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Coordinated Intermodal Transportation Pricing and Funding Strategies

This TCRP digest provides a summary of TCRP Project H-6, "Transit Fare Pricing Strategy in Regional Intermodal Transportation Systems," conducted by Multisystems, Inc., in collaboration with Apogee Research, Inc., and Oram Associates. Included in the digest are (1) a summary of the key issues and study findings, and (2) several technical appendixes providing key background information.

INTRODUCTION

This digest will be of interest to transportation officials and planners considering coordinated pricing issues.

Transit agencies are looking for innovative strategies to address the gap between costs and revenues. Coordinated intermodal pricing is an approach that has the potential to generate new revenues, increase transit ridership, and help achieve regional transportation goals. It means setting the level of transit fares, parking rates, and tolls in order to achieve larger metropolitan area goals with respect to mobility, air quality, and congestion mitigation. This integrated approach, however, is not often considered. Transit Cooperative Research Program (TCRP) Project H-6, *Transit Fare Pricing Strategy in Regional Intermodal Transportation Systems,* was designed to (1) examine factors that influence the ability to coordinate transportation pricing and funding strategies in a regional intermodal context and (2) develop a conceptual approach for pursuing such coordination.

This project presents a framework for transit agencies and their partners to use in developing a coordinated intermodal pricing strategy. While it is not feasible to present a detailed set of "how-to" instructions for introducing coordinated regional pricing in all settings, the TCRP Project H-6 final report is designed to raise awareness and foster consideration of these issues among policymakers and planners and to provide them with a set of guidelines for developing their own plans and strategies. This digest summarizes the approach and findings presented in the final report and also includes, as appendixes, technical background materials that will be of interest to transportation officials and planners considering coordinated pricing issues. Copies of the final report are available through the TCRP, 2101 Constitution Avenue, N.W., Washington, DC 20418.

THE CASE FOR COORDINATED INTERMODAL PRICING

Transit agencies across the United States are facing funding shortfalls with increasing regularity. Increasing costs can be attributed, in part, to the labor- and capital-intensive nature of the transit industry. Reduced ridership and revenue are attributable largely to the suburbanization of jobs and residences and to the convenience of auto travel in the suburbs. These combined factors result in a funding shortfall. At the same time, transit agencies are struggling to comply with such federal requirements as the Americans with Disabilities Act and the Clean Air Act (CAA). The burden of capital expenditures continues to increase

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because equipment and infrastructure require periodic replacement and because systems must expand services in response to changing demographics and legislative requirements. Transit serves a range of public policy and social goals. Transit represents an alternative to automobile travel that can reduce traffic congestion and the resulting air pollution; in addition, transit can encourage economic development and improve mobility for those who are not able to drive because of age, disability, or economic hardship, and for those who prefer not to drive.

Unfortunately, traditional sources of funding are not keeping pace with these growing needs. Overall federal operating assistance has declined consistently since the early 1980s, and even greater reductions appear imminent. Although state and local governments have filled much of this funding gap over the last 15 years, their willingness and ability to continue funding transit at current levels is less certain.

In light of these trends, it is increasingly urgent for transit agencies to find new and effective ways to close the cost/revenue gap. Some agencies have explored the use of innovative funding practices, many of which attempt to capitalize on the relationship between transit and new land development. Typically, however, these strategies do not effectively address the role that a transit system plays in a coordinated regional transportation system. In fact, coordinated intermodal planning has been uncommon, and pricing decisions seldom directly address factors related to multiple modes. Nor do transit decisionmakers seem to take into account the potential effects of their fares on the attractiveness of other modes of travel and their interaction with regional transportation and economic goals. This lack of consideration of the broader transportation context can result in inconsistent public policies; for instance, a transit fare increase (and the resultant ridership loss) tends to work against efforts to reduce traffic congestion or improve air quality.

In contrast, coordination of transit pricing with pricing decisions concerning the single-occupant vehicle (SOV) offers the potential to address both the financial goals of the transit agency and the overall transportation goals of the region. Integrating transit pricing decisions into a broader regional context might assume two basic forms:

- In making pricing decisions, the transit agency considers not only its own internal factors (ridership and revenue trends, fare elasticities, etc.) as well as external economic factors (employment rates, retail sales, etc.), but also price changes in competing modes. For instance, the transit agency may decide to time a planned fare increase so that it coincides with a toll increase or other introduction of congestion pricing in a major corridor. The underlying reasoning might be that the toll increase or congestion pricing will minimize if not completely offset the ridership loss that might normally accompany a fare increase.

- The transit agency or other regional agency seeks to influence one or more other modal agencies in the region to increase auto-related pricing and possibly provide a cross-subsidy to transit. The transit agency might then make its pricing decisions based on the nature of the auto-related pricing measure (such as congestion pricing or a parking fee), and whether or not there will be any cross-subsidy. The rationale here might be that because transit plays an important role in addressing regional transportation goals, its pricing might be coordinated with that of other modes.

Federal policy of the last few years has emphasized intermodal planning and air quality improvement particularly as driven by the Intermodal Surface Transportation Efficiency Act of 1990 (ISTEA) and CAA legislation. These developments encourage transit pricing strategies that are coordinated with regional intermodal transportation policies and initiatives. Transit service may be a key element in efforts to address regional transportation and environmental challenges effectively. A technique for implementing this type of intermodal transportation strategy might be for transit agencies to approach local, regional, or state agencies with a proposal to integrate transit pricing into the regional (and ultimately national) transportation pricing/subsidy decisionmaking process. A successful strategy might begin to alleviate the joint problems of growing transit costs and declining revenues by establishing new transit funding streams and by "leveling the playing field" in subsidizing transit and auto travel.

ISSUES RELATED TO COORDINATED PRICING

Transit is one element in a complex system that includes multiple modes of transportation, land use patterns, and economic activity. An individual's decision to use transit is based on a number of factors, including the costs and benefits (such as travel time) of alternative modes. Thus, in order to assess more accurately the influences on and effects of transit pricing, it is important to take a broader view of the entire regional, intermodal transportation system. Key issues and concerns related to intermodal pricing can be summarized as follows.

Regional and Transit Agency Goals

Regional agencies tend to set goals that address multijurisdictional and multimodal themes. Although these goals vary with the region and the specific agency, they may typically deal with three general, interrelated themes:

- Reducing vehicle miles traveled (VMT) and use of SOVs;
- Maintaining regional access and mobility; and
- Supporting economic development.

Transit agencies, on the other hand, may set goals that conflict with the above regional themes. While transit agencies may strive to maintain a simplified fare structure or to ensure equity, their major goals in modifying their fare structures are invariably one or both of the following: increasing ridership and increasing revenue.

The pricing of public transit in the United States has traditionally been based on the desire to balance these two goals. Transit pricing decisions focus on analyses of the effects of fare changes on ridership and revenues, coupled with evaluations of other related criteria (e.g., equity, affordability, convenience). These evaluations, however, seldom examine factors beyond the transit system itself. The role of transit in the overall transportation system suggests the need to add the regional, intermodal effects of a change in transit fare or of a change in the price of other transportation modes to the list of concerns in the pricing of transit and other transportation services. Considering transit pricing in a regional context may expand the range of potential actions that support the policy goals of transit and other transportation agencies alike.

Transportation Costs and the Influence of Price on Mode Choice

Transportation costs have three major components:

- *Variable out-of-pocket costs,* which include fuel prices and taxes, auto maintenance and repair, tolls, transit fares, and user-paid parking fees;
- *Fixed out-of-pocket costs,* which include the price of a vehicle, licensing and registration fees, and basic insurance costs; and
- *Societal costs and externalities,* which may include the costs of road construction and maintenance, transit capital expansion, traffic enforcement, accident response, and mitigating air and noise pollution.

Even within the expenses that they pay out-of-pocket, auto users typically consider only *variable out-of-pocket costs* such as fuel, parking, and tolls in their daily modal decision. This means that, for the commuter who has free parking and no tolls, even a transit fare of $1.00 or less may seem higher than the daily cost of an auto trip. While it is unlikely that transit pricing alone can influence mode choice, considering transit fares in a larger regional transportation context that takes into account the range of factors influencing mode choice might promote transit as a competitive option.

To understand how changes in the price of each mode affect the choice of mode, there are two basic questions:

- How much does demand for a mode change, given a change in its price?
- As the price of one mode changes, how much of the demand shifts to or from competing modes?

Although the effects can be difficult to quantify, available information indicates that changes in auto-related costs-especially parking fees may significantly influence demand for high-occupancy vehicles (HOV), including transit. Although the effect is smaller, changes in transit fares may also affect SOV use. For example, (1) an increase in transit ridership, as a result of increased parking and roadway costs, may reduce traffic congestion and pollution and (2) an increase in transit fares may lead to more SOV driving, resulting in more congestion and pollution.

The magnitude of these effects will vary with the characteristics of local transportation systems, but these relationships represent key principles underlying the pursuit of intermodal pricing. Thus, in attempting to encourage transit usage, thereby reducing VMT and congestion, a key challenge is to coordinate pricing decisions so as to minimize fare increases.

Integrated Transit Pricing and Transit Fare Subsidies

In considering potential intermodal coordination strategies, it is instructive to review the issues and experiences of transit agencies that have sought to coordinate different operators' pricing efforts. Reviewing the issues associated with developing a coordinated *transit pricing program* can illustrate some of the institutional issues involved with a coordinated *intermodal pricing strategy.* Developing regional fare integration is an ambitious undertaking. It is difficult to determine a mutually acceptable fare structure or fare payment technology as well as a revenue allocation/distribution system for technical and financial reasons, and there will be significant differences in managerial approaches among participating agencies. The difficulties associated with developing agreements within these different *transit institutional settings* suggest the types of challenges in developing *intermodal agreements.*

In considering the pricing of different modes, it is important to keep in mind that the official or stated cost (e.g., fare level or parking charge) is not the most important price related factor affecting mode choice and level of usage. Rather, the perceived cost what the traveler actually has to pay is the key factor. Out-of-pocket costs are both variable and fixed and can differ considerably from the full cost. Part of this differential is attributable to user subsidies (typically from employers) that cover much, if not all, of the actual parking price. Many employers do subsidize transit usage to some extent, and these subsidy programs are important to consider in reviewing transit pricing elements for two reasons: (1) they help equalize the effects of free or heavily discounted parking and (2) they can be used to offset the effects of a fare increase on certain travelers. In fact, it has been shown that the availability of a transit subsidy is more important in increasing ridership than the amount of that subsidy. (Appendix A contains a summary of the research on transportation costs and pricing issues and a list of references, and Appendix B presents several examples of integrated transit pricing and subsidy programs in the United States.)

Distribution of Revenues

One of the key premises in this project is that the revenues raised by increasing auto pricing, particularly through tolls or congestion pricing, may conceivably be used to cross-subsidize transit. In addition to the obvious benefits to transit, using auto-related revenues in this way may help achieve public support for the potentially unpopular notion of congestion pricing. However, there are a number of alternatives for distributing revenues from auto-related pricing strategies, including reinvestment in highway programs, program administration costs, mitigationprograms (including additional transit service), and compensation to affected parties such as merchants, low-income drivers, or local governments. Developing these agreements is clearly a crucial aspect of any intermodal coordination effort.

Implementation of Transit Pricing Changes and Current Coordinated Intermodal Pricing Practices

In considering the potential for regional intermodal pricing strategies, it is important to understand how transit agencies set fare policy and make fare-related decisions. This process may differ widely, depending on such factors as institutional setting, regulatory restrictions or requirements, and the general decisionmaking structure. Most transit agencies require a combination of board approval and public hearings to introduce new fare levels, but some agencies must also receive approval from legislative and judicial bodies. While intermodal and inter-operator coordination efforts involve a different set of issues, any strategy requiring a transit fare change will ultimately face comparable institutional requirements.

With regard to coordinated pricing, there are few examples of coordinated pricing involving transit and auto-related functions in the United States. In Portland, Oregon, and Bellevue, Washington, transit agencies and highway or parking agencies have cooperated to enhance the appeal of transit by improving transit service quality, but not by altering pricing mechanisms. Bellevue city planners sought to have the Seattle area transit agency expand bus service in proportion to increases in the city's employment density. Coordinated pricing has typically been considered impractical or infeasible when it is considered at all. Even those agencies that internally control the prices of both transit and auto travel have been unwilling to use this authority to pursue coordinated regional pricing and have tried to downplay the cross-subsidy connection.

