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The University of California  
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# **Evaluation Methods for Rail Transit Projects**

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## EVALUATION METHODS FOR RAIL TRANSIT PROJECTS

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**Abstract**—The demand for rail transit funds greatly exceeds available monies. Worse, there is widespread disagreement over the wisdom of building rail systems in American cities. The Urban Mass Transportation Administration's (UMTA's) transit analysis methods have relied on cost-effectiveness measures with little attention devoted to the analysis of economic efficiency. We survey the literature on transportation evaluation and propose a model method based on economic theory and on practice in other federal agencies. We review UMTA's past methods and recommend changes.

### INTRODUCTION

Funds requested for new rail transit projects in the United States greatly exceed available monies. Scarce transit resources must be allocated according to some funding criteria. Historically, transit project evaluation by The Urban Mass Transportation Administration (UMTA) has used cost-effectiveness analysis, with no direct accounting of effects on national economic efficiency. The cost-effectiveness method estimates financial (not economic) cost per unit of project performance (labor cost per trip, for example). Efficiency analysis measures the change in the net value of national production of goods and services. The cost-effectiveness method requires decision makers to rank projects judgmentally according to two or more noncommensurate criteria. It cannot tell us when projects are more efficient than one another and, from an economic efficiency standpoint, cannot identify when a project is not worth building at all.

Analyses of transit projects should evaluate effects on economic efficiency, as well as nonmonetary effects on level of service, lower-income riders, and so on. Evaluations of water resources projects have estimated effects on recreation travel time, rural incomes, water quality, wildlife, urban growth, and navigation and flood safety. There is no reason why benefit-cost analysis cannot also be applied to transit projects. The chief effects of these projects (on travel time, vehicle operation costs, auto accidents, pollution, and noise) are not more difficult to quantify in economic terms than the effects of large water resources projects. Large dams that provide flood control and municipal water supplies have large-scale effects on the rate and location of urban growth. Large port developments affect regional urbanization patterns and international trade. Both water resources and rail transit projects can have geographically concentrated costs and benefits, as well as dispersed ones. Both types of projects are locally initiated and are then supported by governors and

members of Congress and are generally highly politicized.

Many of the chief uncertainties in transit project evaluation arise in projecting riders by mode and the changes in travel time on all modes. These uncertainties are common to both cost-effectiveness and benefit-cost analyses. Some additional uncertainty is introduced by using benefit-cost analysis to estimate the economic values of these direct effects. Advances have been made in the last 15 years in such valuation methods, however. We argue that the types of analysis methods used by federal water resources development and land management agencies can be adapted by UMTA for the evaluation of transit projects.

Benefit-cost analysis was first required in 1902 for water resources project planning. In 1932 the rules were strengthened to require that water resources project benefits exceed costs. In 1973 the evaluation process was broadened to include effects on environmental quality and on social well-being and it was required that this information be presented in a set of accounts, together with the efficiency information (U S Water Resources Council, 1979, 1983). The 1983 rules require that uncertainty in the data be acknowledged, by using ranges for estimates where necessary, and recommend that tradeoffs between economic efficiency and other impacts be displayed. These rules apply to all federal water resources agencies (Army Corps of Engineers, Bureau of Reclamation, Fish and Wildlife Service, Soil Conservation Service) and land management agencies (Forest Service, Bureau of Land Management). Many other federal agencies use benefit-cost analysis, under their own rules.<sup>†</sup>

<sup>†</sup>There is a manual for the estimation of the economic benefits of highway and bus improvements (American Association of State Highway and Transportation Officials, 1977). The Federal Highway Administration (FHWA) uses benefit-cost analysis in some project evaluations, but the method has not been formalized in rules. The mandate for

Federal expenditures for transit should (1) be evaluated in terms of changes in national economic efficiency, as well as other impacts (2) acknowledge uncertainty in the impact estimates, and (3) handle the various incommensurable data in an analytical fashion, preferably with an economic breakeven analysis of efficiency vs. all other impacts

#### *Outline of paper*

First we review the transportation evaluation literature and see that authors advocate both the use of cost-effectiveness and benefit-cost analysis. Then we identify the principles of an ideal method and with this theoretical framework in mind review the UMTA project evaluation rules as they have evolved during the last 12 years. Finally, we recommend changes in UMTA's current procedures. This paper adds to the earlier research by tying the theory of evaluation to UMTA's actual methods.

