PART I:  INTRODUCTION

A. BACKGROUND

In recent years there has been an increased interest in public transit at the local level. Many urban areas have undergone substantial reviews of their local transit services and developed ambitious plans for expanding service and for constructing new fixed guideway facilities. This increased local interest often coincides with budget shortages at all levels of government and with increased automobile ownership and usage. Under such conditions this support for transit usually means a larger commitment of local funds. Very often such support is manifested through a referendum or through a major grass roots effort. There is a local perception that the benefits of transit are great – so great that people will accept increased local taxes to pay for them. This has occurred in many cities, but the benefits of transit are still poorly understood. Traditional methods of benefit measurement, with their roots in economic theory, offer only an incomplete understanding how local communities perceive the value of public transit.

An accurate assessment of the benefits of transit service is particularly complex because beneficiaries include the community-at-large, as well as passengers. Local businesses benefit from better transit access; and the community holds certain forms of transit in high esteem, even if only small portions of the population regularly use it. Many automobile drivers feel that transit has an option value; they might need it someday. Moreover, there is the indirect benefit of transit service accruing to society from the increased mobility of the population as a whole.

Conventional methods of measuring benefits, derived from economic theory, provide only partial help in understanding how local citizens value transit or why they are willing to go through considerable effort to increase the amount of service. Typical economic benefit assessments rely on the notion that benefits occur primarily to users and only secondarily to nonusers. Nonuser benefits are added when it can be argued that they result from improved service to users.
These techniques can lead to double counting of benefits if not carefully done. Benefits are usually expressed in monetary units; well-established methodologies are employed for such items as out-of-pocket cost savings, time savings, and accident reduction. Typically these methodologies try to directly relate benefits to these savings by using the difference between the cost of the good and the amount a person is willing to pay for it. In this case, the "good" is either the access provided by transit or one of its many indirect effects.

Transit has unique characteristics that do not fit well with traditional methods of benefit measurement. First, user benefits cannot be easily found because of difficulties in determining the way willingness-to-pay varies across individuals and population segments. A simple time-savings approach, popular in benefit-cost studies of highways, can underestimate user benefits because some individuals can have a large willingness-to-pay, even when the average individual does not. Besides a possible time savings, users can benefit by being able to make trips that would otherwise be foregone, by saving other personal resources, and by being able to make trips to more desirable destinations.

Second, transit has comparatively large nonuser benefits. Many people who rarely use transit are its strongest supporters. There may be an option value ("I-might-need-it-someday"), environmental concerns, sympathy for those who cannot use automobiles, civic pride, or other similarly intangible factors. If people perceive that transit has benefits, then the benefits exist to some extent. This argument is conceptually consistent with notions of consumer surplus, but we possess few means to measure nonuser benefits.

Third, transit may have effects on the location of land development activity. Recent rail transit projects have had significant impacts on the urban areas they serve. Major development projects have been positioned near stations, which lead to overall shifts in regional land-use patterns. Not only can a development project cause a desirable change in the location of activity, it can
cause new activity, at least locally. In addition, the resulting concentration of activities can provide agglomeration benefits, such as a reduction in the costs of providing public services when activities are concentrated. Such benefits are seldom explicitly considered in traditional methods, although they are often cited at the local level as important reasons to construct new fixed guideway transit systems. Clearly there is a need to take a fresh and different look at benefits as they relate to transit.

Besides identifying benefits and determining how they are distributed, there are problems associated with measuring them. The measurement of benefits must be comprehensive enough to permit comparisons between alternatives for the purpose of making decisions. The willingness-to-pay criterion might be used to estimate the direct user benefits of transit service. But the methodology should be sensitive to differences among different population segments. For instance, "captive" users are likely to have inelastic demands for transit service, and consequently, their aggregate benefits may be considerably higher than for people with access to other transportation modes.