CONCEPTUAL APPROACH TO INTERMODAL PRICING

Because of the interrelationships among the various factors that determine mode choice and travel behavior, coupled with the role that transit plays in supporting regional transportation goals, transit agencies may seek to coordinate their own pricing decisions with those that affect other modes. This project developed a conceptual approach to intermodal pricing to provide guidelines that planners and decisionmakers can adapt to their own circumstances as they make pricing decisions. The key elements of this approach can be summarized as follows.

Development of Coordinated Pricing Strategies

The approach described here involves (1) identifying transit and regional transportation goals, alternative pricing actions and strategies to consider, and stakeholders that will be affected by any pricing strategy; (2) evaluating alternative strategies and their associated institutional requirements and responsibilities; and (3) preparing an implementation plan. The interrelationships among the different steps and elements are depicted graphically in Figure 1.

The pricing actions to be considered might include changes to the following:

- Transit fares;
- Auto-related prices (e.g., increase or institute tolls, eliminate free parking);
- Cross-subsidies (e.g., from auto-related to transit-oriented); and
- Transit user subsidies (e.g., employer provided transit vouchers and pass subsidies, or human service agency client-transit subsidies).

Coordinated pricing strategies may consist of combinations of actions. The appropriate strategy in a region will depend on several factors, including the specific goals being pursued, the expected effects on the various stakeholders, and the nature of the institutional requirements and barriers. In general, however, there are four basic types of strategies envisioned:

- The transit agency raises fares without any concomitant change in auto-related pricing; this will address the transit agency's goal of increasing revenue, but will undermine the overall regional goals related to reducing VMT.
- The transit agency raises fares with an accompanying auto-related charge (i.e., congestion pricing or some type of parking fee); this will generate fare revenue and will offset, at least to some extent, the fare increase in terms of the shift from transit to SOV usage.
- The transit agency proposes a fare increase, but agrees not to increase fares because an intermodal arrangement establishes an auto-related charge coupled with a cross-subsidy to transit; this arrangement would produce the needed revenue for the transit agency, while avoiding a fare increase and the resulting increase in SOV mode share.
- A local, regional, or state implements an auto-related pricing action and offers the transit agency a cross-subsidy in return for a reduction in transit fares; this would maximize the reduction in SOV use and, therefore, would best address regional transportation goals.

The first of these strategies represents current industry practice; while there is no direct coordination involved, the transit agency can make its fare decisions in consideration of other pricing actions. The other three strategies represent varying degrees of intermodal coordination. Thus, intermodal pricing strategies fall into two categories: (1) the transit agency initiated strategy designed to meet its revenue needs and (2) the nontransit agency initiated strategy designed to reduce SOVs. Figure 2 shows the process involved in developing the alternative strategies.

Institutional Requirements and Barriers

While there are cogent reasons for integrating transit pricing into the regional intermodal context, it is important to remember that there are barriers to achieving the kinds of coordination described here. Resistance to price increases in any mode, coupled with general barriers to interagency cooperation, may make coordinated intermodal pricing difficult to achieve. Attempting to institute auto-related pricing by itself has proven a formidable task in most locations; this is evidenced by the delays in the actual implementation of U.S. congestion pricing demonstrations to date. Similarly, it may be difficult to impose areawide parking charges or restrictions. Cross-subsidy programs, although they create a direct link between the problem (traffic congestion and auto-relatedemissions) and a potentially key part of the solution (transit), may not obtain sufficient support from the public and local officials.

Understanding institutional and organizational requirements and barriers is critical to developing an effective strategy. Responsibilities for initiation, implementation, and administration of the coordinated effort must be clearly assigned. Furthermore, policies and regulations, as well as review and approval procedures, must be established. Where there is a cross-subsidy arrangement, an interagency revenue transfer agreement must be developed. Regardless of the local situation, there will likely be significant institutional requirements to be addressed.

One agency should take the lead in coordinating an intermodal pricing strategy, identifying separate but complementary roles for the key entities involved in the process. Potential candidates for a lead agency include state DOTs or highway departments, regional planning or transportation agencies, city or county governments, and specialpurpose local governments or metropolitan districts. Each type of agency has advantages and disadvantages; the appropriate agency will differ from one location to the next, depending on the specific strategy being developed and the specific characteristics and capabilities of the candidate agencies in a region. In evaluating alternative strategies, it is necessary to consider the overall institutional feasibility of the strategies and the expected effects on various stakeholders, as well as the extent to which each strategy addresses the key goals of the coordination effort. The consideration of institutional issues and their effects is envisioned as taking place in an iterative fashion. In some cases, though, agencies will choose to evaluate strategies based only on their apparent institutional feasibility before considering the effects, whereas in other cases, agencies will undertake detailed quantitative assessments of ridership and revenue effects before addressing the institutional issues. However, the general approach outlined in this digest may prove useful in at least initiating the consideration of coordinated intermodal pricing. (Appendix C describes a methodology that may be used in assessing potential ridership and revenue effects in applying the intermodal pricing coordination approach developed in this project.)

In summary, pursuing a coordinated intermodal pricing strategy may achieve a wide range of public policy goals. In addition to providing regional agencies with new tools to address concerns about traffic congestion and air quality, an integrated planning process may help ensure that public policy is consistent across agency lines and may forge new partnerships among related agencies. With the current emphasis on intermodal coordination, transit agencies may become active players in larger transportation policy arenas and, to the extent that they generate new revenues for transit agencies, coordinated pricing strategies may help address the growing gap between transit costs and funding streams.

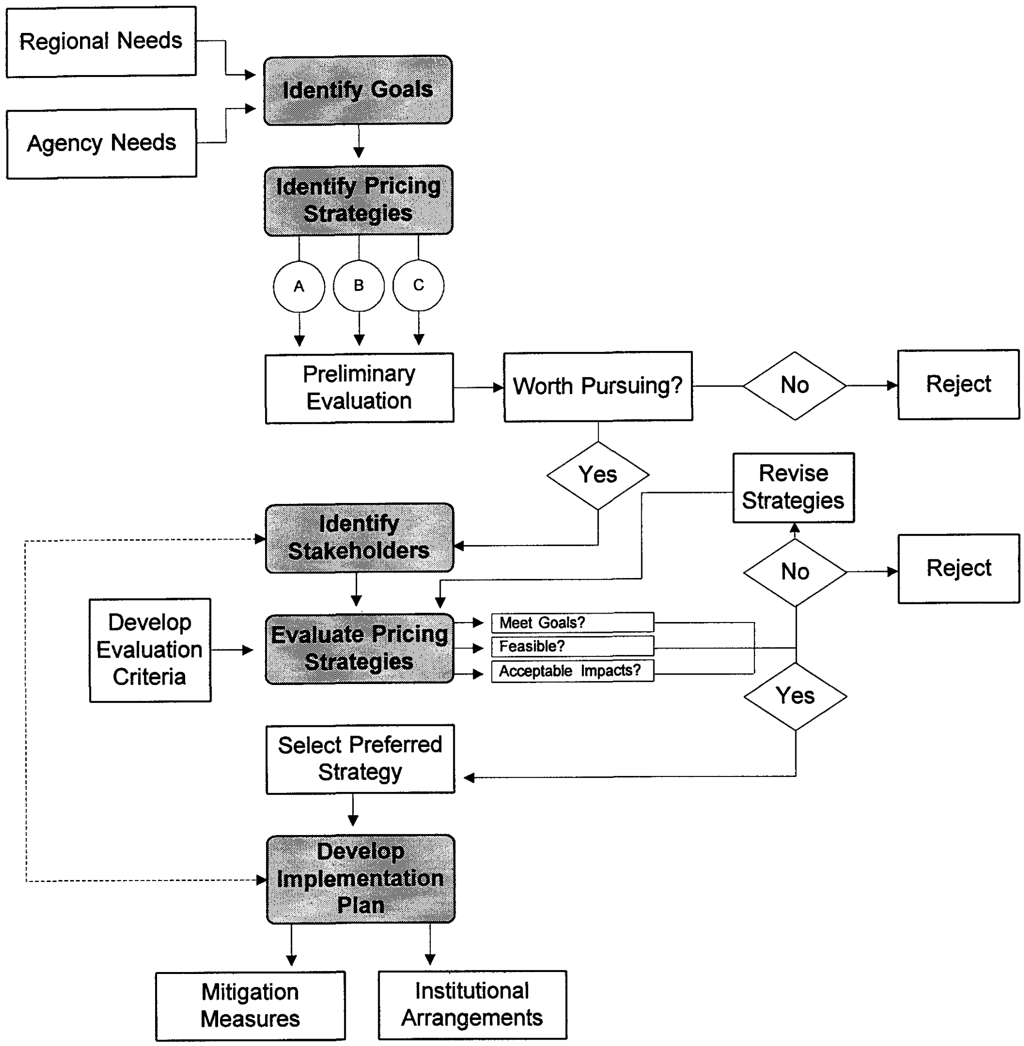

Figure 1. Coordinated pricing process.

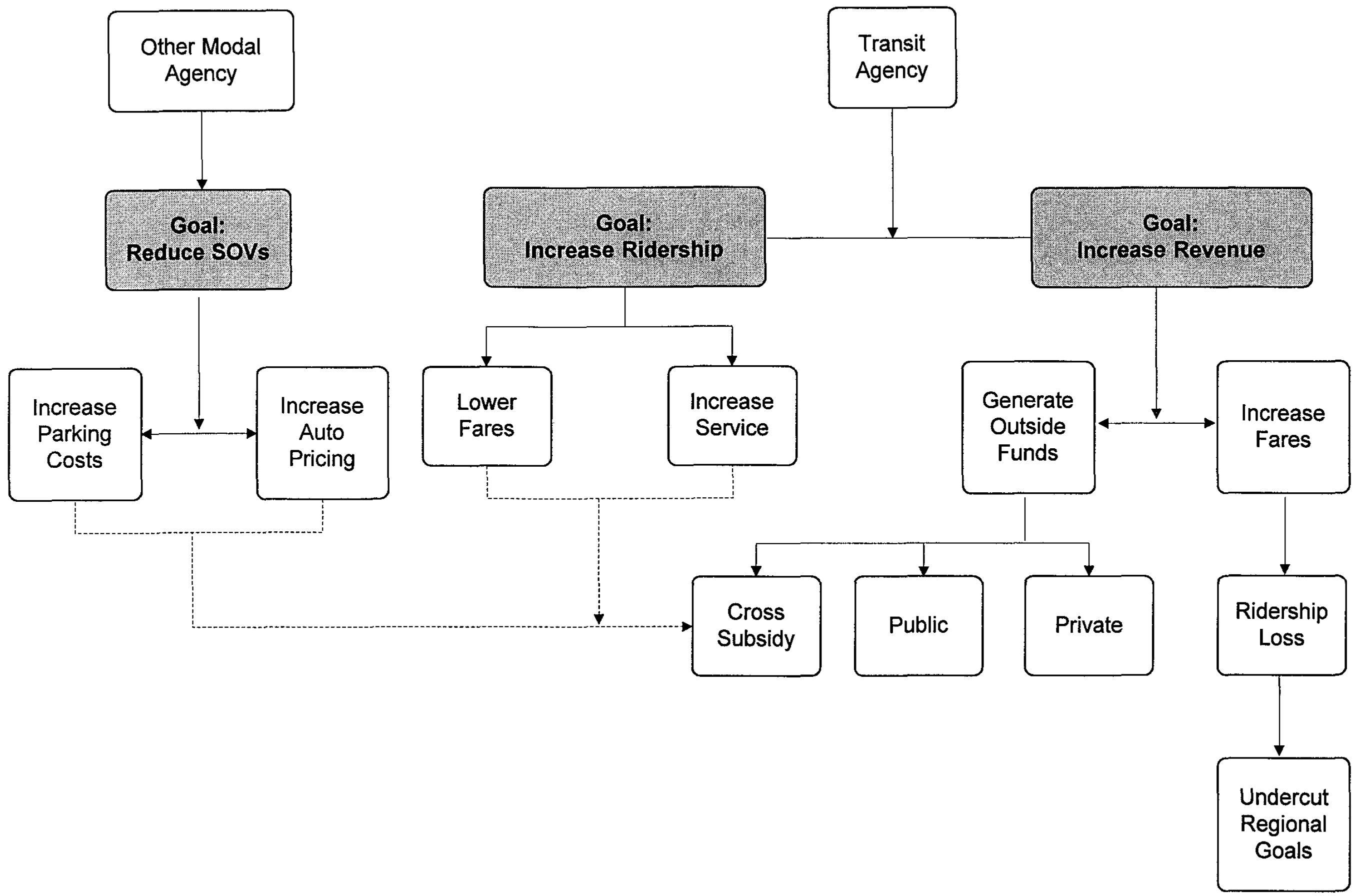

Figure 2. Definition of alternative scenarios.