formalized agency decision-making methods examining economic efficiency and other impacts has been spurred by continuing controversy over porkbarreling by Congress and self-serving behavior by agencies. For example, Maass (1951), White (1969), and Young (1978) criticized the Army Corps for biasing their analyses to build large inefficient projects when smaller, more efficient projects or nonstructural actions, such as water conservation and floodplain zoning, were possible. Loomis (1987) found that the Forest Service tended to bias their evaluations toward development alternatives and thereby frequently adopted economically inefficient plans. Critiques such as these have been generalized in the theory of public choice economics (Buchanan and Tullock, 1962), which describes the self-serving motivations for agency behavior. Benefit-cost analysis is more theoretically sound than cost-effectiveness analysis, but entails problems of its own. First, there is the basic analytic assumption that private markets allocate goods efficiently and so we can use market prices to value the goods and services being analyzed. The economist must be careful to account for market imperfections, such as subsidies and taxes, externalities, irreversibilities, psychological services, and so on. Methods exist for making these corrections. More difficult problems are the correct estimation of long-run price elasticities and determining the effects of inadequate information on the part of consumers (Mishan, 1976). Second, setting the social discount rate is a matter of concern. It is generally agreed that the rate should be somewhat lower than the private opportunity cost of capital because the public investment is usually less risky and the risk is spread much more thinly. Congress has set the discount rate for water resources and land management evaluations at the rate for long-term Treasury bills. For capital intensive projects, the analyst may wish to perform a sensitivity analysis of two or three rates of discount. For an in-depth discussion of discount rate, see Lind *et al.* (1982). Third is the issue of vertical and horizontal equity. We recommend (below in the text) that equity (distribution) effects be handled outside of the efficiency account. Such an analysis would look at the effects of alternative modes and routes and alternative financing methods on gainers and losers. It is not always feasible to predict actual methods of future financing, however. Good reviews of all of these issues are found in Mishan (1976), Musgrave and Musgrave (1973), and Haveman and Margolis (1983).

#### THE TRANSPORTATION EVALUATION LITERATURE

From the mid-nineteenth century through the 1920s, European and American economists produced pathbreaking normative analyses of optimal fares, regulations, and investments for various modes of transportation. These early developments in transportation economics were based on efficiency concepts. After several decades of relative inattention to transportation, economists began in the 1950s to develop advanced methods of analysis, leading to better estimates of the cost of providing services and of demand for transportation. Methods for determining efficient levels of pricing and of investment have also been improved (Winston, 1985).

There is a curious dichotomy in the American transportation literature, with journal articles on transit evaluation almost uniformly recommending cost-effectiveness methods but with textbooks on transportation planning tending to advocate the use of both cost-effectiveness and economic efficiency measures.

#### *Cost-effectiveness methods*

Fielding, Glauthier, and Lave (1978) reviewed nine transit performance indicators, all of them cost-effectiveness measures.<sup>†</sup> Their effectiveness indices measure the attainment of various *locally* set objectives, which vary from city to city. Capital costs do not figure in any of the measures, a serious problem for funding agencies trying to allocate monies.

This impression that transit planners have many conflicting and piecemeal evaluation criteria is reinforced by an international review of transportation program objectives by Horn (1981). The evaluation methods in the nine developed countries reviewed varied widely. The author states that performance indicators in metropolises where transit shares range from 2% to 40% need to be tailored to national and local needs.

Heaton (1980) implicitly rejects benefit-cost analysis and believes that it is difficult even to standardize cost-effectiveness measures. He argues that, within the United States, no single set of indicators should be used to compare transit proposals. Several authors report on the difficulty of performing city-to-city transit project comparisons (McCrosson, 1978; Underwood, 1979; Keck, Zernillo, and Schneider, 1980; Kern, 1982). Stokes (1979) and Talley and Anderson (1981) believe that local objectives should figure prominently in system comparisons. We disagree with these authors with regard to UMTA evaluations and Congressional funding decisions. We do not see how national funding decisions can be made

<sup>†</sup>There are three "efficiency" indicators, four effectiveness indicators, and two indicators that measure both. They define efficiency much more narrowly than do economists, however, and so all nine measures are really cost-effectiveness indicators.

in an efficient or fair fashion without a uniform set of evaluation measures at the core of the analysis