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B. OBJECTIVES

The estimation of benefits from transit investments is a difficult process which can be approached with many different points of view. It is the objective of this report to look at benefits in a broad way to gain a better understanding of why local citizens positively perceive transit services. The report will attempt to provide a comprehensive view of the range of consequences of transit services and to indicate various methods that can be used to assess transit benefits. In addition, comparisons will be made among methods to assess benefits in various communities and to compare benefits from a political viewpoint to those from a technical viewpoint. Guidelines for benefits measurement are provided with examples.
A fundamental understanding of the concept of benefits is important for an understanding of techniques to measure transit benefits. Transit systems have many consequences for a community, ranging from the basic (need for bus stops, purchase of fuel) to direct effects (trips made by transit, employment of workers in transit firms) to indirect effects (changes in land use, independent life styles). These consequences need to be sorted to determine how they relate to one another, whether they are positive or negative, and their relative importance.

Benefits can be viewed as those consequences that are valued by some segment of the population. Benefits exist because people believe they are important, whether or not they can be measured (or even if seemingly objective measurement shows them to be nonexistent). Some communities place a high value on public transit even though it is difficult to find significant benefits by methods used for other means of transportation. These communities may be willing to support transit with high local subsidies and/or dedicated local taxes. These communities value transit highly and are collectively "willing-to-pay" a substantial amount of money to support transit. The level of monetary benefits of a transit system in such places must be viewed as being at least as high as the total local expenditures (user costs + subsidies) for transit, maybe substantially higher.

Benefits can be viewed in different ways, and it is essential to distinguish between approaches. Much of the debate about benefits stems from the chosen point of view. Three common viewpoints are financial, economic, or political.

A financial viewpoint includes only those benefits that can be recovered as income. Benefits are those things that contribute to the rate of return on the investment in transit. Returns (benefits of transit) should occur directly to the agency to pay the expense of providing service. External benefits have no value unless they can be "captured" by the transit agency.
The political process is a democratic system provides a way for a community to express its opinion of what is and what isn’t important.

The economic viewpoint of benefits is broader in that benefits can accrue to others and still be of value. This viewpoint uses a willingness-to-pay criteria for benefits; i.e., how much are users and nonusers of a system willing to pay for a service beyond its price? The difference between willingness-to-pay and price can be viewed as a benefit – consumer surplus. The economic view also assumes that the benefits can be measured (or converted) to monetary units. Benefits are derived from an analysis of supply/demand equilibrium and from the behavior of individuals who make choices in an open market condition.

The third viewpoint of benefits is a political one. The political process in a democratic system provides a way for a community to express its opinion of what is and what isn’t important. When duly elected officials make choices, ideally they are expressing the collective feelings of society about the benefits of different governmental activities. The value placed on transit by voters, primarily nonusers, is an indication of the benefits beyond those accruing to users. If a local community willingly taxes itself to spend large sums of money for transit, this implies they feel there are large benefits of transit, irrespective of any quantitative measures. Promotional materials from transit agencies, citizen groups and referenda advocates often include environmental improvements, access to jobs, economic development, better mobility for others, emergency transportation, and enhanced community image/pride as reasons to support transit.

The political process involves tradeoffs and choices and can be a good indicator of community values. However, there are factors that may cause the political process to represent opinion poorly. Lack of open debate, unfair competition between ideas, over-representation of special interests, or consideration of other unrelated issues (e.g., educational policy or low income housing) can inhibit the interpretation of transit decision making as a means of measuring benefits.
Economic Versus Non-economic Evaluation of Benefits

Benefit-cost analysis is a method of evaluation that, if applied completely and accurately, will select the best projects and best alternatives within projects. Economists have developed benefit-cost analysis to a high degree of sophistication. Nonetheless, there are many aspects of the transit project decision process that cannot be adequately represented in a benefit-cost study. Issues of fairness, health, aesthetics, social interaction, and prestige are difficult to convincingly quantify in monetary terms. Furthermore benefit-cost analysis can mask the tradeoffs between alternatives, their performance and impacts that often become the focus of real world decision making. Difficulties of valuation of benefits, lack of independence of measures, and different viewpoints and goals of decision makers further complicate the process. Finally, other issues (such as land-use impacts and safety) could be quantified in monetary terms, but we often lack the time and resources to do it properly.

This report adopts economic theory where it is of demonstrated value; then broadens that theory to incorporate factors of particular importance to transit projects. Where economic theory does not apply or where it is difficult to implement, other methods are suggested.