APPENDIX A

SUMMARY OF RESEARCH ON TRANSPORTATION COSTS AND PRICING ISSUES

This appendix presents detailed findings of the literature review on transportation cost and mode choice issues, along with the list of references.

A.1 PRICING DISTORTIONS AND THE COSTS OF AUTOMOBILE TRAVEL

The economic ideal in the pricing of a good or service is to set the price of the product at a level that equals the marginal cost of its consumption. For automobile travel, this means that motorists should pay not just their own costs of owning and operating the vehicles, but also the added costs of increased traffic delays and air pollution that their cars' use imposes on others. The typical driver in an urban area bears only a fraction of these "societal" costs. The unpublished interim report from TCRP Project H-3, *Policy Options to Attract Auto Users to Public Transportation,* (Portland State 1994) cites the results of three studies (Meyer, in Johnson 1993; MacKenzie et al. 1992; and Hanson 1992) that computed the extent to which auto drivers are subsidized. These studies estimate that one-half to three-quarters of the total costs of driving are essentially borne by others. Apogee Research (1994) estimated a higher percentage borne by users (on the order of 80%), but this was for peak periods only and represented only a single city (Boston). The assumptions used in deriving such figures clearly affect the outcome. For example, in contrast to the studies cited above, the Highway Users Federation estimates that motorists pay for virtually all costs of highway infrastructure (Beshers, 1994).

Pucher (1995) summarizes estimates of direct and indirect subsidies to automobiles and trucks in the United States. These estimates range from $378 billion to $935 billion per year, with an average of $635 billion. Subsidies include explicit subsidies to roadway construction and maintenance, indirect subsidies in the form of free parking, and hidden subsidies resulting from the costs of congestion, air pollution, noise, and accidents. To put these subsidies in perspective, Pucher estimates that they are roughly one thousand times greater than total federal operating assistance to transit.

Consequences of this underpricing are greater automobile use, a misallocation of resources to auto travel, and, indirectly, pressure to keep transit fares at a commensurately low level (i.e., below the full cost of transit operations). This distortion has had the unintended consequence of encouraging urban sprawl and has led to the often severe traffic congestion characterizing many roadways today.

The costs of driving can be grouped into three categories:

- Out-of-pocket variable costs,
- Out-of-pocket fixed costs, and
- Societal costs and externalities.

Variable costs include fuel prices and taxes, auto maintenance and repair, tolls, and user paid parking fees. A portion of auto insurance costs can also be variable, for example, higher rates for "commuter cars." Variable costs shape modal choices in conjunction with considerations of comfort, convenience, trip time, and transit characteristics.

Fixed costs include not only the price of a vehicle but also licensing and registration fees, which do not vary by VMT, and basic insurance costs. Fixed costs, acting in conjunction with income and even with transit availability and convenience, affect the decision to own a vehicle and hence the transportation choices available--nonowners "choose" transit or HOV travel by default.

Societal costs and externalities are borne by society in general. Subsidization occurs when the individual auto users do not directly bear these costs in proportion to their responsibility. Information on societal costs and externalities allows better understanding of the total resources consumed by the transportation modes within the region. In a proactive context, this understanding feeds into strategic planning which, in turn, can lead to internalization of these costs through policies such as transportation management or translation into out-of-pocket costs through fuel taxes, smog-certification fees and VMT taxes.

Collectively, the literature reviewed for the study addressed all three types of cost. Some studies evaluated the full range of costs whereas others focused on one or two aspects. A number of cost-oriented studies also evaluated transit characteristics. Selected studies explicitly explored the linkages between specific costs and traveler behavior; fewer studies documented the strength of such linkages with empirical data that demonstrate the behavioral implications of changes in driving costs.

Variable Out-of-Pocket Costs

The greater emphasis in direct cost analyses is on variable costs because these are the focus of most policy suggestions. This is appropriate because of all the costs, the traveler is most aware of what he or she pays out-of-pocket. For the auto driver, these are the costs for parking and perhaps for tolls. The motorist might also attribute to the trip some of the cost of gasoline consumed, and perhaps some perception of the value of the time spent on the road and in traffic delays. While the true cost of the trip also includes a portion of the fixed costs associated with owning an auto (purchase or lease price, insurance, and maintenance), the typical driver seldom considers these "sunk" costs in making daily travel decisions. It is against parking charges and tolls (and occasionally fixed costs) that transit competes. Except for special occasions (e.g., the car is in the shop), a traveler who could take a trip by car will only go by transit when he or she perceives the trip-related net costs for the car to significantly exceed the costs for using transit.

A number of studies document the level of individual costs; for example, Apogee Research (1994) identifies the full range of transportation costs for all modes, establishes an analytical framework, and quantifies out-of-pocket and societal costs of transportation modes based on case studies in Boston, Massachusetts, and in Portland, Maine. Several studies move beyond documentation with policy prescriptions to alter travel behavior by manipulation of variable costs. MacKenzie, Dower, and Chen (1992) consider the full range of automobile costs-external and public capital costs, as well as variable and fixed costs and conclude with recommendations for increased fuel, truck, parking, and toll-road taxes to constrain SOV demand. For example, they note that even with a $2 per gallon increase in fuel taxes, U.S. gasoline prices would be significantly below those of most other industrialized nations; equity considerations could be addressed with income tax rebates.

A number of studies address congestion pricing, which reduces congestion on selected roadways by increasing variable costs in relation to traffic volume. These studies, more than others, focus on the behavioral aspects of increased travel costs. All tolls both "flat" tolls and congestion pricing--increase the variable dollar costs of SOV travel. However, under most current proposals these tolls are not assessed across-the-board for all SOV trips (i.e., they propose limited application rather than complete areawide electronic tolling). The effects on transit use may be limited if, for example, pricing on one road leads primarily to a shift in routes rather than to a shift in mode. These studies, which address the influence of price of individual modes on the use of transit and other modes, are described in Section A.2.

Fixed Out-of-Pocket Costs

None of the studies reviewed were confined to fixed costs of driving. Apogee Research (1994) and Litman (1995), however, cite data drawn from other studies that include fixed costs as well as variable and social costs. Litman presents several tables that disaggregate the costs of auto ownership by type of car. He also translates vehicle ownership costs into dollars per vehicle mile, by type of vehicle. For example, his best guess is $0.206 per vehicle mile for an average car, $0.181 for a fuel efficient car, $0.258 for an electric car, and $0.268 for a van. These are approximate sums of the Federal Highway Administration's estimates (presented in Table A-1).

Apogee Research's study estimated a $0.201 cost per passenger mile for depreciation/financing, $0.076 to $0.121 per passenger mile for insurance, and $0.013 per passenger mile for registration/licensing for SOV travel on both expressways and non-expressways in Boston. For Portland, the range was narrower for insurance (a high of $0.94 per passenger mile), registration was $0.001 less, and depreciation was the same.

Societal Costs and Externalities

The need for individual travelers to begin to pay for their trip's societal costs and negative externalities provides the basic rationale for congestion pricing, higher fuel taxes, and parking fees.

Distinct from studies of congestion pricing and other prescriptive recommendations using externalities as justification, several studies focused more on evaluation and estimation of the underlying externalities themselves. Apogee Research (1994) quantified many of these costs and presented them in an extensive table of costs per passenger mile traveled. For example, total cost ranged from $0.713 to $1.050 for peak period SOV travel in Boston, of which $0.563 to $0.880 were borne by the users themselves and the rest was borne by government or society at large. Costs were higher for non-expressway SOV travel. The study also presented costs for HOV and several transit modes.

Similar to Apogee Research's study, Litman (1995) addresses a wide range of external and social costs as well as user costs for transportation. For example, he summarizes water pollution costs from water runoff effects, road salting, and oil spills, and translates these into costs per vehicle mile by type of vehicle. He suggests water pollution costs, external to the vehicle user, of $0.013 per vehicle mile for average and fuel-efficient cars, vans, diesel buses, and motorcycles, and water pollution costs of $0.07 per vehicle mile for electric cars. The Federal Railroad Administration (1993) similarly addressed social costs such as land use, community disruption, energy consumption, safety, and congestion as well as air, noise, and water pollution effects.

MacKenzie et al. (1992) discussed strategic social costs such as dependence on foreign oil supply as well as noise, pollution, congestion, accidents, and vibration and presents estimates of costs drawn from other studies. For example, MacKenzie cites a paper by Ketcham that estimated the national loss in property value (mostly along local streets) due to vibration as about $6.6 billion in 1989, primarily due to heavy vehicles. MacKenzie also cites two studies addressing noise that place the loss per home-property unit in the range of $6 to as much as $182 per decibel of excess noise.

Regarding the application of cost information, Nelson and Shakow (1995) have developed a prototype computer model applying total cost analysis to transportation planning for the Puget Sound metropolitan region. This model compares the total costs of options related to implementation of several projects to increase capacity (e.g., light rail, commuter rail, a bicycle/pedestrian network, and highway construction) and options emphasizing public and private incentives to reduce use of SOVs (e.g., employer-subsidized parking cash-out, congestion pricing, and telecommuting tax incentives). The model also includes the capacity to account for the political environment by forcing one or more options into the final mix or by ensuring that the final mix is "balanced" in some manner, such as between transit and highway improvements. This model indicates that the use of total cost analysis is a

TABLE A-1 Fixed costs to the user for vehicle ownership (in cents per mile based on average usage)

Vehicle	Depreciation	Insurance	Finance Charges	License and Registration
Sub-compact car	8.6	7.1	1.6	0.8
Average car	10.7	7.0	2.0	0.9
Van	14.2	8.5	2.9	1.2
Electric car	15.1	7.1	2.8	0.8

feasible method of analyzing investment and pricing decisions, although the authors point out that the model is in need of considerable improvement before it can be used as an operational tool.

A.2 INFLUENCE OF PRICE ON MODE CHOICE

Public transit is a normal good in the economic sense that as its price goes up, demand (the number of transit trips taken) goes down. The same holds true for trips by auto. While these relationships are intuitively obvious, efforts to coordinate transportation pricing require further understanding of this connection, including the ability to determine (1) how the demand for a mode changes given a change in its price, and (2) how much of the demand shifts to or from competing modes, as the price of one mode changes. This section reviews what is known about the relationships between price and demand for various types of transportation.

The concepts of *price elasticity* and *cross-price elasticity* are used to define these relative degrees of change. Loosely defined, price elasticity describes the "amount that demand for a good or service changes following a 1% change in its price." Cross-price elasticity describes the "change in demand for a competing (or complementary) good given a 1% change in the price of the first good or service." For example, price elasticity measures the percent change in transit ridership for every 1% change in fares. In contrast, cross-price elasticity measures the percent change in transit ridership for each 1% change in *auto-related prices* (e.g., tolls).

It is clear that raising the cost of one mode will cause a shift of at least some travelers to another mode, while reducing a mode's price generally attracts some people to that mode. What is less clear is the exact nature of these effects. In general, however, it appears that changing transit pricing will have a relatively small effect on solo drivers. Specifically, lowering transit fares is not likely to attract significant numbers of SOV users. The impacts of changing auto-related costs (primarily through tolls or parking rates), on the other hand, can be substantial, depending on the nature of the change. Researchers have determined that the availability of free parking has the biggest impact on mode choice, while *changing* parking prices will have significant, but lesser, effects.

There is a relatively extensive body of literature related to transportation demand. Many of these studies relate to specific demand analyses used to calibrate mode split and other urban transportation planning models in individual metropolitan areas. In this regard, policymakers looking to coordinate transportation pricing in many U.S. cities may be able to use some general elasticity figures that were derived from local data. It is unlikely, however, that the elasticities developed for these general plans would yield sufficient details to evaluate the full range of possible pricing measures. In Boston, for example, price only enters into the mode split models for approximately 25% of trips that are considered to be for home-based work purposes, and it is unclear even for this group whether the elasticities implied by the model coefficients would reflect traveler responses to anything more than minor pricing changes.

A similar set of demand models developed in 1979 by Harvey and others for transportation planning in the San Francisco area has been used to assess the effects of significant changes in transportation prices. Cameron (1991) includes a description of these models, collectively called the Transportation Incentive Planning System (TRIPS), and shows how they are used in predicting the effects of transportation price changes in the Los Angeles area. The report claims that with minor adjustments, the model has been used successfully in metropolitan areas throughout the United States; the elasticities implicit in the TRIPS models are noted in the sections that follow.