The problems of evaluation at the national level with incoherent indicators is illustrated by Deen and Skinner (1976), who comment on two transit system evaluations done under the 1976 UMTA policies (reviewed below), which employed many cost-effectiveness measures "The potential number of such [evaluation] measures is unlimited and the use of a large number tends to be duplicative, confusing, and even misleading cost-effectiveness cannot be represented by a single measure" (p. 63)

Attempts have been made to resolve this problem of too many overlapping measures of system performance by selecting single cost-effectiveness indicators. Heaton (1980) states that London Transport uses one indicator to evaluate system improvements, passenger-miles per unit of total cost (p. 52). Forkenbrock (1984), in a similar vein, recommends a single effectiveness measure of added passengers per additional dollar. These methods have the advantage of resulting in unambiguous evaluations, but do not directly measure changes in economic efficiency.

This review of transit journals shows that cost-effectiveness methods employ surrogate measures, such as trips, rather than measuring national economic efficiency. Therefore, the overall economic effects of projects are unknown. The lack of theoretical agreement on cost-effectiveness measures results in widespread disagreement over project funding. There is a need to measure national economic efficiency, so that the effects of transit projects on the national economy can be evaluated and other project effects can be weighed against efficiency.

#### *Efficiency methods*

Texts on transportation planning generally have recommended the measurement of efficiency, *together with* cost-effectiveness. Kuhn (1965), for example, states that cost-effectiveness analysis is appropriate for the local evaluation of projects, but that federal expenditures analysis should be based on economic efficiency. Specifically, he recommends that net present economic value be maximized, for any level of annual federal budget. We agree with Kuhn.

Meyer and Straszheim (1971) state that there are generally two objectives for rail transit systems: (1) the maximization of net present value and (2) maximizing the use of the facility (pp. 230-241). Dickey (1983) agrees that efficiency effects should be measured but states that cost-effectiveness measures also need to be used to measure effects on displacement of persons, lower-income riders, air quality, and so on. We point out, however, that it is possible to measure the efficiency effects of all of these factors. Meyer and Miller (1984) recommend the use of cost-effectiveness techniques in evaluations because of legal requirements to assess impacts on environ-

mental quality, displacement, and many other project effects (p. 373). They say that cost-effectiveness analyses should be tied to community objectives, but that economic welfare measures should be included in the evaluation.<sup>†</sup>

Few recent efforts have been made to apply economic efficiency concepts to transit evaluation, even in the academic literature. One exception is an efficiency evaluation of an express busway by Gordon and Muretta (1983). They analyze travel time and direct cost savings, external costs (congestion and pollution), and parking subsidy costs. This work is conceptually correct, but leaves out some external costs, such as subsidies to petroleum, the external cost of uninsured losses of lives and workdays, and the cost of importing oil (DeLuchi, Sperling, and Johnston, 1987).

These textbook authors, then, recommend an evaluation method that generally meets our criteria. The ideal method will estimate project effects on national economic efficiency and on noneconomic objectives, such as equity. Let us briefly examine the economic theory underlying efficiency measures, since they have not been used in rail transit evaluation.

### PRINCIPLES OF PROJECT EVALUATION

#### *Economic theory*

Choices concerning the allocation of publically provided goods, such as rail transit, in theory can be evaluated by comparing the economic costs and benefits of the alternatives. Generally, the object is to maximize net benefits, measured in dollars. Costs and benefits over the life of the project are discounted to the year in which the decision is to be made. This discount rate reflects society's time preference for money and the opportunity cost of capital.

The direct costs of transit projects are the projected expenditures for the construction and operation of the facility. Indirect costs are effects such as air and noise pollution, not compensated for by the transit operator. Direct benefits are resource, time, and accident savings to existing transit riders and riders diverted from other modes. Indirect benefits include savings to riders on other modes. Working time is usually valued at average wage rates and nonworking time at half of that value (Prest and Turvey, 1965). Travel demand for the period of analysis is scaled upward according to trip projections for the region being studied.

<sup>†</sup>Their discussion of possible cost-effectiveness measures lists over 70 different measures (pp. 379-380). Their critique of economic efficiency measures is puzzling. They state that these measures suffer from (1) "arbitrary definitions of costs and benefits" and (2) the difficulty of comparing close B/C ratios (p. 406). Both of these problems also apply to cost-effectiveness measures.

