Economic Aspects of Urban Passenger Transportation

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•FOR several years the public has expressed concern over the problem of urban transportation (1). Although it is not clear what the problem is, or whether, indeed, there is one, some symptoms can be identified: public transit is losing riders and farebox revenue fails to cover system costs; businesses in the central business districts are losing customers; in some places traffic congestion at the least appears to be growing worse, particularly at peak hours (2); parking appears to be inadequate; population and employment in the central city decline as people and jobs move to the suburbs; and the poor and unemployed left behind in the central cities need costly social and economic support, but those who can pay for these programs have moved out. These symptoms reflect a host of problems and no doubt some of them are conditioned by the nature of the transportation system. Although it is reasonable to seek improvement in the system, it is misleading to postulate an "urban crisis" that can be defined simply in terms of transportation.

Under the pressure of public concern, major planning programs have often taken too narrow a view. They have treated transportation as if it were an isolated problem unrelated to the broader question of how members of the community are to provide themselves with the goods and services that improve the quality of their lives. The demand for transportation is a derived demand. People seldom make a trip for its own sake, but rather to satisfy some want or to earn an income. Although nearly all responsible planners, researchers, and community leaders are aware of this fact, its importance for planning requires detailed attention.

Residential locations have become more decentralized with the movement of households to the suburbs. Similar changes in work, shopping, service, and recreation have occurred. Some would argue that the automobile has caused this decentralization, but it is more likely that in the absence of a highly developed, ubiquitous public transportation system, the automobile has allowed, rather than caused, the migration. It makes living and working in remote locations possible.

The automobile, however, is a relatively expensive means of travel. In planning and evaluating transportation systems it is important to recognize that the outward movement to the suburbs has taken place in spite of a very high money cost, at least for transportation. To an economist, this implies that the consumer finds compensation elsewhere. Where public transit is an alternative, use of the automobile may be compensated by the better service afforded and, where transit is not available, by the open space, privacy, clean air, quiet, better schools, or safety of suburban life.

The dispersion of homes and employers has made the collection and distribution tasks of public transportation systems particularly difficult to accomplish with existing technologies and organization. It would appear that the very substantial decline in public transit usage may be attributed, at least in part, to the failure of transit systems to adapt to decentralization. In effect, this failure can be regarded as an implicit reduction in the average quality of service available to potential trip-makers. The result has often been financial difficulty for public transit leading, in many cases, to further explicit reductions in service. Thus the problem is compounded by making automobile travel even more attractive.

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There is evidence that these trends will become even more pronounced in the future as populations grow, incomes rise, and more leisure time expands (3). The resulting diminution in transit service will make it more difficult to provide for groups with special public transportation requirements. But unfortunately, there is evidence that along with this growth we will still have substantial numbers of poor, handicapped, young and aged, each with their special needs. These groups will not be able to participate fully in our modern society unless some provision is made for their transportation. Careful attention to their specific needs will make it possible to design transportation systems offering appropriate levels of service at prices they are willing to pay.

In the past, nearly all wants could be satisfied in a relatively small area centrally located in the city. Public mass transportation could move large numbers of people efficiently because residential areas were dense and activities were centralized. With the new, lower densities of our metropolitan areas, the transportation technologies developed in the past have become obsolete.

It is important to consider the tools available for solving the urban transportation problem, i. e., the problem of making it possible for people living in modern urban society to gratify their desires. Three basic tools appear appropriate: (a) changes in the physical transportation system (e. g., in vehicles or roadways), (b) changes in the organization of existing technologies to improve the service qualities offered and, perhaps most important, (c) changes in the location and organization of economic activity. The evaluation of the usefulness of these tools requires that we first understand the transportation system available today and observe the reactions of trip-makers to its characteristics.

THE TECHNOLOGICAL TOOLS

Automobiles

The automobile is in many respects ideal. For most door-to-door travel, it is more convenient than any other form of transportation as well as being small, comfortable, and private. Furthermore, the automobile can carry freight—a particularly important feature for shopping trips. Under favorable conditions, the driver is not constrained by schedules and can operate independently of others. For all intents and purposes, the service is totally responsive to the driver's individual demand. Under conditions of severe congestion he may not be so free to act.