This report recognizes that transit decision making is a highly complex process that cannot be replaced by a set of rules or a formula. Techniques are proposed that can be useful to identify the range of transit consequences and their interrelations, to highlight significant tradeoffs between alternatives and to better quantify the effects of transit.
Decision Basis for Benefit Measurement

Benefit analysis is done so decisions can be made. A decision could be for a specific purpose, such as the selection of the best alternative, or for more general reasons, such as to generate support for all transit services. Understanding the nature of decisions is the key to benefit measurement.

Specific decisions involve the comparison of proposed alternatives against a base system. The comparison process is a useful way of dealing with many of the philosophical, conceptual, and mathematical difficulties with benefits measurement. Biases caused by assumptions tend to cancel each other out, since they either have the same effect on all alternatives or have very little differential effect (i.e., it only makes a difference if there is a difference). For example, there may be concern over the choice of an appropriate interest rate, but if all alternatives have roughly the same portion of capital costs and roughly the same time stream of maintenance costs, then interest rates may not make much of a difference in the final decision. Similarly, air quality impacts on health may be very difficult to assess, but all alternatives may have similar effects.

The importance of many of the subjective benefits of transit will be directly related to the type of decision being made. A decision to select a particular technology (i.e., rail versus bus) should include a broader range of benefits than a study of alternative locations of a particular technology. Rail transit is perceived by many civic leaders and elected officials as positively affecting economic development, jobs and civic prestige, while bus transit does not. Rail versus bus decisions may be made at the local level by elected officials considering these factors, but these factors might be ignored at a federal level. Locational decisions, in particular, need not consider quite as many factors, since there may be no differential impact. For example, community prestige may be the same regardless of the chosen location, so it need not be a component of a benefits assessment for that tier of a decision.
National Versus Regional Viewpoints

Benefits of transit from a national point of view may be quite different from those perceived at a regional or local level. As the geographic scope of analysis is increased, shifts from one area to another become internalized and may no longer be viewed as benefits. A benefit at a regional level that involves a taking of activity from another region would be interpreted as a "transfer payment" at a state or national level. Economists, as a rule, prefer to ignore transfer payments in benefit-cost studies. Many important impacts of transit (such as effects of transit on land use, some environmental consequences, employment gains or community prestige) may be of little importance at the national level, since they involve transfers between regions rather than overall national gains. Allocation of money between urban areas is quite a different decision than the local selection of an alternative within a region. Alternative selection would likely emphasize different criteria, including interregional transfers.

It is important to consider the goals of the investment, especially at higher levels of government. A goal at a high governmental level to maximize return on investment would lead to different choices than a goal to help distressed areas. Different goals may require different alternatives, as well as different decision criteria.

It is crucial that everybody involved understand that the selection of benefits and how they are measured depends upon the viewpoint of those who make decisions. For example, an analysis of interregional transfers can be complicated by fairness issues. Often, a city can successfully argue for more transit funds because it has not received a proportionate share of some other federal program. To be perfectly fair, transfer payments should be considered at the national level, too.
Local Versus Areawide Benefits

The geographic scope of analysis will also affect magnitude or even the existence of benefits at the regional level. For example, it may be important to local officials that employment gains occur in a particular neighborhood or political jurisdiction. From a regional point of view, employment may only shift between subareas for no net gain. Similarly, there could be a gain in employment for one metropolitan region because of transit investment, but this could be offset by losses in other regions. The concept of a "zero sum game" is relevant in national or regional analysis, but for small areas there can be substantial gains in employment.

Another example relates to land value and tax base. Transit investment may result in a shift of values from suburban to centralized locations with no change in the overall tax base. From a regional perspective there is no gain in overall value; whereas, from a more local perspective there could be important benefits.

Of course, there can be other benefits representing overall gains, regardless of geographic scope. For example, some experts may argue that a more centralized land-use pattern may lead to a more efficient use of infrastructure and an increase in the efficiency of interaction between people.

The geographic scope will also affect the relative impact of transit services. A large geographic area with a moderate sized transit change will result in a measured benefit that appears small. However, if the geographic area were made smaller, the impact of transit would appear to be more significant. Consequently, care should be exercised when using relative measurements (percentage change in some overall indicator) to avoid misleading results. The change is the same but the percentage is larger or smaller depending on the size of the area that is used for comparison.
Definition of Null Alternative

Benefits are a relative measurement. They are envisioned as savings that occur as a result of an investment. They are found by comparing the world with a transit change against the world without it. Accordingly, the definition of the base or null alternative is important to the measurement of transit benefits. The definition will depend on the type of analysis. For example, the base alternative for a major fixed guideway proposal may represent the current transit system with minor changes over an extended period, including fleet replacements and minor service improvements.