Willingness to pay (WTP) is the accepted concept for measuring direct and indirect benefits. For most passengers WTP is higher than the fare paid. WTP for transit can be estimated from standard travel models. WTP for indirect benefits or to eliminate or reduce indirect costs can be measured with the contingent valuation method (Loomis and Walsh, 1986). Users and nonusers are surveyed to see the highest amounts they would pay to gain benefits or to reduce costs. These responses in natural resource and wildlife surveys have been compared to payments in actual markets and shown to be fairly accurate (Bishop and Heberlein, 1979; Brookshire *et al.*, 1982; Schulze, d'Arge, and Brookshire, 1981). There are measurement problems, however, and so survey instruments must be carefully designed with internal checks for bias and estimates should be verified with actual consumer behavior whenever possible (Rowe and Chestnut, 1983). The contingent valuation method is recommended for use by federal water resources, wildlife, and land management agencies and by the Environmental Protection Agency in project evaluation (U.S. Water Resources Council, 1979, 1983). If these methods are applied to transit evaluation for several years, suitable techniques should evolve.

#### *Policy evaluation theory*

In addition to estimating the economic effects of projects, we must also evaluate noneconomic impacts, such as distributional equity, for the analysis to be politically acceptable. Impacts can be portrayed along with the economic calculations in accounts (comparative descriptive tables).

Then one can apply constraints to one or more of the effects and reject alternatives that will generate effects beyond these limits. In practice, ambient air quality, the protection of historic sites and parks, and other impacts are treated as constraints because of legal standards.

Next, a breakeven analysis can be performed, whereby the analyst shows how much the intangible effects must be worth in dollars to make us indifferent between the most efficient alternative and another one (Stokey and Zeckhauser, 1978, pp. 127–130; Patton and Sawicki, 1986, pp. 271–274).

Uncertainty should be acknowledged in the estimates. Since probability distributions for the attribute values are not available from travel projection models and other methods of estimation, one should use judgmentally determined ranges. We reviewed ridership estimates for recently completed passenger rail systems in North America and found that they are almost always high or low by at least 10% and are often high by 30% or more (Johnston *et al.*, 1987).<sup>†</sup> Gordon and Willson (1984) performed a

cross-sectional analysis of light rail transit (LRT) in all cities in the world using regression equations and found that official ridership estimates were generally too high. Where bias or uncertainty exist, UMTA must correct the estimates to a fair range.

This project evaluation model maximizes the use of welfare economics and still allows for the analytical consideration of all project effects. Because we believe that federal funding decisions should be based *primarily* on economic efficiency and because we think that many effects can be measured in economic terms, we structure the analysis to examine the tradeoff between efficiency and all of the other values together.

We do not advocate that federal funding decisions be made strictly on the basis of the relative efficiency of projects, however, only that efficiency information be prominently displayed for UMTA and Congress to consider. Decision-aiding approaches that reduce *all* effects to efficiency changes suffer from a variety of theoretical and operational problems (Merkhofer, 1987) and so we do not wish to recommend that approach. Also, Congress has not enunciated a clear efficiency objective for transportation funding, as we will see below, and for us to do so would be technocratic. We hope that improving the process of transit evaluation to prominently feature efficiency effects will encourage Congress to fund only the most efficient transit projects in any given year or at least to require that any project in a given city produce the largest net benefits.<sup>‡</sup>

We will now describe the UMTA evaluation procedures used in the past and evaluate them against this model.

#### UMTA's PAST EVALUATION METHODS

Before examining the current evaluation method used by UMTA, we will look at their past project evaluation rules to see if they satisfy our criteria. UMTA's first rules for project evaluation were adopted in 1976 (UMTA, 1976). The method explicitly used "multiple measures of cost and of levels of effectiveness" (UMTA, 1976, p. 41, 512). Effectiveness was to be measured in terms of "national objectives" and "local goals" (UMTA 1976, p.

Cleveland, -13%, Baltimore, +5%, Edmonton, +13%, and San Diego, +17%. Note that there are six systems that overestimated and three that underestimated and that the overestimates are much higher than the underestimates. We averaged the data for lines when there were two lines (Calgary) and averaged actual rider counts when they were for days and annual counts were not available.

<sup>‡</sup>Frankly, it seems likely that transit alternatives within cities will often be practically equal in net benefits due to the high degree of uncertainty in ridership estimates and in other economic estimates and so a single criterion of greatest net benefit may not be useful in reaching decisions. Congress may wish to simply require a benefit-cost ratio of 1.2 or greater, as it does with water projects, to eliminate inefficient transit projects, leaving some margin for error and bias.