Although the driver must (or should) be almost totally occupied with the tasks of driving, he may listen to the radio, smoke without disturbing others, or talk privately with other passengers. Auto passengers, of course, are free to occupy themselves more productively although probably not as easily as on a high-quality commuter railroad.

The automobile requires an extensive roadway system; but the system is also required for truck freight, public bus movements, and utilities; the roadway is multipurpose. Nevertheless, the roadway systems in our major urban areas are often inadequate to provide relatively unimpeded service. This inadequacy is frequently compounded by their use for parking and unloading freight.

Car ownership has become general throughout the United States with the steady rise in personal incomes. Since the decline in residential and employment densities, two-car households have become commonplace. Often one automobile is almost exclusively devoted to commuting trips.

Along with the benefits of good service, the automobile has contributed to the problems of air pollution, land consumption, and the preservation of the aesthetic qualities of urban areas, particularly in the older sections of our cities. Congestion delays are frequent and parking is often inadequate. Where the road is shared with buses, the increased congestion has had an impact on the quality of public transportation service.

Railroad and Rail Rapid Transit

Those who live and work close to rapid transit or commuter railroads can obtain excellent service downtown for very low fares (but perhaps not so low costs). The

vehicle is large making standing, entry, and exit easy for the passenger; and wide, comfortable seating can be provided. There are disadvantages, too, because the exclusive right-of-way is totally unadaptable to changes in the geographic distribution of residential and economic activity, or to changing distributions of trips. This inflexibility makes it necessary for trip-makers who wish to use the facility, and who live or work in new areas distant from the transit line, to ride or walk to the station. Often, where jobs or residences have moved, the existing transit system may no longer provide a desired service.

Urban rail transit is expensive as well as inflexible. Low passenger fares cannot be maintained unless the system is employed at or near full capacity. This means that urban rail transit is economically viable chiefly in areas of high residential and employment density. And only where customers are plentiful can it come close to providing reasonable door-to-door service. In most systems, however, service is generally poor. Passengers are obliged to walk, climb stairs, transfer, and wait until the public transit schedule happens to coincide with their own.

Bus and Other Public Highway Systems

Public transportation systems using only public streets and highways have the flexibility of the automobile but suffer the same impediments to travel. The nature of the roadway and the size of the vehicle provide the essential ingredients for a close approximation to door-to-door service (although few systems attempt to provide it). The smaller size of the bus, however, makes seating less comfortable than in railroad cars. Although in comparison with rail systems the costs of bus service are relatively high per available seat mile, buses may be more efficient for travel in areas of moderate or low density. Under the present organization, bus travel often requires transfers and significant waiting time. Bus system reliability is highly sensitive to weather conditions, particularly ice and snow. (Although it is potentially possible to provide rail service that overcomes some of the sensitivity to weather, as a practical matter it has not been achieved with the principal commuter services in our major cities.)

Taxi service, like the automobile, provides door-to-door service anywhere but without the burden of driving; the disadvantage of having to wait for a taxi compared with private auto travel is compensated for, in part, by the elimination of delays and walking required in parking. The passenger must, however, pay handsomely for this level of service.

Jitney service is not now provided in most urban areas, but is worthy of consideration since it can be operated much like a taxi but at a somewhat lower cost. Even then its costs are higher than those for bus operations, but the improved service may make it worth much more to the passenger. Either door-to-door or near door-to-door service can be achieved and because the vehicle can accommodate only a few passengers, significant delays to the trip-maker owing to picking up other passengers are reduced.

