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Community Values and Socioeconomic Impacts

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Foreword

This RECORD contains three papers and two abridgments that focus on the impacts of transportation facilities and the difficult problem of impact measurement.

Christensen and Jackson report on the problems of relocation of people and businesses that are displaced as a result of expressway development. They emphasize that relocation assistance in theory is simple, but in practice it is difficult, complicated, and time-consuming. Successful relocation depends on solving personal problems, both financial and social, in addition to finding replacement property.

Wheat attempts to determine whether cities with superior intercity highway connections enjoy more rapid manufacturing growth, i. e., whether relatively fast low-cost motor transportation attracts industry. Manufacturing growth rates are compared for two groups of cities, an experimental group located on the Interstate System and a control group located elsewhere. The growth-distance relationship is best described by a probability curve peaking at zero miles and having a standard deviation of five miles; freeways have little effect on cities more than 10 miles away.

Ellis and Worrall explore the possibility of the concept of residential linkages as a basis for a strategy for quantitatively estimating the community or social consequences of transportation projects. They suggest that the linkage definition involves the analysis of two data sets: activity patterns of the household, and the set of destination points the household defines as important. Using travel data of a sample of households along with household interviews, they conclude that their proposed analytical methodology could be employed operationally to define linkages and estimate the community impact of transportation projects.

The Pendakur and Brown abridgment emphasizes that it is possible to measure the environmental quality-accessibility conflict by attitude surveys, and also that people are more consciously aware of problems of accessibility than those of environmental quality.

The Shurberg and Devaney abridgment discusses the methodology used to measure the impact of Interstate 495 in Montgomery and Prince Georges counties in Maryland. Procedures were also developed to measure future impact on land use, traffic and the local economy.

Contents

Problems of Relocation in a Major City: Activities and Achievements in Baltimore, Maryland

ARTHUR G. CHRISTENSEN and ALVIN N. JACKSON,
Department of Housing and Community Development, Baltimore, Maryland

When expressways run through a major city, large numbers of people and many businesses are displaced. Unfortunately, the expressways are frequently routed through the least desirable sections of the city, and those who are displaced are the poor, the aged, and those who are least able to take care of themselves, and there is little likelihood that many of them will use the expressway that displaces them. It is important, therefore, that all possible assistance be given to these people so that they will not have to shoulder the cost of the expressway.

In theory, relocation assistance is simple. In practice, it is difficult, complicated, and time-consuming. Frequently, successful relocation depends on solving personal problems, both financial and social, in addition to finding replacement property. Baltimore's relocation specialists, who are drawn from fields of both real estate and social work, must work with all public welfare resources as a part of successful relocation. Examples of relocation problems are plentiful. Some can be solved, but others remain as the price of highway progress.

The recently passed Federal-Aid Highway Act of 1968 has finally recognized the government's responsibility to relocatees in highway construction and provides adequately for them. While this is a step in the right direction, much remains to be done in order to make the program truly effective.

•EXPRESSWAYS, particularly those associated with the Interstate System, normally run through open country. They are designed for people traveling long distances who want to get to their destination as rapidly as possible. We visualize these expressways as almost endless winding ribbons of concrete or asphalt, with gigantic interchanges and arching bridges. Occasionally, however, an expressway cuts through the heart of a big city, and there the situation changes, for expressway construction disrupts communities, severs economic and cultural areas, and dislocates people. Those who use the expressway seldom realize this, for they see only the completed road along which the remaining houses and buildings flash by as they drive smoothly and rapidly from one point to another.

Behind the construction of each expressway is a long period of planning and development. Designers bend over drafting tables, studying terrain and selecting routes; engineers prepare plans; legislation is passed; contracts are let; and finally, workmen

Paper sponsored by Committee on Socio-Economic Aspects of Highways and presented at the 48th Annual Meeting.

with huge machines construct the road. Behind all of this is the forgotten man of the expressway program, the man who must give up his home or his place of business, before the expressway can be built. In large cities there are thousands of these forgotten men, women and children.

In Baltimore alone, the current expressway program will displace some 3,800 families with an estimated 15,000 persons. Only 20 percent of these families are white; less than 40 percent own their homes; their median income is $4,500. Nearly three-quarters have incomes so low that they qualify either for public housing or for other government subsidized housing programs. A large number are elderly, and many have large families. In addition to families, some 500 businesses will be displaced. These vary in size from the small neighborhood grocery or barber shop to multi-million dollar factories (1).

One may be inclined to say that displacement of this magnitude is the price of progress, and such may be the case. It goes almost without saying, though, that no individual should be required to pay more for such progress than the share he would normally pay as a taxpayer; yet practically every person and every business which must move is injured far beyond any benefit which they will derive from the new road. The chief reason for this stems from the fact that expressways are usually routed through the least desirable sections of cities; sections which have deteriorated, and which are inhabited by the poor. The data just cited confirm this. These poor people are the ones who can least afford to subsidize highway construction or, for that matter, any public improvement. Few of them even own automobiles, and those few who do will seldom use the section of the expressway which is constructed over their former homes.

Governmental responsibility for assisting in the relocation of people and businesses that are displaced arises out of its authority to acquire private property against an owner's will. This authority, known as eminent domain, is provided in both Federal and state constitutions. It may be exercised only when the property is needed for public use and when just compensation is paid to the owner. The courts have traditionally defined "just compensation" in terms of the fair market value of the property which is taken (2). In addition to the fair market value paid for property, however, Congress has provided certain relocation compensation. The same thing has been done by some state legislatures, although many have neglected this responsibility.

Congress took the first step in 1933 when it provided assistance to persons forcibly displaced by the Tennessee Valley Authority. Since then, it has passed a variety of piecemeal relocation legislation. Today, some agencies are authorized to make limited administrative payments for moving expenses and closely related costs, but others have no such authority. Some states have followed the Federal lead and have authorized compensation for moving expenses as well as loss of personal property; others have not (2, p. 62-67). Among the Federal programs, those administered by the Department of Housing and Urban Development, including programs of urban renewal, public housing, code enforcement, have until recently made the greatest progress in assuring adequate relocation assistance and in the generosity of relocation payments. HUD not only requires that the feasibility of relocation be demonstrated before it will approve a project, but it actively encourages communities to develop sound relocation staffs, and to provide adequate assistance to every displacee. Relocation payments in HUD activities have gradually been expanded since they were first authorized in the 1949 Housing Act and now provide a well thought-out, comprehensive system of compensation. In addition to moving expenses, low-income families may be entitled to a subsidy to assist in their relocation. Business concerns may receive moving expenses up to $25,000 or, on a local option the total moving expenses, even though the amount exceeds $25,000. Special assistance is provided for the small businessman, or for businesses which are unable to relocate. HUD relocation payments up to $25,000 are paid exclusively by the Federal Government. Payments over that amount are shared between the locality and the Federal Government on the same basis as other project expenditures (2, p. 16-25).

Other Federal agencies have different regulations. Relocation occasioned by mass transit is administered by HUD and generally follows the HUD pattern except that business payments are less generous (2, p. 81). Some other Federal agencies, such as Defense, Interior, and NASA provide moving expenses, and may also compensate a displacee for expenses in finding a new location. The General Services Administration, on the other hand, pays nothing (2, p. 107).

The Department of Transportation in the Federal-Aid Highway Program has passed the relocation responsibility to the states, which have traditionally been much less willing to provide relocation assistance than has the Federal Government. For example, only eight states had authorized relocation payments of any sort prior to the Federal-Aid Highway Act of 1962. Spurred on by the offer of Federal participation, the number grew to 22 by 1964, of which 12 followed the Federal formula and dollar maximums. Of these, only four provided reimbursement of moving expenses without a dollar maximum (2, p. 68-72).

The 1968 Federal-Aid Highway Act has changed the picture significantly, as will be discussed later.

Equally as confusing and varied as relocation payments have been the requirements and procedures for relocation assistance. The Department of Housing and Urban Development requires a comprehensive relocation program and a demonstration of relocation feasibility before it will approve a project. Federal-aid highways have until the passage of the 1968 Act required only an assurance from each state that relocation advisory assistance will be provided. In practice, the assistance furnished in some areas has been perfunctory. Other Federal agencies have no requirement for assistance. A few states have made a genuine effort to establish sound relocation assistance programs. On the other hand, many states have not yet recognized the importance of relocation assistance.

A significant step forward was taken with passage of the Federal-Aid Highway Act of 1968, which not only provides the increased payments, but also requires the assurance of an adequate program of relocation assistance and the availability of relocation housing before approval of any highway project. Under its provisions, all moving expenses will be paid up to $25,000, with optional payments on a fixed schedule for residential moves, and alternative payments for a business which cannot relocate. Further, the Act provides assistance for the added cost of replacement housing, up to $5,000 for owner-occupants and up to $1,500 for tenants. Unfortunately, prior to July 1, 1970, these new payments and assurances depend on the ability of each state to provide them under its laws. Consequently, almost all states will have to enact legislation if they want to take advantage of the Act before then. As an inducement to the enactment of state laws, the Highway Act provides for 100 percent Federal reimbursement of payments made before July 1, 1970. After that, Federal participation will be on a project basis.

In theory, relocation is a simple process. In practice it is difficult, arduous, and time-consuming even when there is an ample supply of housing, which is seldom the case. It is the job of a relocation service to assist those who must move, to help them to find new homes or new places for their businesses, and to pay them allowances as the law permits. These tasks require the utmost of skill, tact, social awareness, and empathy. A relocation service and the relocation worker are the recipients of many complaints but few words of praise. Yet, relocation assistance is a critical factor in the development of public facilities. If it is performed well, it may go unnoticed; if it is not given primary consideration in the early phases of planning, and if it is not supported intelligently at all levels throughout the development program, the neglect may trigger civil strife or riots (3).

Normally the process begins with a survey to determine the specific workload and identify problems. In Baltimore, this survey is made about the time that appraisals are begun. As property is acquired, each family, each individual, and each businessman is contacted personally, and offered individual assistance. This assistance includes help in finding a new location which is of sound construction, and is accessible to work, markets, transportation, etc., and at a price which the family or the businessman can afford to pay, and may also include problems of zoning, patronage, special licenses or permits and often financing. This is a difficult combination to produce, and so the job of providing relocation assistance is slow.

Especially with residential cases, the amount of assistance given varies with the willingness of a displacee to accept it; for frequently the displacee shrugs off all offers of assistance with the attitude, "You can't fight City Hall," and goes his way without the free advice and guidance of experts. Often he turns to the relocation staff only after his own efforts have failed. There are several reasons that residential relocation is such a difficult task, most of which involve money. As expressway planning is not accomplished overnight, the areas designated for expressway use deteriorate. People move and are not replaced, causing further deterioration. Property owners, especially absentee landlords neglect their property, knowing that sooner or later it is to be torn down. Property values decline. The resulting blight draws the poorest people, those who are least able to take care of themselves, into the area, and poverty is accompanied by all manner of social ills. Successful relocation is not merely a matter of pointing out a new location and sending a family on its way. It requires careful counseling, leading a family or businessman step-by-step, advising them and frequently solving or alleviating financial and social problems. This process taxes the capabilities of even the best staff.

The relocation staff in Baltimore, especially the specialists who work directly with displaced families, are drawn from two principal fields, real estate and social work. This is a fine combination, for each contributes greatly to the relocation process. The real estate man is familiar with the housing market, and with the problems of dealing with landlords or negotiating a purchase. He recognizes basic construction faults and can analyze the appropriateness of rental or sales prices. He knows various methods of financing, and frequently has connections with financial institutions. Working side-by-side, the social worker contributes to the solution of a variety of social problems. Relocation cannot and should not attempt to duplicate existing social agencies, but rather provides a contact with the agencies so that social needs may be recognized and met. Displaced persons are given a priority for public housing and certain other subsidized housing programs if they are otherwise eligible, and these provide a substantial resource to the program.

Problems of relocation are almost infinite, and new ones are encountered almost every day. These problems are not necessarily problems caused by the expressway or other public improvement, and may have existed for months or years before displacement. Yet, they must be faced as a part of the relocation process. Sometimes they cannot be solved and relocation efforts must be classified as a failure. In most cases, however, relocation is successful in finding at least a partial solution, and often the family gains in the long run by their displacement. A few examples are in order.

• Mr. T, 63, lives with his wife and two college-age children. When first approached, he declined relocation assistance, saying he had already found a home in a good section of town. However, his mortgage application was turned down by one lending institution after another because of his age. Unfortunately mortgage processing took so much time that someone else bought the house. At this point, he turned to relocation, which was able to locate another good house in the same block as the previous one. By diligent work, a cooperative lender was willing to provide a mortgage despite Mr. T's age. The family's living conditions are substantially improved and they are happy with the change.

• Mrs. L, 60-year-old widow, lived with her mentally retarded son and daughter, both in their 30's. Conditions were pitiful. They had no furniture and slept on the floor. They had no gas or electricity as these had been shut off in 1960 when they failed to pay a $75 bill. There was no heat. The case looked hopeless when relocation went to work on it. The ideal place for a family of this kind would be public housing, but they refused even to consider it, insisting that they stay in the same general neighborhood. Relocation finally found them a satisfactory apartment nearby at a rent within their welfare allowance. Welfare provided a furniture grant, which was used at Goodwill Industries so as to get the maximum return for each dollar spent. A private charitable organization was found which agreed to pay the back-due gas and electric bill. Finally, relocation provided transportation for the few goods owned, and assisted them in paying the rent deposit. The family is now warm and comfortable, much better than they have been for years.

• Mr. B, a 90-year-old man, lived with his 70-year-old widowed daughter. He had owned the property for many years, but had lost it two years before it was acquired by the city. As the new owner permitted him to stay there and did not collect rent, Mr. B could not realize that he was no longer the owner of the property. The daughter was little better, for she was a mental problem. Relocation sought help from medical sources, and from social agencies but these provided no solution. After several weeks of effort, no progress had been made, and the problem seemed almost insoluble, when Mr. B died. It was then possible to work with a granddaughter who lived elsewhere in the city. The granddaughter was unable to take the mother into her home, but cooperated in every way possible. Relocation found a new apartment, which the granddaughter inspected and approved. Then the granddaughter took her mother by the hand to the new location while Relocation completed the move. The situation is not the most ideal, but this woman seems to have adjusted well to her new surroundings, and is content.

