transit for cities.

The following issues were examined for each case study city, all of which shed light on the true nature of the relationship between transit and economic development:

- Objectives and values guiding transit decisions,
- Effects of transit on the city or region,
- Impacts of transit on different groups and locations,
- Impacts of transit on downtown development,
- Relationship between transit and environmental quality, and
- Relationship between transit and economic growth.

Finally, a comparison of findings from both the case studies and literature review will be made to present relevant lessons for transit planners and other interested parties as to the value of transit to a city's economy.

LITERATURE REVIEW

There is extensive research and literature exploring the economic impacts of transit on cities. Literature on the economic impacts of transit primarily examines the various methodologies used by researchers to measure the extent to which transit has fulfilled its economic objectives. Of interest for this discussion were results of methodological studies in terms of how transit has lived up to its economic objectives.

Studies attempting to measure the economic impacts of transit rely on a variety of methodologies. Among the most common indicators used to determine the extent of economic benefit are

- Increase in property values adjacent to the transit line;
- Increase in development projects (building permits, visual inspection) along the transit line; and
- Changes in business sales adjacent to the transit line.

If these measures increase, then the transit line has brought a benefit to the economy. Inherent in these methodologies is the assumption that changes must be net increases, adding new development to the region. If transit merely shifts economic benefits from one part of the region to another, then the conclusion is that there is no economic benefit at all.

Such a conclusion presents a problem in measuring the true nature of economic impacts that is illustrated by the differences between how academic studies measure economic impacts and what objectives economic planners selected when planning transit projects. For example, although the academic literature uses changes in property values to measure economic impacts of transit on a specific area, transit planners have not selected increasing property values as an objective for planning transit projects to encourage economic growth. Rather, their objectives include a broader desire to promote growth in distressed areas, to expand economic opportunity for the transit-dependent populations (i.e., elderly and poor), to allow more people to access the downtown for employment, among others. Examining property values along a rail line fails to measure broader issues of whether more people have job opportunities, and whether employment in the downtown is growing.

Also problematic is the underlying assumption that net growth is an indicator of economic benefit to a region. In fact, distributional shifts of development may be very desirable from a planning point-of-view. Some areas may be more appropriate for development than others, so encouraging a shift in activity may be beneficial to the city. Concentration of activity also creates benefits of its own, creating economies of land use and transportation that cannot occur when development is dispersed.

Appropriate and accurate measures for the true economic impacts of transit will require further study. However, the difficulties that occur when using academic studies to make policy decisions would indicate that many issues must be examined when making the choice to build or expand transit, including the broader economic planning objectives previously discussed.

Although there are a range of potential economic development objectives for transit investment, generally they can be grouped into three major categories, as follows:

- Sustain and maintain dense development and growth in the downtown core,
- Allocate land use and development, and
- Create and stimulate economic growth and employment opportunities.

Sustain and Maintain Density Development and Growth in the Downtown Core

For some older U.S. cities and cities in which access is constrained by geography, downtown access is becoming increasingly constrained by automobile and truck congestion on the network of downtown streets and highways leading into and out of downtown. Difficulties for employees, residents, and clients in accessing downtowns are increasing and are causing constraints on economic growth and threatening the loss of businesses from the urban core. In examples in the literature, transit investment has been seen as a positive factor for retaining or improving downtown access and as a significant contributor for maintaining and expanding downtown economies.

For example, New York City has been facing the potential loss of businesses because of difficulty in accessing the downtown core. New York's urban character was well established before the use of the automobile became commonplace, and consequently the city grew up transit-dependent. However, the advent of the automobile brought new highway and roadway systems to serve downtown but the established dense development patterns have hindered the construction of roadway systems that adequately serve downtown. As New York and other cities with similar downtowns continued to grow, congestion has reached critical levels and cities have historically looked at transit investments as being necessary for maintaining access to the urban core. Transit improvements in these densely populated cities tend to attract larger ridership than new systems built in metropolitan areas characterized by low-density urban and suburban developments.

In San Francisco, California, the Bay Area Rapid Transit District (BART) system was built to maintain access to a central business district to which access was limited by geographic constraints because San Francisco is located on the tip of a peninsula. From the north and east, the city can only be accessed via bridge, whereas from the south access is constrained by coastal mountains. Although extensive BART impact studies failed to provide significant evidence of related development occurring at stations outside downtown, the transit system provided the crucial link into downtown that has allowed more employees and others to access downtown activities.

The previous discussion is not meant to convey the notion that congestion and access problems experienced by these cities have been solved because as each of these cities continues to grow, access remains a significant problem. It is clear, however, that without continued investment in upgraded and new transit systems, the economies in these cities would be constrained by congestion. Continued growth would be jeopardized, possibly leading to the loss of businesses and employment.

Allocate Land Use and Development

Another major objective that policy makers hope to realize through transit investments is the control of land use and development along specific corridors within a region. From a land use planning point-of-view, concentrating development at specific station areas or along specific corridors may be desirable in order to prevent sprawl and to retain the rural character of suburban areas not served by transit. Corridor development can also concentrate development and thereby decrease the need to use an automobile for every separate errand or shopping trip.

One major objective of the investment in the Metro system in Washington, D.C., was to support a compact pattern of regional centers along major corridors radiating out from a strong downtown. Some evidence exists in the Washington metropolitan area that development has occurred at and around station areas, although it is not clear that the Metro corridors have yet or would in the future stimulate the level of corridor development that was anticipated. In addition, it must be made clear that the development, which has occurred at station sites and along Metro corridors, would undoubtedly have occurred elsewhere in the Washington metropolitan area.

This reallocation of development is important because it means that the transit investment has not led to any net new economic gain for the area, but has simply reallocated land uses within the metropolitan area. Policy makers whose objective for a transit investment is to direct development along a specific corridor must be careful to assess the actual value of this reallocation (with no net gain) against the significant capital expenditure required to build and operate transit systems.

Create and Stimulate Economic Growth and Employment Opportunities

A third objective often cited for investing in major new rapid transit projects or improvements is to create or stimulate growth in an urban area. This objective can be divided into two: (a) revitalize a depressed urban area, and (b) create a world-class city image that will help to attract people and businesses to an area.

Several cities have invested in new rapid transit systems to try to stimulate economic revitalization. Buffalo, New York, based the feasibility study for its new rapid transit system on the premise that the system would help stimulate new downtown development, which would bring new employment and other opportunities, thus helping to revitalize a community that suffered from the decline of basic industry in the region during the 1970s (Gordon Thompson, Manager of Planning, Niagara Frontier Transit, telephone interview, April 1988). Pittsburgh, Pennsylvania, also hoped to reverse an economic decline by modernizing rapid transit in that city.

Both Pittsburgh and Buffalo invested in new transit systems that have managed so far to claim only modest amounts of development in conjunction with the new transit systems. A survey of developers in Buffalo conducted by the Niagara Frontier Transit Authority found that the transit system was considered a positive influence for $650 million of new development in the downtown. However, this development was also affected by other public policy decisions and public investment. The major new downtown development, the Maine-Genessee project, is located at a transit stop but would not have occurred without the expenditure of federal dollars to assemble and purchase the land for the project.

In Pittsburgh, planners and transit agency representatives have been unable to identify specifically any new downtown development attributable to the trolleys (although the trolley may have had a minor positive influence on new downtown development that has occurred). However, there is evidence of a major negative impact of the Pittsburgh trolley. Gimbel's department store, which had been directly located on the above-ground trolley line, went out of business. The store claims the fact that the underground transit system bypassed the store is partially responsible for the store's loss of business and eventual closure.

Knight and Trygg (*1*), in their comprehensive study of the land use impacts of rapid transit, concluded that major rapid transit investments played a key role in new development both in downtown areas near stations and in suburban areas, but only when accompanied by other favorable conditions. Knight and Trygg (*1*) found that in Toronto, Montreal, and San Francisco the new transit systems provided much-needed improvements in accessibility to these downtowns, thus stimulating downtown growth. However, in these cases and in the cases of many other downtowns and suburban areas, many other factors were present that combined with the transit improvements to make development possible. These factors included demand for new office spaces or residential units, a healthy overall economy, timing of construction, availability of land, placement of the station, land use policies, and other public investments. As recognized both in the studies of BART in San Francisco and in Knight and Trygg's work (*1*), development around BART stations in downtown San Francisco occurred in large part because of specific redevelopment planning efforts undertaken for Market Street by the city. In addition, new zoning ordinances encouraged development around the station areas by significantly increasing allowable floor area ratio for developments within 700 ft of stations and by providing density bonuses for buildings adjacent to downtown transit stations. At downtown BART stations in Oakland, California, and at the Lake Merritt station, significant public efforts to assemble land and invest in new development have been critical to new development around the station areas. It is certain that these areas would have realized much less development without significant participation from the public sector.

Several cities have recently undertaken major new rapid transit projects with the objective of creating world-class image for their city. Both Atlanta and Dallas have identified the world-class city objective as a major stimulus for investing in a new transit system. Sacramento, California, and Miami, Florida, both hoped to achieve world-class city status with their new transit systems. Decision makers in these cities believe that a modern rapid transit system is an integral part of projecting an image of their cities as major, vital urban centers. If the world-class city image can be achieved, they believe that new business investment would pour in.

Although modern transit systems may be one characteristic of a world-class city, a new transit system has not shown that by itself it can project a world-class image for a city. A city must have a well-developed infrastructure including road systems and air service, cultural attractions, a critical mass of existing major businesses, and other characteristics in order to qualify as world-class. To date, evidence in the literature has not shown that cities that have built transit systems to attain world-class city status have attracted the related development and investment characteristic of a world-class city, simply because of the transit system.

Summary of Literature Review Findings

Although investments in transit systems sometimes show evidence of leading to new development and increased real estate prices and values around some station areas, these impacts are usually not evident unless other factors encouraging development are also present. Land use policies and public investments supporting the development along with available land are all important to encouraging development in association with new transit development. In fact, a combination of all of these factors in addition to an investment in a transit system are unlikely to create sufficient economic growth in a depressed community. A strong economy complete with a demand for new space is the essential ingredient for stimulating new economic growth in depressed cities.

However, transit investments have been more successful in alleviating congestion in urban areas that must develop mechanisms for transporting commuters into and out of the downtown core. Systems such as the Massachusetts Bay Transit Authority (MBTA) in Boston and the Metropolitan Transit Authority (MTA) in New York attract large numbers of patrons working in downtown locations. However, in these areas, transit is one component of a larger solution to congestion. Transit investment, when coupled with other policies and programs, can address the future of transportation congestion problems in these dense urban areas.

CASE STUDIES

Case studies in four U.S. cities—Atlanta, Boston, Dallas, and Hartford—examined in depth the issues surrounding the impact of public transit on the downtown economy. These studies focused on the broader objectives of transit planning and investment than those often examined in the literature. Cities were selected to represent different levels of transit investment and different types of transit systems. Case studies were conducted to determine what the public (planners, developers, business people, and politicians) expected from transit and why they felt it was important to the economy. Although the case studies did not provide definitive proof of the relationship between transit and economic development, they demonstrated the importance of transit in supporting the economic health and growth in the downtown core. These case studies also underlined the importance of public transit as providing access to employment opportunities for the elderly, handicapped, and poor, who are dependent on transit for their livelihood. This access is important for a city's future not only because transit is a public good, but also because a city's economy depends in part on the level of employment and income of its residents.

Finally, the case studies investigated the importance of transit in supporting higher densities in more congested urban areas. All of the case studies showed the role of transit in bringing workers, shoppers, residents, and clients in and out of the downtown core. This role becomes crucial as parking reaches the crisis stage in many cities and as existing highways operate consistently over capacity. Transit is not the only solution, but remains a crucial tool in the future economic health of U.S. cities. Findings of the case studies revealed some insight into what transit contributes to the urban economy as well as providing a broader, more comprehensive way of viewing transit impacts.

Atlanta

Transit System

Atlanta, the Southeast's largest city, was chosen as a representative newer city with an existing rail system, the Metropolitan Area Regional Transit Authority (MARTA).

MARTA was conceived as part of Atlanta's ambitious plan to become a national and international center of commerce. Transit has always been part of the region's comprehensive regional planning effort and MARTA was constructed with the philosophy that the system would reshape the region's development. To date, the system has not shown evidence of influencing development patterns throughout the entire metropolitan area. However, in areas of the city where all of the proper elements were in place to support economic development, in more recent years MARTA has allowed development of denser downtown projects.

Transit Goals and Objectives

Although the region and its units of government were pressing ahead with plans to expand the highway system, planners promoted transit as a complement to a good, strong freeway system. Transit was envisioned by the planners as strengthening the emphasis on the central business district and reducing suburban sprawl, which might otherwise result. Transit was also seen as a way to achieve the goal of reducing traffic congestion on the region's highways and improving the mobility for the region's transportation-dependent population. Business and civic interests saw public transit in general, and a rail transit system in particular, as part of their plan to place Atlanta among the nation's most prosperous cities and give the city international prominence.

Transit and Economic Development

One of the goals for MARTA was to stimulate widespread and planned regional growth; however, this goal was not achieved regionwide to the original desired level. This failure was largely a result of other factors such as the recession in the early 1980s, a decrease in federal funds for urban improvement projects outside of the rail system itself, and private sector disinterest in developing land near station sites, particularly at stations outside of downtown. As a result, much land was left undeveloped.

However, recently Atlanta's economy has improved and a set of public policies designed to support development has been instituted. As a result, downtown Atlanta has experienced a scale of development and revitalization fulfilling many early desires for the MARTA system. Time was needed for all elements to fall into place, but transit finally contributed significantly to the support of economic development.

Perceptions of transit as a solution for mobility problems and as an attractive and efficient way to travel are beginning to be used by developers of properties near some MARTA stations. Although many developments choose downtown because of the prestige of a downtown address, many are selecting sites near a MARTA station. In one important case, the North Park development, MARTA's proximity allowed an increase in the scale of the proposed development, making larger densities possible. In another, Lenox Park, the proximity of transit appears to have affected the mix of uses. In both cases, substantial increases in transit ridership are expected as a result of the project's presence.

However, in both cases the developments, although large, are only a fraction of the total amount of existing and planned development within the submarket areas. Within these areas, other development is taking place with less obvious ties to the transit system. It appears that transit affects development in the more marginal areas. Some areas, such as near some suburban stations, are not ready for development and no transit system will make something from nothing. On the other hand, some locations are so attractive, such as the prestigious downtown areas, that transit is not a driving factor in development decisions. It is the areas in between, where some elements are in place but some encouragement is needed, that transit can create the impetus for development.

As the importance of MARTA has grown in recent years, its future role in economic development will continue to grow in support of Atlanta's economic growth. MARTA has been cited as a factor of growing importance to locational decisions for two kinds of facilities. For operations centers, MARTA is playing an increasingly important role as the transportation mode of choice for the clerical and technical work force employed there.

Secondly, developers and observers believe that MARTA will play an increasingly important role in locational decisions for regional headquarters of major corporations. An important part of Atlanta's recent growth has resulted from decisions to locate such facilities in the region, given the increased ability to move workers to and from downtown and the airport. With its new terminal within the airport itself, MARTA now offers 20-minute trips to downtown and midtown locations. As long as office parks can be located within an hour's drive to Hartsfield International Airport, Atlanta will continue to attract regional sales and headquarters facilities. When available sites or levels of congestion make this 1-hour trip impossible, MARTA will make the difference in attractiveness as a place to do business.

Atlanta's emergence as a center of national and international importance was based on the recognition that auto dependence is self-limiting. Although the transit system has not generated the levels of development near station stops that were anticipated, the need to reduce congestion, transport a growing work force, and provide Atlanta with an international image and competitive edge make the transit system a crucial part of the Atlanta economy.

Boston

Transit System

Boston was selected as representative of older cities with an existing rail transit system. Boston is served by the Massachusetts Bay Transportation Authority (MBTA).

One objective of transit system upgrades in Boston in recent years has been to improve access into the highly congested downtown. This objective has become particularly important since highway construction was put under a moratorium. As suburban highways become just as congested as downtown streets, moving people efficiently into and out of downtown will become more crucial to the regional economy. A specific economic objective of access to downtown is the ability to move the labor force in and out of the city. This movement was further exacerbated by a freeze on the number of parking spaces allowed in downtown Boston. Boston's office and retail economy is healthy and providing a sufficient labor force to serve the demand, which is important in sustaining the level of economic activity. A subset of the labor force is the lower income, transit-dependent population that relies on transit for its livelihood. Transit serves this group particularly well and provides a social good by providing access to employment opportunities. By the same token, the metropolitan Boston transit system also serves the non-transit-dependent population as both the subway and commuter rail systems have heavy park-and-ride ridership.

A related objective of relieving automobile congestion by public transit is to improve air quality. Boston has a serious pollution problem and one of the important values of transit to the area is to reduce the number of cars traveling to downtown and adding to the air pollution.

Underlying all of these issues—pollution, congestion, access—is the issue of quality of life. In an older, transit-oriented city like Boston, maintaining a clean, useful, well-functioning rapid transit system becomes an integral part of keeping Boston a desirable place to live, which allows the economy to grow and prosper.

Transit and Economic Development

Transit's impact on economic development in Boston has been the subject of much debate. Generally, it has been accepted that transit and the economy are linked together but differing views exist on the nature of the relationship.

For the few remaining parts of Boston not currently served by transit, linkage to the rest of the transit system is considered crucial for supporting new development with the resulting increased labor force and other activity that would take place. For example, in the Fort Point Channel area, the streets simply cannot handle a large increase in worker, resident, and shopper traffic that would result from development. Fort Point Channel is pointed out by all observers and officials as the single most important example of the relationship between transit and economic development.

Transit provides access to employment, especially for transit dependent populations. As one official observed, "The lack of transit puts a limit on finding employment. It is very important to have transit for opportunities for employment." This aspect of transit addresses the social good question by providing access to employment opportunities for a population dependent on transit for traveling to and from work. In this sense, public transit provides both a social good as well as an economic good.

In summary, transit in Boston is linked with patterns of development, but does not control it. Planners and developers considering new projects in the city will need to ask the question: "How will people get there?" Access to downtown will continue to play a key role for Boston's workforce as congestion becomes more critical. Evidence of the importance of transit in this role can be seen in the growing commuter rail investment, which has responded to a large demand for bringing white-collar labor downtown. Ridership on the recently expanded commuter rail network has been higher than expected and has been mushrooming annually. In addition, throughout the construction period for the Central Artery-Third Harbor Tunnel Project, which will be taking place over the next 10 years, a comfortable, easy-to-use means of accessing the city becomes even more paramount.

As Boston's metropolitan area spreads further from the central core, the concept of regional transit becomes more important in maintaining the current level of growth. As is true in many cities, transit is no longer simply a downtown issue. Transit also encouraged regional dispersal of originally downtown functions, such as back office operations and other businesses. For example, the extension of the Orange Line north to Malden and Charlestown and the Red Line south to Quincy and Braintree has supported new office and other construction in these areas. Downtown insurance companies and banking and finance firms have relocated many of their back office and clerical functions in these areas. Although relocation of back office functions is part of a general trend for many industries, the opening of new transit lines played a crucial role in the development of these areas. The role of transit systems must be viewed as a regional one, with commuter rail playing as significant a role as the original subway section of the system.

Dallas

Transit System

Dallas was selected as representative of a newer city considering building a new transit system. Currently, downtown Dallas is served by bus service operated by Dallas Area Rapid Transit (DART). On June 5, 1988, Dallas-area voters defeated a referendum in which DART proposed bond financing for funding a $1.8-billion, 93-mi light-rail rapid transit system through a 1-cent sales tax. The defeat of the referendum means at least a temporary end to public rail transit in Dallas. However, DART has since regrouped to produce a new plan for transit in the city, although many of the suburban members of DART are questioning their future involvement in DART. In June 1989, DART released a new proposal for transit in Dallas, which included a comprehensive package of 66 mi of light-rail, high-occupancy-vehicle (HOV) lanes, commuter rail, and bus service. The new package has been designed to solve current transit problems using a variety of transit alternatives designed to support Dallas' future economy.

The defeat of the referendum to build a light-rail system makes Dallas an important case study for understanding transit impacts on cities and the impact of various types of funding on transit. Dallas-area planners, developers, and most citizens have recently confronted the issue of why transit is important to Dallas and why Dallas does or does not want a transit system. Unlike an older city where a system would already be in place, Dallas has the opportunity to examine the goals and objectives of building a new rapid transit line. The type of financing explored by DART, bond financing, is an alternative to the use of federal funds and raises issues of government funding policies for rapid transit.

DART's first proposal for a 93-mi transit system was an arterial light-rail system planned to operate primarily during peak commuter hours and was to include 210 electrically powered rail cars. One line would have extended south from downtown to Oak Cliff and to West Oak Cliff. A second line was planned to run underground along the North Central Expressway, surfacing near Mockingbird Lane and continuing above ground to Plano, with a spur traveling west to Carrollton and Irvine. The arterial nature of the system provided a downtown orientation for rail service and would have served both residential areas surrounding downtown as well as activity centers outside the downtown.

Another transit project that makes Dallas a good case study for studying transit impacts is a private sector trolley project underway adjacent to the central business district. A group of developers, property owners, and business people along McKinney Avenue joined together to design an antique trolley to run on McKinney Avenue, linking shopping, restaurants, businesses, and a residential neighborhood. Out of a total cost of $6 million, a little over $2.5 million was obtained from UMTA grants with the balance of funds raised from private contributions and some city aid. Currently, the trolley is under construction and there is some interest to continue the trolley service to other parts of the city.

Transit Goals and Objectives

A prevailing view in downtown Dallas is that Dallas needs rapid transit to become a world-class city. Transit would make Dallas competitive with major national and world trade centers such as New York, Boston, and Atlanta. As one official described it (informal communication),

> "World-Class City" is a term that is used all over Dallas and is a very typical term for a new city like Dallas which is trying to achieve status as Boston has, that has all of the attributes of an urban place . . . . The people in Dallas believe that in order to achieve world class status, recognition, and so forth, they have to have a rail transit system.

Apart from the competitive standpoint, a major objective of transit in Dallas is to assist in relieving traffic and mobility problems prevalent in and around downtown Dallas. The rapidly burgeoning suburbs of Dallas, especially north of the central business district, have congested highways both into downtown and between various suburban activity centers. Traffic congestion in Dallas is a regional problem because of the dispersed nature of business and retail activity centers throughout Dallas county. DART's proposed rail system sought to relieve regional traffic congestion with transit lines running into and out of downtown to ease commuting. However, the proposal did not include circumferential rail service to ease congestion between the regional activity centers.

Increased mobility into central Dallas resulting from public transit has value for two important reasons. Transit allows the large working population to move into and out of downtown and serves the transit-dependent population which lives primarily to the south of the downtown area. To a lesser degree, rapid transit also increases mobility of visitors to the area who need to access areas nearby and adjacent to the central business district.

Charles Anderson, Executive Director of DART, summarized the objectives for the rail transit system in an article in the *Dallas Business Journal* (*2*,p.8), as follows:

- Reduction of congestion,
- Reduction of labor-related transportation costs (as opposed to continued reliance on buses and cars),
- Reduction of air pollution, and
- Reduction of dependence on hydrocarbon fuels.

One observer summed up rail transit in Dallas in this way (informal communication), "Rail supporters say that DART would profoundly reshape the urban landscape, curbing unplanned suburban sprawl, reducing the community's reliance on automobiles and making Dallas a very different place at the dawn of the 21st century."

Transit and Economic Development

Planners and business people feel that rail transit is crucial to the continued health of the downtown economy. The downtown area is currently shrinking and many believe that rail transit is necessary to prevent further shrinkage.

These beliefs are tied to the two objectives mentioned previously—mobility of a qualified workforce and a world-class city image. Mobility of a qualified workforce is crucial for the expansion of office and retail activity, which are both central to the Dallas economy, especially as projected growth in the region will make the regional road system unacceptably congested. This mobility is especially important in light of the competition from suburban office parks, where highway access is simple and land costs are much lower than in downtown Dallas. The objective of becoming a world-class city is also a factor in allowing for economic growth and future business attraction. In order to compete against major cities like Chicago, New York, and Boston for attracting and retaining top-notch businesses, Dallas feels it needs to have a rail transit system. However, the ability of rail transit to provide world-class city status has not been proven and whether this objective could be achieved is uncertain.

Because the DART rail system was only proposed and not actually constructed, there is no concrete evidence that rail transit is necessary to support economic growth. What is clear from Dallas policy makers and citizens is that increased mobility within the city of Dallas is a crucial link to economic growth in the region. Rail transit is one possible component to this, as are HOV lanes, improved highway access, and other transit options.

Hartford

Transit System

Hartford was chosen as a representative smaller city with a bus-only transit system.

The Hartford region is served by a system of Interstate highways consisting principally of I-91, the major north-south Interstate through the Connecticut Valley and I-84, which travels in a northeast-southwest direction, both currently under construction.

Consistent with findings in the literature review, the bus system in Hartford has not shown much evidence of directly causing or steering economic development. However, bus transit, in conjunction with other alternatives such as vanpools and carpools, is becoming more important in bringing the workforce into and out of Hartford, as congestion increases and the number of parking spaces decreases.

Transit Goals and Objectives

Hartford's transit system does not have many explicit economic development goals, apart from public service. Transit is seen by the city's transportation department as a complement to its highway construction and operation efforts to help reduce congestion and support growth. Hartford's major employers have an interest in ensuring that congestion does not impede their operations because much of this congestion results from downtown-oriented trips by suburban residents at peak rush hours. These employers have been cooperating for a decade in the development and implementation of transportation system management measures. One goal of their efforts is a 20 percent reduction in single-occupancy vehicles with downtown destinations. Their hope is that such reductions will make available sufficient space on the region's highways to accommodate employment growth now underway in Hartford and in the downtown in particular.

Advocating the social and economic needs of Hartford's residents is of particular concern for the city. For many years, the city has viewed its role as an advocate for its residents, both because Hartford contains a disproportionate share of the region's poor and because decisions affecting transit service were not in their hands, but rather in those of the state.

Planners, policy makers, and public and private decision makers bring different goals and objectives to the transit planning process. All share a common hope that public transportation and paratransit can contribute to reducing commuter time and to offering wider access for employment opportunity to innercity residents.

Transit and Economic Development

The absence of fixed-rail transit in the greater Hartford area casts the discussion about the relationship between transit and economic development in a different light than that of the other case study cities. Hartford's rubber-tired transit system, which includes its extensive and growing paratransit service, has not shown the ability to influence private sector investment decisions.

The connection between economic development and transit in Hartford is viewed in terms of its effects on people, both as workers and as area residents. This view includes the impact on the transit-dependent for whom transit is a source of economic opportunity. At another level, there exists employment opportunities in a large number of downtown firms without corresponding opportunities for parking. Many companies are unable to provide parking for all, and status and pay determine in some part whether parking is available.

Economic viability of downtown Hartford and the success of several of its employers, including hospitals and other institutions with a concentration of lower-wage jobs, depend on public transportation. Transit has become part of the solution to the transportation impacts of economic development in downtown Hartford.

Although there is little evidence in Hartford that the bus system has influenced economic development patterns or decisions, transit plays a role in supporting the city's economy by giving access to the city's workforce under circumstances of congestion and severe parking limitations. As the long-term plan for access to downtown Hartford takes shape, transit will play a role in solving the problem of moving people into and out of an increasingly dense downtown core.

CONCLUSION

Although each of the case study cities has a different type and level of transit and is quite different geographically, historically, and socially, all of the case studies point to common elements concerning the value of public transit for the economy and the impact transit has on shaping economic development. These elements consist of the following general issues:

- Transit is only one of several factors which must be in place to create and direct new development projects. The case studies, particularly Atlanta, support the findings of the literature review, that although transit is an important component in supporting development, it is not the single cause of new development. Other factors are just as important in bringing about economic growth, including the area economy, land use planning and policy, and availability of land, among others. However, when all factors are in place, transit provides an important support for allowing large and more dense development and economic activity to occur in downtown.
- Transit provides crucial access into highly congested downtown cores, which allows more people to access downtown for work, shopping, and other activities. The literature review found this to be particularly true in older cities such as Boston and New York and the case studies supported this position. Older and more densely developed cities such as Boston rely heavily on rapid transit to support the downtown economy. But even newer cities, such as Dallas, have increasing regional mobility crises in which transit can provide part of an overall mobility strategy. Highways alone cannot provide sufficient levels of free-flowing traffic to support further economic development and expansion in many downtown areas.
- Transit contributes to the quality of life in urban areas, which makes a city more attractive for economic development. This contribution includes reduction of air pollution, reduction of traffic downtown, and assistance to the transit-dependent population for access to employment and other opportunities. All of the case studies underlined the importance of transit for these types of issues. The role transit plays in providing economic opportunity for transit-dependent populations was noted in all four cities, whether the transit system was rail or bus. The other issues apply to rail transit and were factors particularly in Dallas and Boston. These issues are not central economic development issues, but they underscore the role of transit in long term viability of urban economies. The health of a metropolitan economy is only as strong as the population living in the city. Without transit, populations such as the elderly, the handicapped, and low-income residents have less access to employment, which lowers the potential earning power of a large sector of the city's population.

What are the implications for the continued investment in transit? Additional study needs to be done to determine more appropriate ways of measuring impacts, as the literature to date has used the wrong measures in trying to determine the benefits created by transit. Although transit itself does not directly cause economic development, transit contributes in a significant way to the metropolitan economy in terms of quality of life and support for growth. It is also clear that with growth and congestion threatening to throttle most American cities, the future survival of downtown economies is tied to quality transit infrastructure. As the case studies have emphasized, transit can be an important part of a metropolitan area's plan for maintaining the economy and allowing the natural progress of growth.

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Framework for Analyzing the Impact of Fixed-Guideway Transit Projects on Land Use and Urban Development

DONALD J. EMERSON

An approach is presented for predicting the impacts of fixed-guideway transit projects on land use and economic development. The Urban Mass Transit Administration developed this approach to help local agencies perform transit project planning studies, including alternatives analyses. The relationships between land use and transportation are reviewed and technical methods for identifying land use impacts at the regional, corridor, and station area levels are described. The importance of supportive land use policies and ways to evaluate the desirability of anticipated land use impacts are identified.

For several years, the Urban Mass Transportation Administration (UMTA) has been developing procedural and technical guidance for the conduct of transit project planning studies. UMTA's *Procedures and Technical Methods for Transit Project Planning* (*1*) focuses on corridor studies for fixed-guideway transit systems (e.g., rapid rail, light rail, busways, and people movers), but much of its guidance can be applied as well to system-level guideway planning studies and to rail modernization and bus service planning. UMTA will update and refine the guidance as new issues arise and as different analytical techniques impart new knowledge.

The section of UMTA's technical guidance on the analysis of land use and urban development impacts was revised earlier this year. UMTA had found that local transit planning reports often predicted economic development would be promoted by a major transit investment, although this conclusion was seldom supported by sound technical analysis. The aim of the revised guidance is to suggest a scope and structure for the land use analysis, and this paper sets forth that framework. Local planners involved in transit planning and others engaged in other types of infrastructure planning may find the information useful. As part of UMTA's continuing effort to refine the guidance, comments are welcome.

The impact of a fixed-guideway transit investment on land use and urban development should be evaluated for at least four reasons, as follows:

- Under the National Environmental Policy Act, federal agencies are required to consider the impacts of proposed projects and alternative courses of action. This requirement includes the consideration of impacts on land use and economic development. Many states have similar requirements.
- Cities often tout urban development benefits as a primary reason for considering a major investment in transit. In such cases, the magnitude of this benefit needs to be estimated to determine whether the combined urban development and other benefits justify the costs, and whether other strategies might produce the desired benefits at less cost.
- Projects that have urban development benefits can often be financed, at least in part, through value-capture techniques, or they may be built through public and private partnerships that rely on a project's development benefits. Preparing a credible estimate of these benefits can be an essential part of the financial planning work done for the project. The property owners most likely to benefit from increased property values should be identified as part of this assessment.
- Community groups may be concerned about how a project will affect neighborhoods along the line and at station areas. They may oppose, for example, a transit project that might stimulate increased activity in quiet neighborhoods or increase local traffic. An urban development impact analysis can help determine whether these concerns are valid and, if they are, help bring about agreement on appropriate mitigation measures.

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LINKAGES BETWEEN LAND USE AND TRANSPORTATION

Transportation access is one of several significant factors affecting the development of land. Any site slated for economic activity must be accessible to the labor and materials needed to develop a product and to a market for selling the product. At the national level, cities have sprung up in areas highly accessible to the national system of roadways, railroads, or waterways and at places where goods are transferred from one mode of travel to another (at ports, for instance). The same holds true within cities. Historically, the central business district (CBD) has been the most accessible point in any given region and thus has engendered the most development and the highest land values. More recently, highly accessible suburban locations, particularly at freeway interchanges, have given rise to dense commercial and retail development.

A 1987 survey (*2*) illustrates how important accessibility is to the chief executive officers (CEOs) of the country's largest corporations. Asked to rank five factors that can affect the location of office facilities, the CEOs put "easy access to domestic markets, customers, or clients" number one, with

37 percent of all CEOs deeming it "absolutely essential." Ranked fourth was "quality of life for employees," which included such factors as good public schools, enough streets and highways, affordable housing, and low crime. Executives of organizations involved in wholesale, retail, or manufacturing operations similarly ranked seven factors affecting their location decisions. Top ranking went to "the availability of sites with existing water, sewage, and roads"; second was "access to domestic markets." "Easy access to raw materials" was ranked third and "quality of life for employees" fifth.

Of course, accessibility is not the only factor that affects the amount and location of urban development (see Figure 1). Nontransportation factors cited in the survey of CEOs include the climate that state and local governments create for business through tax policy and regulation; the cost and availability of housing and labor; the crime rate; the public schools, colleges, and universities; and cultural and recreational facilities. Other nontransportation factors are the strength of the overall economy; the availability and cost of developable land, capital financing, and managerial expertise; the attractiveness of a given site for development; and the availability of other nearby land investments. Should some of these factors be judged to impede or preclude development, an increase in accessibility alone likely will not surmount them; such factors might be termed obstacles to development.

Nevertheless, accessibility is undeniably important, and a major new transportation facility should measurably improve accessibility. (If it does not, the justification for the project would certainly be in question.) As travel time between points is reduced, forces are put in motion that can, over time, change the distribution of economic development. Transportation facilities that significantly reduce travel time between an urban region and other parts of the country can eventually lead to new jobs and growth in that urban region. Likewise, facilities that change the relative accessibility of certain parts of an urban area can lead to a redistribution of growth within that region, although the total amount of regional growth is unlikely to change. Urban mass transportation projects fall into this second category.

Researchers have documented the land use changes that followed some major transit investments. *Land Use Impacts of Rapid Transit: Implications of Recent Experience* (*3*), published in 1977, found the following:

- Major rapid transit improvements were important inducements for intensified development near stations both in CBDs and in outlying areas, although only when supported by other favorable forces.
- Some major commuter rail improvements led to significantly intensified land use, but findings on light rail systems and busways were inconclusive.
- No rapid transit improvements were proved to have led to net new urban economic or population growth.
- The timing of land use impact appeared to be highly dependent on general economic conditions.
- Local changes in land use policy facilitated the impact of transit improvements on land use.
- The transit improvement itself often led to changes in land use policies.

More recent experience tends to confirm these findings.

IDENTIFYING LAND USE IMPACTS

Land use impact assessments are made to predict the amount, type, and density of land development that each transit mode and alignment alternative would produce and to compare the results. To this end, the analyst must isolate the development that likely would be induced by a transit alternative from

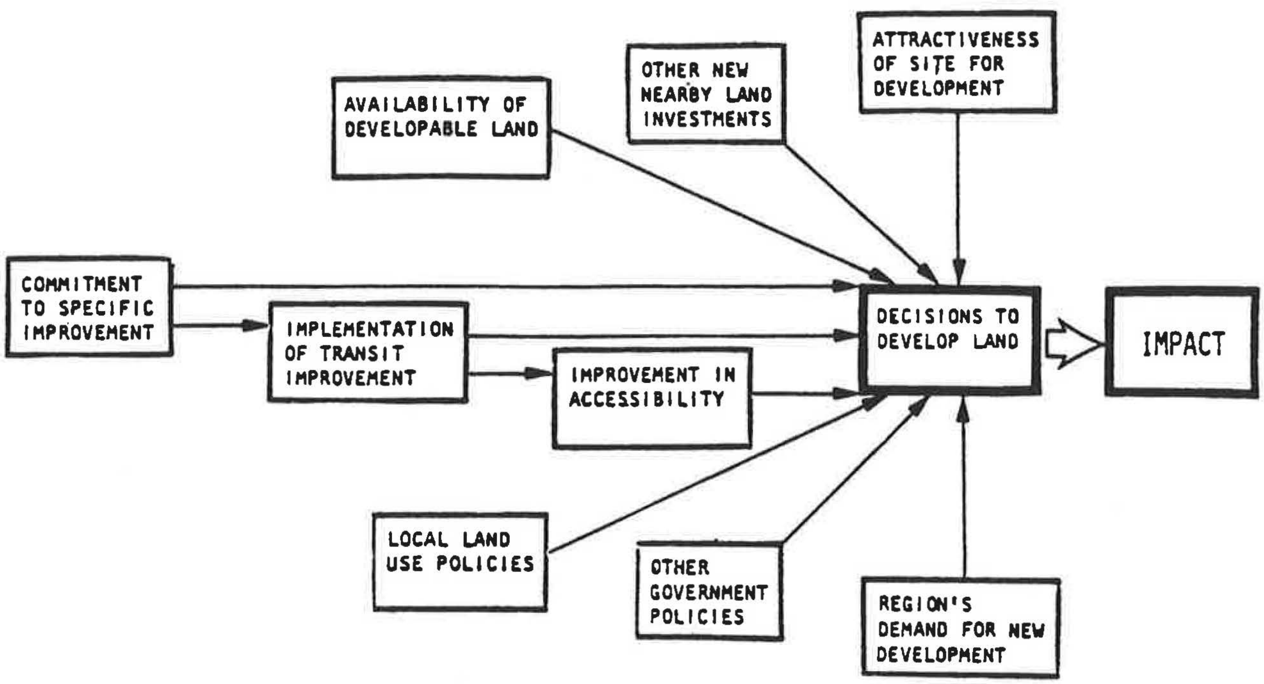

FIGURE 1 Major factors influencing land use impact (*3*).

development that would happen anyway. Once the induced development has been predicted, the analyst must then try to evaluate its desirability. Given the large number of factors that can influence economic development, as well as the difficulties inherent in all economic forecasting, the most the analyst can hope to do is make an educated guess. This section describes a framework for analysis that should make the land use impact forecast more educated and less a conjecture.

The framework can also be used to help identify joint development opportunities that may be created by one or more transit alternatives. Joint development—the linking of private real estate development to public transportation services and station facilities—can benefit the transit operator by increasing ridership on the transit system, providing revenue from the sale or lease of real estate and/or air rights, and reducing land acquisition and construction costs.

In undertaking the land use impact assessment, it is important to

- Rely on sound analysis—not wishful thinking—for projecting market demand;
- Ensure that the projected land use impacts are consistent with projected changes in accessibility;
- Consider the need for supporting public and private actions; and
- Recognize the difference between temporary and permanent employment changes.

Keep in mind, too, that interested parties need to be brought into the assessment process. Local governments should be consulted about development trends and adopted land use plans, policies, and ordinances. The business community can provide information on economic trends and the factors influencing the local economy. Local developers, in particular, can offer insights on regional growth and development and the potential impact of a new transportation facility; they may also be instrumental in bringing about public and private partnerships to help build the project. Community groups should also be asked for their views on development.

Data on existing market and extramarket conditions and trends need to be plugged into the assessment. The identification of market conditions requires data on the direction and performance of the economy, broken down into regional, corridor, and subarea groupings, and should include the following:

- Population data: number of individuals, household size, income, race, and age.
- Land use data: uses and densities, including the location of activity centers, areas of growth and decline, availability and cost of developable land, rents, absorption and vacancy rates, building permits, and availability and cost of development capital.
- Other economic data: employment and retail sales.

Such information may be readily available, because those data are used for financial and transportation impact analyses. Extramarket conditions to be considered include the powers and policies of public agencies, the availability of public services, concentrations of low-income residents, traffic congestion, and land use controls.

The land use impact analysis for major transit projects should be performed on three levels: impact on the region as a whole, impact on the corridor, and impact on specific station areas. The three levels of analysis should produce results that are internally consistent. That is, the sum of the land use changes predicted at the local levels should equal the regional total. If land use impacts are an issue, UMTA urges local agencies to approach the analysis from both the "top down" and the "bottom up," and then to check the results to ensure consistency.

Impact on Regional Development

Although no empirical evidence shows that urban mass transportation investments affect rate of development at the regional level, urban development is often touted as a reason for pursuing major transit projects, particularly rail systems. Some local officials and civic boosters simply assume that transit brings new growth to an area. In such cases, the technical process may need to address regional development impact to help ensure that local decisions are not based on false hopes and dreams. Absent convincing evidence to the contrary, all UMTA-sponsored fixed-guideway planning studies assume that mass transit investments will have no net effect on the amount of regional development.

Should urban area officials wish to pursue an assessment of regional development impact, one possible avenue is exploring before-and-after studies already compiled on cities with similar economic conditions and transportation problems. A second approach consists of examining regional development trends and identifying the factors driving the local economy. In slow-growth areas, attention should be directed specifically to identifying the obstacles that may be slowing development. (For example: A local transit investment could improve regional growth if local traffic congestion is judged a significant obstacle to new development. Land use impact assessments should then address the efficacy with which each mode and alignment alternative relieves congestion. Traffic and travel time forecasts produced in the service and patronage analysis can be useful indicators of potential impacts. Even if traffic congestion is an obstacle, however, a transportation improvement may not lead to increased growth and development unless other contributing factors, such as the health of the local economy, are also positive.

Impact on Corridor Development

Rather than increasing regional growth, transit investments are more likely to help redistribute the current level of that growth. In some cases, transit projects serving a CBD may provide the added transportation capacity that is needed for additional growth in the downtown area. Transit projects that improve CBD access may also promote development along the line and help residential development dispersal in peripheral areas. These effects are seen most often when the CBD and other areas have been hampered, by inferior access, from growing as rapidly as other parts of the region. The methods for identifying land use impacts at the corridor level are similar to those already described for regional analyses. Empirical evidence from before-and-after studies may be useful, along with information on development trends and obstacles in the corridor.

At the corridor level, the analysis can begin to consider the types and densities of land use development that are apt to occur with various transit alternatives. Projected market absorption rates for office, retail, hotel, and residential uses should be set against historic rates to make sure that the forecast is reasonable. Forecasted development should also be compared with the supply of developable and redevelopable land, taking into account local plans and ordinances that affect the use of this land.

If corridor impacts are anticipated, the analysis should clearly indicate how much growth will come from other parts of the region. Decision makers need to keep in mind that corridor impacts tend to be a zero-sum game, that is, increased growth in one area means decreased growth in another; equity and other implications must be taken into account.

Impact on Development Around Station Areas

A fixed-guideway transit project is most likely to affect land use in areas immediately adjacent to stations. These areas experience the greatest increase in accessibility. Stations with high levels of walk access can also create new, pedestrian-targeted markets for retail development. Because of the link between development and accessibility, standard transportation measures—changes in travel time to other points in the region and the number of walk-on riders, for example—can be used to compare each alternative's potential to induce land use changes.

Each alternative's potential to induce station area development might be evaluated using the following measures:

- Percentage of the region's population and employment within x min by transit.
- Changes in transit and highway travel times, weighted by mode share. (For this purpose, the denominator of the logit model can serve as the analysis variable.)
- Number of walk-on riders or, at the CBD level, the volume of transit arrivals.

As at the corridor level, the station area impact analysis should try to identify obstacles to development—local economic conditions and land use policies, for example—and the availability of developable sites. Should the necessary conditions for land use change appear to exist, a market analysis should be performed to determine the type and density of development most likely to occur. Sample pro formas should be prepared to test the viability of different development types and densities.

Joint Development

Joint development is an important tool that can be used to make transit part of an overall development strategy and to help finance the transit system as well. Joint development includes actions to encourage the implementation of desirable land uses in and around station areas or in air rights over or under the transit facility. For example, high-density residential developments at outlying stations may be desirable because they can lead to a higher transit share of work and shop trips to high-density employment and shopping areas (i.e., the downtown area). On the other hand, dense office or commercial activities at outlying stations may hinder system use by increasing congestion and degrading access to the system.

Sites where joint development is possible should normally be identified as part of the land use impact assessment. Specific joint development proposals are not likely to be available at the project planning stage, but suitable land parcels can be identified using the approach described for station areas. Sample pro formas can be prepared, and local and state laws and ordinances concerning joint development should be identified and local policies toward it ascertained.

SUPPORTIVE POLICIES

The development potential associated with each of the alternatives can be greatly enhanced if supportive public policies are put in place. Such policies are usually not formally adopted until the preliminary engineering stage. Nevertheless, it may be helpful during corridor planning to identify and begin evaluating, in concert with local jurisdictions, the kinds of land use policies that might be necessary to induce desired development. Where appropriate, forecasts of land use changes prepared in project planning should specify the extent to which the forecasts depend upon the adoption of new local policies.

The local policies that should be considered include the following:

- Local governments may amend local comprehensive plans and zoning to change permitted land uses and to allow higher densities in areas within walking distance of stations. They might also reduce parking requirements for office development near stations, or possibly establish a ceiling on the amount of parking allowed, thereby reducing development costs.
- If the jurisdiction is already overzoned (or if variances are easily obtained), downzoning areas away from the stations may give the station area a competitive advantage in the market. One approach may be to transfer development rights from an area where lowered densities are desirable.
- Public entities may promise to provide, in a timely manner, the necessary infrastructure (roads, water, sewer, etc.) and services needed to support increased development.
- Desirable development may be promoted by making available suitable land parcels. This might include the sale or lease of excess land or air rights at below-market prices.
- Other supportive public policies may include tax incentives and the assumption of some development risks.

Many of these policies entail substantial public costs. If these policies are proposed, the costs should be calculated and compared with public benefits.

ASSESSING THE IMPACTS OF LAND USE CHANGES

Land use changes brought about by transit alternatives will in turn have their own impact. Issues that often arise include the consistency of anticipated land use changes with comprehensive plans and zoning ordinances, and the effect this development might have on tax revenues and the cost of public services, transit system use, traffic, and parking. These issues often engender considerable local interest, and their analysis can become complex and time consuming. The analyst must keep in mind that the land use impact forecast is little more than an educated guess and be wary of devoting more consideration than is prudent to these issues.

Consistency with Planning and Zoning

The analysis should consider whether the anticipated development is consistent with adopted local comprehensive plans and zoning, which in turn could indicate whether the anticipated development would likely be viewed as desirable by the affected community. The usual procedure is to ask local governments to review forecasts of land use impacts and compare them with adopted plans to determine consistency. Local governments should also be asked to identify any zoning changes necessary for the development and to assess the likelihood of approval of such changes. The land use impact forecast should take into account federal requirements designed to protect certain types of land from development. Federally protected lands include the habitat of endangered species, floodplains, and coastal zones.

Impact on Services and Tax Base

Induced development can increase the tax base of affected jurisdictions, but it may also increase the demand for public services such as schools and law enforcement. In most project planning studies, these impacts are not explicitly considered. However, if the fiscal impact of induced development is at issue, local governments are probably in the best position to estimate the added revenues and costs. Such estimates should consider the type of development expected to occur, the kinds of public services normally required for such development, and the possible need for new capital facilities to provide these services.

Impact on Transit System Use

Station area development can serve specific transportation objectives. First, increased economic activity, represented by commercial office, retail, convention center, and hotel developments, specifically at the downtown end of the corridor, can improve ridership; this same development at outlying stations, however, often hinders access to transit by increasing congestion in the station area and creating greater competition for parking. Medium- and high-density residential development, on the other hand, can increase ridership and farebox revenues at outlying stations.

UMTA requires that a fixed total trip table be used for preparing ridership estimates. Transit ridership estimates always tend to be optimistic, and adding induced development, which is speculative, into the calculation makes results even more tenuous. Ridership estimates are therefore given less weight than other factors in the evaluation of alternatives.

Nevertheless, UMTA acknowledges that induced development, particularly around station areas, can lead to increased transit ridership, and some local agencies may wish to estimate the size of this effect. A sensitivity test is usually the way to proceed.

Impact on Traffic and Parking

The sensitivity test examining the effects of induced land use change on transit ridership will also identify the impact of this development on traffic and parking. Traffic and parking are most likely to be affected around stations, where development impacts are usually most apparent. The added traffic generated by new development, when added to traffic destined for the transit station, can overload the local street system. In such cases, roadway capacity may need to be increased or travel demand managed, or both.

EXPLORING VALUE-CAPTURE OPPORTUNITIES

The analysis of land development impacts should lead to an explicit assessment of the potential for financing some of the transit investment alternatives through recapture of the value added by the investment to certain sites. This assessment should include a review of such public policy and implementation options as joint development, station cost sharing by private developers and public agencies (urban renewal authorities), benefit assessment districts, and tax increment financing. The results of this assessment feed into an analysis of financing options for the project.

In assessing the potential for capturing some of this added value, it is useful to distinguish value capture from joint development. Joint development refers to development occurring in conjunction with the transit improvement, and is usually designed to foster urban development in general, thereby enhancing transit ridership and increasing farebox recovery. The primary goal of value capture strategies is to return income to the transit property. Value capture can include joint development, such as air rights leases, station construction, or improvement by developers, but it can also include a broad range of activities designed to capture part of the value created by the transit investment. For example, assessments on property owners in station vicinities can capture some of the financial benefits accruing to those whose buildings command higher rents and occupancy rates. Another approach is to dedicate to transit the increase in property taxes attributable to increased land values in the vicinity of the investment.

Establishing a mechanism for benefit assessment to help pay for a transit investment is necessarily a political decision, based as much on negotiation as on technical analysis. But the technical process can provide critical information on the extent and magnitude of anticipated benefits. Given the difficulty of forecasting changes in property values and rents, the technical information used in these decisions is often limited to transportation benefits. Changes in travel time, pedestrian volume, and other outputs of the travel forecasting process can be useful inputs to the benefit assessment. Forecasted reductions in automobile use, if translated into reduced parking requirements, can be regarded as a direct monetary benefit to developers. Sample pro formas prepared as part of the land use impact analysis can also help reveal how much can be assessed without unduly affecting the economic viability of desirable development.

CONCLUSION

UMTA's revised guidance on land use impact assessment has been available for only a few months, but many of its concepts were incorporated in earlier fixed-guideway planning studies. In Miami, as part of the environmental impact statement for two extensions to the downtown people mover, the land use impact assessment was presented in accordance with this framework; although an in-depth analysis was not made, the framework offered a useful structure for presenting information to the public and local decision makers. In Milwaukee, a more detailed economic development analysis was performed for a proposed light-rail line. The framework is currently being applied in Buffalo to a major study on economic development and value capture. The Buffalo study is exploring alternative public policy scenarios associated with a possible extension to Buffalo's light-rail rapid transit line.

The recommended framework provides a useful checklist of the topics that should be addressed in a land use impact assessment. It points out important, frequently overlooked relationships between the land use assessment and other technical topics. The framework should help the analyst structure and perform an objective technical study, as well as present the results in a way that allows decision makers to make more informed choices among alternatives. The framework does not advocate specific analysis techniques, nor does it obviate the need for more accurate land use forecasting techniques and better before-and-after data for completed transit projects.

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Distributional Effects of State Highway Investment on Local and Regional Development

YORGOS J. STEPHANEDES

Previous studies suggest that a minimal or restricted relationship exists between transportation and economic development. Conclusions drawn from these studies result from three factors. First, the studies considered the transportation-development relationship at substantially different geographical scales ranging from large-scale multistate regional studies to small land use projects. Second, at the subregional scale most studies used cross-sectional, correlational analysis; however, this type of analysis is unable to determine the direction of the relationship between the two variables. Third, the studies paid too little attention to the long delays inherent in transportation-development interactions. A method that examines the situations in which transportation investments seem to temporally precede changes in the local economy was used in this study. It was found for total employment by using vector autoregressions and causality tests that highways encourage long-term economic development in excess of the normal trend in Minnesota's regional centers and counties under the urban influence of the state.

Where should a state spend money if it wants to positively influence its economy? A research team at the University of Minnesota recently studied this issue, looking at the effectiveness of highway funds in increasing economic development. Researchers examined the employment and income implications for counties in the upper midwestern region of the United States, with emphasis on localities and regions in Minnesota (*1*,*2*).

Most states in the upper Midwest are characterized by a geographically dispersed population, requiring investment of funds into transportation infrastructure. Despite federal aid, transportation investment is typically a major component of the state budget [in the United States, state spending for highways totaled $38.2 billion in 1986, representing 9 percent of the budget, ranking third after education and welfare (U.S. Census Bureau)]; the U.S. Department of Transportation (DOT) bears responsibility for how these funds are spent. In addition, hoping that state policies are more effective than federal ones, some states in the region have been assuming a greater role in the design of economic development programs. Investment policies directed to improving the transportation infrastructure have played a key role in such programs.

Within the United States, 36 states explicitly consider regional economic development as a justification for highway funding and as one factor that influences decisions about the highways in which to invest (*3*). In the upper Midwest, one of the most ambitious programs is Revitalize Iowa's Sound Economy (RISE), which provides $27 million in annual funding dedicated to highway construction and improvement projects intended to foster economic development in Iowa over a 5-year period (*4*). The consideration of regional development objectives in highway funding is valid, however, only if highways have a significant impact on regional development, that is, create jobs, increase income, and improve community welfare. There is disagreement as to whether, and in what contexts, this is the case.

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In Minnesota, government transportation-related policies play both an active and a passive role in regional economic development. Government is a passive player when it improves highways to support economies that are already improving. It has done this, often effectively, in regional centers, where it rewards development and, in turn, acts as a catalyst for more development by removing accessibility barriers and bottlenecks. Government becomes an active player when it improves highways in an attempt to stimulate development in local economies that are deteriorating. Such attempts usually occur in rural areas but are not always effective. Improved roads tend to hurt the economies of rural areas in the long run if such areas are located near regional centers and if no other concurrent policy is instituted to encourage development. Far from regional centers, rural areas stand to benefit from improved roads if they can use them to improve the access of products (timber and farm products, for example) to markets and of tourists to the area.

PREVIOUS FINDINGS

The traditional view in the literature has been that the improvement of the transportation infrastructure is a necessary predecessor to economic development in a region. However, as Sheppard suggests, in the last 10 to 15 years this view has come under heavy criticism from a number of directions (*5*). Empirical research in a number of countries provided a series of counterexamples that called this view into question. In particular, studies of transportation and economic development plans in the Soviet Union and China, as well as of the development of the railroads in the United States, showed that transportation can be concurrent with or a result of regional economic development rather than its predecessor. Similarly, research into the role of transportation in European and third world countries also uncovered many instances where the development of transportation into the interior exacerbated rather than decreased economic development differentials between the major cities and rural regions. Furthermore, the complexities of the interdependencies between places in a well-integrated spatial economic system, such as in Minnesota, may mean that the effects of transportation improvements are hard to predict and not necessarily beneficial (*5*).

For instance, in the Atlantic region of Canada, increased investment in the area's reasonably mature transportation infrastructure would attract few industries (*6*). Similar studies of the Ozark plateau of Arkansas found little correlation between highways and economic development (*7*). In cases in which a relationship was found, the effect was minimal [as in an analysis in the north of England (*8*)] or very restricted [in Connecticut, Pennsylvania, and elsewhere, it was determined that counties with Interstate highways have an advantage over other counties with regard to population and employment growth but long-term effects were observed only in counties within 25 mi of a metropolitan area (*1*)]. It is generally acknowledged that there are few places in the United States where transportation infrastructure deficiencies per se strictly preclude economic activities (*9*).

The inconclusive and occasionally contradictory conclusions on the relationship between transportation and economic development are the result of three major developments. First, previous studies have considered this issue at substantially different geographical scales, ranging from large-scale multistate regional studies on one extreme to small urban land use projects on the other, and on the basis of a wide range of implicit assumptions. There is no reason to believe that the process works in the same manner at all different scales (*5*). Second, at the subregional scale of analysis (i.e., county and multicounty, up to state scale), which is of interest to us, most previous studies have used cross-sectional, correlational analysis, although such analysis is unable to determine the direction of relationship between two variables.

Finally, previous studies have paid too little attention to the long delays that are inherent in the transportation-economy interactions. For instance, a substantial highway reconstruction project may take 2 years to complete, and it may take another 3 years before regional industries fully realize benefits from the highway improvement by restructuring their transportation operations and increasing their competitiveness in their markets. Indirect effects from these immediate benefits, such as expansion of headquarters and employee relocation, may happen over an additional 3 to 5 years. If a 1- or 2-year waiting period is added before an approved reconstruction project actually begins, the results of an investigation of the possible interactions may differ depending on the year—over a 10- to 12-year period—in which the analysis takes place. The time series analysis takes into account time-related effects such as these and, therefore, is more likely to increase the accuracy and consistency of the findings, and can come closer to distinguishing between cause and effect.

In summary, in a well-integrated spatial economic system, the effects of transportation improvements are complex and hard to predict. The best way to empirically evaluate the possible effects of transportation investment on the economy would be to examine situations in which transportation investment does seem to temporally precede changes in the local economy, and to determine whether, in which situations, and after what length of time that impact is likely to be positive, neutral, or negative. This research direction was adopted by this project.

DATA SOURCE

Highway expenditure figures used in this study are based on data compiled by the Minnesota Department of Transportation (DOT) as part of the annual project funding system. The data are broken down by county, for all 87 Minnesota counties for the years 1957 to 1982, and are limited to the state trunk highway system, which includes the major highway projects funded by the DOT. The employment data from *County Business Patterns* represent employment in the middle of March for the years 1964 to 1982. In particular, the analysis includes nine different levels of employment (E), by place of work, and eight different levels of income (Y), by place of residence, as follows:

Manufacturing	E, Y
Retail	E, Y
Service	E, Y
Transportation and public utilities	E, Y
Construction	E, Y
Finance, insurance and real estate	E
Wholesale	E
Agricultural	E
Farm	Y
Earnings by work	Y
Total	E, Y

First, effects reflecting the dominance of the size of a county, regional or national trends, inflation, and other effects that were common across several counties in a group were filtered out. Following a quasi-experimental approach, groups of counties were formed on the basis of county characteristics. Within a group, counties were expected to react more homogeneously to highway changes and may be treated in a similar fashion for policy purposes. Previous research used a primitive classification based on intervals; for instance, a criterion was whether a county in a class included a city with a population of 28,000 or larger (*10*). In this project, the effectiveness of the classification is increased by forming groups on the basis of characteristics that better reflect the local features of counties. In addition, characteristics are included that reflect the interaction between counties, recognizing that counties depend in part for their growth on their neighbors.

In selecting the features for classifying the 87 Minnesota counties, the objective was to develop a set of not-too-data-hungry features sufficient for extracting the major county characteristics necessary for classification. In particular, features familiar to the transportation policy analyst that (a) could be easily quantified with existing data; (b) could capture the socioeconomic, demographic, and accessibility differences across counties; and (c) were least correlated with each other were sought. To achieve this objective, formal feature extraction through pattern recognition was obtained from the Karhunen-Loeve expansion [principal component analysis (*11*)]. The standard feature extraction was modified to allow incorporation of input by experts, including several policy makers, geographers, and government decision makers in Minnesota and some neighboring states. The resulting six most important features, to be used for classifying the Minnesota counties, were as follows:

1. Accessibility within a county, measured by percent county area covered by paved and unpaved roads;
2. Accessibility between counties, measured by number of all roads crossing county border divided by county perimeter, no weight provided for number of lanes per road;
3. Population density;
4. Population dominance, measured by average of population densities of adjacent counties. This feature can indicate the potential for increased travel between counties given improved accessibility;
5. Average salary income per household; and
6. Median age, which can indicate the potential for mobility as, for instance, of people within a certain age bracket who are expected to more easily travel across counties to find work if there is access.

Alternative features could have been considered (e.g., travel time as an access indicator between counties), and every feature has certain strengths and weaknesses. Similarly, adding more features might have incrementally improved the ability of the feature set to capture certain intricate details of a county economy. However, the list, representing the result of the feature extraction subject to the consensus of experts, can be adopted as a working set for county classification.

The filtering was accomplished in several ways. First, all variables of a county (such as county expenditures or employment) were defined relative to the county group to which that county belongs. This definition filters out exogenous events (such as inflation, unemployment, and federal funding) that may have similarly affected all counties in the group. Second, each variable was redefined by subtracting the historical average over the study period (e.g., the time average over 26 years) so that the data from all counties for all the years can be included in the analysis. Third, the dominance of large counties, for which the absolute variation of employment and highway expenditures would be greater than in small counties, was filtered out. Although this filtering does not guarantee that all effects of outside factors were eliminated, it does ensure that the potential influence of the factors considered to be most important was substantially reduced.

Following filtering, time series analysis (vector autoregressions) of the data, enhanced with the employment of Granger-Sims causality tests (*12–14*), were performed. The tests can be an aid in inferring whether a directional influence by a variable (such as highway expenditures) on another (such as employment) also indicates that the first variable "causes" (i.e., consistently precedes) the second. To be sure, causality analysis was used with caution, because of its limitations (*15*, *16*). In particular, the literature and experience suggested that, in most cases, the causality test was overly strict, occasionally indicating no causality although one would be expected from theoretical or empirical considerations. However, the test can document lack of causality reasonably well when two variables would be expected to be irrelevant. Knowing this, when causality was weak, increased emphasis was placed on consistent vector autoregression results. Overall, although the analysis was certainly imperfect, it erred most likely on the conservative side. In other words, there may exist additional causalities between variables, that strict application of the tools—causality tests, direct examination of time series plots, and theoretical and empirical expectations—may have missed.

As the foregoing indicates, classifying the 87 counties in groups on the basis of their characteristics was an essential element of the filtering process. In addition, classification made the analysis of the results more meaningful because it allowed focusing on each group of counties separately. In particular, because possible relationships between highway expenditures and economic development would be likely to differ across groups, a separate relationship was developed and evaluated for each group, thus making easier the identification and understanding of possible impacts by group.

Following classification, four county groups were identified (see Figure 1):

1. *Regional Centers*. Counties in this group are characterized by minimum age and maximum value in all other features relative to all cluster averages. These include nine counties, that is, the Twin Cities greater metropolitan area and Olmsted County in the south, where the city of Rochester is located.
2. *Counties under Urban Influence*. Medium value in all six features (28 counties).
3. *Agricultural Counties*. Maximum age and low value in all other features (37 counties).
4. *Natural Resource Counties*. Minimum value in all features and medium age (13 counties).

Although these classifications and the earlier one (*10*) have several common elements, they also differ in several important ways. In particular, in the new classification the regional centers are not distributed throughout the state as before. Instead, they include the greater Twin Cities metropolitan area plus Olmsted county. Owing to the presence of two major employers in Rochester, the Mayo Clinic and IBM, Olmsted county has a high concentration of health and computer manufacturing services and substantial interaction with the rest of the world via air.

The Minneapolis-St. Paul metropolitan area has been described as a finance, insurance, service, and market center for the upper Midwest. However, with 10 percent of the nation's computer manufacturing in Minnesota, the Twin Cities' reputation in technologically oriented services stems primarily from its involvement in computers. Also contributing to the technological reputation are the companies that have corporate headquarters in the area, tying it with San Francisco-Oakland for seventh place in the nation for the 500 largest U.S. industrial firms. One factor that may have contributed to the impressive development of the service economy is the central location of the Twin Cities within the airline network. Benefiting from this factor, consumer services have also grown, especially tourism and health services.

The rest of the counties that the earlier, population-based classification had identified as regional centers are now in the "under-urban-influence" group. Joining this group are all the counties in the southeast corner of the state. These counties are characterized by light manufacturing and form a southeast-northwest corridor of robust economic activity.

The counties that the previous classification had identified as rural are divided into two groups in agreement with the general character of their economy. Although Minnesota's

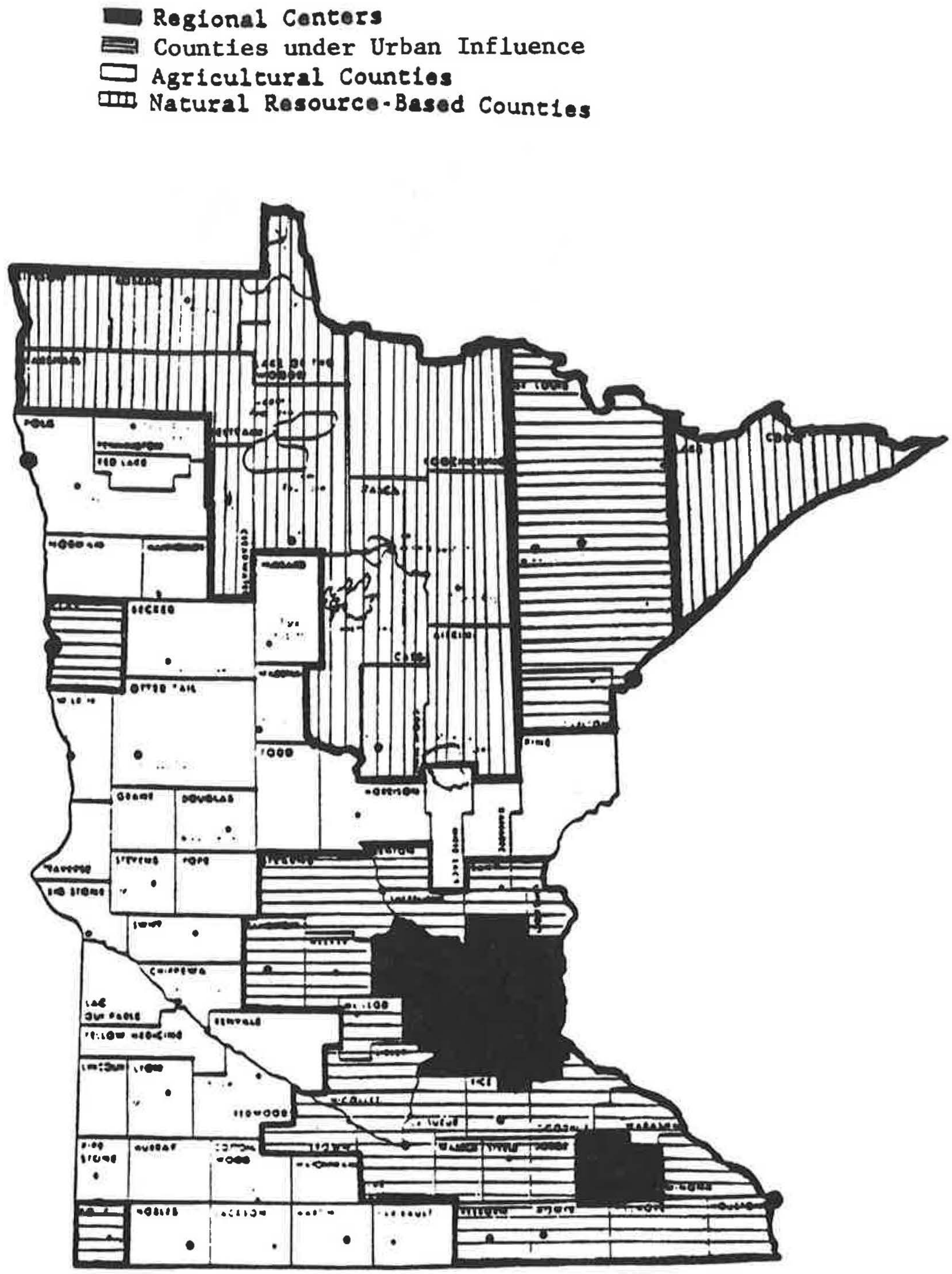

FIGURE 1 Classification of Minnesota counties on the basis of demographic, economic, and locational variables.

economy is diversified, the economy of these areas is specialized. In particular, the north-northeast (natural resource counties) depends heavily upon timber, mining, and tourism, and the west part of the state (agricultural counties) depends on agriculture. Despite the continuing depletion of forests, manufacturing based on lumber products is strong. Although the lumber and wood products industry is evenly dispersed throughout the state, the majority of lumber is harvested in the northeast, where paper producers have also tended to locate (see Figure 2). For instance, in Carlton and Koochiching counties forestry accounts for 75 percent of the local economy. Tourism services have highest concentration in north Minnesota (see Figure 3). Comparisons of specific economic sectors of Minnesota's economy to that of the United States as a whole are shown in Figure 4.