<sup>†</sup>Our review of recently started rail systems in North America shows that actual ridership in the first stabilized year was generally lower than predicted. The values are [(actual - projected)/actual]. Miami -89%, Vancouver -44%, BART -41%, Calgary -31%, MARTA, -15%.

41.513) *No ranked and quantifiable national objectives were set forth. No intercity comparisons were performed. No measures of national efficiency were used.* Transportation systems management (TSM) was required as a part of all alternatives (UMTA, 1976 p. 41.513). In other words, TSM was held to be always cost-effective and the most efficient use of existing facilities in advance of building rail projects. Uncertainty was not acknowledged. The 1976 UMTA evaluation system did not meet any of our criteria for project analysis.

In 1978, UMTA amended the 1976 regulations with a "Policy toward Rail Transit" that stated that funding would be directed toward "densely populated cities that possess well-defined core areas," which would generally mean "older urban centers" (UMTA, 1978, p. 9.428). The 1978 policy also stated that, to get federal assistance, localities "will be required to commit themselves" to a financial plan and transit-supporting measures, such as zoning and parking policies near stations and auto restrictions in central business districts (CBDs) (UMTA, 1978, p. 9.429). This latter statement seems to set forth two constraints but is vaguely worded.

With regard to uncertainty in comparing alternatives, the 1978 UMTA policy stated that "*Applicants will be required to show clearly and convincingly the need for partially or fully grade-separated transit service*" (emphasis in original) (UMTA, 1978 p. 9.429). This statement implies that if a bus alternative is close on key evaluation attributes to the guideway alternatives, then the bus alternative will be chosen. Uncertainty is handled with a decision rule that places the burden of proof on the proponents of rail alternatives.

The 1978 UMTA policy does not meet our criteria for project evaluation, except that there is some recognition of the need to acknowledge uncertainty.

#### *Critique of the application of the 1978 UMTA method*

A case study will illustrate the weaknesses of the 1978 UMTA method. We performed a detailed analysis of the 1983 selection of LRT in Sacramento, California (Johnston *et al.*, 1987). No attempt was made in the selection process (performed in 1981) to define economic efficiency or operationalize measures of it. Many performance indicators were used, including some local ones of doubtful theoretical validity (claimed energy savings and an increase in economic growth) †.

Because of the many indicators of merit, the evaluation process became embroiled in arguments over which indicators to emphasize. UMTA focused attention on total annual cost per transit passenger (year 2000), an attribute that favored the high occupancy vehicle lane (HOV) alternative. The local

planners touted the year 2000 total O&M cost attribute, which favored LRT. All other attributes including year 2000 Operation and Maintenance (O&M) cost per transit passenger favored HOV. There was no clearly dominant alternative, however.

Uncertainty was not properly handled in the analysis. The key locally weighted indicator, total O&M cost, differed by less than four percent across all of the alternatives. Even when we used a technically more realistic estimate for LRT O&M, the difference was only five percent (in the other direction). Many other attribute values were also clearly within the range of estimation error. The values for year 2000 O&M cost per passenger were all within 2-3%. The total cost per passenger figures were all within 11-1%. Estimates that all fall within such ranges are indistinguishable, in our opinion, because of the inability to forecast the underlying variables accurately. In Sacramento, ridership was estimated at 20,500 per weekday and during the first few months of full operation, the actual ridership was 10,880 (Sacramento Regional Transit Agency, 1987). Furthermore, the projected cost for the system was \$131 million and the actual cost came to \$176 million ‡.

In the Sacramento case, the city had control over the choice of mode, since the funds were (unused highway) transfer funds. So, the evaluation was advisory to the city council. Furthermore, local staff members and city councilpersons told us that they did not consider the evaluation procedure to be theoretically sound or very useful in decision making. They felt that many of the UMTA indicators were arbitrary and that the point estimates of their values were inaccurate. The current UMTA evaluation procedure, adopted in 1984, appears to correct some of the problems we found with the previous method, but still falls short of the method we propose.

#### THE CURRENT UMTA EVALUATION PROCEDURE

##### *The regulations*

The 1984 evaluation process does not use national economic efficiency measures. It uses cost-effectiveness measures, based on the belief that most performance measures cannot be valued in economic terms. The new method sets constraints on a few performance and service area attributes to eliminate clearly inferior alternatives in the early stages of evaluation. After projects pass these fairly generous constraints, local political support attributes enter the analysis.