• Mrs. A, a 45-year-old recluse, also has mental problems. Relocation showed her numerous possible locations, yet she refused to move. Because of her very limited income, a charitable landlord was found who agreed to reduce rent to a price she could pay. Still she refused to move. Something had to be done, as the remainder of the block was vacant, and it was dangerous for her to stay in her apartment any longer. Her brother was contacted and asked to assist, but he was unable to change her mind. Finally, with the brother's cooperation, eviction was arranged on court order. As her furniture was moved out of the apartment and onto the sidewalk, her brother arrived with a truck to take her to a new location which he had approved. Mrs. A calls occasionally. It is hard to say whether she is content in her new location or not. Sometimes she says she would like to move, but by the time Relocation reaches her apartment, she has changed her mind and decided that she will stay where she is. Probably this should be rated as a failure, because she had to be evicted; yet she is without any serious problems at her new location, other than those she had before.

• Sometimes all efforts are in vain. Mr. R moved out of a house without telling Relocation. He was traced and visited at his new location which was found to be substandard. He was offered further assistance but refused the offer saying he was satisfied with the new place and would not move again. He had lost ground as a result of his move.

Businesses, too, are a very serious problem, especially the small ones such as the corner grocery store, barber shop, beauty parlor, or tavern. Frequently they are so closely oriented to the community that they cannot be moved, and must go out of business. In urban renewal areas, such businesses may be eligible for a Loss of Personal Property claim, or possibly a Small Business Displacement Payment. Either helps to ease the burden placed upon the businessman and gives him some capital with which to start out anew. In expressway areas the Federal Government made no provision for the small businessman until passage of the 1968 Federal-Aid Highway Act. In it there is a specific payment in lieu of moving expenses to the businessman who cannot relocate. An example of a successful move of a small business is appropriate.

• Mr. S operated a small two-chair barber shop. He suffered from cancer and had had a laryngectomy, which left him virtually unable to speak. His attempts to find a new location were met with failure. Even when he finally found a place he thought he could use, his application for a zoning exception was turned down. He was bitter and depressed. Finally, he turned to Relocation, which found him a new location, assisted in processing an application for a permit, assisted him in obtaining credit, and finally arranged for a SBA loan. He is proud of his new, greatly improved shop, and is getting along fine.

The responsibility for relocation assistance is an important consideration. It is found at various locations of Federal, state, or local government. Under the Federal-Aid Highway Program, for example, the state may contract with a local agency to provide assistance. In most cities, the tendency has been to place it in either a public housing or urban renewal agency, although it is split between two or more agencies in some cities.

In Baltimore, the responsibility for all municipal relocation, including expressways, has been placed with the housing authority, which is a component of the City Department of Housing and Community Development. This is an ideal solution, for the Department combines all of the essential elements of the relocation process from planning to the development of replacement housing. Under this centralized organization, uniform assistance is provided to all regardless of the reason for the displacement, and the workload can be handled in total. Unfortunately, Baltimore has not yet achieved uniformity of relocation payments, for with the recent addition of the new Highway Act there are three sets of laws which are applicable, HUD, Expressways, and Maryland State law which covers other activities. It is hoped that this disparity can be corrected soon.

All of the foregoing assumes that adequate relocation housing is available, which may or may not be the case. In Baltimore, for example, nearly 12,000 dwelling units have been demolished by public takings during the past 15 years; while less than half have been replaced. Because out-migration has exceeded the in-migration during the past decade, the displacees have been absorbed in the remaining housing through a filtering down process. Quite obviously, this cannot continue indefinitely, especially when it is anticipated that nearly 15,000 families will be dislocated during the next six years by currently planned projects.

Every possible means must be used to develop replacement housing, and this is being approached in Baltimore on a variety of fronts. New housing is being sponsored in urban renewal areas, especially housing for the middle-income families. Several urban renewal projects now in the planning or execution will produce more such housing than currently exists. New public housing is being built which will provide for low-income families. In addition to conventional methods, the Housing Authority of Baltimore City is participating actively in new development programs such as "Turnkey," and leased housing. A substantial program of rehabilitation is being undertaken which has a goal of 1,500 units by 1970. The Design Concept Team, employed to minimize the impact of Baltimore's expressway program, is studying joint development intensively. This may include housing adjacent to or on land which is in excess of right-of-way requirements. Only by such intensive efforts will it be possible to provide adequately for all who are to be displaced. As Baltimore's Department of Housing and Community Development is responsible for urban renewal, code enforcement, and public housing, the relocation function can be closely coordinated with these other activities.

Among those who are hardest hit when property is taken are the residents of an area who own their homes. Such people are, in general, the most stable and self-reliant. They are interested in their neighborhood, and have taken care of their homes even though their neighborhood has deteriorated during a long period of planning. Many have owned their homes for many years, and often they are nearing completion of mortgage payments. Some have already retired, and many are living on fixed incomes. Yet the value of their homes has depreciated because of deterioration of properties around them. As a consequence, when the owner-occupant is paid market value for his property, he does not receive enough to purchase a comparable home in a sound, unblighted area. Not only is his life disrupted when he is forced to move, but he is required, in effect, to subsidize the development of the expressway by investing substantial additional capital in the acquisition of a new home.

This problem has long been recognized, not only in Baltimore, but elsewhere in the country; but little has been done to correct it until recently. The magnitude of the financial burden imposed on the owner-occupant is illustrated in a study made by the Baltimore Urban Renewal and Housing Agency late in 1967. Homes were then being purchased for expressway use in two separate areas of Baltimore which were selected for the study. The population of one area was Negro; the other, white. The study compared prices paid by the city for the acquisition of the property with the cost of replacement. Of course, all families did not buy new homes. Those who did, however, bought homes generally comparable to those which the city purchased from them, except that a few families upgraded themselves by moving from nonstandard homes into standard ones. Some bought slightly larger houses, while others bought slightly smaller ones, but on average, the number of bedrooms in the old houses was found to be identical with the number in the new. The average replacement cost was $3,000 above the amount received from the city for the old property. Significantly, the average additional cost was different between Negro and white areas. In addition to increased cost, the study indicated that each owner had to pay settlement costs, refinancing charges, increased interest, etc., which added to the cost of obtaining replacement housing. In summary, displaced owner-occupants paid an average of $3,500 for comparable replacement housing in addition to the amount they received from the purchase of their former homes. Comparative data are shown in Table 1 (4).

The loss revealed by these data was recognized by the Maryland Legislature which in early 1968 adopted a bill to provide supplementary payments to residential owner-occupants in addition to fair market value. These payments, which may be as much as $5,000, are to enable the displaced owner to obtain a comparable home without additional investment. This significant advance toward "just compensation" was included in both the new Federal-Aid Highway Act and the Housing Act by Congress with only slight modification.

The need for equal relocation treatment has been recognized for some time. The Advisory Committee on Inter-Governmental Relations concluded in its report that, "Persons and businesses displaced by local, State, or Federal public works and other programs are entitled to assistance in relocation, and this entitlement extends to lessees and tenants as well as to owners of homes and business establishments" (2, p. 103). Despite these recommendations, however, although numerous bills have been introduced into Congress, none has been approved which would establish uniform procedures in Federal and federally assisted programs. Congress did make a giant step forward when it enacted the 1968 Federal-Aid Highway Act. This requires the Secretary of Transportation to obtain satisfactory assurance that fair and reasonable relocation payments will be afforded to displaced persons, that relocation assistance programs will be offered to displaced persons, and that relocation housing will be available within a reasonable period prior to displacement. It provides for an increased schedule of payments both to residential and business occupants, and provides a payment for relocation housing to both owners and tenants. These advances are significant.

Subsequent to passage of the Highway Act, the Inter-Governmental Relations Act, containing a provision for uniform relocation payments, was passed by the Senate, but the provision was deleted by the House. Hearings on Uniform Relocation Payments were held before the Public Works Committee of the House, but no such law was enacted during the 1968 Session.

In summary, relocation assistance and compensation must be made a part of each public works program, Federal, state, or local. Otherwise persons displaced will bear an inordinate burden as a result of the program. The Federal Government must take the lead in establishing a sound uniform program. It should be designed so that compliance is mandatory if the states and local governments wish to continue to receive aid under the grant programs affected. The program must require adequate provision for relocating persons and businesses before the demolition of property begins and an approved relocation plan should be a condition precedent to approval of any Federal-aid project which will require the displacement. The program should require that relocation activities arising from all public improvements be coordinated under one local relocation agency.

The goal of the relocation program must be to make the displaced person whole again. It must place him in a home or business at least equal to that which he had before, and on the same terms and conditions he enjoyed before, or if this cannot be done, the individual should receive adequate compensation for his loss (5). The establishment of such a program will require leadership of the Fed-

TABLE 1

COST OF REPLACEMENT HOUSING

Item	White	Negro	Total
n	67	45	112
Acquisition price	$5,903	$5,338	$5,676
Replacement cost	$8,357	$9,234	$8,710
Increase	$2,454	$3,898	$3,034
Cost of transfer*	$ 500	$ 500	$ 500
Total increase (rounded)	$3,000	$4,400	$3,500

*Includes settlement charges, transfer taxes, costs of refinancing, etc.

eral Government, as well as the recognition by states and communities that relocation is an essential part of acquiring land for a public purpose. Relocation must start as a planning consideration, and must include not only the specific assistance given to people when they are displaced, but also a comprehensive program of developing replacement housing and business facilities into which displacees can move. Finally, the relocation agency must be placed high enough in the echelon of government with sufficient authority that compliance will be guaranteed. Only through these steps will it be possible to properly aid the "forgotten men, women and children," now being displaced by public programs.

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The Effect of Modern Highways on Urban Manufacturing Growth

LEONARD F. WHEAT, Economic Development Administration,
U.S. Department of Commerce

This study attempts to determine whether cities with superior intercity highway connections enjoy more rapid manufacturing growth, i.e., whether relatively fast, low-cost motor transportation attracts industry. Manufacturing growth rates are compared for two groups of cities, an experimental group located on Interstate System freeways and a control group located elsewhere. The two groups are comparable in all major respects—population, location, air service, economic activity, etc.—except highways; comparability rests on the matched pairs procedure (106 city pairs). A city's growth is its per capita manufacturing employment increase between 1958 and 1963. Differences between group means are tested for significance for all pairs combined and many breakdowns. To clarify the relationship between growth and distance from freeway, correlations for hundreds of curvilinear relationships are compared. Nationwide, there was no significant difference in freeway and nonfreeway performance. But in regions with dense population and uneven terrain—the Northeast, Southeast, East Midwest, and Far West—freeway cities grew much faster. In these regions the freeway advantage was largely confined to cities either above 16,000 in population or served by airline, for which cities significance levels ranged as high as 0.01. The growth-distance relationship is best described by a probability curve peaking at zero miles and having a standard deviation of 5 miles: freeways have little effect on cities more than 10 miles away.

•ONE of the major knowledge gaps in the field of domestic economic development concerns the effect of modern highways on urban manufacturing growth. The present study attempts to determine whether superior highway facilities stimulate industry. The principal finding is that, under some conditions, cities on modern highways grow significantly faster.

SUMMARY

This study was designed to develop knowledge regarding (a) whether cities with good transport facilities have more capacity for growth than other cities and (b) whether transport investment is itself an effective means of promoting economic growth. Toward these ends it compares manufacturing growth rates for two groups of cities, an experimental group and a control group. The first group has superior highways (the Interstate System); the other does not. Cities within 8 miles of Interstate System exits—hereafter called freeway cities—were placed in the experimental group. Cities

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more than 15 miles from Interstate freeways—hereafter called nonfreeway cities—went into the control group. All cities above 5,000 population from the 48 contiguous states were first screened to eliminate suburbs, satellites, and other cities whose proximity to nearby ones might influence their own industrial "pull." For the surviving cities information was recorded on geographic location, population, air service, economic activity, and other factors likely to affect growth. Cities were then matched by pairs, freeway cities with nonfreeway. Paired cities had to be reasonably close to each other, have approximately the same population, have the same type of air service, etc. This operation netted 106 city pairs, or 212 cities. These represented 40 states, and all but a few were between 10,000 and 50,000 in population. Growth data were recorded from the 1958 and 1963 Censuses of Manufactures; the experimental period was 1958-63. Growth was measured by computing freeway and nonfreeway group means for the per capita manufacturing employment changes of individual cities. Experimental and control group comparisons were made for all cities combined and numerous breakdowns.

The study results suggest that superior highway facilities can be an important stimulus to manufacturing growth but only in certain regions and mainly under certain conditions. In the findings below, growth is expressed as new jobs per thousand capita.

- Nationwide, combining all 106 pairs, freeway cities grew slightly faster (19 jobs per thousand capita vs 16) but the difference was not statistically significant.

- In the Southeast, East Midwest, and Pacific Northwest (three fast growing regions with dense population and uneven terrain); the freeway cities outgrew the nonfreeway ones by a 43 to 23 margin, significant at the 0.04 level.

- In these three regions combined with the slow growing Northeast, pairs above 16,000 gave the freeway side a 27 to 4 advantage, significant at the 0.03 level.

- In the same four regions freeway cities had a 27 to 2 advantage among pairs served by air; significance: 0.04.

- Combining cities above 16,000 with the remaining airline cities in the four regions produces a freeway advantage of 27 to 5, significant at the 0.02 level. In the three fast growing regions (Northeast omitted) the margin is 36 to 8, significant at the 0.01 level.

- Nonfreeway cities within 16 to 25 miles of the nearest freeway exit did not grow faster relative to their mates than more distant nonfreeway cities. The growth-distance relationship is best described by a probability curve (bell shaped) with a standard deviation of about 5 miles and a peak at zero miles.

- Although growth is correlated with industry among the crucial pairs, partial correlations between growth and distance to freeway, with industry and other variables controlled, are higher than the original correlations.

- Whereas the two groups were equal in manufacturing, correlations between industry variables and growth reached +0.93 for freeway cities but only +0.33 for nonfreeway cities, suggesting that freeways affect growth indirectly, as a catalyst for the industry stimulus, as well as directly.