Although this classification facilitates analysis, it does not fully address certain county peculiarities. For instance, St. Louis could be divided into three parts, each classified in a

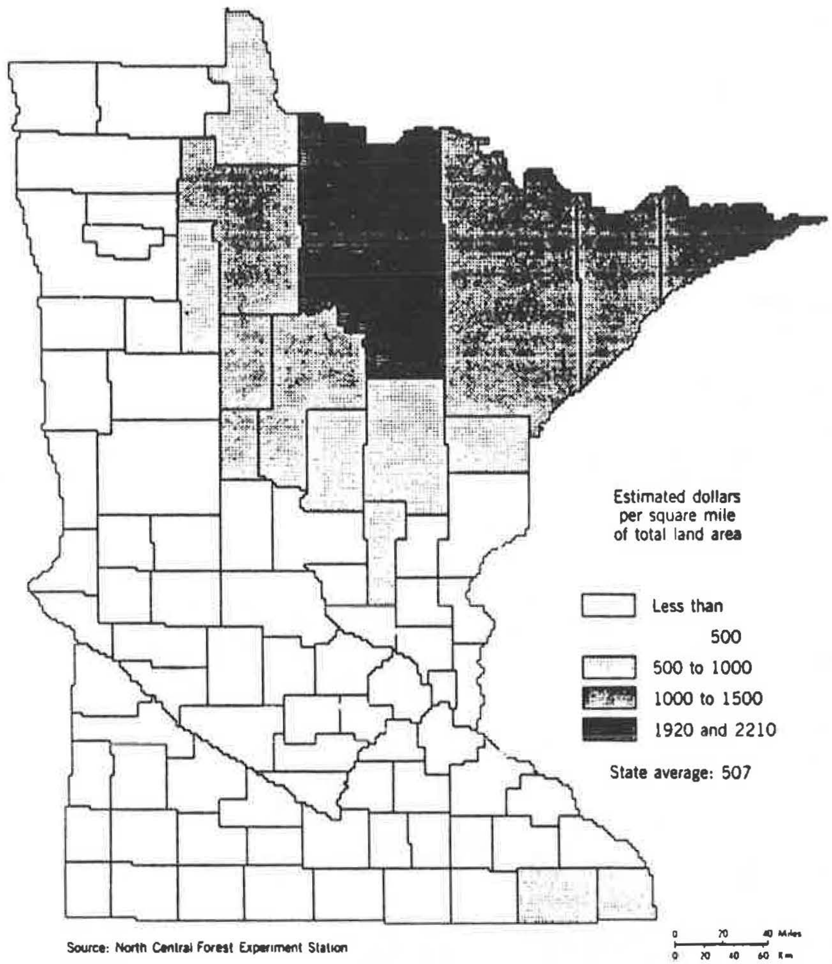

FIGURE 2 Value of timber cut, 1975.

different cluster, if data for each part were available. Further, Clay and Rock are substantially influenced by the neighboring counties Cass (which includes the city of Fargo) and Minnehaha (Sioux Falls) in the Dakotas and, therefore, the Dakota counties could also be included in the analysis. Kittson has a strong agricultural character and, similar to Cook, is strongly influenced by border movements; as a result, the presence of both counties in Group 4 may not be fully justified. If such potential inconsistencies are appropriately treated, the classification could lead to analytical results of higher accuracy.

RESULTS

Influence of Transportation on Economic Development

Regional Centers and Counties Under Urban Influence

Regarding total employment (i.e., the summation of employment for all sectors of the economy), the vector autoregressions and the causality tests provide evidence that highways "cause" (i.e., temporally precede in a systematic manner) long-term economic development in excess of the normal trend in Minnesota's regional centers and counties under urban influence. These counties include the economic centers of the state and, therefore, are most likely to have the economic activity that is necessary for absorbing the highway improvements. Of the new jobs, a few are created in the 2nd year but most are created in the period between the 5th and the 10th year following the highway expenditures. The effect of a one-time increase of highway expenditures on total employment for the regional center counties is shown in Figure 5. This effect was significant at the 1 percent level by a causality test.

Although these findings are in agreement with the earlier results (*10*), they provide certain additional details. For instance, they indicate that, within the original regional center group of the earlier study, the counties that are located outside the metropolitan area [i.e., St. Louis (Duluth), Clay (Moorhead), Stearns (St. Cloud), Blue Earth (Mankato), and Olmsted (Rochester)] are as likely to benefit from highway investment as are the metropolitan area counties.

Natural Resource Counties

Improved highways generate income and employment in the natural resource counties and, in particular, in two sectors, service and retail. (Service employment is up to 33 percent

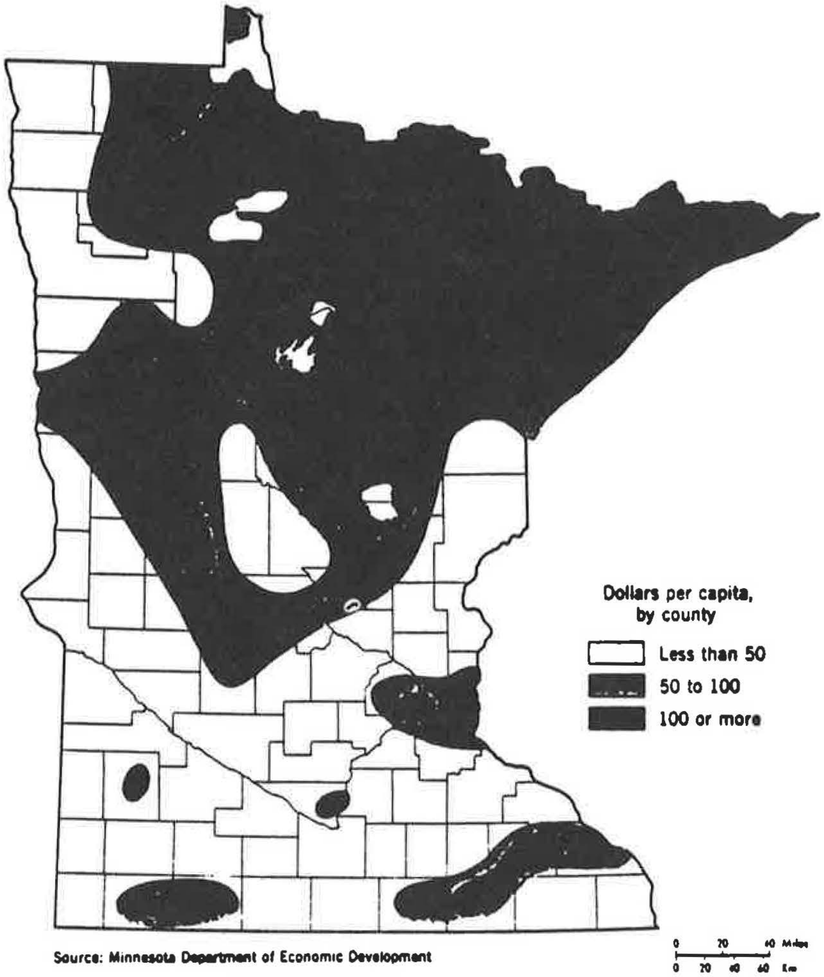

FIGURE 3 Hotel and motel receipts, 1978.

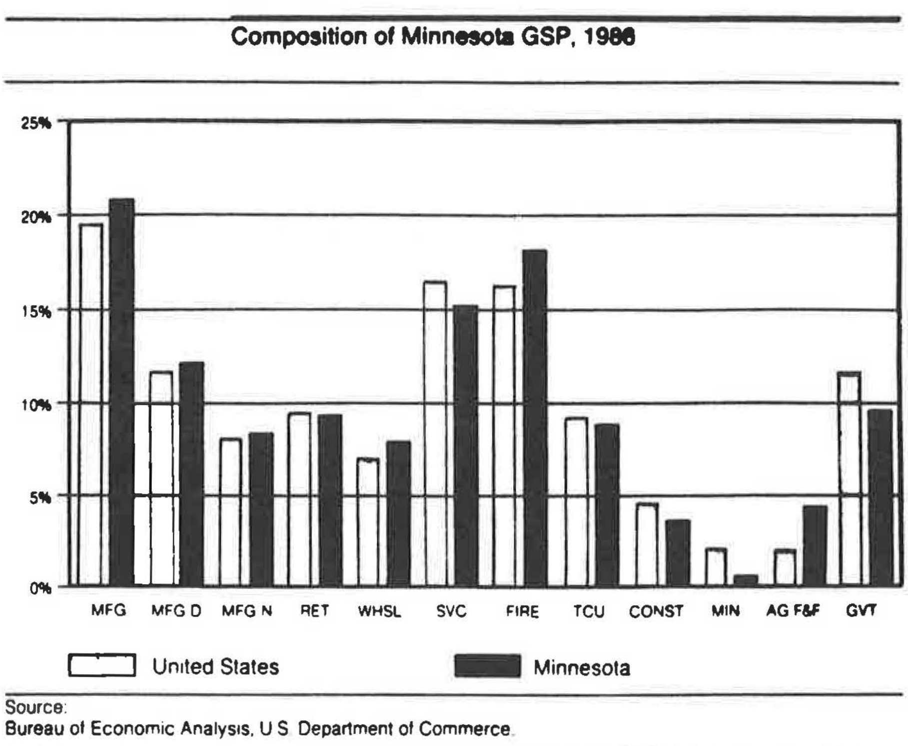

FIGURE 4 Minnesota economy versus the U.S. economy.

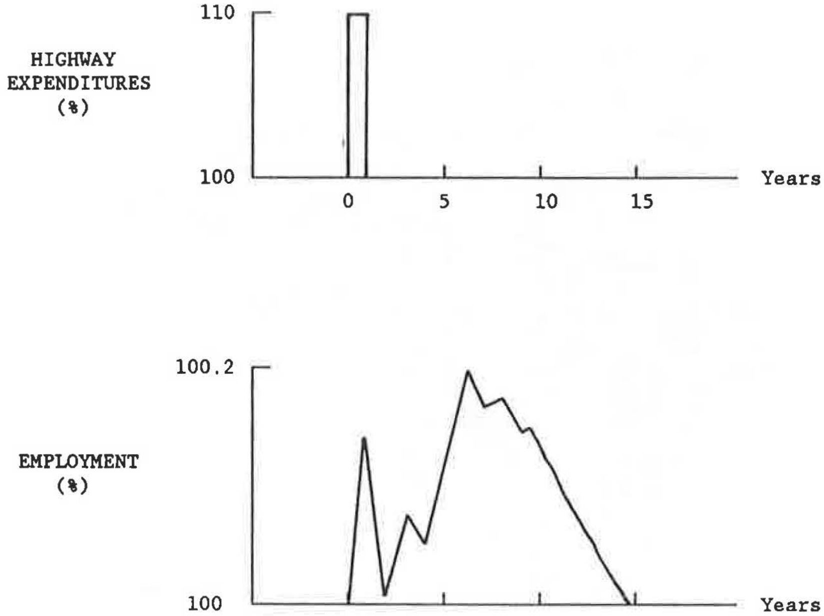

FIGURE 5 Regional center counties: impact of highway expenditures on total employment (percent above trend).

of total employment in these counties, higher than a maximum of 26 percent in the other county groups). Although these effects are in general agreement with the literature, the service effect is also long term, which was not entirely expected. The long-term service effect indicates that the service sector in these counties is eager to provide more jobs to the economy and its expansion can be hampered by the lack of good roads. To be sure, the density of the highway system is low, with only two major highways running through and out of the counties (Highway 62, crossing the northern edge of Lake and Cook, and Highway 29, running right out of the border of Marshall and Kittson). At the northern border with Canada, lakes and forests impede highway communication.

All highway effects on the economy of these counties are positive, indicating a potential for the appropriate use of highway expenditures for economic development in this part of Minnesota.

Retail Impacts

Retail activity is affected by highways in every group of counties. Although highway construction in urban and regional centers can impede business, the effect is stimulative in agricultural and natural resource counties. In the latter counties, retail activity represents a large part of the local economy—up to 31 percent of total employment, compared with a maximum of 25 percent in the remaining counties.

Figure 6 shows the impact of a one-time 10 percent increase in highway expenditures on retail employment in the natural resource counties. As Figure 6 indicates, following the increase in highway expenditures in the first year, retail employment also increases. Although most of the employment increase occurs in the first 6 years, the effect lasts approximately 10 years. The duration of the impact, which is significant at the 1 percent level by a causality test, is as long as that in regional centers (see Figure 5) and much longer than that in the previously defined rural areas [3 years—see discussion by Stephanedes and Eagle (*10*)].

Further, the maximum impact occurs in the second year, when the employment increase reaches a peak of 2.5 percent in response to the increase in highway expenditures. This compares with a peak of 0.2 percent in the sixth year for the case of the regional centers. The comparison indicates that the effect in natural-resource-based rural counties can be higher by an order of magnitude, in relative terms, than in regional centers. However, as the total employment in the latter is high, the absolute effect in terms of total number of jobs in regional centers is greater.

The finding of a positive retail effect is encouraging for policy makers advocating the potential for improvement in the economy of rural areas if the local highways are improved. The finding also indicates that such potential exists only in rural areas already having a strong resource base in place to take advantage of the highway improvements.

Influence of Economic Development on Transportation

Statewide

The response of highway investment to higher total employment is immediate and positive statewide and, in particular, in the agricultural and natural resource counties, indicating the eagerness of the state government to aid any increasing economic activities in Minnesota. In addition, the sensitivity of highway investment relative to changes in employment is substantial: an increase of jobs by a given percentage (say, 10 percent) above the trend attracts an additional investment statewide of almost double the size in percentage terms—18 percent over 10 years; in other words, an extra 100 jobs would attract an extra $28,500. Following detailed accounting of this

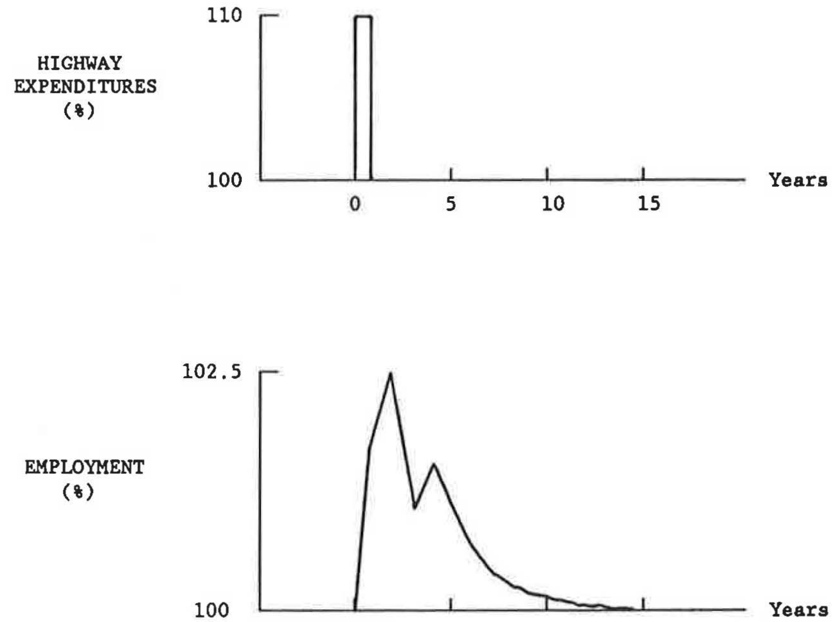

FIGURE 6 Natural resource counties: impact of highway expenditures on retail employment (percent above trend).

effect and the stated influence of highways on employment, at current funding levels and employment, it is estimated that approximately 1 of every 60 new jobs is created by Minnesota Department of Transportation state trunk highway funds.

Government Active and Passive Roles

In general, government reacts to economic improvements and does not seek to play an active role by stimulating a contracting economy. Natural resource counties (and farm-related activities in certain agricultural counties) are the major exception. In these counties, government plays an active role, with a tendency to stimulate the local economy through highway expenditures when income drops. As the results of this analysis indicate, such a policy appears to be effective in the natural resource, but not always in the agricultural, counties.

The effectiveness of the active government role in the natural resource counties indicates that the state policy makers appreciate the needs of the timber and tourist industries in the north-northeast part of the state and their potential benefit from road improvements. At the same time, the local industry is able to take advantage of the improvements. This regional relationship appears to have the ingredients for a success story.

DISCUSSION OF RESULTS

Following the evaluation of the time series results, a sensitivity technique was used to determine whether there are indications that one or more counties have been misclassified, thus influencing the interpretation of the findings. Kittson county, located at the northwest corner of the state, appears not to fit well with the rest of the counties in the natural resource group. Farm income in Kittson appears to substantially affect highway decisions; yet, improved roads have no significant effect on the Kittson economy. In fact, without Kittson, the impact of highway investment on the counties in this group is greater than that found earlier.

An additional finding was that Beltrami and Marshall were the principal representatives of this group, that is, they carried a major portion of the identified relationships between highways and the economy. Furthermore, except for the unwanted influence of Kittson (and, to lesser extents, Lake and Cook), all counties in this group contributed to these relationships, indicating the strength of the effect on the economy of these counties that use the better roads to improve access of timber and farm products to markets and access of tourists to the area.

In an earlier study (*10*), several of the natural resource counties had been classified under the "next-to-urban" or "next-to-regional center" heading. Findings from that study indicated that highways have a long-term negative impact on the economy of these counties, seemingly contradicting the current findings. However, the "next-to-urban" or "next-to-regional center" group had also included several of the counties now called "agricultural." It can be inferred that the negative impact observed is limited to the agricultural counties; improved highways in those counties draw business activity away from them and into the regional centers in the long term.

That improved highways tend to help the economy of regional centers and areas under urban influence and to hurt certain of their adjacent counties should not be surprising. In particular, the adjacent counties tend to depend on these areas for the infrastructure necessary for development; better highways may allow agricultural county residents to conduct more of their economic activities in the nearby centers. Further, a comparison of the percentage of people working (66 percent) and living (47 percent) in the regional centers strongly suggests that highways are helping the residents of the adjacent counties to get to work as well as providing jobs for them.

The distributional nature of the effects is evident when analyzing the different parts of the state. In particular, although certain counties are likely to gain from improved roads, others are likely to lose; the statewide effect is not significant. Moreover, the statewide effect is small in size: over 10 years, a 10 percent investment increase would lead to only a 0.01 percent increase in jobs statewide (or, an extra $1 million would create an average of only 5 to 8 new jobs statewide), most from the spending associated with construction of the highway. This finding is in agreement with conclusions drawn from the geography literature (*5*) indicating that, where the highway network is good and most services are widely available, any effects of transportation improvements on services are likely to be more dramatic in competition between service locations than on the overall disposition of consumers to purchase goods.

The negligible economic effect of highway funding on a statewide basis indicates that, as long as Minnesota is viewed in isolation from its adjacent states, the potential for statewide economic gains could not be a valid argument on which to base decisions for increased highway funding in Minnesota. However, the findings suggest that highway investment can be used for shaping regional development policy within the state. Similarly, it can be argued that, if Minnesota is viewed in competition with the neighboring states in the upper Midwest, transportation improvements in the state could result in economic gains.

CONCLUSION

This project conducted an analysis of the time-dependent impacts between highway funding and economic development in counties and regions in Minnesota. In particular, it examined the effects of highway funding on local employment and income, and the influence of local economic changes on highway funding. The findings indicate that, in Minnesota, government plays both an active and a reactive (passive) role in regional economic development.

Government is a reactive player when it improves highways to support economies that are already improving. It has done this, often effectively, in regional centers and counties under urban influence, where it rewards development and, in turn, acts as a catalyst for more development by removing accessibility barriers and bottlenecks. Government becomes an active player when it attempts to stimulate development in local economies that are deteriorating. Such attempts usually occur in rural areas but are not always effective: improved roads tend to hurt the economies of rural areas in the long run if such areas are located near regional centers. Far from regional centers, rural areas stand to benefit from improved roads if they can use them to improve access of timber and farm products to markets, and access of tourists to the area. The effectiveness of transportation improvements in rural areas could increase if transportation policies were instituted in concert with other types of development policies, for example, policies that improve the business climate, labor force, and education in the area.

Although highway funding can influence the economy of specific regions in the state, such as the regional centers, certain counties in the southeast, and the natural resource counties in the north, it has negligible economic effect on a statewide basis if Minnesota is viewed in isolation from its adjacent states. However, the potential for statewide economic gains vis-à-vis the competing states in the upper Midwest could justify increased highway funding in the state. The findings further indicate that highway investment can be used for shaping regional development policy in Minnesota.

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SECTION 4

Rural and Agricultural Impacts of Transportation Investments

Methodological Review of Analyses of Rural Transportation Impacts in Developing Countries

PETER D. COOK AND CYNTHIA C. COOK

Studies of rural transportation impacts have been carried out over the last 20 years, with emphasis on the methodology and underlying models of causal relationships. The historical sequence of rural impact methodologies and the research on rural mobility and migration carried out in several countries during the last 10 years are examined. Particular emphasis is placed on the Kenya Rural Access Road Program research, Southeast Asian Research for SEATAC, and the Mexico Mobility Study. Present impact methodologies focus too narrowly on agricultural effects, despite early observations of wide-ranging impacts. They also fail to predict the significant increases in nonfarm traffic and related economic benefits that are signaled by the relatively high value placed on travel time demonstrated in the behavior of many rural travelers. This value reflects the importance of nonfarm employment and the benefits of increased mobility and service accessibility, which are crucial to adequate impact evaluation. A causal model of impacts is described, which defines the relationships between access change and rural socioeconomic development, including the role of intervening variables. Conclusions are drawn concerning the types of models that appear most promising for future impact analysis.

Ways are examined in which the analysis of rural transportation impacts in developing countries have evolved over the last 20 years, with the objective of formulating a framework for impact analysis that covers the full range of expected primary and secondary effects. Although evaluators frequently acknowledge the wide range of transportation impacts in rural areas, quantitative analysis of these impacts has focused almost exclusively on direct, readily measurable economic effects. Surprisingly little attention has been paid to the measurement of multiplier effects and to the social distribution of economic costs and benefits. Current models demonstrate an imperfect understanding of the workings of the rural economy, focusing on agricultural production and often exclusively on cash cropping. Little is known of the values placed by rural people on such intangible assets as time, energy, health, security, social interaction, and spiritual intercession. As a result, economic models for predicting the effects of rural transport investments have shown little explanatory power when confronted with the actual consequences of such investments. This does not mean that economic models are inherently wrong, but it does mean that the current models are not good representations of the processes that are actually going on in rural areas of the developing world.

The economic and social consequences of transportation improvements in a rural setting are complexly intertwined. It is this intricate blend of economic and social consequences that is the object of development. Development is defined herein as a process of increasing human welfare for a given population in a region or community through increasing economic and social activities. The concept of human welfare, as it is used here, refers to an aggregate of individual utilities (including producer and consumer surplus concepts) as defined in the work by Hicks (*1*), to include the values of material and nonmaterial goods or services received by all members of the population.

Starting from this broad definition of the purpose for investing in rural transportation improvements, the objective can be satisfied by a variety of possible outcomes and combinations of outcomes with respect to particular utilities. These possibilities include an increase in food supply, cash income, access to consumption goods, access to services, security, social interaction, and increased satisfaction of other human needs and desires, such as personal mobility.

Ranganathan and Arunachalam (*2*) have summarized the results of the latest rural road research in India and pointed out that these recent studies, which have benefited from prior research, were still "not comprehensive enough to bring out tangible results." It is believed that this lack of tangible results can be attributed to the incomplete data bases used in the analyses, and to the lack of an explicit, clearly formulated model of development impact that can be systematically tested and refined as part of the international research agenda.

The absence of an explicit model leads to the testing of simple, plausible, usually bivariate relationships that do not have the appropriate structure to reflect a complex development process. Thus, these tests frequently prove inconclusive. An explicit model is also needed to establish the causal linkages that cannot be inferred from a purely statistical analysis.

Once models are developed to forecast all the impacts of accessibility change, including economic activity and mobility trip generation, it is necessary to estimate economic benefits in the second step of a two-step evaluation process. However, various approaches to benefit estimation may have to be used for different types of impacts. Producer surplus combined with consumer surplus (where price reductions are realized elsewhere in the society) may be the best measure of benefits for primary production increases, but consumer surplus, on the basis of a willingness-to-pay measure, may be the best estimate of the net utility of mobility trips to the traveler. The estimation of these benefits is a topic that demands the attention of professionals in the economic impact field.

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STUDIES OF MODELS RELATED TO RURAL TRANSPORTATION IMPACTS

Much of the theoretical work on rural transportation impacts has been carried out in the context of rural road improvements designed to facilitate motor vehicle traffic. Although there are other forms of rural transport, and most of the transportation that takes place in rural areas does not occur on roads (*3*), practically all of the public investment in rural transport has taken the form of rural road improvements. Consequently, the development of economic evaluation methodologies has also focused on the costs and benefits of rural roads designed to accommodate motorized vehicle traffic. Many of the concepts involved would also apply to other types of rural transportation improvements (i.e., bicycle paths, cart tracks, improved vehicles, or river transport improvements).

There have been many attempts to describe the impacts of rural roads in the last quarter century. An early summary is found in the work by Owen (*4*), which includes the following impacts:

- Increased agricultural production,
- Reduced costs of agricultural inputs,
- Greater health service availability,
- Greater availability of education,
- Greater transport service availability,
- Increased use of resources (fish, timber, etc.),
- Increased trade,
- Increased industrial economies of scale resulting in expansion,
- Increased spatial price stability,
- Greater facilities for communication (more post offices),
- Increased intensity of agriculture,
- Organizational change (more cooperatives),
- More information in rural areas, leading to changes in attitudes and behavior (e.g., risk taking),
- Reduction of illiteracy, and
- Greater productivity in the medium to long run.

Owen also examined the state of knowledge regarding the roles played by transport, communications, and education in the development process. He cited research in India, Turkey, South Korea, and Japan on the relation of communication to development. Owen also mentioned research in the United States, which showed that labor force productivity over the long run is explained to a significant extent (25 percent) by education levels, and a further 20 percent by the adoption of new technologies.

Owen noted that the impacts of rural roads were not uniform from one area to the next, and that the Community Development Program, which had provided all-weather roads to many villages in India, was limited in some cases because "other elements of productive farming were still absent" (*4*). He also discussed the potential role of transportation in reinforcing growth points and market towns in India, and the potential role of these towns in stemming rural-urban migration to the larger cities.

Although he examined the impacts of transport in a relatively systematic manner, Owen did not develop an explicit model of rural road impacts. He left it to the reader to synthesize the various effects he reported into a framework for impact analysis.

Early World Bank studies of rural roads applied the same user cost savings methodology commonly used to evaluate highway construction (*5*). This methodology proved adequate for the evaluation of projects designed to upgrade roads already carrying significant amounts of traffic. However, it failed to capture the dynamic effects on the rural economy of road construction in areas previously without road access, and consequently without vehicle traffic (*6*). In an attempt to formulate a methodology to evaluate the economic contribution of new roads in rural areas, Carnemark et al. (*7*) developed an approach based on the producer surplus that could be realized in areas of potentially high agricultural production. An implicit assumption of this methodology was that the cost savings resulting from road transport improvements would be fully passed on to farmers. This methodology was widely used to evaluate the first generation of World Bank-financed rural road projects.

The Carnemark methodology is based on the forecasting of benefits accruing to generated traffic, resulting from an increase in agricultural production, which in turn results from transport costs decreasing below a certain threshold. Thus, it reflects the benefits of a large expected increase in agricultural traffic. Benefits resulting from an increase in the nonagricultural share of traffic are not included in this model. For this reason, some project evaluations combined agricultural value-added benefits for farm-related traffic and user cost savings for nonagricultural traffic.

In most cases, actual existing shares of agricultural and nonagricultural traffic were not known. This sometimes led to the assumption that all traffic was agricultural (equivalent to assuming a multiplier of 1.0 for nonagricultural traffic) and that a large increase in generated traffic would therefore be realized. However, no benefits were attributed to growth in personal travel, since a zero opportunity cost was attributed to travel time by rural people. This interpretation caused such models to inaccurately predict the traffic impacts of rural transport improvements.

The model embodied in the Carnemark methodology is based on a view of the world where all goods are tradeable, all markets are transparent, all prices are market clearing prices, and all other things are equal. Given the market conditions prevailing in rural areas of most developing countries, it is not surprising that the projects where this methodology was applied gave mixed results. A measurable increase in production of cash crops and a consequent increase in human welfare could be observed in some places. In other places, marketed agricultural production did not increase significantly for a number of different reasons. In some cases, government price controls or the monopsonistic practices of private traders meant that farmers received too small a share of the benefits of road improvements to have an incentive to invest in additional production. In other cases, unforeseen macroeconomic events, such as drought or a fall in the world price for cash crops, meant that additional production failed to yield economic benefits.

Another model that dealt with the relationship between accessibility and growth in agricultural production in a more sophisticated way than the Carnemark model was developed by Liang (*8*). This study analyzed a detailed and wide-ranging data base for prewar China, which allowed the author to examine the constraints of land, labor, and capital on the production response to transport accessibility. Liang showed that Chinese farmers responded to the change in access by shifting out of foodgrains for local consumption and into the production of industrial and high value nonfood export crops, resulting in an increase in net farm income. This shift also generated increased demand for food crops produced in areas with less accessibility change. Liang used a Cobb-Douglas production function to estimate the relationship between total farm output and six types of inputs (labor, land, cropping intensity, irrigation, fertilizer, and farm assets), as follows:

$$\ln Y^* = \ln k + \sum a_i \ln X_i \qquad (1)$$

where

Y^* = expected farm output,
k = calibration constant,
a_i = calibration constant for factor X_i, and
X_i = factor of production.

The factors of production were

X_1 = labor,
X_2 = cultivated land,
X_3 = intensity of cultivation,
X_4 = irrigated land,
X_5 = nonirrigated land,
X_6 = fertilizer applied, and
X_7 = value of farm buildings.

This function enabled Liang (*8*) to trace specific linkages between accessibility change and changes in farm inputs and to associate these changes with specific elasticities for each factor, reflecting the constraints on that factor in the rural economy. For example, Liang (*8*) noted that in the land-constrained rural economy of China, cropping intensity showed a more elastic response to access change than land itself (extension of land under crops). This study is a good example of the use of simple but powerful econometric models to evaluate transportation impacts on the rural economy.

Despite such responses as that described by Liang (*8*) for China, rural roads frequently failed to generate increased agricultural production, but often showed significant traffic increases attributable to transport of nonagricultural commodities (e.g., fuel, firewood, and beverages) and rapid growth in personal mobility. Consequently, rural communities continued to clamor for access improvements, and planners and politicians continued to invest in them because of a widespread view that rural roads were a necessary precondition for programs to improve human welfare in rural areas. Thus, second-generation rural road programs were often undertaken in the context of integrated rural development projects, as part of a package of services that were designed to meet basic human needs and generate increased production for local consumption. Roads programs were often the most successfully executed components of such projects. It was the success of the road components of the Special Rural Development Program in Kenya, for example, that led the Government of Kenya to initiate its Rural Access Roads Program using a multicriteria approach to road selection (*9*). The multicriteria approach to rural road selection was devised as a way of approximating the results that would be obtained by a fully quantified analysis of both tangible and intangible costs and benefits. The ranking and weighting procedures involved in the application of multicriteria analysis incorporate value judgments that can be interpreted as proxies for a more precise measurement of willingness-to-pay for certain kinds of consequences. While such approaches can only approximate the measurement of the utility associated with a potential road improvement, they considerably expand the predictive value of evaluation models at a relatively low cost for additional data collection. These approaches also provide a useful mechanism for involving local groups in rural road decision making. Many governments and donors have adopted multicriteria approaches as the most efficient means for selecting rural road improvements. The World Bank accepts the use of a multicriteria approach to establish a list of candidate roads, but insists on a full economic analysis in support of the final selection (*10*).

Recently, however, the World Bank has shown renewed interest in the role of rural infrastructure, especially in relation to longer term agricultural development in Africa (*11*). The premise of this research is that transportation facilitates market integration through improving the flow of information as well as goods and services. Under favorable macroeconomic conditions, it is believed that public investments in rural transportation improvements can have a high payoff in stimulating economic growth. The initial results of this research indicate that these benefits are not realized when there is inadequate road maintenance (*12*).

In the early 1980s, evaluations of eight rural road projects were conducted, primarily intended to increase agricultural production (*13*). A comparative study of the results showed that new road construction had more of an effect on agricultural production than did road upgrading. The studies also showed that roads led to the proliferation of small shops and the expansion of rural markets. Roads improved access to health and education services but had relatively little impact on the expansion of such services. Interviews with beneficiaries indicated that rural people valued roads primarily for the access they provide to medical services, followed by travel to jobs, schools, recreational and social activities, and access to job opportunities. Increased agricultural incomes were less often perceived as a benefit.

In Kenya, for example, it was found that the incomes of female-headed households in areas served by rural access roads improvements increased more sharply than the incomes of male-headed households (*14*). This anomaly was attributable to a sharp increase in nonfarm income remitted by absent males whose access to nonfarm employment opportunities was facilitated by the new roads. Production of cash crops (produced by men) in the road-influenced areas actually decreased, while production and sales of food crops, livestock, poultry, and dairy products (mainly produced by women) increased, and on-farm consumption of food crops declined in favor of increased consumption of purchased food. Clearly, the main effect of the roads was to further incorporate rural households into the cash economy, largely by facilitating mostly male participation in the nonfarm sector.

A World Bank-financed survey of the impacts of rural road improvements in Bihar State, India, showed a shift over time toward employment in nonfarm occupations in the areas with improved roads, compared to control areas, which showed an increase in agricultural employment (*15*). Few people commuted to work outside the village, but those who did commuted over a longer distance (20 km or more) in areas with improved roads, while the commuting distance was limited to 10 to 14 km in control areas. Similarly, persons living and working away from home were likely to be living at a greater distance from the village when the village was served by an improved road.

The survey also showed that more than half of all household trips were made by marginal farmers, students, and landless laborers. Only 10 percent of the traffic on the improved roads was accounted for by motor vehicles (including tractors, scooters, and motorcycles), 60 percent by nonmotorized vehicles (oxcarts and bicycles), and 30 percent by pedestrian movements. However, the frequency of bus service doubled over 2 years on the improved roads, and the volume of passenger traffic quadrupled over the same period. Passenger travel was primarily related to social purposes, followed by work-related trips, marketing, and service utilization. Use of social (health and education) and administrative services showed a greater response to road improvements than use of economic services (banks, veterinary centers, and cooperatives).

A model of another important subsystem of the rural impact process was developed to measure the multiplier effects of agricultural development (*16*). The major contribution of this model to the understanding of the impact of rural roads on rural development is its emphasis on the relative importance of nonfarm income and activities in the incremental changes taking place in the rural economy. A second significant finding is that consumption, rather than production, linkages account for more than half of the agricultural multiplier effect on the rural economy. This result implies that other nonagricultural activities contribute a significant share (21 to 45 percent, depending on the country) of the total growth in economic activity in rural areas.

A better understanding of the importance of nonfarm activities in the rural economy would also highlight the role of rural centers, which are the location of much of the nonfarm activity (*16*). These rural centers serve two distinct functions: first, as collection and distribution centers for agricultural products and consumption goods, and second, as centers for nonfarm employment and concentrated markets for locally produced goods and services. Secondary roads, connecting rural centers to the national economy, and farm-to-market roads, connecting farms to rural centers, are critical to the effective functioning of these centers (*17*).

STUDIES OF SERVICE AVAILABILITY, MOBILITY, AND MIGRATION

A comparison of data from studies carried out in nine Indian states, under the sponsorship of the Indian Roads Congress, showed a linear relationship between road density and literacy rates (*18*). On the basis of a relatively small number of cases, road density was found to be closely related to postal services, while correlations with primary school and health center availability were weak, reflecting that such services are already more widespread in rural areas than are roads. These results were based on single-variable regression analyses using primarily cross-sectional data.

The SEATAC study (*19*) showed that government officials, especially ones close to the service-providing level, often capitalize on improved accessibility first by providing mobile services, such as agricultural extension, mobile health units, and postal services. In addition, greater accessibility tends to attract more highly qualified professionals, such as teachers and doctors, to formerly isolated areas, as well as to ensure more reliable supplies and supervision. These factors are likely to encourage greater service use, which in the long run may lead governments or communities to invest more in fixed facilities.

However, the response of government services is only a small fraction of the total response of the community to accessibility change. A more significant change noted in the SEATAC study was the increased presence of traders and businessmen in the formerly isolated communities. This increase coincided with the availability of more diverse and reliable goods in local markets, and more information about the outside world, including the prices of cash crops, market opportunities, new ways of doing things, new products to buy for both production and consumption uses, and travel and employment opportunities.

The SEATAC study also found a pattern of small scale migration into the study areas by commercial farmers, traders, and nonfarm entrepreneurs, and an increase in travel out of these areas by local residents, but no major rural-urban migration effects because of accessibility change. The report cited the lack of certain push factors in the study areas, such as high population density, which might lead to a greater migration response in other circumstances. Mobility was increased for rural inhabitants to locations outside the study areas for shopping, marketing, personal travel, and job seeking. Mobility also increased for individuals from other locations coming into the study areas.

Another way to evaluate the impacts of access change is to model its effects on the determinants of personal mobility in rural areas. Rahkonen et al. (*20*) studied personal mobility patterns in a rural area of Mexico in relation to household and community access measures. The study found that more than half of all rural travel was employment related, and was principally determined by household socioeconomic status rather than by community access characteristics. In contrast, general purpose travel was more closely related to access characteristics and consequent transport costs.

Throughout the area, farmers who had adequate land to feed their families and generate a marketable surplus felt less need to undertake work-related travel, whereas farmers with only marginal amounts of land found it necessary to work as wage laborers to make ends meet. The study showed the existence of a segmented labor market; workers in communities with poor road access were constrained to take low-paying local farm employment opportunities, while workers in communities with good road access had options to work within a much wider area, including nonfarm employment (mostly construction) opportunities in rural and urban centers. As a result of this less-constrained labor market, wages for farm labor were also higher in these communities.

The study also found that communities without road service had more agricultural activity and less involvement in wage labor than communities close to a road. Smaller average farm sizes and higher proportions of landless households were found in the areas with road access to local and regional labor markets. The survey data suggest that poorer households, as they are pushed off the land, tend to migrate toward communities with good road access to gain a broader range of employment opportunities.

The Mexico study attempted to use factor analysis to develop an inductive model of rural mobility from data on a large number of interrelated variables. Four factors, explaining 90 percent of the variance, could be characterized as (a) subsistence agriculture, (b) commercial agriculture, (c) land ownership, and (d) livestock activity. The addition of two more factors, wage labor and household life cycle, explained 100 percent of the variance. When household factor scores were calculated, the wage labor factor was the most important single determinant of work-related travel and the only factor positively associated with this behavior. However, the factor analysis approach tended to obscure the detailed relationships underlying personal mobility in the study area.

In the context of Colombia, Udall (*21*) also explored the relationship between farm income, accessibility, and urban-rural migration. He found it necessary to define accessibility in two ways: first, in terms of distance to urban centers, and second, in terms of the frequency of bus service.

$$\ln S - \ln M = \ln N \tag{2}$$

$$\begin{aligned}\ln M = {} & m_0 + m_1 \ln E + m_2 \ln A \\ & + m_3 \ln (A^2) + m_4 \ln \mathrm{DB} \\ & + m_5 \ln \mathrm{DB} + m_6 \ln \mathrm{DC} \\ & + m_7 \ln \mathrm{DR} + m_8 \ln B \\ & + m_9 \ln C + m_{10} \ln y \end{aligned} \tag{3}$$

$$\begin{aligned}\ln N = {} & b_0 + b_1 \ln Z + b_2 \ln E \\ & + b_3 \ln \mathrm{SH} + b_4 \ln F + b_5 \ln \mathrm{MC} \\ & + b_6 \ln \mathrm{LH} + b_7 \ln A + b_8 \ln T \\ & + b_9 \ln \mathrm{DB} + b_{10} \ln \mathrm{DC} \\ & + b_{11} \ln \mathrm{DR} + b_{12} \ln B \\ & + b_{13} \ln y \end{aligned} \tag{4}$$

where

S = labor supply,
M = migration rate,
N = number of family members in the countryside,
E = maximum level of education,
A = age distribution of household,
DB = distance from Bogota,
DC = distance from nearest small city,
DR = distance from nearest road,
B = bus service frequency,
IC = interaction of bus service and DC,
y = per capita family consumption (income proxy),
Z = cultivated land area,
SH = sex of head of household,
F = fertilizer use (dummy),
MC = machinery use (dummy),
LH = hired labor, and
T = tenancy (dummy).

This cross-sectional study showed that, contrary to the conventional wisdom, migration rates increased with distance from cities, but that the strength of this relationship declined with increasing frequency of bus service. That is, for people in remote areas, the value of access to urban job opportunities and amenities overrides the migration cost constraint, but that where frequent bus service is available, adequate access to these opportunities and amenities may be achieved at a lower cost than by migrating.

This study confirms findings in the SEATAC study and elsewhere that long-term migration is more likely to take place where transport options are limited, whereas improvement in rural transport services tends to encourage travel or short-term migration rather than a permanent change of residence.

STUDIES OF TRANSPORT AND COMMUNICATIONS EFFECTS

Since the 1960s, research has been carried out on the relationship between transport and telecommunications (*4*). A certain degree of substitutability between these means of communication has been noted for information flows such as health, education, and economic news. However, the stronger relationship found has been one of complementarity. For example, Owen (*4*) noted a greater number of radios present in areas of better road accessibility and, on the other hand, greater road travel to and from towns with more radios. It has also been found (*20*) that rural people would travel up to 30 km to use rural public telephones, and that telephone contacts frequently resulted in additional personal travel, especially as telephone contacts were used to pass on critical information about family emergencies and job opportunities. Improved information flow reduced the uncertainty involved and therefore enhanced rural people's willingness to take trips in cases where there could be no substitute for physical transport (e.g., laborers traveling to distant job sites).

The SEATAC study systematically traced the changes in information flow that followed transport improvements and their economic consequences for rural areas. For example, pepper planting spread rapidly in Sarawak because of increased knowledge of pepper planting technology, prices, and markets that flowed along the routes of increased transport accessibility. Expanded information flow also had social, political, and cultural implications, leading to more active participation by rural people in the decisions that affect their lives and an increased awareness of options other than traditional behavior. Learning about the opportunities offered in the wider world provided an additional incentive for more personal travel. The feedback effects of improved information flow, with resulting economic and social development multipliers, may prove far more significant in the long run than the direct economic effects of transport improvements.

Organizational changes have also been noted as a response to transport improvements, such as the development of farmers' cooperatives in India (*4*). These organizational changes may reflect new information about the advantages of cooperative organization, or the application of a known organizational technology to capture a share of the profits generated by reduced transport costs. The increase in traders visiting rural areas with improved accessibility assures more competition and changes the economic structure in ways that should lead to more economic efficiency in trade and lower prices for the rural residents as well as for the traders. Other changes in social organization will occur in the longer term for these communities, but it is difficult to separate the organizational response to transport changes from changes that are because of more general increases in the wealth and welfare of the community.

Organizational changes can also occur on a regional or national scale. Such changes are often described in terms of market integration or nation-building. These are system-wide effects that result, in part, from changes in the transport system to increase accessibility. Such changes are considered desirable by national level planners because of the development feedback effects they imply. However, there are few research findings to support a quantitative estimate of these benefits, which are difficult to measure (*11,22*).

ACCESSIBILITY MODELING AND IMPACT

The SEATAC study formulated and tested a model of rural transportation impacts of different types of transportation improvements on income distribution and quality of life in rural areas of four Southeast Asian countries, within a common conceptual framework. The major contributions of the SEATAC study were

1. To explicitly formulate a model of the impacts of rural transportation improvements,
2. To relate the impacts of rural transportation improvements to accessibility change measures,
3. To trace the impacts of the flow of information as well as of material goods and people, and
4. To explicitly identify the roles of intervening variables in conditioning impact outcomes.

Five types of accessibility were identified and defined by the authors in the SEATAC study as follows:

1. Market access is the inverse of travel time from the principal market serving the village (farm) to the principal (regional) center outside the study area.
2. Village access is the inverse of travel time from the village (farm) to the principal market.
3. Trip access is defined as a combination of market access and village access, weighted by the average of short- and long-distance trips in the total (trip) sample.
4. Service access is defined in terms of the frequency of visits to a village (farm) by extension services, health services, and traveling traders.
5. Household access is the combination of trip access (access out) and service access (access in).

Clearly these definitions focus on the farm household unit and were not designed to refer to an industrial unit handling bulk commodities. Different accessibility measures, such as cost or generalized cost, may be more appropriate for industrial shippers of bulk commodities that are not time sensitive.

Changes in the rural economy were found to be related to changes in accessibility in different ways, depending on the type of accessibility that had changed. For example, a transport improvement that significantly reduced travel times between a rural center and the primary network was likely to result in increased availability of goods and services in the rural center, while a decrease in travel time between villages and rural towns was more likely to induce additional travel by village residents.

Accessibility can be defined in cost terms as well as time. Liang's (*8*) work in China defined accessibility as the inverse of total transfer cost (transport plus handling), relating to road, rail, and river transport. Clearly, transport cost change must be part of the impact model, but it does not have to be defined as accessibility.

The recent attempts to model the effects of road availability on the provision of services have not been successful (*23*). One reason for this lack of success may be the specification of the independent variable in terms of road density rather than in terms of accessibility change. There is no obvious link between road density and the reasons why officials would choose to locate service facilities in particular places. However, it could be hypothesized that access change could trigger a response by government officials to take advantage of newly created opportunities. This is one example where substitution of a cross-sectional analysis for a longitudinal analysis without a theoretical model has weakened the explanatory power of regression results.

A further problem with these studies is that government response to transportation change depends on a number of variables, not all of which are directly related to accessibility. Decisions to invest in schools, post offices, and other services are made by civil servants who must consider a number of factors, including pressure from citizen groups and influential inhabitants of the area, as well as the availability of central and local funding. These noneconomic factors can create sufficient noise to prevent a simple bivariate regression model from producing statistically significant results.

Some of the studies of rural transportation impact (*23*) refer to increased accessibility as if it were a positive impact by itself. This approach is taken from traditional urban transport analysis where accessibility is used as a proxy for other expected effects in a type of multicriteria approach to transport planning. Although increased accessibility does have some intrinsic value to rural residents (which can be thought of in terms of the option value associated with personal travel or emergency transportation), it is not very useful as an impact measure unless it can be linked to changes in activities that can be more directly related to improved rural welfare.

Accessibility modelers should also take into account that the impacts of transport improvements can have both negative and positive effects on different groups in the population. For example, the SEATAC study found that rural transport improvements in Sarawak gave local fishermen in some locations new access to the Singapore market (*19*). This increased the amount of fish harvested and increased incomes for fishermen. However, it also increased the prices of local fish and made fish harder to obtain for the local population. Consequently, some households gained and some lost in terms of the net change in standard of living for the rural population. These distributional effects create additional problems for the measurement of costs and benefits associated with a change in transport accessibility.

FORMULATION OF AN IMPACT MODEL

The impacts of rural transportation improvements can be seen as a result of the interaction of many factors as shown in Figures 1–3. These figures incorporate the relationships suggested by the research previously described, and illustrate the sequences of effects that are not presently shown by the simpler impact models used in recent quantitative research. Figure 1 deals with short- and medium-term impacts related to changes in goods transportation that occur within 1 to 5 years of the change in access. Figure 2 shows the short- and medium-term changes related to personal travel, and Figure 3 traces longer-term indirect impacts resulting from the medium-term changes.

The objective of these flow charts is to describe the causal linkages that are involved in each step of the impact process to assist researchers in the specification of causal models. The mediating variables that condition the magnitude of the impacts in each category are included.

Short- and Medium-Term Goods Impacts

Four changes directly due to rural transport improvements are shown as the starting point for goods-related impacts in Figure 1: (a) change in transport conditions, (b) change in transport costs, (c) change in regional accessibility, and (d) change in village accessibility. Changes in transport conditions

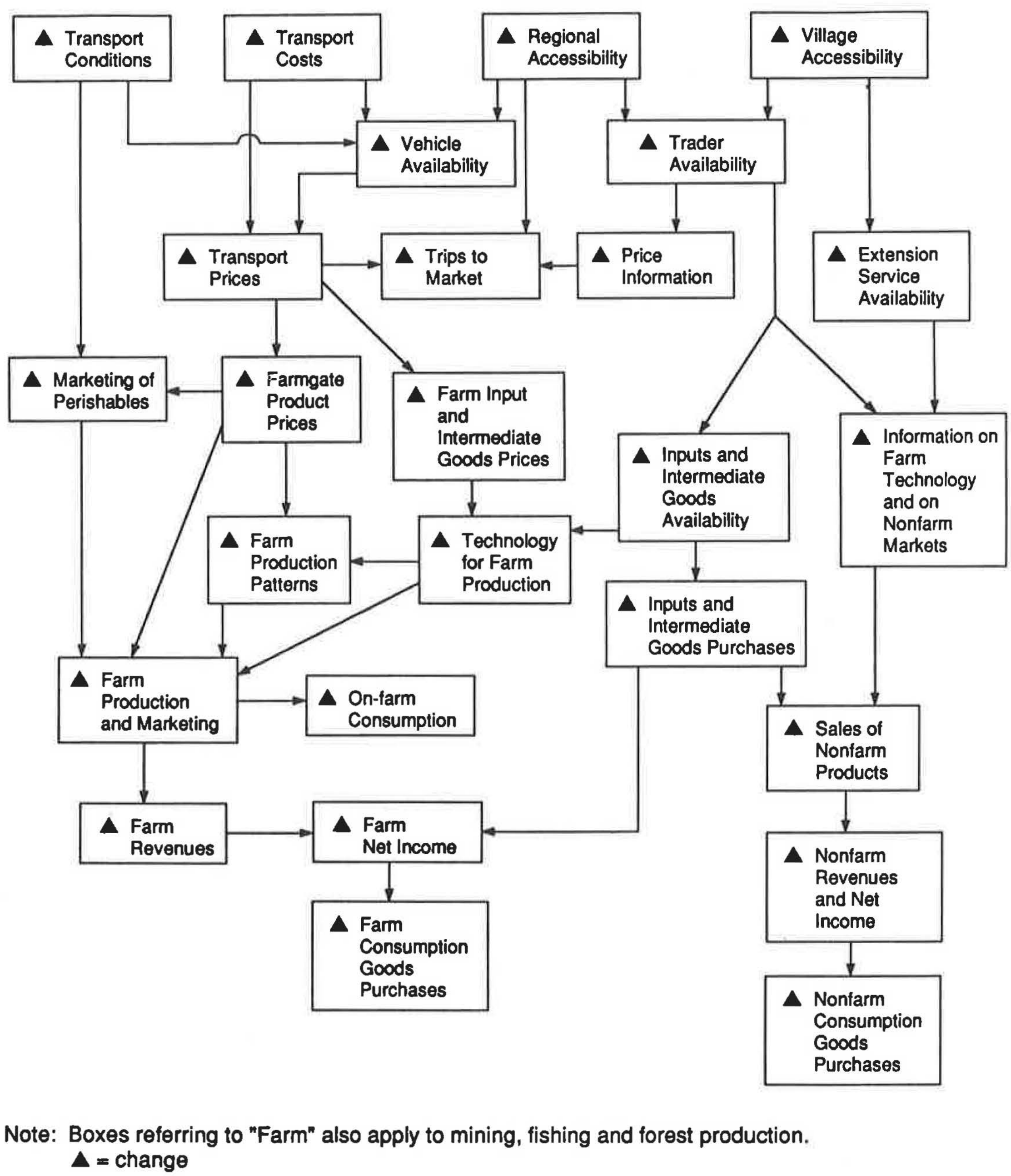

FIGURE 1 **Short- to medium-term goods impacts.**

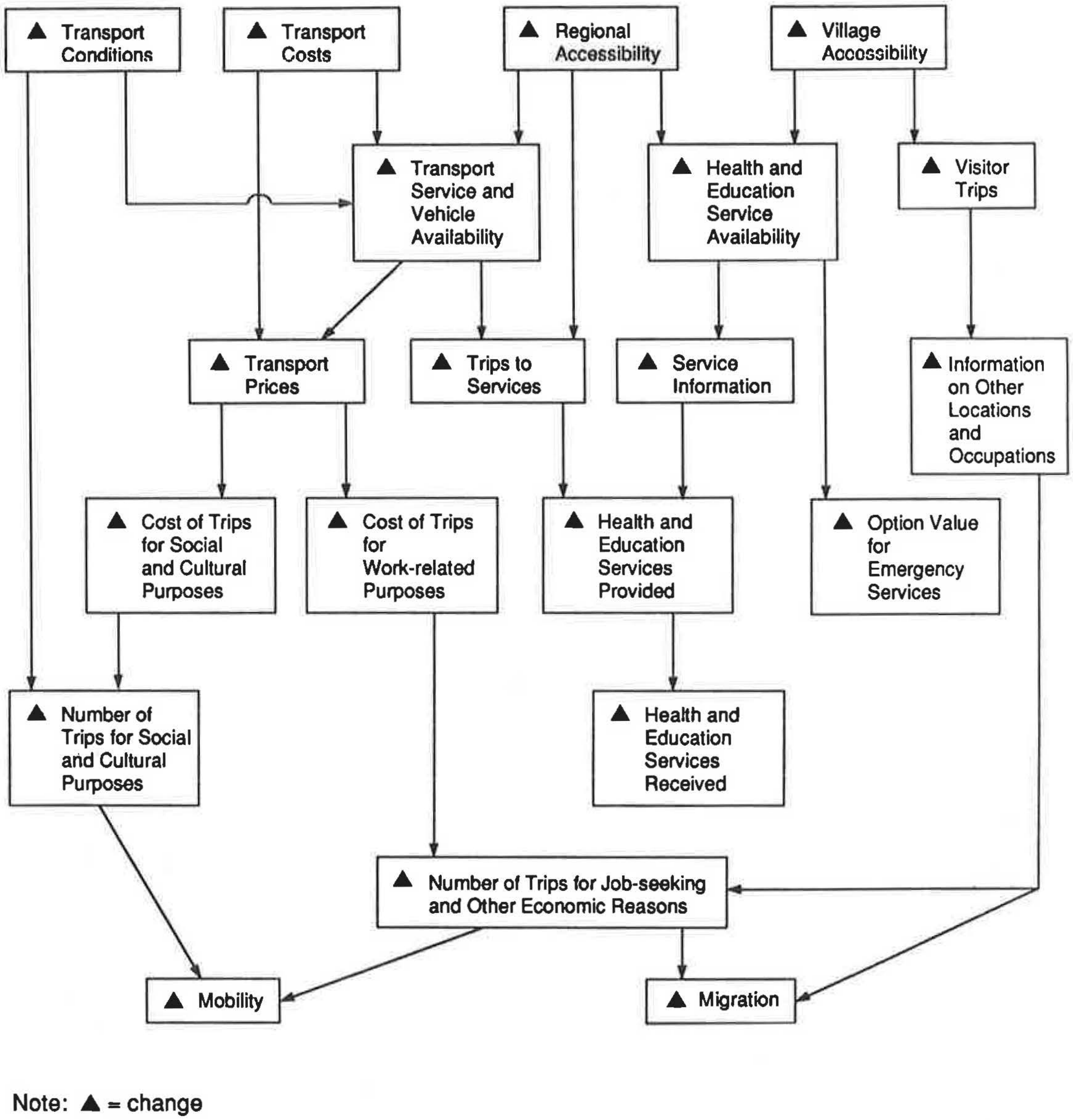

FIGURE 2 Short- to medium-term mobility impacts.

include such effects as the reduced roughness of a paved road compared to a gravel road. This type of change, combined with the time savings of transport on a paved surface, can lead to a decrease in damage and spoilage of goods and have a strong impact on the transport and marketing of perishable commodities such as meat, fish, milk and dairy products, eggs, fruits, and vegetables. These changes have a less-marked effect on the transport of nonperishable bulk commodities such as grains, tubers, bottled beverages, cement, fertilizer, petroleum products, and building materials.

A decrease in transport cost is the most commonly used variable for evaluating the economic impact of rural transport improvements. This decrease reflects cost savings accruing to transporters from decreased wear and tear on their vehicles and decreased use of transporters' travel time. Part of this cost saving, under competitive conditions, is passed through to shippers in the form of lower transport prices. Lower transport costs may also encourage an increase in the number of transport service providers (and vehicles available in rural centers), leading to more competitive conditions, which in turn affect the prices charged for these services.

The decrease in prices charged by transporters leads to higher farmgate product prices and lower-cost farm inputs, which in turn lead to greater farm production. These relationships form the basis for the classical rural transport impact model.

A similar line of reasoning applies to the effects of transport cost changes on other primary economic activities such as small-scale mining, fishing, gathering of forest products, and craft production from local raw materials, which are not shown explicitly in the flow chart, but are likely to occur in both agricultural and nonagricultural zones influenced by the transport improvement. The impacts of transport changes on these

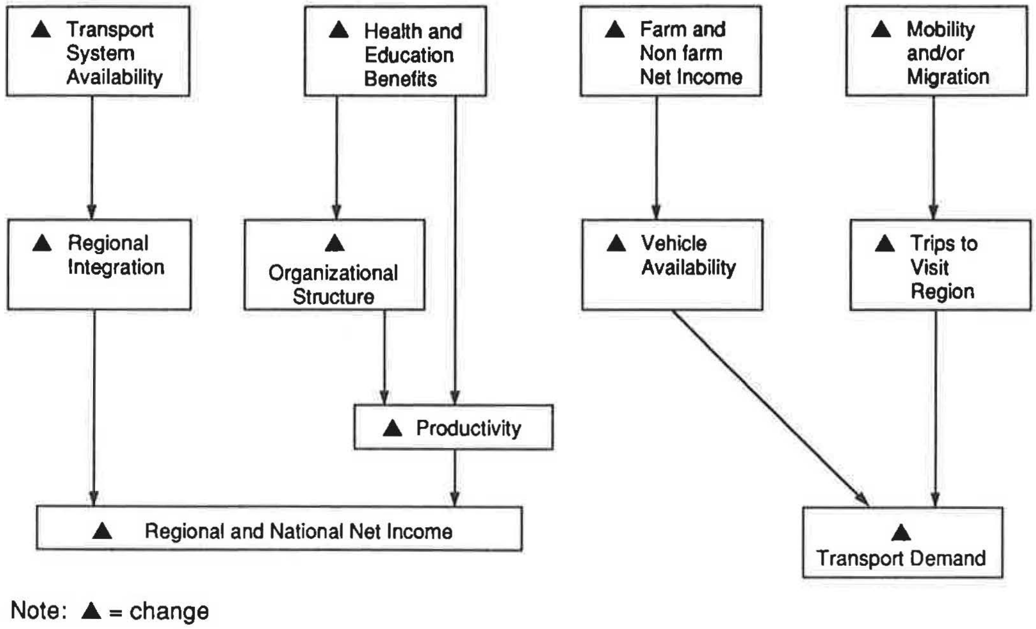

FIGURE 3 Long-term impacts.

activities can be treated in the same way as agricultural change, by assessing the effects on the production and marketing of these products.

The induced changes in production patterns may decrease the output of some goods (e.g., subsistence crops) to increase the production of others (e.g., cash crops) as shown in Figure 1. This will affect the pattern of on-farm consumption as well as cash income for the farm household. In principle, the net welfare of the household should be increased as a result of this change. In practice, however, the effect may be to increase the welfare of the household member who controls the cash flow, at the expense of other household members. Also, there are different effects on those households that are in a position to take advantage of the opportunities (e.g., progressive farmers or those with capital to invest), which leads to differences in the effects of these changes among household groups.

A change in regional accessibility (defined as a reduction in the travel time between the market center within the production zone under study and the outside world—either a regional center or a junction on the primary transport network) is closely related to changes in the availability of outside goods and traders in the market center and the availability of transport services and vehicles from outside to the market center. The expanded availability of outside goods brought in by the traders and the increased market prices in a market center with a transport improvement lead to an increased number of trips from farm to market (both local and outside) and an increase in the consumption of inputs and intermediate goods and services from outside the rural area. Eventually, increased access also leads to the establishment of more social and economic support facilities in the market town, such as schools, health services, credit facilities, equipment suppliers, and equipment repair. These market towns may evolve in the direction of becoming rural centers, providing nonfarm employment opportunities in response to the demand generated by increased farm income.

A change in village accessibility (defined here as a reduction in travel time from villages to a market center, or accessibility within the zone of study) is also related to a greater availability of traders who are attracted by a higher number of products in the market. The presence of more traders leads to better price information and access to better prices for marketed rural products, inputs or intermediate goods, and consumption goods. Improved village accessibility also leads to the increased presence of mobile service providers in the village, such as agricultural extension workers, who bring information to the village concerning prices, markets, and production technology. This communications linkage facilitates the diversification of local production and increases local demand for farm inputs and nonfarm products. Increased sales of nonfarm products lead to increased revenues and net income for nonfarm businesses, and a resulting increase in nonfarm consumption goods purchases (*16*).

Short- and Medium-Term Mobility Impacts

In addition to the effects on local production and consumption of goods described in Figure 1, there are several personal mobility impacts related to the four types of transport changes, as shown in Figure 2. The change in transport conditions, which affects the comfort and convenience of travel as well as time savings and a greater availability of vehicles or transport services in the study zone, leads to a greater number of trips made by local residents. These trips may be made for economic reasons (marketing, credit, employment) or for social and cultural purposes (visiting family, trips to outside services, dealing with administrative matters) or both.

Changes in transport costs usually influence prices charged for transport services (bus and taxi services), and also affect the cost of owning and operating a means of personal travel (motorcycle or bicycle). As with goods transport, better transport conditions, lower transport costs, and increased regional accessibility lead to a greater availability of passenger vehicles and transport services, and this greater availability increases competitive conditions that in turn lead to more cost savings passed through to travelers. The resulting lower cost for trips leads to a greater number of trips for social and cultural purposes and a higher personal mobility as shown in Figure 2.

Changes in village and regional accessibility both play a part in inducing change in rural travel patterns. To the extent that changes in accessibility result in increasing availability of health and educational services in the rural centers, they are more likely to induce village-to-rural center travel than rural center-to-outside center travel. However, an increased flow of information regarding goods, services, and activities available in outside centers (partly as a result of increased trips from outside visitors), coupled with improved regional accessibility, may induce a certain amount of additional travel to outside centers, even in the absence of improved village accessibility. Similarly, village access improvements will have only a limited effect on longer distance travel if access of markets to outside centers is not adequate. However, the combination of improved village accessibility and improved market accessibility can have powerful effects on rural mobility and consequent changes in the rural economy, and somewhat lesser effects on rural migration.

Rural people make trips for a variety of reasons and often combine several purposes in one trip. However, for the purposes of modeling, it is convenient to divide rural travel into two categories: work-related and other. Work-related trips include trips to buy farm inputs and sell farm products, trips seeking credit and other economic services, job seeking trips, and trips for off-farm employment (both farm and nonfarm). Other trips include trips to utilize health, education, or administrative services, trips to visit or accompany family members or friends, and trips to participate in group activities of social or cultural significance. All of these trips generate welfare for the traveler and others (otherwise they would not be taken), even though it is difficult to quantify or attribute a value to these positive effects.

Rural road studies using currently accepted approaches have consistently underestimated the magnitude of the personal mobility-related response to road improvements. This response seems to occur even when there is no significant increase in local incomes, which could account for the increased consumption of personal travel. The failure of current models to predict mobility impacts is primarily because these models fail to recognize the value of time to rural households, including the values they attach to time spent in activities other than economic production and consumption. Significant time savings, even when combined with increased financial outlay (as when one shifts from walking to using a bus service), appear to induce major changes in travel behavior on the part of rural people.

Models of personal mobility are commonly applied in urban transportation analyses, but may need to be reformulated for application to the rural context. Many of these models are data-demanding and therefore difficult to apply in a rural setting. However, one model that appears promising for this type of application is the unconstrained gravity model (sometimes referred to as the direct demand function) described by Quandt (*24*). This model forecasts trip generation as a function of accessibility and socioeconomic characteristics of the origin and destination areas, reducing the constants for which the model must be calibrated in a given case to a small number. As far as is known, this model has never been applied in a study of farm-level rural transport in developing countries. This lack is probably for good reason, because the Mexico mobility study shows that work-related trips, which are the majority of trips, are not a simple function of accessibility measures. Other trip types, however, are closely related to accessibility.

Long-Term Impacts

Building on the short- and medium-term impacts described herein are a number of longer-term impacts that may take 10 years or more to appear. Some of these impacts are shown in Figure 3, which starts from the income, service utilization, and mobility impact outcomes already shown in Figures 1 and 2. Effects, such as regional integration, greater productivity, and greater income because of feedback or multiplier effects in the economy, are more diffused than the short-term impacts.

These impacts are hard to measure in the normal time frame of rural impact studies. Because of their longer time frame, such impacts are also more difficult to separate statistically from the impacts of nontransport activities or changes. An attempt to deal with the long-term impacts of infrastructure on regional integration is provided elsewhere (*22*). However, this study does not distinguish between the effects of transportation and other types of economic infrastructure, and it estimates impacts at a higher level of aggregation than the models presented herein.

ROLE OF MEDIATING VARIABLES

Mediating variables, including situational factors and socioeconomic structures, are characteristics of the rural setting that act as constraints on the magnitude of the response of different rural areas to accessibility change. An outline of the mediating variables follows (*19*):

- A. Situational Factors
  - 1. Physical Characteristics
    - a. Terrain
    - b. Soils and geomorphology
    - c. Hydrology
    - d. Climate and rainfall
    - e. Vegetation
  - 2. Population Characteristics
    - a. Size and growth rates
    - b. Density
    - c. Age/sex structures
    - d. Socioeconomic groups
    - e. Ethnicity
    - f. Religion
    - g. Nationality

B. Socioeconomic Structures
  1. Economic Structure
    a. Land tenure
    b. Land use
    c. Investment in rural industries
    d. Patterns of employment
    e. Structure of transport service sector
    f. Pricing/marketing/storage systems
    g. Credit systems
    h. Tax policies and effects
  2. Social Structures
    a. Settlement patterns
    b. Patterns of association
    c. Formal organizations
    d. Educational levels
    e. Health levels
    f. Social control mechanisms
    g. Information levels
    h. Participation in planning

For example, land tenure may limit the potential change in production patterns, and therefore limit the agricultural production response. Similarly, cultural conventions could limit the amount of personal travel possibly generated by access change for certain population groups. The structure of the transportation service sector may limit the proportion of the transport cost savings that is passed on to the users, thereby limiting the users' potential response to the change. Such mediating variables are important for predicting the differences in responses between different rural areas, and the key constraints must be included in formulating a model to have adequate explanatory power from a statistical viewpoint.