Unfortunately, much of the literature presents price and cross-price elasticities without fully identifying how each was derived and how each should be applied. The often missing information includes the type of elasticity calculation (mid-point, log, or shrinkage ratio), the time-frame for evaluating the results, the level of intermodal competition, and whether the elasticity comes from aggregate demand studies or from discrete choice models. This last item may be particularly important. In most of the aggregate models, the researcher has used empirical time series or cross-sectional data to calculate the demand at different prices. In these cases, direct (own) price elasticities show (for a fare increase) the number of trips reduced on transit; cross-elasticities suggest the number of trips gained by other modes; and the difference indicates the total number of trips lost, that is, trips foregone entirely. With discrete choice models, any trips lost to one mode are (because of the mathematics in these models) distributed among the other identified choices; thus, these models will report no trips as foregone unless "no trip" is among the explicit choices. As "no trip" rarely is a choice, the discrete choice models may tend to exaggerate the cross-price elasticities, whereas the less sensitive aggregate models may underestimate the actual cross-price effects. Note that planners using the standard urban planning process could overcome the lack of a "no trip" option by making selected adjustments to trip generation rates prior to considering mode split.

It should be noted that TCRP Project H-6, *Transit Fare-Pricing Strategy in Regional Transportation Systems,* did not focus on the identification or development of elasticity measures. Two other TCRP projects (TCRP Project H3, *Policy Options to Attract Auto Users to Public Transportation,* and TCRP Project H-4A, *Strategies for Influencing Choice of Urban Travel Mode)* were more specifically concerned with this topic. Nevertheless, it is useful to review the general concepts and findings presented in the literature here in moving toward the development of models/strategies for integrating regional intermodal pricing decisions. The literature on different types of elasticities and the nature of the influence of price on mode choice are presented below.

Price Elasticities for Transit

As reported in the *TCRP Report 10,* "Fare Policies, Structures, and Technologies," transit agencies have used a variety of methods for developing elasticities for use in predicting the ridership impact of a fare change. There are also differences in the application of elasticities; some agencies use a single systemwide elasticity, or perhaps a different figure for each mode. What is becoming increasingly common, however, is to identify a series of elasticities representing the various submarkets making up total ridership. The major types of sources of transit elasticities include the following:

- Time series analysis of the agency's historical ridership data; this often includes a regression analysis to isolate the effects of fare changes from other factors, such as service changes, employment, or fuel prices;
- Before-after ("shrinkage") analysis for a particular fare change;
- Use of a demand function, often based on the results of stated preference surveys (i.e., asking how people would respond to various fare options and changes, or alternatively asking them to "trade off" fare changes with level of service changes);
- Review of industry experience, particularly for agencies of similar size and with similar characteristics; and
- Use of professional judgment in adjusting figures derived from above sources.

There are also various types of elasticity equations; the most common are those known as point elasticity, shrinkage ratio, midpoint arc elasticity, and constant arc elasticity. For small changes (i.e., less than 10%), each formula should produce roughly the same elasticity. However, the midpoint or constant arc elasticity formulas are generally used where larger changes are involved-or where there may be a decrease in some fare categories.

The approach that many agencies take in identifying elasticities is to calculate figures based on their own ridership patterns, and corroborate-and possibly adjust-these numbers based on figures from other properties. This approach is sometimes used for developing market segment elasticities, for instance, based on a single systemwide figure; industry guidelines on ratios of elasticities for different markets-e.g., off-peak ratios are often found to be 1.5 to 2 times peak elasticities-are applied to derive figures for the property.

Despite the range of possible sources and methodologies for identifying elasticities, many transit agencies continue to use the long-time industry standard "Simpson-Curtin Rule." Based on an examination in the early 1960s of a number of fare increases, the formula defines a price elasticity (shrinkage ratio) of transit trips as -0.33. Other work has shown that this is not a constant, and that there is in fact a wide range of price elasticities. The TRIPS model for home-based-work trips, calibrated for Los Angeles conditions, suggests an elasticity of about -0.08, although it is difficult to make a precise inference given the lack of information in the Cameron report about initial conditions for price and other variables. In another study, Goodwin (1992) found an average bus fare elasticity from 50 studies as -0.41. The long-term elasticities are higher than the short-term effects because travelers in the long-run can move or buy a car, whereas they may initially be more captive to the bus.

In what may be the most extensive of the survey reports on transit price elasticities, Lago, et al. (1992) present results from more than 60 studies of elasticities and cross-elasticities. This study disaggregates the effects of price among a variety of conditions and groups, although the actual derivation, magnitude, circumstances, and time frame of the change is not always clear from the text of their review. Another key source of industry experience is an APTA study (1991); *Fare Elasticity and its Application to Forecasting Transit Demand* presented systemwide and peak/off-peak elasticities for 52 U.S. bus systems.

Finally, a key point regarding transit price elasticities is that fare decreases tend to have lower elasticities than do fare increases. This is important because it is likely that a coordinated, regional pricing scheme would look to lowering costs for mass transit instead of raising them.

Cross-Price Elasticities of Auto Use with Respect to Transit Price

Transit agencies have generally sought to keep fares low in part to meet a regional goal of encouraging travelers to shift from auto to transit. There is little evidence that this in itself represents a meaningful rationale for maintaining low transit prices--although there are other reasons, particularly as related to addressing the travel needs of the low-income transit dependent. Domencich and Kraft (1970) concluded that it would be necessary for transit agencies to pay people to lure them from their cars. Lee (1992) suggests that the issue is quite complex, but that the reality is that the cost of auto travel is such a small part of most household incomes that transit cannot be made sufficiently attractive just by lowering its price. It is generally accepted that improved transit *service* qualities are more important than lower fares in attracting auto users to transit, although it is clearly difficult for transit to provide even a near substitute for the qualities of most auto trips.

Of course, since transit agencies seldom lower their fares, the impact of fare *increases* on auto use is of greater importance in the regional context than is a consideration of the effects of fare reductions. When a transit agency raises its fares in order to generate additional revenue, the ridership invariably falls. While a certain portion of this loss is represented by trips that are simply foregone and others shift to ridesharing, many of the trips are clearly taken by auto. The literature review, however, revealed little in the way of estimation of the effects of fare increases by mode. As explained earlier, demand modeling efforts assume shifts of trips lost from one mode (e.g., transit) to the other available mode(s), but these are limited in that they typically assume that no trips are foregone altogether. Meanwhile, the typical analysis of fare-change effects (either projected or after-the-fact) focuses simply on the change in transit trips, without regard to the "redistribution" of the lost trips.

One study that estimated the effect of a fare increase on auto usage was recently completed by the Massachusetts Bay Transportation Authority (MBTA). The MBTA examined the environmental effects of a 1991 fare increase that decreased weekday systemwide ridership by nearly 6%. In the *Draft Environmental Impact Report on the 1991 Fare Increase,* the MBTA estimated that the total increase in regional VMT was 110,685 VMT per weekday (assuming that all lost transit trips shifted to private automobile), or 0.15% of the regional total of 73 million VMT.

The few other studies that have sought to estimate the effects of fare changes on other modes have found the cross-elasticities of auto use with respect to transit prices to be quite low. A study by Glaister and Lewis (1978), for instance, reports the cross-elasticities, shown in Table A-2, for London by peak and off-peak hours.

Lago et al.(1992) found the mean cross-elasticity of auto demand with respect to bus fares is +0.09 ±0.07 (eight cases), and +0.08 ±0.03 (three cases) with respect to rail fares. These studies suggest that the cross-elasticities related to transit fares are significantly lower than the straight fare elasticities (i.e., typically considered to be on the order of -0.3). On the other hand, as shown in these studies, there is some increase in SOV usage, which counteracts regional air-quality goals.

Price Elasticities for Auto Use

The other--and ultimately more significant--component of the transportation price equation is the impact of changes in the price of auto use. Three areas related to auto use pricing have received considerable study: gasoline, parking, and roadway prices. The direct effect on SOV use is considered in this section, and the effect on transit use is considered in the following section.

The literature on demand for gasoline indicates price elasticities ranging from -0.06 to -0.43 in the short run and from -0.07 to -0.93 in the long run. The drop in gasoline consumption is much greater in the long run in part because of shifts in significant changes in trip origins and destinations (people move) that would not have been possible in the short run. This does reflect a drop in VMT. A much more important reason for the greater long-run drop of fuel price elasticity is that the car fleet changes as people buy more fuel-efficient cars. This would lead to a drop in VMT.

Parking pricing can clearly cause significant changes in mode choice and commuting patterns. Kulash (1973) generally receives credit for finding the strongest evidence of the effects of wide scale parking-price increases. Based on his study of a 25% parking tax instituted in San Francisco in 1970, he derived a parking-price elasticity of the number of vehicles parked to be in the range of -0.20 to -0.31. However, the data also showed a marked drop in the average parking duration, thus indicating an even greater effect of the tax than on just the number of trips. With regard to employee parking, Kulash also derived a price elasticity of 0.29 based on a study of Los Angeles employees with and without free parking. Shoup and Willson (1992) found somewhat lower elasticity rates in their examination of five cases of commuter behavior in the presence of free or paid daily parking, with a derived average price elasticity of -0.16.

Shoup (1994) demonstrates that employer-paid parking encourages solo driving to work. On average, employer-paid parking shifts 27% of all commuters into solo driving from other modes and puts 19 more cars on the road per 100 employees. Among solo drivers whose employers offer free parking, 41% drive alone only because their parking is free. (According to the 1990 *Nationwide Personal Transportation Survey,* some 90% of commuters who drive to work have free parking available at their workplace.) Shoup has determined that free parking is often worth more to an employee than free gasoline for the round trip; he further cites Pickrell's (1991) observation that free parking can be worth more than free gasoline *plus* a free car for most commuting trips. In fact, the federal gas tax would have to be increased 16 times to offset the value of the average parking subsidy in downtown Los Angeles. Table A-3, which summarizes data from case studies compiled by Shoup (1994), shows significant increases in the drive-alone mode share when employers paid for parking. The price elasticity of demand ranged from -0.08, in Century City, to -0.23, in Mid-Wilshire, with an average of -0.15. These results updated those from earlier studies by Willson and Shoup (1990) that presented before-and-after data from examples in which employers shifted from free parking for employees to paid. While the computed elasticity for Ottawa remained approximately the same, the elasticities for Mid-Wilshire and Warner Center (a Los Angeles area suburban office center) were considerably higher in the earlier studies, at -0.68 and -0.32, respectively.

Employers have powerful incentives to subsidize the cost of parking (Shoup 1993, CUTR 1993). Employer-paid parking subsidies receive favorable treatment in the federal tax code, benefiting employers and employees. First, as a tax-deductible business expense, the cost of parking is exempted from federal and state income tax, Social Security taxes, unemployment insurance taxes, and all other payroll taxes. Second, the cost of parking is considered a tax-exempt fringe benefit for employees (up to $155 per month). In contrast, the tax-exemption for employer-paid mass transit and ridesharing benefits is capped at $60 per month, less than half the limit for parking benefits. Moreover, employees who pay for parking at work cannot deduct this cost as a work-related expense on their federal income taxes. Among others, the U.S. General Accounting Office (1992) concludes that through these tax policies, which favor employer-provided parking over employer-provided transit benefits, current practice keeps this variable cost below its social/full market cost and thus encourages driving to work.

TCRP Project H-3, *Policy Options to Attract Auto Users to Public Transportation,* presents a comprehensive review of literature that addresses parking and the effects of parking costs on travel behavior. The study first reviews literature in a wide range of areas relevant to modal choices and then focuses in greater depth on the relationship between parking factors and travel decisions. For example, the authors cite two studies that estimate the price elasticity of demand for parking as a relatively inelastic -0.31. Nonetheless, one of these studies found that parking costs have a more important impact on mode choice of commuters than vehicular operating costs.

The unpublished TCRP Project H-3 Interim Report also cites the response to various travel pricing measures for five individual cities, based on studies by DHS and ECO Northwest, Inc., using STEP modeling. The estimated impact of a $3.00 employee parking charge on the number of trips taken in these cities is as follows:

- Los Angeles: -2.0% change in trips,
- Sacramento: -2.1% change in trips,
- San Diego: -2.0% change in trips,
- San Francisco: -1.3% change in trips,
- Seattle: -2.4% change in trips, and
- Average: -2.0% change in trips.

If a typical commute averages 12 mi each way at operating costs of $0.25 per vehicle mile, this charge would constitute a 50% increase in out of pocket costs. The implied elasticity of out of pocket parking costs on total trips is -0.04.