These findings indicate that intercity freeways bolster manufacturing growth in regions where travel on regular highways is especially impeded by heavy traffic, frequent towns, and numerous hills and curves; that is, in regions with dense population and topographic irregularities. The area of significance includes the Pacific Northwest (no data for California) and everything east of the Mississippi Valley states (east of Illinois and Mississippi); the Great Plains mark the approximate limits of the eastern sphere of influence. In the indicated regions, transport sensitive industry is attracted mostly to cities above 16,000 in population or with air service; hence freeways have the most influence in these categories.

PURPOSE OF STUDY

Domestic economic development is a subject of concern not only to the Federal Government but to states and localities as well. Federal programs seek to aid small areas and large regions with high unemployment rates and low income levels; state and local programs are more broadly concerned with securing faster rates of economic growth. Frequently, developmental investments are used to attract industry. Sometimes, as in the case of the billion dollar Appalachian road program, these investments involve transportation. To spend the investment dollar wisely, we need to know which communities have the greatest capacity for growth. Is the, say, industrial park more likely to pay off in a city with good transportation? We also need to know whether transport facilities themselves, as a particular form of developmental investment, can effectively stimulate economic growth. The central role of highways in transportation and of industry in economic development makes it important to learn whether highways contribute to urban manufacturing growth.

To date, this relationship has received very little study. Industrial location research has shown that transportation in the abstract is a major determinant of plant location. What we do not know, however, is whether good highways, as a specific type of transportation, significantly influence manufacturing growth. True, there has been considerable study of the relationship between new roads and commercial establishments—motels, gas stations, restaurants, stores, etc. Some studies have also touched upon manufacturing, though primarily from the standpoint of where new plants locate within a municipal area (beside the new highway or two miles away?). The developmental economist, however, is more interested in another question, namely: do communities with superior highway connections enjoy faster manufacturing growth than other communities?

In theory, better highways might well influence manufacturing growth. Many new plants are branch plants or otherwise produce for regional distribution. They are located within certain regions for competitive reasons—primarily to minimize transport costs and shipping delays entailed in serving regional markets. Assuming that good roads reduce the time and expense of shipping goods to market, and to a lesser extent bring lower freight costs on supplies and raw materials, the roads could prove to be magnets for industry.

With these considerations in mind, the present study was designed to test the following hypotheses:

1. Freeway cities in general have higher manufacturing employment growth rates.
2. Freeway cities grow faster only, or increasingly, in regions where dense population and hilly terrain produce relatively large disparities in traffic speeds between freeways and regular highways.
3. Freeways stimulate urban growth but only/mainly in certain population ranges.
4. Freeways stimulate growth only/mainly where complemented by airline service—for executive transportation.
5. Freeways stimulate growth only/mainly in cities with poor rail service, where highway transport can serve as an offset.
6. Freeways stimulate growth only/mainly where water carrier service is present or absent.
7. There is a curvilinear relationship between growth and distance to the nearest freeway.
8. Freeways enhance any favorable relationship between prior industry and manufacturing growth rate.

METHODOLOGY

The study methodology is based on a well-known procedure for determining the effect of a specific factor or stimulus on mass performance. Two groups are compared, an experimental group and a control group. The groups are matched by pairs with respect to various factors which might influence performance. One group, however, carries the experimental factor (say, a drug in medical research) while the other does not (or gets the placebo). In this manner variables other than the one being tested are isolated or "controlled." At the same time, one tries to make both groups large enough to at least partially compensate for the random influence of hidden variables which cannot be specifically controlled. Properly applied, the procedure gives reasonable assurance that the groups as a whole are comparable, even though it is rarely possible to achieve more than a rough sameness between the two members of a pair.

In establishing experimental and control groups for the present study seven steps were taken: (a) establishing a criterion for identifying superior highway facilities, (b) screening out those cities whose growth might be affected by nearby cities, (c) recording descriptive information for use in matching experimental and control cities with similar features, (d) selecting preliminary pairs, (e) balancing the two groups of cities, (f) determining city growth rates, and (g) statistical analysis.

The Experimental Criterion

The criterion problem was readily solved. The 41,000-mile Interstate Highway System is a network of divided, limited-access freeways which are markedly superior to alternative routes in most situations. Its quality is consistent from place to place and over long distances. Interstate System cities can objectively be said to enjoy superior highway facilities. Hence the system, augmented by a few connecting freeways, becomes the criterion.

It might be objected that the system will not be completed until the mid-1970's. However, a new plant is a long-term investment and is likely to reflect long-range locational considerations. It is presumably not the Interstate segments completed during the study period which count but the entire network which will be operational for the bulk of the life of a new plant. (For this reason, freeway cities were selected without regard for whether portions of the System immediately adjacent to them had been completed.) Admittedly, there was originally some doubt as to whether the study period (1958-63) might not be too early to mirror industry's reaction, but the study findings adequately dispel this doubt.

Another problem was how close to or far from the nearest Interstate System access point should a city be to be classified as freeway or nonfreeway? A tabulation of distance-to-freeway for 550 cities located within 10 miles of System exits showed a natural breaking point of 5 to 7 miles: 501 of the 550 cities were within 5 miles and 530 within 7 miles. Seven miles became the cutoff distance (8 in one case), with all but 8 freeway cities actually used being within 5 miles. To insure adequate differentiation of nonfreeway cities, a gap of about 10 miles between the freeway maximum and nonfreeway minimum was employed. Nonfreeway cities were required to be at least 16 miles (one city) from the nearest Interstate System exit, and the median distance for nonfreeway cities used in the study was 40 miles.

Proximity Screening

Other research has shown that principal cities and their larger satellites are declining in their proportionate share of manufacturing employment while suburbs are gaining. And, going beyond principal cities, one can hypothesize that two nearby cities will act as a unit to some degree, attracting more industry in combination than they could in isolation. City A's influence on B can be expected to increase with A's size and decrease as the intercity distance goes up. To control the influence of proximity, therefore, a procedure for screening cities on the basis of the population and distance away of nearby cities was necessary.

As an arbitrary start, a decision was made to eliminate any city within 12 miles (10 plus 2 for good measure) of another city of 10,000 in population. Higher on the population scale, two other benchmarks were obtained by observing the natural scatter of communities around Boston and Chicago. For Boston (700,000) this was judged to extend about 35 miles and for Chicago (3,600,000) about 55 miles. The next step was to fit a curve to the three population-distance benchmarks. The curve, $D = \sqrt[3.75]{P}$

(distance equals the 3.75th root of population), fits very well. It demands 14 road miles of separation from another city of 20,000 population, 21 miles from a city of 100,000, 36 miles from a city of 700,000 (Boston), and 55 miles from a city of 3,600,000 (Chicago). This formula easily eliminates all cities classified as suburbs or satellites in the Rand McNally City Rating Guide as well as numerous others.

Descriptive Information

For all cities surviving proximity screening, descriptive information was recorded for use in (a) pairing freeway with nonfreeway cities and (b) preparing statistical breakdowns. This information covered geographic location, population, road mileage to nearest Interstate exit, rail service, air service and airports, water carrier service, port facilities, governmental institutions, educational institutions, manufacturing value added (1958), and several economic and special activity ratings.

The necessary data came from many sources. Cities were located by road map coordinates to facilitate subsequent measurement of intercity separation among paired cities. Population figures came from the 1960 Census. Distance to freeway was measured from road maps. Rail service, for which only a crude measure could be developed, was recorded from a railroad atlas in terms of the number of directions in which rail lines ran from a city. Airline route maps and the FAA National Airport Plan provided information on airline service, while the Plan and road maps revealed the location of airports not served by airline. Water carrier service was recorded from a map of inland and coastal waterways. State capitals were identified and, because no two could be matched, eventually eliminated. The Education Directory (U. S. Office of Education) was used to locate colleges of 3,000 or more enrollment which offer graduate degrees. Business importance ratings, trade ratings, economic activity classifications, special activity information, and manufacturing value added index numbers were taken from the Rand McNally City Rating Guide.

Matched Pairs

After the information was recorded, the task of matching freeway cities with nonfreeway cities by pairs began. To limit any influence of city size on growth rate differentials, the population gap between the two cities of a pair was generally held to 15 percent.

In a few instances, e. g., where two cities were otherwise exceptionally well matched, larger differences (23 percent in one case) were permitted, but the median population difference for all pairs was much lower—9 percent. To restrict geographic influences (markets, resources, wages, etc.) the second city of a pair was drawn from the same state as the first or from the near side of an adjacent state. Primary emphasis was placed not on the state but on airline miles of separation between paired cities. This was generally limited to 175 miles in the eastern states, 200 miles in the central states, and 250 miles in the West. Nationally, the median separation between paired cities was 102 air miles.

The matching of transport characteristics was fairly strict. Both cities of a pair (the freeway city and the nonfreeway) or else neither had to have airline service; and if neither had it, both or neither had to have an airport. Again, both cities or else neither had to be located on a navigable waterway. Ports were always paired with ports, non-ports with non-ports. The rail service ratings were too inadequate to apply rigorously, but were used judgmentally in combination with other factors to determine the best match where there was an option. Likewise, although major dissimilarities were not permitted, the economic and special activity ratings were chiefly used judgmentally; anything approaching identity on a large number of points would have ruled out substantially all combinations. However, for college and resort towns, identity on these two factors was required.

Balancing the Groups

Small population differences for individual pairs could (and sometimes did) cumulate to produce large differences in the aggregate, and two-state pairs could lead to unequal representation for a state in the freeway group as compared to the nonfreeway. To prevent such imbalance, the original pairings were refined, region by region.

Both for balancing and for subsequent analytical purposes, the country was divided into eight regions: Northeast, Southeast, East Midwest, West Midwest, South Central, North Central, Northwest, and Southwest. Freeway and nonfreeway city populations were totaled by region, and city counts were tallied for each state. Certain pairs were then eliminated and others reconstituted in order to bring the freeway and nonfreeway totals into agreement. Under the final pairings, the largest regional population difference (freeway vs nonfreeway) was 0.6 percent, while the national difference was 0.004 percent. Moreover, each state had the same number of cities in each group, subject to the reservation that up to one freeway and one nonfreeway city from a state could be counted in an adjacent state if the city was close to the state line.

The final pairings included 212 cities (106 pairs). All but 13 were between 10,000 and 50,000 in population, the smallest and largest being approximately 6,400 and 56,600, respectively, and the median population standing at about 15,000. The Southeast had the most pairs, 20, and the Northwest the least, 6. All but one of the remaining regions yielded 14 pairs. Usable cities were found in all states but Massachusetts, Rhode Island, Connecticut, New Jersey, Delaware, Wyoming, Utah, and Nevada.

Measuring Growth

The Census of Manufacturers proved to be the only satisfactory source of manufacturing growth data for cities. The two most recent manufacturing censuses for which data have been published were conducted in 1958 and 1963; hence the growth period became 1958-63. More recent figures would be desirable, yet the statistically significant findings obtained for the relatively early period indicate that the data are adequate.

Among the many measures of manufacturing activity available in the Census reports, manufacturing employment is the one most relevant to the purposes of this study: jobs are what economic development programs ultimately seek to provide. Manufacturing employment therefore became the basic measure of growth. As a check on the validity of the employment data, the number of manufacturing plants with 20 or more employees was also recorded. Both figures—employment and plants—exclude manufacturing activity located beyond city limits but are otherwise reliable.

The basic statistic used in analyzing and comparing manufacturing growth was per capita increase in manufacturing employment. For each city the net change in employment was obtained by subtracting 1958 employment from the 1963 total. The difference, or absolute change, was then converted to a rate to permit cities differing in size to be combined and compared. Dividing a city's net change by its 1960 population gives the per capita increase or decrease. The per capita figure was deemed better than a percentage increase for analytical purposes because the latter figure is overly sensitive to variations in 1958 employment. Since resources did not permit highly refined analysis of the data on plants, the net increase was the only city value computed in connection with the new plant measure.

Statistical Analysis

In order to allow computation of probability levels, the mean was used as the primary measure of central tendency. In other words, the per capita employment growth rates for individual cities were averaged. Freeway and nonfreeway means were computed separately in all instances. This was done for the 106 pairs combined and for numerous breakdowns, e.g., by region and population interval. The freeway and nonfreeway means were then compared to determine whether and under what circumstances significant differences could be found. Statistical significance levels were computed on the basis of T distributions (non-normal). For changes in number of plants, a different measure of central tendency, the median, was used, and significance levels were not examined.

Supplementary analyses employing correlation coefficients were also prepared. First, in order to examine more closely the relationship between growth and distance to freeway, growth vs distance correlations were computed for hundreds of curvilinear functions of both growth and distance. These correlations were run initially for all 106 pairs and then repeated for significant regional groupings. Here the primary intent was to discover the precise nature of any relationship between the variables—type of curve, rate of attenuation in growth with increasing distance, etc. Second, to investigate the possibility that growth rate differentials resulted from uncontrolled differences in 1958 manufacturing levels between the freeway and nonfreeway cities, growth was correlated with 14 industry variables, e.g., 1958 total and per capita manufacturing employment. Partial correlations between distance and growth were then computed with manufacturing controlled. Finally, separate freeway and nonfreeway correlations for growth vs manufacturing were computed.

FINDINGS AND ANALYSIS

The study findings indicate that modern highways do significantly affect manufacturing growth but not in all situations. Freeway cities grew faster only in regions where traffic flow along regular highways is seriously impeded. And within these regions, the freeway influence was evident largely in cities which were either above a certain size or else had airline service. The availability of good rail service or water carrier service did not affect the response to freeways. In the significant categories, the freeway influence tapered off in curvilinear fashion with increasing distance and substantially disappeared beyond about 10 miles. Local industry had little effect on growth-distance correlations.

All Cities Combined

The first statistical analysis compares all 106 freeway cities with all 106 nonfreeway cities. To repeat, the basic measure of growth is the mean of the per capita manufacturing employment increase values for individual cities. In the findings below, this measure is expressed as new jobs per thousand capita. For the freeway group the average growth rate was 19; for the nonfreeway group it was 16. This small difference is significant only at the 0.67 level of statistical probability. That is, a difference this large could occur by chance 67 percent of the time, in two experiments out of three. Looking at the supplementary measure of growth, median increase in large plants (20 or more employees), both groups grew by the same amount. These findings support the conclusion that, for cities in general, proximity to the Interstate System did not significantly influence urban manufacturing growth during the period 1958-63.