RECOMMENDED MODELS FOR FUTURE RESEARCH

In order to gain accuracy and explanatory power, the types of impact models that should be used in future research in rural areas must have the following characteristics:

- Ability to accept the most appropriate measures of accessibility for the impacts considered,
- Ability to incorporate significant mediating variables or constraints, and
- Statistical reliability in the coefficients or elasticities estimated by the model, as well as correct signs.

Because of the variety of rural transport impacts described herein, it is clear that no single model is adequate to predict them all. Consequently, a combination of models may be the best approach with (a) primary production impacts forecast using a two stage Cobb-Douglas model and submodels of elasticity with respect to accessibility for each major activity (*8*), (b) local manufacturing and consumption forecast with a multiplier model (*16*), (c) personal mobility predicted for work-related trips by using an employment predicting model [possibly based on the farm and nonfarm activity models in (a) and (b)] and for non-work-related trips by using an unconstrained gravity model (*24*) with different accessibility measures for different trip types or distances, and (d) migration forecast by using simultaneous equations on the basis of labor supply and demand (*21*).

In the case of services, including education, health, agricultural extension, and communications, it appears that currently used regression models may have less predictive power than a model based on the actual formal and informal agency rules of service provision relative to accessibility, combined with a model of accessibility change. This combination of models would be much more powerful in explaining the rather complex relationships diagrammed than simpler regression models that attempt to combine a variety of effects.

In many cases, some basic research may be needed to determine model characteristics (such as the Haggblade multipliers), which can then be used by other researchers and planners in broader applications to specific planning areas. Simpler models may also be used in cases where the data are more suited to their use. These choices must be evaluated by the researchers in each specific case.

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Relationships Between Social and Economic Development and Access to Rural Roads in Developing Countries

ALI MAZLUMOLHOSSEINI

The relationship between the level of socioeconomic development and the level of transportation activity in rural areas is examined for developing countries. Because access to roads is the most essential element of a transportation system, the degree of accessibility of rural areas is considered a good indicator of the level of development of the transportation system. Degrees of access to rural roads could be determined according to two simple criteria—proximity of the village to the nearest vehicle road and its distance to the nearest town. Villages with identical degrees of accessibility could be arranged in a group, forming access areas, regardless of the geographical location of the component villages. Four access area categories may be created by the proper choice of distance intervals in the application of accessibility criteria. In the order of increasing accessibility, these four access areas may be described as hardly accessible, poorly accessible, fairly accessible, and easily accessible. Each access area would be assigned an access value proportional to some measurable transportation activity (e.g., the number of daily trips per household in that area). The concepts and data used were developed by surveying households in the Philippines in 1983. The survey included 1,002 households with a total of 5,228 individuals living in 25 different villages in five different municipalities of Cebu Island. Study variables obtained from survey responses were then divided into three groups: (a) major components of socioeconomic development including social security, education, income, home comfort, and housing standard; (b) those variables that determined the transportation pattern and ownership of the means of transport; and (c) those variables that described the agricultural situation. Analysis of the study variables as functions of access value revealed that the major elements of socioeconomic development varied sharply with a change in access value and were strongly associated with it. The analysis also found that both the income from the sale of cash crops and the efficiency of agricultural production increased considerably as access value increased. This relationship would indicate that transportation investments may succeed in generating development in other sectors. However, the degree of success would depend on how efficiently the investment is coordinated with other measures to ensure use of the improved transportation facilities by local inhabitants.

Developing countries are typically characterized by the sharp contrast between the relative concentration of wealth and economic power in urban areas and widespread poverty in rural communities. This phenomenon results in marked differences in all economic activities, and in particular, sharp differences may be observed in the transportation patterns of urban and rural areas.

Although cars and buses constitute significant travel modes in urban areas, the travel modes in rural areas are limited to foot, animals, animal-driven carts, bicycles, and locally adapted motorized vehicles, mostly of paratransit type, which vary in number depending on proximity of the area to all-weather roads. Furthermore, a distinctive feature of transportation in rural areas is that person-trips seldom can be differentiated from the transport of goods.

In most developing countries the majority of villages lack access to all-weather roads. Even for areas connected to the main road network by some secondary rural roads, the transportation system may function poorly because of the lack of appropriate vehicles, spare parts, vehicle repair shops, and road maintenance.

TRANSPORTATION INVESTMENTS

Given the fact that the existing state of transportation in rural areas of developing countries suffers from severe deficiencies, it might be easy to assume that in the past transportation might have been neglected by international and national development agencies. However, an examination of past records shows that this assumption is far from true. Figure 1 shows that since the end of World War II, transportation investments have occupied a prominent place in the investment policies of international aid organizations in developing countries. Nearly one-fourth of the loans made by the International Bank for Reconstruction and Development (IBRD) and one-fifth of the credits granted by the International Development Agency (IDA) have been specifically devoted to the transportation sector, with highways accounting for 45.6 and 52 percent of IBRD and IDA transportation investments, respectively.

Further evidence of the importance attached to transportation not only by international aid agencies but also by the developing countries themselves is shown in Figure 2. This figure shows that the investment priorities of developing countries in various public sectors may vary widely from country to country. However, the funds devoted to transportation constitute a considerable portion of the total public sector investments for all the countries involved. Thus, there has

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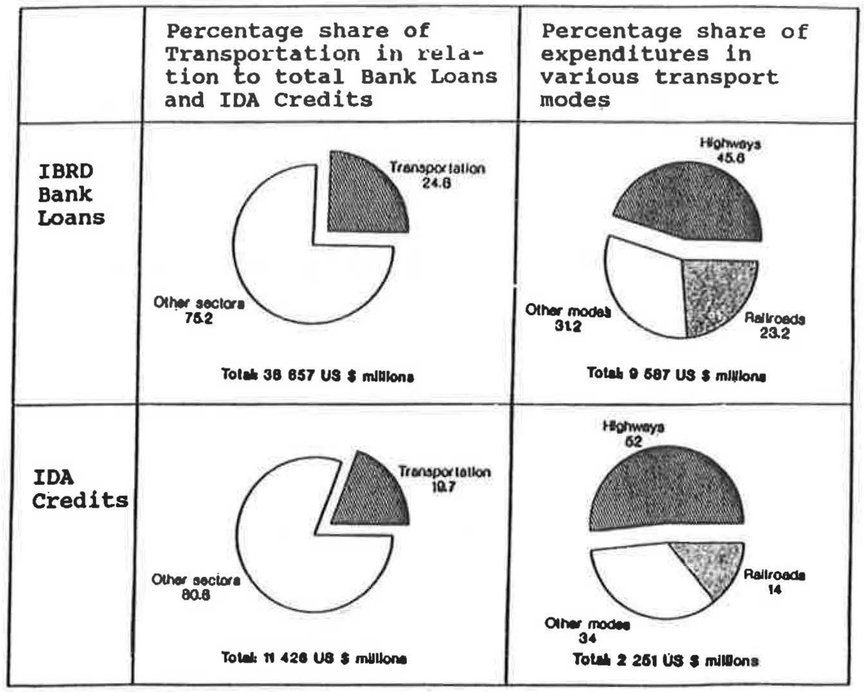
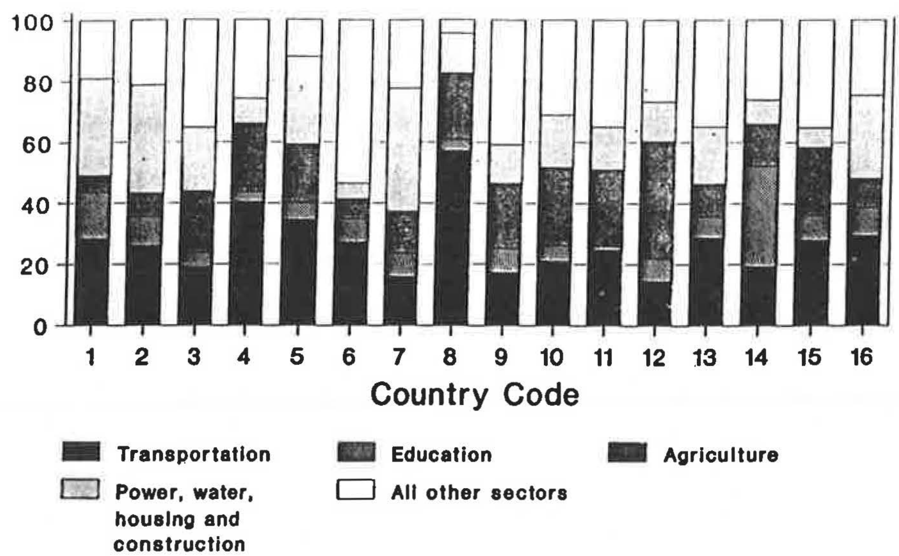


FIGURE 1 IBRD and IDA cumulative lending operations in developing countries to June 1977.



Countries and Corresponding Investment Periods:

1. Barbados	1973-1977	2.	Botswana	1973-1978	3.	India	1974-1978
4. Kenya	1974-1978	5.	Malawi	1971-1980	6.	Nigeria	1975-1980
7. Pakistan	1970-1975	8.	Philippines	1971-1974	9.	Senegal	1973-1977
10. Sierra Leone	1973-1978	11.	Sri Lanka	1972-1976	12.	Sudan	1970-1975
13. Tanzania	1969-1974	14.	Thailand	1972-1976	15.	Uganda	1971-1975
16. Zambia	1972-1976						

FIGURE 2 Allocation of investment funds by developing countries to major public sectors.

been a general awareness of the importance of improving the transportation system in developing countries (*1*).

Most of the earlier investments in road construction were concentrated on major roads. However, there has been a gradual change in policy toward favoring minor rural roads (*2,3*). With this trend have appeared numerous research papers dealing with the economic aspects of rural road projects (*4,5*) as well as the planning aspects of transportation investments that consider the needs and problems of small farmers (*6*). Despite the extensive efforts and investments in the transportation sector during the past decades, transportation in rural areas of developing countries is still in very poor shape for a variety of reasons: (a) road length per capita in developing countries is still far below the corresponding value for developed countries (*7*); (b) earlier investments after the end of World War II were mostly devoted to the construction of highways and major roads; and (c) past investments may have disregarded the actual on-farm transport needs of the poorer inhabitants in rural communities (*8,9*). Whatever the underlying reasons for the state of transportation may be, much remains to be done to understand the nature of the problems facing future investments in rural areas of developing countries.

ALTERNATIVE METHODS OF STUDY

The impact of transportation on social and economic development may be examined by either of two classical methods. In the first method, the changes brought about in the social and economic conditions of a certain region in a developing country are observed subsequent to the successful completion of a transportation investment. In the second method, areas characterized by sharp differences regarding the level of development of the transportation system within a given developing country are chosen, in which the existing social and economic conditions are observed and compared with each other.

Each of these methods has its particular advantages and disadvantages. The first method is a direct approach to the problem. Because this method measures changes observed in the value of socioeconomic variables as a function of time, achieving reliable results requires that the initial state be thoroughly defined, that is to say, the starting values of socioeconomic variables must be known in advance before a transportation investment is implemented. This information would distinguish the influence of the transportation project from the impacts of other factors affecting the community simultaneously. Furthermore, the study should span a sufficiently long period of time after the completion of the transportation project to assess the overall effect of the project.

The second method is an indirect approach to the problem. Establishing a correlation between the level of development of the transportation system and the socioeconomic conditions would only determine the degree of association between transportation and socioeconomic development. Whether a planned transportation investment in a remote rural area of a developing country would generate development in other socioeconomic sectors would not have a unique answer. The outcome would depend on how efficiently the transportation investment was coordinated with other measures that would ensure reasonable use of the improved transportation facilities by local inhabitants.

PRESENT APPROACH

The present approach is based on the second method discussed previously and uses data from a survey carried out in the Philippines in 1983 based on interviews at the household level. The survey comprised 1,002 households with a total of 5,228 individuals living in 25 different villages in 5 different municipalities of Cebu Island. Figure 3 shows the location of Cebu Island in the Philippines as well as the study areas on the island. Households in each village were chosen at random whereas the villages were selected to provide a wide range of

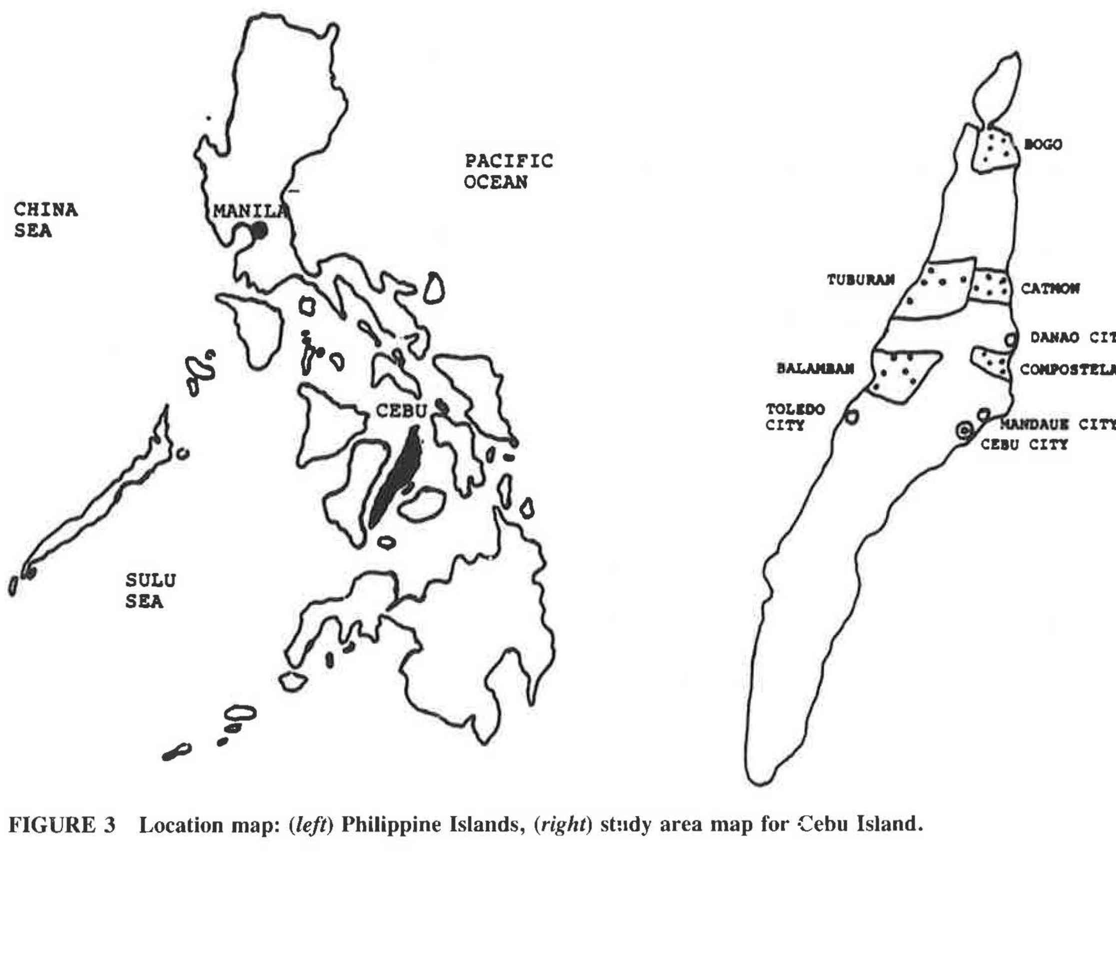


FIGURE 3 Location map: (*left*) Philippine Islands, (*right*) study area map for Cebu Island.

rural areas with varying degrees of access to rural roads. The households interviewed comprised about 10 percent of all households in the chosen villages and about 3 percent of all households in the actual municipalities. Questionnaires were designed to gather information from each household concerning family size, age, education, profession, income, home comfort facilities, housing standard, ownership of means of transport, travel pattern, and trade and agricultural activities.

Because access to roads is the most essential element of a transportation system, the degree of accessibility of each village may be considered as a good measure of the level of development of the transportation system in that village. Therefore, an interval accessibility scale was constructed and the major components of socioeconomic development from the survey (social security, education, income, home comfort, housing standard, and other important study variables related to transportation and agriculture) were studied as functions of accessibility.

The development of new concepts while analyzing the data led to the notion of a socioeconomic development (SED) map for developing countries consisting of an ordinary map of a given country on which individual villages are differentiated by their levels of social and economic development. The concept of SED maps actually evolved from the following question: knowing that social and economic conditions may vary considerably between rural and urban areas of a developing country, would it be possible to identify different levels of socioeconomic development between the villages in rural areas alone? SED maps would be meaningful only if the answer to this question turns out to be positive. Thus, a further objective of this study was to develop a methodology for the determination of the SED map for a developing country.

DEVELOPMENT OF ACCESSIBILITY CONCEPTS

Access Value and Access Area

The degree of access to rural roads for each of the 25 villages was determined according to two simple criteria—the proximity of the village to the nearest vehicle road and its distance to the nearest town. The criteria actually used are presented in Table 1. The notion of far from the road in Table 1 implies approximately more than 3 km from the road. The last column in this table denoted by access value defines the degree of accessibility and is an ordinal accessibility scale consisting of the values 1, 2, 3, and 4. Thus, villages may fall into either one of the four categories with regard to their degree of accessibility. Villages with the same access value may be thought of as being arranged in a group, forming a certain access area, regardless of the geographic position of the component villages. Four access area categories were defined in which the order of increasing accessibility was described as hardly accessible, poorly accessible, fairly accessible, and easily accessible with access values of 1, 2, 3, and 4, respectively. The names of villages studied and corresponding access values and population structure in various access areas are presented in Tables 2 and 3.

Association with Travel Intensity

The relationship between the average number of daily trips per household and access value is shown in Figure 4. The nearly perfect correlation between travel intensity and access value is important because it implies that accessibility in rural areas of a developing country may be directly measured by travel intensity and that the ordinal accessibility scale constructed could actually be considered as an interval scale, which means that it would be mathematically correct to trace the study variables as continuous functions of access value. Furthermore, access value would be exchangeable with travel intensity and the degree of access to rural roads would be measurable by the extent of transportation activity in rural areas.

In all the diagrams that appear in the following discussion, the study variable is always shown on the vertical axis.

MAJOR COMPONENTS OF SOCIOECONOMIC DEVELOPMENT

Social Security

Job and employment opportunities as a function of access value are shown in Figure 5 in which the major single income sources are differentiated. Excluding the zero-income group from calculations, the major income sources of dual type appear in Figure 6. An examination of Figures 5 and 6 reveals that social security expressed in terms of job and employment security is an increasing function of access value. First, this expression may be verified in Figure 5 by observing that the share of the zero-income group (a group with an uncertain income source and insecure job status) decreases rapidly with increasing access values and that the proportion of employees (a group with a secure and steady income source) rises sharply

TABLE 1 CRITERIA FOR ASSIGNING ACCESS VALUES TO VILLAGES

FIRST CRITERION	SECOND CRITERION	
Distance to the nearest town	Location with regard to the nearest motor vehicle road	Access Value
More than 10 Kilometres	Far from the road	1
5-10 Kilometres	Far from the road	2
0-5 Kilometres	Far from the road	3
More than 5 Kilometres	Nearby the road	3
0-5 Kilometres	Nearby the road	4
Zero distance	(the major town itself)	4

TABLE 2 NAMES OF VILLAGES AND CORRESPONDING ACCESS VALUES AND NUMBER OF HOUSEHOLDS

Name of Municipality	Name of Village	Access Value	Number of Households	Total Number of Households		
			Interviewed	(1)	(2)	(3)
Balamban	Balamba Nangka Buanoy Lamisa Biasong Duangan	4 4 3 1 2 1	18 41 58 24 22 37	200	2763	8187
Tuburan	Tuburan Mangga Putat Taminjao Montealegre	4 4 3 3 2	24 24 23 56 73	200	2455	8629
Bogo	Bogo Dakit La Paz Gairan Odlot	4 4 3 3 2	38 30 34 52 48	202	3065	8305
Catmon	Catmon Catmanda-an Duyan Cabunga-an Agsowao	4 4 3 2 1	38 53 22 29 58	200	1491	3421
Compostela	Compostela Estaca Cambayog Dapdap	4 4 3 2	42 56 67 35	200	1193	3333
Total No of Households in All Five Municipalities				1002	10976	31875

(1) Households included in the survey
(2) All households in the chosen villages
(3) All households in the municipality

TABLE 3 POPULATION STRUCTURE STUDIED IN VARIOUS ACCESS AREAS

Access Areas	Households Interviewed No	%	Inhabitants Interviewed No	%	Average Family Size	Men %	Women %	Children age below 15 years %
1	192	19.2	991	19.0	5.16	28.8	30.5	40.8
2	190	19.0	953	18.3	5.02	30.3	29.0	40.7
3	256	25.5	1364	26.0	5.33	28.1	27.5	44.4
4	364	36.3	1920	36.7	5.27	28.4	32.2	39.4
Summary: Total study	1002	100	5228	100	5.22	28.8	30.0	41.2

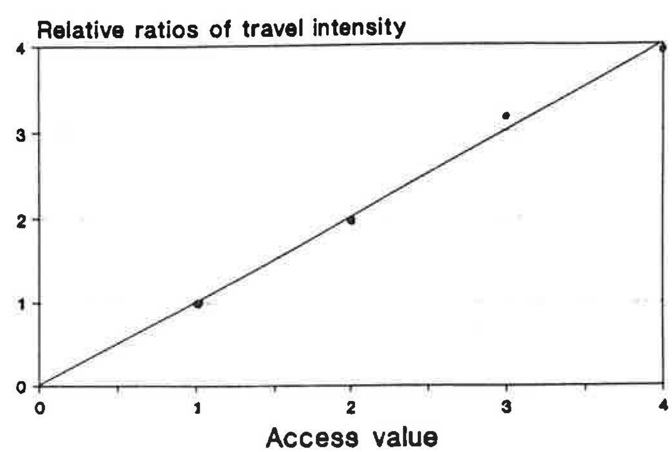


FIGURE 4 Travel intensity per household versus access value.

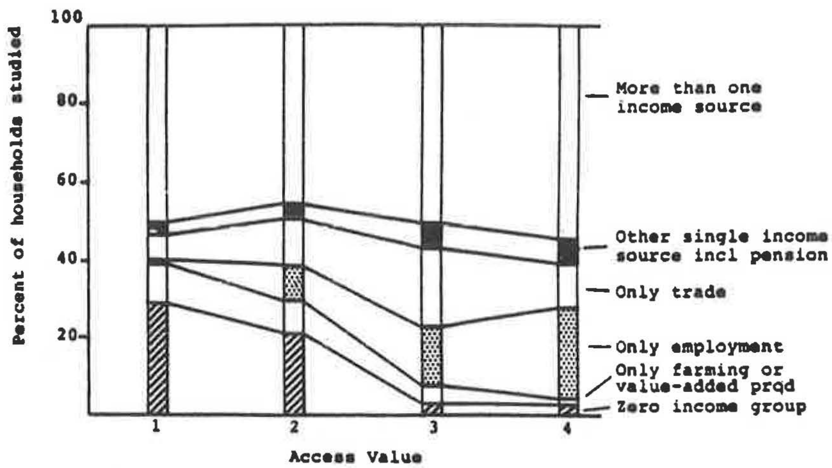


FIGURE 5 Percentage share of households by income source.

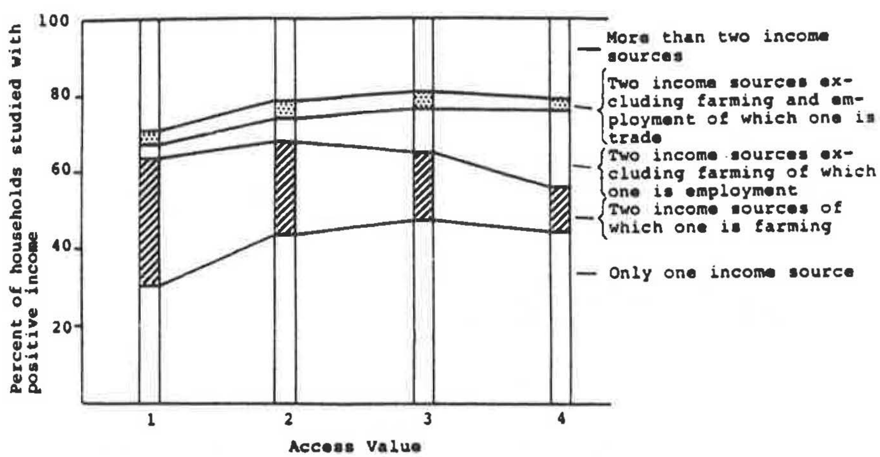


FIGURE 6 Percentage share of households by combination of income sources.

as access value increases. Second, Figure 6 shows that the percentage share of households with a single income source (a group with secure job status) is an increasing function of access value, and that the percentage share of households with more than two income sources (a group with rather insecure and unsteady job status) is a decreasing function of access value.

Main Profession

Most of the local inhabitants lack well-defined single jobs. Nevertheless, there may be only one job that could be considered as a citizen's main occupation. A picture of how the percentage share of both male and female inhabitants engaged in a certain profession may vary with access value is shown in Figure 7. This figure shows that with increasing access values, employment and study opportunities increase considerably for both men and women, whereas small-scale business activities, including farming for men and household work for both men and women, tend to decrease. The number of women doing household work is more than 10 times larger than their male counterparts in all access areas.

Education

For educational levels, by increasing access values the study variable falls rapidly for primary school education and rises sharply for completed high school and university level education (Figure 8). Incomplete high school education appears to be the borderline above which the proportion of higher-educated people sharply declines in less-accessible rural areas. This study shows that the average educational level in the Philippines is relatively high, whereby it could be expected that in most other developing countries, the borderline noted might fall far below the incomplete high school studies.

Income

All income components except farming tend to increase with increasing access value. In fact, total household income and income from employment are sharply increasing functions of access value (Figure 9). In calculating farming income, the value of home consumption of crops has been taken into account, whereby the words farming benefit may replace farming income. In addition, by increasing access value, the per-

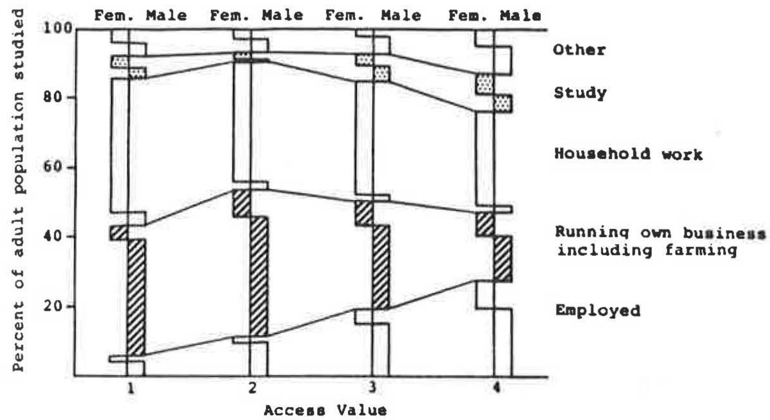


FIGURE 7 Percentage share of adult inhabitants by main profession.

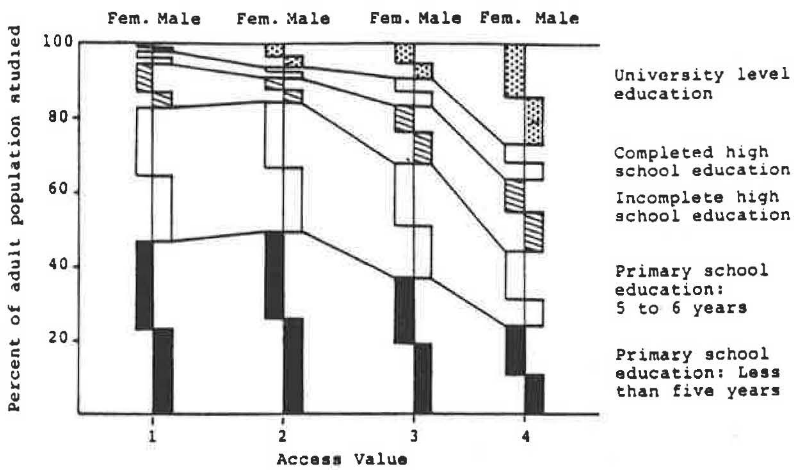


FIGURE 8 Percentage share of adult inhabitants by education level.

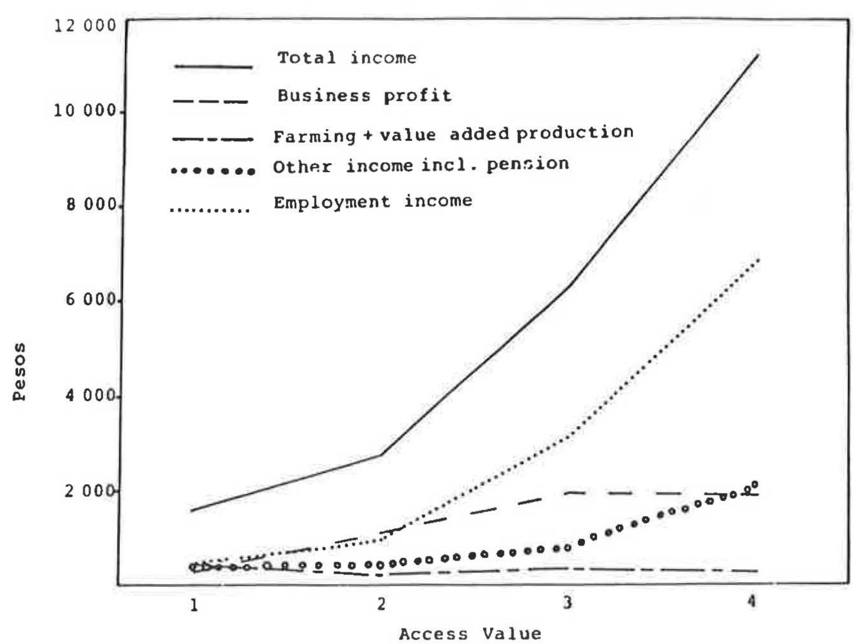


FIGURE 9 Household income versus access value.

centage share of households falls very rapidly for farming benefit plus income from processing farm products (value-added production) and increases sharply for employment income (Figure 10). Components of income generated by running a self-owned business (farming) and the manner in which the components vary with access value is shown in Figure 11. The percentage share of income from agriculture, fishery, and forestry together is a rapidly decreasing function of access value, whereas the share of income from all other trades counted together tends to increase sharply with increasing access value. For income distribution, Figure 12 shows that by increasing access value, the share of households in the

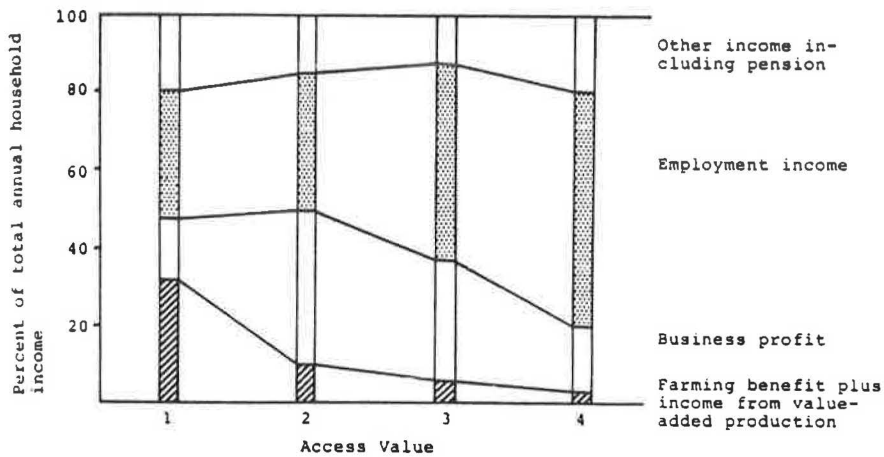


FIGURE 10 Percentage distribution of household income by income source.

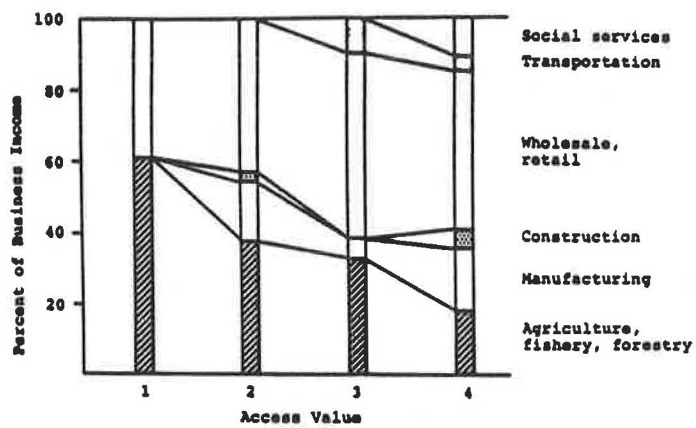


FIGURE 11 Percentage distribution of business income by business type.

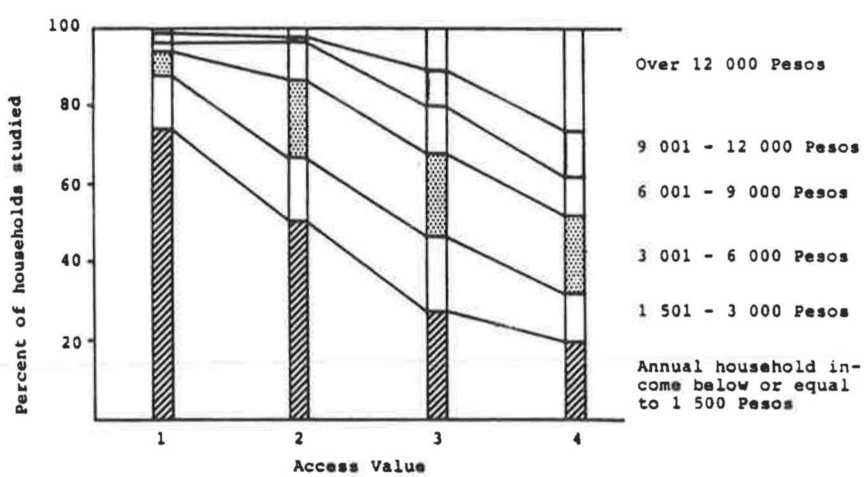


FIGURE 12 Percentage distribution of households by income group.

lowest income group (below 1,500 pesos per household per year) declines rapidly and increases sharply for the highest income category (over 12,000 pesos per household per year).

Housing

The extent of home comfort facilities, water and electricity, and their variation with access value indicates that by increasing access value, the percentage share of households falls sharply for the lowest home comfort level (neither water nor electricity) and tends to rise for medium and high levels of home comfort, a tendency shown to vary greatly for households enjoying the highest home comfort, both water and electricity (Figure 13). Housing standard, measured by the condition of the building's roof and structure, declines rapidly for the poorest housing standard—poor roof and poor structure. For the medium housing standard there is no obvious trend in either direction, but for the highest housing standard—fair roof and fair structure—there is a sharp increase (Figure 14).

TWO IMPORTANT SOCIOECONOMIC SECTORS

Transportation

Ownerships of cars, Jeepneys, trucks, motorcycles, bicycles, carts, and wagons are all increasing functions of access value, whereas ownership of animals as means of transport declines sharply as access value increases (Figure 15). A diagrammatic representation of the percentage share of trips carried out for various aims and purposes and its variation with access value is shown in Figure 16. The shares of work trips, business trips, and trips to school are all increasing functions of access value, particularly for work trips, which have a small share in the most remote villages and a larger share as accessibility improves. Figure 17 shows that with an increase in access value, the share of trips rises sharply when the mode is car or taxi, bus or Jeepney, trimobile, or motorcycle, as well as bicycle. In fact, the share of trips by public transport services including bus, Jeepney, and trimobile and the share of trips by motorized vehicles taken together are both sharply increasing functions of access value. When the transport mode is walk, the share of trips falls very conspicuously.

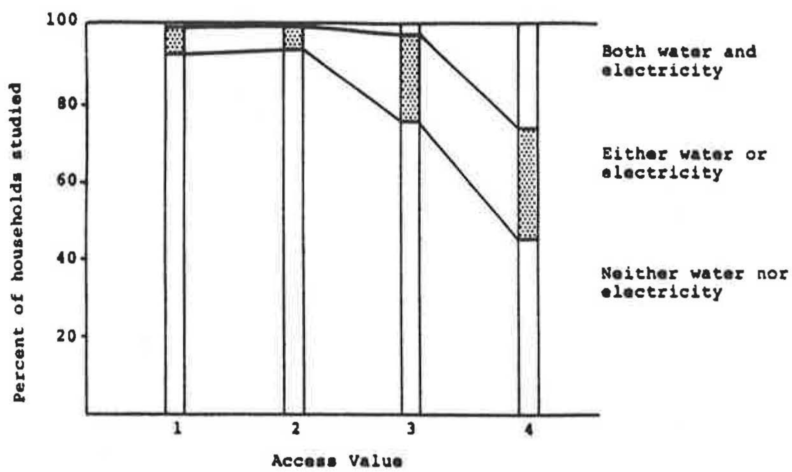


FIGURE 13 Percentage share of households by home comfort standard.

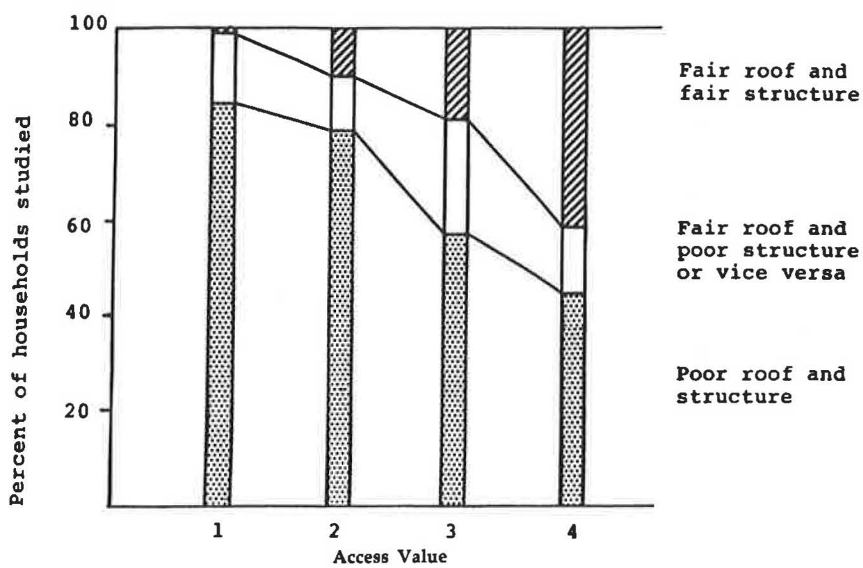


FIGURE 14 Percentage share of households by housing standard.

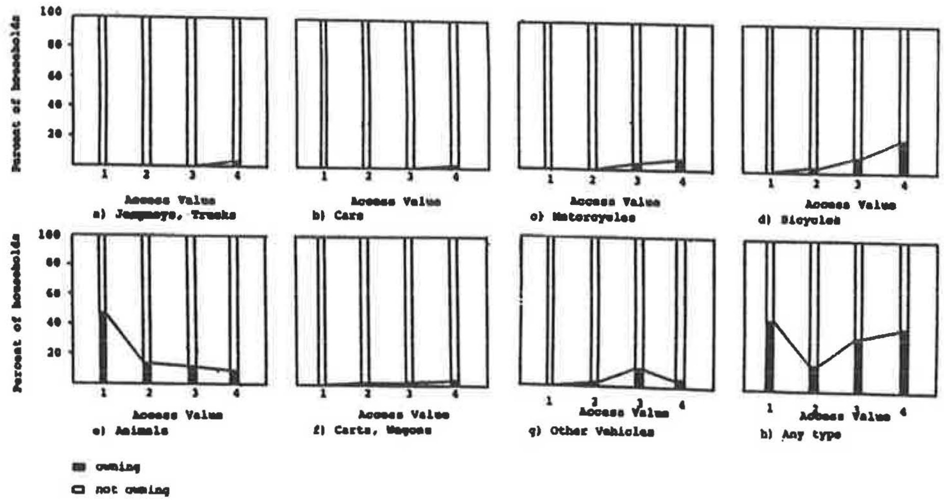


FIGURE 15 Ownership of means of transport.

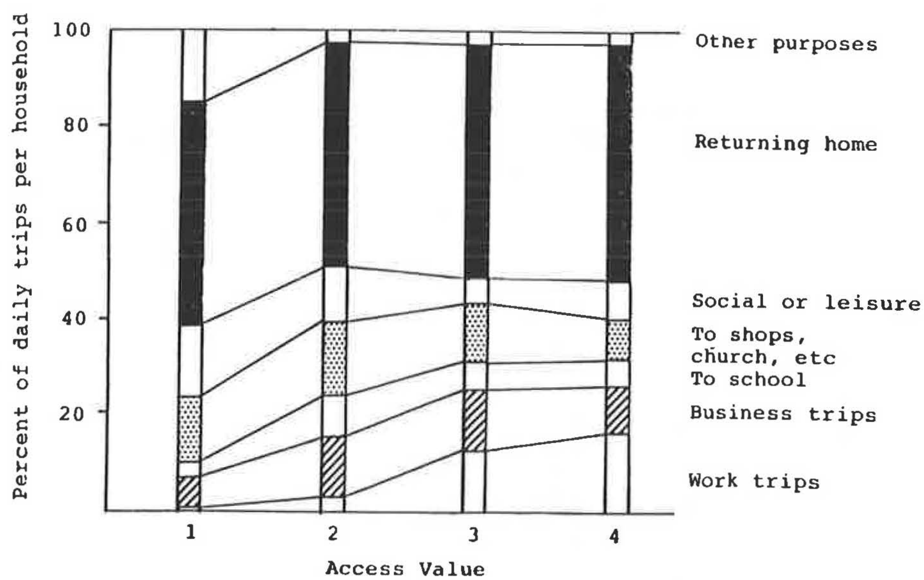


FIGURE 16 Percentage distribution of trips by purpose.

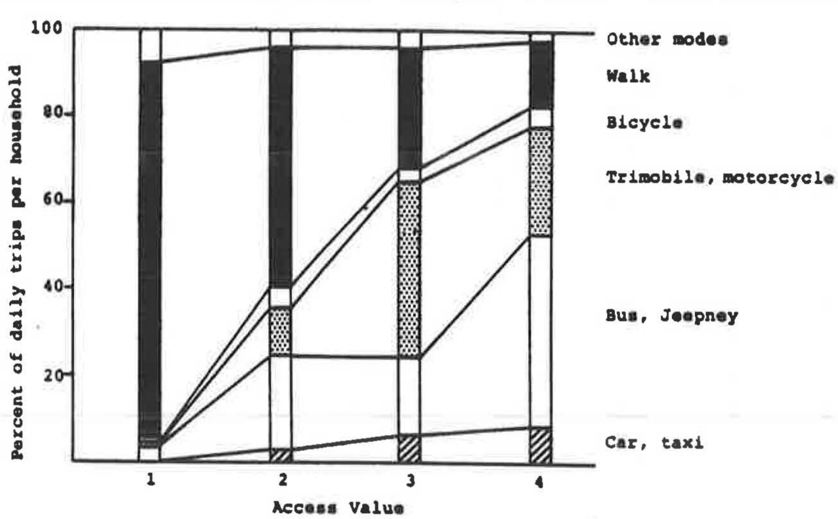


FIGURE 17 Percentage distribution of trips by mode.

The importance of accessibility for the transport of goods by various modes is shown in Figure 18. Transactions are defined as business deals involving the sale or purchase of a commodity that requires to be transported from the market to where it is finally consumed. The figure clearly shows that the share of transactions for goods transported by motorized vehicles, taken all together, is a markedly increasing function of access value, whereas it declines sharply when the transport mode is walk, consisting of head-loading, shoulder-loading, and back-loading. The shares of transactions, both for business site markets and interregional markets, are increasing functions of access value (Figure 19).

Agriculture

Agriculture is an important source of subsistence in rural areas of developing countries. Even households whose main source of income is not farming may own a small plot on which they grow crops for home consumption. Among the 1,002 households studied were 621 families who were concerned with agriculture in one way or another. The extent of farming activities is shown in Figure 20 by three categories of households—no farming activity, producing only for home consumption, or producing both for home consumption and sale. It may be seen that for no farming activity, the share of households is a sharply increasing function of access value, constituting a vanishingly small portion of inhabitants in the most remote villages and the vast majority of people in easily accessible areas. For the other two categories, the share of households turns out to be sharply falling functions of access value.

Farm size and the percentage share of farmers surveyed actually owning a farm of various sizes is shown in Figure 21. The share of farms is an increasing function of access value both for the smallest farms not larger than 49 ares (about half a hectare) and for the largest farms exceeding 500 ares (5 hectares). This relationship implies that both very small and very large farms are more numerous in more accessible areas with very small farms accounting for crops used only for home consumption and very large farms accounting mostly for cash crops. Average farm size, both for farmers who produce cash crops and for those who produce only for home consumption, is a decreasing function of access value in the first three access areas and in the last access area shows a substantial increase for farmers producing cash crops (Figure 22).

Average annual farm income per household as function of access value is shown in Figure 23 for the three categories of farm households defined previously. The figure shows that the average annual farm income for households producing

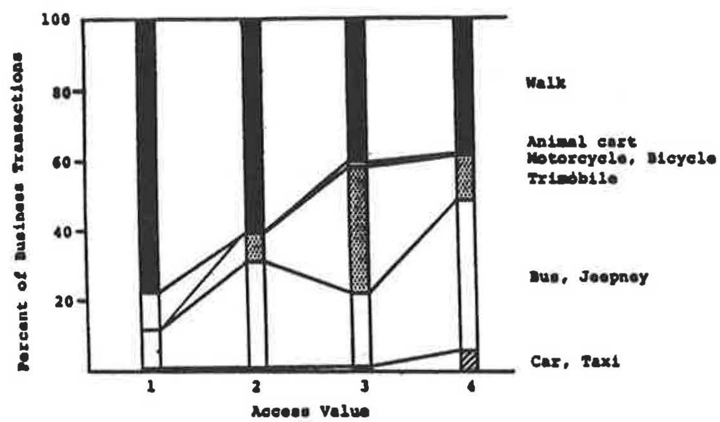


FIGURE 18 Percentage distribution of trade transactions by mode.

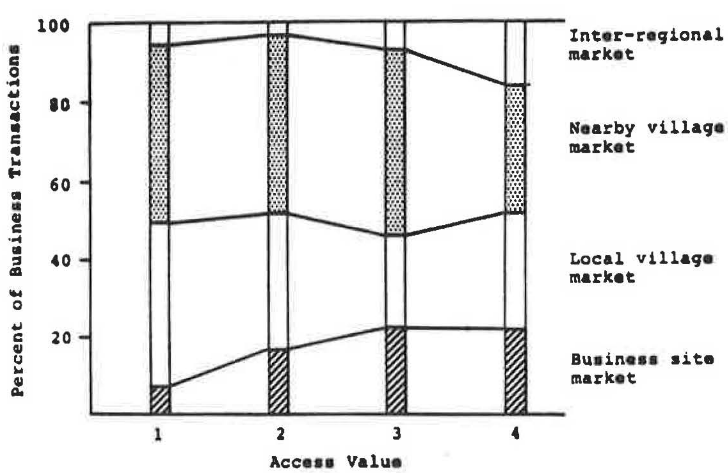


FIGURE 19 Percentage distribution of trade transactions by market.

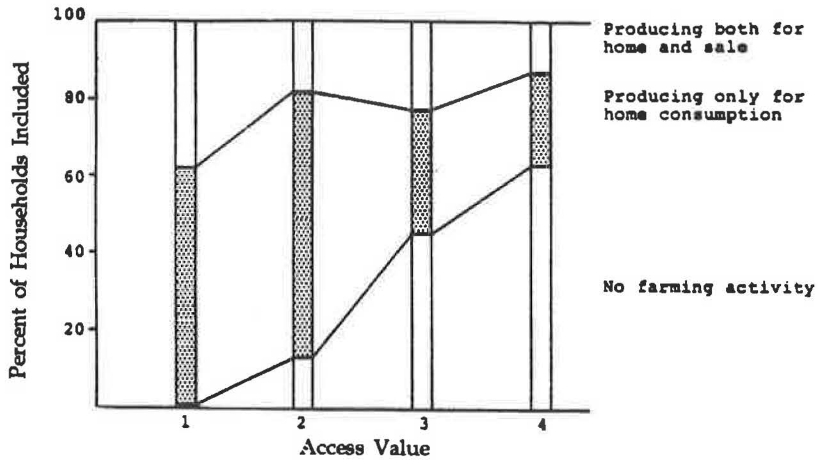


FIGURE 20 Percentage distribution of households by farming activity.

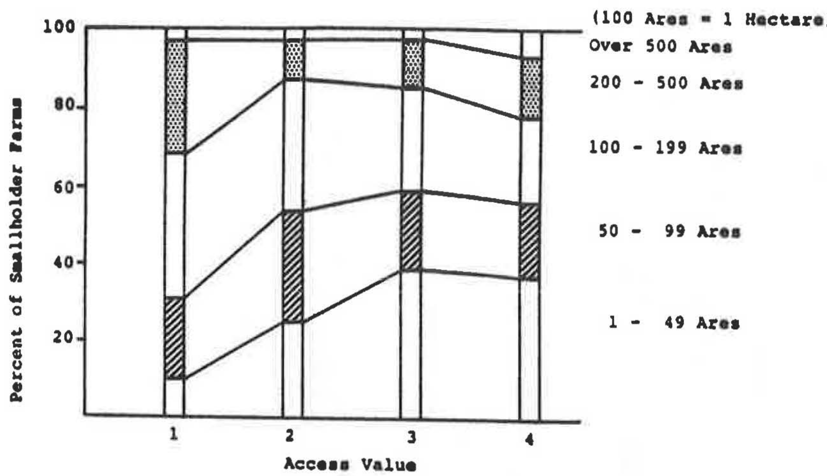


FIGURE 21 Percentage share of farms by farm size category.

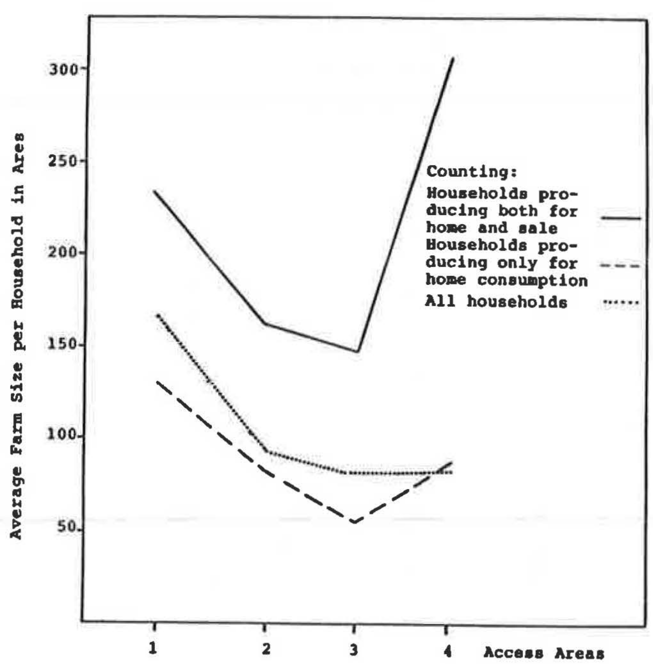


FIGURE 22 Average farm size versus access value.

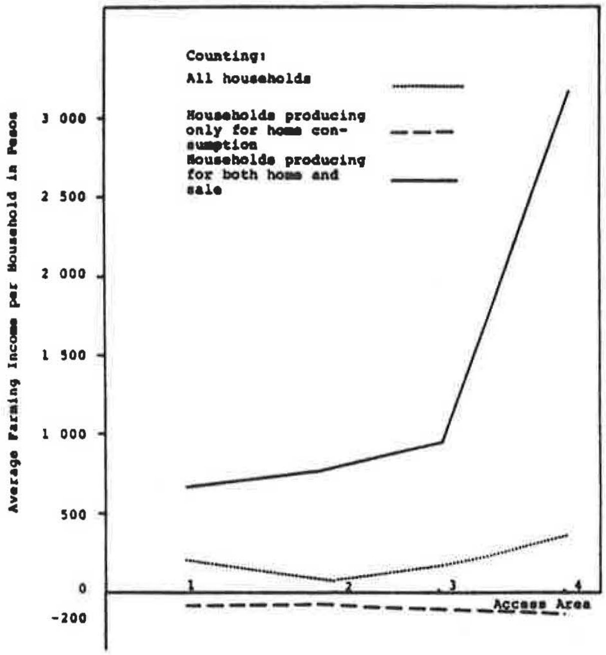


FIGURE 23 Average annual farming income per household versus access value.

cash crops is a continuously increasing function of access value, and in particular, it increases remarkably when the access value increases from 3 to 4. Dividing average farm income by average farm size for households producing cash crops would result in Figure 24, which shows that the efficiency of agricultural production increases considerably with an increase in access value.

CONCLUSIONS

Extension of the Results

The results shown in the previous figures are based on data from the study of a sample survey of the population on Cebu Island. Households were chosen at random in the actual survey and constituted around 10 percent of all households in

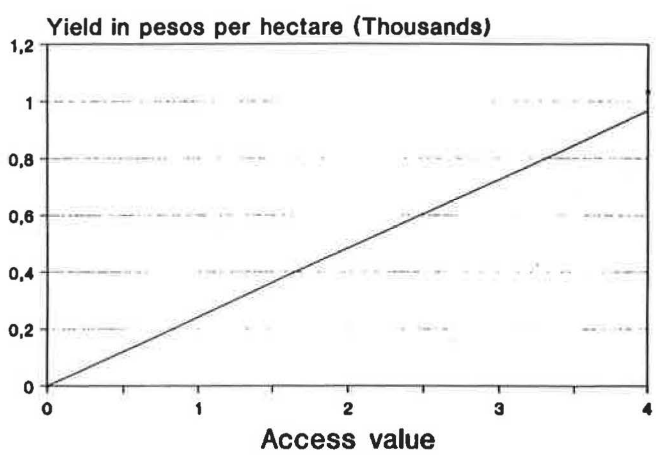


FIGURE 24 Yield per hectare versus access value.

the villages studied. However, the survey raises the question of how far the results obtained from the Cebu study could be extended to rural areas in other developing countries with similar socioeconomic structure. This question is actually the classical inference problem of generalizing conclusions from samples to populations.

Given the assumption that there are no definite relationships between the study variables and access value, a null hypothesis, then the knowledge of the sample size and observations of the actual results displayed in the previous sections would lead to the conclusion that the null hypothesis would be highly improbable if this judgment were based on earlier experiences of statistical analysis of problems involving similar sample sizes and similar relationships. The null hypothesis was tested using the contingency table of modal split corresponding to Figure 17 and the contingency table of the extent of farming activities corresponding to Figure 20. The application of a chi-square test of independence would lead to a significance level probability of approximately 10^{-10} in both cases. In other words, despite the relationships observed in Figures 17 and 20, the chances of the null hypothesis being true are less than 1 in 1 billion.

Impact of Transportation

The results of the study disclosed that major components of socioeconomic development and selected study variables in two economically vital sectors, transportation and agriculture, of rural areas of developing countries are strongly associated with accessibility and may vary sharply with a change of access value. Determining whether investments in the transportation sector generate development in other socioeconomic fields would require a closer examination of the results obtained in the agricultural sector.

Both the income obtained from the sale of cash crops and the efficiency of agricultural production are sharply increasing functions of access value. This relationship implies that an improvement of the existing transportation system would create a potentially new situation where all the local inhabitants, including poorer farmers, could gain advantage by selling their cash crops at higher prices and buying input products both cheaper and at the right time, assuming that everybody would have the possibility to use the newly created transportation facilities. Thus, optimal transportation investments in rural areas would take into account both the on-farm transportation needs involving shorter distances and the inability of poorer farmers to pay for the cost of transporting crops longer distances to bigger markets. Coping with these two problems through a sound financial and management plan would lead to a gradual increase of the farmers' income. Consequently, farmers would be wealthier and more inclined to increase spending on the education of their children and on raising the living standard of their families. Farmers may even be able to buy better and more efficient vehicles for transporting their cash crops to other markets.

Therefore, investments in the transportation sector may generate development in other socioeconomic fields provided that additional effective measures are taken simultaneously in order to ensure the proper use of the improved transportation system.

CONCEPT OF SOCIOECONOMIC DEVELOPMENT MAP

A review of the results obtained reveals that the study variables, which are positively correlated to socioeconomic development, such as social security, education, and so forth, change steadily in the same direction as access value. This relationship is shown in Figure 25 in which the level of advancement of favorable elements of socioeconomic development in the four access areas are assigned rank scores based on the results of the previous sections. The idea conveyed in Figure 25 leads to the conclusion that for a given part of a developing country as small as Cebu Island, it may be possible to identify different groups of villages denoted by SED zones with entirely different levels of social and economic development and that the SED zones would coincide with access areas. This result is particularly striking because in a small island of the size of Cebu, the existence of SED zones in rural areas cannot be explained by any ethnic reason, any unusual natural or social phenomenon, or any other extraordinary cause. SED zones in the order of increasing development level may be described as hardly developing, poorly developing, fairly developing, and easily developing with corresponding development scores of 1, 2, 3, and 4, respectively. Development scores are analogous to access values and have the similar function of ranking development levels as access values measure accessibility.

The most useful application of SED zones may be in constructing SED maps of developing countries. SED maps are simply an ordinary map of a country on which all individual villages are marked by their development scores. SED charts would always consist of a SED map plus an arbitrary number of other diagrams conveying desired information in percentage form about strategically important variables describing the SED zones. In Figure 26 the SED chart is made up of the SED map of the villages included in the survey plus two piecharts (SED pies). The first gives the percentage distribution of all inhabitants studied, and the second, the percentage distribution of those households earning more than 6,000 pesos per year (approximately the average income of the households studied) in the SED zones. SED pies for other variables are shown in Figure 27.

SED maps may be useful in planning and implementing investments in rural regions of developing countries because they pinpoint the neediest areas where greater investments are needed. A desirable long-term investment strategy should lead to a situation where the development scores of 1 and 2 would completely disappear from the SED map. Thus, the SED map and associated SED pies may also be used as val-

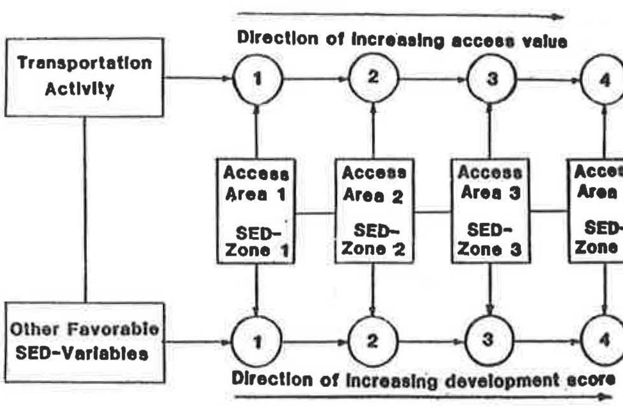


FIGURE 25 Rank scores of SED variables.

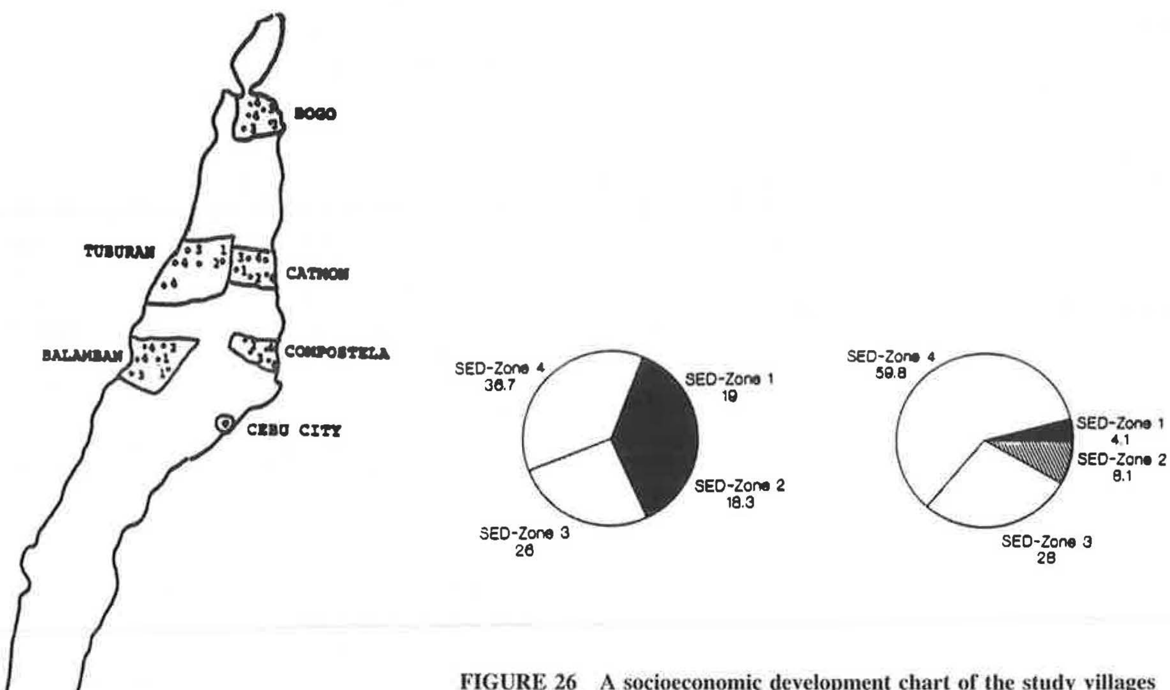


FIGURE 26 A socioeconomic development chart of the study villages in Cebu Island: (*left*) Cebu Island, (*middle*) population SED pie—percentage distribution of inhabitants by SED zone, (*right*) income SED pie—percentage distribution of households earning more than average income by SED zone.

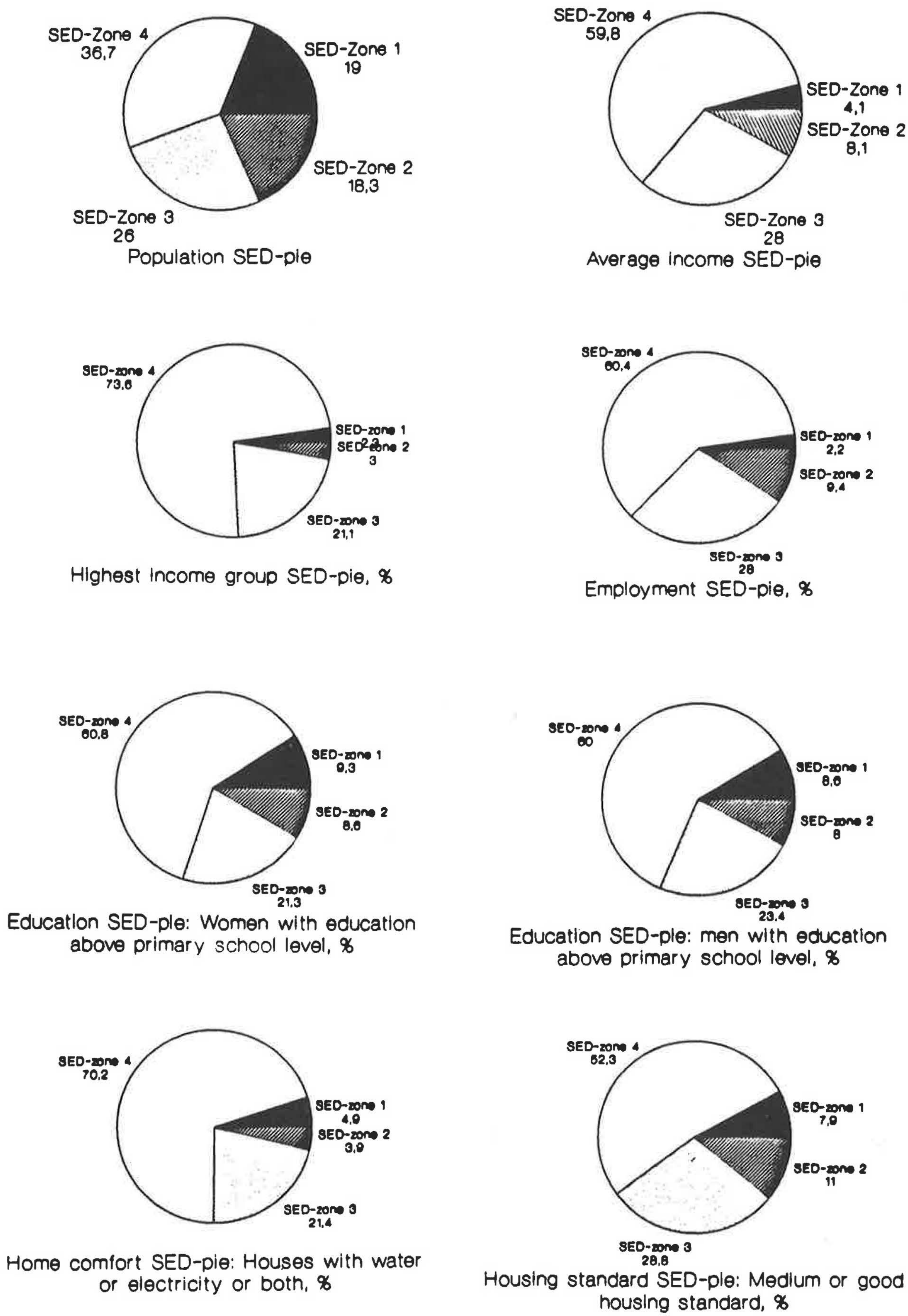


FIGURE 27 SED pies for individual study variables.

uable tools for observing the extent of achievements of past investments in rural areas of developing countries.

ACKNOWLEDGMENTS

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Transportation Issues for Agroindustrial Project Preparation and Development

OSCAR DE BUEN AND MANUEL LAPIEDRA

Contributions of transportation to economic development and, more specifically, to the agroindustrial sector in Mexico are presented. The way in which transportation considerations should be linked to agroindustrial project design and implementation to increase the probability of success of firms dealing with them is examined. The definition of agroindustry is presented along with a description of its basic characteristics in Mexico. A description is offered of how transportation must be taken into account when preparing agroindustrial projects, as well as some initial ideas on how transportation can contribute to improving firm performance. Several case studies are presented that show different forms of linkage between transportation and agroindustry and that concentrate on exploring the ways in which transportation contributes to a project's success or failure. Some general conclusions are offered together with a broad description of Mexico's agroindustrial development plans along with comments on how transportation and product logistics can be managed to increase the plan's probability of success.

Agroindustry can be defined as a series of processes that are applied to agricultural or forestry raw materials to transform them, including facilities in which raw materials are only superficially treated, as well as complex industrial plants in which elaborate consumer goods are produced. Agroindustrial businesses process raw materials to transform them into products that are more valuable because the products (a) become edible or usable, (b) can be stored for longer time periods, (c) can be more easily transported, or (d) have greater nutritional value. Raw materials used by agroindustry are perishable, seasonal, of changing quality and quantity, and are of high cost in relation to the finished product.