POSSIBLE NEW TECHNOLOGIES AS TOOLS FOR TRANSPORTATION SYSTEM IMPROVEMENT

Many new technologies have been suggested for mass transportation, but these often focus on line-haul trip characteristics and ignore the problems of collecting and distributing passengers. These systems are intended to provide increased comfort, speed, and greater aesthetic quality to our urban environment. If analyzed in terms of the service characteristics of door-to-door travel, most of the systems that provide these other qualities appear to be very much like existing rail rapid transit. One concept, however, appears to be a notable exception.

Perhaps the most interesting technological concept is the dual-mode vehicle—i. e., a vehicle capable of operating as a private automobile in fulfilling the collection and distribution functions in low-density areas, and operating as part of a high-speed train for the arterial links of the trip. One suggestion is to have a self-powered vehicle that can operate normally on city streets and would be used to take a trip-maker from his door to an exclusive, grade-separated guideway where the vehicle would be automatically controlled to become part of a high-speed train. Although the system requires a

separate roadway that cannot be shared with other vehicles, it meets the door-to-door service requirement and the need for high-speed mass movement over the major network links.

The system would be much improved, however, if the mass movement mode could be accomplished on existing roadways. Perhaps median strips or separate lanes could be converted for this use. Maximum exploitation of the facilities already available would obviate the need for new rights-of-way and thus limit the investment required. Of course, in addition to the technical problems that remain to be solved, the economics and regulation of the system must be thoroughly explored before such an innovation is adopted.

Past emphasis on public mass transportation has been on costs per capacity unit. It is not at all clear that low-cost transportation per se is the answer. As indicated earlier, current mass transportation travelers, automobile riders, pay a very high price to obtain a high level of service. Although costs cannot be ignored, solutions must give consideration to the characteristics of service provided; it may well be necessary to charge much higher fares, but these might be gladly paid if the service warranted them. Here a significant problem arises: we have little or no information on the values trip-makers place on service characteristics. Without this information the design of new solutions is virtually impossible.

We do not know how travelers value their time. We do not know if, for example, they find the time getting to and from transit terminals, or waiting and transferring, more or less onerous than equivalent amounts of time spent in the vehicle. There is some evidence that reductions in these excess times evoke greater traveler response than do similar reductions in the in-vehicle time (4). If it should become the aim of public policy to design systems that lure trip-makers away from the automobile, then we must look carefully at the travel qualities of the automobile and attempt to provide competitive qualities in our public systems.

ORGANIZATIONAL CHANGE AS TOOL FOR IMPROVING TRANSPORTATION

Progress toward improved service may not require technological change. A significant step forward may be possible if we take an entirely new look at our existing systems. Routes and schedules are largely an outgrowth of patterns developed during a different era of urban living. Perhaps if we consider abandoning them and starting over again, we can design a system without any additional cost, but one that will provide greatly improved service. It is often difficult or impossible with today's systems to get people from their homes to present locations of jobs. The transportation problem of the ghetto resident is probably not so much high transit fares as the near impossibility of traveling to distant jobs without extreme discomfort and sacrifice of time. The present growth in job opportunities for workers from the ghetto is in the suburban and fringe area rather than in the CBD. Public transit to these outer areas is often nonexistent; where service is provided from the ghetto areas, it is generally poor, requiring multiple transfers, long waits at stops unprotected from inclement weather, and long walks to the place of work from the transit stop.

It is often argued that public transportation must be provided to take care of the aged, the handicapped, or those who either have no car or are too young to drive. There is no particular reason to require it to do so. A system requiring the passenger to step up to board a bus, or to climb stairs to reach a subway platform, will be of little or no use to the feeble or handicapped. Separate, special systems might be provided for these groups, at relatively low cost, without seriously compromising mass transportation needs. Low-fare taxi or jitney service may be the most appropriate mode for accommodating this rather small fraction of our population.