Regional Breakdowns

When the city pairs were broken down by region, significant differences began to appear. Large employment growth rate differences favoring the freeway group were found in three regions. The freeway advantage was 52 to 31 in the Southeast, 30 to 19 in the East Midwest, and 25 to 4 in the Northwest. In the other five regions the nonfreeway cities exhibited small advantages. The results are of particular interest be-

TABLE 1

NATIONWIDE AND SELECTED REGIONS

Region	Pairs	Freeway	Non-Freeway	F - NF	Significance
Nationwide					
Employment	106	19	16	3	0.67
Large plants		1	1	0	
SE + EMW + NW					
Employment	40	43	23	20	0.04
Large plants		2	2	0	
SE + EMW					
Employment	34	46	26	20	0.07
Large plants		2	2	0	

cause of the tentative support offered to the hypothesis that freeways have an impact in regions of dense population and hilly terrain, i.e., regions where the traffic flow benefits of freeways are greatest. Among such regions, only the Northeast failed to show a strong freeway advantage. (Lack of city pairs prevented any findings for the Rocky Mountain area and the lower two-thirds of California.) And, to anticipate, even in the Northeast the freeway cities displayed faster growth when the analysis was confined to larger cities. The relatively poor performance of freeway cities in the Northeast may have been influenced by the region's status as the slowest growing region of the country; growth rate differentials are difficult to detect where little growth occurs.

Because of the small number of cases in any particular region, significance levels were not computed for single regions. However, two multiregion combinations were tested for significance. First, the three freeway sensitive regions—Southeast, East Midwest, and Northwest—were combined. Here the freeway cities enjoyed a 43 to 23 advantage in employment growth rate. The difference between means was significant at the 0.04 level. Second, because there are theoretical objections to including a noncontiguous region (the Northwest) in the combination, a separate analysis combining only the Southeast and East Midwest was made. This time the freeway advantage was 46 to 26, significant at the 0.07 level. (The lower level of significance reflects the smaller number of cases on which the finding is based.) The findings for the nation as a whole and for the two regional combinations are summarized in Table 1.

Other variables having a catalytic effect on freeways must still be considered, but the findings begin to suggest that in certain regions freeways significantly influence manufacturing growth. In the eastern United States, dense population means heavy traffic, with towns causing relatively frequent interruptions. At the same time, rough topography produces numerous hills and curves which limit the sight distance for passing and otherwise restrict speeds. Eastern freeways therefore offer extra large advantages, particularly where trucks moving on grades are concerned. But to the west beyond the Appalachians, the Great Plains appear. The terrain becomes flatter and, simultaneously, population and traffic thin out. Freeways still help, but not as much.

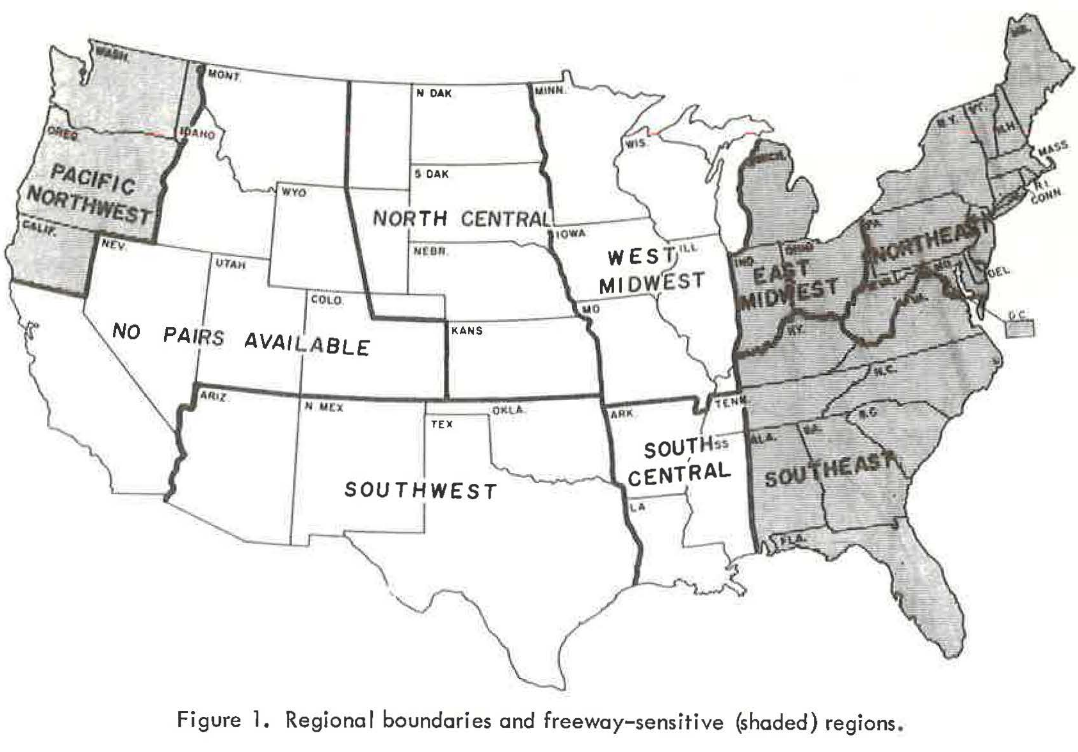

Figure 1. Regional boundaries and freeway-sensitive (shaded) regions.

On the West Coast, traffic again becomes heavy and topographical irregularities reappear. The findings thus display a logical pattern for the hypothetical freeway influence. (The West Coast findings are limited to the Northwest—Idaho, Washington, Oregon, and northern California—because the abundance of freeways in California made it impossible to obtain city pairs from central and southern California. Rocky Mountain pairs are also lacking.)

Population

When the study cities were broken down by population intervals, it became obvious that the freeway group had an advantage chiefly among the larger cities. Experimentation showed the 16,000 population level to be the optimal breaking point for differentiating between cities which respond to freeways and those which do not. Obviously, 16,000 is not a magic number but merely indicates a tendency for industry to respond to freeways as the cities they serve grow larger. This tendency, though, is consistent from region to region among the four regions. And it is further confirmed by the findings of two other studies conducted in conjunction with the present one. In a study comparing airline with nonairline cities, it was found that air service significantly (confidence levels as high as 0.01) influences growth in cities above 19,000. A waterway study showed that waterway cities on the Mississippi-Ohio River System grew significantly slower (0.06 level) than comparable nonwaterway cities (possibly because of flood hazards) but only among cities above 15,000. The likely explanation for the consistent influence of population is that large firms and branch plants, which tend to locate by more nearly rational criteria, seek locations in cities above roughly 15,000, whereas small city industry has a higher proportion of "home town" firms.

Nationwide, freeway cities above 16,000 outgrew their nonfreeway mates 14 to 5. Data for individual regions indicate, however, that the freeway advantage was largely confined to the three regions previously identified as sensitive to freeways plus the slow-growing Northeast. In the West Midwest and South Central regions, freeway cities above 16,000 actually showed a slight disadvantage. The shaded area in Figure 1 defines the four freeway sensitive regions. The addition of the Northeast (beginning with West Virginia) to the sensitive regions is important, for it overcomes the one exception to the evidence supporting the traffic flow hypothesis. (The Northeast freeway advantage was only 0.5 to -0.2, hardly significant in itself but at least consistent with the assumption that freeways boost growth where nonfreeway traffic is severely impeded.)

Pairs in which both cities were above 16,000 population were tested for significance for several regional combinations. These are shown in Table 2. For the four sensitive regions combined, the freeway advantage was 27 to 4, significant at the 0.03 level of probability. The Northeast had so many cities which experienced losses that its data are not entirely meaningful: 8 of 16 Northeast cities (3 of them freeway) declined. If this region is therefore dropped from the combination, the freeway advantage goes up to 34 to 6, significant at the 0.02 level. The freeway cities also develop an appreciable lead in new plants. If the noncontiguous Northwest is also dropped, the freeway

TABLE 2

PAIRS ABOVE 16,000 POPULATION

Region	Pairs	Freeway	Non-Freeway	F - NF	Significance
NE + SE + EMW + NW					
Employment	26	27	4	23	0.03
Large plants		2	1	1	
SE + EMW + NW					
Employment	19	34	6	28	0.02
Large plants		3	1	2	
SE + EMW					
Employment	15	38	7	31	0.04
Large plants		4	1	3	

margin rises to 38 to 7, but with fewer cases the significance level falls to 0.04. Because the freeway group has a relatively greater advantage in new jobs than new plants, part of the job gain seems related to established firms.

For cities below 16,000 in the three more sensitive regions, the freeway group still grew faster, 52 to 38. But the difference, covering 21 pairs, is significant only at the 0.37 level. Viewed in the context of the highly significant difference for cities above 16,000, the below 16,000 difference cannot be entirely discounted. A cautious conclusion would be that there is weak evidence of a freeway impact among smaller cities but that any such impact is relatively mild.

Airline Cities

Economists have long suspected that cities with airline service grew faster: most business travel is by air, and it is known that some firms insist on locations where air service is available (e.g., to facilitate contact between branch plans and headquarters.) Indeed, the previously mentioned companion study comparing airline and nonairline cities shows the airline group growing significantly faster, particularly in the South and West, for pairs above 19,000 population. This suggests the possibility that industry is attracted to freeway cities only, or especially, if there is concomitant air service. To examine this possibility, airline pairs were broken out for separate analysis. (Remember, the two members of a pair are always matched on air service: both have it or else neither has it.)

Nationwide, the airline cities located on freeways grew faster (12 vs 4) but not significantly. However, as in the case of cities above 16,000, the freeway group did significantly better than the nonfreeway in the four sensitive regions. The airline pair findings are summarized in Table 3. It shows substantial freeway advantages for all regional combinations, with the significance level reaching 0.03 for the three region combination (Southeast-East Midwest-Northwest).

Is this finding due to the fact that most airline cities are above 16,000? Conversely, do freeways affect larger cities simply because most of them have air service? Further analysis suggests that the catalytic effects of population and air service are substantially independent of one another. A 26 to 10 employment growth rate advantage held by the freeway group for 12 nonairline pairs above 16,000 in the four regions points to the independence of population. A majority of the freeway cities outgrew their mates

TABLE 3

AIRLINE PAIRS

Population and Region	Pairs	Freeway	Non-Freeway	F - NF	Significance
Population Unlimited					
NE + SE + EMW + NW					
Employment	18	27	2	25	0.04
Large plants		1	0	1	
SE + EMW + NW					
Employment	13	40	7	33	0.03
Large plants		1	0	1	
SE + EMW					
Employment	8	51½	8	43	0.07
Large plants		2½	0	2½	
Above 16,000					
NE + SE + EMW + NW					
Employment	14	27	-1	28	0.06
Large plants		-½	-½	0	
SE + EMW + NW					
Employment	10	39	2	37	0.05
Large plants		½	1	-½	
SE + EMW					
Employment	7	50	2	48	0.07
Large plants		4	1	3	

in each region. Air service's independence of population can be inferred from an even larger freeway advantage, 27 to -1, found among 14 airline pairs above 16,000 in the same four regions. Below 16,000 the freeway city grew faster in three of four airline pairs in these regions (the fourth case was a tie), giving freeway cities a 28 to 11 advantage. Corroborating evidence of the independent significance of air service as a freeway catalyst comes from the companion study of air service, which included eight eastern freeway pairs (both the airline and the nonairline member of each pair were freeway cities). Freeway-plus-airline again proved an effective combination, though this time in comparison with freeway-but-no-airline: the airline advantage was 27 to -1, significant at the 0.09 level, for all eight cases and 19 to -3 for five cases below the air study's critical population level of 19,000. In short, freeways stimulate growth even in smaller cities if they are also served by air.

The findings for airline cities above 16,000—the two catalysts operating in combination—are of particular interest. Cities with both catalysts grew markedly faster when located on a freeway (Table 3). For the two region combination, all seven freeway cities outgrew their mates. This could happen by chance 1 time in 128.

Combined Categories

If, in the sensitive regions, either a population above 16,000 or airline service tends to enable manufacturing growth to respond to freeways, one would expect results of even greater statistical significance to be obtained from a supercategory including city pairs from both groups. The logic of this combination is simply that most firms which locate rationally seem to demand not only good highway connections but (a) the suppliers, services, amenities, and labor supply found in a larger city, (b) air service, or (c) both. Table 4 indicates what happens when all pairs in the greater than 16,000 range are combined with the remaining airline city pairs.

As anticipated for the larger numbers of cases, probability levels reach their peaks for all regional combinations. When the Northeast is dropped from the picture, a difference between means which could occur by chance only once in 100 experiments appears. The 1 percent level of probability represents the norm frequently applied in conservative statistical interpretations. Five percent, however, can ordinarily be regarded as significant, and even a 10 percent level evokes interest. Therefore, assuming that the principal nonhighway variables have been adequately controlled and that the freeway and nonfreeway groups do not differ appreciably with respect to some unrecognized factor of significance, the findings appear to justify the conclusion that freeways aid manufacturing growth under certain conditions.

It is interesting to see what happens when the freeway and nonfreeway cities in the four region combination (60 cities) are combined and ranked by growth rate. Freeway cities dominate the top quartile, nonfreeway cities the bottom. The number of freeway cities declines in each successive quartile below the top, an impressive showing

TABLE 4

ALL CITIES OVER 16,000 PLUS AIRLINE CITIES UNDER 16,000

Region	Pairs	Freeway	Non-Freeway	F - NF	Significance
NE + SE + EMW + NW					
Employment	30	27	5	22	0.02
Large plants		2	1	1	
SE + EMW + NW					
Employment	22	36	8	28	0.01
Large plants		3½	1	2½	
SE + EMW					
Employment	16	40	10	30	0.04
Large plants		3½	1	2½	

of internal consistency in the data. The following table shows how many cities of each group fall in each quartile.

Group	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile
Freeway cities	11	10	5	4
Nonfreeway cities	4	5	10	11

Rail and Water Carrier Categories

Additional categories which conceivably would respond to freeways are cities with or without good railroads or water carrier service. Cities with poor rail service might experience "catch-up growth" with the advent of a freeway, with road becoming a substitute for rail. Alternatively, firms might demand excellence of both rail and highway facilities, or of both water and highway service.