Classification of agroindustry depends on the type of economic activity or process used. The first criterion includes food and nonfood agroindustries. Food-related agroindustries include the meat, milk, beer, sugar, and coffee industries, whereas the nonfood industries include tobacco, textiles, shoes, and paper. For the second criterion, process type, agroindustries are either primary, intermediate, or final. Primary industries change the presentation of the raw materials without altering their form or quality. Intermediate and final industries change presentation, form, and quality; however, final industries require additional materials for production, which are not necessarily agricultural, and the final products are destined for consumption.

Agroindustries are important to developing countries for a number of reasons, including (a) their capabilities of transforming agricultural and forestry raw materials into consumer products, (b) their dominant position within the manufacturing sector, (c) their significant export development potential, and (d) their ample potential for creating jobs at decentralized locations, thereby positively influencing local economic development. In Mexico, agroindustry is important both economically and politically because it not only links primary sector production with the satisfaction of consumer needs, but also helps to mitigate rural poverty by allowing rural zones to retain a higher proportion of industrial value-added production.

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From an economic viewpoint, during the 1970s agroindustry contributed an average of 11 percent to gross domestic product and employed about 7 percent of Mexico's total work force. The industry's contribution to the manufacturing sector during that period was 45 percent of gross domestic product and 50 percent of that sector's employment. More recently, from 1982 to 1987, agroindustry accumulated a net positive trade balance of $5.27 billion, which represented about 10 percent of the country's total balance of trade surplus. According to figures of the 1980 economic census, Mexico's total agroindustrial production was produced by 79,581 firms of which 361 were responsible for 20.3 percent of the total. Of these, 170 were controlled by foreign investors, 80 by the Mexican private sector with some foreign participation, and 111 owned by the public sector. The remaining 79,220 firms are private and use mostly Mexican capital. Of them, 499 employed 250 or more workers and generated 20.7 percent of total agroindustrial production. Another 796 firms employed between 100 and 249 workers and contributed 8.5 percent of total production, whereas the remaining 77,925 are small firms, which employed less than 100 persons each and accounted for 50.5 percent of production. In addition, 1.6 percent of the total number of firms (multinational corporations, large public firms, and private firms) account for 29.2 percent of total production. At the same time, the 77,925 small, private Mexican firms, many of them nongovernment social organizations, make small individual contributions but together account for about half the country's total production. These structural characteristics of Mexico's domestic agroindustry are reflected in the technological, organizational, and financial means at the disposal of each firm. Although the major firms tend to be powerful and modern industrial groups, the small ones are traditional farmer associations and family businesses with little managerial sophistication.

Mexican agroindustry's current problems include poor organization, lack of financing, a depressed domestic market, and inefficient marketing. Factors posing the most relevant obstacles to marketing processes include excessive participation and influence of intermediaries, lack of storage facilities, insufficient financing for marketing operations, inadequate criteria for providing government subsidies, and inadequate transportation infrastructure and services.

During the 1980s, Mexico's economic climate underwent profound changes. To overcome an economic crisis with no precedents during the modern history of the country, the government instituted an economic policy that included innovative measures with the potential for radically transforming activities in all aspects of the country's economic and commercial life. These measures included Mexico's entry into the General Agreement on Tariffs and Trade (GATT), new regulations for foreign investments, a smaller public sector through the sale of public firms, incentives to the private sector, deregulation of federal road freight transportation, and other actions. These are examples of recent measures that have shaped a different economic environment for the country. Such measures imply significant challenges and opportunities for domestic agroindustrial activities. The most relevant of these challenges relate to the inflow of foreign capital and to the need to rapidly increase competitiveness and productivity to retain domestic market shares. Opportunities have surged as a consequence of the political willingness to revitalize Mexican agriculture. The new policies have transformed agroindustrial activities into a rapidly growing segment of the economy that is capable of bringing foreign exchange into the country, creating new jobs, and promoting economic development in rural areas.

PREPARATION OF AGROINDUSTRIAL PROJECTS

Agroindustrial projects are prepared by firms and nongovernment social organizations frequently aided by financial agencies. The preparation process includes identifying, designing, implementing, and evaluating projects. According to Austin (*1*), preparing a project requires the analysis of three activities that are decisive for any project's success: procuring raw materials, processing raw materials, and marketing finished products. Raw material procurement is relevant because of potentially significant implications for the quality and cost of the finished product and because of links with both agriculture and industry. Processing activities are the heart of agroindustrial transformations and involve technological choice, plant location, inventory management, acquisitions and supplies, and process control and management. Finally, marketing moves agroindustrial products to markets within restrictions imposed by consumers and by the competition.

In all of these phases the proper integration of transportation is key to increasing the chances for a project's success. In supplying raw materials to the plant, an effective performance by the transportation system is crucial for meeting the requirements of the plant in terms of quantity, quality, cost, reliability, and organization. Transportation services must be able to not only move the raw materials to the plant, but also minimize in-transit damages and partial or total losses despite the highly perishable and delicate nature of the raw materials. From an economic viewpoint, the origin and amount of transportation costs out of total production costs must be adequately identified in order to reduce the likelihood of making decisions based on distorted information.

For the agroindustry, time is one of the variables most directly affecting the supply system. Given crop seasonality and raw material perishability, the supply system must be precise. If the transportation system is incapable of rapidly moving raw materials between fields and plants, or if storage facilities are lacking and flows between production and transformation cannot be regulated, then the probability of projects failing will be high. Because established organizations, special interests, group attitudes, and power structures can potentially affect the performance of the project's activities, they have to be carefully analyzed to avoid implementing supply schemes that are likely to encounter opposition from any of the participating groups.

Transportation considerations also may play an important role in agroindustrial plant location decisions. Relationships between raw materials and markets, among other factors, are essential items for deciding where to locate a plant. Product type and characteristics may be decisive for locating the plant close to production and far from the market or vice-versa. Transportation infrastructure, transportation costs, and their likely evolution and incidence on product price will also be relevant for location decisions.

During the marketing and distribution phase, transportation operations play a role in defining the distribution system's structure, functions, integration, and sales strategies, and therefore must be studied within that specific perspective. In addition, flow structures, availability of properly equipped trucks, distribution of power and control among the different actors, adopted sales strategy, and other activities heavily involve transportation and logistics operations that must be properly conceived and executed if the project is to succeed.

In summary, transportation and more broadly the logistics supporting physical product flows are a necessary but not sufficient condition for ensuring an agroindustrial project's success. Even if all project stages are studied to perfection, if transportation is not systematically analyzed and properly integrated into project design then the probability of a project falling short of its stated objectives, or not reaching them at all, will be high (*2–5*).

CASE STUDIES

Case studies were taken from different regions and involve various products, including produce exports from Sinaloa, fruit exports from Michoacan, marketing forestry products in Chihuahua, lentil production and marketing in central Mexico, and milk distribution in central Mexico.

Produce Exports from Sinaloa

An agricultural association in the state of Sinaloa located in northwest Mexico annually exports around 650,000 to 700,000 metric tons of produce to the United States. These exports generate foreign exchange earnings of about $400 million and include tomatoes, cucumbers, zucchinis, watermelons, and melons. The export season extends from November through May with peaks occurring during February, March, and April. The products are sold in Nogales, Arizona, to local brokers that market them in the United States. Sales are made through the association's agents in Nogales, who monitor local market conditions and provide information to the farmers back in

Sinaloa about local prices and about convenient times for scheduling export shipments. Obviously, all products are subject to strict sanitary measures enforced by U.S. authorities and to the buyer's specifications concerning product size and quality.

Sinaloa's export-oriented farmers have developed highly capital-intensive and efficient operations with, in many cases, packaging plants located near the fields where the crops are concentrated, selected, cleaned, and packaged and then shipped to Nogales, on the border. The distance from Culiacan, the state capital and main agricultural center, to Nogales is about 1,000 km (600 mi), and both highway and railway transportation are available. Under these conditions, the challenge for transportation in the marketing operations of the local agroindustry is great. From small packaging plants dispersed throughout the coastal plains of the state, perishable products that are seasonally grown must be moved 1,000 km to be sold at a price fixed by the buyer according to market conditions and to the quality and presentation of the product. In order to accomplish a successful commercial operation, transportation services must be fast, reliable, refrigerated, safe, and economical.

Transportation services offered today to the local farmers that meet their quality requirements and allow them to integrate marketing chains, permitting sales in the strict but attractive U.S. market, include trucks and piggy-back. Of the total exported tonnage, 70 percent goes by truck at a cost of approximately 2.2 million pesos per trip (about $1,000), whereas the remaining 30 percent uses piggy-back service at a cost of 1.3 million pesos ($560) if the trailer belongs to the railway or 0.9 million pesos ($380) if the trailer belongs to the farmer. Travel times are similar.

Despite the relative backwardness of railway services in Mexico, their performance in this operation clearly illustrates significant potential for participating in nontraditional markets. Railways, supported by a strong performance from their marketing agents and good coordination from their traffic departments, are able to offer integrated services to the farmer that include pickup by truck, using either the farmer's own trailer or one supplied by the railway; ramp services to place the trailer on the rail platform; transportation from Sinaloa to Nogales; and border crossing services, for an additional $100. The railway uses refrigerated trailers and its announced delivery time is between 13 and 16 hr, which is reasonable for the farmer.

Sinaloa's agroindustrial export project has been working successfully for more than 25 years. From the start a key element in ensuring feasibility was the ability to solve difficult transportation problems. For Mexico, the solutions introduced were pioneering in at least two fields: the implementation of a highly successful, custom-designed piggy-back service, which even today is unparalleled in other regions of the country, and the use of refrigerated trailers. Refrigerated trailers were started by the railways and later adopted by truckers.

Melon Exports from Michoacan

A regional farmers' association in the western part of Michoacan in central Mexico affiliates about 5,000 producers of vegetables and fruits, of which melons, watermelons, and cucumbers are the most important. The association participates in exporting these products mostly to the United States but at below-potential levels because of difficulties in adequately handling and shipping the products with the regularity, timeliness, and quality levels expected by its clients.

The region's melon is famous for its high quality, which is high enough to meet any market's requirements. However, the product deteriorates rapidly because of inadequate handling after harvesting. Melons are cut piece by piece and collected in a basket that is manually placed on a 3-ton truck that takes them to the packaging plant. Usually, the truck lacks refrigeration and any other protection for the product, despite travel distances of up to 30 km (18 mi) under temperatures that can reach 40°C (104°F).

At the plant, the melons are manually unloaded onto a continuous band system where damaged pieces are separated and the others classified, according to size, into lots for export or domestic consumption. After each piece is selected it is cleaned, waxed, and packaged for final shipment. Exports are specially packaged and piled to await the arrival of trucks that will move them to their destinations. Loading operations are also manual and once the melons are loaded, one-half ton of ice per ton of product is added to the truck in order to avoid or reduce in-transit losses. Trucks have a typical capacity of 15 to 18 tons. The shipments are then covered with a piece of cloth, and other than the ice, there is no temperature control during the trip. Even on those rare occasions when refrigerated trucks are available farmers have observed that the drivers do not use their refrigerating equipment, mostly because of ignorance. However, farmers do not consider the railway a good option, even though services are available, because of its excessive trip times and its lack of specialized, good-quality refrigerated cars.

The region's annual melon crop is about 80,000 metric tons, which exits the region in about 3 months. During the season an average of 80 trucks are required per day, a demand that generates significant economic benefits for local truckers. In all, the region produces about 500,000 tons of various products throughout the year and therefore generates transportation demand that would make it attractive, at least in principle, to invest in transportation equipment to overcome current service shortages.

In this case, difficulties in handling and transporting the product reduced otherwise feasible export opportunities. The main drawbacks related to the type of packaging, to product protection while in transit, to the recurrent lack of transport service supplies, and to the absence of quality control processes that would ensure high confidence levels in dispatching shipments and complying with the delivery schedules set by clients. Despite these problems, it is likely that the main obstacle to increasing exports is that they have not been conceived as integrated agroindustrial projects, but rather as a marginal activity that is subject to each crop's annual results.

Marketing Forestry Products in Chihuahua

A state-owned firm specializing in forestry products in the northern state of Chihuahua will soon be transferred to local organizations involved in forestry. The firm produces two main product lines: raw materials for the cellulose, paper, and pulp industries and rigid finished products for furniture and carpentry. More specifically, the items produced at the firm's five plants, which are located closer to the forests than to markets, are logs, three types of cellulosic products (logs, sawable, and piles), air-seasoned sawed timber, stoved sawed timber, structural timber, and furniture. The five plants are directly supplied from the forests that cover a significant portion of western Chihuahua.

One of the key elements for the financially viable operation of the firm as a private concern is transportation, because transportation costs account for a substantial percentage of finished product costs. This is because of the volume and weight and cost relationships of forest products, not only during the log extraction phase, but also during the processing and marketing stages. Transportation costs represent, on average, about 60 percent of forest product prices. Half the costs are incurred while moving logs from the forest to the processing plant, whereas the other half is expended during processing and marketing. The industry traditionally cited the lack of and deficiencies in the region's road infrastructure as the major obstacle to increasing forest exploitation, but not because of its incidence on costs but because of the physical restrictions it imposed on production. Today, however, the recent changes in the economy's environment have increased the firm's sensitivity to transportation costs and to greater international competition. Given the location of the firm's plants, the average distance traveled by the 1.6 million tons moved annually is 244.5 km. In 1985, available services were provided by a fleet of 2,250 two- to five-axle trucks capable of moving 8- and 16-ft logs. With these trucks, it was estimated that there was a shortage of about 500 trucks per year.

In this industry, the specific conditions under which transportation operations take place vary according to type of product, economic value, and market. Table 1 presents a summary of each product's typical operating conditions. The significance of transportation costs is high for nearly all products, with the possible exception of furniture. For that reason, transportation is becoming a key element for designing the most adequate strategy for transferring the firm to the producer organization. As a consequence and in contrast to the previous stages of the firm's development, transportation is being explicitly studied as a decisive element for increasing the return on investments.

Lentil Production and Marketing in Central Mexico

A farmer organization in central Mexico engaged in the production of lentil has been traditionally subjected to the abuses of intermediaries that control their product's marketing channels. These intermediaries penalized the prices paid to the producers and thus reduced the farmer's income to their advantage. To avoid such problems, the farmers decided to construct a packaging plant and storage facilities, and to incorporate their organization into the CONASUPO distribution system, which the government operates to regulate national food markets. Once accomplished, this arrangement helped to increase farmer income by avoiding the intermediaries.

Despite their apparent success, the farmer organization's marketing project would not have been feasible if Diconsa, another public sector enterprise belonging to the CONASUPO system, had not loaned the organization a fleet of four 12-ton trucks for distribution and two smaller trucks for moving the product from the field to the storage facility. Although the operation of the truck fleet allows the farmer organization to accomplish its goals by having greater control of their product's distribution activities, it is an extremely expensive solution made possible only because of the special circumstances in which the trucks were made available to them—the fleet is unused most of the time because of the seasonality of production. However, this project would undoubtedly have failed if the farmer organization had been unable to ensure the operation of its own transport fleet and their dependence upon the intermediaries would have persisted.

Milk Distribution in Central Mexico

Members of a farmer organization in central Mexico received financial aid to carry out a project to provide milk for families in their own community. Liconsa, a state-owned firm dealing with milk marketing and distribution at the national level, provided the aid through one of its broader programs that included technical assistance. In this case, money was used to purchase cows and to construct stables.

This project turned out to be successful and started producing quantities of milk that surpassed the community's demands. Producers tried to sell their milk surplus at the closest urban center, a very small city, where they rapidly exhausted this market because residents preferred pasteurized milk instead of the nonpasteurized product offered by the producers. Faced with an oversupply of milk, the producers studied the convenience of installing a pasteurizing plant, but they soon found that it was not economically feasible because of low production quantities. Another alternative proposed transforming the milk into cheese, but it also was not feasible because of low production volumes. A final option consisted of building a refrigerated tank where milk could be stored before sending it to the market, but this option was canceled because transportation services suitable for the project's needs were unavailable.

In all options, transportation was analyzed as an afterthought and in the end was identified as an obstacle to realizing the project's full benefits. The failure to take a comprehensive view of the available options, including the role and contribution of transportation in daily operations, prevented this theoretically successful project from being highly successful in practice.

RELEVANCE OF TRANSPORTATION IN AGROINDUSTRIAL PROJECTS AND CASE STUDY ANALYSES

Because transportation is a highly relevant element for the different phases of agroindustrial project development, it is absolutely necessary to analyze and design the role transportation plays in providing raw materials for the plant, in defining plant location, and in marketing and distributing finished products. Despite such relevance, it is hypothesized that transportation issues have historically attracted little attention within the realm of agroindustries. This hypothesis undoubtedly var-

TABLE 1 TRANSPORTATION OPERATING CONDITIONS FOR FORESTRY PRODUCTS IN CHIHUAHUA (6)

PRODUCT AND USE	MARKET	TRANSPORT SERVICE CHARACTERISTICS	TRANSPORT COSTS
Logs for basic sawed products and plywood	Local or regional sawmills; plywood plants	The trip from forest to sawmill is made on a two-axle truck owned by the producer.	For an average distance of 25 km, $4-8 dollars per ton; for 60 km, $16-28 per ton.
Cellulosic log for cellulose, pulp and paper production	Three plants located in the state; others at out-of-state locations	The trip from forest to plant is made on two-axle trucks owned by the producer and acquired via financial leasing arrangements.	Transport costs are 70% of FOB costs at the sawmill, and 45% of costs at the processing plants. For a 45 km distance, costs are about $12/ton.
Piles and sawable products	Local sawmills; mining industry	The trip from forest to sawmill is made on two-axle trucks owned by the producer.	Transport is the major component of finished product costs. For a 40 km distance, costs vary between $10 and $16 per ton.
Air-seasoned sawed timber for various uses	Regional and national.	The trip from the sawmill to the buyer's facilities is made by for-hire, 15 to 35 ton trucks, by 25-45 ton railway cars and by private trucks.	The buyer arranges transport for his/her products and covers costs.
Stoved sawed timber for various uses	Furniture and door factories. Carpenters and artisans.	The trip from the sawmill to the buyer's facilities is made by for hire, 15 to 35 ton trucks.	The buyer arranges transport for his/her products and covers costs.
Structural timber	National railways. Construction industry	The trip from sawmill to plant is made on two-axle trucks owned by the producer. Rail is used occasionally.	About $8 per cubic meter.
Furniture	Domestic and export	Specialized services by moving companies.	About 5% of selling price, depending on each case.

ies from case to case and according to each industry's specific circumstances, as will be seen. Within the research community, efforts dedicated to the simultaneous, joint study of agroindustrial and transportation issues in Mexico and probably in other developing countries have been sparse, and as a consequence there is much to learn and to study in future projects dedicated to this topic.

Firm Size and Transportation Solutions

The broad relationship between agroindustry and transportation hides an enormous heterogeneity of cases that prevents general conclusions from being made. This heterogeneity rises from existing differences among product types, processes in which they are used, regions where they are grown or transformed, types of markets where they are commercialized, and relevance of transportation in costs and operations. Such differences are large and lead to the need for preparing specific studies for particular products and regions that can be expected to reach pertinent conclusions. Despite these comments, it seems reasonable to distinguish firms according to size because size is relevant for approaching, analyzing, and solving agroindustrial problems. Large firms with vast technological, organizational, and financial means at their disposal have a radically different view of their problems than do small firms lacking technological sophistication, opportunities for negotiation, and financial resources.

From the analysis of the case studies, it can be safely concluded that large firms invariably solve their transportation problems, whereas the same cannot necessarily be said of smaller firms. When users generate large traffic volumes with established flows and periodicities, their position vis-à-vis the transportation operator is favorable not only in terms of having services available, but also in negotiating rates and service attributes. The case of agroindustrial export products from Sinaloa reveals that it is even possible to generate technological innovations in transport, such as using refrigerated trailers or introducing piggy-back services, which the operator may be willing to introduce if such actions allow him to capture a stable and lucrative market.

Transportation in a More Competitive Environment

A second point that can be extracted from the case studies is that transportation was not a priority concern in the heavily regulated market which had prevailed in Mexican truck transport until recently. In part, that was a result of not only the lack of alternatives available to the user, but also to the fact that the market was held captive by a few producers and transportation service providers that were insensitive to consumer needs. In the end, consumers did not have any other choice but to pay for the excess costs resulting from inefficiencies. Under Mexico's abandoned regulatory system trucking service availability was ensured by establishing compulsory rates, by giving route authorizations to farmers, or by negotiating agreements at national or regional levels to ensure that adequate capacity was provided at points where crops required transportation in large quantities for short time periods, especially if those crops were for satisfying basic needs.

Today, both agroindustrial and trucking firms have started to feel pressures from a more competitive environment. Agroindustries must endure higher levels of competition because of the country's liberal trade policies, whereas truckers no longer enjoy the protection of regulation. As a consequence, it is likely that both groups will start to seek higher efficiency levels, to adopt innovations that allow them to expand their market shares, and to comply with their clients' quantity and quality requirements.

Transportation Cost Contribution to Price

The significance of transportation costs as a portion of a product's final price is as varied as are the products. In some cases, such as produce exports, furniture, or melons, the incidence of transportation costs is low or of minor significance with respect to other problems, such as ensuring the availability of services. However, in other cases, such as forestry products, transportation costs are the decisive component of the product's final price. In general, the more basic the treatment that the raw material receives before being sold, the greater the significance of transportation costs in its price. When the incidence of transportation costs is low, the availability of a transportation system that can provide high-quality service becomes of paramount importance to the shipper.

Logistics Support for Exports

Availability of a good product is a necessary but not sufficient condition to launch successful export operations. As the case of melon exports shows, successful exporters must comply with their clients' quality and price requirements. To accomplish this the exporter must develop a comprehensive project that includes all the details of the operation; otherwise, exports would be impossible. By incorporating transportation in a more ample logic dealing with the handling of products, both transportation operators and shippers may discover new, interesting commercial opportunities that may help them increase their firms' economic returns.

Establishing an agroindustry that is both serious and efficient cannot be accomplished without properly planning and designing all activities involving the handling of products, particularly where export projects are concerned. For this reason, in order to maximize the contribution of agroindustrial projects to national and regional economic development, it is necessary to design all the activities belonging to product logistics before actually implementing the project. Improvising as the project progresses is equivalent to condemning it to failure.

Traditional Approach to Transport Problems in Agroindustry

The analysis of the case studies shows that failure to consider transportation issues when preparing agroindustrial projects is an important limitation that affects and sometimes even cancels the feasibility of projects. In the past, a frequent attitude during agroindustrial project development appears to have been that the solution of transportation problems was not an integral part of the project, but rather an additional activity that someone had to confront at some time. Such an approach prevented transportation from being actively incorporated into product logistics as an activity that is capable of adding value to the agroindustrial product and of multiplying the potential benefits of the project.

Private Truck Fleets

One of the most frequent approaches in solving transportation problems in agroindustrial firms consists of forming and operating private truck fleets that allow a timely solution of problems without having to deal with public transportation providers (7). Given crop seasonality and perishability, agroindustrial firms require timely and reliable transportation services to ensure deliveries that prevent the loss of product value. However, their tonnages are generally low and therefore not particularly attractive to public service providers, who usually do not like the demand fluctuations derived from the seasonality of production. In such circumstances, public service providers typically react by either not offering services (also because roads are frequently bad) or by significantly increasing their rates.

Confronted with such realities, agroindustrial managers find that private fleets are convenient for managing product flows according to their own needs, for reducing or eliminating uncertainties, and for attaining the availability, reliability, and service quality levels that they wish. However, such a solution has the drawback of perhaps requiring prohibitively high investments as well as needing to establish an internal organization that is exclusively dedicated to the provision of transportation services and the maintenance of the fleet. Such an endeavor also has potentially far-reaching implications for the company's finances.

Perspective for Transport Solutions

The detailed analysis of the relationship between transportation and agroindustry reveals complexities that are otherwise difficult to discover and thus can be ignored or attributed to other causes. Given the involvement of many different groups, each with its own interests and positions of power derived from their specific participation in different activities of the agroindustry, frequently many of these conflicts surface as transportation problems. As a consequence, focusing exclusively on the transportation part of the problem may prove to be inadequate for solving it because the problem may have other origins and require other approaches for finding a solution.

Opportunities for Transportation Firms

Another interesting conclusion derived from the case studies is that transporting agroindustrial products is full of opportunities for transportation firms, and more broadly for logistics service providers, because there are multiple market niches defined by product type, region, or market characteristics that can be exploited through strategies that provide efficient, high-quality services and personalized attention to clients.

CONCLUSIONS

In general, the analyses of the case studies reveal that agroindustrial project preparation must devote more attention to transportation-related factors if project success is to be attained in a more open and competitive economy.

Today, such an approach is particularly helpful because the Ministry of Agriculture and Water Resources is establishing the foundations for a strategic project for developing rural industries that will provide the framework for the future development of agroindustry in Mexico. The project includes six agroindustrial corridors located in different regions of the country that will be developed to promote agroindustrial production and to help increase exports. The basis for developing such agroindustrial corridors consists of exploiting regional advantages for domestic and export production, depending both on product types and external demands. Because exports will be an important objective of the project, transportation will be extremely important to reach the productivity and reliability levels that will be required in all project phases. In particular, options to improve physical product handling and to reduce transit losses, including the use of refrigerated vehicles and storage facilities, will have to receive priority if efficient transport chains are to be constructed.

In the end, two things can be safely concluded from this study: first, transportation has to be properly regarded during agroindustrial project development because otherwise it has enough potential to disrupt project design and to reduce or eliminate its contribution to economic development. Second, detailed, industry- and product-specific studies are needed to better understand the agroindustrialist shipper's needs and to better shape the response that transportation services can provide.

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Transaction Costs Approach for Estimating Development Benefits of Rural Feeder Roads

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The most direct benefit from improved access to markets is a decrease in transaction costs, including transport and storage costs. In developing countries, all-weather roads act as a catalyst that accelerates economic development by reducing transaction costs. A transaction costs model can explain most of the price variation between areas with good access and areas with bad access. Therefore, this type of model becomes a more powerful tool in analyzing the impact of rural roads when compared with the standard transport cost differential approach. In a study of rural roads in Bangladesh, poor access was found to keep competitive agricultural products traders from entering markets. For example, with poor access there is a relative shortage of buyers compared with the number of sellers. However, in areas with good access the opposite is true. If the traders did not perceive that accessibility was a problem, then competition would increase until the price differential would approach transport costs plus spoilage. Traditional transport cost approach begins with transport, storage, and spoilage savings that are passed on to agricultural producers who respond to the higher prices and profit. This approach tends to underestimate the benefits because the actual increase of producer prices is significantly higher. The transaction costs approach should be used to estimate agricultural benefits of new rural roads because these models can distinguish between financial and economic prices. The results of the Bangladesh case study using the transaction costs approach were much greater than those predicted by the transport savings model.

The process of economic development, apart from encouraging growth in material income, is one that results in making more choices available to the population of a growing region. The key variable in increasing the range of options is increased mobility. Greater accessibility provides more freedom for its residents to choose how or where to earn their livelihood. For example, in an inaccessible area it is difficult to contemplate commuting to better job opportunities (or to better markets for a producer). As options increase, better matching between jobs and skills (or between producers and markets) becomes possible and productivity increases. Increased productivity results in improved output and higher incomes. For producers, easier access to markets makes it possible to initiate a production pattern more reflective of their comparative advantage. This reduction in autarky leads to increases in value added.

The most direct benefit from improved accessibility comes in decreased transaction costs which include transport and storage costs. The broader range of benefits previously discussed is to a large extent a result of reduced transaction costs.

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RURAL ROADS AS A CATALYST FOR LOCAL DEVELOPMENT

Psychologist Alex Inkeles, writing about modernization in India, argues that the development of a state of mind acts as a catalyst for rapid development. Development of this modern mentality comes as a consequence of several factors. One of the most important is improvements in the quality of the transportation infrastructure. As in 19th century Europe, railway access was taken as a key point in entry to what was then called the modern age. In today's developing world, having regular bus service to the village is key in developing the mentality of modernization, which is a major event in the process of economic development.

In addition, all-weather roads act as a catalyst that brings together various ingredients to accelerate economic development. This catalytic role is in addition to the road's direct contribution of reduced transaction costs.

A TRANSACTION COSTS APPROACH TO THE IMPACT OF RURAL ROADS

Transaction Cost Economics Applied to Rural Roads

One of the findings of field work, which seems to contradict the logic of traditional thinking in transportation economics, is that price differentials between a market with bad access roads and a nearby market with good access roads were found to be significantly greater than transportation costs, even for relatively nonperishable goods such as rice. However, using the findings from the new field, transaction cost economics, the results are not so surprising.

The recent rapid development of the economics of transaction costs has revolutionized thinking in modern economics in the past few years, which has implications for the development of rural roads. A rather simplistic formulation of the transaction costs model with application to the impact of rural roads on prices is

$$P = P^* + T \quad (1)$$

where

P = price in markets with good road access,
P^* = price in markets with bad road access, and
T = transaction costs.

$$T = dc + f(x,t) + g(x,t,d,p) \quad (2)$$

where

d = distance to a market with good access,
c = per-unit cost of transportation,
x = perishability of the product, and
t = transport time on lower-quality roads.

Functions f and g are in the first quadrant only (i.e., they only take positive values). Both functions have positive first and second partial derivatives with respect to x, t, p, and d (i.e., they are increasing at accelerating rates with respect to all the variables).

The function f represents product perishability, which will affect prices, whereas the function g represents entrepreneurial premium accruing to those who move products from areas with bad access roads to areas with good access roads. The premium depends on travel time (which is a proxy for degree of badness of the road) as well as distance and degree of product perishability.

This model explains most of the price variation between areas with good access and areas with bad access. Therefore, it is a much more powerful tool in analyzing the impact of rural roads than the standard transport cost differential approach.

Components of Transaction Costs

Table 1 presents the various components of transaction costs in Bangladesh. Entrepreneur return has been estimated as a residual.

Transport Costs

Transport costs traditionally have been the components focused on in most of the feasibility analyses of rural roads. However, this focus represents an incomplete approach to the problem. For this study, the rate used has been uniform, the cost of operating a bullock cart on 8 to 10 km of dirt road. Travel time for a bullock cart over this distance is about 8 hr. In comparison, the travel time for a truck would be less than ½ hr.

Storage and Perishability

Storage and perishability factors are particularly critical for certain vegetables such as tomatoes. However, systematic data on such an important element were difficult to obtain. Yet, each harvest season's spoilage, caused by the lack of good transport, is an important feature of Bangladesh agriculture.

In Table 1, the rates used were derived from discussions with food technologists and preservation specialists at research institutes and take into account the climate of the harvest season and also assume a 1-day travel time savings. For example, cauliflowers are harvested in the cool season and will last between 10 and 15 days without refrigeration before spoiling, whereas tomatoes are harvested at the beginning of the warm season and can spoil within 3 days. Potatoes are more robust and can last up to 1 month before being put in costly storage. Spinach and similar leafy vegetables are harvested all year with their perishability highest in the rainy season and lowest in the cool season. For this study, the rate assumed is based on a seasonal average. Spoilage rates for cereals, pulses, and oilseeds are almost negligible.

Entrepreneurial Overhead

The key factor in entrepreneurial overhead is that bad access makes it more difficult for competitors to enter, and those willing to take the chance earn a premium profit. The mechanics are simple. In areas with poor access, there is a relative shortage of buyers compared with the numbers of sellers. It is traditionally a buyer's market. However, the situation is reversed in areas with good access. If buyers did not perceive that the accessibility of an area was a problem, then competition would increase until the price differential would approach transport costs plus spoilage.

Beyond the opportunity costs of entrepreneurial time, entrepreneurial overhead consists of higher profit from lower competition, that is, an element of monopoly or excess profit. It also includes a risk premium that increases at an accelerating rate with the perishability of the product. For example, if for some reason the bad roads cause a 3-day delay for a bullock cart loaded with tomatoes, the whole load would spoil. However, the same 3-day delay for a load of rice leads to a negligible loss.

Data on entrepreneurial overhead presented in Table 1 are estimated on the basis of residuals. Apart from product perishability, the data also vary with the market price of the product. Entrepreneurial overhead is never reduced to zero. As access improves, more entrepreneurs will enter the business and reduce the level of overhead until it approaches a limit close to the price of the entrepreneur's time.

Entrepreneurial overhead includes two components, one of which is the cost of the entrepreneur's time and return to his or her management skills. The other component is a monopoly premium caused by less competition in areas with poorer access. In such areas, there are relatively more farmers with products to sell than traders who buy them. Consequently, farmers have less bargaining power, which allows the traders to earn a monopoly profit. In areas with better access, this monopoly profit is eliminated through competition among traders.

IMPLICATIONS OF THE TRANSACTION COSTS MODEL FOR ANALYZING BENEFITS OF RURAL ROADS

Traditional approaches of transport economics in estimating the agricultural value-added impact of rural roads begin with savings in transport, storage, and spoilage. These savings are passed on to the agricultural producers who respond to the higher prices and profitability. This result applies to area surplus products. Prices of products that are in deficit will actually be reduced because with improved access imports can more easily flow in from the outside. This study was conducted in the Greater Dinajpur region of Bangladesh, which is a surplus agricultural region. Most basic agriculture products are in surplus in the area and improved access will therefore increase

TABLE 1 COMPONENTS OF PRICE DIFFERENCES BETWEEN AREAS WITH GOOD ACCESS AND AREAS WITH POOR ACCESS—BANGLADESH TAKAS IN 1988 PRICES

Crop	Market Price with Good Access	Components of Transactions Costs: Transport Charges	Storage Spoilage	Entrepreneur's Return	Market Price with Bad Access	Price Differences in Financial Prices	Monopoly Premium of Traders in Areas with Bad Access
A. Cereals							
1.Rice							
- Aman High Yielding	5,500	100	6	395	5,000	500	197
- Aman Local	5,500	100	6	395	5,000	500	197
- Boro High Yielding	5,500	100	6	395	5,000	500	197
- Boro Local	5,500	100	6	395	5,000	500	197
- Aus High Yielding	5,000	100	5	395	4,500	500	198
- Aus Local	5,000	100	5	395	4,500	500	198
2.Wheat	6,000	100	6	394	5,500	500	197
3.Kaun	3,000	100	3	397	2,500	500	199
B. Pulses							
1.Mungbeans	18,000	100	18	482	17,400	600	241
2.Blackgram	15,000	100	15	485	14,400	600	243
3.Lentil	18,000	100	18	482	17,400	600	241
4.Chick Pea	12,000	100	12	488	11,400	600	244
C.Oilseeds							
1.Mustard	10,000	100	10	490	9,400	600	245
2.Groundnuts	12,000	100	12	488	11,400	600	244
D.Vegetables							
1.Potato HYV	4,000	100	120	580	3,200	800	290
2.Potato Local	4,500	100	135	565	3,700	800	283
3.Brinjal	3,000	100	150	650	2,100	900	325
4.Cauliflower	5,000	100	500	800	3,600	1,400	400
5.Cabbage	4,000	100	400	700	2,800	1,200	350
6.Tomato	3,000	100	900	1,000	1,000	2,000	500
7.Radish	2,000	100	60	590	1,250	750	295
8.Spinach	2,000	100	600	800	500	1,500	400
E.Spices							
1.Onions	10,000	100	80	470	9,350	650	235
2.Garlic	12,000	100	96	454	11,350	650	227
3.Ginger	15,000	100	120	780	14,000	1,000	390
4.Turmeric	5,000	100	40	510	4,350	650	255

Notes:

1.The market prices are harvest season averages over three years.

2.The spoilage and storage loss was estimated in discussions with food technologists at the Bangladesh Council for Scientific and Industrial Research.

3.The entrepreneurial premium is estimated as the residual of price difference excluding transport, storage and spoilage costs.

producer price and profitability. The transport costs approach tends to underestimate benefits because the actual increases of producer prices are significantly higher. Consequently, producer supply response is going to be much greater than predicted by the existing model. Most economists would estimate supply responses as the product of the increase in profitability and the supply elasticity of the product. Thus, the greater price and profit increases, the higher the production response if supply elasticities remain unchanged. Therefore, the increase in agricultural value added will be underestimated by the traditional model. Postevaluation studies of rural roads in the developing world have indicated the actual development impact (increase in value added) to be significantly larger than expected in feasibility studies. This result is only true if there are no other constraints such as shortage of public transport or official policy constraints. The transaction costs approach should be used to estimate agriculture benefits of new rural roads. Reports from field extension agents contacted noted that adoption of high-yielding varieties (HYV) tends to be higher along the roads and, in fact, varies with the quality of roads. According to Agricultural Extension Service officials in one upazilla (i.e., county), HYV adoption for Aman crop was 80 percent along good bitumen roads (allowing a 1-km-wide influence on each side), whereas it was 40 percent along bad herringbone brick roads. The overall adoption rate for the upazilla was only between 25 and 30 percent.

The development impact is pronounced only for the first good road into an area and the transaction costs model should only be applied in those cases. In all other cases, the consumer surplus model should be used.

This study demonstrates the comparative results from using both models on a rural road in Bangladesh. The results indicate that the transaction costs approach demonstrates significantly higher benefits than the transport costs savings approach.

Financial Prices Versus Economic Prices

Relative profitability is a measure of private returns to farmers. Analysis of relative profitability has to be carried out in financial prices. Changes in cropping pattern will be affected by private returns. However, the impact of this cropping change will have to be assessed in economic prices to provide a measure of the return to society. The transaction costs models presented previously can be used to distinguish between financial and economic prices.

Among the three components of price differences between accessible and less accessible areas in the transaction costs model, two—direct transport costs and loss because of product perishability—represent both financial and economic costs in their totality, that is, these are costs both to individuals and to society. On the other hand, entrepreneurial overhead contains three elements: value of the entrepreneur's time, a risk premium, and excess monopoly profits because of restricted entry into the market. Of these elements, only the last can be considered a genuine loss to society—an economic cost as well as a financial cost. Thus, the savings in economic prices with and without transport improvements will include transport cost savings, product loss savings because of perishability, and monopoly profit.

Restated differently, the savings in economic prices because of improved access will be the savings in financial prices less the sum of the risk premium and the value of the entrepreneur's time. Risk premium rises with difficulty of access and product perishability. Therefore, it is reasonable to postulate a directly proportional relationship between the elements. The value of the risk premium will be assessed to be half the residual of the entrepreneurial overhead.

From the total savings estimated, the cost of extension services and the transport subsidy provided to fertilizer must be deducted. This deduction is calculated at 1 percent of the total costs per unit of land. This percentage is reasonably high in view of the fact that in the conversion to economic prices some items such as labor should be shadow-priced downward. The extra use of different inputs for the higher-yielding crops is already reflected in the production costs.

Application of the Two Models to Estimate Increases in Value Added

The relative returns presented in Table 2 are in financial prices. Values in financial prices are important in determining the change in cropping pattern because that is a private decision. For this study, an assessment of the relative profitability of different crops was done on the basis of budget data provided by the agricultural research stations and in discussions with extension service officials. The greatest change occurred for tomatoes, cabbage, and cauliflower, whereas the lowest increase was for crops such as Kaun (a variety of millet). As a group, the least affected is pulses followed by oilseeds.

Negative returns for spinach-type products is immaterial because without good transport such leafy vegetables are grown only for the farmer's own consumption. The highest returns, both in the traditional approach and transaction costs approach, tend to be for vegetables. However, the area planted with these crops and other high-profit crops such as pulses remains small for reasons previously discussed. Table 3 presents gross value per acre and per ton for different crops in economic prices. These data will be required to compute value added by the road improvement.

Increases in profitability with improved access are shown as percentages in Table 2 for crops for both methods. Increases in profitability will induce changes in agriculture production.

The key factors, assumed to underlie the cropping decision, are

- Relative profitability in financial prices,
- Easy and reliable supply of inputs,
- Availability of extension services assistance to help overcome the aversion of small holders, and
- Dietary constraints.

Using the transaction costs model, relative profitability undergoes a sweeping change. Thus, farmers with a surplus to market (or with the potential to generate a surplus) make a switch to planting the more profitable crops (vegetables) while keeping in mind the various dietary and cultural constraints. Dietary preferences are important even to surplus farmers because the market demand would be significantly higher for the preferred items and fear of market saturation would be limited. Profitability increases will induce a shift to more profitable but nontraditional crops such as vegetables or potatoes. Surplus farmers will respond to the changes in relative profitability by taking a two-pronged approach to hedge against risks. More intensive cultivation of traditional crops such as rice will occur. In addition, the farmers will also plant the riskier, though much more profitable, nontraditional crops such as potatoes and vegetables.

Relative profitability is not as important an issue in the view of subsistence and below-subsistence farmers because they do not have any surplus to market. Yet improved access does affect their production cost through cheaper and more readily available inputs. It becomes easier and less risky for them to undertake the planting of high-yielding crops. At the same time, the agricultural extension service is better able to service the more accessible farmers. The combination of these factors induces a shift in cropping patterns by subsistence, below-subsistence, and near-subsistence farmers. However,

TABLE 2 PROFITABILITY OF DIFFERENT CROPS WITH AND WITHOUT IMPROVED ACCESS—BANGLADESH TAKAS IN 1988 PRICES

Crop	Market Price with Bad Access	Expected Farmgate Prices Good Access: Excluding Monopoly Premium	Expected Farmgate Prices Good Access: Including Monopoly Premium	Average Yields per Acre	Production Cost: Costs/ Acre	Production Cost: Costs/ Ton	Profitablity per Ton: Bad Access	Profitablity per Ton: Good Access Exc. Premium	Profitablity per Ton: Good Access Inc. Premium	Percent Increase in Profitability with Good Access: Exc. Premium	Percent Increase in Profitability with Good Access: Inc. Premium
A. Cereals											
1.Rice											
- Aman High Yielding	5,000	5,106	5,303	1.8	3,644	2,024	2,976	3,081	3,278	3.5%	10.2%
- Aman Local	5,000	5,106	5,303	0.5	2,024	4,048	952	1,058	1,255	11.1%	31.8%
- Boro High Yielding	5,000	5,106	5,303	2.0	4,858	2,429	2,571	2,677	2,874	4.1%	11.8%
- Boro Local	5,000	5,106	5,303	0.7	2,834	4,049	951	1,057	1,254	11.1%	31.8%
- Aus Local	4,500	4,605	4,803	0.4	1,215	3,038	1,463	1,568	1,765	7.2%	20.7%
- Aus High Yielding	4,500	4,605	4,803	1.2	3,239	2,699	1,801	1,906	2,103	5.8%	16.8%
2.Wheat	5,500	5,606	5,803	1.2	3,239	2,699	2,801	2,907	3,104	3.8%	10.8%
3.Kaun	2,500	2,603	2,802	0.3	506	1,687	813	916	1,115	12.7%	37.1%
B. Pulses											
1.Mungbeans	17,400	17,518	17,759	0.4	486	1,215	16,185	16,303	16,544	0.7%	2.2%
2.Blackgram	14,400	14,515	14,758	0.4	486	1,215	13,185	13,300	13,543	0.9%	2.7%
3.Lentil	17,400	17,518	17,759	0.6	810	1,350	16,050	16,168	16,409	0.7%	2.2%
4.Chick Pea	11,400	11,512	11,756	0.7	810	1,157	10,243	10,355	10,599	1.1%	3.5%
C.Oilseeds											
1.Mustard	9,400	9,510	9,755	0.6	2,024	3,373	6,027	6,137	6,382	1.8%	5.9%
2.Groundnuts	11,400	11,512	11,756	0.8	3,644	4,555	6,845	6,957	7,201	1.6%	5.2%
D.Vegetables											
1.Potato High Yielding	3,200	3,420	3,710	6.1	8,907	1,460	1,740	1,960	2,250	12.6%	29.3%
2.Potato Local	3,700	3,935	4,218	4.0	7,287	1,822	1,878	2,113	2,396	12.5%	27.6%
3.Brinjal	2,100	2,350	2,675	4.0	4,049	1,012	1,088	1,338	1,663	23.0%	52.9%
4.Cauliflower	3,600	4,200	4,600	8.1	10,121	1,250	2,350	2,950	3,350	25.5%	42.5%
5.Cabbage	2,800	3,300	3,650	12.1	10,121	836	1,964	2,464	2,814	25.5%	43.3%
6.Tomato	1,000	2,000	2,500	12.1	6,073	502	498	1,498	1,998	200.8%	301.1%
7.Radish	1,250	1,410	1,705	8.1	4,049	500	750	910	1,205	21.3%	60.7%
8.Spinach	500	1,200	1,600	2.0	2,024	1,012	(512)	188	588	36.7%	114.8%
E.Spices											
1.Onions	9,350	9,530	9,765	4.0	3,239	810	8,540	8,720	8,955	2.1%	4.9%
2.Garlic	11,350	11,546	11,773	3.2	2,834	886	10,464	10,660	10,887	1.9%	4.0%
3.Ginger	14,000	14,220	14,610	6.1	4,049	664	13,336	13,556	13,946	1.6%	4.6%
4.Turmeric	4,350	4,490	4,745	10.1	3,239	321	4,029	4,169	4,424	3.5%	9.8%

Notes:

1.The price excluding the monopoly premium would be the price with improved access using the transport economics approach to estimating increases in agriculture value added. The price including the premium is the one predicted by the transaction costs approach. The transaction costs suggests that not only is the transport, storage and spoilage, cost saving transferred to the farmer but also all of the trader's monopoly premium due to increased competition among them.

most of the shift is expected to focus on expanded production of staples. Therefore, in Bangladesh that shift is most likely to be marked by an increase in output of traditional crops, such as rice and potatoes, through more intensive methods of production.

This supply response can be expressed in a parameter by the price elasticity of supply. Price elasticities can be estimated from either time series data or from cross section data. Time series estimates are more appropriate for showing responses over time. In addition, it may be difficult to estimate from cross section data when real farmgate prices do not vary significantly. For this study, the estimates used were selected from various existing estimates for Bangladesh and are based on planning commission data. The elasticities are presented in Table 4. On the basis of these elasticities and the expected increases in prices, the expected percentage increase in pro-

TABLE 3 ECONOMIC RETURNS PER TON AND PER HECTARE FOR DIFFERENT CROPS—BANGLADESH TAKAS IN 1988 PRICES

Crop	Average Yields per Acre	Production Costs: Financial Prices Costs/ Acre	Financial Prices Costs/ Ton	Economic Prices Costs/ Acre	Economic Prices Costs/ Ton	Value Added(GVA) Economic Prices GVA/ Acre	GVA/ Ton
A. Cereals							
1.Rice							
- Aman High Yielding	1.8	3,644	2,024	3,680	2,045	6,220	3,455
- Aman Local	0.5	2,024	4,048	2,044	4,088	706	1,412
- Boro High Yielding	2.0	4,858	2,429	4,907	2,453	6,093	3,047
- Boro Local	0.7	2,834	4,049	2,862	4,089	988	1,411
- Aus Local	0.4	1,215	3,038	1,227	3,068	773	1,932
- Aus High Yielding	1.2	3,239	2,699	3,271	2,726	2,729	2,274
2.Wheat	1.2	3,239	2,699	3,271	2,726	3,929	3,274
3.Kaun	0.3	506	1,687	511	1,704	389	1,296
B. Pulses							
1.Mungbeans	0.4	486	1,215	491	1,227	6,709	16,773
2.Blackgram	0.4	486	1,215	491	1,227	5,509	13,773
3.Lentil	0.6	810	1,350	818	1,364	9,982	16,637
4.Chick Pea	0.7	810	1,157	818	1,169	7,582	10,831
C.Oilseeds							
1.Mustard	0.6	2,024	3,373	2,044	3,407	3,956	6,593
2.Groundnuts	0.8	3,644	4,555	3,680	4,601	5,920	7,399
D.Vegetables							
1.Potato High Yielding	6.1	8,907	1,460	8,996	1,475	15,404	2,525
2.Potato Local	4.0	7,287	1,822	7,360	1,840	10,640	2,660
3.Brinjal	4.0	4,049	1,012	4,089	1,022	7,911	1,978
4.Cauliflower	8.1	10,121	1,250	10,222	1,262	30,278	3,738
5.Cabbage	12.1	10,121	836	10,222	845	38,178	3,155
6.Tomato	12.1	6,073	502	6,134	507	30,166	2,493
7.Radish	8.1	4,049	500	4,089	505	12,111	1,495
8.Spinach	2.0	2,024	1,012	2,044	1,022	1,956	978
9.Winter Vegetable Composite(1)	5.4	4,191	895	4,232	904	10,532	1,846
E.Spices							
1.Onions	4.0	3,239	810	3,271	818	36,729	9,182
2.Garlic	3.2	2,834	886	2,862	894	35,538	11,106
3.Ginger	6.1	4,049	664	4,089	670	87,411	14,330
4.Turmeric	10.1	3,239	321	3,271	324	47,229	4,676

Notes:

1. The composite winter vegetable is constructed from cropping patterns for the district as found in the agriculture census. The composite is necessary because the zone of influence data is estimated from upazilla data which reports winter vegetables as one category.
2. Economic costs allow for government overhead such as extension services, irrigation etc.. Economic prices are national prices.

TABLE 4 EXPECTED INCREASE IN PRODUCTION OF DIFFERENT CROPS WITH IMPROVED ACCESS—BANGLADESH TAKAS IN 1988 PRICES

Crop	Percent Increase in Profitability with Good Access: Exc. Premium	Inc. Premium	Price Elasticity of Supply	Expected Increase in Production with Good Access: Exc. Premium	Inc. Premium
A. Cereals					
1.Rice					
- Aman High Yielding	3.5%	10.2%	0.20	0.7%	2.0%
- Aman Local	11.1%	31.8%	0.20	2.2%	6.4%
- Boro High Yielding	4.1%	11.8%	0.20	0.8%	2.4%
- Boro Local	11.1%	31.8%	0.20	2.2%	6.4%
- Aus Local	7.2%	20.7%	0.20	1.4%	4.1%
- Aus High Yielding	5.8%	16.8%	0.20	1.2%	3.4%
2.Wheat	3.8%	10.8%	0.20	0.8%	2.2%
3.Kaun	12.7%	37.1%	0.00	0.0%	0.0%
B. Pulses					
1.Mungbeans	0.7%	2.2%	0.10	0.1%	0.2%
2.Blackgram	0.9%	2.7%	0.10	0.1%	0.3%
3.Lentil	0.7%	2.2%	0.10	0.1%	0.2%
4.Chick Pea	1.1%	3.5%	0.10	0.1%	0.3%
C.Oilseeds					
1.Mustard	1.8%	5.9%	0.10	0.2%	0.6%
2.Groundnuts	1.6%	5.2%	0.10	0.2%	0.5%
D.Vegetables					
1.Potato High Yielding	12.6%	29.3%	0.20	2.5%	5.9%
2.Potato Local	12.5%	27.6%	0.20	2.5%	5.5%
3.Brinjal	23.0%	52.9%	0.30	6.9%	15.9%
4.Cauliflower	25.5%	42.5%	0.30	7.7%	12.8%
5.Cabbage	25.5%	43.3%	0.30	7.6%	13.0%
6.Tomato	200.8%	301.1%	0.30	60.2%	90.3%
7.Radish	21.3%	60.7%	0.30	6.4%	18.2%
8.Spinach	36.7%	114.8%	0.30	11.0%	34.5%
E.Spices					
1.Onions	2.1%	4.9%	0.05	0.1%	0.2%
2.Garlic	1.9%	4.0%	0.05	0.1%	0.2%
3.Ginger	1.6%	4.6%	0.05	0.1%	0.2%
4.Turmeric	3.5%	9.8%	0.05	0.2%	0.5%

Notes:
1.The quantity response is the product of the percent increase in profitability and the price elasticity of supply. The elasticities are taken from various studies and are on the conservative side.

duction can be estimated. The actual volume of increase depends on the present characteristics of the zone of influence.

TESTING THE MODEL ON A SAMPLE ROAD

The road chosen for this analysis is located in Thakurgaon district, which is located in the northwest part of Bangladesh, is 18 km long, and connects a growth center, Ramnahat, with district headquarters. The area to be served by the road is an agricultural surplus area, and road development would result in increased farmgate prices. However, if the area had been an agricultural deficit area, improved access would result in a decrease in the farmgate prices for which there is a shortfall. This decrease would be greater than the transport, storage, and spoilage costs alone because of increased competition among traders. Consumer surplus would increase significantly. But, at least for those products in short supply, producer surplus would be either unaffected or fall. Development benefits estimates attempt to measure the producer surplus. The average distance to be traveled on the proposed road is assumed to be about 9 km (i.e., about half the length of the road). This assumption is valid because the population is evenly distributed along the length of the road.

Basic zones of influence (ZOIs) were defined as the area extending for 2 km on each side of the road. This assumption was made on the basis of a review of similar studies carried out in Bangladesh and other countries, which showed ZOIs ranging from 2 to 6 km. The 2-km area is considered to be a conservative estimate, tending to somewhat understate the agricultural benefits of the proposed road improvements. For example, one study used a screening system with a zone of 3 to 5 km on each side of the road (*1*).

The basic ZOI was reduced in cases where the areas of influence of other roads, having standards equal to or better than the proposed improved road, overlapped with the ZOI of the Ramnahat-Thakurgaon road. Availability of railway and river transportation was not considered as a factor reducing the ZOI, because these are generally not competing modes of transport for primarily short-haul traffic carried by the feeder road.

The ZOI of the Ramnahat-Thakurgaon road covers 14,170 acres of land and serves a population of 40,589. The net land area is less than the gross cropped area because of multi-cropping. Its principal crop is Aman (or winter) rice. Next in importance is Aus (or summer) rice followed by Kaun (a form of millet). About 750 acres are planted with potatoes—both traditional varieties and high-yielding varieties. Almost 400 acres are planted with winter vegetables (see Table 5).

The model was applied using the ZOI of the sample road previously discussed. Development benefits estimated using the transaction costs model were much greater than those predicted by the development response to the transport savings model. Considering that the level of traffic is low on most feeder roads before they are upgraded, the consumer surplus component of benefits would not be much.

Total benefits obtained using the more traditional approach for estimating development benefits of the road would be too low to justify the road development given the construction costs in Bangladesh. However, using benefits from the transaction costs model, the road development would be justified.

The differences are stark. These results are obtained using strict economic theory to supply responses. Generally, most feeder road feasibility studies do not use such a strict approach with supply elasticities determining the production response. Supply elasticities assess development benefits by assuming a cropping pattern change in response to transport costs savings. Benefits estimated (or rather assumed) using this method come closer to the benefits using the transaction costs approach

TABLE 5 ESTIMATES OF INCREASES IN AGRICULTURAL VALUE ADDED ON SUBJECT ROAD—VALUES IN THOUSANDS OF BANGLADESH TAKAS IN 1988 PRICES

	Cropping Pattern Before Road Improvement		Expected Increase in Production with Good Access		Production Pattern in Tons after Road Improvement		Expected Increase in Value Added with Road Improvement ('000s Takas)	
Crop	Acres Planted	Output in tons	Exc.(1) Premium	Inc.(2) Premium	Exc.(1) Premium	Inc.(2) Premium	Exc.(1) Premium	Inc.(2) Premium
A. Cereals								
1.Rice								
- Aman High Yielding	4,352	7,834	0.7%	2.0%	7,889	7,993	191.9	27615.8
- Aman Local	6,586	3,293	2.2%	6.4%	3,366	3,502	103.1	4945.4
- Boro High Yielding	304	608	0.8%	2.4%	613	622	15.2	1896.2
- Boro Local	13	8	2.2%	6.4%	8	8	0.2	11.7
- Aus Local	2,087	835	1.4%	4.1%	847	869	23.2	1679.5
- Aus High Yielding	744	893	1.2%	3.4%	903	923	23.7	2098.4
2.Kaun	1,767	530	0.0%	0.0%	530	530	0.0	687.0
B.Vegetables								
1.Potato High Yielding	390	2,379	2.5%	5.9%	2,439	2,518	151.9	6359.1
2.Potato Local	388	1,552	2.5%	5.5%	1,591	1,638	103.3	4355.7
3.Winter Vegetables	372	1,934	12.5%	26.5%	2,176	2,446	446.7	4515.5
Total Increases in Value Added With Road Improvement							1059.2	54164.3
Length of Selected Road		18 kms						
Population in Zone of Influence		40,589						
Increases in Value Added per Kilometer (in Thousands of Takas)							58.8	3009.1
Increases in Value Added per Person (in Takas)							26	1,334

Notes:

1. Excluding monopoly premium refers to the case where the only increase in farmgate prices is the savings in transport, storage and spoilage costs due to road improvement.
2. Including the monopoly premium refers to the case when the increase in farmgate prices includes also the eliminated monopoly premium received by traders due to greater competition in addition to those savings in transport, storage and spoilage costs.

rather than the strict transport costs savings approach. However, in order to reach that point the logic of economic analysis would have to be abandoned and the response would have to be assumed even though economic theory would indicate that the response depends on the proportionate change in prices and the underlying price elasticities. The assumed changes, although being closer to what actually happens, do imply price elasticities of supply several times greater than unity, thus violating most findings that the price elasticity of supply for food products tends to be significantly less than unity.

This study provides the theoretical rationale for the development benefits assumed in most rural road feasibility studies. It bridges the gap between economic theory and the large development benefits that are not only assumed in such studies, but also are actually observed after the road is built.

CONCLUSIONS

The transaction costs model provides a way to bridge the gap between what is observed in most cases during studies of rural feeder roads and what actually happens. Theory suggests that the benefits to producers are because of transport costs savings. However, applying that model strictly to the benefits estimated would be much less than actually observed or estimated in most postevaluation exercises. Price differences between areas with good access and areas with poor access tend to be greater than transport, storage, and spoilage costs. The transaction costs model starts from this reality and provides a theoretical framework for estimating development benefits, which come much closer to the observed reality in postevaluation studies.

Most economists working on road feasibility studies come closer to calculating the benefits estimated by the transaction costs model than those predicted by the model they are actually using. Economists assume the production response to transport costs savings. Their assumptions are closer to reality, but they imply underlying price elasticities of supply several times greater than unity. Most studies of supply price elasticities of agricultural products in developing countries tend to show these elasticities to be less than unity (in fact, even lower for the more common crops).

The transaction costs model described eliminates such theoretical absurdities. This model provides economists working on rural road feasibility studies with a theoretical framework for estimating the benefits that they have generally known to be closer to reality than those estimated by strictly using present theory. This framework enables these economists to depart from the need to assume the benefits and to stay within the confines of economic theory.

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Transportation and Economic Development in Botswana: A Case Study

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The transport sector in Botswana has played an important role in economic growth in the 23 years following independence. The country has been fortunate in discovering natural resources to finance economic developments, and sound policies have ensured that the transport sector grew at an affordable pace commensurate with demands for services. The system of national planning and project appraisals, major historical developments in transport, and policies that have evolved to encourage future growth are highlighted.

Botswana is a landlocked country in southern Africa surrounded by Namibia in the west and northwest, Zambia and Zimbabwe in the north and northeast, and the Republic of South Africa on its remaining borders. A map of the country is shown in Figure 1. The country has a relatively large area of 582,000 km^2; however, the Kgalagari desert constitutes 75 percent of the land mass and is largely uninhabitable. In 1986, Botswana's population was estimated at 1.13 million, but it is growing rapidly at 3.7 percent per year. The majority of the people live in settlements along a north-south axis in the east of the country, adjacent to the desert. In this population belt are four centers classified as urban areas of which the capital Gaborone is the largest, with a population of approximately 125,000 people.

In 1966, Botswana had a pastoral and agricultural economy that was at subsistence levels. Per capita income was less than $100. Employment in the public sector was minimal, industrial activity was almost absent, and educational facilities were poor. An insignificant number of citizens had graduated from universities. Such was the degree of neglect that for decades before its independence the Bechuanaland Protectorate had been administered from outside its borders—from Mafikeng in the Republic of South Africa.

The situation in the transportation sector was no different. A railway ran through the country and functioned as a link in the southern African rail network. The railway was used mainly by traffic between South Africa and the Rhodesias (Zimbabwe and Zambia) and the Belgian Congo (Zaire). Airfields were few and air services were minimal. One statistic drastically illustrates the paucity in the transportation infrastructure and capabilities—there were only 12 km of tarred roads in the entire country at the time of independence in 1966.

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Transportation projects were oriented toward meeting the commercial and political interests of their owners. Because all of the owners were foreigners, they had no incentive to develop transportation in Botswana to assist in the country's development. The country's geographical and economic situation, dispersed population, poor transportation infrastructure, and overwhelming dependence on neighboring states for transportation services made it imperative that Botswana develop the transport sector. Transportation was recognized as a service sector, that acted only as a catalyst and was rarely the prime mover of growth. Nevertheless, improvements in transportation were seen as prerequisites to stable population growth and balanced economic development.

PLANNING IN BOTSWANA

National Development Plans

Botswana adopted comprehensive national development planning to meet the aspirations of its people because the demand for investments always exceeded the financial and human resources available. Planning methods have been chosen that can establish priorities for directing the limited resources toward the most productive and efficient projects. Because Botswana has been a staunch proponent of democratic values, comprehensive consultations have been an essential feature of the process in evolving successive national development plans (NDPs), each running for 6 years. NDPs are first debated and approved by the nation's parliament, and later during a detailed midterm review of each plan a similar process of consultation and approval by the legislature is conducted. Consultation is a traditional practice used to make decisions on important issues affecting the community. One of the reasons behind the success of development planning in Botswana is that it reflects such norms of Botswana culture.

NDPs are initiated by the government through a major macroeconomic review that examines the state of the economy, potential impact of international and domestic developments during the plan period, availability of critical resources, and constraints affecting growth. The review indicates the possible framework for the plan and also highlights major policy issues. Studies on each sector of the economy are also prepared and together with the macroeconomic review are considered within the government and by the public. Ministers and members of parliament frequently discuss NDPs with villagers at Kgotla meetings to ensure that their views on

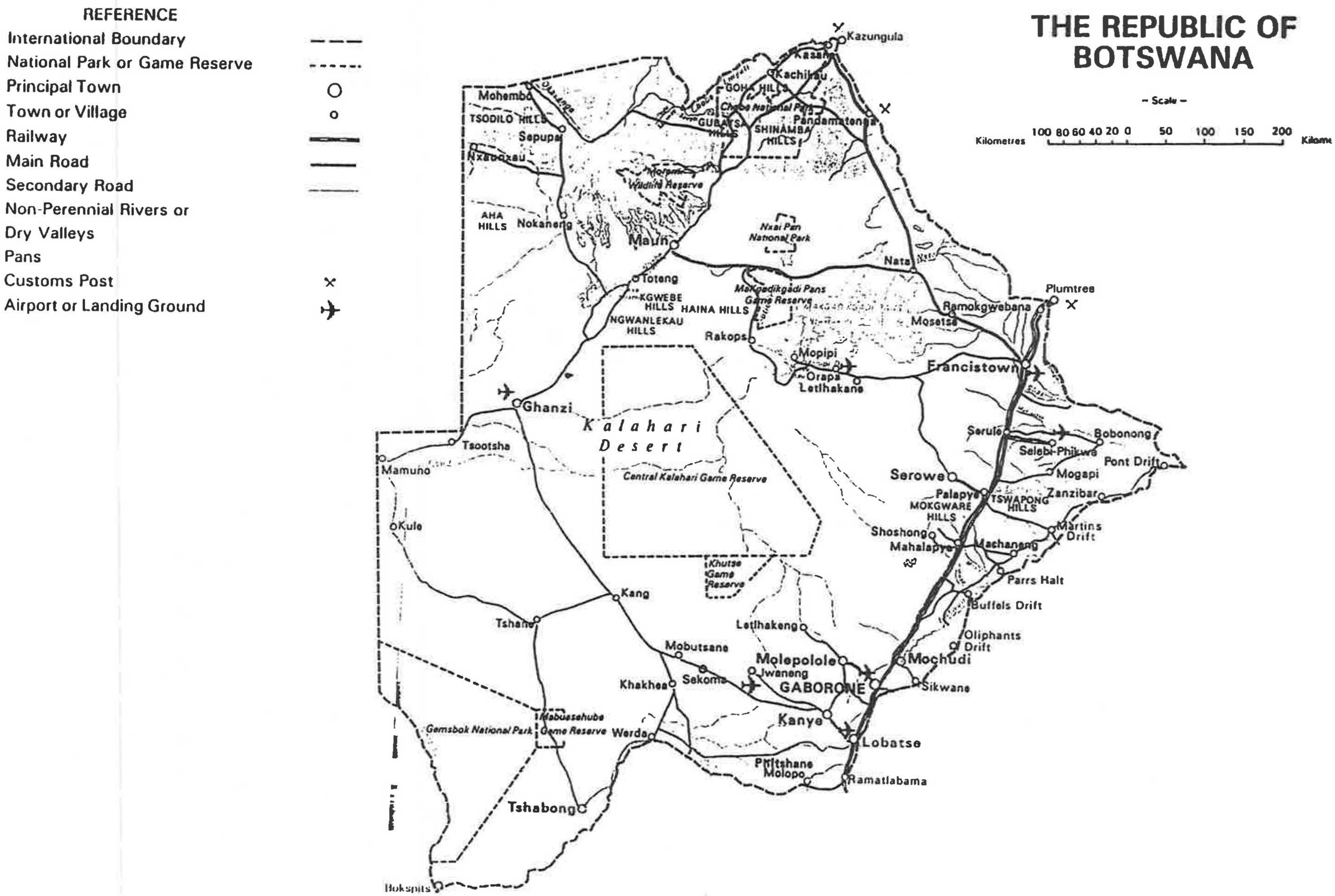

FIGURE 1 Map of Republic of Botswana.

projects are ascertained and incorporated into the plan. A consensus then emerges on a program of investments and projects. After the NDP is approved, annual implementation plans are developed to cover its lifetime. Planning is coordinated by the Ministry of Finance and Development Planning, which sends officers to other ministries to assist in developing their sectoral plans. Frequent consultations between planners and between more senior levels of permanent secretaries and ministers ensure that plans are evolved and implemented after considering all viewpoints and with the commitment of all people concerned. Botswana's guiding principles in planned development are

- Rapid economic growth,
- Social justice,
- Economic independence, and
- Sustained development.

All development projects are formulated on these four principles and wherever possible also cater to the themes of job creation and rural development.

Project Appraisals

Projects and other economic activities are undertaken by Botswana that can be afforded and justified. Every project is subjected to rigorous economic analysis that considers all costs and benefits over the project's lifetime to ascertain its net present value and whether the internal rate of return is satisfactory. Such analyses include checks on the sensitivity of projects to variations in basic assumptions. The analyses indicate optimal choices between alternatives and permit different projects to be ranked when funds are insufficient and priorities have to be established. Normally, all quantifiable and nonquantifiable factors are addressed including social and environmental aspects where applicable. Projects also go through a cycle of studies to examine their feasibility, followed by a detailed design and an updated economic appraisal, and ending with a review after the project has been implemented. Considerable use is made of microcomputers at various stages of project analysis.

Botswana receives financial assistance for projects from a wide spectrum of bilateral and multilateral agencies and always attempts to meet their technical investment criteria. Often, project appraisals by these agencies constitute a second view of projects. Botswana government officials try to prevent such reviews from unduly delaying project implementation, but these officials consider it better to invest wisely and correctly than to inadvertently commit errors by hurrying matters. An additional aspect of project implementation is the commitment of government funds for future operating, maintenance, and replacement costs.

TRANSPORT DEVELOPMENTS SINCE 1966

Within the framework of the NDPs, the government has always set aside at least 15 to 20 percent of annual investments for the transport sector, reflecting its importance in the overall economy. Further, in most years, transportation has received more investments than any other sector in the national economy with the proportion of total funds committed often exceeding the percentages mentioned.

