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.

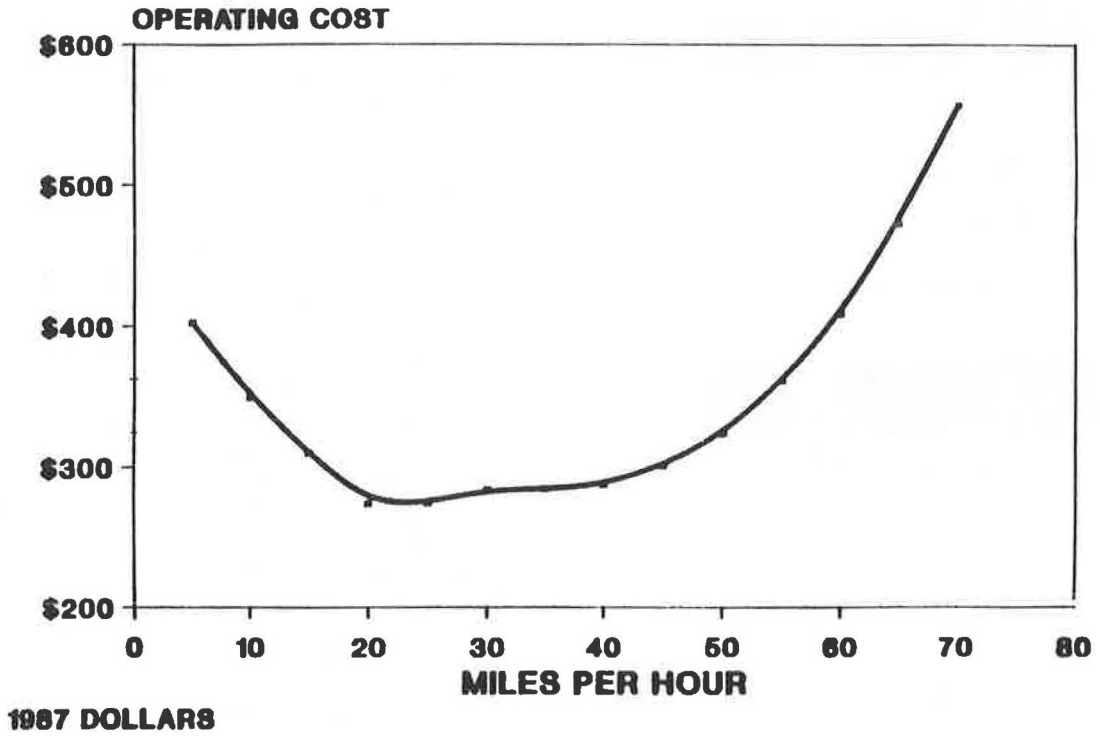

FIGURE 2 Truck operating costs per 1,000 mi of travel: four-lane highways for 1988.