Despite these possibilities, analysis of rail and water carrier breakdowns failed to show any unusual advantage for freeway cities. To test the rail hypothesis, pairs in which both cities had rail service in only one or two directions (all had at least one rail line) were compared with pairs having rail service in three or four directions. This was done nationwide and for the four sensitive regions. For both geographic comparisons, the difference between freeway and nonfreeway employment growth rates was about the same for both rail categories. Nationally, the freeway city advantage was 6 jobs per thousand capita for pairs with good rail service and 2 jobs for the poor service pairs. In the four regions, the comparable differences were 21 and 18. This seems to reflect the fact that almost all cities with poor rail service are below 16,000.

Only 5 waterway pairs (10 cities) were available for analysis, and three of these were outside the four sensitive regions. A comparison was nevertheless made. It showed both groups, freeway and nonfreeway, losing jobs. (Nine of the ten cities declined!) The freeway "growth" rate was -6, the nonfreeway rate -9. This is not a significant difference.

Distance to Freeway

The next relationship explored should prove of special interest to highway planners. It concerns how close a city must be to the nearest freeway exit (access point) to gain a manufacturing advantage, assuming there is an advantage to be gained. Two procedures were used to explore the relationship between distance (road mileage from city to nearest freeway access) and manufacturing employment growth rate.

Under the first test, the 30 sensitive pairs (Table 4: four regions) were separated into two categories based on the nonfreeway city's distance from the nearest freeway. In one category were placed 8 pairs in which the nonfreeway city's distance was 16 to 25 miles; into the second went 22 pairs with a nonfreeway distance on more than 25 miles. The more distant nonfreeway cities actually did better relative to their freeway mates than the closer-in nonfreeway cities. (Considering geographic disparities involved, the difference was not significant.) Moreover, all 8 nonfreeway cities in the 16- to 25-mile category grew more slowly than their freeway mates. The odds against this happening by chance are 256 to 1.

Correlation analysis provided a second and more precise test of the relationship between distance and growth. The two variables were correlated for (a) nonfreeway cities alone and (b) freeway and nonfreeway cities combined. For each category, separate correlations were run using all 106 pairs and then just the 30 sensitive ones from the four regions. In each situation hundreds of curvilinear functions of distance, as well as the unadjusted and dummy (explained below) values, were correlated with growth and functions of growth. For example, growth and its log were correlated with 50 powers of distance ranging from $D^{0.1}$ to $D^{5.0}$. The idea was to identify and measure any curvilinearity in the relationship.

If proximity to a freeway has any influence on nonfreeway cities (defined as more than 15 miles from a freeway), there should be a reasonable correlation (r) between growth and distance for nonfreeway cities. Actually, the highest r's were quite low: -0.23 (log G vs $D^{1.4}$) for all 106 nonfreeway cities and -0.15 (log G vs $D^{2.0}$) for the 30 nonfreeway cities from the sensitive pairs. These values do not suggest that freeways appreciably affect cities more than 15 miles away.

For freeway and nonfreeway cities combined, one can theorize that growth will decline with increasing distance according to the pattern of a normal probability curve: variations in distance should have little effect over the first few miles, but growth should then begin to decline more rapidly until distance approaches the limits of its influence, after which the curve should flatten out again (so that growth does not become highly negative at extreme distances). This bell shaped pattern is just what materialized. Although no significant r's were found for the nationwide grouping of 212 cities, some fairly good r's appeared in the sensitive categories. The distance function producing the highest r's was based on the probability curve relationship $y = \exp\left(-\frac{D^2}{2\sigma^2}\right)$, where y is a function of distance, e = 2.718, D is distance (miles), and σ is an experimental standard deviation varying from one to fifty on successive iterations.

The 30 pair findings are summarized in Table 5. Because observers may be interested, three r's are shown: the linear r for growth vs distance (unadjusted), the r produced by a dummy variable equal to 1 for freeway cities and 0 for nonfreeway, and the r for the normal curve function described. The σ column gives the standard deviation at which the maximum r, shown under "Curve," was obtained. The "Significance" column shows the degree of probability that the r under "Curve" differs significantly from zero. Separate findings are again presented for three regional combinations. The "Full Correlation" line under each regional heading shows the r's between distance and growth. Since regional influences, particularly the Northeast's lack of growth as it affects growth in Northeast freeway cities, tend to obscure the relationship, the Type A entries have been added to show partial r's resulting when ten state variables are controlled. Three other sets of partial r's for as many combinations of 10 state and local variables being controlled follow. These are based on an 80 variable multiple

TABLE 5

GROWTH CORRELATED WITH DISTANCE TO FREEWAY: SENSITIVE REGIONS
(All Cities Over 16,000 plus Airline Cities Under 16,000)

Region	Cities	Linear	Dummy	Curve	σ (miles)	Significance
NE + SE + EMW + NW	60					
Full correlation		-0.26	+0.30	+0.33	5	0.011
Partial: Type A		-0.29	+0.40	+0.46	4	0.001
Partial: Type B		-0.32	+0.46	+0.48	5	0.001
Partial: Type C		-0.27	+0.44	+0.43	7	0.001
Partial: Type D		-0.30	+0.48	+0.48	6	0.001
SE + EMW + NW	44					
Full correlation		-0.27	+0.38	+0.40	5	0.008
Partial: Type A		-0.32	+0.47	+0.54	3	0.001
Partial: Type B		-0.25	+0.51	+0.52	6	0.001
Partial: Type C		-0.20	+0.43	+0.42	7	0.005
Partial: Type D		-0.25	+0.46	+0.46	6	0.005
SE + EMW	32					
Full correlation		-0.23	+0.36	+0.41	4	0.02
Partial: Type A		-0.29	+0.40	+0.50	3	0.01
Partial: Type B		-0.18	+0.44	+0.45	5	0.02
Partial: Type C		-0.11	+0.38	+0.40	5	0.03
Partial: Type D		-0.30	+0.33	+0.47	2	0.02

Type A: controls 10 state variables—4 forced and 6 free (free means computer selects highest partial r at each step of regression series).
Type B: controls 9 state variables (4 forced, 5 free) plus best local variable, viz., value added per capita weighted by state growth rate.
Type C: controls 4 best state, 3 local industry, and 3 free variables.
Type D: controls 10 free variables, state and local (computer selects all).

regression analysis and relate primarily to the analysis of industry and growth, which follows.

The findings in Table 5 support the theory that freeway-induced growth tapers off with increasing distance from a freeway in a manner described by the positive side of a normal probability curve peaking at zero miles. Depending on the regional grouping and type of r examined, this curve has a standard deviation of from 2 to 7 miles. A curve with a standard deviation of 5 miles (the average reading) means that if the growth-distance relationship were perfect, a growth rate of 100 (height of ordinate) at 0 miles would be associated with rates of 61 at 5 miles, 14 at 10 miles, and 1 at 15 miles. Two standard deviations look like the approximate distance beyond which the freeway influence becomes insignificant. Hence one might say that freeways have little influence beyond about 10 miles, or to be punctilious, beyond an indeterminate distance between roughly 5 and 15 miles.

Industry and Growth

Is a city's manufacturing employment growth rate affected by the amount of industry with which the city started? If so, any uncontrolled differences (freeway vs nonfreeway) in 1958 manufacturing employment, or perhaps some other measure of industry, could have distorted the study findings. That is, the freeway cities might have benefited from a favorable industrial posture at the start of the 1958-63 growth period. Further analyses were undertaken to check this possibility.

First, with regard to the specific possibility that employment was not adequately controlled, 1958 manufacturing employment was totaled for each of the two groups. This was done both for all 106 pairs and for the 30 pairs (Table 4: four regions) in the freeway-sensitive categories. Nationally, the difference was one percent (freeway, 234,659; nonfreeway, 231,889). For the 30 pairs it was 4 percent (freeway, 114,577; nonfreeway, 119,675), the advantage going to the nonfreeway group. In short, whatever the significance of manufacturing employment as a stimulus to its own growth, the freeway cities did not enjoy a running start.

Next came a series of correlation tests. The first tests correlated two variables (1958 total manufacturing employment and 1958 per capita manufacturing employment) with growth. The tests covered the 212 cities combined and 17 breakdown categories. Generally low and frequently negative r's were encountered: for all 212 cities the r's correlating growth with employment and per capita employment were -0.03 and +0.22. But for certain geographic groupings the r's were significant: the Northeast showed one of -0.47 between growth and per capita employment, and the other regions combined showed a comparable r of +0.39. (Heavily industrialized cities had greater losses in the Northeast and greater gains elsewhere.)

More rigorous tests were then conducted using the 30 sensitive pairs. These and all subsequent correlation analyses employed a stepwise regression program equipped to handle 80 variables. Besides the dependent variable (city growth rate) the variables included 10 functions of distance to freeway, 21 other local variables (with 16 relating to industry), and 48 state variables. The distance functions were those covered in Table 5 and included the eight probability curve functions for σ = 2-9. The state variables included five growth measures plus other values (e.g., temperature) shown by independent research to be highly correlated with state growth.

Interesting r's appeared. For the 60 cities the r between growth and manufacturing value added (a measure of industrial output) per capita was +0.38. Further analysis showed even higher positive r's between industry and growth (reaching +0.62 for value added per capita) among the 44 cities in the three fast growing regions (SE + EMW + NW) offset by negative r's (reaching -0.63 for employment per capita) in the Northeast, where most cities either declined or grew very slowly. Thus, when value added per capita was weighted by state 1958-63 per capita employment growth rate (negative for some Northeast States), the 60 cities produced an r of +0.62 between growth and the weighted variable—well above the unweighted +0.38. The "sensitive" cities thus repeated the 212 city pattern whereby cities with the most industry registered the biggest gains and losses, depending on whether their states grew or declined.

This finding invites doubt as to whether very similar employment totals between the freeway and nonfreeway groups fully rule out possible effects from industrial disparities. The next analysis tackles this question. It involves partial r's between growth and the distance variables. Each partial r entails simultaneous control of ten variables, differing from test to test. First, the Type A partials described in the distance analysis (ten regional variables controlled) were compared with some Type B partials, which substitute weighted value added per capita for the weakest state variable. The findings in Table 5 show that controlling the strongest industry variable has little effect: the Type B partial r for the dummy variable is actually higher than the Type A partial for all three regional groupings, and the optimal curvilinear r for type B is higher for the four region combination. Second, additional partial r's were computed based on more extensive control of local variables. This time four state and three local industry variables were forced into the stepwise regression program to insure reasonable control of state and industry disparities, and three additional variables were freely selected by the computer as those with the highest partial r's (but with distance suppressed) going into each of the last three steps.

The ten variables "partialed out" in the four region analysis (Table 5) were (1-2) state 1958-63 per capita and percentage increases in manufacturing employment, (3) state January mean temperature times state ratio of income to value added, (4) $\sqrt{(50 - \text{latitude})(\text{longitude} - 65)}$, (5) manufacturing employment, (6) value added, (7) value added per capita weighted by state per capita employment growth rate, (8) number of plants with 20 or more employees, (9) ratio of manufacturing employment to value added, and (10) Rand McNally business importance rating. All values are local except where "state" is indicated. Table 5 shows that the new partials, designated Type C, were slightly lower than the Type B ones yet higher than the original correlations. Finally, to place things squarely on an objective basis, the computer was given free rein to choose all ten controlled variables (variable with highest partial enters regression equation at each step). The resulting Type D partials (Table 5) fall right in the middle of the range of values for Types A, B, and C—still above the original r's. These findings indicate that the relationship between freeways and growth is not due to a coincidence of freeways and industry.

Freeway Effect on Industry's Effect

The r's between growth and distance to freeway are lower than might have been anticipated considering the rather large differences between means examined earlier. And this discrepancy introduces a final industry analysis, again involving r's between growth and the industry variables. This time the freeway cities were separated from the nonfreeway cities for the 44 cities from the three fast-growing regions. (The Northeast was omitted because its positive r's between losses and industry tend to cancel the positive r's between growth and industry in the other three regions, obscuring high correlations.) Full and partial r's were computed for the 14 local industry variables; the

TABLE 6

GROWTH CORRELATED WITH MANUFACTURING: SE + EMW + NW
(All Over 16,000 plus Airline Cities Under 16,000—22 Pairs)

Manufacturing Variable	Freeway Cities		Nonfreeway Cities	
	Full r	Partial	Full r	Partial
Mfg. employment	+0.69	+0.78	+0.15	+0.15
Mfg. value added	+0.79	+0.83	+0.18	+0.24
Mfg. employees per capita				
Unweighted	+0.78	+0.81	+0.33	+0.26
Weighted by state growth	+0.79	+0.80	+0.31	+0.26
Value added per capita				
Unweighted	+0.85	+0.90	+0.32	+0.25
Weighted by state growth	+0.87	+0.93	+0.30	+0.26

partial r's entail control of the four state variables listed above plus population and Rand McNally business importance rating.

Highly impressive differences between the freeway and nonfreeway r's appeared. The freeway cities generated numerous very high r's of up to +0.93 (partial r for per capita value added weighted by state 1958-63 manufacturing employment growth per capita); none of the nonfreeway r's rose above +0.33. Table 6 summarizes the r's for the six highest industry variables. Considering that the freeway and nonfreeway groups are approximately equal in aggregate manufacturing employment, the findings in Table 6 strongly suggest that freeways affect growth indirectly as well as directly. Existing industry is helped to expand—the more industry, the more expansion—and/or to attract other industry. Part of the freeway impact shows up not in the distance r's but in higher industry r's.

CONCLUSIONS

The study findings appear to justify several conclusions. Because the 1958-63 period studied may be too early to mirror the full impact of the Interstate System and in view of the limited number of cities available for analysis, these conclusions may be regarded as tentative. Broader effects may become evident as the System nears completion.

1. Freeways aid manufacturing growth, but only under certain conditions, in the cities which they serve. Rapid, low-cost motor freight attracts industry and facilitates increases in manufacturing employment.

2. The freeway impact is confined to regions characterized by dense population and uneven terrain—regions where freeways offer relatively substantial time savings. These regions embrace (a) all eastern states beginning with Indiana and Alabama and (b) the Pacific Northwest states. General industrial stagnation in the Northeast, beginning with West Virginia, limited the freeway impact in that region. Lack of data precludes findings for the Rocky Mountain states and central and southern California.

3. In the four sensitive regions, freeway related manufacturing gains are mainly confined to cities above 16,000 or (regardless of population) with air service. Many firms desire not only good freight transportation but good personal transportation and other medium-sized city amenities.