The unpublished TCRP Project H-3 Interim Report also notes that the effect of tax-induced increases in parking charges depends on the elasticity of demand for parking, which determines how much of the increase is borne by the user and how much by the supplier. Moreover, reduced parking supply may or may not affect transit use because parking may shift to other locations without shifting travel to transit unless all areas are incorporated in a comprehensive parking plan. For example, higher costs or restricted supply of off-street parking may result in greater on-street parking in nearby residential areas unless a permit program is instituted simultaneously. The study also addresses the equity issues associated with increased travel costs such as higher parking fees.

Shoup (1994) has proposed a program for *cashing out* parking subsidies, whereby employees would receive a taxable cash travel allowance to use for parking, transit, carpooling, or other modes. Shoup estimates that cashing out employer-paid parking subsidies would have the following effects on automobile commuting to downtown Los Angeles:

- Reduce the solo driving share from 69% to 55%,
- Reduce the number of vehicle trips to work by 9,000/day,
- Reduce the demand for parking by 9,000 spaces,
- Reduce VMT for work trips by 285,000/day,
- Reduce gasoline consumption for automobile commuting by 3.5 million gallons/year, and
- Reduce the total cost of automobile commuting by $40 million/year (17%).

Besides parking prices, the other key focus in the literature is road pricing, including tolls and congestion pricing strategies. There are no areawide road pricing schemes in the United States from which to draw relevant empirical evidence of the effect of this approach on auto demand. The TRIPS model estimates that a $.15 per mile average fee on southern California roads, with traffic volumes approaching capacity, would yield a 5% drop in VMT, and a 3.8% drop in trips. Lack of information on which roads and what drivers would

TABLE A-2 Cross-elasticities in London for pk-hr service

Price Change		Change in Peak Auto Use
Bus	Peak	.025
	Off-Peak	.0016
Rail	Peak	.056
	Off-Peak	.0034

TABLE A-3 Change in SOV mode share in response to parking charges

	Who Pays for Parking			
Case Study Location	**Employer**	**Driver**	**Change**	**Elasticity**
Mid-Wilshire (LA)	42%	8%	-76%	-0.23
Warner Center (LA)	90%	46%	-49%	-0.18
Century City (LA)	92%	75%	-18%	-0.08
Civic Center (LA)	72%	40%	-44%	-0.22
Downtown Ottawa (Ontario)	35%	28%	-20%	-0.10
Washington (DC)	72%	50%	-31%	-0.13
Downtown Los Angeles	69%	48%	-30%	-0.15
Average	67%	42%	-37%	-0.15

Source: Shoup 1994

be affected by these costs prevents the calculation of an elasticity covering this impact. Among other studies, Wuestefeld and Regan (1981) reviewed the effects on certain toll roads and found the elasticity of use with respect to toll increases to range from -0.03 to -0.31, with the largest changes appearing to be on the shortest roads. The longer roads in their study (such as the Pennsylvania Turnpike) would have the lowest elasticities because they offer the fewest alternative routes and the greatest time savings. The New York Regional Plan Association estimated that the toll authorities would have to charge $10.00 per vehicle in order to reduce peak-period traffic delays at the Hudson River tunnels between New Jersey and Manhattan. It is possible, however, that this analysis does not account for changing price elasticities with higher tolls. According to the Golden Gate Bridge and Transit District in San Francisco, the agency charges a $3.00 toll and estimates the effects of further changes with an elasticity of -0.10. Ten years ago, when the toll was $1.00, the District used an elasticity of -0.01.

The relatively low elasticities of auto trips with respect to price raises a common perception among analysts that imposition of small fees has little impact on travel behavior. However, Shoup (1994) demonstrates that the mode shifts in response to changes in parking price are quite significant despite the low derived elasticities. Table A-3 shows that charging for parking (on average) reduced the share of solo driving from 67% to 42%, a decrease of 37%. Similarly, eliminating the parking subsidy reduced the number of cars driven to work from 72 to 53 per 100 employees, on average, a 26% decrease. He characterizes these shifts as "enormous" in comparison to results obtained from other transportation demand measures, such as free transit passes or guaranteed rides home for carpoolers.

Bhatt (1994) proposes congestion pricing for the Washington, DC, region and discusses which facilities would be priced as well as attendant issues such as operation and enforcement, legal impediments, feasibility and acceptance, and institutional issues. He presents a quick and rough estimate of potential effects of 4.0-12.0 million reduction in daily VMT, a 10-15 min reduction in average round-trip travel time, and 10-30 fewer tons per day in volatile organic compounds. These benefits are based on an assumption of program coverage of major corridors within a 700 sq mi area, served by 250-300 pricing points, charges of $0.15/VMT during the 6:30-9:30 a.m. and 3:30-6:30 p.m. peak travel periods, and 4-5 million vehicle trips per day facing charges. He notes the need to coordinate policies to prevent spillover into neighborhoods, and suggests that bus transit using HOV and other tolled roadways would benefit from reduced congestion, attracting greater ridership.

In an earlier study, Steiner (1992) drew analogies from other industries--in this case, electric utility demand-side management. She concluded that congestion pricing gives proper price signals through its effect on variable costs of driving but that price inelastic demand of commuter traffic, political barriers, and equity considerations will make implementation difficult. For example, she cites studies that indicate commuter willingness to pay tolls as high as $0.25/mile to save time. (Note that, by implication, demand is only "inelastic" if *some drivers* get off the road so the remaining paying drivers can save time.) She also notes that any transportation demand management policy must be implemented uniformly throughout a region to achieve its intended objectives.

Cross-Price Elasticities of Transit Use with Respect to Auto Price

While numerous studies have shown that increasing the costs of driving has reduced the share of drive-alone commuting, the effects on transit use are less clearly understood. Raising the price of auto travel will lead some motorists to shift to transit, but the greatest effect of a price increase--assuming that the price change is noticeable at all--would likely be in the growth of ridesharing or simply fewer trips. Nevertheless, the relative proportions of trips taken by transit versus auto is so lopsided in most areas that a small percentage of auto trips lost to transit would mean a much larger percentage of transit trips gained from auto. (Regarding elasticity assumptions, Lago reports that the mean cross-elasticity of transit demand with respect to total automobile costs is +0.85.)

Willson (1992) used data from a 1986 mode-choice survey of downtown Los Angeles office workers in a logit model for mode choice and parking demand. He estimated that elimination of free parking would reduce SOV share from 72% to 41%, increase carpool share from 13% to 28%, and double the transit share from 15% to 31% of employee travel. The computed cross elasticity for transit was +0.35.

Kain (1994) looks at the relationship between congestion pricing (or comparable increases in driving costs) and mode choice in some detail. Because they have generally not addressed the effects of congestion pricing on transit use, Kain believes, "previous analyses and discussions have very likely underestimated the shift to transit that would take place with the implementation of congestion pricing and overestimated the level of tolls that would be required to achieve desired congestion levels." (Kain, p. 531) He attributes this lack of analysis to two factors: "(a) the effects are complex and (b) obtaining estimates about the effects of congestion pricing on transit use requires detailed and explicit assumptions about both the level of congestion tolls and their effects on the speeds of roadway segments that are used by transit vehicles."

As suggested above, since transit accounts for only a small percentage of peak-period trips, even a small percentage shift from SOVs to transit would have a significant impact. Kain concludes that "...the increases in transit ridership that would result from implementation of congestion pricing would greatly increase transit deficits and create serious fiscal problems for already hard-pressed local governments, who currently directly or indirectly fund the bulk of operating losses." (Kain, p. 533)

Implementing congestion pricing would make transit and carpooling more attractive. First, solo driving would become more expensive in relation to high-occupancy modes. Second, reducing roadway congestion will improve trip times and reliability for these alternative modes. (Even rail trips with exclusive rights of way would benefit from improvements in road-based passenger access.) Third, as Shoup (1994) also points out, congestion pricing would increase the number of potential carpool matches as more commuters seek alternative modes. Finally, if transit demand increases sufficiently, transit operators might respond by expanding service frequencies and route coverage--thereby further increasing transit demand.

In general, the relationship between transit and carpooling is not well understood. Shoup (1994) hypothesizes that cashing out parking would "reshuffle cars and commuters in some surprising ways." Not only would carpooling increase, but this shift could increase the number of people commuting to work in automobiles, especially if former solo drivers recruit transit passengers for their new carpools. Moreover, if transit passengers shift to carpools, cashing out parking could reduce peak-hour transit ridership.

Finally, DeCorla-Souza and Gupta (1989) explore the effect of auto pricing and transit policies (including HOV) working together to shift travel demand to higher occupancy transportation. In their analysis, they used computerized travel models to forecast mode choice under several alternative policies. For example, under a transit-preferential strategy, which included high-level peak-period transit supply and pricing policies to encourage transit (reduced fares) and discourage auto use (tolls and parking charges), they forecast a 35% contraction in peak-period SOV work travel in the year 2010 compared to a traditional context. They forecast that policies focusing only on ride-sharing would be less effective and that a combination transit/ride-share strategy would divert more travelers from SOV, though transit would capture fewer of these than under a transit-only focused strategy. This study was instrumental in the development of transit and ridesharing policies in Toledo, Ohio's Year 2010 Transportation Plan to ameliorate congestion anticipated for the area.

A.3 MODELS FROM OTHER INDUSTRIES

Finally, it may be instructive to review how other industries have used pricing to affect demand among alternative or complementary commodities or have used total cost analysis to assist in planning. None of these use models/strategies that would appear to be directly transferable to the development of intermodal public transportation pricing approaches, because of, for instance, the large number of decisionmakers/stakeholders involved in the regional transportation setting. Other industries, however, provide certain conceptual frameworks, as well as lessons, that should be considered in making regional transportation pricing decisions. Utility industries are the richest source of relevant information, and the telecommunications industry has long experience with utilizing pricing to affect demand and to accomplish social goals. Electric and gas utilities in particular have experience with time-of-day pricing, and are leaders in the use of total cost analysis to assist their long-range planning and pricing.

With regard to the relevant literature in this area, Gillen (1994) examined several industries/markets for lessons regarding the feasibility and implementation of time-of-day road pricing. These industries include electric utilities, telecommunications, airport runways, and transit. All of these markets showed that pricing can be effective in influencing demand. They also provide some important general lessons regarding implementation of pricing strategies. One lesson is that the handling of equity and social issues is a key factor in the public acceptance of new pricing approaches. In all the markets, there was a recognition that there needed to be a balance between accomplishing social goals (e.g., providing telecommunications and utility service to low-income individuals) and obtaining the most efficient pricing strategy. A second lesson was that, in all the markets, institutional changes led the move to more efficient pricing. Gillen concludes that the introduction of road pricing may therefore need to be preceded by some institutional change "that distances roadway managers (and price setters) from government and politicians" as this would affect "both manageability objectives and the public attitude to road pricing as a tax grab" (p. 148).

As suggested above, the electric and gas utilities have made extensive use of total cost analysis to make decisions regarding investments and pricing. The total costs are summed as of one or more target dates--assuming that no changes are made by the utility. Following this, the effects of a range of supply- and demand-side measures on total costs are analyzed, separately and in combinations. The supply-side measures include capacity increases, while the demand-side measures include changes in pricing to affect the level and timing of demand, as well as actions such as providing discounted installation of insulation.

Air pollution credits are another area that may provide a conceptual model for transportation and transit pricing. The basis of this strategy is that every company in an area is required to produce no more than a certain level of specific pollutants. If the company produces less pollution, it can sell its remaining "right to pollute" to another company in the area. In addition, the government also sells a limited amount of pollution rights. This represents a change in philosophy from relying exclusively on non-market mechanisms (i.e., limits on the production of pollutants) to combining this with the use of pricing. A great deal has been written to date about how this approach should operate; however, the strategy is still new and there has been little analytical work regarding the extent to which actual operations have matched with expectations or, regarding lessons to be learned, for adding pricing to an environment currently limited only by non-market mechanisms.

Overall, it is apparent that HOV (including transit) demand can be significantly influenced by changes in auto-related costs, especially parking prices. While the effect is apparently smaller, changes in transit fares also affect the use of SOVs. These relationships represent key principles underlying the argument for pursuing intermodal pricing:

- Transit ridership grows from increases in parking and roadway costs, thereby leading to lower congestion and pollution.
- Increases in transit fares lead to greater solo driving and greater congestion and pollution.

Developing any type of regional pricing coordination will therefore require, first of all, the establishment of consensus (i.e., among transit agencies and stakeholders affected by auto-related charges) regarding (1) the overall transportation goals in a region and (2) a commitment to work toward these goals cooperatively. Such coordination might take the form of integrated planning for price changes or cross-subsidization of modes.

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APPENDIX B

EXAMPLES OF SELECTED TRANSIT PRICING AND SUBSIDY PROGRAMS

This appendix presents examples of integrated transit pricing arrangements, findings regarding the effects of employer fare-subsidy programs, and selected incentive programs for promoting employer fare subsidies.