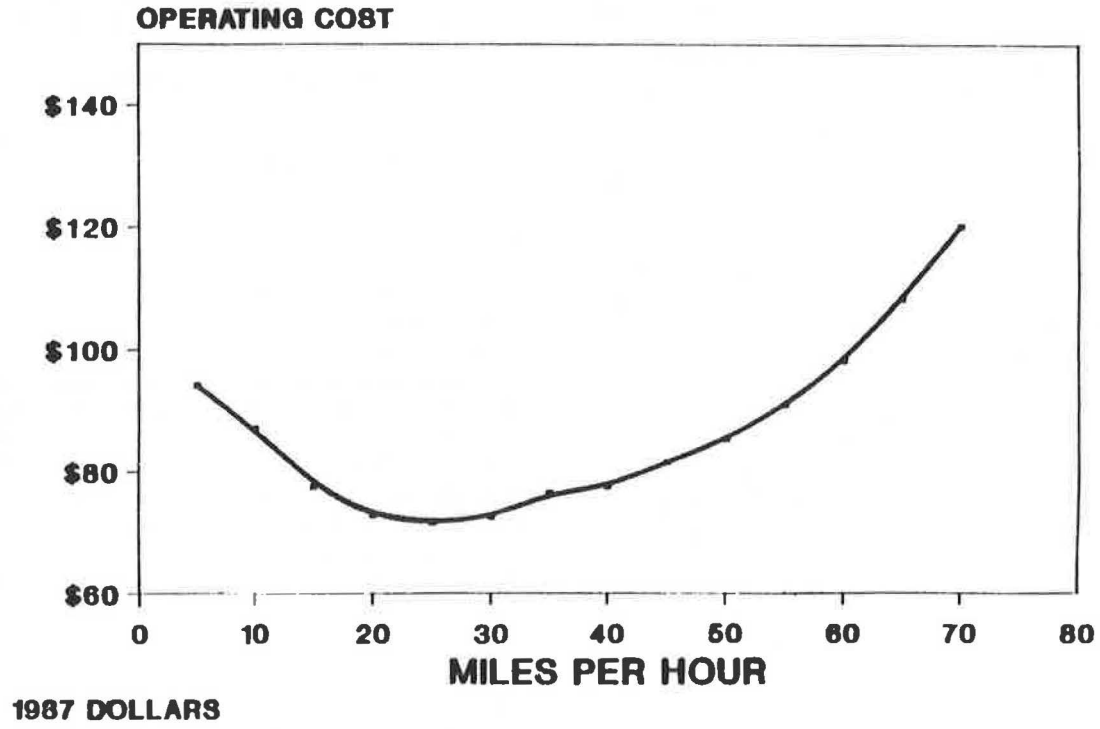

FIGURE 3 Automobile operating costs per 1,000 mi of travel: four-lane highways for 1988.

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

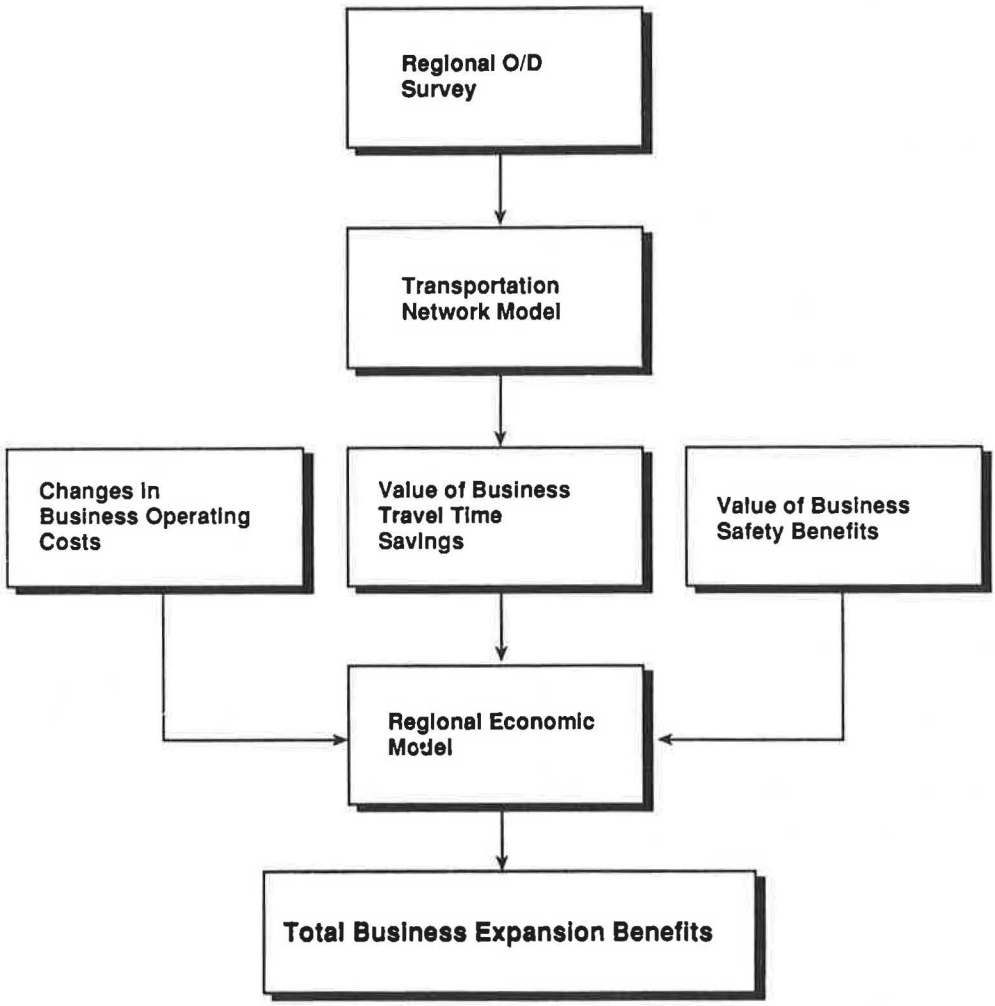

FIGURE 5 Business expansion analytic framework.