In the first two decades following independence, investments in transportation mainly consisted of building infrastructure although the government did acquire a fleet of vehicles for its own operations. Of the three modes—rail, road, and air—government investments were not made in railways because the railway was owned by Rhodesia Railways Ltd., a company based in Southern Rhodesia. However, Botswana did construct low-standard branch lines to Morupule and Selebi Phikwe in 1972 that made the establishment of a coal mine and nickel smelter feasible. Existing airfields were improved, but air transportation was not given priority in the early years. Therefore, the majority of projects undertaken were the construction of new roads.

Government policy for developing the road infrastructure was aimed at striking a balance between major road construction and the improvement and upgrading of roads serving rural areas. The major thrust was centered on establishing an axial, paved road running through the populated eastern side of the country linking Botswana with its southern and northern neighbors and on building spurs from this road to settlements. International links with Zambia were strategically important in the difficult period of Rhodesia's unilateral declaration of independence. Following Zimbabwe's independence in 1980 and the formation of the Southern African Development Coordination Conference (Angola, Botswana, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia, and Zimbabwe), paved road links with Zimbabwe and Zambia took on added importance in providing improved transportation routes to facilitate trade and as alternative routes in the event international sanctions were imposed against the Republic of South Africa resulting in a South African border closure. The result of this road building program was that Botswana's road network in mid-1989 had increased to approximately 2 400 km of paved and 2 200 km of engineered, gravel roads.

Certain infrastructure projects were undertaken as essential components of developments in the mining sector such as the branch railway lines already discussed. In addition, two connecting roads were built to appropriate standards from the eastern highway to the mining towns of Orapa and Jwaneng in 1970 and 1980, respectively. Without these transportation investments, the exploitation of minerals at these locations would have become more expensive and less profitable for the country. Continuing this trend, Botswana Railways (BR) is constructing a 175-km branch line from Francistown to Sua Pan that will assist in exporting about 700 000 metric tons of soda ash and salt each year. This railway line is expected to greatly assist in making BR profitable within 2 years. Although the justification for these specific roads and railways was the particular mining projects they served, there have been spinoffs to the economy from the completed infrastructure that were envisioned but not completely quantified during project appraisals. For example, the road to Jwaneng is the first stage of the link to the western settlement of Gantsi and thereafter to Namibia, a project now being studied. The branch railway for the nickel smelter at Selebi Phikwe has encouraged other industrial activity and the development of the settlement as an urban center.

In 1974, the Botswana government decided to nationalize the railway to integrate it with the national mainstream to help in development of the country. However, the policy was difficult to implement without Rhodesia's whole-hearted agreement, which was not forthcoming. Other more pressing demands also got higher priority. The independence of Zimbabwe gave this project a push and the takeover was finally achieved in 1987. As a result, considerable investments have been made during the last 6 years on purchasing the railway, rehabilitating tracks, establishing maintenance facilities, installing communications and train control systems, procuring rolling stock, and training employees. The government takeover and expenditures together with the Sua Pan branch line has led to the creation of a sound rail transport sector in Botswana.

The end of the second decade following independence also saw the establishment of a major international airport at Gaborone (the Sir Seretse Khama Airport, opened in 1984). As envisioned, the facility has led to increased direct regional and intercontinental air links, providing a boost to tourism and business activities. In addition, the government decided to establish a national airline in the early 1980s. After a study and with some considerable deliberation, a decision was made to revamp national and regional air services by additional investments in Air Botswana. From 1987 to 1989, maintenance facilities were established and new planes purchased, which considerably increased Botswana's civil aviation capabilities.

TRANSPORTATION POLICY FRAMEWORK

Need for Policies

At every stage in the last two decades, transportation investments were made that were required for either strategic or developmental reasons. Timing for these projects was closely coordinated with actual transportation needs and availability of funds. During this period, the lean financial situation reinforced a conservative, pragmatic approach to making investments. Only recently has Botswana had considerable surpluses from the export of minerals. However, these accumulated reserves are not being squandered, but are being carefully managed to be used to develop productive sectors that could generate future growth in the economy.

The priority in the past two decades has been to establish infrastructure; in this the nation has been largely successful. Although considerable infrastructure has still to be developed, the major, initial tasks are complete or under way. Now that all the transport modes have started developing and are under Botswana's control, coordinated intermodal policies are necessary to get the best out of the existing infrastructure. A policy framework has been evolved, the primary objective of which is to enunciate principles that will provide appropriate, safe, efficient, and cost-effective services in the sector, so that transport can aid the development process in the country.

Government's Role in Infrastructure and Investment

The government already plays a major role in the transportation sector by virtue of its policy of assuming responsibility for its infrastructure. With a few exceptions, all major investments in infrastructure have been the government's responsibility. The sparsely populated terrain, desert and topographical conditions (flat land but high drainage requirements to deal with flash floods), as well as a shortage of good natural construction materials, combine to make the provision of infrastructure technically difficult in Botswana and expensive in per capita terms. For practical considerations, it is sensible to continue with the existing policy on the provision of infrastructure.

In the exceptional cases in which infrastructure is built by private organizations for public use, the standards of design and construction will need to be approved by the relevant government authority. Because vast sums have been spent on developing infrastructure, it would not be prudent to allow privately owned transportation infrastructure to be constructed for private use, when existing transportation networks could be more intensively used or expanded economically to accommodate additional traffic.

The policy on further development of infrastructure will be to consider projects on the basis of economic justification with particular consideration of nonquantifiable strategic and social factors in individual cases, including environmental aspects. However, this approach must be tempered by the macroeconomic resource scenario as reflected in the midterm review of the current NDP, in which the potential for significant growth in revenues from mineral developments must be considered to have reached a plateau. This consideration and the nationwide shortage of skilled manpower are the limitations within which successive NDPs will set global priorities and indicate the resources available for individual sectors, including transportation.

The mosaic of investment projects will also develop from the roles visualized for each transportation mode and the linkages between various modes. The modes themselves will have corporate plans (if they are corporations) or indicative plans (if they are not) that should evolve through some degree of market research and public consultation. Presently, it is considered unlikely that the railway infrastructure will be expanded after the Sua Pan branch line is completed. For roads, the government would like to eventually complete all the international links (particularly to Namibia) and connect the district centers with an all-weather, engineered (and preferably paved) network that will be supplemented by feeder roads of appropriate standards. (Two out of 10 district headquarters do not have satisfactory access.) For civil aviation, a major airport is under construction at Kasane in the north to cater to tourists and to provide safe air access in that area. A flight information region is being established with a view to effectively control Botswana's airspace and to improve flight safety in the country. Incremental improvements to other major airfields will take place as justified by traffic volumes.

Linkages that will be considered between the modes to decide on projects will be trade-offs between options (alternative investments as well as other policy options) to get the best transport product mix within the context of available macroeconomic resources. For example, investments in road-rail container terminals could take some heavy-vehicle traffic off the roads, resulting in more intensive use of rail infrastructure and permitting the postponement of road reconstruction. Passenger transport subsidies are a policy option in some rural areas where there are problems of poor roads and isolated villages. Similarly, there is justification for a modest rural air service that would limit vehicle movements on poor roads.

Leaving aside the provision of infrastructure, government investment policies in transportation will vary in the different subsectors, depending on the characteristics of the mode, the government's share of activities in it, and the mix of policy instruments available in each case.

TRANSPORTATION OPERATIONS AND REGULATION

Botswana has a market-oriented economy because the government generally views free-market activities as an efficient method of supplying goods and services to meet demands and as a creative outlet for entrepreneurs.

The transport sectors of other developed free-market economies have reached their current state of development through a mixture of open-market activities and regulatory policies. No economies have been left free for any extended period of time to operate in an entirely laissez-faire manner. There are useful lessons to learn from this experience. Although the government appreciates the principle of competition in the market place to achieve efficiency in transportation services, it will need to intervene to avoid competition that is wasteful in resources. Sensible regulations will help nurture the transportation sector until it achieves a measure of growth and maturity and meets planning objectives. Because competition exists between modes and within some modes, the government will need to watch for destructive anticompetitive behavior. These approaches, which have evolved over the past two decades out of pragmatism and which are considered least wasteful of resources, are in between the extremes of laissez-faire policies and total state ownership. Because Botswana is a large country with a small population and limited resources, this is the sensible path to take. If pragmatism were to be replaced by extreme views in formulating policies in the sector, inefficient and high-cost transportation services would result.

Road Transport Operations and Regulations

For road transportation, the government will continue to try to influence matters through appropriate regulatory and promotional policies, but will not enter directly as a participant except for transportation on its own account. It is desirable that a healthy, indigenous, road transportation industry develop in Botswana. This objective provides an economic sector for entrepreneurial activities and job opportunities for citizens as well as for the strategic reason of developing an important transportation capability in a landlocked country. One of the aims of regulation in this subsector is to provide the means by which such an industry can develop. Presently, offshoots of large transportation companies from neighboring states dominate road transportation in the country. In 1987, regulatory measures were introduced to stem this flood and to begin the process by which domestic companies could develop and capture market shares. This process will be intensified through emphasizing citizen shareholding in the companies and the plans of these organizations to establish maintenance facilities and bases in Botswana as factors to permit entry into the industry.

Because road transportation in Botswana is closely tied to cross-border traffic (mainly imports) within the Southern African Customs Union, the serious difficulties faced by Botswanan companies in obtaining permits in the Republic of South Africa for hauling goods has been a significant deterrent to entrepreneurs. Botswana, Lesotho, and Swaziland have been jointly negotiating with the Republic of South Africa for several years for equality in cross-border traffic and equitable arrangements to regulate this traffic. Recently, progress has been made on this matter.

Besides encouraging local participation, regulations are also required for safety standards, protecting the existing infrastructure from damage, monitoring and gathering information, and for avoiding harmful or unfair competition in certain areas. Developed countries, after reaching appropriate stages of growth and maturity, have found regulatory environments in road transportation a hindrance to further growth. A quality control approach is now the favored trend in such economies. The Botswana government considers these trends will provide useful guidelines for developments in the distant future, but for some considerable time to come the areas discussed will need to be regulated.

Road passenger transport will be regulated for safety aspects, frequencies of services, and prices charged to the public. There needs to be no discussion on the desirability of ensuring safe means of transportation for people who wish to travel by road. There are, however, views that prices and frequencies of services charged should be deregulated. The main differences between Botswana's situation and that of other countries, for which such deregulation has produced benefits, lie in the dispersed population and low traffic levels prevalent in the country. Regulation of timetables and tariffs is considered by the government an appropriate method of protecting the public on long-distance routes. However, within cities only maximum tariff regulations are presently used. Consideration will be given to eventually establishing bands of fares within which operators could charge tariffs to encourage competition. The tariffs are being set using computer models of road operating costs after ascertaining actual conditions of seat occupancy on various routes. These are reviewed periodically.

Transportation in the cities is presently provided by licensed taxis and minibuses. Because of the growth in city populations in the past decade, service improvements are desirable, including elements of time-tabled services on scheduled routes and the ability to call for taxi services from cab ranks. Appropriate methods will be studied and implemented, starting with Gaborone, which has the largest problem. Improvements in city transport operations will also be facilitated by increases in road widths, divided lanes where appropriate, signaled crossings, lay-bys for public transport vehicles, lighting, and other changes. These improvements will evolve and be implemented gradually. Suitable methods will be considered to strengthen the abilities of urban authorities to deal with transportation matters.

Rail Transport Operations

For rail transport, BR is a hybrid commercial enterprise with the government having exclusive modal operating rights to avoid wasteful competition within the subsector. However, BR does not monopolize the sector and has to compete for traffic with other rail routes outside Botswana, with road transport, and even with air services. The railway is expected to improve its services and market itself aggressively to retain a proper share of the available traffic. In exceptional cases and only after careful consideration has been given to all factors, the government might rule that certain kinds of traffic move only by rail. Presently, such instructions apply to most petroleum products because the government wants to maintain high levels of petroleum stocks, which make it uneconomical to use more expensive road transport.

Marketing of rail services in Botswana was characterized by benign neglect in the period leading to the railway takeover. Reliability of train services, running block and unit trains, better information to customers about their consignments, the ability to quote competitive tariffs, and the need to orient the BR work force toward efficiency and profits are all facets of the expected improvements. In addition, BR must use two container terminals planned for Gaborone and Francistown as important aids in modernizing itself and reaching for new markets.

Air Transport Operations and Regulations

During the last four decades, civil aviation all over the world has been subjected to a regulatory framework controlled by individual states acting in concert through the International Civil Aviation Organization. As a means to share the market for international travel, the principle that sovereign states have the right to decide how their airspace should be exploited has been accepted. When properly administered by civil aviation authorities, this regulated environment has led to the development and growth of air transport markets and safe air travel facilities. In many developed countries, a stage has been reached where free-market operations can now accelerate growth better than regulation, leaving civil aviation authorities the task to set and control quality and safety in services.

In Botswana, civil aviation is in a comparatively embryonic stage and the government has opted for a regulatory system to help the industry grow. The government desires that the regulatory framework be eclectic, take into account international trends in aviation, and aim to ensure the highest possible standards of safety, efficiency, regularity, security, and economic viability in air transportation.

After several years of permitting relatively free entry into the air transport market, the government did not see positive results either in terms of cost-effective air services provided to the community or in the form of local air transport capabilities with associated local skills. Air Botswana therefore was created as a parastatal corporation and given the exclusive concession as the national air carrier for scheduled domestic and international traffic. The aim is to foster orderly growth in air transport without excluding private enterprise in the process. There are many areas in which other operators can supplement scheduled services so long as they meet the technical regulations of the government.

Because the government owns the national air carrier and also regulates the market, it is possible that conflicts of interest may occur. The guiding principle will be to give priority to national interests, the interests of the traveling public, and those of Air Botswana—in that order. No concessions will be given on matters dealing with safety and, in any case, commercial considerations will move the airline toward high safety standards. It is the government's conviction that these monitoring arrangements can work in Botswana, as they have elsewhere.

PRICING AND TAXATION IN TRANSPORT

Botswana is committed to the principle that economic activities be undertaken only when they can be paid for. Furthermore, users of services should pay for what is used and unless there are clear benefits to the economy, financial subsidies should be avoided. Subsidies must meet the test of high comparative economic and social returns before they are instituted because resources spent on the subsidies in one sector could be used productively in another.

User charges in each of the transportation subsectors will need to be set in a manner that covers marginal or avoidable costs at a minimum and to make a contribution toward meeting full costs wherever possible. The government's transportation enterprises will be expected to provide reasonable returns on the investments made with their first target being to break even financially. The market-oriented, mixed-economy approaches for transportation previously discussed will allow reasonable competition between and within modes and also permit pricing mechanisms to operate. This environment is expected to encourage efficiency and to ensure that the sector pays its way.

Profitability is particularly required in the context of developments in the mining sector, which has been the main resource base for the economy since independence. As previously discussed, the growth of revenues from mining will start tapering off soon. Other productive sectors of the economy will have to offset the revenue loss if Botswana is to continue its development at a sustainable pace. In the past, government invested in the transportation infrastructure (mainly roads) and maintained it without expecting a direct return in the form of revenues. Economic benefits were envisioned through increases in the efficiency of transportation operations or in higher levels of general economic activity resulting from the provision of the transportation services. Because of the prospect of a reduced, or at best a static, resource base, it is important that the transportation sector meet its costs. However, it is unlikely that transportation can become a major contributor to state revenues because unlike other service sectors the volume of annual transactions (turnover) is often a fraction of total investments. Profit margins are low, and high levels of taxation would inhibit appropriate growth in transportation services.

Rail Pricing

An important aspect of BR's competing effectively with others in the market is its ability to price its services correctly. Railways have traditionally charged for their services on the principle of what the traffic can bear. This practice often led to large-scale cross subsidizations as well as the pricing of transportation services well below marginal costs of operations. BR's tariffs will be set at levels that will not be below marginal costs. Thereafter, market forces will decide to what extent customers can be charged to ensure that BR recovers all its costs and also provides a return on the investment made by the government.

The government has decided that BR's full costs will include all operating expenditures, interest payments on loans, provision for future replacement of assets in a sinking fund, and provision for pensions. Assets will be revalued periodically. In this way, the state will provide the initial funds for railway services and BR must structure itself financially toward maintaining the organization as a profitable concern. It is envisioned that after the initial refurbishment the government will not need to provide funds for replacement of assets.

In its present form, BR is not required to pay taxes because it is a governmental department. Taxation would unnecessarily increase the cost of transportation services and coupled with a relatively low traffic base and high annual fixed costs, BR would find it difficult to retain its market share. But once a degree of stability has been reached, profitability targets could be set for BR without driving away customers. As the sole shareholder, the government would be entitled to dividends from profits that may accrue.

Road User Charges

It is the aim of the government that expenditures on roads and road transportation facilities be recovered from road users. A number of options are available to facilitate this, including toll roads, taxes on fuels, license and permit fees for freight and passenger public service vehicles, and customs and excise duties on vehicles and spare parts.

Tolls would require the construction of plazas with a permanent staff for collection and to allow rapid flows of traffic through gates. The public considers tolls an inconvenience unless they are associated with limited-access highways that allow higher average speeds. It will be many years before traffic levels in Botswana justify such highways, and tolls should not be implemented until then. Taxes on fuels are easy to administer and proportionate to distances traveled (fuel consumed), but are not proportionate to vehicle weights; heavier vehicles, which cause the most damage to roads, will not pay their proportionate share. Transit vehicles, which take little fuel in Botswana, will also not pay in proportion to their economic costs. Vehicle license and permit fees are not difficult to collect and can be configured to impose proportionately higher levies on heavier vehicles. For example, flat-rate, time-based fees could act as an incentive to use vehicles more intensively. However, the government for the present will use customs duties, taxes on fuels, and vehicle license and permit fees to recover costs.

The level of such fees must, at a minimum, meet the variable costs of road maintenance. The initial steps toward implementing this policy have been taken recently, and in the process legislation has been approved that differentiates between road traffic pertaining to Botswana (internal, imports, and exports) and transit traffic. Ultimately, the government will seek to recover fixed and variable costs of maintenance and the costs of replacing roads. Although the state will provide the initial capital to build roads that are economically justified, road users should eventually pay for their maintenance and depreciation. This arrangement is also desirable because the roads' competitor, BR, is expected to provide for replacement of infrastructure as well as full maintenance costs and competition between the modes should take place in a balanced environment. At an early stage, the government will seek to ensure that transit traffic bears its full costs because with foreign companies dominating the industry the transportation of these goods adds very little to the economy of Botswana.

Further reasons for taxes on fuels include the need to find additional sources of revenue, discourage the drain of foreign exchange on a commodity in short supply, and fund improvements in the road network from a safety viewpoint. But there are obvious limits to what can be raised from this source, and these levies will not be increased to the extent of deterring entry into the road transportation industry. Similar reasons underline duties imposed on equipment used in road transportation, though under the terms of the Southern African Customs Union Agreement Botswana has limited fiscal discretion and is being compensated for this loss by revenues from the common customs union pool.

Pricing of Air Services

In the airline industry, empty seats on a plane are a lost product. Therefore, Air Botswana will seek to fill marginal seats with concessional tickets that will assist in making the airline profitable and in creating a market at the same time. For normal business travelers, the fare should recover full costs plus a profit. Conditions will be attached to concessional fares to prevent sharp reductions in the number of full-fare-paying passengers and will not be pegged below marginal operating costs. Substantial increases in revenues have been achieved in the first few months of implementing this policy.

Because the market segment of business travelers is largely inelastic to variations in price, attempts to generate profits in this segment could result in the tendency for the airline to charge very high full fares without seeking to reduce costs to become efficient. In monitoring this quasi-monopolistic situation, the government has special responsibilities to seek reasonable levels of fares from Air Botswana before approving them.

In addition, the government will seek methods of raising revenues to meet some of the costs of providing civil aviation infrastructure and services with the aim toward balancing operating and maintenance budgets. Civil aviation levies such as landing fees and charges for licenses and examinations must be in step with regional trends. Certain direct levies such as passenger taxes have been considered and will be introduced at the appropriate time. Indirect levies such as taxes on aviation fuels and charges from rentals for kiosks, advertising space, and use of other airport facilities will also be considered. However, for a long time, Botswana will not achieve traffic levels in civil aviation that can generate sufficient revenues through taxes to finance the capital or replacement costs of infrastructure, and therefore the government will not seek to recover these costs.

TRAINING AND DECENTRALIZATION

The government is committed to raising the levels of skills in the country and to training citizens to run the economy. Decentralization of skills will lead to greater job opportunities for citizens, which is a desirable goal. A spectrum of educational disciplines and skills is required by the transportation sector to achieve full decentralization particularly in engineering, economics, accounting, and administration.

In addition, training to improve skill levels must be considered an intrinsic part of operations of any industrial enterprise because this increases productivity and enhances safety. Organizations in the transportation sector are no exception. Training as a component of any activity in the sector has been, and will continue to be, emphasized by the government. For example, purchases of equipment must be accompanied by training, and expatriate officers providing technical assistance will be expected to train counterparts.

Because the transportation sector is a major user of technical manpower at different levels it has an important role to play in formal engineering training. A decade ago, the government was the pioneer in training craftsmen and technicians in the automotive sector in relation to maintaining its own vehicle fleet. At higher levels, the sector has played a role in the formative stages of engineering courses in the country. In the future, transportation organizations will provide practical training for engineering students at institutions in Botswana and will continue to influence curriculum development to obtain the manpower most appropriate to meet the sector's needs.

PROMOTIONAL POLICIES

Owing to historical and geographical factors, at the time of independence Botswana inherited a transportation sector largely controlled by foreign interests. Therefore, the policy of the government has been to promote Botswana's participation in its own transportation sector. What led to the evolution of this policy was not a mere sense of national pride but rather the need to integrate transportation with national development, transfer certain economic activities to Botswana that were undertaken elsewhere, and reduce the nation's total dependence on its neighbors. However, a paucity of resources and higher national priorities in other sectors have caused progress in this matter to be slower than desired. Additional measures need to be evolved to increase national participation in the sector in the coming years.

Establishment of a framework within which it will be possible for a Botswana road transportation industry to grow has been previously discussed. However, in addition, access to capital for the industry needs to be investigated. Although capital ought to be no easier for transporters to obtain than for entrepreneurs in other economic activities, the present conditions for borrowing funds are probably more stringent for transportation activities. Lack of skills at various levels in citizen road hauling firms is a major impediment to their growth. It is necessary to consider methods by which such firms can improve their capabilities, particularly at management levels. The government will encourage such activities.

A particular service that the government wants to foster is essential transportation in rural areas. Several areas of the country suffer from poor transportation facilities because of the existence of dispersed small villages served by poor-quality roads. Available traffic volumes and the passenger tariffs that can be charged prevent operators from offering viable services. Until the road network expands and replaces the sand tracks existing in the remote areas, operating costs cannot be reduced. If operators charge passengers more in rural areas to make up their losses, the very people who need support will be penalized further. This situation provides the rationale for the rural bus subsidy scheme whereby operators who run weekly return and mail service to selected destinations will be subsidized for every bus-kilometer traveled, depending on road conditions and seat occupancy for each route. The scheme has recently been reviewed and the subsidies will be periodically updated using computer models.

It is also government policy to encourage citizen contractors in construction activities, including road construction and maintenance. Without compromising quality, financial guarantee requirements are reduced for such firms and assistance will be provided to help them learn the skills of tendering, controlling projects, and monitoring costs. Certain activities are also reserved for citizen firms as an inducement for them to enter the field.

A specific promotional policy in civil aviation is to develop rural air services. A nucleus of destinations will be connected in southern and western Botswana that are not properly served by other transportation modes. Essential scheduled services will be provided through subcontracted charters so that costs can be kept low and services can be withdrawn with minimal exposure if they are not well patronized. The services will feed into the existing Air Botswana network.

INTERMODAL ISSUES

Containers have introduced a new element in transportation making it possible to move goods securely and rapidly using several linked modes of transportation with acceptable levels of total costs. Botswana has been largely left out of the benefits this revolution has produced mainly because container-handling facilities in the country are minimal, resulting in a forced dependence on the container-handling capabilities of neighboring states. As a corollary, road transportation is presently the main mode for small customers to move containers to their premises. Coupled with permit restrictions in the Republic of South Africa, this lack has resulted in the transportation of containers being dominated by foreign road haulers. The government seeks to change this situation and transfer a proportion of this activity to the Botswana economy. Containerization is also perceived as a potential growth area in Botswana both for its overseas and regional trade and to facilitate modal transfers in the country between railheads and places like Maun to which the paved road network is expanding. The government has decided to construct two container terminals at Gaborone and Francistown that will be serviced by road and rail modes and will be common user facilities. These facilities will also provide Botswana with flexibility in routing its external trade in the event of problems with South African routes. Additionally, these terminals will facilitate the introduction of through-bills of lading for Botswana cargoes by shipping lines.

As mentioned previously, the government does not intend to resort to regulation or taxation to encourage particular modal choices among transportation users. Exceptions to this principle will occur when economic considerations (and ecological ones in the future) clearly lead the government to a different modal choice than that made by a transportation user from a narrower perspective. Government will also intervene in the case of emergencies and where national interests are of overriding importance.

For passenger transport, the government would like the different modes to supplement one another. The modes are not competing for traffic to destinations that are only connected by roads and do not have rail services or airports. But where the modes compete, market forces should decide the best product mix that should emerge on the basis of the preference of travelers and their reaction to prices. Although agencies of the government currently set prices for the modes, the various services offered are meant for different target groups. The principle that tariffs should not be below marginal costs will bring considerable efficiency into these arrangements.

CONCLUSIONS

The framework of policies and planning perspectives within which Botswana's transport sector has grown from a negligible size to a size at which it has considerable capabilities has been described. By using rational methods of developing this service sector according to demands, the future development of transportation in Botswana will continue to provide a catalytic effect on the country's economic development.

ACKNOWLEDGMENT

The authors would like to thank the government of Botswana and, in particular, the Permanent Secretary, Ministry of Works, Transport, and Communications, for permission to write this paper and for encouragement.

SECTION 5

Case Studies of Modal Investment Impacts

Economic Impacts of Aviation on North Central Texas

JULIE K. P. DUNBAR

The North Central Texas Council of Governments has evaluated economic impacts of the North Central Texas airport system, which includes more than 40 public-use airports. A representative sample of these airports included 23 existing airports and 4 new or proposed airports. Direct, indirect, and induced economic impacts were estimated to determine the total economic impact of the 23 existing airports. The economic impacts of these airports on their surrounding communities were determined, including the numbers of jobs attributable to the airports. Forecasts were then developed of the economic benefits that might be expected from existing and proposed airports by the year 2010.

The North Central Texas Council of Governments (NCTCOG) is the metropolitan planning organization for the Dallas-Fort Worth metropolitan area. The entire North Central Texas region consists of the 16 counties including and surrounding Dallas-Fort Worth, an area of approximately 12,800 mi^2 with a 1988 population of 4.1 million.

Since the early 1970s, NCTCOG has been responsible for the regional coordination and planning of the North Central Texas airport system, which includes more than 40 public-use airports. In an attempt to promote this airport system, NCTCOG prepared a study of the airports' economic impacts. The study was completed in December 1988.

A representative subset of the North Central Texas airport system was evaluated. The economic impacts of the Dallas-Fort Worth International Airport were determined in a separate effort by the airport as part of a recent update to the airport's master plan. Airports of similar size are frequently the subject of economic impact studies. The main purpose of the effort by NCTCOG was to measure the economic benefits generated by the other airports in the North Central Texas region. There were five main objectives to the study:

1. To quantify the annual economic impact of 23 existing airports in the North Central Texas region,
2. To determine the extent to which the communities surrounding each airport benefit from the airport's activities,
3. To determine the number of jobs attributable to each airport and estimate the number of individuals in the region whose jobs are directly or indirectly dependent on these airports,
4. To estimate the probable economic impacts of four new or proposed airports, and
5. To forecast the economic impact of the total of 27 airports to the year 2010.

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Figure 1 shows the location of all of the airports included in the analysis. A wide variety of sizes and capabilities is represented. The airports range from Dallas Love Field, which has a substantial amount of air carrier activity as well as a full range of general aviation (GA) services, to small, privately owned airfields such as Bourland Field or Hicks Airfield. Seven of the 27 airports are privately owned, public-use airports. This variation in size and capability is one of the unique characteristics of the analysis and is indicated by Table 1, which presents the based aircraft and operations associated with each of the airports.

The study took over 1 year to prepare and was monitored by NCTCOG's Air Transportation Technical Advisory Committee (ATTAC). ATTAC's members represent all facets of aviation in the North Central Texas region, including municipal airports, private airports, air carrier airports, airlines, the aviation industry, the U.S. Air Force, and FAA. ATTAC developed the study objectives and reviewed the process and results in accordance with those objectives. This type of committee review structure helped eliminate many of the biases that are often suspected in studies of this nature.

METHODOLOGY

The basic methodology used to estimate the economic impacts of the airports is consistent with that advocated by FAA (*1*). The methodology is an impact approach, not a transportation benefits approach. In other words, it is not the efficiencies of air travel that are explored, but rather the contributions of these local airports in terms of jobs and dollars in the region's economy.

Three different types of impact were estimated to determine the total economic impact for the 23 existing airports in the Dallas-Fort Worth region:

- Direct impacts,
- Indirect impacts, and
- Induced impacts.

Direct impacts typically occur at the airport and are the provision of some type of aviation service. Indirect impacts most frequently occur at locations in the region that are away from the airport. Air passenger expenditures on entertainment and accommodations are examples of indirect impacts. This category also included the expenditures of large, aviation-related industries that were located on or near an airport but could not be considered completely airport dependent. These impacts were referred to as industrial development impacts and included

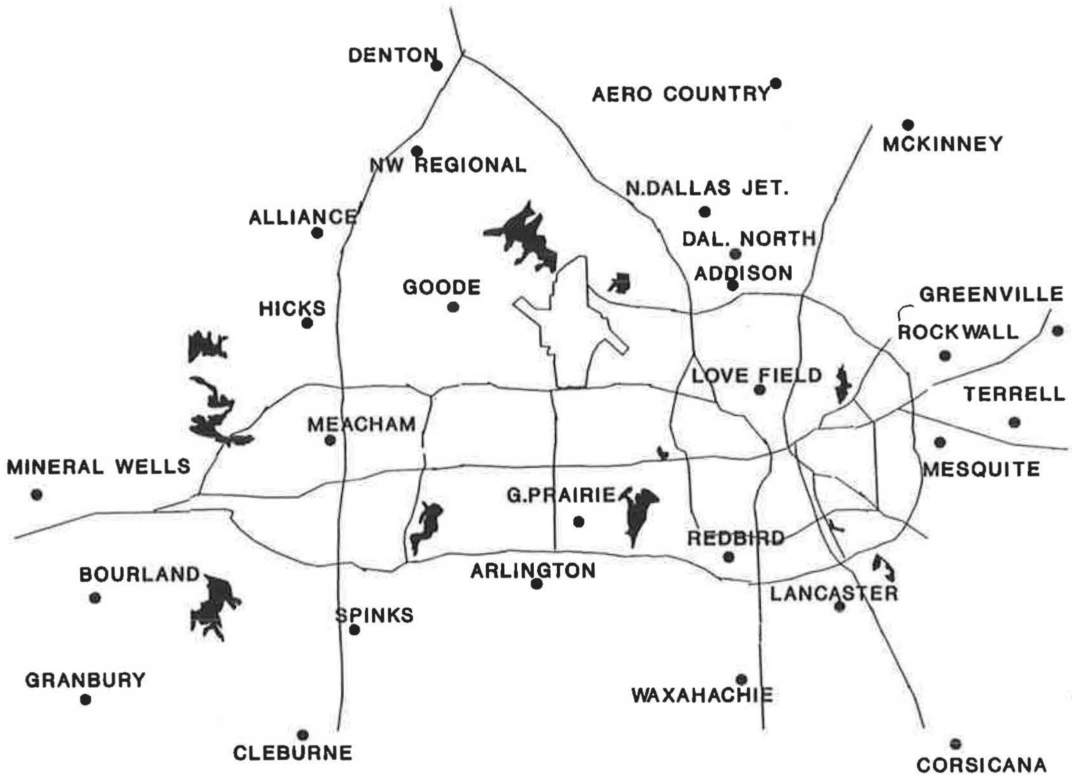

FIGURE 1 **Airports included in the NCTCOG economic impact analysis.**

TABLE 1 BASED AIRCRAFT AND OPERATIONS FOR NORTH CENTRAL TEXAS AIRPORTS IN 1987 AND 2010

AIRPORT	BASED AIRCRAFT 1987	BASED AIRCRAFT 2010	ANNUAL AIRCRAFT OPERATIONS 1987	ANNUAL AIRCRAFT OPERATIONS 2010
Addison Municipal	750	966	169,250	241,500
Aero Country	90	146	40,360	65,000
Alliance	n/a	110	n/a	44,000
Arlington Municipal	263	370	266,300	300,000
Bourland Field	83	108	16,500	27,000
Cleburne Municipal	94	142	15,000	28,400
Corsicana Municipal	48	65	22,920	26,000
Dallas North	123	169	61,500	67,600
Denton Municipal	135	247	115,500	140,000
Goode	110	147	25,000	32,000
Granbury Municipal	40	154	16,000	77,000
Grand Prairie Municipal	291	401	204,000	251,000
Greenville Majors	36	56	77,000	90,000
Hicks Airfield	91	130	12,500	20,000
Lancaster Municipal	110	136	55,100	68,000
Love Field	494	622	226,225	301,000
McKinney Municipal	81	300	63,800	135,000
Meacham Field	375	453	310,402	362,400
Mineral Wells	45	59	20,400	23,600
North Dallas Jetport	n/a	50	n/a	12,500
Northwest Regional	425	462	57,600	62,600
Phil Hudson/ Mesquite Municipal	135	213	n/a 67,500	106,500
Redbird	185	236	148,000	188,800
Rockwall Municipal	90	153	51,000	76,500
Spinks	n/a	147	n/a	73,500
Terrell Municipal	112	142	52,930	71,000
Waxahachie Midlothian	n/a	130	n/a	65,000
TOTAL	4,206	6,314	2,094,787	2,955,900

Data prepared for NCTCOG by Wilbur Smith Associates.

a few non-aviation-related businesses that leased space at an airport.

Induced impacts represent the multiplier effect of the direct and indirect impacts that results when direct and indirect impacts represent net increases in final demand. For example, assume an aircraft maintenance worker is paid $300 per week. Approximately $100 of this salary goes toward his monthly apartment rent. The landlord of the apartment then takes $50 of the $100 and hires a lawn care business to maintain the apartment grounds. The lawn care business then uses $20 of the $50 to pay a part-time employee, and so on.

In this example, the initial $300 is considered a direct impact of the airport; the other transactions represent the multiple impacts of the $300 on other sectors of the economy. In this study, the multiplier impacts were estimated using the Regional Input-Output Modeling System (RIMS–II), calibrated for the 16-county North Central Texas region by the U.S. Department of Commerce (*2*).

Figure 2 shows the relationship of the direct, indirect, and induced impacts and lists examples of each.

SURVEY AND DATA COLLECTION EFFORT

To produce reliable current-year (1987) impact estimates, an extensive amount of data was collected for the 23 existing airports. The following steps were performed to obtain the desired level of data.

Airport Data Request Form

An Airport Data Request form was mailed to the airport managers of the 23 airports. The form was sent with an introduction to the project to encourage cooperation. It included questions concerning the airport's activity levels, types of services, number of jobs, expenses and revenues, and types of related businesses (both on and off the airport). Questions concerning future development at the airport were also included to assist in the forecast phase of the study. A 100 percent response rate was obtained from these forms.

Airport Visits

Each airport was visited by a member of the study team to verify the information on the Airport Data Request form and to learn more about the economic viability of each facility.

Participating Firms Survey

A list of firms was developed from the Airport Data Request forms. The firms included either provided some type of aviation service, were a major user of the airport, or both. The study team attempted to conduct personal interviews with representatives of each targeted firm. When personal interviews were not possible, the surveys were mailed and followed up by a telephone call. A 100 percent response rate was obtained at most of the airports.

Field Work—Consistency Check

To ensure consistency in the data collected by the various members of the study team, a checklist was developed listing the key items needed from each airport. These items ranged from tenant lists and fuel sales to the number of itinerant

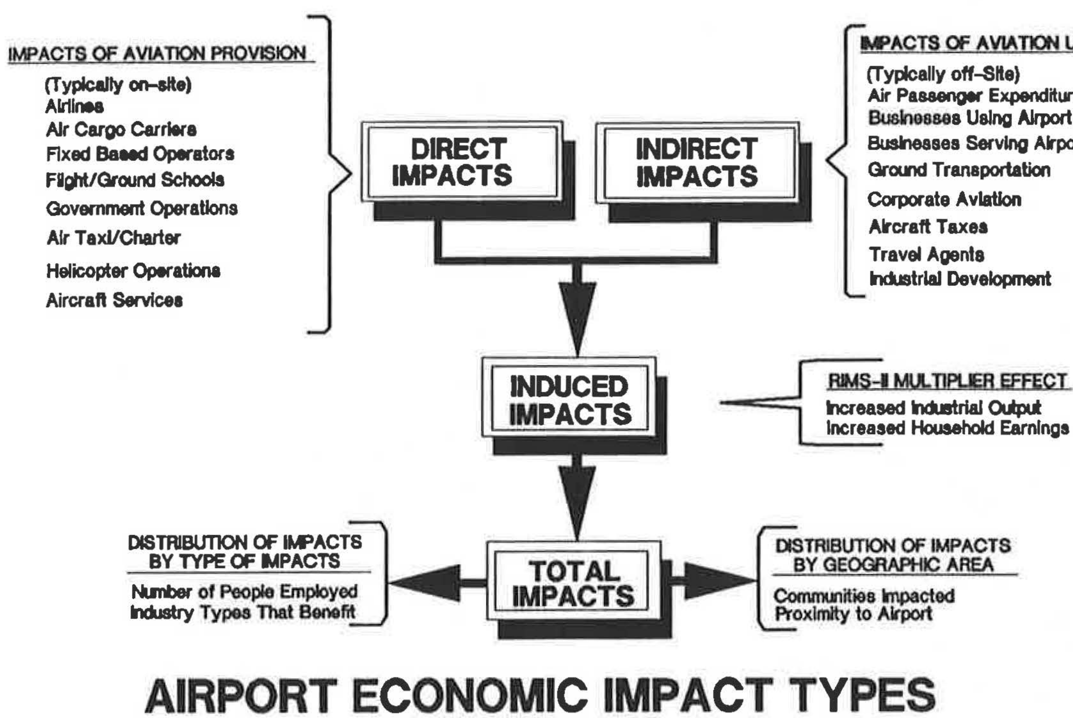

FIGURE 2 Impact relationships (data prepared for NCTCOG by Wilbur Smith Associates).

operations. This checklist helped eliminate any potential bias introduced by having different team members gather the data.

Air Passenger Surveys

Because air passenger expenditures are a key component in the estimation of indirect impacts, air passenger surveys were conducted at three of the airports. Dallas Love Field was the only airport in the study that had air carrier activity; therefore, a survey of the air carrier passengers was performed there. Two representative GA airports, Addison Municipal and Arlington Municipal, were surveyed to estimate GA passenger expenditures. It was not possible to survey the GA passengers at all of the airports, so the information obtained from the surveys at the Addison and Arlington airports was applied to the others.

ESTIMATION OF BASE-YEAR (1987) IMPACTS

To obtain accurate and reasonable estimates of each airport's economic impact, the base-year data base needed to be extensive. One of the primary objectives for the study's results was to promote general aviation to the nonflying public. Because of the skepticism that exists with regard to the benefits of local airports, the base-year estimates needed to be based on reliable data.

The direct, indirect, and induced impacts of each of the 23 existing airports were determined first (see Figure 2). These impacts were then related to the surrounding communities. The jobs associated with each airport were determined as well.

Direct Impacts

For the estimation of direct impacts, the survey data obtained from the participating firms were reviewed, and each firm or activity was identified as either "airport related" or "other." Those that were determined to be airport related were used in the direct impact calculation. The other firms were either on-site airport tenants whose businesses were not related to aviation or the airport, or large aviation industries that could not be entirely attributable to the airport. As explained previously, these firms were included as indirect impacts under a special "industrial development" category.

Once the distinction between aviation related and other firms had been made, the expenditures of the airports and all aviation-related firms were summarized by three categories: payroll, capital, and expenses. The payroll category represented salaries paid to those individuals who work at the airport and live in the 16-county region. The capital category represented capital expenditures to recipients located within the region and often included payroll-type expenditures as well (to employers of construction firms, for example). The expenses category included payments for local utilities or goods and for local taxes. All of these expenditures are of economic benefit to the local 16-county region. Table 2 presents the direct impacts by category for each airport, with a regional total of $560.9 million for the base year.

Indirect Impacts

The indirect economic impacts of each of the 23 airports were divided into three categories: visitor expenditures, regional

TABLE 2 DIRECT ECONOMIC IMPACTS FOR NORTH CENTRAL TEXAS AIRPORTS IN 1987

AIRPORT	DIRECT IMPACTS Payroll	Capital	Expenses	Total
Addison Municipal	$12,500,000	$3,580,000	$11,570,000	$27,650,000
Aero Country	$35,000	$5,000	$25,000	$65,000
Arlington Municipal	$3,063,000	$4,299,000	$1,522,000	$8,884,000
Bourland Field	$130,000	$50,000	$43,400	$223,400
Cleburne Municipal	$580,000	$478,000	$175,000	$1,233,000
Corsicana Municipal	$206,000	$41,500	$156,800	$404,300
Dallas North	$235,000	$445,000	$365,000	$1,045,000
Denton Municipal	$480,800	$271,400	$474,400	$1,226,600
Goode	$60,000	$50,000	$27,000	$137,000
Granbury Municipal	$39,000	$25,000	$117,000	$181,000
Grand Prairie Municipal	$228,000	$895,000	$380,000	$1,503,000
Greenville Majors	$36,000	$10,000	$79,000	$125,000
Hicks Airfield	$432,000	$200,000	$100,000	$732,000
Lancaster Municipal	$271,300	$281,700	$202,200	$755,200
Love Field	$223,810,000	$57,770,000	$186,350,000	$467,930,000
McKinney Municipal	$244,600	$45,000	$411,000	$700,600
Meacham Field	$13,220,000	$6,170,000	$8,430,000	$27,820,000
Mineral Wells	$1,122,000	$76,500	$689,300	$1,887,800
Northwest Regional	$1,690,000	$250,000	$478,000	$2,418,000
Phil Hudson/ Mesquite Municipal	$612,000	$2,005,000	$981,000	$3,598,000
Redbird	$4,437,000	$4,041,000	$2,961,000	$11,439,000
Rockwall Municipal	$182,000	$145,000	$160,200	$487,200
Terrell Municipal	$137,000	$80,000	$239,400	$456,400
TOTAL DIRECT IMPACTS	$263,750,700	$81,214,100	$215,936,700	$560,901,500

Data prepared for NCTCOG by Wilbur Smith Associates.

expenditures, and industrial development. Visitor expenditures represented money deposited in the local economy by visitors to the region who arrived via a specific airport. Care was taken to ensure that only expenditures by people visiting the region were included. The air passenger survey data were used to estimate the number of visitors, the number of days and nights they spent in the region, and their individual level of expenditure. For those airports where air passenger surveys were not conducted, assumptions were drawn from the surveys at Addison Municipal and Arlington Municipal airports and applied to the other airports. Of the annual number of itinerant operations, 40 percent was assumed to be the number of aircraft at an airport that carry passengers, with an average of 40 percent of the visitors spending the night. The expenditures by overnight visitors were estimated at an average of $76.10 per night per person, and the daily visitor expenditures were $21.18 per day per person.

Regional expenditures represented transactions by regional airport users. This category primarily included pilots and mechanics of firms that own aircraft based at a specific airport as well as the local taxes and daily costs of those aircraft. The specific local tax rates of each airport's municipality were used.

The industrial development category represented the regional value-added impact of each firm, as estimated from the surveys. The distinction between aviation-related and other firms was maintained as described earlier. This category was included at the request of the local government representatives on ATTAC. Again, to convince the nonflying public of the impact their local airport might have, ATTAC believed it would be shortsighted not to quantify these impacts. Depending on the audience, the inclusion of these impacts could either correct the underestimation of an airport's impact or overestimate the airport's impact. For this reason, the industrial development impacts were kept separate from the total indirect impact.

For each airport, care was taken to avoid double counting. For example, if a corporation purchased fuel and aircraft parts from a fixed-based operator (FBO), the transaction was included as a direct impact for the FBO. The corporate expenditures were not counted. Table 3 presents the indirect impacts by category. The regional total for indirect impacts is $1,135 million, with 68 percent included in the industrial development category.

Induced Impacts

RIMS–II multipliers were applied to the direct and indirect impacts to obtain the induced impacts, otherwise referred to as the "multiplier effect." The multiplier traces the flow of money through the region. The larger the region, generally speaking, the longer the money tends to remain in the region, resulting in a high average multiplier. Because of the size and economic viability of the North Central Texas region, an average multiplier of 2.73 was determined. In other words, for every $1 spent on aviation, $1.73 is generated in the rest of the economy. The full set of multipliers provided by RIMS–II for the estimation of total impacts was used. The induced impact represented 62 percent of the overall regional impact for the base year. Table 4 presents the induced impacts for each of the 23 existing airports.

TABLE 3 INDIRECT ECONOMIC IMPACTS FOR NORTH CENTRAL TEXAS AIRPORTS IN 1987

	INDIRECT IMPACTS				
			Industrial Development		
AIRPORT	Visitor Expenditures	Regional Expenditures	Aviation Related	Other	Total
Addison Municipal	$11,186,800	$21,527,200		$20,313,000	$53,027,00
Aero Country	$65,100	$37,200			$102,30
Arlington Municipal	$4,108,100	$503,300	$87,989,000	$125,000	$92,725,40
Bourland Field	$225,700	$85,800			$311,50
Cleburne Municipal	$142,300	$293,500			$435,80
Corsicana Municipal	$320,900	$147,700			$468,60
Dallas North	$854,400	$83,700			$938,10
Denton Municipal	$2,622,000	$263,500			$2,885,50
Goode	$102,500	$59,800			$162,30
Granbury Municipal	$259,400	$43,500			$302,90
Grand Prairie Municipal	$2,743,700	$630,300	$136,117,000	$177,000	$139,668,00
Greenville Majors	$593,900	$76,700	$418,705,000		$419,375,60
Hicks Airfield	$21,600	$31,300			$52,90
Lancaster Municipal	$767,500	$103,700	$2,082,000		$2,953,20
Love Field	$241,247,000	$50,572,000			$291,819,00
McKinney Municipal	$396,800	$151,900			$548,70
Meacham Field	$10,480,700	$7,150,100			$17,630,80
Mineral Wells	$93,100	$83,700	$10,209,000		$10,385,80
Northwest Regional	$83,300	$231,100			$314,40
Phil Hudson/ Mesquite Municipal	$1,898,900	$234,600			$2,133,50
Redbird	$2,107,500	$727,300		$44,502,000	$47,336,80
Rockwall Municipal	$333,500	$104,400			$437,90
Terrell Municipal	$754,800	$143,200		$50,231,000	$51,129,00
TOTAL INDIRECT IMPACTS	$281,409,500	$83,285,500	$655,102,000	$115,348,000	$1,135,145,00

Data prepared for NCTCOG by Wilbur Smith Associates.

TABLE 4 INDUCED ECONOMIC IMPACTS FOR NORTH CENTRAL TEXAS AIRPORTS IN 1987

AIRPORT	INDUCED IMPACTS
Addison Municipal	$93,549,000
Aero Country	$234,700
Arlington Municipal	$23,390,600
Bourland Field	$823,100
Cleburne Municipal	$2,694,200
Corsicana Municipal	$1,341,100
Dallas North	$3,332,900
Denton Municipal	$6,786,900
Goode	$456,700
Granbury Municipal	$753,100
Grand Prairie Municipal	$8,159,000
Greenville Majors	$1,264,400
Hicks Airfield	$1,267,100
Lancaster Municipal	$2,707,600
Love Field	$1,241,955,000
McKinney Municipal	$1,919,700
Meacham Field	$72,360,200
Mineral Wells	$3,154,400
Northwest Regional	$4,243,600
Phil Hudson/ Mesquite Municipal	$9,970,500
Redbird	$24,005,200
Rockwall Municipal	$1,525,900
Terrell Municipal	$2,131,600
TOTAL INDUCED IMPACTS	$1,508,026,500

Data prepared for NCTCOG by Wilbur Smith Associates.

Surrounding Community Impacts

It was clear that the impacts of the airports could be traced throughout the North Central Texas area. However, to make the study more useful to the local airports, the direct and indirect impacts were disaggregated to the communities near each airport using the survey information on the employees' residential locations and the places arriving passengers go when they leave each airport, as well as the geographic location of the impacted firms. This information was only an approximation of the local community impacts, but it was very useful in relating the overall airport impact to a local jurisdiction. Because so many of the airports in the Dallas-Fort Worth area are relatively close to each other, the impacts of many of the airports spilled over into the surrounding communities. Figure 3 shows an example of this spillover effect for several of the airports at the center of the Dallas-Fort Worth metropolitan area.

Airport Employment Impact

The economic impact or benefit of an airport can also be expressed through the jobs it creates. Sometimes the general public can relate better to an expression of impact in terms of jobs or employment than in terms of millions of dollars. The direct, indirect, and induced jobs were estimated, with the industrial development jobs reported separately. These employment estimates were obtained from the survey infor-

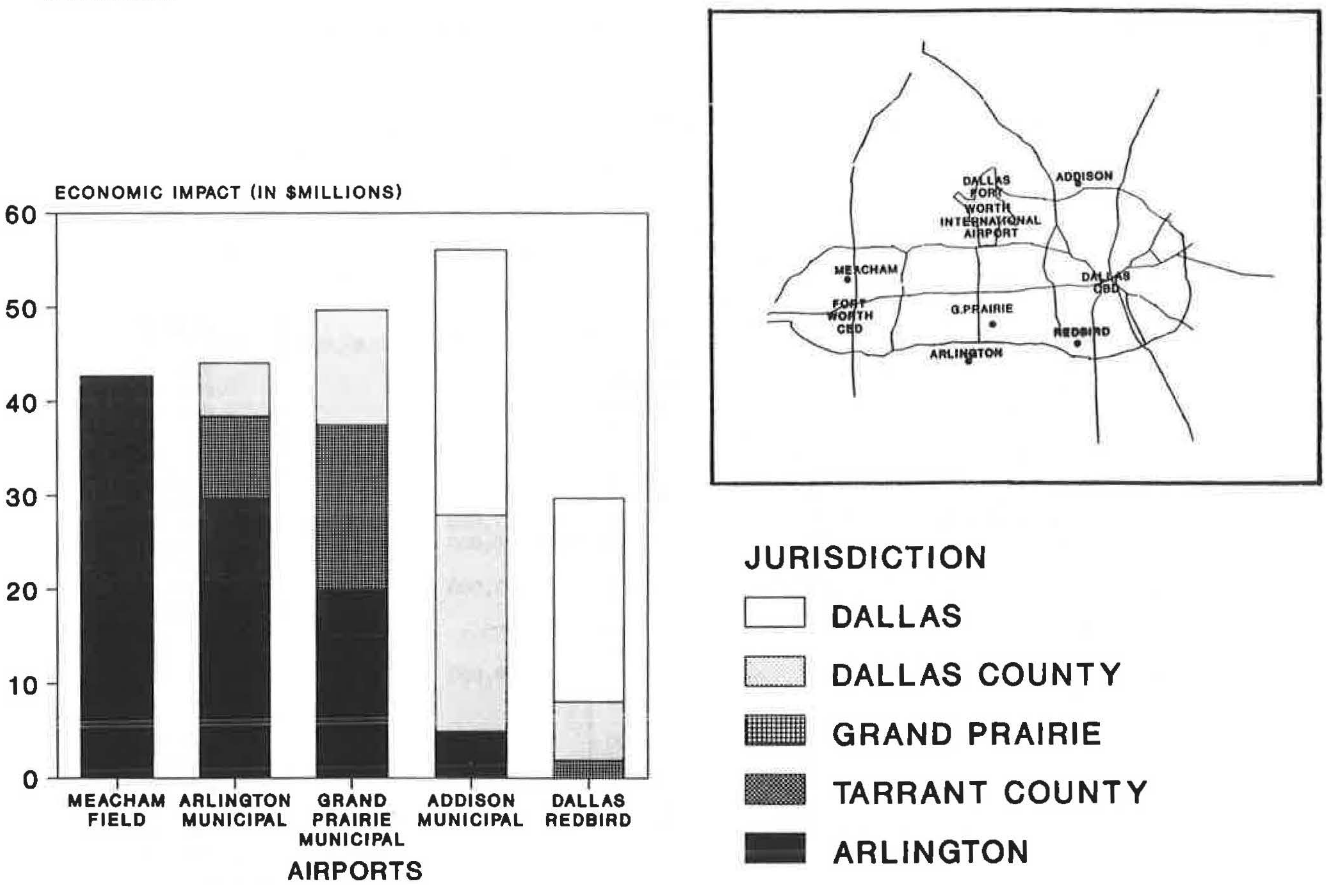

FIGURE 3 Airport impacts on local jurisdictions (data prepared for NCTCOG by Wilbur Smith Associates).

mation using the RIMS–II process. Table 5 presents these employment estimates for each airport.

ESTIMATION OF FORECAST IMPACTS

Another objective of the study was to estimate the level of economic benefit that might be expected from the airports by the year 2010. In general, the more activity an airport had, the greater the economic benefit. Future activity can be indicated by a combination of actual aviation activity in terms of based aircraft and operations or industrial development activity. Industrial development was considered too difficult to forecast, so the future activity relates only to increases in based aircraft and operations. This assumption was conservative but believed necessary to maintain the appropriate level of reliability.

Forecasts of based aircraft, annual operations, and passenger enplanements (for the air carrier facility only) were generated for the region and then allocated to the 27 airports included in the study (see Table 1). The four new airports were assumed to be in place by 2010 and the 23 existing airports were assumed to remain open.

Relationships between aviation activity and economic impact were assumed, as presented in Table 6. The impact forecasts were then developed from these relationships, taking into account the productivity changes that would occur in some categories. Table 7 presents the forecast economic impacts for each airport excluding industrial development impacts.

PRESENTATION AND USE OF STUDY RESULTS

For several years NCTCOG and the southwestern region of FAA have felt a strong need for the information provided by this study. As in many metropolitan areas, many of the local GA airports are fighting a constant battle against encroaching development and neighborhood opposition. Economic impact information can be an important component in efforts to increase the awareness of the nonflying public regarding an airport's benefit on its surroundings.

The study results can be used or interpreted in a variety of ways. Some of these are listed below:

- Comparisons Between Airports. The economic impacts of the majority of the GA airports in the North Central Texas area can be directly compared because the impacts were developed using the same methodology. Even if the absolute numbers developed to show the impacts are disputed, the relationship between airports still holds true. This comparability is especially useful in the Dallas-Fort Worth metropolitan area, where several airports often compete for tenants.
- Identification of Potential Impact. Another use of these data is by airport owners who are contemplating development. For example, if a runway extension is being considered, the owner can gain insight regarding the magnitude of impact that might be expected by reviewing the economic impacts of airports with similar characteristics. This capability might be useful for local governments that are trying to convince their elected officials of the economic viability of such an improvement.

TABLE 5 AIRPORT-RELATED EMPLOYMENT ESTIMATES FOR NORTH CENTRAL TEXAS AIRPORTS IN 1987

AIRPORT	AVIATION-RELATED JOBS	INDUSTRIAL DEVELOPMENT JOBS	Total Jobs
Addison Municipal	1,676	220	1,896
Aero Country	4		4
Arlington Municipal	447	806	1,253
Bourland Field	15		15
Cleburne Municipal	44		44
Corsicana Municipal	25		25
Dallas North	69		69
Denton Municipal	154		154
Goode	7		7
Granbury Municipal	13		13
Grand Prairie Municipal	180	1,297	1,477
Greenville Majors	29	3,900	3,929
Hicks Airfield	24		24
Lancaster Municipal	55	21	76
Love Field	24,243		24,243
McKinney Municipal	35		35
Meacham Field	1,335		1,335
Mineral Wells	50	91	141
Northwest Regional	64		64
Phil Hudson/ Mesquite Municipal	199		199
Redbird	417	613	1,030
Rockwall Municipal	27		27
Terrell Municipal	45	743	788
TOTAL JOBS	29,157	7,691	36,848

Data prepared for NCTCOG by Wilbur Smith Associates.

TABLE 6 AVIATION ACTIVITY-IMPACT RELATIONSHIP

IMPACT TYPE	ACTIVITY RELATIONSHIP	PRODUCTIVITY CHANGES
Direct Impacts:		
Payroll	Aircraft Operations	X
Capital	Aircraft Operations	
Expenses	Aircraft Operations	X
Indirect Impacts:		
Visitor Expenses	Itinerant/Visitor Operations	
Resident Expenses	Local Operations	
Corporate Aviation	Based Aircraft	
Induced Impacts	Base Year Ratio	

Data prepared for NCTCOG by Wilbur Smith Associates.

TABLE 7 FORECAST ECONOMIC IMPACTS FOR NORTH CENTRAL TEXAS AIRPORTS IN 1987 AND 2010 (EXCLUDING INDUSTRIAL DEVELOPMENT)

AIRPORT	ANNUAL AVIATION-RELATED ECONOMIC IMPACTS 1987	2010	PERCENT INCREASE
Addison Municipal	$153,913,000	$181,125,000	17.68%
Aero Country	$402,000	$649,000	61.44%
Alliance	n/a	$27,100,000	n/a
Arlington Municipal	$36,886,000	$40,500,000	9.80%
Bourland Field	$1,358,000	$2,017,000	48.53%
Cleburne Municipal	$4,363,000	$7,599,000	74.17%
Corsicana Municipal	$2,214,000	$2,671,000	20.64%
Dallas North	$5,316,000	$6,197,000	16.57%
Denton Municipal	$10,899,000	$14,700,000	34.87%
Goode	$756,000	$991,000	31.08%
Granbury Municipal	$1,237,000	$5,591,000	351.98%
Grand Prairie Municipal	$13,036,000	$16,315,000	25.15%
Greenville Majors	$2,060,000	$2,595,000	25.97%
Hicks Airfield	$2,052,000	$3,100,000	51.07%
Lancaster Municipal	$4,334,000	$6,291,000	45.15%
Love Field	$2,001,704,000	$2,478,620,000	23.83%
McKinney Municipal	$3,169,000	$9,450,000	198.20%
Meacham Field	$117,811,000	$137,535,000	16.74%
Mineral Wells	$5,219,000	$6,004,000	15.04%
North Dallas Jetport	n/a	$7,700,000	n/a
Northwest Regional	$6,976,000	$7,322,000	4.96%
Phil Hudson/			n/a
Mesquite Municipal	$15,702,000	$19,100,000	21.64%
Redbird	$38,279,000	$47,640,000	24.45%
Rockwall Municipal	$2,451,000	$4,019,000	63.97%
Spinks	n/a	$4,797,000	n/a
Terrell Municipal	$3,486,000	$5,043,000	44.66%
Waxahachie Midlothian	n/a	$4,654,000	n/a
TOTAL IMPACT	$2,433,623,000	$3,049,325,000	

Data prepared for NCTCOG by Wilbur Smith Associates.

- Enhancement of Airport System Concept. Within the Dallas-Fort Worth metropolitan area, many of the airports are close enough to each other that their impacts overlap. The allocation of economic impact to the communities surrounding each airport helps to quantify this overlap and demonstrate the interrelationship among the airports.
- Independent Data Source. Economic impact estimates are usually developed by an airport for itself. Although the input data used in this effort were mostly provided by the individual airport operators, the data were reviewed and compared in an attempt to eliminate any reporting bias. The economic impacts reported for each airport were developed in a similar manner by an independent agency, resulting in data less likely to be accused of bias toward specific airports.

To provide the survey results to the many different types of interested organizations, the data were summarized in several ways:

- Final Report. The final report contained a complete discussion of the methodology and results, including sections on each airport.
- Fact Sheet. A fact sheet was developed for initial distribution to the press. It included a summary of the total regional impacts and an indication of the types of information available.
- Individual Airport Summary. A summary of individual airports was prepared to help local government staffs demonstrate an airport's significance to elected officials and organized airport opposition (i.e., neighborhood groups).
- Visual Aids. A series of pie charts and graphs was developed for use during presentations to various local governments, chambers of commerce, and group meetings to explain the process and disseminate the impact information.

Information such as this is of no benefit if it is not properly distributed. It is equally important both to discuss the impacts themselves, in terms of jobs and dollars benefiting the local economy, and to explain how the information was obtained. A simplified explanation of the process often increases the likelihood that the information will be accepted as factual.

The timing of the release of the information is also important. When this study was conducted, the airports included in the analysis were primarily free of any controversy surrounding their continued operation. Therefore, the study was not undertaken in response to unusually strong airport opposition or other similar crises. When such information is offered to the public simply as additional knowledge, rather than in response to a challenge or dispute, it is often much more widely accepted. This sort of information should be part of a regular data base for an airport or a system of airports so that, as conflicts arise, the data cannot be accused of being adjusted to meet a specific challenge.

ACKNOWLEDGMENTS

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Transportation Factors as Catalysts for International Trade Development, Case Study: East Boston, Massachusetts

MARK R. FERRI

This case study stems from an ongoing project to demonstrate that trade and economic development could be enhanced by transportation investments. The project was initiated by a private-sector foreign trade, development, and management firm (the Consortium for International Trade and Investment). The correlation between transportation access and the viability of international trade and investment activity is examined by focusing on a case study in East Boston, Massachusetts. With an intensified push for U.S. exports, several factors should be integrated into the private-public export investment strategy—urban goods movement, international transportation features, infrastructural capacity, and the entire export transportation network. To realize the necessary catalysts for such an export trade investment strategy, both the public and private sectors must be informed, educated, and mobilized to the urgency of the problem. Creating a multifaceted solution requires the input of transportation planners, economic development specialists, governmental entities, private sector concerns, and the communities affected. Such an interactive coalition-building process is discussed and recommendations are provided.

The origins of this case study can be traced to a fall 1986 internal research memorandum of the Consortium for International Trade and Investment (CITI) that attempted to examine the relationship between urban transportation access and the viability of international trade and investment activity in Boston and the region. Using transportation access as a focus, CITI analyzed the public policy issues revolving around ground access problems at Logan Airport, including traffic, parking strain, congestion, disruption, and delay, and each issue's impact on Logan's continuing expansion, interplay between the airport and the seaport, and the airport's surrounding residential community. In addition, these factors' collective impact on the attractiveness of the Boston area as a haven for foreign trade activity and investment was examined. An unfolding backdrop and impetus for the examination of these issues was the Third Harbor Tunnel-Central Artery transportation project.

ISSUES

The 1986 CITI memorandum set out as points for discussion a list of specific issues and broader themes, asking

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- What were the adverse impacts of swollen ground access (parking, gridlock, congestion, and delay) on the airport's and seaport's connecting network in terms of its ability to transport goods and passengers domestically and worldwide?
- In what ways were neighborhood quality of life issues compromised by the presence of an expanding urban airport, and how could the operational concerns of the facility be reconciled with or integrated within a strategy that mutually benefitted the residential livability and stability concerns of the local community?
- What impact would the Third Harbor Tunnel project have on potential export-related traffic conduits?
- With knowledge that the level of foreign trade or free trade zone activity in Boston and the Massachusetts area was sluggish, to what extent could this be attributed to an export transportation network that had either failed to fully develop or was impeded in achieving its full potential?
- In light of the seemingly prolonged overhaul of its major infrastructural and transportational connections, how well is Boston poised to vie for its share of the world economy?

In the context of this case study, CITI sought to address these issues and to demonstrate the proactive role of a private-sector-initiated public partnership intended to achieve both public and private objectives. Approaches used in the study included

- Extensive field research and site visits,
- Examination of the last two decades of transportation patterns-area planning studies and airport master plans,
- Interviews with city and state public works engineers and transportation planners,
- Historical survey of both out-of-service and operational rail corridors and related corridor land use patterns and issues, and
- Inventory of compatible transportation megatrends.

Moreover, during the course of this case study an attempt was made to formulate a broad-based coalition by conducting informational, developmental, and conceptual presentations to a cross section of public and private actors including private rail carriers, freight forwarders, multimodal transportation firms, shipping associations, trade groups, small business representatives, multinational corporations, community groups, port operators, and elected officials at the local, state, and federal levels.

Seaport Versus Airport: Dynamics of Imbalance

The Port of Boston has historically played a preeminent if not dominant role as the undisputed port of New England and major eastern seaport for domestic and international commerce. Even today, its name conjures images of Yankee clipper ships and trading vessels, a veritable mecca for merchants plying their trade. These distant images, however quaint and appealing, bear little semblance to today's realities.

Such romantic notions quickly give way to sobering characterizations of Boston's port of the 1980s as a marginal seaport operation, or even as economically abandoned (*1*,*2*).

The Port of Boston can trace its relative decline to a structural flaw reflected in Boston's economic base. Because of its traditional hunger for imports, Boston, from the mid-1980s, became the first port of call for shippers. However, shippers failed to unload the bulk of their cargo in Boston because sufficient exports were not available at the port. The shippers proceeded from Boston to other ports to unload their remaining cargo and take on exports, thus contributing directly to the ascendancy of the ports of New York, Baltimore, and Hampton Roads (*3*).

Moreover, the Port of Boston's appeal was further diminished by the drop during the last 50 years in freight companies operating in the New England area. Aside from the general inadequacy and overall poor condition of existing truck and rail access to the port area, a dearth of freight companies precluded the Port of Boston from participating in the double-stack container business (*3*). These factors, along with high terminal charges and the volatility of longshoremen's labor, further dampened Boston's already slow entrance into intermodal transportation and containerization in the late 1960s and early 1970s.

However, since its inception in the mid-1960s, containerization did lead to a resurgence in the Port of Boston. The growth spurred by containerization has prompted the Massachusetts Port Authority (Massport) to continue to invest in the modernization and upgrading of its box facilities. As a means of capitalizing on New England's regional growth, Massport ordered its policy by priority of increasing container-handling capacity. The debate does not focus on the merits of containerization but instead on how rapidly Massport arrived at the decision to containerize its facilities and how effectively it deployed the resources and funds to do so.

The argument is that Massport did not move fast enough to plan for the move toward containerization of ship cargo, and this lack of aggressiveness caused the Port of Boston to lose out on the full benefits of intermodalism. Furthermore, some critics have placed the blame on Massport's piecemeal approach to a long-range plan for the development of the seaport, its refusal to cooperate with other public agencies to develop a comprehensive and coordinated transportation package complementing all modes of transport, and its lethargy in actively preparing and implementing such a plan. Massport has been roundly criticized by the shipping community for its seeming overemphasis on Logan Airport's development and expansion to the detriment and neglect of the Port of Boston.

Interestingly, Massport's stand-alone approach has evoked praise from the business community for what it collectively regards as the authority's privately run efficiency and sense of independent professionalism. However, Massport's surrounding communities construe this cavalier independence and lack of interplay with other state and local planning agencies as naked arrogance and insensitivity toward quality-of-life issues, especially in East Boston, Logan Airport's partner of strained coexistence. East Boston views the automobile and truck congestion, the blighted port lands, and the spillover and encroachment of its residential streets by airport-related service industries as a direct result of Massport's maverick operating style in virtual isolation from the governmental transportation network. Massport concedes that its staff is predominantly psychologically oriented toward Logan Airport and considers Logan and not the port as critical to the well-being of the city of Boston and the region. Thus, in a glaring paradox the 13th busiest airport overlooks one of the nation's least trafficked seaports (*1–3*).