B.1 INTEGRATED TRANSIT PRICING

Reviewing the specific experience of transit operators related to the coordination of pricing and fare payment/collection arrangements can illustrate some of the issues involved in developing and implementing coordinated intermodal pricing strategies. Included below are examples of (1) interoperator agreements permitting transfers between adjoining transit properties and (2) integrated fare payment among multiple operators.

Inter-Operator or Intermodal Pass or Transfer Agreements

In many regions having multiple transit operators, individual operators have established formal arrangements with other operators allowing the mutual acceptance of certain types of fare media. Examples of three different approaches are summarized below.

Chicago. Two types of cooperative approaches have been in place in the Chicago area. The Chicago Transit Authority has had separate agreements with the other two transit operators in the region: Metra (commuter rail) and Pace (bus and van service outside of Chicago). CTA and Pace have traditionally priced their passes the same and accepted each other's monthly passes. Metra has offered a CTA "link-up pass" that allows use of CTA as well as Metra; this pass requires payment (in addition to the regular Metra pass price) of half the price of the CTA monthly pass. Of course, these agreements have been facilitated largely by the fact that all three properties fall under the aegis of an umbrella agency, the Regional Transportation Authority (RTA).

Orange County (CA). An example of such arrangements between properties *not* linked through an umbrella agency can be seen in Orange County. The Orange County Transportation Authority (OCTA) and the Metrolink commuter rail service offer a free transfer to/from the other service with presentation of some form of prepaid instrument. OCTA has somewhat different arrangements with other connecting operators; a discounted fare ($0.30) is paid for transferring to/from Amtrak commuter rail, while interagency transfers with other transit systems are either free (e.g., North San Diego Transit District, La Mirada Transit) or $0.10 (e.g., Los Angeles County Metropolitan Transportation Authority, Long Beach Public Transportation Co.). OCTA negotiates separate agreements with each property.

Southeast Florida. Four transit properties in Southeast Florida (Metro-Dade Transit Agency, Broward County Transit, Palm Beach County Transportation Authority, and Tri-County Commuter Rail) executed a Memorandum of Understanding regarding the fares on the commuter rail (Tri-Rail) and connecting bus and rail service. The agreement stipulates that "...no fare will be charged for any route established solely to service the Tri-County Commuter Rail service." Tri-Rail in turn provides payments to each of the three local operators; the payments are based on each property's farebox recovery ratio. The three local operators also have separate agreements among themselves, requiring different transfer/upgrade fares between intersecting services (i.e., Palm Beach and Broward, and Miami and Broward). Finally, in an effort to move toward more comprehensive regional integration, the Center for Urban Transportation Research (CUTR) conducted a *Fare Coordination Study* (1994) designed to consider other fare coordination approaches for the four properties. CUTR recommended a range of strategies, including standardizing fare policies and offering more convenient regional media (e.g., a Daily Regional Pass and a Multi-Agency Pass).

Integrated Fare Payment

Beyond the types of inter-local agreements regarding acceptance of fare media described above, several regions have begun to develop comprehensive fare integration programs involving multiple operators. This has been approached through either an institutional strategy or a technological strategy. Two examples of regional integration efforts now underway are described briefly below.

San Diego. The San Diego region has achieved regional fare integration by establishing a uniform fare structure for the region's operators. Most of the region's fixed-route operating entities have banded together to form a "federation" of transit service providers called the Metropolitan Transit System (MTS); the purpose of MTS, and the related MTS symbol, is to identify this unified transit system to the public. The MTS includes bus and light rail (San Diego Trolley) service. The Metropolitan Transit Development Board (MTDB) serves as the policy setting and overall coordinating agency for public transportation in the metropolitan area. MTDB, as the state designated regional transportation coordinating agency, took the lead in establishing fare integration and developed the Uniform Fare Structure Agreement in conjunction with the San Diego Association of Governments (SANDAG). This agreement applies to fixed-route operators only, although dial-a-ride operators participate in the agreement, and extends beyond the jurisdiction of MTDB to include the North San Diego County Transit Development Board bus and commuter/express rail (Coaster) services. The basic elements of the agreement, which is updated annually, are that it does the following:

- Establishes a uniform fare structure for the region, providing a coordinated transit system in a multi-operator environment;
- Establishes a regional transit pass valid for travel on all fixed-route services in the San Diego region, and establishes a formula for distribution of pass revenue; and
- Establishes a regional policy of free transfers between equal or lower levels of service and sets upgrade fares for transfers to higher levels of service.

The methodology for allocation of revenues from passes and other prepaid media is that the participating operators submit monthly summaries of rides taken with prepaid media (as well as transfer upgrades) to SANDAG, which then determines the relative proportions of revenue for each operator. Based on these proportions, MTDB then pays each operator its portion.

San Francisco Bay Area. TransLink is a program designed to institute a common-use stored-value fare card for multiple transit properties in the Bay Area. It will allow the passenger to use a single fare card on any of the participating systems, on both bus and rail (BART, Muni, and Santa Clara Valley). A central clearinghouse will be established to handle card management (issuance, distribution), revenue management (collection, reconciliation, and settlement), and ridership tracking. The program was initiated and has been developed by the Metropolitan Transportation Commission and its partner properties. The initial TransLink ticket was a magnetic-stripe stored-value ticket, and was tested at BART and on two bus systems (CCCTA and BART Express). The technology basis of the program, however, has been reevaluated by MTC and the individual agencies; the program is now being developed based on "smart card" technology.

B.2 EFFECTS OF SUBSIDY PROGRAMS

As discussed in Chapter 2, many employers subsidize transit usage to some extent, either through regional transit vouchers or distribution of monthly passes. Both programs offer a way to help equalize the effects of free or heavily discounted parking, as well as to offset the effects of a transit fare increase. Consequently, subsidy programs are important to consider in reviewing transit-pricing elements.

The effects of fare-subsidy programs vary among cities and employment sites. Effects of fare subsidies will vary according to fare levels, pre-existing transit use, transit service levels, employer size, parking availability, required co-payments, and the level of subsidy. Findings from recent studies of the effects of transit voucher programs are presented below.

New York. Three studies have been done of the effects of New York's TransitChek program, although the results of the most recent effort are not yet available. The first, a survey of employees at the first 500 employers to enroll, was done in 1989, when the maximum subsidy level was $15.00 per month. This study generated responses indicating that transit use had risen by 17% and that auto use had decreased by 16%. The second New York study, which used essentially the same methodology as the first, assessed the impacts at one major employer-The Port Authority of New York and New Jersey. This second study was done in 1990 and yielded these results (basically corroborating findings of the first study): transit ridership was found to rise by 22% for commuting trips and 21.5% for non-commuting trips, and vehicle (auto and taxi) use was found to fall by nearly 23% for commuting trips and 21.5% for non-commuting trips. Among Port Authority employees, roughly two new transit trips were created each month for each $15.00 voucher redeemed.

Milwaukee. The Milwaukee County Transit System (MCTS) Commuter Check Program began in 1991. MCTS uses $7.00 and $9.00 vouchers for its program, because it has only weekly passes. The lack of monthly passes had generally precluded pass subsidies before the voucher program began. Having low denomination vouchers, Milwaukee employers have the option of providing subsidies of different levels, such as $7.00, $14.00, $21.00 or $28.00 a month. (The $9.00 voucher began late in 1994, after an MCTS fare increase.) MCTS has tracked impacts of Commuter Check at four employers, each with different subsidy factors. At the employer (a downtown bank) that subsidizes $7.00 a month, MCTS reports that ridership grew by 16%. At a medium-sized law firm that subsidizes $14.00 a month, ridership grew by 26%. At a major utility, where the parking price rose from $20.00 to $40.00 a month at the same time that transit fare subsidies of $21.00 a month began, transit use rose 81%. Finally, at an insurance company that began monthly subsidies of $21.00, with no change in parking prices but some concurrent increases in company employment, transit ridership also rose more than 80%.

San Francisco. In late 1994, the Metropolitan Transportation Commission (MTC) performed a thorough study of the impacts of the Bay Area Commuter Check program by sending surveys to employees at 239 of the employers that had purchased vouchers. These employers were essentially all the firms that had purchased vouchers between October 1992 and April 1994 and remained active in the program. The Bay Area program began in September 1991, and through March 1995, more than 700 employers had purchased Commuter Checks. The Bay Area's survey results are still being analyzed, but some initial results were obtained. The overall results of the survey are consistent with the findings noted above, but extend further. Key findings of the survey were as follows:

■ More than one-third of the recipients of Commuter Checks report riding increases, with more occurring at employer locations outside San Francisco. Transit *commuting trips* were calculated to rise by 31% for the full study, 25% at San Francisco employers and 48% at employers outside San Francisco. *Non-commute trips* were found to grow by 29% for the overall survey, and grew slightly more in San Francisco than outside the city.

■ The overall increase in transit trips (including both commute and non-commute trips) was calculated to be 3.24 trips per week (3.03 in San Francisco and 3.74 outside the city). As roughly 10,000 people received Bay Area Commuter Checks per month in 1994, the added trips suggest Commuter Check generated about $1.6 million of new transit revenue in 1994. As program growth is expected to increase average participation to 15,000 employees per month in 1995, the current increment in transit operator revenues is estimated at $2.4 million.

■ Nearly 60% of all employees surveyed reported that they receive a $20.00 Commuter Check each month, with 29% receiving a $30.00 Commuter Check and 12% receiving more or a different level. Yet, surprisingly, there was no correlation between the Commuter Check value received and amount of induced usage. The *fact* that fares are discounted may have more impact than the *level* of the discount.

■ Those who reported transit riding increases for commute trips represented 33.8% of all respondents; 66.2% reported no increase. In looking at the results, it is evident that those who increased their use of transit for work trips had been riding at lower frequencies than the overall sample. This is entirely logical, given that those already riding regularly had less opportunity to further increase their use. Yet, these data also suggest that the "first dollars" of subsidy may be far more important than the last dollars, as regards new transit trips induced, and that considerable reduction in auto trips could result from very nominal subsidies on a far more widespread basis.

■ Further analysis of the Bay Area data is now ongoing. Refined understandings are expected to arise as the data are further disaggregated by the dollar amount of subsidy received, the geographic locations of the employers, the reported increases in transit usage, and other factors.

B.3 STATE AND LOCAL PROGRAMS PROMOTING EMPLOYER FARE SUBSIDIES

A number of cities and states have introduced tax credit and incentive programs promoting the use of employer fare subsidies. Selected examples are described below.

Southern California Emissions Reduction Ordinances

The city of Los Angeles and the South Coast Air Quality District in California have evolved through several versions of emission reduction ordinances, including provisions for employer transit fare subsidies. In 1988, the Los Angeles City Council adopted an ordinance that required employers with 100 or more employees to offer a $15.00 transit fare subsidy to all employees using (or interested in using) transit to commute to work, if the employer offered free or subsidized parking to any employee. By 1990, the administration of this program was integrated with the progressive implementation of Regulation XV, which applied to the four counties in the South Coast Air Quality Basin. Regulation XV was a mandatory employee trip-reduction program. In 1995, in response to a prohibition on mandatory trip-reduction plans by the California legislature and amendments to the federal Clean Air Act that permit equivalent emissions reduction strategies, the South Coast Air Quality Management District rescinded Regulation XV and and its successors, Rule 1501 and Rule 1501.1 and replaced them with Rule 2202, a nonmandatory trip-reduction program. Rule 2202 permits a variety of options for employers: (1) emission reduction strageties, such as old vehicle scrapping, clean on-road vehicles, clean off-road vehicles, remote sensing, and other approved efforts; (2) the Air Quality Investment Program (AQIP), a per employee payment into a special fund for emission-reduction projects; and (3) an employee commuter-eduction program known as employee ridesharing. Ridesharing includes car and van pooling, bus and rail programs (which include transit fare subsidies), bicycle programs, and walking programs.

In September 1996, SB 836 was enacted into law by the California legislature, providing an approach for the gradual replacement of mandatory Rule 2202 with a voluntary program. Under SB 836, worksites with 100 to 249 employees are no longer required to comply with Rule 2202 for a demonstration period of 18 months. The ultimate replacement of Rule 2202 depends on whether the voluntary program can achieve equivalent emissions reductions compared with what would have been achieved had the exempt worksites remained regulated. SB 836 also includes demonstration funds for marketing activities in support of voluntary ridesharing efforts, which may include transit fare subsidy projects.

Proposed New York City Fare-Subsidy Ordinance

In 1994, a New York City Council bill was introduced to require city companies that pay for employee parking to offer the full $60.00 transit benefit to its workers.