Another pressing problem in most central cities is the reduction of taxable property through land takings for transportation roadways. (The mere reduction in the total land available for building may not destroy taxable property value. Depending on the elasticity of demand for land, the value of remaining land may increase by an amount that more than compensates for the lost land.) To avoid congestion while maintaining a suit-

able tax base there has even been talk of keeping the automobile out of the CBD. Such action, in failing to recognize urban society's transportation demands realistically, might very well restrict the use of the city to those few having access to good public transit and might well be the death knell of the city. It is surprising that other solutions have not been more extensively explored and implemented. In particular, much more attention should be given to the use of air rights over the major roads of the CBD; air rights can be used for buildings or for pedestrian malls that would separate people from vehicular traffic, and so improve the flows through the CBD. Other advantages would also accrue such as keeping the often expensive results of inclement weather from interfering with the flow of traffic in these highly congested areas. It would seem that the use of air rights could make large areas available for transportation without significantly adding either to the cost of building or to any deterioration of an already troublesome tax base.

Simple methods of increasing roadway capacity should not be neglected. Substitution of off-street for curbside parking would seem to be an essential consideration before engaging in major new roadway construction. Elimination of curbside parking may cost less than the construction of a new road, even when land acquisition and construction costs seem reasonable. For in addition to these costs, a new road disrupts traffic during construction and does little to relieve the congestion and hazards caused by curbside parking.

Other low-cost improvements that should be considered are more elaborate signalization systems, effective use of one-way streets, and better control of pedestrian traffic. Rather than use major new road construction as a panacea for increasing roadway capacity, all other techniques at our disposal should be thoroughly explored. Often, external incentives distort these analyses. Federal or state funds may be available for road building but not for other, simpler solutions, thus making a comparative analysis favor socially expensive alternatives. In other cases a division of responsibility between agencies prevents consideration of a comprehensive set of alternatives.

CHANGES IN THE LOCATION AND ORGANIZATION OF ECONOMIC ACTIVITY AS TOOLS FOR IMPROVING TRANSPORTATION

When it is fully recognized that travel demand is derived from the demands for other goods and services, other areas for improvement in transportation become apparent. Functions once served by the CBD, when the city was more concentrated, may no longer be economic. As a prime example, the CBD served as a major shopping center for the metropolitan area. As the area grew and densities declined, automobile usage became more common, causing congestion and parking problems that disadvantaged retailers in the CBD. Soon the large suburban shopping center began to compete by providing a wide variety of goods and services, easy access, and convenient parking. There the automobile could be used as it should be both for passengers and freight. Needless to say, suburban shopping centers often prospered at the expense of downtown merchants who consequently complained. In this case, one could argue that natural market forces are playing a role in the adjustment process making the use of land for general retailing, such as food and everyday clothing, relatively more attractive in the suburbs than in the CBD. By focusing attention on the location economics of various activities, the planner may hasten the functional development of the CBD. Activities that draw on very large segments of the population may require a central location; those that can achieve sufficiently large markets in suburban areas might best avoid the CBD. Thus, the CBD may be appropriate to highly specialized retailing, art galleries, theaters, exhibition halls and museums, financial activities, and government offices. The suburbs may yield production economies to industries that require large tracts of land or single-story structures. Suburban industry can usually provide better facilities for rail and highway freight movements, and better access and parking for personnel.

By considering the sources of input for each activity, its market, and the behavior of the consumer, planning can achieve better functional use of land in the urban area. In fact, failure to give appropriate attention to the services that should be provided by the city will only compound the city's problem. Although attention should be given

to aesthetic design, its emphasis at the expense of function may only result in a modern beautified city serving few if any needs of society.

In addition to changing land uses to conform to the functional needs of society, perhaps other approaches might improve the quality of transportation in our cities. A large part of the transportation problem is the peak hour. Often our highway systems are more than adequate during off-peak periods, but are badly congested during peaks. New facilities are "demanded" to accommodate growing peak traffic. The problem of peak periods is even more pronounced for public systems where large investments remain idle for most of the day. The accommodation of peak travel makes our urban transportation systems very expensive and leads to poor utilization. Rush hours, however, reflect our social habits and practices. Business hours are generally uniform in the city. It is possible that some small changes in business hours could result in substantial improvement in transportation service with no corresponding increase in investment. Retail activities might, for example, open later in the morning and remain open in the evenings; school hours might be rearranged so that the traffic schools generate would not impede the journey to work. There are, of course, important reasons for all businesses to maintain similar hours, for communication and coordination, but incentives could perhaps be created that would induce some to change. Before embarking on a program to encourage staggered hours, more detailed analysis is required, however. They may produce serious undesirable effects such as reduction in car-pooling opportunities and disruption of family schedules. Even marginal changes may bring major relief from peak-hour congestion. For example, substantial improvement in downtown highway circulation might be brought about if deliveries were made at night.