4. The manufacturing impact of freeways is not dependent on or affected by the presence or level of rail or water carrier service.

5. The relationship of growth to distance-to-freeway is described by a probability curve (bell shaped) peaking at 0 miles and with a standard deviation of roughly 5 miles. Benefits do not accrue to cities located more than about 10 miles from the nearest freeway.

6. Although growth is significantly correlated with prior industry, the freeway advantage was not thereby influenced: freeway cities started with slightly less industry, and partial correlations between distance and growth with industry controlled are higher than the original correlations.

7. Freeways probably stimulate existing industry as well as attracting new plants, for (a) the ratio of freeway to nonfreeway gains is higher for employment than new plants and (b) existing industry has a much higher correlation with growth in freeway than in nonfreeway cities.

Toward Measurement of Community Impact: The Utilization of Longitudinal Travel Data To Define Residential Linkages

RAYMOND H. ELLIS, Peat, Marwick, Livingston and Company; and
RICHARD D. WORRALL, Northwestern University

The concept of residential linkages has previously been proposed as the basis for a strategy for quantitatively estimating the community or social consequences of transportation projects. The objective of this paper is to present a method for empirically defining existing residential linkages and linkage patterns. It is suggested that linkage definition involves the analysis of two data sets: the activity patterns of the household and the set of destination points which the household defines as important. Activity patterns are determined by analyzing an average of 3½ weeks of travel data for each of 35 households residing in Skokie, Illinois. Household interviews would be used to identify the set of destination points that the household defines as important. A discriminant iterations analysis is then used to refine the initial classification used by the household and to insure that the set of developed linkage definition criteria are uniformly applied to each activity pattern. It is concluded that the proposed analytical methodology could be operationally employed to define linkages as part of an effort to estimate the community impact of transportation projects.

•RECENT events have emphasized the importance of incorporating consideration of the community consequences of the transportation program into the planning methodology. Numerous political controversies have developed throughout the country regarding the design of major urban transportation facilities. Examination of these controversies would demonstrate that the social and environmental impact of the transportation system is frequently the most important issue in these controversies (3). Because of the dimension of the problems of the American city and the level of public and private expenditures devoted to urban transportation, decision-makers are increasingly requesting transportation planners to analyze the contribution of the transportation program to the achievement of social, environmental, and other goals.

A review (15) of the community impact literature (1, 13, 17) would suggest that researchers and planning groups have been using a restricted approach to measuring community or social consequences. Significant variables have been only partially identified and little is known of the basic structure of the impact process. Two measures of the outcome of the impact process, property value and mobility, are being examined but they do not provide insight into the impact process nor do they provide information to aid in the location and design of new facilities. While considerable technical progress is being made on measuring the noise and air pollution produced by operation of the transportation processor, the consequences of these by-products are not well understood. Everyone has an opinion on the aesthetics of the transportation system, but little progress has been made toward introducing quantitative estimates of aesthetics into the design process. The problem of integrating environmental

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impact over a social and physical space so that a given transportation program may be evaluated has barely been considered.

In order to effectively consider community consequences, it is necessary to understand the transportation impact process and not to treat it as a "black box." This black box approach is reflected in the observation that in spite of the fact that social consequences should be defined in terms which are "relevant" to both the social process and the transportation system, there presently appears to be a tendency to estimate social impact using metrics such as "number of trees" or " number of historic monuments" removed. Such a strategy is unfortunate in that it utilizes a measure of the quality of the physical environment as a surrogate for social impact. If the park in which the trees are located is not visited, there would appear to be little justification in defining "preservation of trees" as a social consequence.

In previous papers (5, 6, 7), it was suggested that one approach to identifying the relevant social consequences may be based on a theoretical perspective which views the community as a system which has certain social and physical requirements for proper functioning and within which a process of interaction takes place among the residents. The social consequences of a transportation program, then, are changes in the system which may be estimated by measuring perturbations in the process of interaction. An activity map, which defines the individual's allocation of resources in generalized spatial and activity purpose dimensions, is one methodological approach which may be utilized to empirically define the interaction process (7).

However, a metric providing a more precise spatial definition is needed, particularly to measure the community impact of transportation facilities on the areas through which they pass. This requirement is met by the use of residential linkages (6) which are defined as ties between the housing site of the individual and other points which are of importance to the individuals involved. In the next section, the residential linkage concept is presented in greater detail.

The objective of this paper is to present a prototypical methodology to define existing residential linkages so that linkage patterns may be used to estimate the social consequences of alternative transportation programs. A prototypical methodology which employs longitudinal travel data, attitudinal data, and a discriminant iterations analysis to define existing linkage patterns is presented in the third section of the paper. The remaining sections describe a case study in which the prototypical methodology was applied to define linkage patterns in Skokie, Illinois. It is emphasized that this empirical investigation is concerned with describing household activity and linkage patterns and not with examining the impact process per se. Thus, the application of residential linkages to the measurement of social consequences will not be demonstrated in this paper and remains a topic for further investigation.

RESIDENTIAL LINKAGES AS A STRATEGY FOR MEASURING COMMUNITY IMPACT

Residential linkages may be defined as ties between the housing site of the household and other spatially distinct points which are of importance to the individuals involved. The specification that a linkage exists implies that communication, but not necessarily a movement of people or goods, will take place between the housing and activity site. In the vocabulary of the transportation engineer, the residential linkage is a "desire line" for communication. The aggregation of the desire lines for all of the individuals in the community represents the process of interaction from the viewpoint of the individuals involved.

The impact of a new transportation facility on a linkage would appear to be a function of the mode of communications being used. Clearly, the impact of a new freeway on mail or telephone service is comparatively minor, as compared to its potential impact on the pedestrian and public and private transportation subsystems. Thus, it could be argued that when estimating community consequences, the empirical determination of linkages should be confined to situations in which a physical transfer of people or goods takes place between activity sites. While data on vehicle trips have been obtained for metropolitan areas throughout the United States, walking trip data are comparatively rare.

To estimate community or social impact, it is useful to determine the importance of the linkage to the individual, although this is difficult since it involves measurement of levels of satisfaction. The importance of a linkage would appear to be related to its substitutability, which may be defined as the facility with which an alternate linkage could be developed.

At least three factors appear relevant in estimating linkage substitutability: the characteristics of the existing linkage pattern, the availability of alternative activity sites, and the characteristics of the household. Important aspects of the existing linkage pattern include the linkage type, the mode of travel, and the frequency of communication. Unless a store serves other than commercial functions, it is comparatively simple to stop shopping at one store and begin shopping at another, but establishing a new linkage at a church or school or with an individual involves considerably more cost. It is hypothesized that the latter linkages are less substitutable and, therefore, more important to the individual. Within each linkage type, importance would appear to be a function of the frequency of interaction and the mode of communications. Although trip rate is important, the considerable variance in travel behavior among households makes a given trip rate, such as 0.25 person trips per day, for an activity site difficult to interpret. A low trip-making household might place considerable importance on this activity site while a high trip-making household might place little or no importance. Linkages involving automobile travel would appear to be intrinsically more flexible and less subject to disruption than linkages involving public transportation or walking. Further, activity opportunities for which public transportation or walking are the principal modes may be extremely limited. Thus, existing activity patterns involving nonautomobile principal modes may be more important than those for which the car is the principal mode.

In defining the availability of alternate activity sites for purposes of estimating linkage substitutability, it is necessary to consider the activity type and its accessibility by each travel mode. Finally, it is important to recognize that linkage substitutability will vary as a function of the people involved and that it is necessary to consider the social characteristics of the group in estimating the social or community consequences of a transportation program. Wachs (18, 19) found some relation between socioeconomic level and perception of the benefits or disbenefits of a nearby freeway. Gans, in discussing recreation facilities adjacent to a densely populated area of low rent housing notes: "most West Enders thought of these facilities as being outside of the area: physically, because they were separated by a busy expressway; and socially, because they had been put there by people from the outside world" (10). These citations illustrate the importance of considering the characteristics of the people involved when evaluating the community consequences of the transportation program.

To this point, the discussion has focused on linkage patterns from the perspective of the housebold terminus. Since each destination point may have a unique identification number, linkages could also be analyzed at the nonhousehold terminus. Destination points generating high levels of activity could be interpreted as major community institutions, whose integrity should be protected when planning public improvements. The assumption underlying this approach is that the dollar value of land may not always be a good proxy for its social value. Some activity sites, such as parks or community meeting halls, may have an intrinsic social importance and for these cases, the activity focused on the site may be a useful measure of social importance. Some form of spatial aggregation appears critical for a complete analysis of community institutions. Further, it may be necessary to have the interaction criterion used to define an institution be a function of the type of activity under consideration. Finally, attention must be devoted not just to the nonhome site, but to the pattern of interaction associated with that site and, in particular, to the spatial and modal characteristics of travel.

Implicit in the residential linkage concept is the observation that the household places considerable value on maintaining a tie to only a portion of the total set of points with which it interacts. During the course of the longitudinal travel survey used in this study, the sample of 35 households visited a total of 1263 destination points ranging from an annual visit to a specialty shop to almost daily travel to a worksite or school. Clearly, considerable differences exist in the importance which households attach to interaction with various activity sites. In order to derive a reliable estimate of community consequences from the analysis of activity patterns, it is necessary to evaluate the relative importance of various activity sites.

One approach to defining differential importance would assign some value to every activity site, letting the weight be a function of the socioeconomic characteristics of the household, the type of activity, and the rate of interaction. Evaluation then implies summing the weighted impacts for all the activity sites of all households, for each alternative. While conceptually seductive, this approach places an unnecessary strain on evaluation procedures which are already both complex and expensive. It is wasteful to devote enormous resources to defining impacts which will not contribute heavily in the summation process. The sample of households had trip rates of less than 0.05 person trips per day for over 60 percent of the activity sites and it is difficult to argue that there is a substantial impact on an activity pattern with such a low rate of interaction. An explicit decision not to consider all activity patterns could lead to the development of more efficient data mechanisms. Finally, considerable methodological difficulties would be encountered in developing the set of weights.

An alternative and more promising approach is based on the assertion that only a segment of the set of activity patterns is of substantive importance to the household. These are defined as residential linkages and analysis may be confined to defining the residential linkages of the households in an area and to estimating a facility's impact on these linkages. This approach is based on an integer assignment procedure: an activity pattern is or is not a linkage. In the next section, a prototypical linkage definition methodology is presented.

MEASURING RESIDENTIAL LINKAGES: A DISCRIMINANT ITERATIONS APPROACH

The objective of this section is to develop a rational procedure to define the set of residential linkages associated with a household. The approach suggested below is viewed as an experimental step necessary to develop an efficient linkage definition methodology. Eventually, it may be desirable to follow an approach which directly isolated the residential linkages and eliminated the intermediate step of defining the complete set of activity sites visited by the household.

The linkage definition methodology has four major steps:

1. A longitudinal travel survey is used to identify the complete set of destination points visited by the household and the characteristics of travel associated with these destination points;
2. The household is asked in a carefully structured interview to identify the set of activity sites which it considers important to be able to interact with and these are a priori defined as its linkages;
3. A discriminant iterations analysis is carried out to identify the criteria underlying the household's choice of certain destination points as linkages; and
4. The discriminant procedures developed in the discriminant iterations analysis are applied directly to the activity patterns defined in longitudinal travel surveys of other households for which attitude data are not available, thus providing a systematic analytical basis to define linkages directly from a longitudinal travel survey without requiring the use of an attitude survey.

Procedures for conducting a longitudinal travel survey and an attitudinal survey have been discussed (11, 18, 23) and the reader is referred to other sources for a discussion of these topics. Two data sets, one defining the household's activity sites or activity vectors and the other specifying its residential linkages, would then be available. Presumedly, some unspecified rationale motivated the household to denote certain activity vectors as linkages and the objective of this discussion is to explore one approach to identify and simulate this rationale.

Members of the family would probably identify linkages using an interconnected set of criteria relating to both the individual activity vector and the household activity pattern. Desirable attributes of a methodology to define linkages from activity vectors would include:

1. Identification of the set of criteria used by the household;
2. Removal of irrational and random choices from the original classification by uniformly applying the criteria to develop a revised classification which is in agreement with the set of identified criteria and the data set; and
3. A capability to apply the defined set of criteria to the activity vectors of households for which survey data on linkage definition is unavailable.

The issue of linkage definition may be viewed as a taxonomic problem. In effect, two sets of activity vectors have been defined. One set contains those activity vectors which the household defined as linkages while the other contains the remaining activity vectors. The objective of the taxonomic analysis is to utilize various measures of: (a) the existing activity and linkage pattern, (b) alternate activity sites, and (c) the socioeconomic characteristics of the household to optimally discriminate between linkage and nonlinkage activity vectors and to classify previously unassigned activity vectors. Several authors have discussed the analytical techniques which may be applied to classification problems of this type (4, 16, 20).

Casetti's technique of discriminant iterations is particularly applicable to the problem at hand. Discriminant procedures may be defined as "a set of rules for allocating a new object to one of the classes of a classification" (2). Discriminant iterations involve the repeated development of discriminant procedures until an optimal classification and optimal discriminant procedures are achieved. A discriminant analysis is performed on a set of data which has been initially classified, for example those activity vectors defined as linkages and those which are not. The discriminant procedures developed are used to determine the probabilities of group membership for each of the data points used to calibrate the function. Some data points may have group membership probabilities which are higher for another group than the one they are in. These points are reassigned to the group for which they have exhibited the highest group membership probability and a new discriminant procedure is developed. The process iterates in this fashion until each data point has its highest probability of group membership for the group to which it was assigned when calibrating the discriminant procedure and this is called the limit or optimal classification.

This approach may be directly applied to the residential linkage identification problem noted previously. Several measures of the characteristics of each activity vector are obtained. The classification of linkage and nonlinkage activity vectors furnished by the household is utilized as input to the first discriminant analysis and discriminant iterations are performed until the limit classification is achieved. Discriminant procedures used to develop the limit classification may then be utilized to classify activity vectors which were not employed in the calibration. Discriminant iterations are particularly applicable to the linkage definition problem because they refine the initial classification used by the household and insure that the set of criteria developed are uniformly applied to each activity vector. In the following sections, the suggested methodology is utilized to define residential linkages using a longitudinal travel survey conducted in Skokie, Illinois.