Prelude to Conflict: Massport and the East Boston Community

Ironically, this perceived emphasis on Logan Airport and the attendant perceived insensitivity toward the East Boston community became a pivotal obstacle to Massport's East Boston seaport expansion plans as well. Following its initial foray into the containerized cargo arena in the early 1970s, an independent engineering consulting firm predicted that Massport's existing facility would soon reach overcapacity and recommended a site from a narrowed list of alternatives to allow Massport to expand its containerized operations.

Accepting this recommendation, Massport attempted to establish additional containerized facilities on a 52-acre seaport parcel in East Boston owned by Massport and abutting the East Boston community. The engineering consulting team's study had selected this site because of its available land area, deep water ports, and local rail access. However, community antipathy toward Massport's lack of consultative decision making had so embittered local residents and heightened fears of increased congestion and encroachment that East Boston mobilized to block the container terminal project. In effect, the abutting East Boston community's perception had become so galvanized against Massport's roughshod approach to airport expansion and its erosion of the community's quality of life that it was incapable of differentiating between airport and seaport development and saw only the callous hand of Massport. As such, Massport was forced to retreat to a less suitable port site at the former South Boston naval annex, a U.S. government-owned parcel, which for purposes of disbursement of surplus property, ultimately involved Massport's negotiation with federal, state, and local authorities in the mid-1970s.

The Third Harbor Tunnel and the Future of Boston's Waterfront

In its 1989 efforts to expand container capacity at this South Boston site and to reduce vehicular congestion and ameliorate access to this containerized port facility and the South Boston waterfront, the state incorporated a seaport access haul road as a component of the Third Harbor Tunnel-Central Artery project. In fact, a survey of Massachusetts infrastructure needs for the 1990s specifies this seaport access haul road as an element of improved roadway design and as an integral link for the Third Harbor Tunnel. In sharp contrast, the East Boston pier area remains vacant and underdeveloped more than 15 years after the container facility siting was blocked. Moreover, access to its deepwater ports in the form of a corresponding access road to East Boston piers is conspicuously absent from the Third Harbor Tunnel-Central Artery project agenda despite the fact that such an access road could align directly with the proposed Third Harbor Tunnel roadway network (see Figure 1).

However, the ongoing planning phases of the Third Harbor Tunnel-Central Artery project have forced a greater degree of integration of the agendas of city and state planning agencies as well as stimulating a renewed assessment of the overall transportation network for all modes. Thus, the requisite coordination demanded by the massive Third Harbor Tunnel-Central Artery project has become a focal point. In this access, infrastructural, and modal context, the East Boston pier site should be viewed for its maritime and foreign trade potential. Moreover, an ideal location because of its proximity to Logan Airport, the East Boston site represents a unique opportunity for Massport to reconcile its ongoing airport-seaport investment rivalry while integrally satisfying the economic development and quality-of-life concerns of the East Boston community.

Thus, this project case study will attempt to address the relationship between foreign trade expansion and local neighborhood economic development using the foreign trade zone and enterprise zone concepts as mechanisms and transportation and infrastructure access factors as catalysts.

SITE DESCRIPTION

Because it is considered an endangered resource by the shipping community, the 52-acre East Boston pier site represents the last reserve deepwater pier site on Boston Harbor with rail access (see Figure 2). However, although rail access is available, the approximately 40-ft-wide, 1.8-mi stretch of former Penn Central and now the East Boston section of Conrail's Grand Junction corridor has been idle for almost 20 years. Conrail maintains that should industrial commerce development become a reality on the East Boston piers then it would handle the freight service. Upgrading of this corridor would be necessary to provide truck and rail access to the pier area as an intermodal link between seaport and land distribution.

An additional component of the project provides immediate access to Logan Airport. Currently, access to Logan exists only via the elevated East Boston expressway or by local residential streets. In addition to being circuitous and time consuming, forays into the local community worsen congestion on already vehicle-swollen streets. The option to be presented provides immediate, 1-min access to Logan Airport's designated air cargo center without retracing existing routes or impinging on the community. Furthermore, the anticipated mode of conveyance between the East Boston pier site and the airport roadway network will be a people-and-goods-mover shuttle system. Such technology completely eliminates the specter of vehicular congestion and hazardous emissions while accelerating the likelihood of the site as a multimodal transfer hub.

Two abandoned tunnels stretching beneath four East Boston residential streets have the capacity to create an underground airport-seaport conduit linking Logan Airport to the East Boston pier site if they are extended approximately 80 to 100 ft. The two tunnels, former rail passageways for the narrow gauge line of the Boston, Revere Beach & Lynn Railroad were constructed between 1875 and 1894. Although now both are sealed at the East Boston pier site, the tunnels remain structurally intact, dormant since the railway's dissolution and abandonment in 1940. Thus, with minor extension construction the two tunnels—one ingress and one egress—could convey people and goods to and from Logan Airport and the East Boston pier site. Furthermore, construction of the tunnels' extension would not disrupt a single residential dwelling. The path of eventual cut and cover tunnel construction is on vacant land that once supported a railroad bridge between the port and the preairport land area. Surfacing at Logan Airport, these two tunnels could conceivably align with the existing or proposed post-Third Harbor Tunnel airport roadway system.

These two elements, the East Boston section of the Grand Junction Branch of the Conrail corridor and the rediscovered tunnels, could develop an intermodal transportation loop bordering and linking both the airport and the inner harbor port of East Boston (see Figure 3). In addition, this transportation loop would function as a cordon or buffer, redirecting port-related traffic away from local streets. This transportation network would also mesh with planned future airport access improvements and complement overall ground access. Improvements in the Conrail corridor and the tunnels would establish an intermodal truck and rail link to the seaport and a goods-and-people-mover system to the air cargo facility at Logan and the general airport terminal area while servicing the East Boston pier site.

Transportation Corridor as a Development and Management Tool

Thus, much more than a mere access loop to and from the East Boston seaport and airport via the Conrail right-of-way and the narrow gauge tunnels, this transportation access system serves as a focal point and catalyst for development. The transportation corridor concept is directly applicable to this project case study as a mechanism for transportation modal integration and as a tool for growth management. This project case study satisfies the basic criteria for the transportation corridor model by incorporating (a) the maximum right-of-way required to meet the transportation needs generated by the project population and employment growth throughout the life of the corridor plan and (b) all adjacent areas that are impacted by, and reasonably necessary to, accomplish the objectives established in the plan.

As established, the project case study is sensitive to the quality-of-life and economic development concerns of the East Boston population. East Boston was recently rated one of the poorest communities in Massachusetts. In combination with

FIGURE 1 East Boston pier site.

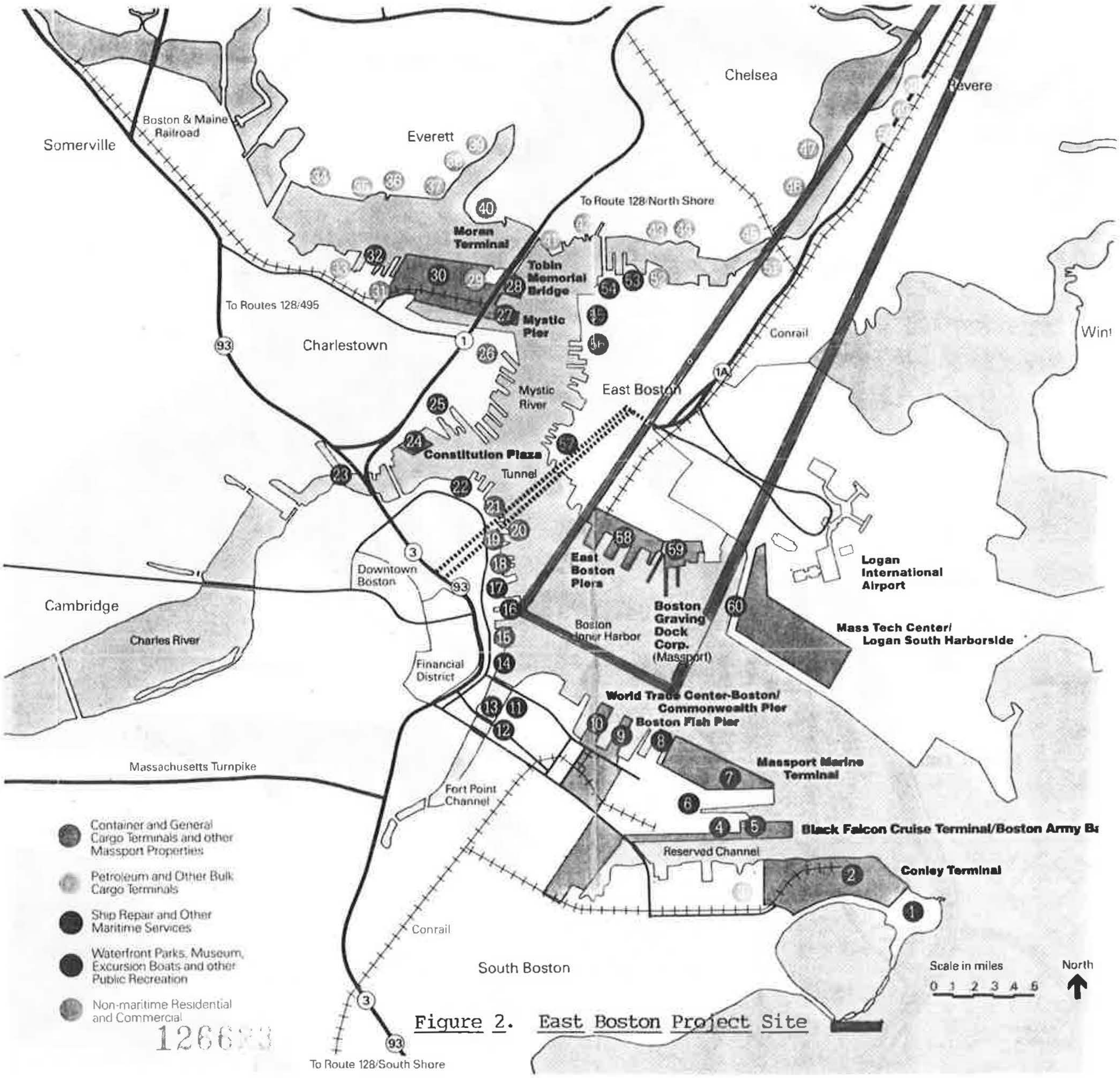
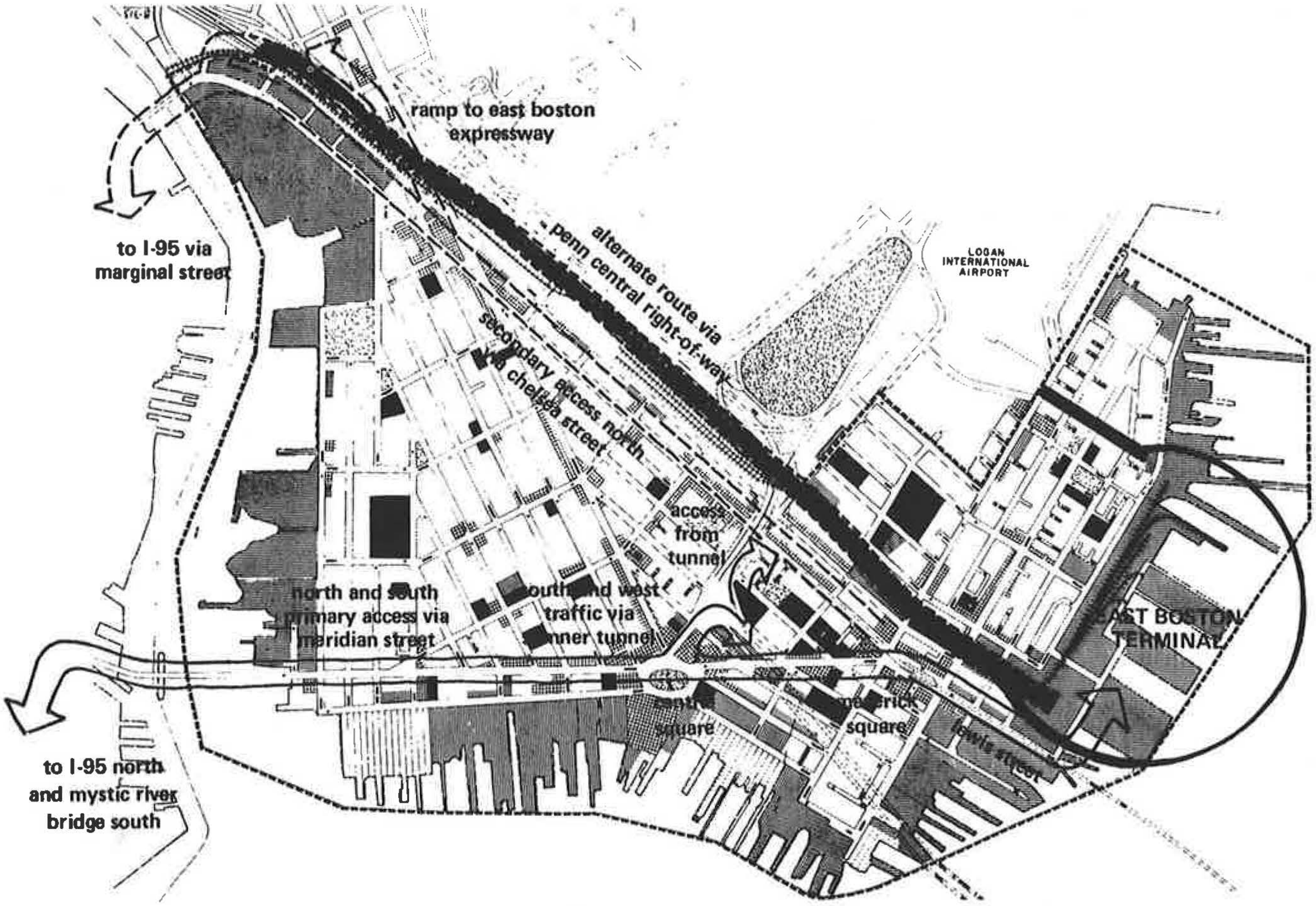


FIGURE 2 East Boston project site (Boston Shipping Association, Port of Boston Handbook 1986–1987).



East Boston Terminal: Access

FIGURE 3 Conrail corridor—narrow gauge tunnels loop.

gentrification of its neighborhoods, influx of unassimilated immigrants and transient new arrivals, flight of second- and third-generation residents to suburbia, and erosion of a sense of community, this growing disparity and lack of cohesiveness has left East Boston adrift and bankrupt of revitalization strategies and schemes for balanced urban development.

As such, the potential multimodal connector in this study presents a perfect site for joint planning and development. In geographic and functional terms much more than a highway link, the transportation corridor is a broad conceptual tool. More than the area between two points used for the movement of people and goods, each corridor is the nexus for the state's major commercial, office, and industrial needs and is the site for high-density residential development. Thus, the transportation corridor could take the form of a canal, high-speed rail line, an airport with its major access routes, or any combination of existing or proposed transportation facilities (*4*).

The transportation corridor project proposal in this way becomes the central focus for a regional growth management system by heightening the site's access to both the sea lanes and the air cargo center, integrating both the airport and the shipping community's best interests, and creating both a local community economic development asset and a working harborfront with neighborhood access and amenities.

If properly implemented, the transportation corridor concept as embodied in the project case study can achieve the following public purposes and objectives: (a) promote the development of multimodal transportation systems that integrate highways, air, mass transit, and other transportation modes; (b) promote a comprehensive transportation planning process that coordinates state, regional, and local transportation plans; (c) act as a focus for joint public-private development at major interchanges or multimodal junctures to enhance the state's economic development activity including research, technology, office, commercial, and industrial site location to promote the expansion of employment and ensure the continued growth of the state's economy; and (d) assist in the construction of infrastructure, including state and local streets and highways through fees generated by the new developments that create the need for such infrastructure.

It is obvious that our nation's infrastructure is declining at a rapid rate. In fact, Massachusetts alone predicts a transportation infrastructure obligation of over $6 billion over the next decade. However, the relationship between infrastructure, intermodalism, and economic development has yet to generate the sense of urgency required to muster bold, focused initiatives.

Infrastructure, Intermodalism, and Urban Economic Development

Although a special report by the National Governors Association (*5*) on the state of infrastructure as a prerequisite for international competitiveness stopped short of indicating a direct relationship between infrastructure, productivity, and competitiveness, the Massachusetts Institute of Technology Commission on Industrial Productivity sees a direct link between investment in the macroeconomic environment and our nation's productive-performance capacity. The commission states that "Investment in the broadest sense is crucial for productivity . . . Investment is any use of current resources for the purposes of achieving a future return . . . for example, the use of public resources to improve roads, airports, harbors, and the like" (*6*,p.35). Moreover, recent research posits a positive effect between infrastructure and economic development (*6*). The effect of capital investment as a catalyst for economic growth and transportation initiatives and interactive investments as a function of economic growth and productivity has been displayed in the "virtuous circle" (*7*).

Accepting the premise that the transportation sector is an infrastructure sector, the curve of intermodality is highlighted by the complexity of intermodalism among modes of transport, goods and persons transported, and patterns of transport and distribution (*8*). Thus, Massport's development of containerization and attempts to improve the potential for double-stack freight handling are characteristic of the intermodal reach for economies of scale. There is a direct correlation between lower transportation costs and the expanded economic activity generated through allocation of resources in the domestic economy. Growth and efficiency also contribute to a heightened international competitive position. The relevance of this research to the project case study is to demonstrate the potential benefits between infrastructural improvements and enhanced economic development.

Thus, the overt and more subtle benefits of intermodal transportation offer a range of economic opportunities especially for reducing costs and improving the marketing and distribution of goods on a domestic and an international basis. Creating efficient infrastructural access is essential for realizing the described benefits (*7,9*).

In the urban context of the project study, incidences of intermodal transfer are at their height. In the urban setting, the link between infrastructure, an intermodally conducive network, and economic development is played out (*10*). The project case study seeks to reduce bottlenecks in urban goods movement by specifying solutions to the following problem areas for trucks and other vehicles:

- Congestion of streets and sidewalks is because of on-street or over-sidewalk deliveries where off-street facilities are not available. Access via the Conrail corridor to the East Boston pier site would be restricted to truck and freight-hauling modes.
- Adverse effects on residential neighborhoods are created when local streets are used for through-truck movements. For the project case study, not even a single vehicle would encroach on local streets. Moreover, the entire access roadway will be suppressed subgrade to the extent possible and decked over as plaza areas in spots where the corridor directly abuts local residential housing units. The same holds true for the tunnels from the East Boston pier site to the air cargo terminal area. Several modes of transport—walking, shuttling, shipping, rail freight hauling, trucking, driving, and flying—are all facilitated through this operation.

Urban Goods Movement and the Export Transportation Network

The nexus between urban goods movement and economic development is not usually planned for and if included is generally less than effectively integrated. However, the bond is a mutually reinforcing one. The efficient transfer of goods between modes (motor carrier to rail link, motor carrier to air freight link, and rail and road link to seaport) can, if well located and well designed, have a beneficial effect on those business establishments engaged in both domestic and international commerce that are served by these transport facilities (*10–12*).

Conversely, the collective results of goods movement inefficiencies and bottlenecks at all levels have negative impacts on productivity and growth. Such impediments include delays in shipments because of infrastructural repairs, time-consuming traffic delays and congestion, poor rail infrastructure, congested rail yards, dilapidated or obsolete port facilities, deteriorated roads, inadequate access to distribution centers, and insufficient space for loading or unloading goods. These bottlenecks cut across transportation modes of trucking, rail freight, port operations, and air cargo. A strong relationship exists between the efficacy of goods movement, capacity of transportational and infrastructural access facilities, and ability of business to compete and provide services domestically and internationally (*10*). In addition, transportation facilities and ease of goods distribution are both pivotal factors in business and industrial site location decisions and can be competitive marketable tools for communities' economic recruitment (*12*).

This research mirrors factors and situations encountered in achieving accessibility and compatibility at the East Boston pier site. Infrastructural improvements both on the right-of-way corridor and on the twin-tube tunnels will provide the trucking and freight service required to revive the seaport and to enhance the air cargo operation.

Furthermore, airports, seaports, and other such transportation facilities are now being recognized as strategic sites, not only to shape and target economic development, but also to increase the flow of goods movement throughout the international economy. Such international transportation factors are the determinants of an effective export transportation network that can meet international freight movement requirements to service and handle a variety of foreign destinations, multiple volumes, weights, sizes, time sensitivities, and cost requirements, and that can achieve compatibility with both intermodal and multimodal transport connections (*11*).

An adequate infrastructure undergirds the nation's transportation system and sustains the efficacy of the export transportation network. Investments in maintenance and expansion of reliable infrastructure depend on the involvement of all levels of government, a strong degree of intergovernmental cooperation, and substantial input from the private sector. However, the problem remains that exports and transportation are not a conscious part of the public policy system design. The role of transportation in the export process receives lowest priority. Unfortunately, this fragmented, uncoordinated policy approach at the federal level is reenacted at the state and local levels.

Private-public partnerships, coupled with a proactive private sector role, appear to loom as remedial mechanisms for joint planning and development.

Joint Public-Private Partnerships

Massport's East Boston pier site, bordering both the Conrail right-of-way and a convenient underground access to Logan Airport, serves as an ideal site for promoting successful joint public-private partnerships. Moreover, the existing high-density, working-class residential profile of East Boston complements multimodal transport's potential for meeting the needs of the community as well as the seaport and airport work environments. Perhaps most important, the balance in such a joint public-private partnership can be struck between community-enriching economic development and the mix of social and residential amenities such as open space. Such areas provide a respite from urban sprawl and dot the busy scene with oases of urban tranquility.

Within the partnership, the public sector's role is broadened considerably from being solely a passive enforcer of codes and regulations to an initiator of potentially lucrative commercial development. The public sector would create a package of incentives for the private sector developer to renew the dilapidated urban core. Thus, as Freilich (*4*) points out, the role of government has moved from that of regulator to that of genuine partner. The government's role in facilitating the actual process of development in the project case study is also significantly enlarged. Massport can dedicate the East Boston pier site area as an enterprise zone-foreign trade zone development. Moreover, Massport can structure a bundle of financing, zoning, and permitting incentives that would provide the private sector developer with flexibility. Furthermore, Massport can act as an actual clearinghouse to attract and channel federal funds and state matching monies.

The traditional role of the private sector developer is also significantly altered within the joint public-private development process. Rather than assuming a contractor's role once the project has been designed by the public sector, the private sector developer is involved in the initial planning, designing, financing, and marketing of the project. The benefits accruing to the private developer are (a) reduction of land acquisition and site preparation costs; (b) opportunity to share expenses and risks with a public agency; (c) opportunities to capitalize on land use options created by the linkage to transportation facilities; (d) use of tax depreciation and credit allowances; (e) cooperation with the governing body in the determination of land uses, density, and processing; and (f) receipt of grant monies, tax-exempt financing, and sales and property tax abatement or exemption (*4*).

Foreign Trade Zones

Up to this point in the project case study, the interactive and mutually reinforcing catalysts of urban goods movement, transportation access, and infrastructural improvements have been discussed in the context of a joint public-private process. These elements have formed the basis for integrated, coordinated site planning. The site mechanism or program concept that best uses the transportation, infrastructure, goods movement, and economic development aspects in both domestic and international terms is the foreign trade zone (FTZ).

Put simply, an FTZ is a site within the United States designated legislatively to be an area in international commerce. Within this enclave, foreign or domestic merchandise may enter without a formal customs duty and be manipulated or processed in several ways without incurring customs or government excise taxes. If the goods leave the zone and are reexported, then no duty is paid. If the goods enter the United States, a duty is paid at the time of official entry into the United States. Thus, FTZs allow users the opportunity to defer customs duty on products or goods in the zone and realize significant duty and tax savings on processing or manufacturing of goods in the zone (*13*).

The benefits of FTZs are many and varied. FTZs facilitate a firm's global marketing and logistics by providing more flexible linkages of inflows and outflows from country to country. FTZs function as export chains allowing firms to reap the rewards of minimum production and distribution costs especially on exported goods. By using an FTZ, firms can practice just-in-time marketing when products are stored within an FTZ until a market arises for that particular product. Firms could also use FTZs as an out-sourcing strategy to allow domestic producers lower tariffs on imported goods within a zone to remain competitive with overseas production and as havens for production sharing and comanufacturing (*13,14*).

FTZs are also viewed as economic development assets in terms of job creation and capital investments and as engines of export growth and facilitators of increased international trade (*15*). In the United States, FTZs are magnets for attracting manufacturing and processing that might otherwise benefit overseas labor and for enhancing the value of port lands as well as parcels adjoining airports (*16*).

Even from this encapsulated and cursory inventory of the benefits of FTZs, it is plain to see how firms can gain in terms of transportation logistics, duty and production cost savings, and the increased flexibility of product introduction, marketing, storage, handling, and processing. Communities gain substantially by expanding indigenous employment, transferring know-how and managerial expertise, attracting foreign and domestic investment, garnering exports, and revitalizing their cohesive fabric through local job creation and training.

CONCLUSIONS AND RECOMMENDATIONS

The strategic concept of an export transportation network in an airport or seaport's overall investment strategy has to be integrally associated with the components of goods movement and its reliance on transportation access and infrastructure needs and their inextricable tie to broader economic development.

The bridge between foreign trade development and community betterment and shared economic empowerment through jobs creation, skills training, and other benefits must be actively constructed, articulated, and implemented in the context of a private-public partnership with the community as the core element.

Local, state, and federal officials must be made conscious of and accountable to the export transportation network as more than a subsidiary to the domestic transportation system. Site and access points surrounding or adjacent to airports or seaports must be strategically viewed as much more than way stations or transfer points and more as transportation and goods-processing areas.

For an urban goods movement and export transportation network to be realized, public-private export partnerships (transcending the city, state, and federal levels) must recognize the important role of international transportation factors and the indispensability of adequate infrastructure, and

- Maintain an inventory of strategic parcels (i.e., seaports, airports, industrial and enterprise areas, intermodal transportation centers, etc.) for the purposes of potential international trade development and view each such multipurpose transportation facility as an economic development resource, a strategic site for goods transfer, and a gateway to domestic and international markets;
- Actively use strategic site selection and site management techniques to enhance international trade development opportunities;
- Integrate transportation and infrastructure access factors and goods movement considerations into the planning, development, coordination, and strategic implementation of economic project initiatives; and,
- Formulate public-private ventures that highlight the relationship between international trade development and local community revitalization through jobs creation and skills training.

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Rail Line Abandonment and Public Acquisition Impacts on Economic Development

RICHARD S. TAYLOR, KENNETH L. CASAVANT, AND J. C. LENZI

Railroads are not the dominant transportation mode they once were, but they still play a large role in freight movement and are the only practical means of transport for a variety of commodities. Railroads also comprise a principal component of a community's economic development infrastructure as rail service still ranks as a prime site selection criterion for many industries. As U.S. railroads continue to restructure and reduce the size of their physical plant in an effort to reduce costs, light-density branch lines will continue to be targets for abandonment. Effects of rail line abandonment on both public and private costs in a region are evaluated. Drags on economic development in the region caused by this structural change are identified. Specifically, methodology and results of a statewide examination of the rail freight system in the state of Washington are discussed. This procedure, developed for use by the Washington Rail Development Commission, details the revenue and costs incurred for the existing Class I railroads on each branch line segment in the state. Then, for those segments where the railroads experience a revenue deficiency an analysis is presented on the public impacts of increased transportation costs to shippers and damage to roads of any decision to abandon a line segment. The need and rationale of public acquisition to retain local rail service for economic development purposes are discussed. Low traffic levels and poor track conditions typical of light-density rail lines are not going to attract for-profit railroad operators, and thus many locales may have no choice but to acquire the lines to retain them. Examples of public ownerships in Washington State are provided.

As U.S. railroads continue to restructure and reduce the size of their physical plants to reduce costs, light-density branch lines will continue to be targets for abandonment. Thus, many communities will continue to be faced with the loss of rail service. Public and private sector costs and infrastructure deterioration associated with rail line abandonments inhibit economic development. A methodology developed for use by the Washington State Rail Development Commission provides a means to measure the impacts and associated costs. Preservation of rail service can translate into benefits for local and regional economic development, the extent of which is difficult to quantify. Both current and potential impacts are considered in the following discussions.

The portion of the rail system discussed provides what has become labeled as local rail service. This label is appropriate as the concerns and impacts are indeed local. From a state perspective, transportation infrastructure requirements to retain or locate a business can be found in one part of the state or another, but the local community does not have the same selection expanse. Thus, at the local level, preserving and improving infrastructure becomes necessary.

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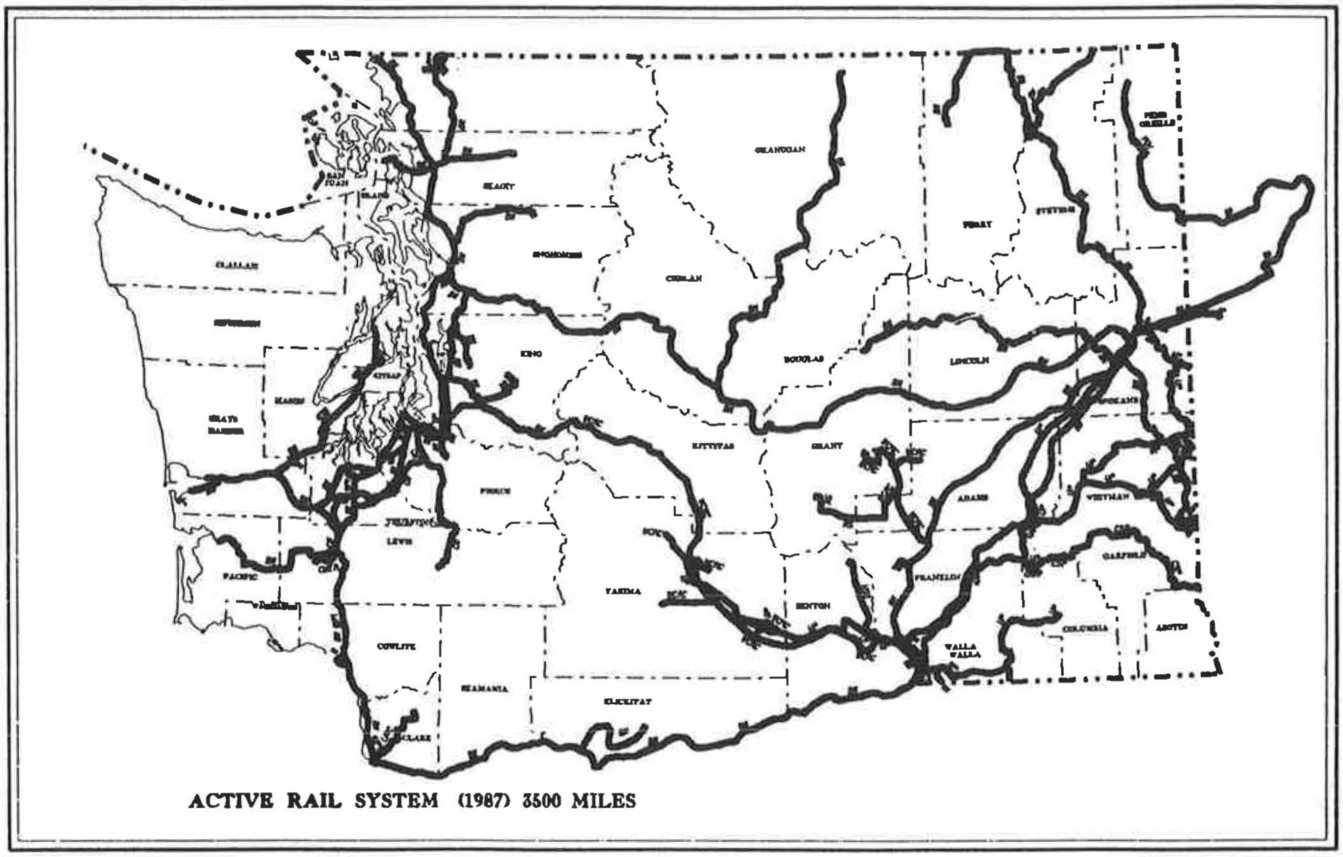
STATEWIDE LIGHT-DENSITY LINE EXAMINATION

In 1987, the Washington State legislature created the Rail Development Commission to conduct a comprehensive examination of rail freight and passenger service and to develop policy and recommendations for the state's future role and programs. The principal thrust of the rail freight effort was directed toward the state's branch or light-density line (LDL) system and consisted of a two-step approach: (a) a determination of which components of the system were likely abandonment candidates, and (b) an assessment of abandonment impacts. The Washington State rail system (see Figure 1) consists of some 3,500 route-mi, almost half of which are LDLs. The LDL mileage investigated comprised 37 lines totaling 1,462 mi owned by two Class I carriers.

The Local Rail Service Assistance Act of 1978 and its predecessors made federal funds available to states for enhancing the viability of LDLs or for mitigating the effects of abandonment of such lines. Section 803(a) of the act stated, however, that to be eligible for funds a state must have a rail plan that "includes . . . a methodology for determining the ratio of benefits to costs of projects . . ." The Washington State Department of Transportation (WSDOT) has developed appropriate state rail plans, and incorporated in each plan is a methodology that has been accepted by the Federal Railroad Administration as meeting the requirements of Section 803(a). The general WSDOT benefit-cost methodology provided the basis for the analyses. Methodologies developed for the LDL system determinations did not involve detailed examinations because of data, time, and budget constraints, and because the purpose of this particular effort was to develop policy and responsive programs, a generalized approach was deemed acceptable.

RAIL LINE REVENUES AND COSTS

First, rail lines likely to be abandoned were identified by assessing attributable revenues and costs. Lines were analyzed



SOURCE: Washington State Department of Transportation

FIGURE 1 Washington State railroads—1987.

using Interstate Commerce Commission (ICC) procedures for abandonment cases. Although the procedures contain both on- and off-branch elements, data, time, and budget constraints prohibited an assessment of off-branch costs. Thus, the procedures were modified as necessary and only on-branch elements were evaluated (*1*).

Revenues

Revenues attributable to each line were made available by one carrier and proportioned from the ICC waybill sample based on the number of cars provided by the other carrier. A similar disparity existed in carloadings. Three years of data were supplied by one, and 1 year by the other. An average volume for the 3 years was used in the former case. Estimates of on-branch revenues were made using a 25 percent division of each carrier's total revenue.

Costs

Line costs were computed according to ICC procedures as defined in Title 49, Code of Federal Regulations, Part 1152, for on-branch costs. On-branch cost elements cover train operations as well as maintenance and ownership considerations and the following were used in the analyses:

- Maintenance of way and structures (normalized),
- Maintenance of equipment,
- Transportation,
- Freight car costs,
- Return on investment from locomotives,
- Property taxes,
- Return on value, and
- Rehabilitation needs.

Cost elements, with the exception of maintenance of way and structures, property taxes, return on value, and rehabilitation, are largely a function of the level of service required to handle the traffic generated by the line. The other cost elements are a function of the line's length and physical characteristics.

Service frequency and hours of operation were estimated for each line on the basis of its traffic characteristics. Service-related costs were computed using system-average unit costs for each of the Class I carriers and the service units estimated for each line. Length and physical characteristics were determined from railroad track charts supplemented by limited field inspections. Right-of-way values and tax rates were obtained from local contacts and data from the Washington State Department of Revenues.

For analysis and need assessment purposes, costs were viewed as comprising three principal components—operating, opportunity, and rehabilitation.

Operating costs were classified as those costs associated with line operations and maintenance, more specifically crew, fuel, train supplies, locomotives (servicing, maintenance, and depreciation), freight car costs, maintenance of way and structures, and property taxes. These costs can be considered as out-of-pocket costs or the costs that have to be met to maintain day-to-day operations.

Return on value or opportunity costs reflect those costs that can be attributed to retaining ownership of an LDL as opposed to liquidating its assets and investing the proceeds elsewhere. As such, return on value represents the opportunity foregone by retaining the investment in the line. This cost considers the value (i.e., salvage or market value of the line's assets less the cost of removal and sale) of the assets of the line segment—right-of-way, track materials, and any other facilities. Estimates of the value of track materials and rights-of-way were made as previously discussed. A 14.5 percent rate of return, consistent with ICC determinations at the time, was applied to the value to derive an annual cost.

In the case of a Class I branch line operation where the cost of the investment has been retired for many years, opportunity costs can be viewed as paper costs as opposed to out-of-pocket costs. For example, if the LDL were being operated by a short line that recently acquired the line, these costs would most likely be real out-of-pocket costs in the form of debt service.

Rehabilitation needs of the state's LDL system were considered as a cost item for purposes of this analysis for the same reason opportunity costs were included—the line's operations should be earning enough to cover the associated costs. Rehabilitation costs are incurred when the physical condition of a line is substandard or not capable of handling traffic in the manner desired or required.

Rehabilitation brings the line up to the standard desired when it is retained at that level through normalized maintenance. Thus, rehabilitation costs are usually one-time expenditures. In order to place the expenditures on an annual basis for purposes of this analysis, however, they were addressed as the amount required yearly to retire a loan equal to the needs over a 10-year period at a 10 percent interest rate.

Needs estimates were prepared from railroad track charts, spot field inspection (where clarification was needed), and Washington State Utilities and Transportation Commission inspection file data. Data taken into consideration from secondary sources consisted of the weight and age of rail, and timbering and surfacing dates. All rail weights less than 100 lb were considered too light for modern day carloadings and were replaced with 100-lb material in preparing the estimates.

Analysis Results

When revenues and costs (including rehabilitation) were compared, 11 of the 37 lines evaluated (approximately one-fourth of the mileage) were estimated to cover all estimated costs, as presented in Table 1. Six other lines were estimated to generate revenues sufficient to cover all costs except rehabilitation. These lines would then become candidates for outside rehabilitation assistance. Similarly, the six lines, which failed to generate revenue adequate for return-on-value considerations, would become acquisition candidates.

Lines failing to cover even operating costs would require operating subsidies as well as other forms of assistance if rail service preservation were to be accomplished. However, these lines will most likely become abandonment candidates.

Sensitivity

Revenue-cost comparisons just discussed were also made using 20 percent increases and decreases in costs to test the sensitivity of the analysis. The 20 percent increase resulted in one additional line estimated to have a loss, whereas the 20 percent decrease in costs resulted in two more lines showing an overall profit. Thus, it was concluded the analysis was not sensitive to the levels of change tested. Given the purpose of the analysis, to determine the order-of-magnitude needs of the state's LDL system, the analysis was deemed to be adequate for the purpose for which it was performed.

IMPACTS OF RAIL LINE ABANDONMENT

Impacts of abandonment vary in magnitude as well as users affected. Generally, benefits or losses are defined in terms of the net difference in conditions before and after an abandonment. These benefits include economic costs avoided or gains achieved by shippers, carriers, or the general public. When a line is abandoned, former rail users and the surrounding community may experience higher costs to move their product or to receive goods. Additionally, shippers, the community, and the general public may also experience employment, tax, highway, personal income, environment, energy, and other impacts. On the other hand, the abandoning railroad enjoys a benefit by reducing losses associated with the line and better utilization of the assets tied up on the line. A schematic of the potential impact framework is shown in Figure 2. This framework identifies the affected parties, possible actions by these parties, and the impacts of these actions.

Case studies of actual abandonments and the resulting impacts have provided somewhat mixed results (*2,3*). In many cases, there appears to have been little adverse impact, but then again, in individual cases, the impacts have been severe enough to force business closures and relocations. The methodology adopted focused on the most probable and quantifiable impacts.

Increased Cost of Transportation

Impact on transportation costs is the most direct and often-discussed impact by all parties involved in abandonment analyses. In most cases, the alternative available to the rail user or community is the use of truck transport to another rail site, to barge transportation, or to or from the final destination or origin. Such movements entail, in two of the cases, transshipment or double-handling expenditures as well as trucking costs.

Associated impacts concern the loss of quality of service (flexibility) caused by rail line abandonment. Seasonal movements over roads constrained by weight limits or closures could result in lost market opportunities. Further, the loss of the competitive environment surrounding rail and truck modes

TABLE 1 REVENUE-COST COMPARISON

		REVENUE COVERS		
Line No.	Length (miles)	Operating Costs	Operating & Opportunity Costs	Operating, Opportunity & Rehabilitation Costs
1	38			
2	3	■	■	
3	31			
4	98	■	■	
5	26			
6	48			
7	38			
8	26			
9	28	■		
10	7	■	■	■
11	46			
12	82	■	■	■
13	76	■	■	■
14	109			
15	86			
16	9			
17	35	■		
18	42	■	■	
19	36	■	■	■
20	19	■	■	
21	38	■		
22	35	■	■	
23	45	■	■	■
24	17	■	■	■
25	23			
26	11	■	■	■
27	9	■	■	■
28	137	■	■	
29	35	■		
30	5	■	■	■
31	19	■	■	■
32	57	■	■	■
33	68			
34	2	■		
35	11			
36	56			
37	12	■		
TOTALS				
Lines 37		23	17	11
Miles	1,463	848	698	364

SOURCE: Wilbur Smith Associates

has resulted in rate changes and has upset the negotiating balance between shipper and remaining carrier. In most instances of rail line abandonment, the total demand for transportation is quite inelastic (especially in rural agricultural areas) and the net price to producers simply decreases.

Although grain is by far the principal rail traffic in eastern Washington, traffic in central and western Washington is more diverse. Wood products, principally finished lumber and chips, along with food products (much of which is dry milk, cheese, and other processed dairy products) are the dominant traffic that would be transshipped in the event of branch line abandonments in these areas of the state. Many of the rail segments in western Washington depend heavily on one principal shipper, usually a wood products or dairy manufacturing firm, for the traffic to recover expenses incurred on the line.

Grain Transportation Costs

In eastern Washington, the cooperative grain elevator is a multiplant firm; its closest alternative facility with rail service will usually be charged the same rail rate. Thus, the additional costs comprise the costs to truck to the alternative elevator plus those of the alternative elevator throughput.

A review of approximately 10 rail line analyses done earlier indicated a conservative average increase in transportation costs faced by grain elevator firms is around 10 cents per bushel (5 cents trucking and 5 cents handling). This cost is multiplied by the annual volume to be moved to identify total cost increases. This 10 cents average will be modified to reflect the competitive situation facing elevator firms in different parts of Washington. For example, elevators close to the river,

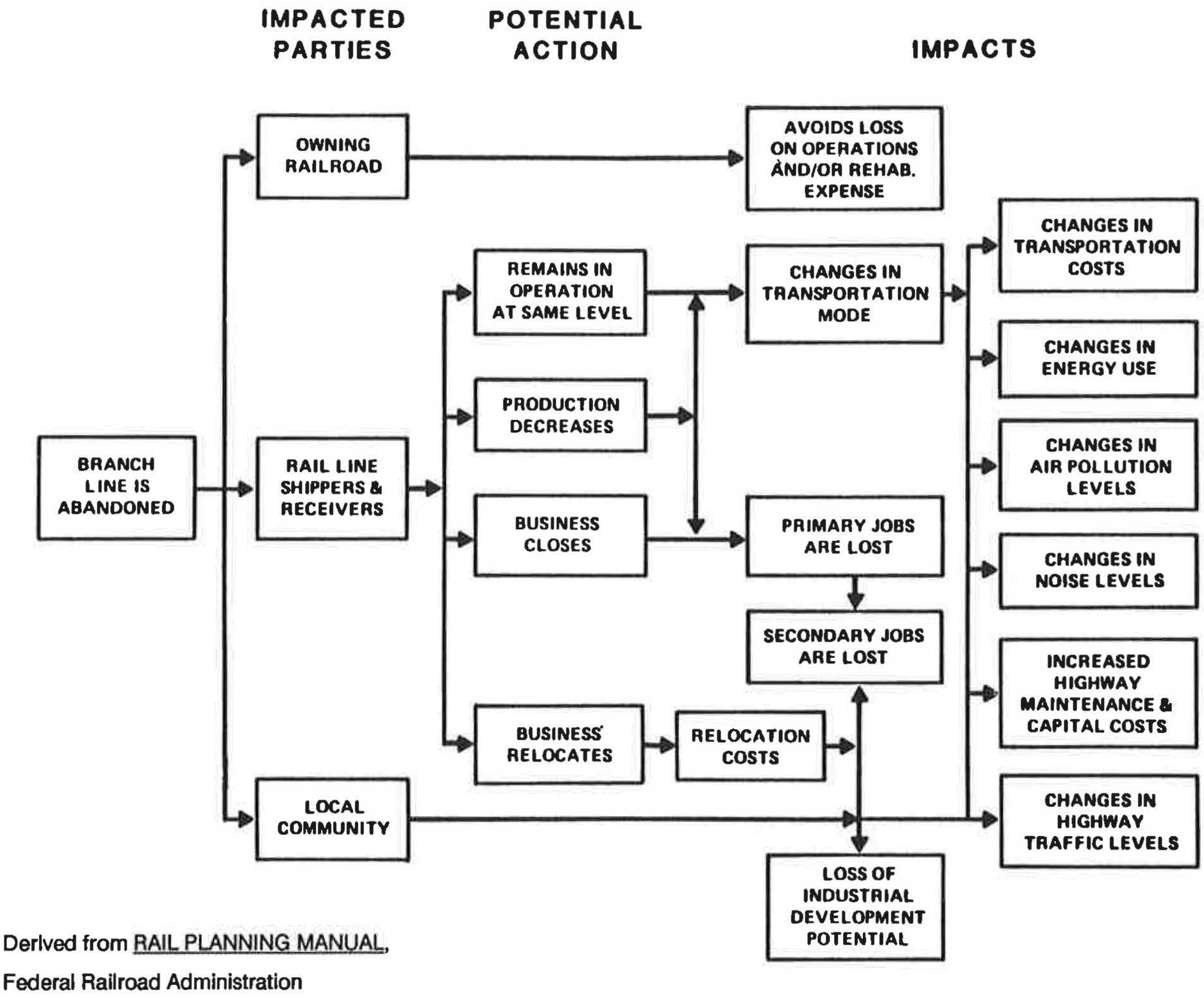


FIGURE 2 Potential impacts of branch line abandonment.

such as many of those in Whitman County, would receive a smaller increase or have no impact from rail line abandonment because of a readily accessible and low-cost transportation alternative (truck or barge). A major study by the U.S. General Accounting Office (GAO) (*3*) indicated an average increase in shipper cost of 19 percent, only slightly above the 10 cents average.

Other Commodity Costs

For other commodities (e.g., forest products and milk products), a similar comparison of the cost of trucking to alternative rail stations and transloading was used to determine cost increases to shippers. Discussions with firms in Washington shipping each product, supplemented by a review of recent studies, indicate the following cost impacts faced by shippers of these products is appropriate. Dairy products are moved in 80,000- to 85,000-lb movements (gross weight) throughout the year. These loads mean costs for trucking (at $1.20/mi) would be $0.06/ton-mi for a 20-ton payload with a transloading cost of $50 per truckload ($2.50/ton).

For wood chips, the average load is 70,000 to 75,000 lb because in many cases the physical volume capacity of the truck (cube) is reached before the weight limit. The average net payload then is about 17 tons, so the cost is $0.07/ton-mi with a $60/truckload (if a facility exists) to $120/truckload (if a facility has to be developed) transloading cost, or about $3.50/ton to $7.00/ton, respectively. Finished lumber often moves in loads of 95,000 to 100,000 lb, so trucking costs are $0.05/ton-mi with transloading costs of $4.00/ton (including crane investment, and driver and crane operator labor). These costs were then applied to each line segment on the basis of its commodities and trucking distances to the nearest alternate railhead.

State and County Highway Impacts

Another impact of rail line abandonment is damage to roads caused by the shift in traffic resulting in additional trucks on area roadways. Such traffic shifts cause increases in road maintenance and reconstruction costs and are costs borne by the public but resulting from private decisions. Several studies have provided estimates of impact of past rail line abandonment on county roads and state highways in Washington. Preliminary examination of impacts on state highways found rail line abandonment to be having only marginal effect in general but was creating "pockets of potential problems"(*4*). A subsequent examination of impacts on county roads found rail line abandonments between 1970 and 1987 had caused \$5 and \$6 million of damage to roads in Lincoln and Spokane counties (see Figure 1), respectively, over the period, most of which occurred after 1980 (*5*). Total estimated funds needed to repair the roads was about \$1.5 billion for the 10-county study area in eastern Washington (approximately \$400 million related directly to rail line abandonment). Later work defined the circumstances and costs more precisely.

Pavement Life

Pavement deterioration and the rate at which it occurs are affected by the environment, principally the moisture and freeze-thaw cycle that creates internal stresses that limit a pavement's life. Although the environment causes pavement deterioration, the process is accelerated by heavy traffic.

Pavement life is directly affected by pavement design relative to traffic patterns and loads. It is not just the maximum size of a load that is critical; the number of loads applied to the pavement is also important. Loads are evaluated using the common measures of Kips (1 Kip = 1,000 lb) and equivalent single axle loads (ESALs) (usually 1 ESAL = 18 Kips), such that all loads, both single and tandem (dual) axles, are expressed in the number of ESALs impact.

Load weight impact depends on gross vehicle weight (GVW), per-axle weight, and the distance between axles (measured by the bridge formula). The general relationship between vehicle weight and damage is shown in Figure 3. Damage increases in a greater proportion than the increase in weight, thus overloaded trucks are especially tough on roads not designed for those loads.

Impact Magnitude

In reality, the loss of rail service usually adds only a relatively small number of trucks to the local road network on a daily basis. This incremental increase in truck traffic is normally small in comparison to the existing truck traffic. However, in rural areas such impacts increase in magnitude. Rural roads are often built to lower design standards, are older in age, and were not built for today's heavier (often overloaded) trucks.

The WSDOT Pavement Management System (PMS) has been used in numerous studies of road impacts over the past 5 years. These analyses indicate an average annual impact of \$4,400/mi of state highway caused by abandonment of the different rail lines previously analyzed. Over the 20-year design life of the highway, the increased cost is \$88,000/mi. This annualized cost of \$4,400 serves, on average, as the basis for generation of impact estimates on state highways. Dividing these per-mile estimates by truck tonnage identified in each study allows a per ton-mile estimate to be developed. These estimates range from \$0.01/ton-mi to \$0.06/ton-mi with the average cost being \$0.05/ton-mi. The range of impact occurs because of the differing environmental conditions (seasonal movement problems), pavement design, and traffic patterns (e.g., overloading of trucks) in each case study. For this analysis, ton-mile costs were adjusted for each segment of potential abandoned rail line to reflect known conditions.

County road impacts, based on a previous study and county engineer estimates, are more severe mainly because of poorer surfaces and lower design standards. A conservative estimate of \$7,200/mi each year (including required bridge repair or reconstruction) is more representative of county road impacts. On a per ton-mile cost basis, the range of damage was \$0.02/ton-mi to \$0.09/ton-mi with an average of \$0.075/ton-mi. This general estimate along with the state highway estimate was modified and applied to reflect known conditions.

However, these costs do not include a major reconstruction caused by traffic levels above the design standards of differing road segments. Present estimates for new construction of highways average \$1 million/mi for a two-lane road.

Critique

The state's Rail Development Commission road damage methodology was based on preliminary results of an ongoing

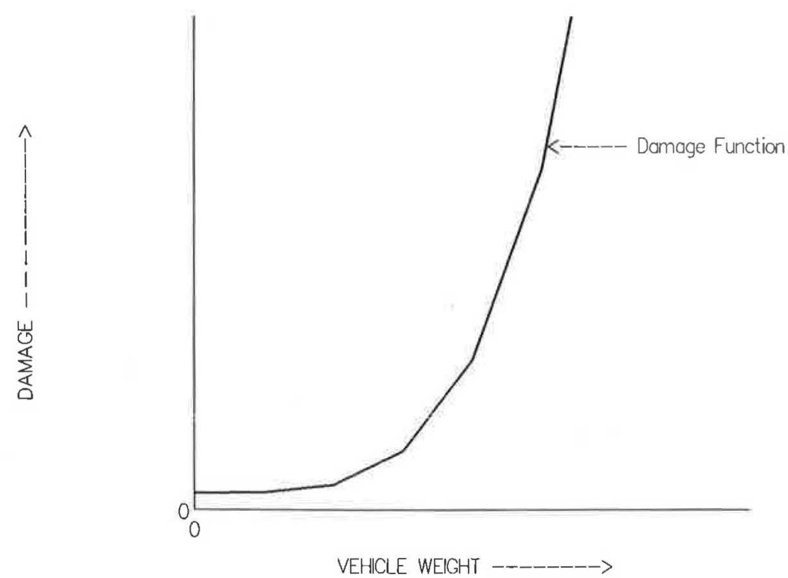


FIGURE 3 Roadway damage and vehicle weight.

(at the time) evaluation by the Washington State Transportation Center. More complete results now available (*6*) derived from four case studies reveal that no discernible increase in deterioration can be identified for highways adequately designed for truck traffic (most components of the state and federal system) unless significant truck volumes are involved. However, local and county roads, often gravel or thin 2-in. bituminous treatment over a 4- to 5-in. base, can be severely damaged. This finding is shown in Figure 4 as the relationship between pavement quality and pavement life. The difference between the expected life of a given pavement quality and its new (and shorter) life resulting from increased loadings becomes greater as pavement quality decreases.

The case studies also revealed that it was appropriate to include corroboration of the PMS findings by surveying WSDOT district and county engineering personnel. The hands-on knowledge available from these sources provided a more complete and specific picture of road impacts.

Economic Development

If increased transportation costs are the abandonment impact most frequently mentioned by rail users, then the loss of economic development potential is the most frequently mentioned by local communities. The GAO study found in examining impacts of railroad abandonment that "of most significance was the perception . . . that their communities' abilities to attract new industry in the absence of rail service would be reduced" (*3*,p.50).

However, GAO also points out that according to the ICC's Office of Public Assistance abandonment "protesters often inappropriately focus their rebuttals on the adverse community impact potentially posed by loss of rail service." They further advise that "testimony on potential impacts alone will not provide a sufficient basis to deny the abandonment" (*3*,p.40). This view results from the Commission's attitude toward speculative developments and the costs (losses) a carrier would incur while waiting for them to materialize (if ever).

Location Considerations

There is no doubt that rail service availability is a contributing factor in many industrial location decisions. In fact, in a survey of managers of newly located plants of Fortune 500 companies, rail service was the most frequently mentioned "must" factor considered in final site selection (see Table 2) (*7*). However, conclusive proof that the presence of rail service will attract new industry in a given community is not possible because there are numerous other factors in the locational decision.

Many industrial location requirements including developed infrastructure and community activities tilt the table toward developed areas and away from the rural portions of the country. Some major rail-traffic-generating industries such as pulpmills have an entirely different set of locational criteria. Thus, predicting specific needs is difficult when discussing the location of industry unless a particular prospect is being considered.

Impact Measures

Methodologies previously discussed provide a means of quantifying impacts on rail users and roadways. The same factors translate into economic growth impacts in terms of cancellation of business expansion plans or in extreme cases, business relocations or closures. Roadway impacts relate to infrastructure deterioration and diversion of public funds from development-oriented projects.

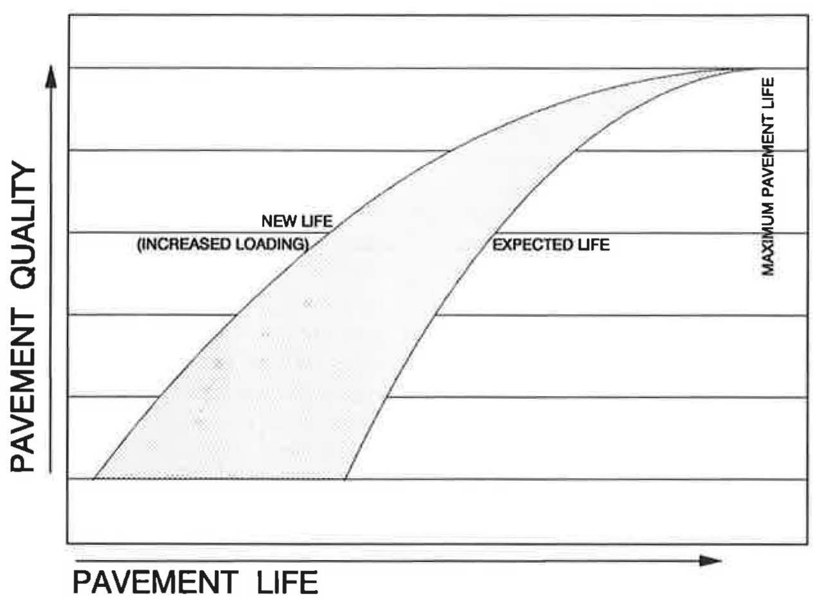


FIGURE 4 Weight and pavement life.

TABLE 2 CONSTRAINTS ON FINAL SITE SELECTION: FACTORS VIEWED AS A MUST BY ALL INDUSTRIES (*7*,p.150)

Factor	Percent of Plant Openings Citing at Least 1 Factor
Rail service	47
On expressway	42
Special provision of utilities (Water, sewage, gas)	34
Rural area	27
Environmental permits	23
Within metropolitan area	21
On water	16
Available land/building	8
Transportation (airport, truck service)	3
Community financing, support	1
Proximity to other division plant	1
Minimum acreage	1
Non-union site	1

Note: Number of plants citing at least one factor = 159

Although not considered in the Washington State methodology per se (survey of 10 LDLs—four that had been abandoned and six that were not—had mixed results) economic development impacts can be included in a statewide rail system examination. Although it is not possible to predict the relationship between the availability of rail service and impending economic developments, certain measures do exist that can provide valuable insights.

Suitable industrial sites, especially developed sites, are basic to the whole development process and one measure of both the increased potential for the location of industry and a community's commitment to encouraging economic development. Various organizations including state and local agencies and the railroads themselves maintain site files and can be a source of information on industrial site locations along each rail line.

If there are no sites cataloged or being promoted, it should be determined if there are properties along a particular line that are suitable for rail-oriented industrial location. Although there are means of providing rail service for off-line industry (intermodal or piggyback services), it is preferable for rail-dependent businesses, especially those with heavy traffic volumes, to locate on a rail line where a track can be constructed directly to the facility. Not only should the property be located adjacent to a line, but also because of gradient and curvature requirements that are more restrictive for railroad tracks than for roadways the property should be easily reached following the necessary engineering parameters.

In particular, unique sites (which meet the needs of industries with rare or difficult requirements, or types of sites in short supply) and their locations should be noted and steps taken to protect them for future development. The level of general economic activity or past and present industrial prospect records can provide other clues as to the potential for rail-related development. Availability of natural resources is another measure that should be noted. All provide clues for the types of industry that might locate in a given locale, the probability of occurrence, and whether rail service might be a requirement.

Rail Service Preservation-Impact Relationships

The typical approach to determining the worthiness of railroad branch line preservation efforts used in federal and state local rail service programs is to compare the costs of providing rail service with the impacts of losing it. The impacts become benefits, if avoided, and benefit-cost tools and methods are used.

Comparisons

Because the statewide branch line evaluation was not performed in detail, a rigid benefit-cost approach was not used.

It was deemed sufficient for the purposes of the effort to compare the levels of service preservation costs and impacts. Annual costs of operating, maintaining, and owning the total LDL system analyzed were estimated to be $53.3 million. This figure equates to $5.9 million in excess of the yearly abandonment impact estimate of $47.4 million ($31.9 million for transportation and $15.5 million in road damage). Eliminating the 11 lines that were estimated to earn sufficient revenues to cover all costs and thus not to be in danger of becoming abandonment candidates and comparing the remaining 26 resulted in $38.6 million in annual costs versus $22.9 million in impacts. This widened gap between costs and impacts is indicative of the heavier traffic volumes associated with the profitable lines and lighter traffic of the unprofitable lines (thus, the reduced impacts). Rail service costs remain more in proportion to the number of lines because of the large amount of fixed costs compared to variable costs typically associated with light-density operations.

Figure 5 shows the service-impact cost relationship for the remaining 26 lines (three rail lines not shown in the figure because they do not fit any of the cost scenarios used). Impacts from abandonment of one of the lines exceed all costs associated with it. For another, the abandonment impacts exceed operating plus return on value costs and the abandonment impacts exceed operating costs for three other lines. Based on federal Local Rail Service Assistance Act guidelines, the first case would most likely be eligible for any type of assistance, whereas the second would be rehabilitation candidates and also candidates for acquisition and rehabilitation.

Revenue Consideration

If each LDL's revenue earning potential were taken into consideration and a comparison made (see Figure 5) of impacts and revenue deficiencies (revenue minus costs), the number of lines that would be classified as potential assistance candidates increases roughly threefold. Three lines are estimated to have impacts exceeding the total revenue shortfall; whereas the impacts on 12 other lines exceed the revenue deficiency for all costs except rehabilitation. The impacts on three additional lines exceed operating costs.

PUBLIC OWNERSHIP

As presented in Table 1, the analysis performed in Washington State revealed that less than one-third of its LDLs (11 of 37) were estimated to earn sufficient revenues to cover all existing and anticipated expenses. Thus, two-thirds of the number of LDLs representing 1,099 mi (3/4 of the total mileage), would have little attraction for for-profit operators and could potentially become abandonment or public assistance candidates. Given the ICC's position on potential impacts, it is unlikely that future development potential will deter approval of line abandonments. Thus, public action (or action of some other nonprofit entity) would appear to be necessary to preserve service over the majority of the state's LDL system for economic development purposes.

The National Experience

Much has been written about the resurgence of local and regional railroads formed from lines that have been abandoned or spun off by larger carriers. Between 1970 and 1987 (November 1), almost 19,000 mi (*8*,p.7) of railroad had come under the domain of newly created short-line (or local) and regional railroads. Of the total, 4,420 mi are owned by public entities and 829 mi are owned by the shippers served by the line as opposed to lines acquired as for-profit operations by private companies. Public acquisitions over the period were made on behalf of states (2,287 mi) and various local organizations (2,133 mi) such as cities, counties, port authorities, local improvement districts, industrial development corporations, and transit authorities (*8*,p.12).

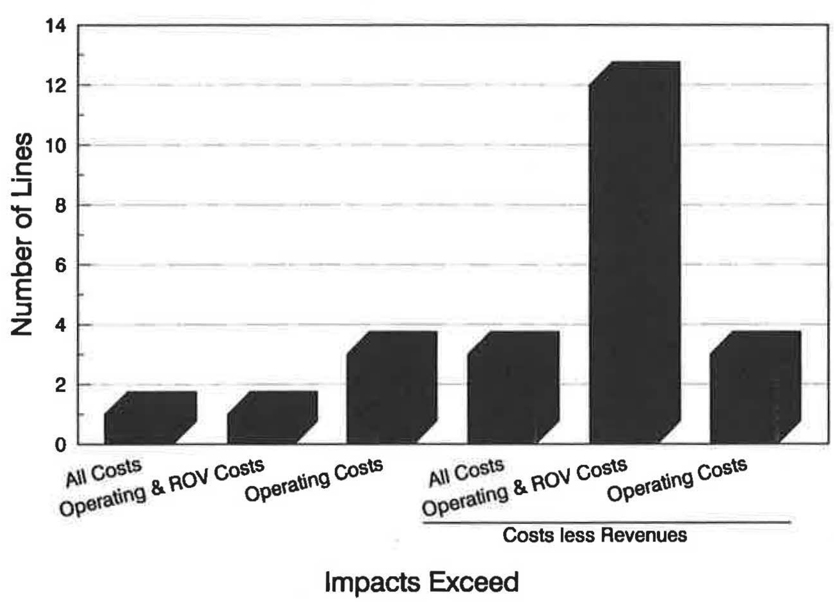


FIGURE 5 Impact cost summary.

Thus, public ownership accounts for almost one-quarter of the mileage taken over from larger railroads between 1970 and 1987. When viewed in relation to only local mileage (11,430 mi after eliminating regional railroads and all for-profit operations), public acquisitions increase to 39 percent of the total.

Washington State

Public ownership of rail lines in the state of Washington is permissible under state statutes for port districts and county rail districts. Three such rail operations now exist. One is both owned and operated by a port district and the other two are owned by a port district and a county rail district, respectively, but are run under contract or lease by short-line operators. The three lines total 177 mi in length.

Pend Oreille Valley Railroad

The Pend Oreille Valley Railroad extends 61 mi between Newport and Metaline Falls in Pend Oreille County and came into existence because of financial troubles of the Milwaukee Road that led to a 1978 abandonment filing on the line. An assessment of abandonment impacts indicated 170 jobs ($2,358,000 in annual wages) would be lost in addition to increased transportation costs of $723,000 per year. The Pend Oreille Port District was formed to acquire the line when it became apparent that was the only way to preserve service. The line was initially leased to an outside operator, but the port district took over all operations in 1984. A new industry, the Ponderay Newsprint Company, will begin operations this year and was attracted to the line through a joint state and local effort. Because rail service was a locational requirement, this business would have gone elsewhere had the line not been preserved.

Lewis and Clark Railway

The Lewis and Clark Railway operates over approximately 30 mi of the former Chelatchie Prairie Railroad acquired by Clark County in 1987. Clark County purchased the line just before it was dismantled for the purpose of promoting industry in the northern part of the county. The railway (a short-line operator) is interested in developing business by recapturing and expanding traffic from both existing industries on the line as well as attracting new industries. The Columbia River Economic Development Council recognizes that rail service is an important tool in drawing industry and market sites along the railroad. However, the Council does not show preference to sites along the railroad in order to preserve its public sector neutrality and because it is also interested in developing high-technology industries (which typically do not use rail) as well as maintaining its traditional resource-based industries. In the latter vein, a new aggregate pit is to be developed on the railroad.

Port of Royal Slope

In 1980, an embargo of service by the Milwaukee Road of all lines west of Montana was the reason for the Port of Royal Slope acquiring 25.6 mi of rail line in Grant and Adams counties. Annual transportation cost increases if the line were abandoned were expected to total $582,000 with an additional loss of sales by on-line users of $231,800. Rail service proved to be critical for one business that was handling local agricultural products. The port district line is operated by a short-line railroad that owns and operates other lines in the area.

Public Ownership Rationale

Although public acquisition of a rail line often results as an act of last recourse, there are valid reasons for public ownership.

Financial

Rail line acquisition and, more often than not, rehabilitation can require a sizeable amount of capital. Some new operations have failed because they were undercapitalized (*8*,p.22). Commercial loans have generally been available for acquisition of lines but not to fund rehabilitation. One reason for this is because the railroad's assets are already encumbered (debt represents between 75 and 90 percent of total capital for most newly formed small railroads) (*11*,p.65) and the lender would have to assume greater risks for additional loans. Also, in the case of truly light-density lines most purchase prices equate to the net liquidated value and a lender can usually recapture its funds in case of default. However, rehabilitation involves large quantities of labor and nonsalvage materials, which means the full cost of the effort cannot be recovered. Public acquisition (and rehabilitation) eliminates front-end capital requirements for the operator and thus assists in eliminating one potential cause of failure.

Stability

Another reason for public ownership, which is of primary importance for economic development purposes, relates to shipper perceptions. The location of new development on light-density lines has been viewed as a sizeable risk for some time given the past collapse of the northeastern and midwestern carriers and the current implementation of plant rationalization programs by healthy railroads. Short-line operators, especially during the early days of the period mentioned, were also viewed with skepticism as their tenure was questionable. However, ownership by a government entity alleviates many of these feats by promoting a perception of stability for an industrial prospect.