The 1984 Congressional Appropriations Conference Report required UMTA to include in their evaluation system the following project attributes: (1) cost-effectiveness, (2) local fiscal effort, (3) private sector participation, (4) "the results of alternatives

†For doubts see Lave (1978) on energy and Altshuler (1981) on economic growth.

‡It is apparent from statements in the press by decision makers involved in the Sacramento LRT project and the San Jose LRT project that the ridership estimates in both cases were "high-end guesses."



analysis," (5) participation by disadvantaged businesses, and (6) local government support (UMTA, 1984a, p. 21,285). This direction is not much of an advance over past ambiguous Congressional norms. We note that Congress did not prohibit UMTA from also using an economic efficiency criterion. The first four criteria were combined by UMTA into aggregate system performance and service area attributes. The fifth criterion is set as a constraint on all projects. The last attribute is subsumed under criteria (2) and (3).

All alternatives are evaluated at the margin, beyond a baseline of TSM, which includes expansion of bus service. TSM "should" be included in each alternative, but apparently *is not required* (UMTA, 1984a, p. 21,290, col. 3). Projects are evaluated in segments, one corridor at a time, to prevent overbuilding. Locally preferred alternatives are compared and ranked on an annual basis across all cities. This is a major advance over past practice where no national comparisons were done.

There are three steps in the evaluation process. Fixed guideway alternatives must pass two threshold tests in the first round of evaluation. A corridor must have at least 15,000 daily linked transit trips and the alternative must have an average annual cost per *new* rider of \$10.00 or less for guideway or rail projects to be considered. The cost is calculated in two ways: (1) as the sum of annualized capital, O&M, and travel time (for existing riders) costs—this is the "total cost-effectiveness (CE)" index, (2) as in (1), but with local capital costs subtracted—this is the "federal CE" index. At this stage, both the total and federal indexes must be less than \$10.00 per new rider. The \$10.00 is estimated to be three times the national average savings to an auto driver diverted to transit and is intended to include indirect benefits. These are generous constraints, used to eliminate only clearly non-cost-effective projects from further study.

In step two, three tests must be passed for fixed guideway projects to remain under consideration: (1) transit ridership must increase relative to the TSM alternative, (2) the locally preferred alternative must have the lowest cost per new rider of all the local alternatives, and (3) the project must have an annual cost per *new* rider of \$6.00 or less (federal CE). The rationale behind the first two tests is one of relative cost-effectiveness among local alternatives. The third test is a generous absolute national cost-effectiveness constraint.

In the third step, projects are ranked loosely by the federal and overall "merit" indices into high, medium, and low categories. A top rating on both the federal and total measures places an alternative in the high overall category. Not being top ranked in either measure places an alternative in the low category. The alternatives are not discretely ranked more finely due to uncertainty in the attribute values. In an example of uncertainty, total annual costs per new rider of \$1.50 and \$1.60 (13% difference) are considered "indistinguishable" (UMTA, 1984b,

p. 17). This is a sound principle. We are still left, however, with a partitioning problem. Classifying the projects into three categories for each merit measure will be arbitrary.

To improve the ranking of their preferred alternative, local officials may increase the local funding match, which reduces the federal cost per new rider and improves that attribute value. Also, an alternative can get a higher ranking if local O&M funds are guaranteed with a tax or other dedicated source. To a lesser degree, supportive local zoning, parking, and auto restraint policies can also improve a project's rating. Except for the local match, these changes in ranking are carried out "judgmentally." An increase in local capital match and the dedication of local O&M funding sources could be viewed as very crude measures of rider and nonrider WTP, expressed through local political decisions.

Many other project attributes are locally estimated, as required by transit statutes, the National Environmental Policy Act (NEPA), and local preferences. These attributes do not directly affect the UMTA rankings. Many of these attributes, such as reductions in air pollution, could be valued in economic terms, however.

#### *Critique*

The 1984 procedure appears to employ the new rider as the economic good being produced. This procedure assumes that a new rider receives a benefit of \$6.00 or less. This measure, based on estimates of the time and operation costs of auto trips, may approximate actual rider WTP. UMTA, however, does not require the actual measurement of WTP in each city.

The policy analysis strengths of the 1984 procedure are: fewer evaluation criteria, constraint cutoffs set for some of them, uncertainty handled through three stages of evaluation where one constraint is tightened up in the second round, and the use of one attribute to rank alternatives, also in round two. The 1984 procedures appear to be better than the earlier process in terms of using one indicator of merit that is, arguably, a sound overall cost-effectiveness measure. This coherence of evaluation based primarily on one indicator could make it easier to later proceed to a method employing efficiency evaluation as its primary component.