A goal of some planning activities is the promotion of the central city as a place to live and work, so that higher densities might be achieved. It is difficult to know whether people can be induced to return to the city. If they live in the suburbs for the sake of suburban life, it may not be possible to induce them to return. The experiment has not been performed and furthermore, because such an experiment would require renovation of very large tracts of land, it may not even be feasible—failure would mean substantial waste of resources.

PROVISION FOR UNCERTAINTY

Plans for new transportation facilities should recognize the uncertainties of our forecasts. The problems created by uncertainty are no less severe for the automobile highway system than for urban public transportation systems. There is much we do not know about consumer behavior with respect to transportation. Although it is relatively easy to describe the trips made today with today's systems, trips must be related to the characteristics of the traveler and to the geographic distribution of activity. It is difficult to gage these relationships, let alone to predict the future, even if we assume an unchanging transportation system instead of a new one. Proper planning and implementation of new systems require detailed knowledge of future origin and destination patterns. Errors in these forecasts can lead to wasteful land taking, unnecessary relocation of people and utilities, and useless construction. The costs of such errors can be substantially reduced if the uncertainty in forecasting is explicitly acknowledged in the planning process.

Flexible systems provide some insurance against uncertain forecasts. The placement of steel rails or the pouring of asphalt or concrete is very costly and the result is long-lived. New public systems that make use of existing roads are highly flexible; in fact, the provision of new bus routes on existing streets is relatively risk-free. Rail rapid transit construction, however, is very inflexible and, hence, risky. Proper allowance for these considerations in planning decisions may require overwhelming evidence of large volumes of traffic to come before rail systems are introduced, but much less evidence is needed for new bus routes. Where new highways appear to be justified, and construction is begun, rights-of-way can be reserved for future increases in lanes, and underpasses or bridges can be built to accommodate future expansion. Where forecasts indicate that future highway expansion will be desirable, land reserved now might lower the costs of future acquisitions and eliminate some of the social disloca-

tions that so often occur. Land reservation for future contingencies might preclude new building construction or placement of utilities that would have to be relocated in any future land taking if their expected useful life over which their costs must be recovered is severely shortened. Although there is no way to avoid errors completely, precautions should be taken to insure that they are not too costly.

FINANCING URBAN PUBLIC TRANSPORTATION

A major issue of transportation today is the question of subsidy. With the decline of transit usage many transit operations, particularly in our larger urban areas, may not be able to continue operating without some form of subsidy. In some cases, it is thought that subsidy is more desirable than a fare increase, even though the latter might provide adequate revenue. Commuter railroads have had constant financial problems. Before dealing with the question of whether to subsidize, the question of need should be resolved. Perhaps with new approaches to public transportation systems, no subsidy would be required or it could at least be reduced. This does not mean reducing service to a bare minimum; indeed, the application of this solution in the past may well be the root of the problem. Instead, improved service may produce added revenue without increasing costs (5).

Furthermore, if a service were offered that competed in quality with that provided by the automobile, it is very possible that much higher fares could be exacted. Limited evidence indicates as much: large amounts of money are spent for automobile travel; and recent studies made of the value of time indicate travelers place a value of between two and four dollars per man-hour on their travel time, including the entire package of service qualities (6, 7). This would indicate that public transit improvements in door-to-door travel time could be priced fairly high. Significant improvements in these times probably will not be achieved from higher line-haul speeds, but rather from stops closer to homes and places of work and from elimination of long waits and transfers.