CONCLUSIONS

Economic development and rail service currently have a different relationship than the two experienced in the past. At one time, the existence of a railroad was essential to a community's economic well being. This relationship is certainly no longer the case, but even so, the presence or lack of rail service can still have an impact on local economic development. Although the impacts cannot always be fully quantified, part of the transportation infrastructure is lost with a corresponding loss of economic development potential, and local resources that could have been devoted to economic growth and development efforts are required to overcome abandonment impacts.

Economic development has to be approached from the local level if local interests are to be protected. Given current trends in the railroad industry, continuation of local rail service provided by a branch or LDL could prove to be a problem. Thus, it appears that more and more communities will have to become directly involved in local rail service preservation efforts once it is decided that rail service is important enough to the community to warrant the necessary capital expenditures and continuing obligations.

The analytical procedure applied in staff work for the Washington Rail Development Commission for the purposes of determining rail needs and development of a responsive state rail program appears to work well in identifying potential problem lines and order-of-magnitude costs and benefits associated with rail line abandonment. The procedure allows the different entities to approach the problem with a better understanding and quantification of the overall economics and costs to be avoided or benefits achieved. Costs involved also represent a negative draw on resources that would be available for economic development.

The comparison of railroad deficits (revenue minus costs) and private and public impacts that could result from abandonment can be viewed as the amount shippers and county or state taxpayers might be willing to pay to avoid rail line abandonment and to preserve economic development opportunities that the availability of rail service might promote. The decision process should also recognize that attracting the proper industry could eliminate deficit rail operations. Thus, it is incumbent on each area potentially impacted to carefully weigh the value of rail service in light of transportation needs of existing industry and those likely or desired to locate locally.

The work performed for the Rail Development Commission led to a finding that "the state, counties, local communities, railroads, labor and shippers all benefit from continuation of rail service . . ." and that rail lines that provide benefits "should be assisted through the joint efforts of the state, local jurisdictions, and the private sector" (*12*,p.10). The Rail Development Commission also recommended funding of the Essential Rail Assistance Account, already in the statutes but not funded, totaling $4.7 million in the 1989 to 1991 biennium (*12*,p.15). In 1989, the Washington legislature subsequently approved appropriations of $2.3 million for distribution to county rail and port districts for the purposes of acquiring, maintaining, or improving branch lines.

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SECTION 6

State Planning Issues in Transportation Investments for Economic Enhancement

Role of Non-Interstate Highway Transportation in Enhancing Economic Development in Iowa

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Over the past decade, the state of Iowa has moved toward establishing a highway improvement programming process that attempts to balance engineering and economic considerations. In 1988, the state legislature directed the Iowa Department of Transportation (IDOT) to designate a network of commercial and industrial highways. During its 1989 session, the legislature established a clear mandate for IDOT to give this network the highest priority in programming future improvements. The research was initiated by IDOT to develop a methodology that could be used to factor economic development considerations into the programming of improvements for the network.

Iowa, like a number of other states, has experienced two trends in the past decade. First, since the 1970s, Iowa's primary highway system has accumulated a backlog of construction needs because of inflation, a reduction in motor fuel tax revenues (a result of the improved fuel efficiency of the motor vehicle fleet), and reductions in the share of federal highway funds allocated to rural areas. Second, an agricultural recession during the first half of the 1980s awakened business and government leaders to the need to diversify Iowa's economy.

The first trend is characterized by the state's decreasing ability to reconstruct and modernize its primary highway system. As documented by Iowa's last Quadrennial Needs Study (*1*,p.2), completed in 1986, backlogged construction needs on the primary highway system had grown to almost $3.4 billion. Prospects for overcoming these backlogged needs are not good; after maintenance, pavement preservation, and bridge repair and replacement requirements have been funded, the Iowa Department of Transportation (IDOT) has been able to modernize or replace only 40 to 50 mi of primary highway per year. At this rate, the state's 10,000-mi primary highway system can only be recapitalized every 200 years.

Realizing that Iowa did not, and would not in the foreseeable future, have adequate resources to satisfy all of its highway needs, in 1978 IDOT began developing a way to rate the primary highway system for improvement programming purposes. A four-level stratification of the state highway system was the result of this process, and it has been the basis for targeting funds to high-priority projects in Iowa since 1979 (*2*).

The second trend led to the emergence of economic development as a goal of the Iowa highway improvement program. The state's first effort in this regard, a program called Revitalize Iowa's Sound Economy (RISE), was established in 1985 (*3*). The Iowa legislature funded RISE by increasing the state motor fuel tax by 2 cents/gal, which yields approximately $33 million annually. Half of these funds are used to provide road improvements needed to attract new businesses to the state and to retain and support the expansion of existing businesses.

Only county and city governments are eligible to apply for these RISE funds, and they must provide a match to the fund contribution. In this manner, state funds provide leverage for other sources of support for local economic development initiatives.

The other half of the RISE fund is dedicated to regional development projects. These projects are intended to modernize and increase the traffic-carrying capacity of state highways. Regional-development RISE funds are used for new construction or pavement reconstruction, not for preservation, bridge repair, or maintenance purposes.

The RISE program and the four-level highway system plan represent the origin of the state's efforts to concentrate highway improvement programming in order to maximize the benefits earned from road investments and to foster opportunities for the diversification and growth of Iowa's economy. During its 1988 session, the Iowa General Assembly took the next step when it directed IDOT to designate a network of commercial and industrial highways. In addition, during 1989 the Iowa legislature strengthened its commitment to the commercial and industrial network (CIN) by directing IDOT to make the improvement of this network its highest priority and to explicitly consider the promotion of economic development in the state.

Research was initiated by IDOT to develop a methodology that could be used to factor economic development considerations into the programming of improvements for the CIN. Background is provided on the system currently used to program highway improvements in Iowa. The legislative mandate for creation of the CIN and the procedure used to designate this system are discussed. Existing research on economic development and transportation is discussed, and an explanation is given of the methodology being developed to analyze Iowa's economy as a basis for setting priorities for corridor improvements to support economic development. A preliminary statewide application of priority levels and guidelines for programming and scheduling projects is covered. Finally, a discussion is provided on research currently being conducted, a way to combine the methodology with standard highway improvement programming procedures, and alter-

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native procedures for incorporating equity considerations into the methodology.

IOWA HIGHWAY IMPROVEMENT PROGRAMMING PROCESS

Through the early 1970s, the main focus of the Iowa highway program was on new construction. As work on the Interstate system approached completion, the emphasis shifted toward preservation and rehabilitation. Before 1977, IDOT relied primarily on a 100-point sufficiency rating system to annually analyze each portion of the primary road system and develop a list of potential projects. This rating system considers roadway safety, service level, structural adequacy, and geometrics. Any segment found to have a rating of 50 points or less is considered to be in critical need of improvement.

However, as Iowa began to experience funding problems during the 1970s, the State Transportation Commission decided to look for a way to ration highway investment dollars more effectively. In 1977, IDOT initiated a study that resulted in the stratification of the primary highway system into four levels: A (Interstate), B (high-service-level principal arterials), C (low-service-level principal arterials), and D (nonprincipal arterials). Nineteen service characteristics—such as population, retail sales, manufacturing employment, and access to airports, railroad terminals, motor carrier terminals, hospitals, and institutions of higher education—provided the basis for stratifying the system. In this manner, Iowa began to incorporate economic development considerations into the process of programming highway improvements.

Since 1979, sufficiency ratings in combination with the four-level system map have provided the basis for identifying potential primary highway modernization and reconstruction projects. This combined method of evaluation has permitted IDOT to better focus resources toward the more heavily used portions of the state's primary highway system. This focusing of resources is accomplished by setting increasingly restrictive sufficiency rating thresholds to qualify for funding, progressing from the top to the bottom of the four-level hierarchy.

Similarly, the consideration of portions of the primary highway system for preservation work, which involves safety improvements and resurfacing but only small changes in roadway geometrics, is based on both the four-level system map and a 100-point pavement condition rating (PCR) system, which focuses exclusively on roadway surface characteristics. Again, funds are targeted toward the high end of the primary highway system by varying PCR thresholds so different portions of highway can qualify for improvement. For example, for the B-level system, a PCR of 60 or less qualifies a portion of highway for resurfacing; for the C- and D-level systems, PCRs at or below 50 and 40, respectively, are required to be considered for preservation improvements.

As a result, from 50 to 60 percent of non-Interstate primary highway investment has gone to the B-level system since 1980, 20 to 30 percent to the C-level system, and only 15 to 25 percent to the D-level system.

The formal programming of improvements begins in January each year when the Office of Program Management and the Office of Advance Planning prepare a candidate list of projects using the process previously outlined. These candidate projects are then submitted to IDOT's six district offices for review. The general public is given the opportunity to review staff proposals, submit their own project requests, and present their views to the State Transportation Commission. This year-long review process culminates in December with the publication of a 5-year Transportation Improvement Program.

Finally, in addition to attempting to make the most efficient use of highway program resources, state law requires that primary road service be equalized in both rural and municipal areas. Therefore, a review of the geographic distribution of highway system improvements is made periodically to assess how different areas of the state have fared. This analysis of service equity also uses highway sufficiency ratings, which are compared by district and between rural and municipal areas. Following these reviews, adjustments are often made to the highway improvement program to equalize service throughout the state.

Therefore, over the past decade Iowa has moved toward establishing a highway improvement programming process that attempts to balance both engineering and economic considerations. The recent action taken by the state legislature in creating the CIN represents the next evolutionary step in this process of recognizing the economic role of highways. In the following section, a discussion is provided on the legislature's mandate to create the CIN and on the ways that creation of this system can be expected to further change highway improvement programming in Iowa.

LEGISLATIVE MANDATE AND DESIGNATION OF THE CIN

In 1988, as part of the appropriations bill for IDOT for FY 1989, the state legislature directed the State Transportation Commission to "identify within the primary road system a network of commercial and industrial highways" (*4*). In the same legislation, IDOT was instructed to allocate a minimum of $30 million of primary road funds to the network each year, beginning with FY 1991. No statement of purpose, priority, or other direction for implementing the network was provided.

During its 1989 session, the Iowa legislature affirmed its support for the CIN by establishing a clear mandate for IDOT to give this portion of the state primary highway system the highest priority in programming future improvements. This supplementary legislation (*5*) clearly states that the purpose for developing the CIN is "to enhance opportunities for the development and diversification of the state's economy." The 1989 legislation further states, "The purpose of this highway network shall be to improve the flow of commerce; to make travel more convenient, safe, and efficient; and to better connect Iowa with regional, national, and international markets."

The State Transportation Commission initially designated the CIN in June 1988 and made additions to the network in October 1989. The following criteria were used to designate the network:

1. *Service to Regional Growth Centers.* The CIN includes linkages between 16 regional growth centers identified in Iowa

(mainly places with populations of more than 20,000 located in the center of 30-min to 1-hr commutersheds) and several major metropolitan markets outside Iowa. These outside markets include Chicago, Minneapolis, St. Louis, Kansas City, Denver, and Milwaukee.

2. *Continuity*. Continuity with routes considered to be major through routes by adjacent states was a criterion.

3. *Total Current Traffic*. Generally, a minimum standard of 3,000 average daily traffic (ADT) was applied.

4. *Current Large-Truck Traffic*. A minimum standard of 250 tractor-trailer/semitrailers (TTSTs) per average day was applied.

5. *Area Coverage*. Routes were added until nearly all locations in Iowa were within 25 airline-mi (about 30 highway-mi) of a route. Qualifying routes in adjacent states (e.g., I-90 in Minnesota) were included for analysis purposes.

The resulting system includes 2,325 mi (23.7 percent) of Iowa's 9,830-mi primary highway system, as shown in Figure 1.

The 1989 legislation codified the criteria used to designate the network and restricted its size to no more than 2,500 mi. The legislation also gave IDOT special powers to permit it to complete improvement of the network in a timely manner. For example, the law gave IDOT the power to preserve right-of-way for the future development of CIN routes, a power the department is not generally afforded for other types of highway projects.

Designation of the CIN is already affecting the programming of highway improvements in Iowa. Funds dedicated to this portion of the primary highway system are expected to far exceed the $30 million per year required by the state legislature. Investment on the network in 1990 alone is expected to approach $90 million (*6*). Furthermore, the transportation component of Iowa's Futures Agenda, the state's strategic plan, calls for at least 40 percent of the annual highway improvement budget to be invested in the CIN. Also, IDOT is currently developing a new five-level highway hierarchy to replace the four-level scheme discussed in the previous section. The major difference between the two hierarchies is the identification of the CIN as a separate level.

The following section explains how funding priorities and the scheduling of improvements within the CIN will be further refined. The methodology described draws on central place theory and other well-established methods of regional economic analysis. Because Iowa does not have an operational network model or current origin-destination study, a more mathematical approach is not possible. The regional economic analysis methodology is designed to address economic development needs while minimizing primary data research and using an economical approach to transportation system analysis.

RESEARCH FINDINGS AND CASE STUDY OF ECONOMIC DEVELOPMENT ANALYSIS METHODOLOGY

The most basic definition of state-level economic development is an increase in income and product generated within the state. Development occurs when productivity is increased or when the state produces goods and services for export or as substitutes for goods that would otherwise be imported.

However, economic development implies more than simply an increase in economic activity. Iowa's initial economic development plan noted, "How development occurs is as important as whether it occurs. The state might not, for example, wish to follow policies that attract only low-wage industry, even though doing so would increase total economic activity in the state" (*7*,p.3).

The basic premise of a state-level economic development effort is that state government can influence the course of a state's economy to achieve specified development goals. In this context, transportation improvements are one of a number of tools to help achieve these aims. The methodology proposed to guide improvements on the CIN is designed to support several generally accepted goals for Iowa (*7*,p.9). These include the following:

- Increasing the income of Iowans by increasing production and employment in the state,
- Diversifying the economic base to provide a stable foundation for long-term growth,
- Retaining and expanding employment in sectors that are currently a significant part of Iowa's economic base, and
- Supporting the rural economy of Iowa.

The assumptions made about the purpose of economic development and the relationship between transportation and economic development are key to devising an analysis methodology. The methodology proposed in this section is designed to be responsive to the findings of previous research on transportation and economic development.

Review of Previous Research

Early research on the relationship between highway transportation and economic development, which dates from the 1960s, focused largely on economic and demographic changes occurring after the construction of a section of Interstate highway. Research since 1980, on the other hand, has begun to explore the link between highway transportation and economic development, not simply economic change. However, little research has been done that identifies how best to target future transportation investment to encourage economic development.

Clearly, major highway system changes promote change in local and regional economies; however, whether transportation infrastructure investment causes long-term economic development remains in question. For example, in 1980 the National Council for Urban Economic Development could not identify any comprehensive study of the effects of highways on economic development activities (*8*,p.92). Furthermore, the literature in this field is often contradictory. Nevertheless, common themes do emerge.

The following observations provide the basis for Iowa's efforts to incorporate economic development considerations into its planning and programming of future highway improvements. The first seven are based on a paper by Plazak (*9*) and supported by a variety of research, as noted.

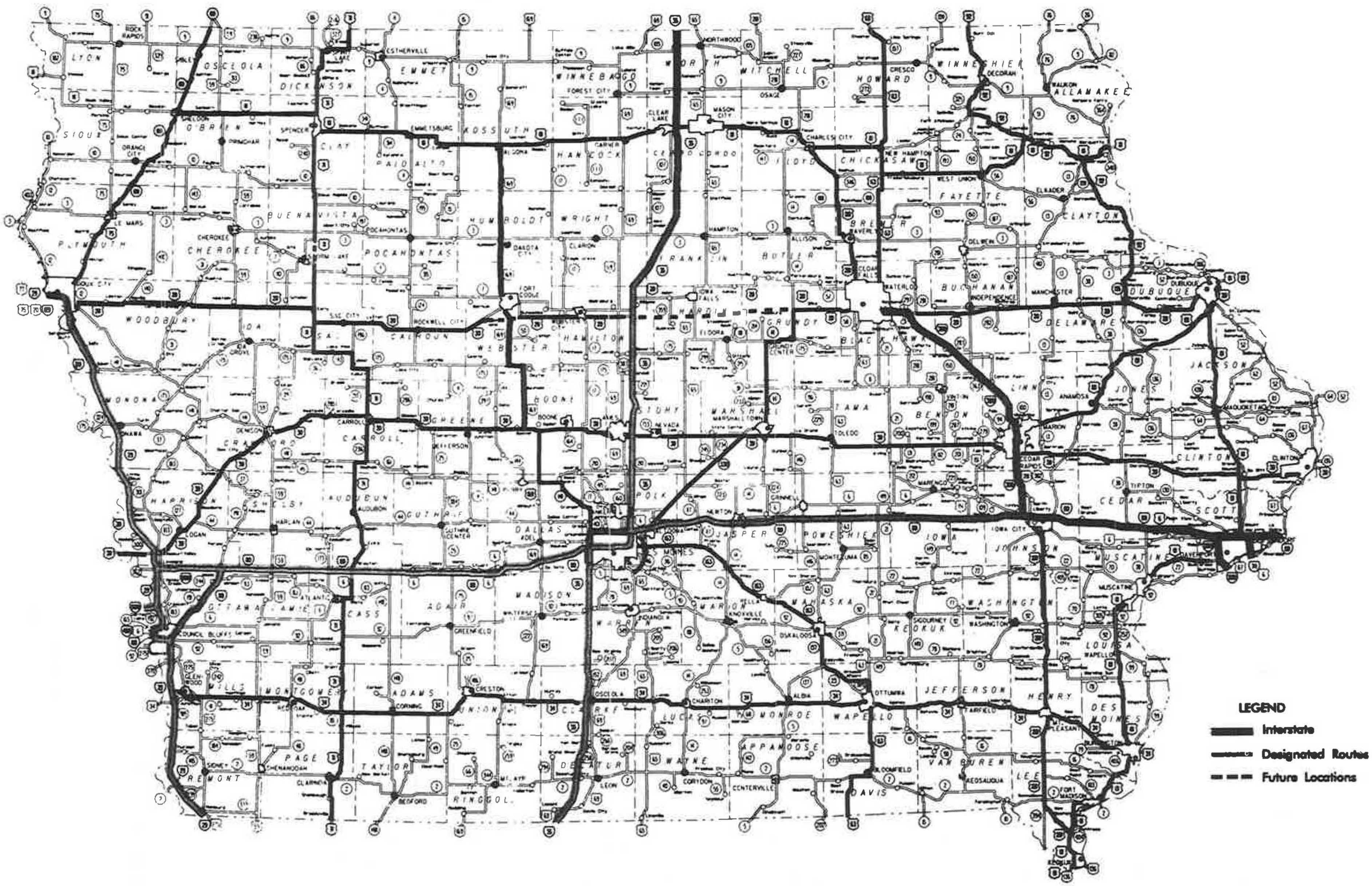

FIGURE 1 Iowa CIN.

Transportation Investment Alone Will Not Cause Development

Experience, common sense, and previous research all show that transportation investment alone will not cause economic development to occur. Even massive highway investment, in new freeways or expressways, for example, may only result in the relocation of existing business.

Factors that enable economic growth to occur include targeting growth on the basis of resources; local leadership, cooperation, and initiative; a well-thought-out and accepted strategic plan; available financing; adequate infrastructure; a trained and high-quality work force; and a supportive community and business environment.

Highway Investment Is Permissive

Investment in transportation, although unable to cause development, may permit otherwise impossible or unlikely projects to proceed. Highway deficiencies, such as narrow pavement, congested roadways, and embargoed bridges, may prove significant barriers to economic development.

Bottom Line Is Lower Transportation Costs

Highway user costs are mostly made up of vehicle operating costs (e.g., fuel, tires, oil, depreciation, maintenance, and repairs) and the value of travel time (e.g., truck driver wages). Pavement deterioration contributes to vehicle maintenance and fuel costs. [According to a 1984 study (*10*), 37 percent of the pavement on Iowa's highways is 40 to 50 years old and an additional 2 percent is more than 59 years old.] Hence, rehabilitation and reconstruction to maintain high-quality highways may be one of the best investments for economic development.

Relative Quality of Transportation System Is Important

Businesses make location decisions on a comparative basis, so communities and regions with transportation systems substantially poorer in quality than the norm may be placed at a serious competitive disadvantage. On the other hand, investing large amounts of money in transportation to improve a system to a standard well above average may not yield a commensurate payoff.

Proximity to raw materials and markets tends to be the major factor considered by heavy-manufacturing companies in making location decisions. This observation is supported by a variety of sources (*11–13*). Once the search has been narrowed down to a particular region, transportation access, services, and costs become major considerations.

Road With Lowest Operating Cost Is Not Always Four-Lane

Under conditions of low-to-moderate traffic, a good-quality two-lane road may result in operating costs and travel times comparable to those of a four-lane highway. Four-lane limited-access highway improvements generally promote economic development only if access to markets and resources located outside the state is improved. Both underbuilt and overbuilt infrastructure can reduce a state's ability to serve business needs at a cost that helps them to be competitive.

The Iowa Department of Economic Development (*7*,p.45) makes strong statements on this topic:

> While one might argue on the basis of equity that the state should upgrade roads serving smaller communities that are not near to metropolitan areas (in an effort to foster growth in those communities), doing so probably would not significantly bolster the Iowa economy. In fact, the costs of upgrading would add to the overall cost of government in Iowa and, on that score, decrease the attractiveness of the state. Furthermore, research has shown that upgrading two-lane primary roads to four lanes with limited access can actually render smaller, nonmetropolitan communities along the route worse off (*14*). Whereas a two-lane road may run through the community, providing visibility to its business, a limited access highway is more likely to pass it by.

Roggenburk and Mufti (*15*) concluded that the link to the Interstate system is critical for most industries for which the flow of materials and products is of significance. Also, Schwartz and Schwartz (*16*) found that the cost of transportation is far lower for industries located in cities linked to the Interstate highway system. Contradictory conclusions were presented by Briggs (*14*,p.9–3), who found that Interstates were not clearly associated with manufacturing and wholesaling.

Perceptions of Transportation System Quality May Be as Important as Actual Conditions

User costs and levels of service provided by two-lane highways may be comparable to those of four-lane roads, yet regions without four-lane service may be viewed as somehow isolated or inferior. Lines on a map may influence development location decisions, placing communities without four-lane access at a relative disadvantage.

Recent literature on the role of perceptions as a factor in business location decisions is scant. As noted by Bowersox (*17*), if the road was paved and in good condition, it was judged adequate. However, the sentiment that four-lane highways are critical for economic development to occur is still prevalent. This perception was confirmed by the Committee on Iowa's Future Growth (*10*,p.43), which concluded, ". . . we must also address the legitimate needs of those Iowa cities that are still not served by an expressway that connects the major markets inside and outside the state."

Needs for Highway Transportation May Vary Greatly Among Industries

For many industries, efficient truck transportation is vital. It is especially important for manufacturing industries, agriculture, and wholesale trade. For high-technology industries, quick access to air service and the ability to efficiently move employees to work each day appear to be more important concerns.

This variance in transportation needs makes an analysis of the current and anticipated economic structure of a region critical. The failure to anticipate significant technological or marketplace changes can have major consequences. The location or potential location of high-growth industries with highway transportation requirements should be considered.

Economic Growth Will Primarily Occur in and near Urbanized Areas That Have Necessary Physical and Human Resources

By focusing transportation improvements on regional economic centers with growth indicators, including cluster communities that share area resources, a state can use transportation improvements to support those areas with economic growth potential.

Increases in highway expenditures do not generally lead to increases in employment other than temporary increases during construction. However, in the counties that are economic centers of the state, highway expenditures have a positive long-term effect (*18*); that is, employment increases more than it would for the normal trend of economy (*19*).

Greatest Economic Impact Will Result from Greater Access

From a statewide perspective, the greatest economic impact will come from creating better access to regional and national markets, better access to raw materials, and better access to the regional labor force for companies that use state inputs and produce exports or import substitutes.

Statistics show that every $40,000 in exports creates one job and that, for every job created by export industries, two additional jobs are created in the economy. Transportation service provides important support for export-related business.

Improving access to local markets, local services, and retail trade outlets is important but will have a lesser impact on economic growth from a statewide perspective. However, such improvements have potential for making a difference in the locations of local growth.

Economic Location Theory

Four general categories of location theory exist, each of which provides key concepts useful in developing a system of targeting transportation investment to support economic development. These categories include industrial location, central place, growth center, and diffusion theory.

Industrial location theory was first proposed by German economist Alfred Weber in 1909. The theory seeks to explain factors in industrial location from the perspective of an individual firm. Key concepts include the desire to maximize profits (or minimize costs) and the economies provided through agglomeration. More detailed discussion of the factors involved in the location of industry is provided by Alexandersson (*20*) and Webber (*21*).

Central place theory, initially developed by German theorists Walter Christaller and August Losch in the mid-1930s, links the disciplines of geography and economics to explain the location and features of smaller urban places that serve as central places for services and retail trade. This static theory postulates a hierarchy of central places located in a balanced, geometric fashion in order to serve the surrounding rural areas, or hinterlands. In general, central place functions will be service activities and will not include manufacturing that serves more distant markets and is unrelated to the needs of the rural region (*22*,p.20).

Growth pole or growth center theory is the most recent addition to location theory, first proposed by French economist Francois Perroux in the mid-1950s. Perroux conceptualized development as essentially occurring around poles caused by economic forces that lead to the clustering of economic activities and growth and toward an imbalance between industries and geographic areas. Dynamic sectors provide the driving force in the development of growth poles, and Perroux stressed the importance of entrepreneurial innovation in this growth process. Perroux's original concept of growth poles can be characterized as abstract, dynamic, unbalanced, and occurring in the economic space rather than in geographic space.

Diffusion theory maintains that growth occurs as a result of the filtering of innovations downward through the urban hierarchy and from the urban centers out to surrounding areas. The emergence of axes of high development between main urban areas is one channel of diffusion that is readily observable. In 1963, French economist Pottier contended that economic development normally tends to be propagated along the main transportation routes linking the most important industrial centers and that development therefore manifests itself in linear paths. His work serves to integrate theories of the effects of the transportation network with theories of urban hierarchies and geographic development poles (*23*).

These theories can be linked together as building blocks in a planning methodology for choosing the locations of highway improvements that can best assist in reaching Iowa's development goals. Research in the early 1970s discussed the existence of such bridging concepts, including the close relationship of economic growth poles and the city hierarchies of central places, and contended the theories could be regarded as complementary (*23*,p.179). Linking the key concepts—agglomeration, location dynamics, growth poles, diffusion, cost minimization, and service centers—provides a strong theoretical basis for planning efforts.

Development of a Methodology

To identify regional centers with potential for growth, Iowa's 954 incorporated cities and 99 counties have been analyzed on the basis of existing economic size and change (*24–27*). The resulting city and county rankings are the basis for identifying and ranking corridors in which transportation linkages can help Iowa achieve its overall development goals.

City Analysis

Two rankings of Iowa cities were developed to measure relative economic importance (economic size) and change. Four factors were considered in these rankings:

1. Population,
2. Community service level,
3. Number of manufacturing firms, and
4. Number of wholesale firms.

Community service level was specifically developed to reflect the current status of a community as a central place within a region. The community service level is based on the services believed to be important to provide a physical foundation for economic development. A six-level hierarchy was developed to categorize the extent of service provided by each Iowa community, with Level 1 providing the highest level of service. Each higher level in the hierarchy meets not only the requirements for that level but also the requirements for all previous levels. The requirements are as follows:

- *Level 1.* Three of the following are required:
  —Scheduled air passenger service
  —Daily newspaper
  —Television station
  —Post-high-school educational facility
  —Public high school

- *Level 2.* Three of the following are required:
  —Airport (with hard-surfaced runway, at least 4,000 ft long)
  —Radio station
  —Hospital
  —County seat

- *Level 3.* Three of the following are required:
  —Public library
  —New-car dealer
  —Physician
  —Daily or weekly newspaper

- *Level 4.* Two of the following are required:
  —Public or private high school
  —Bank
  —Funeral director

- *Level 5.* Both of the following are required:
  —Post office
  —At least 10 retail businesses

- *Level 6.* One of the following is required:
  —Post office
  —Less than 10 retail businesses

To measure economic size, the four factors were ranked using the most recent information available. The four separate rankings were then combined to obtain a single ranking that measures relative economic size.

To measure economic change, these same four rankings were considered along with rankings for change in population and change in number of manufacturing firms. Published information that could be used to measure change in the number of wholesale firms or in status as a community service center does not exist.

A comprehensive community economic data base was compiled during the analysis. The data base includes a wide variety of factors that were not considered in developing the rankings but are available for informational or comparison purposes. Data are included on retail sales and change, growth centers identified by various studies, community planning and economic development efforts, bank loan and deposit rates, rail service, county seat status, median age, and whether the county contains or is adjacent to a metropolitan area.

Existing community classification systems were considered in developing this method to evaluate economic size and change, including work by Borchert and Adams (*24*) and Berry (*25*), as well as a Bureau of Census scheme described by the Southern Iowa Council of Governments (*28*).

County Analysis

A similar method was used to measure economic size and economic change at the county level. Because a broader range of economic indicators is available at the county level, more factors were considered. A decision tree was then used to assign each county to a group showing its economic size and change status (see Figure 2). The following six factors were considered at the county level:

1. Population,
2. Total employment,
3. Labor force,
4. Retail sales,
5. Manufacturing employment, and
6. Wholesale employment.

Four rankings were developed to answer the questions posed in the county decision tree. Rankings were made for manu-

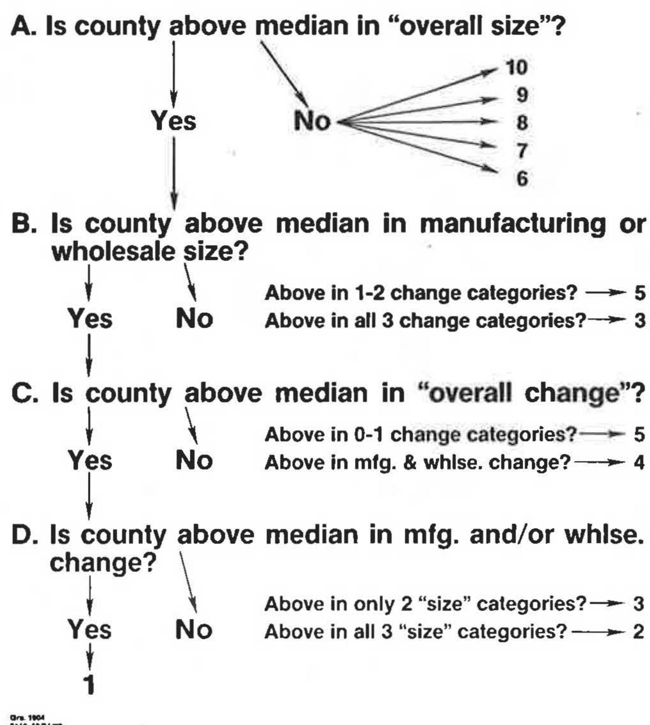

FIGURE 2 County decision tree.

facturing employment, wholesale employment, economic size, and economic change (which considered change in all six factors). The ranking of economic size was based on the most recent data available (generally 1988 figures), and the ranking of economic change was based on the 1980 to 1988 period (except in the cases of manufacturing and wholesale employment, for which 1988 data were not yet available).

As with communities, a wide variety of data was gathered that was not included in the decision-tree process but is available for informational and comparison purposes. These data include the percentage of residents with a high-school degree, percentage with a college degree, amount of value added through manufacturing, amount of capital investment in manufacturing, and value of shipments. Additional research on the linkage between these factors and economic growth or change is needed because these factors may be useful in predicting the likely locations for growth.

Combined City and County Analysis

As previously discussed, this analysis of Iowa communities and counties reflects a variety of economic development themes. These themes include the importance of economic size and resources as a basis for economic development, the linkage between manufacturing and wholesaling and transportation, and the relationships among communities that serve as central places and centers of growth and their surrounding areas.

Figure 3 shows the combined results of the city and county analysis in Iowa. The Iowa communities that are in the top 50 rankings of economic size are shown. The solid symbols indicate cities with a high rate of growth, whereas open symbols indicate cities with a lower rate of growth, or a decline in some cases. County groupings that result from applying the county decision tree are also shown. Only the results for those counties above the median rank in economic size are provided.

Finally, highway improvement priorities were developed. These priorities reflect the principle that highway investment can best support economic development by creating improved linkages between centers with growth potential. The priorities established are presented in Table 1.

Advantages and Disadvantages

The methodology responds strongly to the legislative mandate to improve the flow of commerce and to better connect Iowa with regional, national, and international markets. In addition, it provides a useful tool for describing local economies and providing information at a city and county level. It also provides a mechanism to encourage the maximum amount of regional economic development possible within the constraints of Iowa's current economy. The technique incorporates the concept of growth centers, while providing broader support for Iowa's rural economy. The technique is also adaptable to public input because it permits incorporation of other considerations and goals identified as important by local community and business leaders.

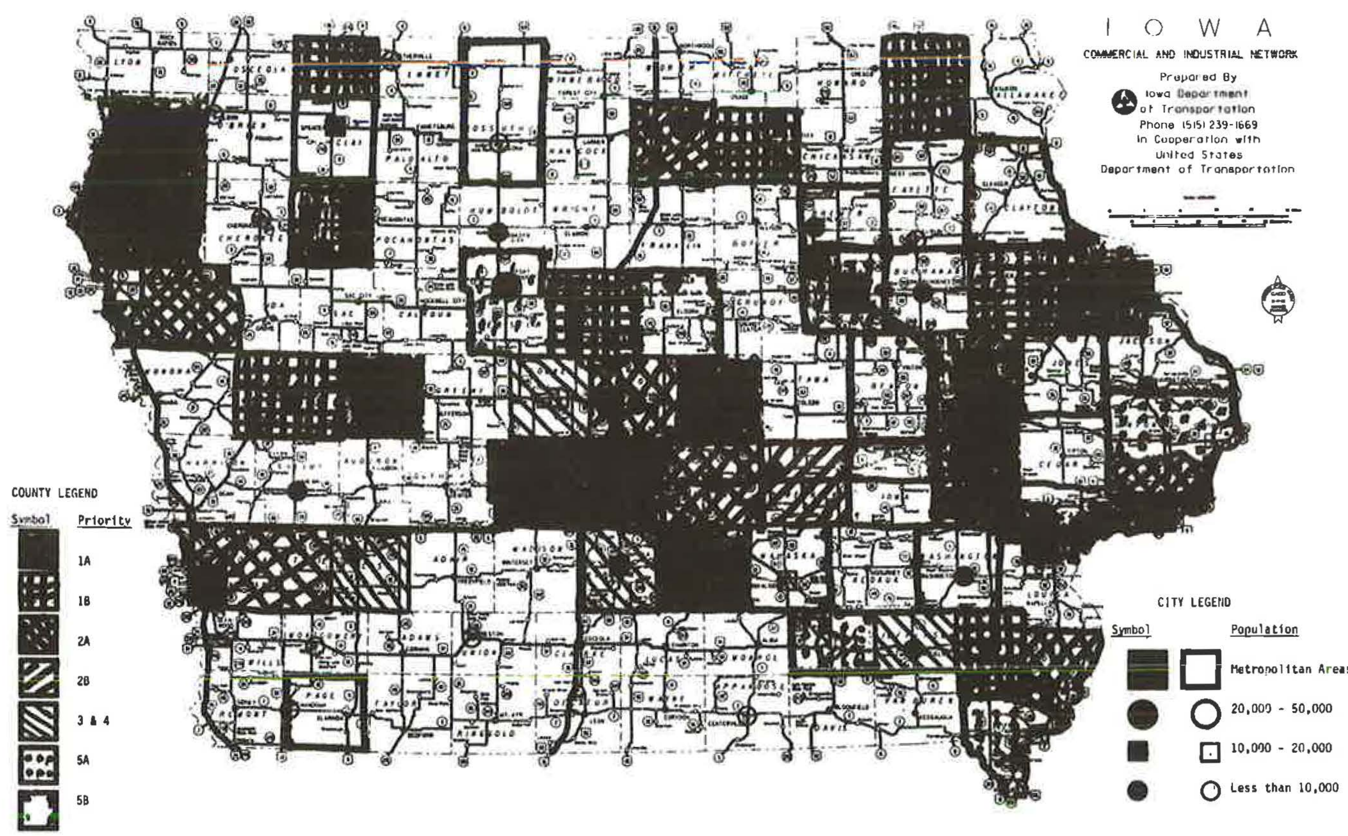

FIGURE 3 Iowa CIN city and county economic analysis.

TABLE 1 DESCRIPTION OF PRIORITY LEVELS FOR CORRIDORS OF ECONOMIC IMPORTANCE

Priority	Connect Place	To Place
1	Connect metro areas	To regional markets
2	Connect metro areas	To each other
3A	Connect large, growing communities in large, growing counties	To metro areas
3B	Connect large communities with city OR county growth	To metro areas
3C	Connect mid-sized, growing communities in large, growing counties	To metro areas
3D	Connect large communities without city or county growth	To nearby metro areas
4A	Connect mid-sized communities with city OR county growth	To nearby metro areas and/or Interstate
4B	Connect smaller communities with city AND county growth	To nearby metro areas and/or Interstate
5A	Connect smaller communities with city OR county growth	To nearby metro area or Interstate
5B	Connect smaller and mid-sized communities without city or county growth	To nearby metro area or Interstate

NOTE: All remaining portions of the Commercial and Industrial Network were assigned to a level based on the current amount of traffic.

One drawback that Iowa has largely overcome is the heavy emphasis on collection of secondary data in developing the rankings. A variety of problems was encountered in the collection of both city and county data.

The need for consistent, comparable, and reliable data was perhaps foremost among the problems encountered. Sources of employment figures, for instance, include the U.S. Department of Commerce census data (every 10 years), the Economic Census data (every year ending in Years 2 and 7), the U.S. Department of Commerce County Business Patterns (annual), the Bureau of Economic Analysis data (gathered in Iowa through the state's Department of Employment Services), and the Bureau of Labor. Because employment data may be collected by place of work or residence; may be derived using statistical models; may or may not include self-employed, government, or farm workers; may contain different types of data breakdowns; and may experience periodic data collection and presentation changes, any reliable analysis of data must be performed with a thorough knowledge of the type of data being used and its limitations. These economic data problems present difficulties not only for economists but especially for transportation specialists, who may be considerably less familiar with government economic data. Data collection problems are insignificant, however, in comparison with the primary data collection needs required for more quantitative methods of analysis, such as developing a statewide transportation or economic model.

PRIORITY CORRIDOR LEVELS: SELECTING AND SCHEDULING IMPROVEMENTS

As previously discussed, the city and county analysis provides the basis for establishing priority corridors for improvement on the CIN. The priority levels outlined in Table 1 are presented in further detail in Table 2. Figure 4 shows a map of these corridor improvement priorities.

It is recommended that improvements be scheduled starting with the highest priority levels, radiating out from the larger Iowa cities. Within each level, the cities have been ordered by their ranking in economic size. This ordering is intended to be combined with cost-benefit analysis and considerations of regional equity in scheduling projects within a category.

TABLE 2 PRIORITY CORRIDOR LEVELS FOR IOWA CIN IN OCTOBER 1989

DOT DISTRICT	COUNTY NAME	CITY NAME	POP GROWTH LEVEL	SERVICE LEVEL (1-6)	1986 POP	CITY RANK: W/ CHANGE	CITY RANK: W/O CHANGE	COUNTY SIZE RANK	COUNTY CHANGE RANK	COUNTY LEVEL
PRIORITY 1: Connect Metropolitan areas to Regional Markets										
Tier 1: Metro areas with growth (top 50 in change) in growing counties (county level 1 or 2)										
1	Polk	Des Moines	1	1	192,060	2	1	1	2	1A
6	Linn	Cedar Rapids	2	1	108,370	1	2	2	3	1A
6	Scott	Davenport	2	1	98,750	3	3	3	16	2A
6	Dubuque	Dubuque	2	1	59,700	4	6	6	33	1A
4	Pottawattamie	Council Bluffs	1	1	56,900	9	8	8	11	2A
6	Johnson	Iowa City	2	1	50,490	5	10	7	1	1A
Tier 2: Metro areas showing city or county growth, but not both										
3	Woodbury	Sioux City	4	1	79,590	187	4	5	45	2A
2	Black Hawk	Waterloo	2	1	70,010	7	5	4	74	5A
PRIORITY 2: Connect Metropolitan areas to each other										
PRIORITY 3A: Connect large, growing communities (≥ 20,000 population with city change in top 50) in large, growing counties (1A and 2A) to metro areas										
2	Cerro Gordo	Mason City	1	1	30,200	14	7	9	13	2A
1	Story	Ames	2	1	44,460	6	11	10	15	2A
1	Marshall	Marshalltown	2	1	26,070	10	12	13	10	1A
5	Muscatine	Muscatine	1	1	23,580	15	14	14	6	1A
1	Polk	West Des Moines	1	3	23,790	11	15	1	2	1A
6	Scott	Bettendorf	1	3	27,930	12	16	3	16	2A
6	Linn	Marion	1	3	20,570	13	18	2	3	1A
PRIORITY 3B: Connect large communities (≥ 20,000 population) with either city growth (top 50) OR county growth (1 and 2) to metro areas										
1	Webster	Fort Dodge	2	1	27,070	16	9	12	87	5A
5	Des Moines	Burlington	4	1	28,000	203	9	9	22	2A
2	Black Hawk	Cedar Falls	2	3	33,200	8	13	4	74	5A
PRIORITY 3C: Connect mid-sized, growing communities (10,000 to 20,000 population and city growth in top 50) in large, growing counties (1, 2, or 3) to metro areas. **NOTE: All connections are addressed in previous levels**										
1	Polk	Urbandale	1	3	19,760	17	22	1	2	1A
1	Jasper	Newton	2	2	14,800	22	23	16	23	2A
1	Polk	Ankeny	1	3	16,730	19	25	1	2	1A
5	Warren	Indianola	1	3	11,670	24	31	37	4	3
PRIORITY 3D: Connect large communities (≥ 20,000 population) without city or county growth (city change below top 50; county level of 5) to nearby metro areas										
6	Clinton	Clinton	3	1	30,080	188	14	11	75	5A
5	Wapello	Ottumwa	4	1	25,290	224	17	19	77	5A

TABLE 2 (*continued on next page*)

TABLE 2 (*continued*)

DOT DISTRICT	COUNTY NAME	CITY NAME	POP GROWTH LEVEL	SERVICE LEVEL (1-6)	1986 POP	CITY RANK: W/ CHANGE	CITY RANK: W/O CHANGE	COUNTY SIZE RANK	COUNTY CHANGE RANK	COUNTY LEVEL
PRIORITY 4A: Connect mid-sized communities (10,000 to 20,000 population) showing city growth (top 50) OR county growth (1, 2, or 3) to nearby metro area and/or Interstate										
3	Clay	Spencer	2	1	10,970	18	19	33	79	5B
1	Boone	Boone	2	2	12,190	111	23	32	38	3
PRIORITY 4B: Connect smaller communities (~5,000 to 10,000 population) with city growth (top 50) AND county growth (1, 2, or 3) to nearby metro areas and/or Interstate										
5	Jefferson	Fairfield	1	1	9,570	23	22	40	28	3
3	Carroll	Carroll	2	2	9,450	21	24	20	27	1A
5	Marion	Pella	2	2	8,300	20	26	18	19	1A
3	Buena Vista	Storm Lake	2	2	8,530	28	27	21	20	1A
1	Hamilton	Webster City	2	2	8,380	39	27	28	18	1B
1	Poweshiek	Grinnell	2	2	8,430	27	28	26	26	2B
6	Johnson	Coralville	1	5	9,310	21	28	7	1	1A
5	Henry	Mount Pleasant	2	1	7,200	31	29	27	12	1B
2	Winneshiek	Decorah	2	2	8,000	27	30	30	7	1B
4	Cass	Atlantic	2	2	7,500	37	32	43	52	4
3	Plymouth	Le Mars	2	1	7,850	29	33	23	6	1A
2	Cerro Gordo	Clear Lake City	1	3	7,930	26	34	9	13	2A
3	Crawford	Denison	1	2	6,790	32	40	31	41	1B
1	Polk	Altoona	1	4	6,470	30	45	1	2	1A
1	Story	Nevada	1	3	6,270	35	47	10	15	2A
3	Sioux	Sioux Center	2	3	4,360	36	50	17	28	1A
PRIORITY 5A: Connect smaller communities (~5,000 to 10,000 population) with city growth (top 50) OR county growth (1, 2, or 3) to nearby metro area or Interstate										
2	Floyd	Charles City	4	2	8,560	248	29	42	24	1B
6	Jackson	Maquoketa	1	2	6,350	30	34	44	40	5B
5	Washington	Washington	1	2	6,820	45	35	35	58	5B
2	Bremer	Waverly	2	2	8,200	25	36	29	52	5B
1	Hardin	Iowa Falls	2	2	5,870	41	37	24	83	5B
5	Marion	Knoxville	2	2	7,920	78	38	18	19	1A
4	Dallas	Perry	2	2	6,650	65	41	22	14	1A
6	Buchanan	Independence	2	2	6,150	42	44	41	60	5B
3	O'Brien	Sheldon	2	2	4,710	57	46	53	49	9
6	Delaware	Manchester	2	3	4,860	54	47	46	34	1B
4	Shelby	Harlan	2	2	5,130	50	48	57	47	9
2	Humboldt	Humboldt	2	3	4,470	49	49	62	42	8

TABLE 2 (*continued on next page*)

TABLE 2 (*continued*)

DOT DISTRICT	COUNTY NAME	CITY NAME	POP GROWTH LEVEL	SERVICE LEVEL (1-6)	1986 POP	CITY RANK: W/ CHANGE	CITY RANK: W/O CHANGE	COUNTY SIZE RANK	COUNTY CHANGE RANK	COUNTY LEVEL
PRIORITY 5B: Connect smaller and mid-sized communities (5,000 to 20,000 population) without city or county growth to nearby metro area or Interstate										
5	Lee	Keokuk	4	2	13,010	229	20	15	78	5A
5	Mahaska	Oskaloosa	4	1	10,800	209	21	30	50	5B
5	Lee	Fort Madison	4	2	12,360	228	21	15	78	5A
4	Union	Creston	3	1	7,800	246	32	58	66	9
4	Montgomery	Red Oak	3	2	6,250	238	37	55	61	9
2	Fayette	Oelwein	4	2	6,840	262	38	25	86	5B
2	Kossuth	Algona	2	2	5,920	60	39	34	91	5B
5	Appanoose	Centerville	4	2	5,920	276	42	59	53	10
4	Page	Shenandoah	4	2	5,720	271	42	40	88	5B
2	Emmet	Estherville	3	1	6,420	251	43	67	85	10
3	Cherokee	Cherokee	4	2	6,280	276	44	52	64	7

NOTE: All connections not previously assigned were assigned priority based on current traffic levels:
*West of Decorah (IA 150 and US 18): red, level 5
*Burlington to Keokuk (US 61): green, level 3

1. POPULATION GROWTH LEVEL:
   1 and 2: Shows population growth during 1950-1986
   (1 shows growth during both 1950-1980 and 1980-1986; 2 shows overall growth but decrease in one of the periods)
   3 and 4: Shows population decrease during 1950-1986
   (3 shows overall decrease but decrease in only one of the periods; 4 shows decrease during both 1950-1980 and 1980-1986)

2. City growth was based on being ranked in the top 50 in city change.
   County growth was based on being included in county levels 1, 2 or 3.

Some improvements will be made to lower priority corridors early in the program. However, these will be limited to localized safety improvements and surface preservation projects.

The type of improvement planned for a corridor will depend on the corridor priority level, design guidelines established for the CIN, projected traffic and percentage of trucks, public input, and sufficiency ratings. Departing from the traditional approach of programming improvements in small segments, improvements on the CIN will be undertaken on a corridor-wide basis. This change reflects the realization that the benefits of improvements will not occur until major links in the system are completed. Also, the rapid improvement of major portions of the network will enhance Iowa's image as a state dedicated to supporting economic growth and diversification.

Decreasing travel time and travel costs will be main objectives in planning improvements in the CIN. The design guidelines established for the CIN system generally exceed traditional engineering standards. For instance, Priority 1 corridors may be considered for four-laning even if traffic levels do not currently warrant a four-lane improvement. Also, climbing and passing lanes will be more liberally used than on other two-lane primaries.

Following is an explanation of the five major CIN corridor improvement priority levels.

CIN Priority 1 Corridors

Beginning with the highest-priority corridors, Figure 4 shows routes that connect metropolitan areas in Iowa with major midwestern business centers in surrounding states (Chicago, Minneapolis-St. Paul, Omaha, Kansas City, and St. Louis). Many of these Priority 1 corridors would provide connections of near-Interstate quality between Iowa metropolitan areas and major markets in surrounding states. For programming purposes, improvement of these routes would receive top priority because they would yield the greatest economic payoff for the state.

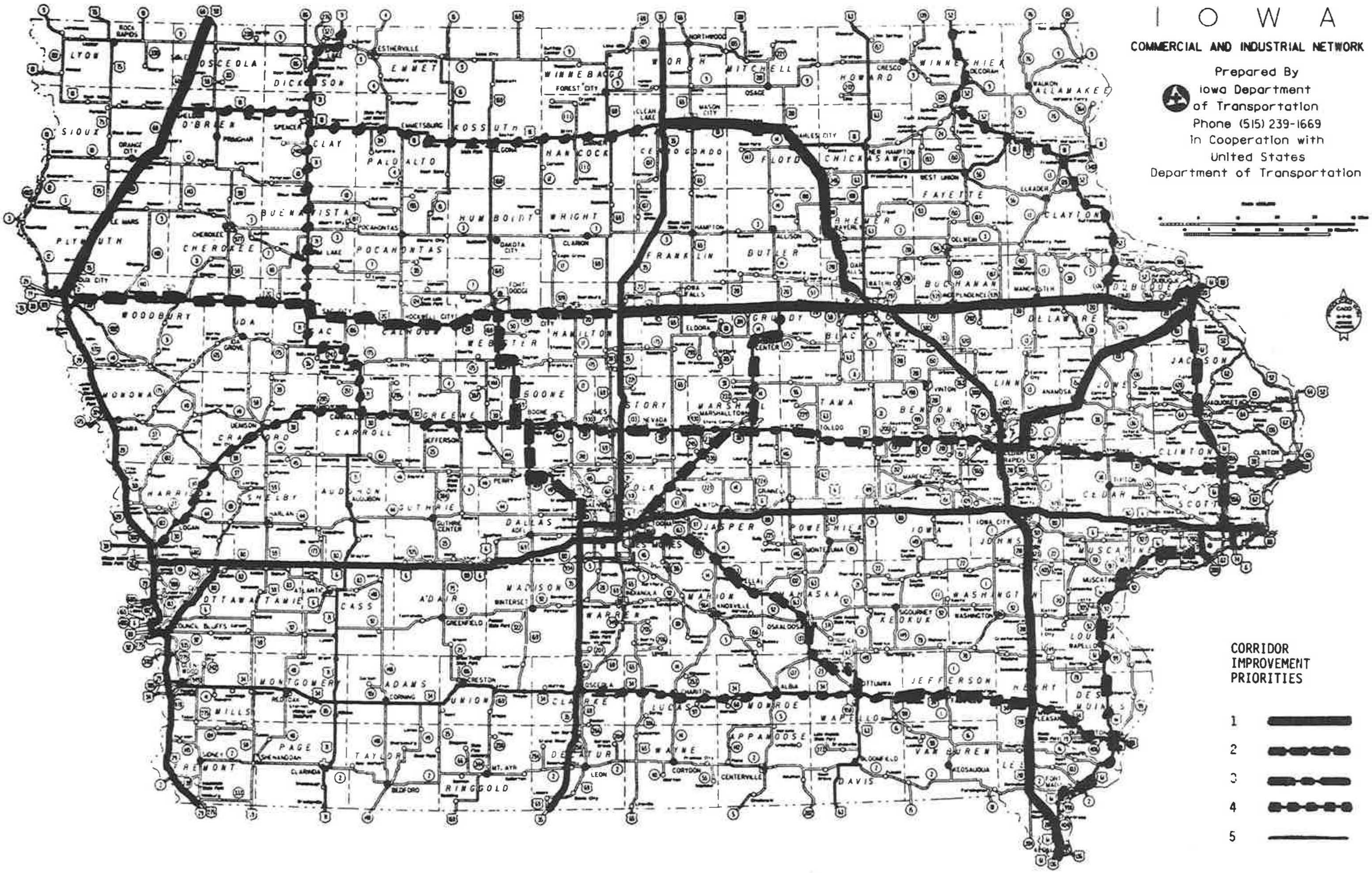

FIGURE 4 Iowa CIN corridor improvement priorities.

CIN Priority 2 Corridors

The second priority for improvement would include corridors connecting Iowa metropolitan areas. The two routes at this priority level, on the basis of current conditions, link Dubuque to Davenport and Sioux City to Waterloo. All other intrastate metropolitan area connections are already satisfied by the Interstate system or would be satisfied by the CIN Priority 1 corridors. Priority 2 corridors provide opportunity for Iowa-based industry to develop branch facilities as well as an efficient network of local suppliers. For these reasons, the level of improvement made on Priority 2 corridors would be either to expressway or high-quality, two-lane standards. However, because major investment on these corridors would not be made until Priority 1 improvements were completed, their level of improvement would not be determined until later.

This same programming philosophy applies to all lower priority levels because early improvements to the network may induce changes in traffic that would alter system needs. Also, because the improvement of Priority 2 corridors would not begin for a number of years, prudence dictates delaying the specification of design standards for these corridors.

CIN Priority 3 Corridors (3A–3D)

The third priority for improving the CIN would involve upgrading connections between large nonmetropolitan communities and both Iowa and out-of-state metropolitan areas. This would be accomplished by linking such cities as Ames, Burlington, Clinton, Marshalltown, Muscatine, and Ottumwa to previously designated corridors and the Interstates. All of these communities are important nonmetropolitan commercial centers, but not all can be characterized as growth centers. Some, such as Burlington, Clinton, and Ottumwa, experienced a significant decline in economic activity during the 1980s. However, these communities remain dominant commercial centers within their areas of the state. Thus, CIN corridors serving these communities have been classified as Priority 3 corridors to provide a high level of highway service to communities most important to the state's rural economy and most likely to generate future growth in rural Iowa.

CIN Priority 4 Corridors (4A–4B)

The city and county analysis also shows relatively stable growth in portions of west central Iowa—the area bounded by I-29 on the west, I-35 on the east, I-80 on the south, and US-20 on the north. The level of development and industrial diversification in this area is not as great as in east central Iowa, but the communities and surrounding counties show potential for industrial growth. Therefore, the CIN corridors transversing this area have been classified as Priority 4. US-52 in northeast Iowa has also been assigned this priority.

CIN Priority 5 Corridors (5A–5B)

Priority 5 corridors serve communities that are smaller and have experienced more limited success in diversifying and expanding their industrial base. Although some of the communities experienced growth between 1950 and 1986, the counties are still predominantly agricultural and have experienced significant losses of population, particularly among the young adult age groups, which are necessary to attract new business. Therefore, portions of the CIN that traverse these areas would likely not be improved until the end of the planning period. Local efforts to develop the plans and resources needed to expand and strengthen the industrial economies of these communities could affect the priority placed on improving the CIN in these areas.

Figure 4 represents a statewide application of the methodology outlined in the previous section. This methodology is one of the approaches being explored for establishing improvement priorities on the CIN, and the example given in this section is based on current information. If the methodology is adopted, a design-year analysis will be undertaken that will then be used to modify the system plan for the CIN.

CONCLUSIONS

The methodology described and applied in previous sections represents the initial phase of development of a system plan for Iowa's CIN. Issues remaining to be addressed include the following:

- What types of highway transportation improvements do manufacturers, wholesalers, and distributors perceive as necessary to support their businesses?
- Where are the principal suppliers, customers, and branch facilities of area manufacturers, wholesalers, and distribution centers located?
- From how large an area do various Iowa businesses draw their work force?
- How are industrial centers and residential communities linked in Iowa?
- Where do area residents make different types of retail purchases?

The results of research in this area, such as surveys and interviews, would be useful for selecting the types of corridor improvements.

Several other areas may merit additional in-depth study. First, recent trends show that growth both in manufacturing and in wholesale employment is occurring in many of Iowa's poorest counties, on the basis of county economic size rankings. Even in some rich counties, employment growth is occurring outside the major center. Further research into the reasons for these trends, and whether or not area highway improvements are needed and cost-effective, is warranted.

Second, the quality of jobs and life is a high priority on Iowa's economic development agenda. Although it is intended that targeting resources at regional economic centers will help support this priority, the issue is not specifically addressed in the economic analysis. Further research into areas with high rankings in value added by manufacture, new capital expenditures, and educational attainment is merited, including examination of per capita and change rankings. Evaluating whether area highway improvements are needed to support growth in "pockets of quality" would complement the corridor priority analysis.

Finally, the economic analysis of Iowa's communities and counties indicates that economic growth in the state has not been equitably distributed. Because population and economic activity are concentrated in the eastern half of the state, and because existing economic activity can be expected to strongly influence future development, any method of transportation investment that proposes to maximize the return on investment dollars will likely result in future investments being geographically concentrated.

Traditionally, Iowa highway programs have addressed the issue of equity by trying to equalize highway quality, as measured by annual sufficiency studies. IDOT is not required to follow this practice for the CIN. Nevertheless, to maintain broad-based support for this system, it will likely be necessary to ensure that benefits of the program are spread throughout the state.

The regional center analysis attempts to combine considerations of equity with the objective of maximizing benefits. This goal is accomplished by targeting highway improvements to the most important regional centers in more economically disadvantaged areas of the state, generally communities with lower service levels or in areas showing a lack of growth. However, major highway investments should not be made in areas that lack the necessary infrastructure, raw materials, strategic planning, or other resources required to support manufacturing, wholesaling, or distribution facilities.

Although the economic development benefits of highway improvements should be as broadly distributed as possible, such improvements cannot, by themselves, provide an economic lifeline for all of Iowa. Strategies aimed at supporting regional economic centers, encouraging cooperation between smaller communities, forming cluster communities to share complementary resources, and developing broader structures for educational and governmental support are necessary to spread economic benefits throughout the state.

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Economic Impact of Wisconsin's Transportation Economic Assistance Program

KENNETH J. LEONARD

The Transportation Economic Assistance (TEA) program was created in Wisconsin to help communities and businesses pay for road, rail, harbor, or airport improvements needed for economic development. The objectives of the program were to attract employers and to create more jobs in Wisconsin. Using an appropriation of $9 million, the state has funded up to 50 percent of the cost of 18 transportation improvements. These projects were expected to create over 2,800 jobs directly and an estimated 2,800 jobs indirectly. The annual increase in wages paid because of those jobs over the next 10 years amounts to $106 million. The present value of the state sales and income taxes paid over 10 years totals $58 million. TEA applications are evaluated against a dozen criteria to determine the project eligibility. These criteria include transportation costs and benefits, number of jobs, value of increased wages, ratio of cost to the number of jobs, local funding, compatibility with other transportation in the area, tax benefits to the state, and financial soundness of the business. The economic impacts of TEA improvements involve both reductions in transportation cost because of the transportation improvement and changes in the state's economy caused by the economic development project. Transportation costs and benefits are measured, in this case, by the Highway Investment Analysis Package. If the benefits, such as reduced travel time, traffic accidents, and operating cost, exceed the improvement and maintenance costs, the project is considered a good investment from a transportation standpoint. The other economic development benefits are calculated using a model of the Wisconsin economy. This model, developed by Regional Economic Development Models, Inc., measures changes due to economic development projects. It measures net increases in employment, employee wages, sales taxes, and income taxes. If a project meets the eligibility criteria, it is ranked competitively with other projects and funded according to its rank.

The economic health of a region or state is dependent on the condition of the transportation system. Advocates of local and regional development commonly request funding for a transportation improvement because they feel it will create economic development. However, a transportation improvement will not necessarily create economic development. The transportation improvement may be needed for the development to occur, but it will not by itself create the development. Good transportation is necessary but not sufficient. Other factors, like a skilled labor force, utilities, raw materials, and financing, must also be present. In addition, not enough transportation money is available at any governmental level to allow expenditures based largely on speculation.

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This situation motivated the establishment of Wisconsin's Transportation Economic Assistance (TEA) Program. Instead of responding to speculation, the program is designed to provide funds for transportation improvements tied to definite economic development projects—projects that need a transportation improvement in order to occur.

An important part of implementing the TEA program was the use of economic analysis techniques. These techniques have helped determine which projects were justified for improvement.

TEA ADMINISTRATION

TEA represents fast money from the state. The evaluation of an application normally takes only 6 to 8 weeks. Communities or businesses may use TEA money to help pay for road, rail, harbor, or airport work that they need to help attract an employer to Wisconsin. If a transportation improvement is needed for a business to locate or expand in the state, TEA funds can be made available. The overall objective of the TEA program is to create more jobs in the state of Wisconsin.

The administration of a proposed TEA project involves many actors: the local unit of government, the business, a local development agency, state agencies (departments of transportation, development, and natural resources), the governor's office, an engineering consultant, and federal agencies like the Environmental Protection Agency and the Economic Development Administration (EDA). Within the Wisconsin Department of Transportation (WisDOT), the evaluation includes design, planning, real estate, environmental assessment, and construction staff. Coordination of all these actors requires special attention.

Figure 1 is a detailed flow chart of the TEA project development process. A local unit of government or business must first make an application to WisDOT. WisDOT will screen the application, particularly reviewing the cost of the improvement and the number of jobs that will be created. If the application passes the initial screening, the applicant is asked for additional information.

EVALUATION

On the basis of the additional information, WisDOT evaluates such issues as the job effects, wages paid to the employees, income and sales taxes generated, and capital improvements

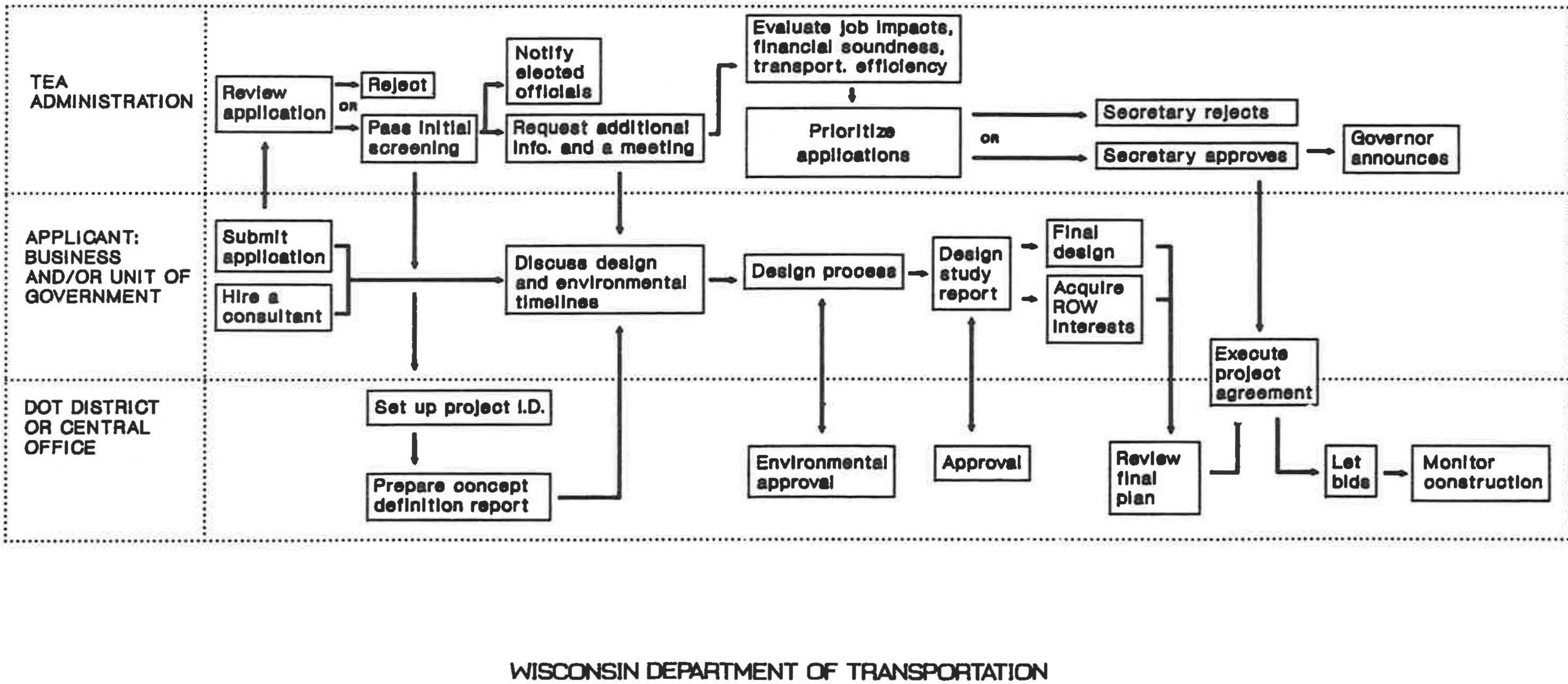

FIGURE 1 TEA project development process.

committed. The financial soundness of the business is evaluated, and the efficiency of the transportation improvement is calculated. Also, state officials make a number of visits to the local agencies, the businesses, and the site. The following criteria are used in the evaluation of proposed TEA projects to determine eligibility:

1. Whether the transportation costs of the improvement are balanced by the transportation benefits,
2. The cost of the improvement,
3. Ratio of the cost of the improvement to the number of jobs,
4. The number of jobs that are increased or retained in the state,
5. The amount of funds provided by the local government,
6. Whether the improvement is compatible and complementary to other transportation in the area,
7. Whether the improvement serves a local purpose,
8. Whether the improvement will be in an area of high unemployment or low-average income,
9. Whether the project will contribute to the economic growth of the state and the well-being of the residents,
10. Whether the business that would be helped is financially sound, and
11. Whether the transportation improvement would have a significant negative impact on other businesses.

The highest dollars/job ratio for an approved TEA project has been slightly below $5,000/job. This experience has led to the establishment of a rule that no projects with a ratio greater than $5,000/job are approved. A cap of $1 million in TEA funds per project was also set. These rules are designed to promote significant overall employment gains from the limited funds available for the program. The rules are consistent with those of other Wisconsin programs that provide public funds for the training of employees in private businesses.

TEA program funding is generally appropriate when the business development does not involve the transfer of jobs from one part of the state to another and when the business development is not retail in nature. Retail businesses are not eligible for funding in this program, because they are likely to involve the transfer of employees from one area or region of the state to another.

Other types of businesses that are excluded include wholesale outlets, hotels and motels, eating and drinking establishments, and entertainment and recreation facilities. Private roads or buildings are not eligible.

RANKING PROCESS

Applications are evaluated three times during the year: June 1, September 1, and December 1. All applications and accompanying additional information that are received by a given application date are ranked competitively and funded according to their rank until the TEA funds allocated for that period have been exhausted. After it has been determined that a proposal meets all the eligibility criteria, the funding priority of a project is determined by the following criteria: improvement cost per job created, transportation efficiency improvements resulting from the project, the county unemployment rate at the location of the project, and geographic diversity. The greatest weight is given to the ratio of the transportation improvement cost to the direct jobs created.