MEASURING RESIDENTIAL LINKAGES: DATA ACQUISITION AND PREPARATION

During the autumn of 1965 and winter of 1966, a sample of households was asked to prepare travel diaries in which each person in the household recorded all of his trips for a 4-week period. The design of the study and an intensive analysis of the tripmaking characteristics of the respondent households have been reported elsewhere (11).

Household activity and linkage patterns may be extremely complex and involve multielement sets of related trips and considerable care must be exercised in the coding of activity data so that patterns may be identified and analyzed. Three activity patterns for a three person, one car household are shown in Figure 1a. In the morning the wife drives the husband to work, and the child to school, and returns home (pattern 1). In the evening, she reverses the journey, stopping at the supermarket before picking up the child (pattern 2). On weekends, the family goes from church to the domicile of the husband's parents and then returns (pattern 3).

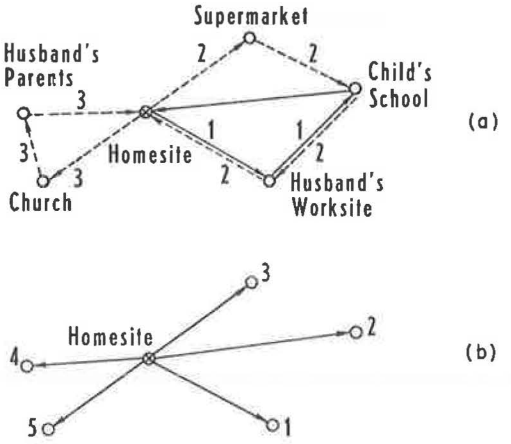

Figure 1. Representation of household activity patterns: (a) the activity pattern, and (b) representation of activity pattern.

Activity patterns are described in this analysis by assigning a vector to each destination point visited by the households, as shown in Figure 1b. The vector for each destination point originates at the homesite and contains elements describing the characteristics of the activity site, such as geographic location and type of activity, and measures describing the household's interaction with that site, such as trip rate, mode and travel time.

Admittedly, the computational flexibility provided by this representation is achieved at the cost of some loss of information on travel between two nonhome activity sites. Vector representation is most appropriate for either two-leg or three-leg activity patterns (patterns 1 and 3 in Fig. 1a), since information would be available on the time required to travel from and/or to the homesite, to and/or from the activity site for these trip sets. This information would not be available for four-leg patterns (pattern 2 in Fig. 1a), since the time required to travel from the homesite to the second destination point (the child's school in pattern 2) would not be available.

Data organization and analysis for the entire study are based on this vector representation of activity patterns. An activity vector is defined by the interaction of a given household with a given activity site and is uniquely identified by a five digit code, two digits to specify the household and the remaining three to denote the activity site. In

TABLE 1

DEFINITION OF ACTIVITY CATEGORIES AND CHARACTERISTICS OF ACTIVITY PATTERNS

Category and Mode	Percent of Total Trips	Percent of Total Destination Points	Trips per Destination Point	Trips per Household	Destination Points per Household
Activity Categories:					
1. Regular, full-time work	16.5	3.7	0.63	0.84	1.34
2. School	11.3	2.5	0.65	0.58	0.89
3. Part-time work, religious	12.1	4.6	0.37	0.62	1.66
4. Shopping	31.8	49.3	0.09	1.62	17.80
5. Passive and participant recreation	6.1	7.4	0.12	0.31	2.66
6. Informal socializing	10.0	11.7	0.12	0.51	4.22
7. Restaurants	7.4	10.5	0.10	0.38	3.77
8. Community activities and formal socializing and other	4.8	10.4	0.07	0.24	3.74
Principal Mode:					
Car	79.4	86.8	0.13	4.06	31.34
Public transportation	10.7	4.0	0.37	0.53	1.46
Walk and other	9.9	9.2	0.15	0.50	3.29

addition to the identification number, elements of the activity vector include the activity type, the daily person trip rate, the weekend day trip rate, the mode or modes used, and the distance, time, and speed required for a trip from the homesite to the destination point.

MEASURING RESIDENTIAL LINKAGES: RESULTS AND ANALYSIS

For the purposes of this study, a set of 35 travel diaries containing high-quality travel data for the longest time period was selected. All of the characteristics of each activity vector for each of the 35 households were measured and the results are given in Table 1. Various multivariate grouping techniques were used to develop the set of eight activity types.

Following the development of two data sets, the set of activity vectors and the set of activity vectors defined as linkages, a discriminant iterations analysis is used to identify the linkage definition criteria used by the household, to remove irrational and random choices, and to develop a set of procedures for defining linkages solely from activity patterns. It was suggested above that the initial classification of linkage and nonlinkage activity vectors should be determined by interviewing the households from which the activity data were gathered. Unfortunately, constraints on the resources available for this study rendered such an approach infeasible. Seven households were randomly selected from the 35 for which activity data had been coded and the 278 activity vectors associated with these households were individually examined to determine if they should be defined as linkages. Several criteria, of which the most important were

TABLE 2

VARIABLES USED IN DISCRIMINANT ITERATIONS ANALYSIS

Variable Number	Mnemonic	Interpretation
1	DAYDAT	Length of surveillance period for the household with activity vector
2	WORK	Dummy variable for work purpose
3	SCHOOL	Dummy variable for school purpose
4	CHURCH	Dummy variable for religious purpose
5	SHOP	Dummy variable for shopping purpose
6	P/PREC	Dummy variable for passive or participant recreation purpose
7	INFSOC	Dummy variable for informal social purpose
8	REST	Dummy variable for restaurant and related activities purpose
9	FORSOC	Dummy variable for formal social and community purposes
10	TTRATE	Daily person trip rate
11	WKRATE	Daily person trip rate for weekend trips
12	PCCAR	Percent of the trips which were by car when this was the most popular mode
13	PCPUPT	Percent of the trips which were by public transportation when this was the most popular mode
14	PCWALK	Percent of the trips which were by other than car or public transportation when this was the most popular mode
15	PCWKTR	Percent of the total trips which were made on weekend days
16	DIST	Distance from the homesite to the activity site
17	SPEED	Average speed of travel from the homesite to the activity site
18	PCTPUR	The ratio of the trip rate for this activity vector over the trip rate for all of the household's activity vectors in this purpose category
19	DPTPUR	The ratio of one over the total number of activity vectors of the household for this purpose category
20	CAR	Dummy variable for car being the principal mode
21	PUBTR	Dummy variable for public transportation being the principal mode
22	WALK	Dummy variable for mode other than car or public transportation being the principal mode
23	AVTIME	Average time in minutes for travel from homesite to activity site
24	TTRPUR	Total trips by the household for this activity purpose

activity purpose, trip rate, principal mode, and total household travel, were employed to make the initial classification. These criteria were not precisely specified and no attempt was made to uniformly apply the set of criteria to all households. Therefore, the discriminant procedures developed to define a residential linkage represent the value set of the authors and not the value set of the households, and for this reason this analysis should be viewed as only an illustrative application of discriminant iterations methodology to the linkage definition problem.

In spite of this reservation, it is useful to consider the results of the discriminant iteration analysis and to examine the set of residential linkages which was developed. While the initial classification used may not be identical to the one which the households would specify, considerable overlap would exist since households would probably use many of the criteria employed by the writers. Although the numerical results of this work are partially invalid, it is useful to illustrate the types of analysis and output which can be developed. A total of 95 out of 278 activity vectors, or 34 percent, were initially defined as linkages.

Twenty-four measures, defined in Table 2, were used to specify the characteristics of each activity vector for the experimental discriminant iteration analysis. Eight dummy variables were employed to represent the eight activity purpose categories (Table 1). Three dummy variables were used to represent choice among the automobile, public transportation, and other modes. Kendall notes that, although discrimination problems often arise in which dummy variables are employed, "the method is rather rough" (14). In view of the relatively large number of variables employed in the analysis, this problem is somewhat less serious than might first appear.

Results of the discriminant iterations are given in Table 3, which contains scaled vectors which show the relative contribution of each variable to the discriminant function and the location of the group centroids. The signs and relative importance of coefficients for variables in a discriminant function are interpretable. Throughout the analysis, the centroid for points defined as linkages was negative and the centroid for nonlinkage points was positive. Variables with a negative coefficient therefore contribute to defining a point as a linkage, while variables with a positive coefficient have the opposite effect.

Only four variables, SHOP, REST, TTRATE, and PCWALK, entered the discriminant function in the first iteration. The larger the trip rate and the larger the proportion of walking trips, the greater the probability that a given activity vector would be defined as a linkage. All activity categories, except shopping and restaurants, etc., were of equal importance. Activity sites in these two categories are more substitutable, and there should be some bias against defining vectors with these purposes as linkages. These results

TABLE 3

SCALED DISCRIMINANT VECTOR AND GROUP CENTROIDS FOR EACH ITERATION

		1	2	3	4	5	6
1	DAYDAT	----	0.39	0.48	----	----	----
2	WORK	----	-1.24	-1.15	-1.64	-1.66	-1.66
3	SCHOOL	----	----	----	-1.26	-1.32	-1.32
4	CHURCH	----	-0.50	-0.54	-1.55	-1.53	-1.54
5	SHOP	1.95	1.94	2.91	0.18	0.03	----
6	P/PREC	----	-0.37	0.61	----	0.01	----
7	INFSOC	----	----	1.36	----	----	----
8	REST	1.07	1.35	1.88	----	----	----
9	FORSOC	----	----	1.75	0.11	0.04	----
10	TTRATE	-3.35	-2.09	-1.48	0.11	0.22	0.22
11	WKRATE	----	----	----	-0.66	-0.91	-0.92
12	PCCAR	----	----	----	----	----	----
13	PCPUBT	----	----	----	----	----	----
14	PCWALK	-0.89	----	-2.86	-2.63	-2.43	-2.39
15	PCWKTR	----	----	-0.17	-0.16	0.06	-0.05
16	DIST	----	----	----	0.06	----	----
17	SPEED	----	----	----	-0.03	----	0.03
18	PCTPUR	----	----	----	----	----	----
19	DPTPUR	----	----	----	----	----	----
20	CAR	----	----	-0.03	0.16	0.15	0.15
21	PUBTR	----	----	----	----	----	----
22	WALK	----	-1.81	0.43	0.83	0.67	0.64
23	AVTIME	----	----	----	----	----	----
24	TTRPUR	----	----	----	----	----	----
	Centroid for points defined as linkage	-0.22	-0.42	-0.38	-0.53	-0.52	-0.51
	Centroid for nonlinkage points	0.11	0.22	0.40	0.06	0.04	0.04

represent an accurate quantitative mapping of the qualitative criteria used to establish the initial classification. The manner in which these criteria were refined and the underlying criteria established through the discriminant iterations analysis is illustrated by examining the discriminant vector for the sixth iteration.

Ten variables entered the discriminant function calibrated in the sixth iteration. The relationship of activity purpose and trip rate to linkage definition was reversed during the iterations. As noted, trip rate was the most important variable influencing linkage definition in the first iteration, but its impact on shopping or restaurant activity vectors was reduced by the appearance with opposite signs of the dummy variables for these categories. The influence of dummy variables for work, school, and church on the final discriminant function is to cause the vector to be defined as a linkage. The coefficient for the trip rate in this iteration has the opposite effect. Since many shopping trips have a high trip rate, the effect of these four variables is to discriminante between work, school, and church vectors with a high trip rate and shopping vectors with a high trip rate.

Other variables entered the discriminant function in a logical manner. A high weekend trip rate helped vectors to be defined as linkages. The automobile is a more flexible mode of travel than public transportation or walking. Hence, activity sites for which the principal mode of travel is by car are inherently less important to the household. Therefore, the coefficient associated with principal mode car (CAR) has an appropriate positive sign.

Discriminant procedures developed in the sixth iteration were applied to the 985 activity vectors of the 28 households which were not included in the discriminant iterations analysis. Linkage patterns for the sample of 35 households were tabulated in the same format used to tabulate activity patterns, and the two patterns are compared in Table 4. Only 7.5 out of the 36.2 destination points visited by the average household during its surveillance period were chosen as linkages. This 79 percent reduction in number of activity vectors resulted in only a 51 percent reduction in daily person trips.

TABLE 4

COMPARISON OF ACTIVITY AND LINKAGE PATTERNS

	Total Trip Rate—Linkages / Total Trip Rate—All Destination Points	No. of Linkages / No. of Destination Points
Activity Type:		
1. Work	0.99	0.98
2. School	1.00	1.00
3. Religious, part-time work	0.98	0.98
4. Shopping	0.12	0.11
5. Recreation	0.18	0.09
6. Informal socializing	0.26	0.18
7. Restaurants	0.16	0.14
8. Community activities and formal socializing	0.07	0.07
Total all activity types	0.49	0.21
Principal Mode:		
Car	0.38	0.11
Public transportation	0.84	0.55
Walk and other	1.00	1.00

	Activity Patterns (Units = Destination Points)	Linkage Patterns (Units = Linkages)
Total trip rate-unit/household	5.09	2.48
Units/household	36.2	7.5
Total trip rate/unit	.14	.33

An average of 0.33 trips per day are made to each linkage as compared to only 0.14 daily trips to each destination point. Interaction with activity sites defined as linkages is considerably more intensive than interaction with the average destination point.

EVALUATION

The analyses presented here have achieved a qualified success in exploring the use of longitudinal travel and attitudinal data to define residential linkages. The assertion made in a previous paper (6) that residential linkages may be defined empirically has been substantiated. Further, the analytical methodology developed in that paper has been applied successfully to an operational situation.

The success of the analyses is limited, however, in global terms by the quality of the available data. The available sample of 35 households is clearly far too small and too concentrated geographically to permit the development of significant inferences concerning the total population of households in the Chicago metropolitan area. The discriminant iterations analysis of linkage definition was based solely on measures of activity; the quality and content of the data precluded inclusion of household characteristic measures and/or measures of the availability of alternative activity sites. Further, the initial classification for the discriminant iterations was established arbitrarily by the writers, rather than by the households whose behavior was observed.

Further tests of the methodology should desirably be made for a larger, more spatially diffuse sample of households. Additional attention should also be directed to three other interrelated areas: (a) development of a more efficient data collection mechanism; (b) initiation of a continuing program to evaluate the social consequences of urban transportation investment under conditions of at least partial experimental control; and (c) formulation and validation of a set of "social consequence" models based on the evaluation program outlined above.