There is little if any evidence that free parking at suburban terminals or lower fares will attract many to the public system. The transit industry sometimes uses a rule of thumb that each one percent increase in fare will result in a 0.3 percent loss in riders. If the rule has any validity, the reverse should also be approximately true. Recent empirical work of a more detailed nature indicates that travel demand is insensitive to fares, but relatively much more responsive to improvements in service. In the study by Domencich and others it was found, for example, that the elasticity of demand with respect to line-haul cost was -0.09 for work trips, but the elasticity with respect to the non-line-haul portions of travel time was -0.71, a relative response seven times greater (4).

It is often argued that raising fares will hurt poor people. Certainly it will, but the poor service offered them may hurt much more. In fact, it is reasonable to assume that where no service is provided it is equivalent to charging an infinite fare. Improved service may afford the poor a wider choice of job opportunities that could lead to higher incomes. Since transit subsidies are generally financed by regressive local taxes, the burden of low fare systems often falls on these same poor people. These methods of financing subsidies usually transfer income from the poor to the rich. This is partly owing to the nature of the route systems; i. e., there is a cross subsidy between heavily used segments in the downtown areas and the lightly used suburban segments. The heavily used segments often pay their way, while the lightly used routes are deficit operations providing public transportation for wealthier groups in society. Certainly this aspect of subsidy is undesirable.

Indirect subsidies are inefficient; from an efficiency point of view, direct payments to the poor coupled with fares that can meet costs will lower the total costs of both activities and, in part, will eliminate the income transfers from the have nots to the haves. The subsidy problem may not be simple; from a political point of view, it may be more expedient to subsidize transit from general funds than to make direct welfare payments. Arguments that welfare payments destroy the pride of the recipient should perhaps carry some weight. There are administrative procedures that could be used

to alleviate some of the psychological effects of the dole, such as the negative income tax or impersonal methods of distributing welfare checks. In any event, it would be unwise to confuse these considerations peculiar to welfare with the already over-complicated problems of public transit.

Those persons requesting subsidies for transit often justify their demand by arguing that the private automobile system is subsidized but the public system is not. The facts are not clear; it appears that the urban automobile traveler may in fact pay more money in the form of user charges than is spent on urban highway facilities (2). In any event, even if there is a subsidy, two wrongs certainly do not make a right, and it is not at all obvious that if the subsidy (if any exists) were removed from the automobile system by increased user charges (or by some other means) any benefit would accrue to transit.

The most vociferous proponents of subsidized transit are often the merchants of the CBD who have undoubtedly suffered from the new development patterns of our cities. Subsidies may bring temporary relief but eventually the pain will become unbearable. Because the demand for transportation is derived, any subsidy to transportation is ultimately a subsidy to other activities. One must question the merit of using public moneys to subsidize moribund private activities. This is not to argue that subsidies are never appropriate, but to suggest that thorough consideration must be given the question before resorting to this solution. Subsidies are often useful for overcoming short-run phenomena. The most efficient allocation of our resources may require a geographic reshuffling of activities that will be governed by the incentives of the marketplace. The subsidy may serve only to distort the natural incentives or to delay needed adjustments. Yet they may be useful supplements in the interim while the needed adjustments are taking place. Some insurance should be provided, however, that such adjustments will be made.

RESEARCH NEEDS

Before economic principles can be applied to our urban transportation problems, several areas of research must be more fully investigated. We must learn a great deal more about consumer responses to changes in the transportation system. The models generally used for urban transportation planning have many serious deficiencies that must be overcome. These models have grown erratically; they fail to recognize many fundamental economic principles explicitly, making it impossible for the planner or systems designer to investigate the sensitivity of travel to system changes.

The usual approach to urban transportation modeling divides the trip-making process into several separate and distinct submodels: trip generation, trip attraction, trip distribution, route assignment, and modal split. The models treat these operations largely as separate decisions. For example, models that describe selection of mode and trip generation are constructed independently of each other, as if the factors used to explain modal choice had no effect on trip generation. Economic theory tells us, however, that if travel is costly, or otherwise onerous, fewer trips will be made. Thus, one of the very relationships we must explore, the effect of modal characteristics on the number of trips made, is explicitly denied.