If the project meets the evaluation criteria and ranks high enough to be funded, the Secretary of WisDOT approves the project and the Governor announces it. Finally, local, state, and private workers implement the project. Figure 1 shows in more detail all the project development steps, such as design work, right-of-way purchasing, and environmental evaluations, which go on at the same time as the economic evaluations. All of this leads to implementation.

TEA SUCCESS

The TEA program was appropriated $9 million in state funds during its first 2 years (FYs 1988 and 1989). Using this money, WisDOT funded up to 50 percent of the costs of 18 transportation improvements. The remainder of the expense was paid for with a combination of local government and private funds or in-kind services. The 18 projects are listed in Table 1, which presents the location of the project, type of project, kind of business, cost of the project, and number of jobs created.

These projects involved the commitment of $7 million in state funds. Assisted by the TEA program, they will create over 2,800 direct jobs and an estimated 2,800 indirect jobs. "Direct jobs" are those jobs created at the new business development, and "indirect jobs" are created in the sectors of the economy that sell to the new business and its employees. TEA contributed an average of $2,500 for every direct job created through the program.

As presented in Table 2, the annual increase in wages paid for those jobs over a 10-year analysis period amounts to $106 million. The present value of the state sales and income taxes paid over the same analysis period totaled $58 million.

The businesses created with the help of the TEA program accounted for $85 million of capital investments in the state. In general, TEA projects have had a capital investment of $5 million per project.

When the TEA concept was being debated by the legislature 2 years ago, one concern was that the projects would all be in the more populated southern part of the state, which includes Madison and Milwaukee. Figure 2, which maps the project locations, shows that this has not been the case. Only five projects have been approved in the Madison and Milwaukee metropolitan areas and surrounding regions. Many of the projects are in the northern part of the state.

In addition to wide geographic distribution, the project locations exhibit a wide distribution in population size (Table 3). The populations range from 4,000 in Florence County to 350,000 in Dane County. Seven of the projects up north are in counties that average less than 35,000 in population.

The typical TEA project is an access road to a new industrial park in a small- to medium-sized community. The larger metropolitan areas have less demand for TEA funding, because their transportation systems are already well developed. Also, many projects that are needed in or around the larger areas are too expensive for the TEA program.

TABLE 1 APPROVED TEA PROJECTS, JULY 1989

Project Name	Project Location	Project Description	Business Description	TEA Grant Amount	Direct Jobs Created	Indirect Jobs Created
Lacrosse/ Gateway Industrial Park	City of 48,347 pop. in southwestern Wisconsin	Construct a route connecting industrial park to CTH B.	Gateway Foods: wholesale grocery. Marigold Foods: dairy products.	$1,500,000	300 (Gateway only)	540
WISPARK/Kenosha/ Pleasant Prairie	Town of 12,071 pop. in southeastern Wisconsin	Extend CTH Q from Lakeview Corporate Park to I-94.	Utility developing an industrial park for a variety of industries.	$2,500,000	550	1003
Rice Lake/ Nichols-Homeshield	City of 7,691 pop. in northwestern Wisconsin	Upgrade 970 feet of gravel road to urban-type road.	Building products manufacturing and warehouse.	$61,500	43	36
Fort Atkinson/ Metal Container	City of 9,785 pop. in southcentral Wisconsin	Construct access road for industrial park.	Can manufacturer.	$85,000	130	144
Florence/Pride	Town of 1,800 pop. in northeastern Wisconsin	Build access roads into 80 acre site (extra load bearing).	Wood products.	$172,000	150	79
Winnebago (Oshkosh)/ EAA (Experimental Aircraft Assoc.)	City of 51,700 pop. in eastcentral Wisconsin	Improve access roads to airport and convention grounds.	Convention and museum operator.	$162,500 incentive $5,000	259	Not applicable
Outagamie (Appleton)/ Air Wisconsin	City of 62,924 pop. in eastcentral Wisconsin	Build hangar apron and strengthen 1,400' by 75' taxiway.	Airline's maintenance facility.	$375,000	300	345
Stoughton/ Stoughton Trailers	City of 8,456 pop. in southcentral Wisconsin	Extend CTH N to industrial park.	Truck trailer manufacturer.	$280,000	80	80
Arcadia/ Ashley Furniture Co. I	City of 2,235 pop. in westcentral Wisconsin	Build roads to improve circulation near plant.	Furniture manufacturer.	$265,000	125	105
Prentice/Biewer Lumber Company	Village of 605 pop. in northcentral Wisconsin	Upgrade a gravel 7600' road and construct a 400 foot access road.	Sawmill.	$267,650	130	43

TABLE 1 *(continued on next page)*

TABLE 1 (*continued*)

Project Name	Project Location	Project Description	Business Description	TEA Grant Amount	Direct Jobs Created	Indirect Jobs Created
Janesville/ Lab Safety	City of 52,202 pop. in southcentral Wisconsin	Improve an arterial adjacent to the plant and warehouse.	Manufacturer and distributor of industrial safety equipment.	$138,000	165	95
Barron/ Jerome Foods	City of 2,899 pop. in northwestern Wisconsin	Relocate STH 25 to allow plant expansion.	Food wholesaler.	$264,611	150 120 retained	61
Sturgeon Bay/ Hatco Corp.	City of 9,270 pop. in northeastern Wisconsin	Build an access road.	Designer and manufacturer of food service equipment.	$116,000	60	44
Bloomer/Bloomer Plastics, A-J Industries	City of 3,520 pop. in westcentral Wisconsin	Build a 4000′ access road in an industrial park.	Plastics and building products.	$260,300	45 20 retained	55
Arcadia/ Ashley Furniture Co. II	City of 2,235 pop. in westcentral Wisconsin	Rebuild access roads near plant expansion.	Furniture manufacturer.	$125,000	33	27
Whitewater/ Trostel LTD.	City of 11,520 pop. in southeastern Wisconsin	Build an access road.	Manufacturer of precision molded rubber components.	$65,810	50	45
Ashland/Bretting Manufacturing	Village of 8,963 pop. in northcentral Wisconsin	Widen road and reconstruct intersection.	Manufacturer of napkin folding machines.	$95,800	35	68
Mellen/North Country Lumber and Superior Kilns	City of 1,034 pop. in northcentral Wisconsin	Build an access road and a rail spur in an industrial park.	Lumber mills and kilns.	$218,612	40	50
		Subtotals:		$6,957,783	2785	2820

TABLE 2 ECONOMIC IMPACT OF TEA PROJECTS

In Million of Dollars

Project Name	Private Capital Investment	Annual Increase In Wages	P.V. of 10 Years Of Taxes
Lacrosse/ Gateway Industrial Park	$2.45	$13.57	$7.91
WISPARK/Kenosha/ Pleasant Prairie	unknown	$33.15	$19.33
Rice Lake/ Nichols-Homeshield	$1.03	$1.32	$0.67
Fort Atkinson/ Metal Container	$30.00	$5.32	$3.00
Florence/Pride	$2.25	$3.52	$1.62
Winnebago (Oshkosh)/ EAA (Experimental Aircraft Assoc.)	$0.00	$6.28 est.	$3.14 est.
Outagamie (Appleton)/ Air Wisconsin	$7.35	$13.70	$7.96
Stoughton/ Stoughton Trailers	unknown	$2.35	$1.18
Arcadia/ Ashley Furniture Co. I	$2.10	$6.97	$3.35
Prentice/Biewer Lumber Company	$17.00	$4.25	$1.97
Janesville/ Lab Safety	$4.00	$3.41	$1.53
Barron/ Jerome Foods	$5.07	$3.08	$1.47
Sturgeon Bay/ Hatco Corp.	$1.10	$1.43	$0.65
Bloomer/Bloomer Plastics, A-J Industries	$2.00	$1.73	$0.82
Arcadia/ Ashley Furniture Co. II	$3.30	$0.92	$0.45
Whitewater/ Trostel LTD.	$2.10	$1.93	$1.10
Ashland/Bretting Manufacturing	$2.90	$1.80	$1.05
Mellen/North Country Lumber and Superior Kilns	$2.05	$1.48	$0.76
TOTAL	$84.70	$106.21	$57.96

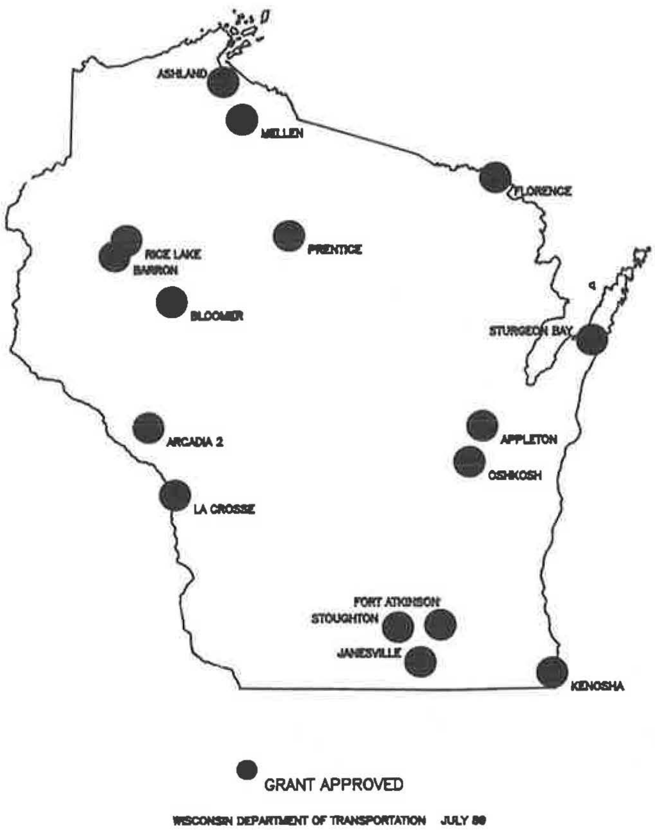

FIGURE 2 TEA jobs in communities across Wisconsin.

ECONOMIC EFFECTS

The economic effects of these TEA-assisted transportation improvements involve reductions in transportation cost caused by the transportation improvement and changes in the state economy caused by the economic development project. Together, these benefits have more than justified the improvements.

Transportation Effects

For each transportation improvement requested as part of a TEA project, a justified transportation need must exist. A need is considered justified when the transportation benefits exceed the transportation costs. For projects that improve the capacity of existing highways or alter regional traffic patterns, the Highway Investment Analysis Package (HIAP) is used to estimate the value of the reduction in transportation costs.

The HIAP is a computerized evaluation and investment programming model developed by FHWA to help state, regional, and local organizations effectively use limited highway funds. HIAP analyzes alternative improvements to individual roadway sections and networks of sections. The model analyzes the economic and safety consequences of a wide range of highway improvements, including new construction, reconstruction, resurfacing, detours, hazardous areas, and railroad grade crossings.

HIAP may be used to evaluate and compare alternative improvements to the same highway section or to several highway sections or to examine a pool of improvements proposed for a finite period within an area, and to prepare a prioritized construction program. The model provides investment programming under constraints that replicate the financial, political, and environmental requirements of public investment planning.

A means for developing a tentative investment program, HIAP is best seen as a starting point for further discussion incorporating subjective or nonquantifiable considerations. It can, for example, be used to estimate economic benefits foregone by implementing investment programs structured to address political considerations rather than simple cost-effectiveness.

The minimum data required to operate the model consists of relatively basic existing and improved roadway cross-section information (number of lanes, lane width, type of median, type of access control, surface type, and type of area served by the road), at least two average daily traffic estimates for different years, and the capital cost of the improvement. The user may select HIAP default tables and calculations instead of manually calculating other data items.

The HIAP computer package assigns dollar values to construction costs, maintenance costs, travel time, operating costs, and the cost of traffic accidents. If the benefits, such as reduced travel time, traffic accidents, and operating costs, exceed the improvement and maintenance costs, the project is considered a good investment. Even if other aspects of the project are questionable, a positive benefit-cost analysis may offset the other aspects.

To perform the benefit-cost analysis, reliable travel forecasts are needed. Locally generated forecasts are reviewed to make sure they are logical and reasonable. In some cases, the transportation improvement is to provide new access to an industrial park, and before-and-after traffic costs cannot be compared. In these cases, the improvement is judged on the basis of how well it provides service to a new development. In some cases, the design of the access is adjusted to ensure it is cost-effective.

Rail projects submitted for TEA consideration are typically rail spur projects. They also receive a benefit-cost analysis. The cost of shipping by rail is compared to the cost of shipping by truck or some combination of rail and truck. Costs for each alternative are identified and plotted over time. This stream of costs is then discounted to a present value (the discount rate is 5 percent in real terms). The costs that are considered include the amount charged to the shipper by the carrier, handling costs that differ between alternatives, facility costs that differ between alternatives, and loss and damage.

Effect on State's Economy

Changes in the economy caused by an economic development project are measured in terms of net increases in employment, employee wages, sales taxes, and income taxes. The economic development benefits are calculated using a model of the Wisconsin economy. This model, developed by Regional Economic Development Models, Inc. (REMI), takes into account

TABLE 3 COUNTY POPULATIONS OF TEA PROJECTS, 1988 ESTIMATE

County	Community	County Population
La Crosse	La Crosse	97,002
Kenosha	Kenosha/Town of Pleasant Prairie	123,127
Barron	Rice Lake	40,968
Jefferson	Ft. Atkinson	66,876
Florence	Florence	4,387
Winnebago	Oshkosh	139,107
Outagamie	Appleton	137,777
Dane	Stoughton	346,591
Trempealeau	Arcadia	26,335
Price	Prentice	16,125
Rock	Janesville	139,344
Barron	Barron	40,968
Door	Sturgeon Bay	26,905
Chippewa	Bloomer	54,220
Walworth	Whitewater	73,357
Ashland	Ashland	16,848
Ashland	Mellen	16,848

Source Population Estimates: DOA, Demographic Services Center; Official Population Estimate For 1988

the inputs and outputs that flow between businesses in Wisconsin and between Wisconsin businesses and those outside the state.

The economic simulation is performed using information on direct employment, indirect employment, and income that is generated by the new businesses. The number of jobs by standard industrial classification code and the average hourly wage for those jobs are used to determine the present value of the wages over a 10-year period. On the basis of that income, the state income and sales taxes that will be paid can be estimated.

The REMI forecasting and simulation model and conjoined 490-sector input-output model is a regional economic model with a rigid structure, calibrated specifically to a given region or state, so the underlying structure of the model is consistent from region to region, while the behavior of the model for one region differs from that of another region. This model is designed to yield quantitative estimates of indirect and direct effects of proposed policies as a change in any variable is transmitted through the entire web of economic linkages within the state. It comprises price-responsive demand and production functions around an input-output matrix. It includes input, output, and cost parameters for all significant industries in the state, as well as interindustry linkages. In this computable general equilibrium model, any given change is seen to simultaneously affect all product and labor markets, endogenously determining quantities and prices, as well as wages and employment for all occupations and industries in Wisconsin.

The REMI model contains such elements as state interindustry structure, consumer and government demand, capital stock adjustments, industrial location based on comparative cost of doing business, derived demand for factors of production, labor supply, and income distribution. For example, in considering out-of-state exports, the model accounts not only for national and international demand, but also computes the relative cost of Wisconsin (versus other areas) as a location for production for each manufacturing and nonmanufacturing industry. An increase in production costs for a Wisconsin industry relative to costs in the rest of the United States—such as a new state tax—will lead to a reduction in Wisconsin's national share of that industry. Production costs of industries in the state include state taxes and property taxes, as well as the costs of intermediate goods and labor.

Also included in the model are regional purchase coefficients for each industry, reflecting the fact that a region is an open economy. Goods and services for production input or for final demand will be brought into the state to the extent that regional comparative costs and product transportability warrant. Input, output, and employment estimates reflect these leakages of purchases typical of an open economy.

Generally, there are three major causal links in the model: (a) demand and supply linkages, (b) cost linkages, and (c) wage determination linkages. Demand and supply linkages link external demand for local output of a good with concomitant levels of local production of that good, output of intermediate goods required for that production, regional incomes that affect local consumer spending, changes in investment spending, and changes in population (through migration) that affect government spending.

Cost linkages link a region's wage costs and nonlabor production costs with the mix of productive factors used to produce a good, with the total production costs, and consequently with the region's share of extraregional markets, local output, and local employment directly and indirectly involved in that output.

Wage determination linkages are the web of interactions between employment levels by industry, occupational skill requirements by specific industry, and demand for specific occupations. These links interact in turn with wage rates by occupation, and wage rate levels in specific industries. Changes in these wage cost elements also produce changes in the previously described cost linkages. In addition, increased employment levels tend to increase population (through inmigration), thereby increasing labor supply and dampening the effects on wage rates of an increased demand for labor.

Although the REMI model produces estimates of indirect jobs, they are not considered as strongly in the TEA evaluation as the direct jobs. For instance, the ratio of TEA cost per job only considers direct jobs. One reason for this is because it is difficult to determine exactly what portion of the wages is spent outside the state, thereby producing indirect jobs in other states; average relationships are used in the estimates.

The TEA program concentrates on assisting basic activities that produce goods and services sold beyond the state's borders. The flow of income into the state from the payments associated with its exports are the primary fuel that keeps the economy strong and growing. The businesses that are excluded are largely ones that involve the transfer of jobs from one part of the state to another.

PROBLEMS

Some problems have been encountered in administering the TEA program. One of the biggest has been the short construction schedule desired by applicants for the proposed economic development project and the transportation improvement. Sometimes, applications were received only weeks before the developer wanted to start construction of the building and the improvement. Usually, no preliminary engineering had been done. As a result, a few projects were delayed. In other cases, the process could be shortened enough to get the project into the construction schedule.

In five cases, the rights-of-way still had to be acquired, taking a number of months. In one case, the community had to acquire the real estate by condemnation. Also, two projects required detailed Environmental Impact Statements (EISs). Luckily, they were already underway and took only a few additional months. The EIS for a recently received request will take 2 years to complete.

Many times, businesses did not want to submit financial information because they were afraid a competitor would get the information. As proof of financial soundness, the TEA program requires 3 years of audited profit and loss statements. The state is not able to keep that financial information confidential. If someone asks to see the information, it has to be provided. This situation has become a real concern. In some cases, WisDOT has had to insist on seeing the financial information, because it cannot take the chance of investing in an unsound business.

WisDOT has had trouble validating forecasts of new jobs and determining that those jobs would not occur without state TEA funding for the transportation improvement. As a result, the local government is asked to sign a guarantee that the jobs will be created. If the jobs are not created, the applicant (local government) must pay back all or a portion of the grant.

Some applications were so small in terms of the cost and size of the project that it hardly paid to take them through the process. Projects that involve only $10,000 to $20,000 are best constructed and funded at the local level.

As mentioned earlier, many actors are involved in these projects. Therefore, some of the projects were difficult to coordinate. Also, the smaller communities often lacked adequate staff to help coordinate and implement projects. In some cases, regional planning commissions were able to assist the community.

CASE STUDIES

The following case studies of projects in Kenosha, Fort Atkinson, Oshkosh, and Florence represent a good cross section of the TEA projects WisDOT has approved to date. The projects vary in kind of development, type of transportation improvement, number of jobs, size, and location. Figure 2 shows the location of these sites.

Lakeview Corporate Park in Kenosha

Lakeview Corporate Park is a new 1,200-acre industrial park owned by WisPark, a subsidiary of Wisconsin Electric Power Company, which serves southeastern Wisconsin. Energy officials estimate that the park could provide 7,000 to 12,000 jobs in the next 7 to 15 years.

The TEA project involved the construction of a 2-mi extension of a county trunk highway. This four-lane divided road connects the new industrial park directly with Interstate 94 between Milwaukee and Chicago. This link to the Interstate is considered vital to the development of the industrial park. Lakeview Corporate Park is in the Pleasant Prairie township of Kenosha County.

The 2-mi extension of County Highway *Q* is projected to help the industrial park win as many as 800 new jobs in the next 3 years through businesses relocating to or expanding in Kenosha County. The park is projected to create 1,323 indirect jobs—with businesses that sell to or buy from the new business, or benefit from the additional consumer spending. This development will increase earned wages by $254 million and sales and income tax revenue by $26 million over the next 8 years.

Transportation efficiency benefits (reductions in travel time, vehicle operation, and accident costs) and avoided maintenance costs to alternative roads were higher than the costs. The benefit/cost ratio was 2.5, and the net present value was over $9 million.

The total cost of this county road extension was $6.8 million. The TEA grant paid $2.5 million, Kenosha County paid $1.9 million, and $2.4 million came from WisPark (providing a good example of partnership between the public and private sectors). The local government and WisPark provided the state with a written guarantee that at least 580 jobs, new to Wisconsin, would be created in the park within 3 years from the time the roadway was opened. If the job requirement is not satisfied, reimbursement may be necessary.

This joint economic development will be a boon to the state, especially in an area that has been losing employment and where unemployment rates have been running at twice the state average. Two large firms have already announced plans to build in Lakeview Corporate Park. Super Value will build a $53 million grocery distribution center that will add 700 jobs to the area over the next 5 years. Rust-Oleum Corporation, a major manufacturer of rust-preventive and moisture-resistant coatings, will build a $20 million plant and employ about 200 people.

Metal Container Corporation in Fort Atkinson

Metal Container Corporation, a wholly owned subsidiary of Anheuser-Busch Companies, Inc., has built a metal can manufacturing plant on the northern edge of the city of Fort Atkinson, in south-central Wisconsin. The 200,000-ft^2 plant, representing a capital investment of $30 million, will make aluminum cans for a nearby Pepsi bottling plant, which is the largest soft-drink operation in the world.

The transportation project is an access road extending 1,200 ft east from Main Street through the industrial park to the Chicago & Northeastern Railroad. The street is 36 ft wide and has 7-in. nonreinforced concrete and curb and gutter. The total cost of the transportation improvement was $170,000, with WisDOT's share being $85,000.

Anheuser-Busch Companies, Inc., considered 39 communities before selecting Fort Atkinson. Transportation, including proximity to rail, was a key factor in the decision. Rail service is required for the inbound shipment of raw materials and the outbound shipment of scrap aluminum for recycling.

TEA funds can help create substantial new employment in relatively small communities such as Fort Atkinson, which has a population of about 10,000. The new plant will create 130 direct jobs and 144 indirect jobs. Thus, WisDOT will spend $650 in TEA funds for every direct job created. The new industry will create $5.3 million a year in personal income for citizens in the next 10 years. Income and sales taxes generated by the project should total $3 million over 10 years.

Experimental Aircraft Association in Oshkosh

The Experimental Aircraft Association (EAA), with over 110,000 members, has the largest collection of private aircraft in the world. Membership in EAA involves 725 chapters in 90 different countries. It is based in Oshkosh, Wisconsin.

Oshkosh is also the site of the EAA annual convention and fly-in at Wittman Field. The 2-week convention has grown steadily to current attendance of over 800,000 people and an economic impact of over $60 million in Wisconsin. Visitors from over 70 countries, including the Soviet Union, attended this year's fly-in. The attendance and the resulting economic impact are forecasted to continue to grow as long as public facilities to support the growth are constructed.

The EAA employs 114 full-time and 36 part-time employees. During the summer season, 100 additional part-time employees are added to the work force. During the 2-week convention period, over 1,000 local citizens are employed for various services.

To alleviate congestion during the 2-week fly-in, EAA requested $162,500 in TEA funds to widen local streets from two to three lanes, to rebuild two intersections, and to build new sidewalks. The widened roads would have the capacity to serve a greater number of vehicles per hour, and the new sidewalks would reduce pedestrian and vehicular conflicts. The benefits of the improvements include less delay because of reduced congestion and safer travel because of avoided accidents.

If these transportation improvements were made, it was estimated that annual expenditures at the convention would increase from $65 to $81 million. Using the model of the state's economy, expenditures of $16 million on goods and services translate into 648 jobs. Because businesses buy goods and services from outside of Wisconsin, the expenditures represent 259 jobs for Wisconsin.

This project is an example of successful, rapid provision. The project was completed in only 2 months, just in time for the 1988 fly-in.

The TEA project was the second transportation project during the year designed to improve facilities for EAA. Federal and state funds of $1.5 million were used to lengthen a runway and taxiways. The ability to augment and influence other projects and funding is another attribute of the TEA program.

Pride Manufacturing Co. in Florence County

Pride Manufacturing Co. has built a wood turnings plant and mill in the town of Florence in northeastern Wisconsin. The 200,000-ft^2 plant represents a capital investment of $2.5 million. Florence, an unincorporated town of about 1,800 people, was chosen over sites in Michigan, Minnesota, North Dakota, and Canada.

Wisconsin was chosen because of its receptive business attitude (including the TEA program) and because it has the necessary raw material. The Florence area contains the white birch the firm needs to manufacture its over 400 different wood components, which include products varying from its original wooden cigar holder to golf tees and parts for toys, games, crafts, and furniture. Pride said that the site was appealing but that the WisDOT grant made it all possible.

TEA funds provided $172,000 to help construct a 24-ft-wide, 1,000-ft-long road providing access to the new plant. The new road provided employees and heavy trucks the access they needed.

Pride Manufacturing Co. will create 150 new jobs. The cost of TEA funds per direct job is quite favorable at $1,147. Payments made by the direct job holders to other parties in the regional economy will in turn produce another 79 jobs. The REMI model estimates that personal income in the state will increase $3,520,000 annually because of these jobs. The project will also increase the tax base in the state. The present value of all income and sales taxes generated by the project during the 10-year period is equal to $1,620,000.

CONCLUSIONS

The TEA program is a success. The program is meeting its objective of securing more jobs for Wisconsin and has allowed the state to move more quickly to help communities attract new jobs. Wisconsin's ability to effect transportation improvements rapidly has many times been the key to creating new jobs and economic opportunities.

Also, the TEA program has been instrumental in acquiring additional funds for local communities. The program, when used with local funds, has helped acquire additional funds from other agencies, such as EDA.

The TEA program represents more than just money. The program is a way of sending a positive message from the state to private industry; it shows that the state cares about private business and can be responsible. The private sector appreciates that positive attitude.

TEA has demonstrated that local, state, and federal government can work as partners with the private sector in fostering economic development. TEA's success has been based on extensive cooperation between all parties. In Wisconsin, state government wants to be a strong partner in fostering economic development.

Overview of Methodology

DONALD R. DREW

Major emphasis of this conference was the identification of models and methodologies for organizing and using existing data for designing future data collection efforts and for applying systematic analysis and scientific procedures to the understanding of policy problems and the making of public decisions regarding transportation system improvements and economic development.

Transportation benefits accruing to road users in terms of time savings, cost savings, and savings from accident reduction are the primary effects of transportation improvements. These transportation user benefits, the main components of benefit-cost analysis, provide a quantitative assessment of the relative benefits of different alternatives in a common monetary measure.

Economic impacts measure the secondary effects of capital expenditures on the regional economy. The impacts affect income, employment, production, resource consumption, pollution generation, and tax revenues. These impacts may be classified broadly into three types: direct, indirect, and induced impacts. Direct impacts are consequences of economic activities carried out on the site during construction and operation. Indirect impacts derive primarily from off-site economic activities associated with the production of intermediate goods and services required for the construction and operation of the improvement. Induced impacts are the multiplier effects of the direct and indirect impacts.

USER BENEFIT ANALYSIS

Improvements to the transport system can change travel characteristics in terms of the amount of tripmaking, trip distribution, time patterns, users, and cost or level of service of the trip. In addition, changes can occur in the capital, labor, and service requirements for designing, building, and operating the physical transport facilities and vehicles.

A basic premise of economics is the intimate relationship between price and demand on the one hand, and price and supply on the other. Demand functions or demand curves are statements of the number of trips that will be made or purchased at different levels of overall trip price, for which the perceived price of travel is the total payment in expense, time, and effort that the traveler perceives or thinks about in making a trip.

On the one hand, it is necessary to know how the unit price of travel will change as more and more tripmaking is made and as system design and operation are changed. On the other hand, it is necessary to know what price different volumes of tripmakers would be willing to pay for the trip in question. The interplay between these two relationships will permit determination of the actual use that a facility will experience and of the benefit or value accruing to its users.

Once the equilibrium point or intersection between the supply and demand curves has been determined, the total system costs can be computed. This information is equally applicable to an improvement in an existing system, to the construction of an entirely new system, or to the comparison of consequences of different levels of improvement (*1*).

CURRENT APPROACHES TO IMPACT EVALUATION

By far the largest number of transportation impact studies have been evaluations of highway projects. The most important distinction is between impacts on users and impacts on nonusers. With respect to the latter, considerations that have been emphasized in the literature are location and land use, land values, and levels of economic activity. Changes in the uses of land served by a highway improvement are extensively documented in impact studies. The implicit theory behind most of these studies seems to be that the new economic activity in the vicinity of a highway improvement represents a net benefit for the region and that it is caused only by the highway improvement.

No subject has received more attention in impact studies than land value changes induced by a new highway. From the way land value data are interpreted, the implicit theory seems to be that changes in the market price of land represent the capitalized value of the entire future stream of user benefits. But there is another important way in which benefits to users are transferred to nonusers that has been largely ignored in highway impact evaluation. A firm whose transportation costs decline will find that this user benefit is transferred internally in terms of increased profits if the benefit is not also received by the firm's competitors. In this case, the benefit is capitalized into land value. However, if the firm's competitors also receive the benefits, the firm may be forced by competitive pressure to decrease its prices, passing on some or all of the benefits to the consumers of its production (*2*).

Some studies attempt to measure the impact of a transportation change on such variables as retail sales, industrial investment and employment, and postal receipts, a more direct approach than analyzing land use data. However, at no place in impact studies does there appear to have been a rigorous examination of relationships between these variables and changes in community welfare.

The research design that dominates impact studies is the before-and-after method. In its simplest form, this design may be regarded as two snapshots, one before a transportation

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change and one after. Observations are made of the impact variables at the two times, and the difference that is detected between the values of each variable is considered the impact of the transportation change.

Firms and households often take a long time to locate or relocate their establishments because of the time required for planning, administrative procedure, and construction. Hence, variables representing the impact on land use and location may not stabilize for some considerable time after the opening of the highway. However, it is clear that over a long period of time there will be many exogenous influences upon the variables being observed. In the simple before-and-after approach, the assumption is made that the change in a variable under observation is caused only by the transportation change. This assumption is violated when the observations are contaminated by influences other than those attributable to the transportation improvement under study (*3*).

THEORIES OF URBAN AND REGIONAL GROWTH

Development is much more than simple growth because it involves changes in quality as well as quantity. However, in an economic context they can be assumed to be synonymous for many purposes, such as in studying transportation impacts. Consistent explanations of patterns of urban and regional growth are provided by economic theory.

Techniques currently available for forecasting urban or regional growth make direct use of one or more facets of trade, location, or staple theories. Each available method assumes that the regions for which forecasts are required have already been defined, that good historical data are available, and that historical relationships will continue to hold in the future. Most forecasting methods link regional fortunes to those of the nation and are predicated on the hypothesis that a solution to the basic economic problem of optimal area development is public and private investment at levels high enough to at least maintain the competitive position of the area's export industries and to provide for the growth of both export and local markets at a rate equal to or greater than the rate of increase in regional labor productivity (*4*).

Long-run effects of transportation changes derive from their influence on locational decisions of firms, households, and other establishments. Variables that are held constant in the short run—job location, place of residence, retail, and industrial locations, for example—are allowed to vary in the long run. However, the state of understanding of these effects is poorly developed. No model represents the market for urban land capable of any but the most primitive types of application, and no model, good or bad, seems to represent the dynamics of the market—the rates at which relocation occurs and the factors influencing the rates.

MEASUREMENT OF THE EFFECTS OF TRANSPORTATION CHANGES

The treatment of the subject of impact measurement is divided into two parts: (a) sources of secondary data, and (b) survey procedures for gathering primary data.

Much useful secondary data exists in various forms such as administrative data used by government agencies at all levels and common data as gathered, compiled, and published by the Bureau of Census and other government agencies. Secondary data of interest include transportation variables, socioeconomic variables, land use variables, housing sector variables, and business sector variables.

In addition to making use of existing data, obtaining primary data involving the impacts of urban transportation changes by means of sample surveys is often necessary. Because the principal application of the data will be to study changes in travel demand and locational decisions of the population, the major emphasis will be on surveys that obtain information from individuals in households or businesses with questionnaires or similar instruments that can be self-administered or administered by an interviewer. Generally, such surveys provide the only hope of obtaining economic and behavioral data in a sufficiently disaggregated form to relate changes in these activities to possible specific causal changes in the environment. Survey methods include household interviews, telephone interviews, mail questionnaires, rider surveys, and office interviews.

MODELING IMPACTS OF TRANSPORTATION INVESTMENTS

In order to evaluate appropriate methodologies for relating transportation and development, visualizing the process by which methodologies are used to develop models that can, in turn, be used for policy evaluation is helpful. A formal model is a synthetic representation of the modeler's mental conception, whereas a methodology is the means by which that conception is transformed into the model. Methodologies provide the modeler with ready-made tools and constructs with which to create a model to allow the modeler to use the work of others instead of creating tools from scratch. Use of an accepted methodology makes it easier to perceive the structure and rationale of a new model, but may lead to restrictive assumptions about the reference system. A methodology developed from repeated model-building efforts in a given field for a particular type of problem may not be applicable to other situations.

A few of these methodologies and their innovators are as follows: linear programming—Dantzig, input-ouput (I–O) analysis—Leontief, econometric modeling—Tinbergen, land use analysis—Lowry, and system dynamics—Forrester (*5*).

Linear economics is the basis of two regional development methodologies: (a) I–O analysis, and (b) linear programming. I–O analysis pictures the economy as a set of interdependent industries and activities each of which requires the productive output of the others as input to its productive process. In the United States, the Bureau of Labor Statistics began publishing official I–O tables in 1952. Many governments have used I–O budgeting in preparing their 5-year plans (*6*).

Whereas I–O analysis postulates a single set of industry outputs (i.e., one feasible solution) as being uniquely determined by a specified set of final demands, linear programming generally allows for any of a number of feasible solutions or combinations of activity levels to produce enough commodities to meet or surpass an indicated set of final demands (i.e., satisfy a set of constraints). To help choose among the possible alternatives, an objective function, typically a cost or benefit criterion, is provided that is expressed in terms of the decision variables. Linear programming models have been developed to predict interregional commodity flows in many countries.

A second field within economics, which fostered two approaches to regional development modeling, might be referred to as statistical economics or quantitative economics. Two methodologies that fall into this class are econometric modeling and microanalysis. An econometric model is, in practice, a set of simultaneous difference equations relating exogenous and endogenous variables. Econometric models of a national economy take major sectors of the economy, such as the business and household sectors, as their components and are highly aggregative.

Microanalysis is a methodology for modeling a national economy that operates at a microunit level. Its primary components are the decision units of which the economy is composed: households, firms, labor unions, etc. These decision units interact through probability statements. A microanalytical model is moved forward in time by the process of Monte Carlo simulation. The probability of an action is calculated and the computer is made to draw a random sample that is compared with the derived probability to determine whether or not the action is to take place and to what degree.

A methodology specifically developed by Forrester of the Massachusetts Institute of Technology to analyze feedback systems is system dynamics. System dynamics is a way of analyzing the behavior of complex socioeconomic systems to show how organization and policy influence behavior.

ECONOMIC BASE ANALYSIS

Present theoretical and empirical findings all stress the importance of export activity as a determining factor in economic growth. Any region within a specialized economy must import to survive—and, to pay for its imports, the region must in turn export to other regions. Thus, a basic sector of urban activity will be the production of goods and services for export. Another sector consists of output activity that, because of convenience and comparative cost, will always be local (e.g., retailing and repair services). If the city is in equilibrium with imports equaling exports and with local (residentiary) output just equaling demand, the question is, on which sector will the equilibrium most depend? Export activity will be the most important, especially in the short run, according to staple or export theory. Urban export activities essentially limit residentiary activities unless these too become a part of the city's exporting base. Fluctuations in the levels of urban exports are a prime cause of changes in urban economic activity. Consequently, forecasts of urban economic activity may be based on multipliers that relate residentiary activities to exports.

In economic base analysis, certain activities are classified as exogenous. These activities comprise the export industries whose fortunes are determined by forces outside the city or region. All other industries are classified as endogenous or residentiary. The fortunes of these industries are determined by internal forces that can be represented by a multiplier linking the export sector to total regional activity. This multiplier is estimated by observing historical relationships between export activity and total regional activity. Then, given estimates of the future magnitude of export activity, application of the multiplier will yield a forecast of the total regional activity.

The inability of simple economic base, two-sector models to adequately depict the urban economic structure has been amply demonstrated. Therefore, in recent years most students of the urban economic base model have favored the multisector approach known as I–O analysis. This method reveals the internal and external relationships of an urban economy in great detail. In this respect, I–O analysis overcomes many of the defects of the simpler methods, especially for purposes of short-run analysis.

I–O ANALYSIS

First developed by Leontief in 1936, I–O analysis is now one of the most typical approaches to the assessment of secondary impacts of public sector development projects and programs. The I–O approach distinguishes itself from other methodologies in that it is more disaggregated and expresses more interdependence between economic activities. Therefore, it more readily shows the behavior of an economic system explicitly and in detail at the national, regional, and local level in response to various economic development policies (7).

However, because of their inability to express explicitly the feedback relationships between producers and the transportation system resulting from an oversimplification of input coefficients and interregional trade flow coefficients, conventional I–O models can hardly be used for projection purposes concerning the impacts of various transportation investments.

In the mid-1970s, the Bureau of Economic Analysis (BEA) completed development of a nonsurvey method for estimating regional I–O multipliers known as the Regional Industrial Multiplier System (RIMS). More recently, BEA completed an enhancement of RIMS known as the Regional Input-Output Modeling System (RIMS–II). In RIMS–II, direct requirements coefficients are derived mainly from two data sources: (a) BEA's national I–O table, which shows the input and output structure of more than 500 U.S. industries, and (b) BEA's four-digit Standard Industrial Classification (SIC) of county wage-and-salary data, which can be used to adjust the national direct requirements coefficients to show a region's industrial structure and trading patterns. Regional multipliers for industrial output, earnings, and employment are then estimated on the basis of the adjusted coefficients.

REGIONAL ECONOMIC MODELS

In addition to the I–O approach, economic models that include some transportation variables are spatial equilibrium analysis, production function models, regional econometric models, and regional projection models.

Transportation investments influence the location of industries, firms, and people, which in turn influence the cost of transportation of inputs of production. Thus, unlike most other economic models, transportation tools need to be unusually sensitive to spatial issues. Indeed, the following discussion largely concerns ways in which long-standing approaches can be adapted to problems with significant spatial variation.

Spatial general equilibrium analysis divides an economy into several geographic regions. Market demand and supply equations are used to represent each region's behavior with a typical assumption that supply and demand functions are linear. A major drawback of this type of model is the difficulty in estimating a demand and supply equation for each type of good because of the need for detailed data and the multiplication of the number of demand and supply equations as the number of regions multiplies. Although most of these models date from the 1950s and 1960s, they have received some renewed interest.

Production function is not the ideal form to investigate in detail an economic impact of an infrastructure investment because it is best used for global analysis of the United States, of a state, or of an industry (specifically manufacturing).

For any commodity, the production function is the relationship between the quantities of various inputs used per period of time and the maximum quantity of commodity that can be produced with it. More specifically, the production function is a schedule (table, graph, or an equation) showing the maximum output rate that can be achieved from any specified set of usage rates of input given existing technology.

Limiting the components of the production function to highway investments and nonhighway investments could be useful for investigating the efficiency of highway investments at the state level. An index could be developed and standardized to the average U.S. highway investment efficiency to detect under- or overinvesting in highways at the state level. Presumably, disaggregation of the capital stock for highways is feasible and a measure of efficiency could be derived providing that the price of the disaggregated inputs and output are known (*7*).

SYSTEM DYNAMICS MODELING

Difficulties in solving the problem of the interrelationships between regional development and transportation investments arise because the problem is the object of two different disciplines—development planning and transportation economics—using different languages. System dynamics methodology is used to bridge the gap between the two disciplines by establishing chains of causality from variables within decision makers' control (levels of investment, resource allocations, regulatory actions, and taxing and pricing policies) to socioeconomic development indicators (industrial growth, job creation, unemployment, in- and out-migration rates, population, population density, land use intensity, and per capita income).

A model of this process can be complex and can consist of hundreds of variables. Because of the necessary feedbacks, the determination of the optimal transportation system to maintain a desired level of development can be, to say the least, elusive.

SUMMARY OF MODELING ECONOMIC IMPACTS

All economic models are limited in their ability to duplicate the complex reality of a dynamic economy. Selection of an economic model depends on the type of uses for the results and on the details of information sought. The strength of economic models lies in their theoretical soundness, whereas their pitfalls result from a lack of empirical data needed to support every theoretical intricacy. As a result, applied economic models often are relatively unreliable in practice.

The effects of transportation investments can be divided into three parts: (a) a multiplier process generated by the initial spending on implementing the project, (b) a series of changes in economic structure and then in sectoral outputs or indirect effects attributable to the performance changes in the transportation system, and (c) changes in final demands or induced effects from income effects and population shifts. Direct effects are more or less defined by the economy and can be calculated by using conventional I–O models. Although transportation is a prerequisite of economic growth, its significance as a catalyst may largely depend on the socioeconomic condition of the region concerned.

Changes in the transportation system may take different forms ranging from changing transport costs (money and time) to transport amenities (convenience, comfort, fewer accidents, etc.). The changes may set in motion the whole economy or have only minor influence on it, depending on (a) production sensitivity of the economy to transportation costs, (b) availability of markets and input factors and the possibility of using substitutes, (c) existence of economies of scale and economies of agglomeration, and (d) local attitudes toward production expansion. Relationships between those aspects of the economy and transportation savings should be predicted and quantified and the possible changes in input coefficients and trade flow coefficients caused by the investment should be estimated before using I–O analysis to project the indirect effects of the investment. At present, the computational burden seems to be formidable.

In general, a transportation improvement reduces the spatial resistance between regions. Therefore, improvements help to open up the economy in the sense of more choices of substitution among factor inputs and product outputs. Transportation savings may be put to two uses. First, savings can be used to expand production capacity and market area and to reduce commodity prices. Under a competitive economy, this will create a new system of input combinations, market shares, and equilibrium prices. Furthermore, the final demands in all regions will also be changed (income effects). Second, savings may be used to increase primary inputs that will not only shift the inputs from the transportation sector to primary sectors, but also induce more final demands (income effects). Income effects of the transportation savings from nonbusiness travel should also be considered.

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Conference Summary

DONALD R. DREW

The Conference on Transportation and Economic Development was divided into six plenary sessions. The first session contained papers on economic impact methodology.

ECONOMIC IMPACT METHODOLOGY

The total benefits and impacts that result from a transportation improvement are never realized immediately. As Perera pointed out, a subtle but important distinction exists between transportation user benefit and economic impacts of a transportation improvement.

Hirschman and Henderson reported on a methodology used to project and evaluate the potential land use impacts of a proposed limited-access highway extension in the Rochester, New York, metropolitan area. The analysis examined the potential impacts of linking the towns of Brockport and Albion west of Rochester to the Rochester central business district via an extension of Route 531. It was decided that local land use impacts from improved highway access could be disaggregated into

1. Impacts on residential location decisions, plus associated impacts on locally based retail and service establishments that support residential development; and
2. Impacts of business location decisions occurring as a result of three possible actions: expansion of existing businesses in the corridor; attraction of new businesses from entirely outside the metropolitan region; and shifting of business to the corridor from other areas within the metropolitan region.

The approach used to project potential residential location decisions was to develop a "gravity model" of residential location. In general, gravity models, when applied to residential location, require calculation of "accessibility index scores" for subareas, which are then used to reallocate a regionwide growth projection to the subareas. The key advantage of this approach is that it is explicitly sensitive to changes in travel times between residential zones and major employment nodes.

A more qualitative approach was used to evaluate business impacts. The basic methodology involved a review of the competitive advantages of the area with and without the highway extension. This was supplemented by a more detailed analysis of such factors as developable industrial land, available financial incentive programs, and complementary transportation facilities. A separate regionwide marketing analysis was performed to assess retail development possibilities in the Brockport-Albion corridor.

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There is much to learn about the role of transportation investments in manufacturers' satisfaction with locations. Hartgen et al. reported on a study presently under way in North Carolina the goal of which is to better understand this complex relationship. With factor analysis and cluster analysis, the 100 counties of North Carolina were classified according to transportation access, economic structure, manufacturing composition, and socioeconomic characteristics. The 100 counties were then grouped into six clusters. On the basis of this cluster structure, about 1,000 manufacturing firms in North Carolina were surveyed with an extensive mail questionnaire. Manufacturers were requested to describe their perceptions of the importance of transportation systems and other factors in the import of materials, the export of products, and the access to labor markets. These data will be correlated with information on highway investments, location of the firm with respect to the highway system, and other transportation access measures. Techniques such as factor analysis, discriminant analysis, and canonical modeling will be used to determine the relative importance of transportation versus other socioeconomic and fiscal variables in determining manufacturer satisfaction. Then policy analysis of various transportation funding strategies will be used to determine effects of investment. Findings will be used to help prioritize transportation systems investments that are intended to strengthen the state's industrial base.

Most studies of linkages between transportation and economic development focus on the effects of transportation facilities on employment or on some indicators of economic productivity. Bell and Feitelson described an approach that focuses on transportation services as intermediary goods in the production and consumption processes. Because of economic restructuring in the United States and global economies, production and consumption processes change constantly over space and time. Thus, the role of various transportation services in the economy and consequently their effects on economic development are constantly in flux. To analyze the linkages between transportation services and economic development in such circumstances requires that analysis begin by identifying the role and potential of various sectors and functions in the economy (local, regional, or national). Then the importance of transportation services for the most important sectors and functions in the economy have to be identified. This requires highly disaggregate analyses of the role of transportation services in the location of the relevant industries and services differentiated by function rather than only by sector.

Such an analysis can help identify situations where the lack of specific transportation services is a bottleneck for economic development. This analysis process is a necessary first step toward a cost-effective policy for economic development.

However, it is not sufficient for formulating or evaluating transportation policy contributions to economic development. For this additional step, it is necessary to analyze the attributes of both transportation services and prospective users. Specifically, Bell and Feitelson suggested that the concentration ratios of users and operators be considered, as well as how footloose they are. These flexibility considerations are important to reduce the risk that long-term public investments will be made on the basis of an ephemeral conjunction of circumstances in the rapidly changing economic scene.

MODELING IMPACTS OF TRANSPORTATION INVESTMENTS

Beemiller described a hybrid approach to estimating economic impacts that uses survey information on the direct output effects in conjunction with RIMS II multipliers. He demonstrated that impacts can be estimated when the direct output effects of a change in final demand are themselves used as changes in final demand and applied to I-O multipliers to estimate the indirect effects. He then compared the impact estimates that result when the direct output effects applied to RIMS II earnings multipliers are (a) based on survey information and (b) estimated by RIMS II. The comparison indicated that the accuracy of the impact estimates can be significantly improved when the hybrid approach is used. In addition, the comparison indicated that survey information need only be collected on the most important inputs. The hybrid approach is demonstrated by estimating the earnings impacts associated with the operation of a General Electric Company plant in Charlottesville, Virginia.

Bennathan and Johnson described the links between the transport industry and other economic sectors of production or demand in Cote d'Ivoire, India, Mexico, the Philippines, and the United States. Their account was based on recent input-output tables of those countries.

Basic to all regional projection models are forecasts, which are relied on for making major long-term investment decisions. Hardison et al. framed aviation demand and economic impact forecasting in terms of the probabilities of meeting demand under selected development scenarios. The process to carry out the simulation was risk assessment. The risk assessment framework, customized for use in aviation strategic planning, would simultaneously evaluate the potential variability in the forecast inputs and therefore the potential variability in the outputs. Beyond the results, the process of preparing the analysis itself led the identification of new opportunities for the application of risk assessment. For example, the economic impact of each development scenario depends on the baseline used and assumptions pertaining to the redistribution of aircraft demand at capacity-constrained airports. The analysis presented focused on comparisons with what would happen under the base case with a predefined set of changes in aircraft mix. However, the base case is itself a moving target, with the practical capacity of the airport continually changing. In addition, in the face of severe capacity constraints, it is likely that the aircraft mix would change either as a result of fees, through restrictions, or naturally (as often happens when pilots of general aviation aircraft find capacity-constrained airports less attractive).

In another air transportation oriented economic development study, Norris and Golaszewski outlined a methodology for using consumer surplus as a proxy measure of the net economic development benefits from the construction of a regional airport. This methodology involves partitioning the impact of an airport into two parts: (a) the impact due to the purchases of air transportation services and (b) the consumer surplus due to a decline in the prices subsequent to the construction of the facility.

To identify the factors determining the size of the impact, these authors made a cross-sectional comparison of the economic impact of two airports, one in an island economy—with very few alternative means of transportation and no other airports—and the other in the Dallas-Ft. Worth Metroplex with an abundant supply of alternative airports and other modes of transportation.

The central thrust of the discussion was that although the size of the purchase impact closely relates to diversity of the economy, the size of the consumer surplus is a function of the accessibility of the region, its industry mix, and the importance that consumers attach to the continuing operations of the airport. To illustrate, in the Dallas-Ft. Worth Metroplex where demand for air transportation is elastic and there are extensive input-output linkages within the economy, there are substantial output multipliers indicating the number of times each dollar spent rolls over within the region. Here, both the absolute and relative size of the transportation purchase impact were larger when compared with those for the island economy. In the same two economies, because of the differences in accessibility and industry mix characteristics, the relative magnitudes of the consumer surplus were reversed. The Dallas-Ft. Worth region showed a relatively small economic development impact, whereas the island economy showed a relatively large impact ($11.03 billion), which was three times as large as the purchase impact.

ECONOMIC IMPACTS OF MODAL INVESTMENTS

The variation of results in studies of transport and development may be explained by differences in two main factors: (a) the creation of economic opportunity and (b) the response to economic opportunity. The first depends upon the quality and quantity of resources in the regions served, the actual change in transport rates and service, and commodity price levels. The second depends on an awareness of opportunity and what may be broadly defined as attitudes toward economic change.

Attaran and Auclair tested the hypothesis that productivity in the private sector of the economy is strongly associated with the availability of highway stock. For this purpose, two separate sets of economic models were constructed to try to explain this association in terms of productivity of both capital and combined labor and capital inputs in the private sector. The first model attempts to construct a relationship between private-sector capital productivity and the level of public infrastructure stock. The second model simulates the relationship between total private-sector productivity and the level of public infrastructure. The results of the model confirm the proposed hypothesis, that variations in the availability of highway stock can, to a large extent, explain variations in the productivity of private-sector capital investments as well as that of capital and labor combined. In other words, full economic benefits of investments in capital and labor in the private sector can be achieved when an adequate supply of public infrastructure in general, and highways in particular, exist to go along with such private investment. Conversely, a decline in the availability of highways would lead to a decline in the productivity of both labor and capital in the private sector of the economy. These findings are strongly supported by highly significant statistical results of the two models (over 98 percent explanatory power). Given this strong correlation, where should a state highway investment be made to promote local and regional development?

A research team at the University of Minnesota recently conducted a study on this issue, looking at the effectiveness of highway funds on economic development. Stephanedes described the research, in which employment and income implications for counties in the upper midwestern region of the United States, with emphasis on localities and regions in Minnesota, were studied using a time-series analysis.

The finding that improved highways tend to help the economy of urban areas and may hurt certain of their adjacent counties should not be surprising. In particular, counties adjacent to urban areas tend to depend on these areas for the infrastructure necessary for development; better highways may allow agricultural county residents to conduct more of their economic activities in the nearby centers. Further, a comparison of the proportion of those working in the regional centers (66 percent) and those living there (47 percent) strongly suggests that highways are helping the residents of the adjacent counties to get to work as well as providing jobs for them.

The distributional nature of the effects is evident when analyzing the different parts of the state. In particular, although certain counties are likely to gain from improved roads, others are likely to lose and the statewide effect is not significant. In addition, the statewide effect is very small in size; that is, over 10 years a 10 percent investment increase would lead to only a 0.0 percent increase in jobs statewide (otherwise stated, an extra $1 million would create an average of only five to eight new jobs statewide), most jobs due to the spending associated with the construction of the highway. Although highway funding can influence the economy of specific regions in the state, such as the regional centers; certain counties in the southeast; and the natural-resource counties in the north, it has negligible economic effect on a statewide basis. On the basis of these findings, it could be argued that the potential for statewide economic gains could not justify increased highway funding in Minnesota.

Airports and aviation make important contributions to local, state, and regional economies. A review of literature on the links between airports and economic development indicates that air transport is usually associated with significant portions of local business. Furthermore, the influence on local and regional economic activity extends well beyond the airport site itself. Also, the location of airports influences the geographic distribution of industries and can be a significant factor in the decisions of certain industries to locate in a given state or region. Data indicate that access to air transport plays an increasingly important role in the ability of some high-technology industries such as computers and electronics to compete and that the location of airport facilities influences the location of these industries. Tourism has also been shown to be sensitive to air travel access.

Weisbrod presented findings from two recent studies specifically aimed at addressing these issues of economic benefits of general aviation airports. The first project was the state of Wisconsin's effort to develop and implement a computerized tool for assessing the economic benefits of airport improvements and prioritizing alternative airport investments. Known as the Airport Benefit-Cost (ABC) system, the evaluation tool provides a wide range of alternative measures of the economic impact of airport projects from the state's perspective and from the local perspective. The second project was the Massachusetts Aeronautics Commission study of the relationship of general aviation airport facilities to business attraction and growth. Findings from a detailed survey of businesses using general aviation aircraft in Massachusetts provided a basis for documenting the role of general aviation aircraft in business location, expansion, and investment in the state. These relationships were then implemented in a personal computer analysis tool known as the Airport Impact Model (AIM). Findings from these two studies highlight the multifaceted ways in which improvements to general aviation facilities can affect local and state economies and demonstrate the need for more analysis to better measure such effects.

For several years, the Urban Mass Transportation Administration (UMTA) has been developing procedural and technical guidance on the conduct of transit project planning studies. The section of UMTA's technical guidance on the analysis of land use and urban development impacts was recently revised. UMTA had found that, although many local transit planning reports stated that a major transit investment would promote economic development, this conclusion often was not supported by sound technical analysis. Emerson drew from UMTA's revised procedures. His framework may be of use not only to local planners involved in transit planning, but also to those engaged in other types of infrastructure planning. In it, he stated that the land use impact analysis for major transit projects should be performed on three levels: impacts on the region as a whole, impacts on the corridor, and impacts on specific station areas. The three levels of analysis should produce results that are internally consistent. That is, the sum of all of the land use changes predicted at the local level should add up to the regional total. Where land use impacts are an issue, UMTA urges local agencies to approach the analysis in both a "top down" and a "bottom up" manner and then to check the results to ensure consistency. In assessing the impacts of land use changes, Emerson, said, the following should be considered: (a) consistency with planning and zoning, (b) impacts on services and tax base, (c) impacts on transit system use, (d) impacts on traffic and parking, and (e) exploring value added to certain sides because of the investment.

RURAL AND AGRICULTURAL IMPACTS OF TRANSPORTATION INVESTMENTS

In the initial stages of economic growth, the introduction of modern transportation makes a wide variety of new economic opportunities available simultaneously and is therefore likely to promote growth; in the more advanced stages, transportation is one of the many sectors in which productive investment may be channeled, and the observed effects of initial transportation provision should not be falsely projected as likely results of modern transport elaboration.

The economic and social consequences of transportation improvements in a rural setting in a developing country are intertwined in a complex fashion. It is this complex blend of economic and social consequences that is taken to be the object of "development"—the process of increasing human welfare for a given population in a region or community through increasing economic and social activities. Cook and Cook examined the ways in which the analysis of rural transportation impact in developing countries has evolved over the last 25 years, with the objective of formulating a framework for impact analysis that covers the full range of expected primary and secondary effects. Although evaluators frequently acknowledge the wide range of transportation impacts in rural areas, quantitative analysis of these impacts has focused almost exclusively on direct, readily measurable economic effects. Surprisingly little attention has been paid to the measurement of multiplier effects and to the social distribution of economic costs and benefits. Current models demonstrate a very imperfect understanding of the workings of the rural economy, focused as they are on agricultural production and often exclusively on cash cropping.

In another study Mazlumolhosseini examined the correspondence between the level of advancement of major components of socioeconomic development and the level of transportation activity in rural areas of developing countries. Because access to roads is the most essential element of a transportation system, the degree of accessibility of a certain rural area was considered in this study as a good indicator of the level of development of the transportation system.

The degree of access to rural roads can be determined according to the joint consideration of two simple criteria: the proximity of the village to the nearest motor vehicle road and its distance to the nearest town. The villages with identical degrees of accessibility can be thought of as arranged in a group forming a certain access area, regardless of the geographical location of the component villages. The creation of four such access areas may be considered as adequate through the proper choice of distance intervals in the application of stability criteria. In the order of increasing accessibility, these four access areas may be described as hardly accessible, poorly accessible, fairly accessible, and easily accessible. Each access area can be assigned an access value proportional to some measurable transportation activity, for example, the number of daily trips per household in that area.

The concepts developed by Mazlumolhosseini in this study are illustrated by data provided through a large survey based on interviews at the household level carried out in the Philippines in 1983. The survey included 1,002 households with 5,228 individuals living in 25 different villages in 5 different municipalities on Cebu Island. The analysis of the study variables as functions of access value revealed that the major elements of socioeconomic development vary sharply with a change of access value and are strongly associated with it. It was also found that both the income from sale of cash crops and the efficiency of agricultural production increase considerably as access value increases. This indicates that a transportation investment may have a good chance to succeed in generating development in other sectors. However, the degree of success would depend on how efficiently the investment is coordinated with other measures that would ensure reasonable utilization of the improved transportation facilities by local inhabitants.

All-weather roads act as a catalyst that brings together various ingredients leading to accelerated economic development. Their catalytic role in addition to their direct contribution through reduced transaction costs was discussed by Khan. It was found that the total benefits obtained using the more traditional approach to estimating development benefits of the road would be too low to justify the road development given the construction costs in Bangladesh. However, using the benefits from transactions costs model the road development would be justified.

The results of a first effort to highlight the contribution of transport to economic development in Mexico, specifically in the field of agroindustry, were presented by de Buen and Lapiedra. The purpose of this work was to examine the way in which transport-related considerations should be linked to agroindustrial project design and implementation in order to increase the probability of success of the firms dealing with them. Two conclusions were drawn from this study. First, transport has to be properly regarded during agroindustrial project development, because otherwise it has enough potential to disrupt project design and to reduce or eliminate its contribution to economic development. Second, detailed industry and product-specific studies are needed to gain a better understanding of the agroindustrialist shipper's needs to better shape the response that transportation services can provide.

A review of the transport sector in Botswana is of interest because of the important role it has played in the growth of the economy in the 23 years following independence. Although the country has been fortunate in discovering natural resources to finance economic developments, sound policies have ensured that the transport sector grew at an affordable pace commensurate with demands for services. Lionjanga and Raman highlighted the system of national planning and project appraisals, the major historical developments in transport, and the framework of policies that has been evolved to encourage future growth.

CASE STUDIES OF MODAL INVESTMENT IMPACTS

In the first case study, presented by Dunbar, a representative subset of the North Central Texas airport system was evaluated. The economic impacts on the Dallas-Ft. Worth International Airport were determined in a separate effort by the airport as part of a recent update to the airport's master plan. Airports the size of the Dallas-Ft. Worth International Airport are frequently subjects of economic impact studies. The main purpose of this effort by NCTCOG was to measure the economic benefits generated by the other airports in the North Central Texas region. The basic methodology used in this study is consistent with that advocated by the Federal Aviation Administration. It is important to distinguish that this is an "impact" approach, not a "transportation benefits" approach. In other words, the efficiencies of air travel are not explored, but the contributions of these local airports in terms of jobs and dollars in the region's economy are. Three different types of impacts were estimated to determine the total economic impact for the 23 existing airports in the Dallas-Ft. Worth region: direct, indirect, and induced impacts.

Direct impacts typically occur at the airport and usually involve the provision of some type of aviation service. Indirect impacts most frequently occur in the region removed from the airport. All passenger expenditures on entertainment and accommodations are most representative of indirect impacts. This study also included the expenditures of large aviation-related industries that might be located on or near an airport but could not be considered completely airport dependent. These impacts were referred to as industrial development impacts and were added to the indirect impact category. The industrial development impacts also included a few nonaviation-related businesses that happened to lease space at an airport. Direct and indirect impacts represent net increases in final demand, whereas induced impacts represent what is called the multiplier effect of the direct and indirect impacts. In this study, the multiplier impacts were estimated with the Regional Input-Output Modeling System calibrated for the 16-county North Central Texas region by the U.S. Department of Commerce.

Airports, seaports, and transportation facilities are now being recognized as strategic sites, not only to shape and target economic development but also to increase the flow of goods throughout the international economy. Such international transportation factors, as described by Ferri, are the determinants of an effective export transportation network, one that can meet international freight movement requirements to service and handle a variety of foreign destinations and multiple volumes, weights, sizes, time-sensitivities, and cost requirements as well as to achieve compatibility with both intermodal and multimodal transport connections. An adequate infrastructure undergirds the interconnection of the nation's transportation system and sustains the efficacy of the export transportation network. The investment in maintenance and expansion of reliable infrastructure depends upon the involvement of all levels of government, a strong degree of intergovernmental cooperation, and substantial input from the private sector. Catalyzing such a coherent, coordinated strategy, as learned, requires overcoming a number of problem areas: institutional, intermodal, and intergovernmental. Ferri described a case study stemming from an ongoing transportation-investment-trade-economic development project initiated by a private-sector foreign trade, development, and management firm. Ferri examined what, if any, correlation existed between urban transportational access and the viability of international trade and investment activity. With an intensified push for U.S. exports, several factors should be integrated into the export investment strategy: urban goods movement, international transportation features, infrastructural capacity, and the entire export transportation process. To assemble the necessary catalyst for such an export trade investment strategy, both the private and public sectors must be informed, educated, and mobilized to the urgency of the problem. Creating a multifaceted solution requires the input of transportation planners, economic development specialists, governmental entities, private-sector concerns, and so on. The author discussed such an alternative, coalition-building process.

As U.S. railroads continue to restructure and reduce their physical plants in an effort to reduce costs, light-density branch lines continue to be targets of abandonment actions. Thus, many communities continue to be faced with loss of rail service. The public- and private-sector costs and infrastructure deterioration associated with rail line abandonments inhibit economic development. A methodology developed for the Washington State Rail Development Commission (RDC) that provides a means to measure the impacts and associated costs was discussed by Taylor et al. The case study involved what has become labeled as local rail service. This is appropriate, because the concerns and impacts are indeed local. From a state perspective, transportation infrastructure requirements to locate a business can usually be found in one part of the state or another, but the local community does not have the same selection expanse. Thus, at the local level it becomes necessary to preserve and improve what infrastructure exists.

STATE PLANNING ISSUES IN TRANSPORTATION INVESTMENTS FOR ECONOMIC ENHANCEMENT

The methods of analysis of economic impact associated with growth centers, functional economic centers, central places, and trade centers have been well documented. This "center" theory provides the basis for the economic analysis methodology utilized by Baird and Lipsman. The agricultural recession led to the emergence of economic development as a goal of the highway improvement program in Iowa. The state's first effort in this regard, the Revitalize Iowa's Sound Economy (RISE) program, was established in 1985. The Iowa legislature funded the program by increasing the state motor fuel tax 2 cents per gallon, which yielded approximately $33 million annually. Half of these funds were used to provide road improvements needed to attract new businesses to the state and to retain and support the expansion of existing businesses. Baird and Lipsman described the research initiated by the Iowa Department of Transportation to develop a methodology that can be used to factor economic development considerations into the programming of improvements for the commercial and industrial network.

Leonard reported on the Transportation Economic Assistance (TEA) program, which was created in Wisconsin to help communities and businesses pay for road, rail, harbor, or airport improvements needed for economic development. The objective of the program was to attract employers and to create more jobs for the state. The TEA applications were evaluated against a dozen criteria, including transportation costs and benefits, numbers of jobs, ratio of cost to the number of jobs, local funding, compatibility with other transportation in the area, and financial soundness of the business. The most important criteria have been the ratio of the transportation improvement cost to the number of direct jobs, transportation costs and benefits, value of increased wages, and the income and tax benefits to the state's economy. The economic impacts of TEA improvements involve both reductions in transportation cost due to the transportation improvement and changes in the state's economy due to the economic development project. Transportation costs and benefits were measured, in this case, by the Highway Investment Analysis

Package (HIAP). If the benefits, such as reduced travel time, reduced traffic accidents, and possibly reduced operating cost, exceed the improvement and maintenance costs, the project is considered a good investment from a transportation standpoint. The other economic development benefits were calculated using a model of the Wisconsin economy. This model, developed by Regional Economic Development Models, Inc. (REMI), measures changes due to economic development projects. It measures net increases in employment, employee wages, sales taxes, and income taxes.

WHAT HAVE WE LEARNED?

The relationship between transportation and development is a subject that has occupied a good deal of attention over many years in both advanced and less-developed countries. Policy concerns as well as political and analytical issues are increasingly driven by questions of economic development impacts at the regional level, program level, and for specific projects. As a result, efforts to analyze the link between transport investment and economic development must take a broader view both spatially and in the range of analytical tools used.

Experience and research tend to support the following conclusions:

- Transportation investment alone will not result in development.
- Transportation investment may remove barriers to development.
- The bottom likne is lower transportation costs.
- Businesses make decisions on a comparative basis, and accessibility to materials and market is a major consideration.
- Both undercapacity and overcapacity of infrastructure can reduce a region's ability to serve industrial needs at a cost that helps them to be competitive.
- Perceptions of transportation system quality may be as important as actual conditions.
- Transportation needs may vary greatly from industry to industry.
- Economic growth will occur primarily in or near urbanized areas that have in place the necessary physical and human resources.
- A good transportation system is a necessary but not a sufficient condition for development.

The question at this conference was whether transportation can induce economic development and, if so, whether the causative relationships can be established and measured. Development, however, is one of those ambiguous concepts that means what the user wants it to mean. Transportation is "a growth shaper," but development is more than growth. If transportation's impact on development is to be measured so as to optimize investments, development must be quantified, and the role of transportation investment must be apportioned.

The tie between future economic growth and improved productivity is clear. What is unclear is whether transportation improvement contributes more to increasing productivity than other investments (whether they are public or private). Questions concerning cause and effect and how public capital stocks are incorporated as components of production are extremely relevant if transportation investment is to be used as an element of a fiscal policy for stimulating growth beyond the localized benefits of individual transportation projects. The frequently found correlation between the level of infrastructure services and income does not really reveal much about whether there is a causative or merely a coincidental relationship.

After reviewing the methodologies and modeling that were presented at this conference, one must conclude that there is no single causal-based, policy-sensitive methodology applicable to all modes for all levels of analysis (national, regional, or project level). In considering the conclusions from the impact studies it is instructive to recall that even though an impressive amount of effort was spent on this type of research, the results were meager.

The need for a causal-based methodology has been stressed over and over during this conference. Unquestionably, there is a relationship between transportation and economic development. Transportation affects both product and service costs and provides opportunities to obtain needed materials and services and to deliver goods and services to markets at a competitive price. However, transportation, although a necessary element in the economic development equation, is only one of many elements. With the current state of knowledge, it is impossible for public policy makers to establish reliable, measurable, causative relationships between given levels of transportation investments and resulting economic development. This problem is further compounded by the current pattern of incremental change in the quality and level of transportation that is currently attracting most transportation investments in the developed countries.