Our critique will identify problems with the existing rules and suggest changes that could be made with this procedure that would move it toward our model system.

*The cost-per-new-rider criterion.* Our main concern is with defining project merit in terms of lowest cost per new rider, rather than measuring net benefits (the total willingness-to-pay of riders and nonriders for the transit system minus total costs). UMTA counts as benefits only direct impacts on mobility. Secondary effects, such as reducing freeway congestion costs, are considered to be proportional to the direct effects in the overall merit measures, and so adding these effects to the merit measure

is thought to not change project rankings (with the merit indicators expressed as ratios). The proposition that secondary benefits are linearly related to primary benefits may not be true. For example, rail alternatives may produce secondary benefits, such as reduced diesel smoke and odor and increased community pride, that HOV alternatives do not.<sup>†</sup>

Given the uncertainties of predicting indirect effects (Knight and Trygg, 1975; Lave, 1978; Altshuler, 1981; Lee, 1981), UMTA is justified in currently using local capital overmatch as the surrogate measure. UMTA, however, should develop methods for predicting these indirect effects more accurately. Lee (1981) and Knight and Trygg (1975), for example, identify conditions for certain secondary effects to occur. Forkenbrock (1984) performed a telephone survey that showed a 2 mil property tax for transit was supported because of perceived improvements in air quality, business, and jobs for poor people. Respondents did not place much weight on benefits to themselves as users. This survey shows the need for WTP research on potential riders and nonriders. UMTA also should perform follow-up studies on the effects of transit improvements on travel costs, air quality, and mobility for nondrivers.

*The use of a TSM baseline.* UMTA evaluates rail projects against a TSM baseline so that all alternatives are compared against a similar low-capital-cost alternative. This results in several problems, which would be eliminated if UMTA evaluated against the status quo. One problem is that UMTA requires that transit ridership increase for any funded guideway alternative relative to TSM. There are two problems with this. First, it is conceivable that an efficient transit system could be built that had lower total costs and lower ridership than TSM. Second, the ridership increase requirement is entirely insensitive to uncertainty. If a rail project cost \$1 more than TSM and served one less person, it would be eliminated, even though the projects were not significantly different.<sup>‡</sup>

A related problem with the TSM baseline, which may be unavoidable, is the lack of specification of the TSM alternative to assure that it is efficient. An efficient bus system must be included as part of TSM, but there is lots of room for local officials to design an inefficient TSM alternative to improve the marginal merit of their rail plan.

Finally, by measuring the cost-effectiveness of rail only relative to TSM, UMTA cannot compare the absolute CE of TSM proposals or the absolute CE of rail projects. Ideally, the UMTA would recommend funding the mix of projects that maximized net benefits, nationally.

Uncertainty and bias present problems, even though UMTA intends to review the local estimates of costs and ridership. But since UMTA has not done a study of actual vs. projected riders for completed U.S. or world rail transit systems, it is unclear how they would correct the local ridership numbers. Also, no definition is given of how great the percentage differences can be between rankings and have them be treated as similar.

Overall, the 1984 evaluation procedure appears to be an improvement over the 1976 system, but does not meet any of our criteria.

#### *UMTA's 1986 refinements*

UMTA issued an advisory manual in 1986 and these guidelines could lead to several improvements in future regulations. To reduce local fudging on ridership estimates, travel models are reviewed and modeling suggestions made. Also, transit O&M cost categories are standardized, for the same reason. To eliminate double-counting, it is made clear that land value increases are not a benefit of transit improvements, but are derived from the reductions in trip costs. The manual also states that projects can be funded when ridership falls if they are cost-effective. This is a major improvement. The most significant improvement is the suggested estimation of travel benefits using WTP methods based on data from travel models. This WTP data is not required, however, and does not feed into the actual evaluation. Other improvements in measurement include defining time costs more accurately, estimating the external effects of the alternatives rather than assuming that they are proportional to direct effects, and recommending a standard method for local WTP surveys. We hope that these recommendations become required practice in the future, as they move toward our ideal method by measuring changes in efficiency.

The guidelines make for less accurate evaluations in several ways. Time discounting is dropped for both benefits and costs. The opposite approach should be taken and all effects discounted. Auto O&M costs are understated (DeLuchi, Sperling, and Johnston, 1987), which could lead to the underprovision of transit.