An average of 26 days of travel data was analyzed for each of the sample households in this study. The cost of obtaining and coding these data was relatively high—approximately $5 per household per day. The total cost of obtaining equivalent data for a sample of the size required for a fully operational study would clearly be extremely high, unless significant modifications were made in the data acquisition and coding process.

Although the topic is not addressed here, it is feasible to consider developing linkage patterns from cross-sectional travel data, provided information is available on walking trips. One relatively inexpensive way of collecting the necessary data, therefore, would be the acquisition of home-based walking trip data during the home interview travel survey conducted by all major transportation studies. Alternatively, one of the authors has for some time belabored the notion that the analysis of urban travel demand should be based at least partially on longitudinal rather than purely cross-sectional data. If such data were acquired as part of the urban transportation planning process, the marginal cost of utilizing this information to estimate activity and linkage patterns would clearly be small. A variety of sampling devices have been proposed (24), including shortening the time duration of the longitudinal sample, the use of monitored recall data and the use of partial and full overlap designs, which would cut costs considerably. Some of these techniques have been tested empirically in a recent study in Chicago (25).

Once an efficient data acquisition technique has been identified, a range of continuing experiments may be readily conceived to test the social consequences of specific transportation projects. These experiments may be structured to examine specifically the sensitivity of household activity patterns to changes in the transportation system and in other public investment programs. Such experiments may also have a larger objective.

At present, planners do not have a realistic basis for assigning any normative content to changes in the activity patterns of different groups. If a relationship could be established, on the basis of continuing, controlled observation between activity perturbation and measures having an obvious normative content (e.g., health and pathological behavior) a normative information base may be brought at least a step nearer. Limited studies of this type have been conducted to investigate the consequences of rehousing families in Boston (8, 9) and Baltimore (21, 22).

Finally, we may remark that any realistic consideration of social impact within the transportation planning process, requires an ability to forecast the consequences of alternative transportation programs on a very broad base. This suggests a need, albeit a very ambitious one, for predictive models which are sensitive to the differential effects of alternative programs, their incidence on different population groups, and their staging over time. This paper represents a rather faltering step toward such a goal.

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Discussion

FLOYD I. THIEL, Federal Highway Administration—Many readers will no doubt agree with this paper's recognition of some of the shortcomings of earlier efforts to analyze social and economic effects of highways. But for readers who are not familiar with the community impact literature, which the authors indicate they have reviewed, the references to this literature in the paper may provide an inaccurate understanding. For example, it is stated that "Two measures of the outcome of the impact process, property value and mobility, are being examined but they do not provide insight into the impact process. . . . " This statement seems unclear for at least two reasons.

First, such measures as property value and mobility can surely provide some insight about community impact. Many of the researchers at MIT, Harvard University, Texas A&M University, George Washington University, Pennsylvania State University, University of Washington, University of Connecticut, University of Illinois, and elsewhere who have included land value analysis in their studies of highway effects would undoubtedly maintain that land value analysis can help provide insight; such analyses were especially useful during the period when today's study techniques and financial and management support were not available. To gain such insight, these researchers have analyzed land values to discern:

1. Undesirable highway effects (which might not be reflected in some other measures);
2. How parkway effects differed from effects along other highways;

3. The rate of mortgage foreclosures for highway affected property;
4. Whether and how highway beautification measures affect property owners;
5. Resale rates and values for highway affected property, etc.

Second, land values and mobility are by no means the only measures that have been examined in impact studies. Other measures of impact which the paper seems to ignore include:

1. Commuting patterns;
2. Participation rates in school, church, clubs and other organizations, recreation, etc.;
3. Attitudes of those affected (including attitude change differentials between citizens and community leaders);
4. Land use changes;
5. Living accommodations and mortgage indebtedness for relocated families;
6. Shopping patterns;
7. Land development patterns;
8. Business starts and stops;
9. Public service effects; and
10. Availability of mobile and drive-in products and services.

The authors refer to the problem of estimating social impact using "number of trees or historic monuments." They state "If the park in which the trees are located is not visited, there would appear to be little justification in defining 'preservation of trees' as a social consequence."

Earlier, the authors referred to social and environmental impact, which seems to suggest that effects of a general nature are being considered. Trees or monuments surely do not equal social consequences, as the authors suggest. But the quotation suggests that a social consequence occurs only if the place (e. g., the park) is physically visited. Surely the authors do not maintain that parks (or museums, schools, churches, etc.) have no social consequences for those who do not visit these facilities. Perhaps these effects are regarded as environmental and outside the residential linkage concept of the paper.

"The automobile is a more flexible mode of travel than public transportation or walking. Hence, activity sites for which the principal mode of travel is by car are inherently less important to the household."

Except that walking is pretty flexible (at least as far as time and routing are concerned), the first sentence seems to be so. But the second sentence appears to have so many exceptions one wonders whether the general statement is so or whether it is being misunderstood. For example, several activity sites for which the principal mode of travel is by car seem inherently more important to households (e. g., trips for hospital, doctor, wedding, or funeral purposes) than some trips by public transportation or walking (e. g., recreational trips within walking distance or that are accessible by mass transit). Emergency trips aside, the second sentence may be generally correct. The auto is the principal mode for both recreation and the journey to work, but more so for the former than the latter. And the recreation trip is probably inherently less important to the household than the work trip. Perhaps (as a colleague of mine, G. Broderick, notes), the authors' statement can be taken as an hypothesis should be recast to suggest that the more important a trip is to a hosehold the more likely it is that alternative means to make the trip will exist.

Some of the questions raised here should cause a reader to wonder whether he has understood what preceded the portion questioned. I have wondered about this and admit that the questions raised may result from my failure to understand portions of the paper in the context of the whole paper. Even so, it may be that understanding for other readers would also be increased if the authors could clarify some of the matters referred to above.

R. H. ELLIS and R. D. WORRALL, Closure—The authors would like to thank Mr. Thiel for his remarks, and to briefly reply to three of the points which he raises in his discussion. Our comments will focus on (a) the existing body of highway impact literature, (b) the use of visitation frequency as a value measure in analyzing community impact, and (c) the relative sensitivity of automobile and nonautomobile linkages to severance by highway construction.

Limitations of space in the original paper precluded a thorough discussion of the extensive and somewhat diffuse literature of community impact. Our collection of references simply represented those which we considered most germane to the theme of the paper, namely, the use of household activity analysis as a mechanism for estimating one dimension of community impact. We certainly agree with Mr. Thiel that "such measures as property value and mobility can surely provide some insight about community impact" and that "such analyses were especially useful during the period when today's study techniques were not available." Our differences, if any, are essentially ones of degree. We believe that the large majority of existing impact studies, although they include a broader range of measures than we may have implied in our comments, and although they served a useful purpose at the time the studies were conducted, are essentially too coarse to be fully responsive to some of the important questions which are currently being raised concerning the location and design of urban freeways. The objective of our research was simply to propose one, and only one, method of analysis which might add something to our total analytical ability in this area. We did not intend to imply that our work was a substitute for all previous studies, but rather that it represents a useful complement.

A comment by Horwood (13) is perhaps relevant here. He divides the existing impact literature into three broad classes: "by-pass studies," "urban circumferential studies," and "urban radial freeway studies"—our work being most closely related to the third of these categories. He then comments that the principal variables investigated in the "classic" radial freeway impact studies (26, 27, 28, 29) have been land value and land use, and remarks: "The radial corridor studies known about appear to have three distinct shortcomings—the use of assessed valuation as a criterion, the bias of the sample of land values, and the nature of the control areas" (13).

Elsewhere one of the authors (7) has suggested that the "transportation impact process" has been generally viewed as a "black box." Measures such as land value have been used as surrogates for the wide range of transportation impacts on the quality of the traversed environment. It is our hypothesis that, in order to treat the question of community consequences meaningfully, it is necessary to understand the details of the social impact of highway investment more clearly and to treat these details directly within the evaluation model. This cannot be achieved through the use of systemic black box analysis. This theme has been developed by both of the authors in some detail elsewhere (7, 11), the latter reference dealing explicitly with questions of sample design, and the monitoring of highway impact as a continuous process.

Mr. Thiel took some exception to our simple paradigm concerning trees or parks which may or may not be visited by the residents of the community. Our example was perhaps unfortunately phrased. The point which we wished to make was simply that considerable insight may be gained into the potential impact of a new road or transit line on the region through which it passes by viewing community structure in terms of a set of "activity linkages." The value to the community of a given facility or institution such as a park, school, church, or museum may be measured at least in part by its use, although this does not imply that the facility be used by all residents of the community. It is not unreasonable to argue that facilities which are used frequently are of perhaps slightly greater value to the community as a whole than those facilities which are used infrequently.

Perhaps the paper should have more strongly emphasized our distinction between the importance of an activity, such as work or recreation, and the importance of that activity taking place at a given geographic location. Earlier in this paper, we suggest that the importance of a linkage would appear to be related to its substitutability, which may be defined as the facility with which an alternative linkage could be developed. In this sense, one may argue that as linkages involving walking as the travel mode necessarily cover a smaller area, and hence are likely to have a relatively smaller "opportunity space" of alternative destination points than those involving the auto mode, they are also likely to be less substitutable and hence potentially more important than the latter. Further, there would appear to be considerable validity to the basic assumption underlying this argument, namely that the disadvantaged, young, and old residents of our central cities cannot substitute an automobile trip for a walking trip simply because they do not have a car available to them.

Mode of interaction is only one of a number of variables suggested in the paper as a surrogate for the importance of a linkage and the consequences of its severance for the community Additional measures, not all of which were discussed in the paper, include the frequency of visitation, the number of different destination points visited by a household for the same activity, the total number of opportunities for performing a given activity within a particular distance of the household's location, and the existing use of more than one mode of travel for a given activity/linkage type. This methodology was used with some success by one of the authors in a study of probable household impact of the Chicago Crosstown Expressway. This study suggested strongly that the concept of residential linkages as an empirical device for implementing the concept of household activity analysis provides a valuable additional analytical tool to the urban highway designer (30). Again, it should be emphasized that this analysis was not designed to replace all other techniques of highway impact analysis, but rather to serve as a useful supplement to a wide range of detailed studies of land acquisition costs, traffic patterns, land value analysis, retail trade and market area structure, employment patterns, etc.

In closing, we would like to thank Mr. Thiel for his comments and hope that our remarks may lead to a clearer understanding of the paper.

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Accessibility and Environmental Quality

V. SETTY PENDAKUR and G. R. BROWN, University of British Columbia, Canada

ABRIDGMENT

•THE adverse effects of motor vehicles on the quality of community life have become a matter of serious concern. The efficiency of the automobile, combined with its flexibility for personal travel, has produced a conflict in which the high level of accessibility desired by the motorist tends to contradict the social objectives of a safe, attractive, urban environment. Traffic planning objectives can be diametrically opposed to those of maintaining a high standard of environmental quality. The planning process must transcend these diverging objectives and rationalize the trade-offs between them.

In this study a system framework is developed that portrays the components of the conflict, and in which environmental quality is represented by factors relating to pedestrian movements, and accessibility by those relating to automobile movement. Elements that serve to measure pedestrian safety, comfort, convenience, and visual sensation are compared with those measuring motor vehicle driver safety, convenience, penetration, and visual harmony. Of those elements that interact, some are conflicting, while others are mutually supporting. The former group requires an evaluative procedure to select the optimum mix of intensity of interaction, whereas the latter group requires only that sufficient funds are available for improvement.

To test the framework, a pilot study was made of a ribbon-type commercial district. Pedestrians were interviewed to determine their perception of the shopping environment in the role of pedestrian. The respondent scored each accessibility and quality item on two scales. The results of 88 interviews showed that almost 50 percent of those interviewed thought environmental quality was "satisfactory," while the rating for accessibility was almost equally divided between those who thought it was "good" (28 percent), and those who thought it was "poor" (30 percent).

Two conclusions emerged from this study: (a) that it is possible to measure the environmental quality-accessibility conflict by attitude survey, and (b) that people are more consciously aware of problems of accessibility than those of environmental quality. Further research is needed to substantiate these hypotheses.

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Maryland Capital Beltway Impact Study

MERWIN SHURBERG and F. JOHN DEVANEY, Wilbur Smith and Associates

ABRIDGMENT

•THE Maryland Capital Beltway Impact Study was prepared for the Maryland State Roads Commission in cooperation with the U. S. Department of Commerce, Bureau of Public Roads. It is an investigation of Interstate 495, the Capital Beltway, in Montgomery and Prince Georges counties in Maryland. These two counties, are part of the rapidly growing Washington D. C. metropolitan area.

The study was designed to determine initial impact, project impact to 1976, and to develop procedures to measure future impact on land use, traffic, and the local economy. All aspects of potential impact were investigated. Techniques developed in other studies throughout the United States were applied and modified where appropriate. Methodological innovations were developed and follow-up studies suggested to test and refine the procedures followed.

The first phase of the study involved the investigation of specific factors to explain the Beltway's influence on land use and traffic. Such factors included shopping trip length frequencies to existing shopping centers, work trip length frequencies to existing places of work, characteristics of goods movement in the Washington area, and criteria which influenced the location of production, distribution, and research establishments in suburban Washington. Coded street networks were developed for use in assigning current and future traffic with and without the Beltway and to calculate indices of accessibility by traffic zone. Time-series data on population, employment, land use, accessibility, income, utilities, and other variables were then tabulated by traffic zone and were analyzed statistically to determine the allocation of future land use with and without the Beltway. Available data on the economy of the Washington metropolitan area, including its Maryland segment, were also analyzed to determine the relative importance of various industry groups to the economy of the Washington area and the Maryland study area.

Finally, recommendations were developed on methodology to compare projections of traffic and land use with actual developments. This continuing program is designed to strengthen research aspects and is one of the principal objectives of the study, namely to advance the science of estimating the comprehensive impact of proposed highways.

The impact study found that the primary contribution of the Beltway has been to increase the accessibility of all parts of the Washington metropolitan area, including the Maryland counties, to all other parts. In accomplishing this, the Beltway has served to weld the suburban counties and the entire Washington area into a more viable whole. This has had varying degrees of impact on virtually all elements of the community.

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