Some progress has been made toward incorporating all the elements of the trip-maker's decision in a single model that describes the effect on travel of changes in travel times, travel costs, socioeconomic characteristics, and the characteristics of all the alternative transportation choices available (4, 8, 9). Although these models are still at a very primitive stage of development, their further exploration may well lead to improved forecasting and design.

A second area requiring intensive research is land use modeling. We must learn how people facing a particular geographic distribution of activities locate their places of residence, employment, shopping, recreation, etc. The decisions people make must be related to the characteristics of the areas considered, their personal socioeconomic situation, and the characteristics of the transportation system available. Study of this aspect of consumer choice points to the necessity of introducing some dynamics into the entire urban modeling process, because changes made in the transportation system and in land use are likely to influence each other.

The development and application of such large-scale models is not at all simple; a great deal of research is required. But this is not impossible with the research tools at our disposal. Ultimately, the present separation of land use and transportation modeling must be eliminated if good planning is to result.

These models must explicitly incorporate variables to describe the characteristics of the policy tools available to the system designer. The transportation system designer should be able to evaluate the effects on travel behavior of changes in public transit fares, line-haul travel times, parking charges, transfers, walking time, zoning regulations, etc. Without explicit understanding of how such characteristics affect travel, the designer must operate on assumptions, either implicit or explicit, and the chances for error may be greatly increased.

Once the effect of policy changes on travel behavior is understood, analysis of the benefits derived from various system improvements can begin. While it appears that the models required to describe and to forecast transportation and land use can be based on sound existing theory, the same may not be true for benefit/cost evaluation—the basic process for the determination of priorities and the allocations of limited capital budgets. Conceptually, the problem is similar to that of capital budgeting for private industry, but in that case, benefits can be measured as profit. No comparable single measure has found universal acceptance for application to public investments. If user charges are imposed through use taxes, tolls, transit fares, or parking charges, this revenue could be used to offset costs and we may attempt to apply the private standard of profit, or the excess of willingness to pay over cost, to these investments. It is often argued, however, that these systems frequently create external effects that are not directly reflected either in the measured costs or in the money revenues. To the extent that any net external additions to or subtractions from benefit are created by the system, they should be incorporated in the benefit/cost calculus. Changes in the transportation system often create income transfers. Although such transfers may be desirable, it seems best to exclude the value of such transfers from the benefit/cost analysis in determining whether a change is worthwhile. If the change is not worthwhile when the value of desirable transfers is included, it may be possible to effect the transfer at lower total social cost through other, more direct means.

Beyond the problem of measuring benefit, the specific analysis of the relative values of different systems has also been the subject of controversy on several levels. The major problem is that transportation improvements are long-lived and create streams of future benefits and costs. A means must be devised to account for this time dimension. Several measurements have been used or proposed for comparing individual projects: the annual cost method, the benefit/cost ratio, the rate of return, and the net present value. It appears that net present value is generally the best measure for taking account of the time dimension while remaining consistent with capital budgeting theory, particularly when priorities are to be established. The measurement makes it relatively easy to compare initiation of a project now with delay to a later time when some degree of uncertainty may have been eliminated. In practice, however, the other techniques are often used in the evaluation of transportation improvements (10).

Two further problems must be resolved for any formula selected for measurement: (a) the appropriate discount rate, and (b) the life of the investment. There is a strong tendency on the part of engineers and planners to apply low discount rates and long lives to transportation investments, thereby tending to justify nearly any investment. Some attention should be given to these issues so that realistic values are insured.

These research problems are primarily of a fundamental nature. It is unlikely that their solution will be found in a practical day-to-day planning environment. Although it is important that research in these areas should recognize the practical problems of application, we should not expect their solution to be the result of any specific planning study. Instead, some purely developmental effort in a research environment seems warranted.

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