The 1986 guidelines do not change the basic nature of the 1984 method, but introduce several improvements that will make it easier to use efficiency analysis in the future.

#### CONCLUSIONS AND RECOMMENDATIONS

Methods of evaluating transit proposals have improved in the United States during the last 10 years. The UMTA review procedures now describe economic efficiency as the desirable theoretical basis for evaluation and discuss possible benefit-cost analysis methods that could be used (UMTA, 1986). The agency, however, rejects the use of these techniques in the actual evaluation framework because it believes that the problems of quantification are too

<sup>†</sup>The local governments can pay more of the capital costs for the preferred alternative, of course, if they strongly believe that desirable secondary effects will occur.

<sup>‡</sup>In the 1985 new rail start project ratings, UMTA recommended the rejection of the St. Louis Airport LRT Project because of a 0.6% decrease in ridership.

great (UMTA, 1984a, UMTA, 1986) Some concepts of welfare economics are used by UMTA, though Projects are evaluated at the margin and the various criteria enunciated by Congress have been collapsed into one measure of merit so that projects can be ranked unambiguously (UMTA, 1984) The willingness-to-pay of riders is now a recommended supplemental measure (UMTA, 1986) Also, many definitions and measures of benefits and costs have been standardized These recently adopted and recommended conventions of analysis make it easier to progress to a policy analysis method in which efficiency is measured, as well as other effects

The current UMTA method incorporates some useful policy analysis concepts that can lead to trade-off analysis Nonperformance information is incorporated into decision making in a second analysis step, and can affect project rankings, within set limits This is a useful framework that allows for the use of noneconomic information

The current method acknowledges uncertainty in the regulations, but does not properly consider uncertainty in actual evaluations, which results in unsound distinctions being created among projects

Many transportation planners retreated from benefit-cost methods in the 1960s because of the increased range of impacts being evaluated With improvements in methods that have occurred in the last 20 years, however, it seems that efficiency measures can be used to encompass most of the effects now being evaluated and we can return to an analysis framework that includes efficiency measures as its main element This is what many major federal agencies now do in evaluating plans and projects with very complex effects

#### Recommendations

First, UMTA evaluates rail projects at the margin against TSM, but does not require TSM to occur, even if it is more cost-effective This is a serious problem *UMTA needs to require TSM whenever it is more cost-effective than rail projects* Later, when efficiency measures are used, TSM should likewise be required when it is shown to be efficient *When TSM is not required, projects should be evaluated against the status quo*

The second problem is using a cost-effectiveness measure as the most important indicator of merit, instead of using a measure of economic efficiency *UMTA should employ benefit-cost methods that include indirect costs and benefits to the maximum extent that is feasible* We believe that UMTA underestimates the practicality of doing this

Third, once efficiency effects are measured in a fairly broad way, that is pollution, congestion, and other major indirect effects are monetized, tradeoffs with noneconomic effects can be evaluated Such an analytical framework will allow decision makers to compare projects in a way that permits them to see the economic costs of the other values being obtained *UMTA should use a tradeoff analysis method*

*to assist in the valuation of the noneconomic effects of projects* We believe that many important effects, such as reductions in air pollution, can be valued in efficiency terms, and so the tradeoff analysis step would have to show the breakeven economic worth of only a few types of impacts, such as distributional equity and other locally identified noneconomic impacts

The fourth major problem is with uncertainty and bias UMTA uses the local projections for the estimates of effects Apparently, UMTA sends consultants to candidate cities to review the financial cost projections, but it is unclear if this is a regular practice It is also unclear if UMTA checks the other estimates carefully Ridership projections tend to be high, as we noted above O&M cost projections tend to be low, as Wachs and Ortner (1979) and Johnston *et al* (1987) have observed It is as though Congress allowed local water districts to perform their own project evaluations of proposed Army Corps dams *UMTA should be funded to perform the evaluations or at least to thoroughly check the local estimates*

Progress has been made in methods of evaluating transit projects in the United States UMTA now needs to go one step farther and make use of economic efficiency analysis methods in a policy analysis framework Considerable experience has been gained by the other federal agencies that use such a method and transit agencies can learn from these studies Improved transit evaluation methods can lead to a more efficient allocation of federal funds and a more explicit awareness of the value of noneconomic impacts in decision making

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