Connecticut Matching Subsidy Program

The Connecticut Department of Transportation is providing matching subsidies for employers that provide employee fare discounts. The state is matching subsidies for train, bus, or vanpool commuting at $1.00 for every

$2.00 of employer expenditures. The monthly maximum is $20.00 per employee (equaling $60.00 of total monthly subsidy per employee), and the maximum subsidy period is 1 year.

California Tax Credits

Employee fare subsidies are eligible for tax credits, based on a sliding scale related to the provision of free or subsidized parking. If the employer provides no free or subsidized parking, 40% of the fare-subsidy expense is eligible for the tax credit. If the employer provides only subsidized parking, 20% of the fare subsidy expense is eligible for the tax credit. If the employer provides free parking, 10% of the fare subsidy expense is eligible for the tax credit. The costs of vans purchased for employee vanpools is also subject to a 20% to 30% tax credit. Between 1990 and 1993, 941 companies filed for a total of roughly $718,000 in tax credits.

Connecticut Tax Credits

A fixed sum maximum total tax credit was budgeted for 1994 by the Connecticut Legislature at $1.5 million, and is expected to raised to $3 million in 1995. The tax credits are available for eligible ECO-related implementation costs. The implementation of this program was delayed, with reporting forms for the 1994 tax credits not provided until spring 1995.

Delaware Tax Credits

The TraveLink Tax Credit Act was passed in 1989. It allows employers of 100 or more to be eligible for direct tax credits for allowed expenditures supporting traffic mitigation efforts. It functions as a dollar-for-dollar credit toward state tax credits owed.

New Jersey Tax Credits

For eligible ECO program costs (items included in a state-approved ECO compliance plan for the company), up to $36.00 per employee in 1994 and $72.00 per employee in 1995 may be claimed by employers as a credit against state taxes. While eligible expenses could include many other types of program costs, the maximum tax credit amounts were set as 5% and 10% respectively of the $720 per year maximum tax-free benefit that employers can provide to their employees to subsidize travel.

APPENDIX C

APPLICATION OF INTERMODAL PRICE COORDINATION IMPACT ASSESSMENT METHODOLOGY

C.1 HYPOTHETICAL EXAMPLE--INTRODUCTION

To illustrate the use of the conceptual approach proposed in this project, a hypothetical example was developed. The project final report describes a coordinated intermodal pricing strategy for the hypothetical Gotham City region. Gotham City was identified as a large midwestern city located on Lake Gotham. The region's transportation characteristics can be summarized as follows. The Metropolitan Gotham Transit Authority (MGTA) operates a multimodal system, comprising bus and rapid rail transit. The annual operating budget is about $200 million. Population of the service area is approximately 2 million. The MGTA service area includes Gotham City and the suburbs of Alfred, Gordonville, and Robinwood. The MGTA Board of Directors includes representatives from these municipalities and three members appointed by the Governor. The Gotham Turnpike Authority (GTA) operates both the Gotham Turnpike and the toll bridge over the Wayne River. The state DOT has responsibility for all other highways. The Gotham Metropolitan Planning Organization (GMPO) includes representatives from Gotham City, its suburbs, MGTA, GTA, and the State Highway Department.

The final report explained that, like many older midwestern cities, Gotham is losing population, jobs, and retail activity to its surrounding suburbs. Transit is unable to serve these new suburban markets effectively, and regional traffic is growing as a result. Traffic congestion is particularly noticeable on the Wayne Bridge. MGTA receives federal, state, and local assistance, but has no dedicated funding source. Recent fiscal circumstances have forced the state to reduce its operating assistance, and the MGTA faces a shortfall of $5 million next year.

The GTA's Wayne River toll bridge charges a $1.00 toll, collected in both directions throughout the day, while MGTA fares are also $1.00 for buses and trains systemwide. Both GTA and MGTA have decided independently to increase the bridge toll and transit fares to raise additional revenue, and the GMPO has led the effort to analyze the effects of price changes on commuting behavior and agency revenues. This appendix describes the details, including underlying assumptions, of the analysis of potential ridership and revenue impacts associated with various actions or strategies (i.e., several possible fare/toll combinations).

C.2 PRICE AND CROSS-PRICE ELASTICITIES

To perform this analysis, GMPO planners first made assumptions regarding transit and auto demand elasticities with respect to transit and auto price changes. As indicated earlier, a *price* elasticity of demand represents the percent change in demand for a transportation service given a 1% change in the price of that service. A *cross-price* elasticity of demand represents the percent change in demand for a transportation service given a 1% change in the price of a *competing* service. Table C-1 shows typical values and ranges of values for price elasticities and cross-price elasticities of demand with respect to the competing services of automobiles and transit. The data in this chart summarize the results of the elasticity research reviewed in Appendix A, and were used by GMPO to determine appropriate estimates for the pricing changes under analysis.

GMPO, which believed that the "average" value for the price elasticity of demand for transit service with respect to transit fares (upper left quadrant of Table C-1) was appropriate in this case, used the corresponding value of -0.30 in its analysis. As explained in Appendix A, and as evident in Table C-1, *cross-price* elasticities *(between* transit and auto modes, as represented by the upper right and lower left quadrants in the table) have received much less research attention than *price* elasticities, and therefore required additional judgment on the part of GMPO planners to determine appropriate values in this case. Recognizing that there is rail transit service in the MGTA system, a cross-price elasticity of 0.06% change in auto demand (which is within the empirically determined "rail travel" range) with respect to a 1% change in transit fare was chosen. Data on cross price elasticities of transit demand with respect to auto costs were even more scarce, so the GMPO decided to test two estimates in order to establish a range of likely outcomes. The "low" cross-elasticity estimate used was 0.20, while the "high" value was 0.60. Finally, a price elasticity of auto demand with respect to auto costs was estimated from the range given for "toll" based costs. The upper limit (-0.31) reflects empirical evidence from road facilities with abundant travel alternatives (including other streets and transit services) and the lower value reflects a road with limited alternatives (such as a bridge). Because the toll facility in question is a bridge and because transit service alternatives are available, an intermediate value of -0.20 was chosen for this elasticity.

C.3 ESTIMATED EFFECTS OF ALTERNATIVE PRICING STRATEGIES

Under present conditions, 55 million vehicles use the toll bridge annually, while 70 million trips are made on MGTA buses and trains per year (approximately 14 million of which occur in the toll bridge corridor). Table C-2 summarizes the results of GMPO's entire analysis and Tables C-3 through C-5 detail the methodology that the GMPO planners used to determine the impacts of various pricing strategies in a worksheet format; the same basic

TABLE C-1 Empirically estimated values for price and cross-price elasticities*

	% Change in Transit Demand		% Change in Automobile Demand		
			low range	high range	
1% Change in Transit Fare	-0.10	home to work commute	0.03	0.08	rail travel
	-0.15	rail travel	0.07	0.09	bus travel
	-0.20	peak period			
	-0.30	average			
	-0.35	bus travel			
	-0.40	off peak travel			
			low range	high range	
1% Change in Auto Costs	0.35	parking fees	-0.06	-0.43	gas tax (short range)
	0.85	average total auto costs	-0.07	-0.93	gas tax (long range)
			-0.10	-0.23	parking fees
			-0.08	-0.27	(downtown)
			-0.03	-0.31	parking fees (suburban)
					tolls

* See Appendix A for sources of these values

methodology was used (with different input variables and results) to analyze alternative pricing strategies.

Initially, MGTA arranged for the GMPO to conduct an analysis of the impacts of increasing fares to $1.10 systemwide--assuming GTA tolls would remain the same. In the Table C-3, Scenario 1, the current conditions were identified as described above, and current passenger and toll revenue was determined to be $70 million and $55 million, respectively ($1.00 per passenger or vehicle). The transit fare increase was calculated to be 10%, while the toll charge remained the same. The demand elasticities described above were entered into the worksheet, and the corresponding changes in transit and auto demand were calculated based on these elasticities and the change in transit fare and auto cost. Note that since there was no change in auto cost in this analysis, there was also no change in the components of transit and auto demand related to auto cost. In this case, the non-toll corridor and toll corridor commuters were affected equally by the transit fare increase, but in potential scenarios where a toll is added, that cost will only affect the subset of commuters in the toll corridor. Therefore, the impacts on travel behavior were calculated for both the toll corridor *and* the overall transit system area. These results and their corresponding revenue implications are detailed at the bottom of Table C-3.

Although this initiative would provide most of the $5 million needed to balance the MGTA budget, the MPO officials were discouraged that raising transit fares would decrease annual transit ridership by more than 2 million passengers systemwide and increase automobile traffic in the toll bridge corridor by more than 300,000 vehicles annually--conditions that ran counter to their regional transportation and clean air goals. However, GMPO soon learned that GTA would be raising tolls on the Wayne River Bridge to $1.25, and conducted a new analysis of the impacts of increasing *both* tolls and fares. As summarized in Table C-2, the combined toll and fare increase (Scenario 2) raised more than the requisite $5 million for MGTA. It also reduced the projected overall loss of transit riders resulting from a fare increase alone and decreased congestion on the toll bridge. When the low estimate of the cross elasticity of transit demand with respect to auto use was assumed (Table C-2, box A), annual transit ridership was off by 1.4 million systemwide, but up by nearly 300,000 in the toll corridor, while traffic on the bridge was thinned by almost 2.5 million vehicles. Using the high estimate of the cross elasticity of transit demand with respect to auto use (Table C-2, box B), more than 1.6 million transit trips were added in the toll corridor-nearly canceling out the ridership loss experienced by the remainder of the system. A worksheet detailing the calculations involved in Scenario 2 is presented in Table C-4.

The outcome of the combined increase strategy prompted the MPO planners to consider the implications of a coordinated intermodal pricing strategy whereby transit fares would remain at $1.00 and toll bridge users would pay $1.35 (a $1.25 toll with a $0.10 congestion mitigation and transit enhancement "surcharge"). In this plan (Scenario 3), the excess toll revenues (above that which would have accrued from a $1.25 toll) would be used to meet the revenue goals of MGTA, while further reducing congestion on the toll bridge and *increasing* transit ridership. To perform this analysis, GMPO first calculated the impacts of a $1.25 toll with no fare change or transit

TABLE C-2 **Impacts of alternate intermodal pricing strategies in Gotham City**

A: Low Cross Elasticity of Transit Demand with Respect to Auto Cost	**Baseline**	**Scenario 1**	**Scenario 2**	**Scenario 3**	
		Toll Same, Fare Increase	Toll Increase, Fare Increase	Toll Increase, Fare Same	Toll Increase plus Surcharge, Fare Same
Toll:	$1.00	$1.00	$1.25	$1.25	$1.35
Transit Fare:	$1.00	$1.10	$1.10	$1.00	$1.00
Change in Annual Toll Bridge Trips	*0*	*330,000*	*-2,420,000*	*-2,750,000*	*-3,850,000*
New Annual Toll Bridge Trips	*55,000,000*	*55,330,000*	*52,580,000*	*52,250,000*	*51,150,000*
New Annual Toll Revenue:	$ 55,000,000	$ 55,330,000	$ 65,725,000	$ 65,312,500	$ 69,052,500
Change in Annual Transit Trips - Toll Corr.:	*0*	*-417,900*	*278,600*	*696,500*	*975,100*
New Annual Transit Trips - Toll Corr.:	*13,930,000*	*13,512,100*	*14,208,600*	*14,626,500*	*14,905,100*
Change in Annual Transit Trips - Overall:	*0*	*-2,100,000*	*-1,403,500*	*696,500*	*975,100*
New Annual Transit Trips - Overall:	*70,000,000*	*67,900,000*	*68,596,500*	*70,696,500*	*70,975,100*
New Annual Transit Revenue - Overall:	$ 70,000,000	$ 74,690,000	$ 75,456,150	$ 70,696,500	$ 70,975,100
Change in Annual Toll Revenue	**$ -**	**$ 330,000**	**$ 10,725,000**	**$ 10,312,500**	**$ 14,052,500**
Change in Annual Transit Revenue	**$ -**	**$ 4,690,000**	**$ 5,456,150**	**$ 696,500**	**$ 975,100**
"Excess" Toll Revenue (above $1.25 toll):	$ -	$ -	$ -	$ -	$ 3,740,000
Total Increase in Revenue to Transit:	$ -	$ 4,690,000	$ 5,456,150	$ 696,500	$ 4,715,100

ELASTICITIES TABLE	*% Change in Transit Demand*	*% Change in Auto Demand*
1% Change in Transit Fare =>	**-0.30**	**0.06**
1% Change in Auto Cost =>	**0.20**	**-0.20**