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

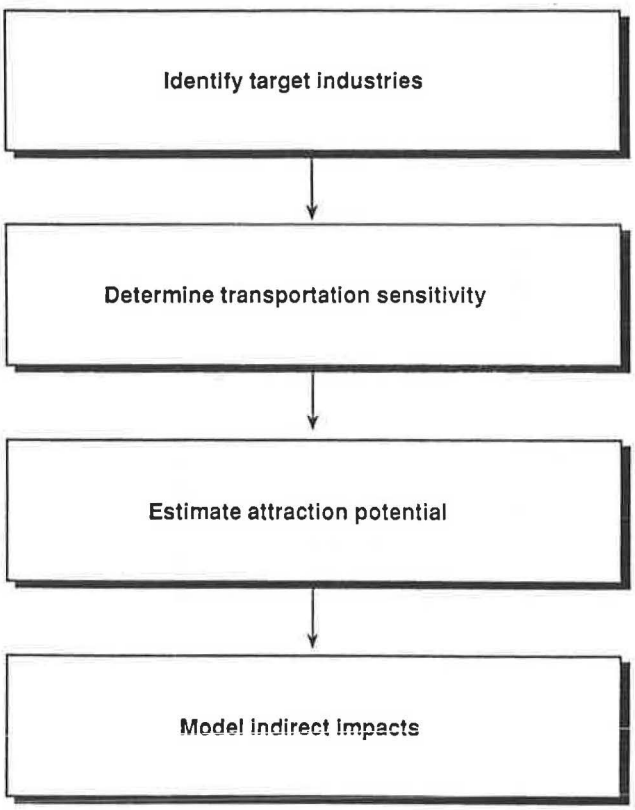

FIGURE 6 Business attraction analytic framework.

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.

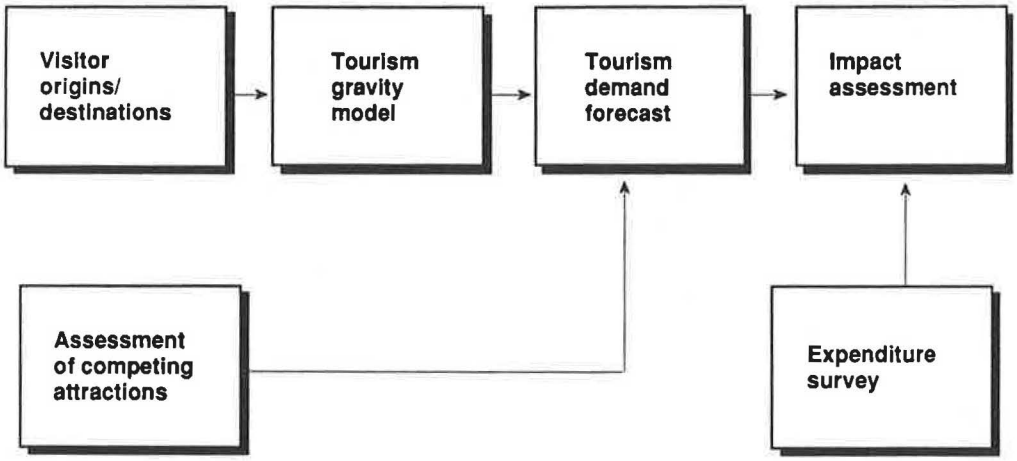

FIGURE 7 Tourism analytic framework.

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

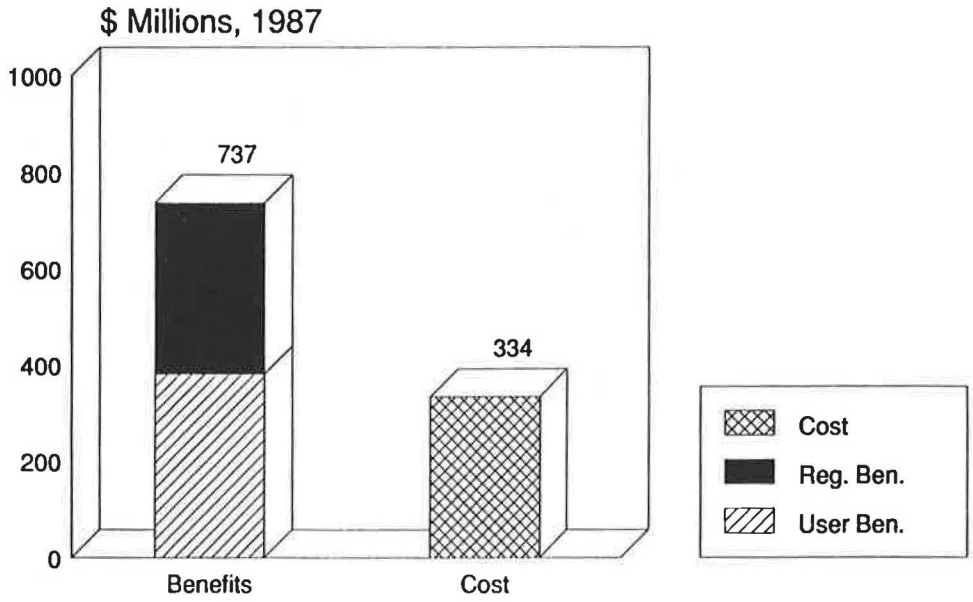

FIGURE 8 Ratio of benefits to costs for SH-29 and US-45 in Wisconsin.

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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