B: High Cross Elasticity of Transit Demand with Respect to Auto Cost	**Baseline**	**Scenario 1**	**Scenario 2**	**Scenario 3**	
		Toll Same, Fare Increase	Toll Increase, Fare Increase	Toll Increase, Fare Same	Toll Increase plus Surcharge, Fare Same
Toll:	$1.00	$1.00	$1.25	$1.25	$1.35
Transit Fare:	$1.00	$1.10	$1.10	$1.00	$1.00
Change in Annual Toll Bridge Trips	*0*	*330,000*	*-2,420,000*	*-2,750,000*	*-3,850,000*
New Annual Toll Bridge Trips	*55,000,000*	*55,330,000*	*52,580,000*	*52,250,000*	*51,150,000*
New Annual Toll Revenue:	$ 55,000,000	$ 55,330,000	$ 65,725,000	$ 65,312,500	$ 69,052,500
Change in Annual Transit Trips - Toll Corr.:	*0*	*-417,900*	*1,671,600*	*2,089,500*	*2,925,300*
New Annual Transit Trips - Toll Corr.:	*13,930,000*	*13,512,100*	*15,601,600*	*16,019,500*	*16,855,300*
Change in Annual Transit Trips - Overall:	*0*	*-2,100,000*	*-10,500*	*2,089,500*	*2,925,300*
New Annual Transit Trips - Overall:	*70,000,000*	*67,900,000*	*69,989,500*	*72,089,500*	*72,925,300*
New Annual Transit Revenue - Overall:	$ 70,000,000	$ 74,690,000	$ 76,988,450	$ 72,089,500	$ 72,925,300
Change in Annual Toll Revenue	**$ -**	**$ 330,000**	**$ 10,725,000**	**$ 10,312,500**	**$ 14,052,500**
Change in Annual Transit Revenue	**$ -**	**$ 4,690,000**	**$ 6,988,450**	**$ 2,089,500**	**$ 2,925,300**
"Excess" Toll Revenue (above $1.25 toll):	$ -	$ -	$ -	$ -	$ 3,740,000
Total Increase in Revenue to Transit:	$ -	$ 4,690,000	$ 6,988,450	$ 2,089,500	$ 6,665,300

ELASTICITIES TABLE	*% Change in Transit Demand*	*% Change in Auto Demand*
1% Change in Transit Fare =>	**-0.30**	**0.06**
1% Change in Auto Cost =>	**0.60**	**-0.20**

TABLE C-3 Ridership and revenue impacts of intermodal pricing strategy, scenario 1

The steps outlined below represent a standard format for guaging the ridership and revenue implications of implementing an intermodal pricing strategy between a toll bridge and complementary transit service, using estimated demand elasticities.

Scenario Description: Raise MGTA fares from $1.00 to $1.25 throughout the day systemwide. Use incremental increase in revenues to offset loss of state operating assistance.

Initiating Agency: Metropolitan Gotham Transit Authority (MGTA)

Mode:	***Transit***	***Automobile***
Facility/Responsible Agency:	Bus and Rail System / MGTA	Wayne River Toll Bridge / GTA

Identify Current Conditions

	Transit	Automobile
Annual Trips Overall.	70,000,000 trips	
Annual Trips in Toll Corridor:	13,930,000 trips	55,000,000 vehicles
Fare/Toll	$1.00 (per passenger)	$1.00 (per vehicle)
Annual Revenue from Toll Corr.:	$13,930,000	$55,000,000
Annual Revenue Overall:	$70,000,000	

Describe Proposed Changes

	Transit	Automobile
New Peak Fare/Auto Cost:	$1.10 (per passenger)	$1.00 (per vehicle)
Percent Change (average):	10.0%	0.0%

Select Appropriate Elasticity/Cross-Elasticity

	% Change in Transit Demand	*% Change in Automobile Demand*
1% Change in Transit Fare =>	**-0.30** (average)	**0.06** (rail travel)
1% Change in Auto Cost =>	**0.20** (estimate)	**-0.20** (tolls)

Perform Calculations

10.0% Change in Transit Fare	=>	-3.0% Change in Transit Demand
10.0% Change in Transit Fare	=>	0.6% Change in Auto Demand
0.0% Change in Auto Cost	=>	0.0% Change in Transit Demand
0.0% Change in Auto Cost	=>	0.0% Change in Auto Demand

Identify Impacts

	Transit	Automobile
Change in Annual Toll Corr. Trip	-417,900 trips	330,000 vehicles
New Annual Trips in Toll Corr.:	13,512,100 trips	55,330,000 vehicles
Change in Annual Trips Overall·	-2,100,000 trips	
New Annual Trips Overall:	67,900,000 trips	
New Annual Revenue Overall·	$74,690,000	$55,330,000
Change in Annual Revenue:	**$4,690,000**	**$330,000**

TABLE C-4 Ridership and revenue impacts of intermodal pricing strategy, scenario 2

The steps outlined below represent a standard format for guaging the ridership and revenue implications of implementing an intermodal pricing strategy between a toll bridge and complementary transit service, using estimated demand elasticities.

Scenario Description: Raise toll on Wayne Bridge from $1.00 to $1.25 throughout the day and raise transit fares from $1.00 to $1.10 systemwide.

Initiating Agency: Gotham Metropolitan Planning Organization (GMPO)

Mode:	***Transit***	***Automobile***
Facility/Responsible Agency:	Bus and Rail System / MGTA	Wayne River Toll Bridge / GTA
Identify Current Conditions		
Annual Trips:	70,000,000 trips	
Annual Trips in Toll Corridor:	13,930,000 trips	55,000,000 vehicles
Fare/Toll	$1.00 (per passenger)	$1.00 (per vehicle)
Annual Revenue from Toll Corr.:	$13,930,000	$55,000,000
Annual Revenue Overall:	$70,000,000	
Describe Proposed Changes		
New Peak Fare/Auto Cost:	$1.10 (per passenger)	$1.25 (per vehicle)
Percent Change (average):	10.0%	25.0%

Select Appropriate Elasticity/Cross-Elasticity

	% Change in Transit Demand	*% Change in Automobile Demand*
1% Change in Transit Fare =>	**-0.30** (average)	**0.06** (rail travel)
1% Change in Auto Cost =>	**0.20** (estimate)	**-0.20** (tolls)

Perform Calculations

10.0%	Change in Transit Fare	=>	-3.0% Change in Transit Demand
10.0%	Change in Transit Fare	=>	0.6% Change in Auto Demand
25.0%	Change in Auto Cost	=>	5.0% Change in Transit Demand
25.0%	Change in Auto Cost	=>	-5.0% Change in Auto Demand

Identify Impacts

	Transit	Automobile
Change in Annual Toll Corr. Trip	278,600 trips	-2,420,000 vehicles
New Annual Trips in Toll Corr:	14,208,600 trips	52,580,000 vehicles
Change in Annual Trips Overall.	-1,403,500 trips	
New Annual Trips Overall:	68,596,500 trips	
New Annual Revenue Overall:	$75,456,150	$65,725,000
Change in Annual Revenue:	**$5,456,150**	**$10,725,000**

TABLE C-5 Ridership and revenue impacts of intermodal pricing strategy, scenario 3

The steps outlined below represent a standard format for guaging the ridership and revenue implications of implementing an intermodal pricing strategy between a toll bridge and complementary transit service, using estimated demand elasticities.

Scenario Description: Raise toll on Wayne Bridge from $1.00 to $1.35 throughout the day. Transfer incremental increase in toll revenues to MGTA to offset loss of state operating assistance and prevent need for a fare increase.

Initiating Agency: Gotham Metropolitan Planning Organization (GMPO)

Mode:	***Transit***	***Automobile***
Facility/Responsible Agency:	Bus and Rail System / MGTA	Wayne River Toll Bridge / GTA
Identify Current Conditions		
Annual Trips Overall:	70,000,000 trips	
Annual Trips in Toll Corridor:	13,930,000 trips	55,000,000 vehicles
Fare/Toll	$1.00 (per passenger)	$1.00 (per vehicle)
Annual Revenue from Toll Corr.:	$13,930,000	$55,000,000
Annual Revenue Overall:	$70,000,000	
Describe Proposed Changes		
New Peak Fare/Auto Cost:	$1.00 (per passenger)	$1.35 (per vehicle)
Percent Change (average)	0.0%	35.0%

Select Appropriate Elasticity/Cross-Elasticity

	% Change in Transit Demand	*% Change in Automobile Demand*
1% Change in Transit Fare =>	**-0.30** (average)	**0.06** (rail travel)
1% Change in Auto Cost =>	**0.20** (estimate)	**-0.20** (tolls)

Perform Calculations

0.0%	Change in Transit Fare	=>	0.0% Change in Transit Demand
0.0%	Change in Transit Fare	=>	0.0% Change in Auto Demand
35.0%	Change in Auto Cost	=>	7.0% Change in Transit Demand
35.0%	Change in Auto Cost	=>	-7.0% Change in Auto Demand

Identify Impacts

	Transit	Automobile
Change in Annual Toll Corr Trip	975,100 trips	-3,850,000 vehicles
New Annual Trips in Toll Corr :	14,905,100 trips	51,150,000 vehicles
Change in Annual Trips Overall·	975,100 trips	
New Annual Trips Overall:	70,975,100 trips	
New Annual Revenue Overall:	$70,975,100	$69,052,500
Change in Annual Revenue:	**$975,100**	**$14,052,500**

"Excess" Toll Revenue (above $1.25 "base case" toll): **$3,740,000**
Total Increase in Revenue to Transit: **$4,715,100**

"Base Case" Impacts (transit = $1.00, toll = $1.25)

	Transit	Automobile
Change in Annual Toll Corr. Trip	696,500 trips	-2,750,000 vehicles
New Annual Trips in Toll Corr :	14,626,500 trips	52,250,000 vehicles
Change in Annual Trips Overall:	696,500 trips	
New Annual Trips Overall:	70,696,500 trips	
New Annual Revenue Overall:	$70,696,500	$65,312,500
Change in Annual Revenue:	**$696,500**	**$10,312,500**

"surcharge" (in order to establish a "base" revenue level for GTA-see the bottom of Table C-5.) This pricing strategy netted a $10.3 million "base" increase in revenues for the GTA. It is also interesting to note that this increase in auto costs alone resulted in a projected diversion of 0.7 to 2.1 million annual passengers to transit, and a corresponding revenue increase of $0.7 to $2.1 million (depending on which cross elasticity of transit use with respect to auto cost was applied). The worksheet calculations were then performed for a $1.35 toll with no fare increase, yielding a $14.1 million increase in toll revenues, 3.9 million fewer vehicles contributing to congestion per year, and between 1.0 and 3.0 million more transit riders annually. Applying the $3.7 million in "surcharge" revenues to the fare revenue from the increased transit patronage yielded a projected increase in transit revenue of $4.7 to $6.7 million, depending on which cross elasticity of transit use with respect to auto cost was applied (see Table C-5).

Scenario 3, the toll "surcharge" strategy, yielded the best results with respect to Gotham City regional transportation and air quality goals by increasing MGTA ridership and reducing traffic congestion on the Wayne River toll bridge to the greatest extent.

C.4 CONCLUSIONS

Although this analysis shows the potential for integrating transportation pricing strategies between modes by applying a "transit surcharge" to a congested toll facility, the toll increase/fare increase pricing strategy (Scenario 2) also illustrates how a less extensive degree of coordination-raising fares and tolls at the same time-can help offset net transit ridership losses and further enhance revenue. Raising tolls in a particular corridor and applying the proceeds to the entire transit service area (as was intended with this particular "transit surcharge") raises equity implications with regard to the people who pay the surcharge and the people who are able to benefit from it. Ideally, a coordinated intermodal pricing strategy would take place on a regionwide basis, but short of that, equity concerns need to be addressed explicitly from the outset of intermodal pricing strategy considerations. It is also important to emphasize the influence of the chosen demand elasticities and cross-elasticities on the projected travel behavior. These elasticities are often based on limited empirical data or on assumptions regarding the characteristics of commuter behavior in a particular locality. Care must be taken to estimate mode usage and revenue impacts conservatively until experience with intermodal pricing strategies has provided more accurate local data for estimating travel behavior impacts.

These **Digests** are issued in the interest of providing an early awareness of the research results emanating from projects in the TCRP. By making these results known as they are developed, it is hoped that the potential users of the research findings will be encouraged toward their early implementation. Persons wanting to pursue the project subject matter in greater depth may do so through contact with the Cooperative Research Programs Staff, Transportation Research Board, 2101 Constitution Ave, N.W., Washington, DC 20418.

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