An occasional study has been performed\(^1\),\(^2\) of the impact of having no transit service in a particular community. These studies start with the assumption that transit service has been eliminated, and then they calculate the costs that are incurred (additional travel costs, social services, etc.) as a result. Attempts are made to develop a total cost that includes all impacts of removing the system. Such studies are used to establish a baseline for transit benefits. Similar approaches are widely used, topic by topic, to demonstrate the benefits of an existing transit service. For example, air pollution and energy savings could be calculated by looking at the air pollution reduction per transit trip versus the same trip by automobile. Unfortunately, this approach is not very realistic in that seldom does a community seriously consider the elimination of all transit service. Assessing benefits in this manner would be acceptable only if service might be eliminated in entire areas of a city or parts of a state.

In all cases there is considerable judgment in definition of the base system. Assumptions about the base system could substantially affect on

\(^1\)Dockendorf, J., October, 1972.

\(^2\)Urban Institute, June, 1991.
calculated benefits, while other assumptions might have only a minor effect. All assumptions should be made explicit and well documented. Good documentation will enable discussion and lead to more defensible conclusions. Furthermore, sensitivity analysis should be conducted to determine the relative impact of various assumptions on the results of a benefit calculation.

A sensitivity analysis is relatively easy to do, compared to the effort of the original benefits calculation. A base case is defined with a set of assumed values of parameters. Then each parameter is varied independently by a fixed percentage above and below its assumed value. The relative change in benefits per change in parameters (a type of elasticity measure) can be calculated. This process is completed for all parameters having some uncertainty as to their value. The result is an indication of the importance of each assumption. A good sensitivity analysis creates considerable insight into the nature of the system being analyzed and frequently helps generate additional options that might be more efficient or have more benefits.
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**Perceived Versus Measured Benefits**

Benefits occur because people believe them to be important. People are willing to pay a certain price for something because they believe it to have positive effects. The perceptions of people as well as the actual characteristics of the good must be considered. Benefits that are perceived may be much different from ones that can be measured, and there could be important perceived benefits that are impossible to measure. For example, there may be a strong perception on the part of the community that transit substantially reduces lung disease from air pollution. Calculations of air quality impacts may show very little actual change in community health. Nonetheless, the perceived substantial benefit for health will be an important factor in the debate that leads to decisions. In this case, the real benefit is what is believed to exist, not the measurement.

A similar example relates to the community image of transit. Residents of an urban area and their elected officials may feel that their community needs a certain form of transit to enhance the status and image of the community. As a result they decide to increase their taxes to support the system. The actual level of benefit from community image is nearly impossible to measure; nonetheless, it is a determining factor in the decision. The level of the overall perceived benefit could be interpreted to be as at least as large as the amount of local money spent on the system.

Over time, the real benefits of a system will prevail over perceived benefits, if there are major differences. As people gain experience with a system, they see the actual benefits. Sometimes there is disappointment in the system; in other cases people might be pleasantly surprised.
Double Counting

There are four basic steps in benefit assessment. First, benefits must be identified, then measured, then valued and then combined. As one proceeds through these steps, possibilities of misrepresentation increase. Questions of double counting arise in the processes of valuation and combination.

Double counting of benefits is a serious and complex issue. As a rule one does not want to count the same thing twice when calculating benefits. Double counting should be avoided, especially when benefits are compared to costs for the purpose of making build or no build decisions. Double counting tends to inflate benefits, resulting in unnecessary investments.

For example, benefits calculations may include savings from reductions in accident costs and changes in vehicle operating cost. If vehicle operating costs include an insurance component, there would be a double counting because accident costs and insurance measure the same thing. Similar problems can occur between energy savings, fuel taxes and vehicle operating costs, because fuel use is counted several times.

Similarly, it is generally agreed among economists that travel time savings and land value increases can involve a double counting of benefits. Land may change its value as a result of greater accessibility as time savings are capitalized. Including both items in a benefit total, without careful consideration, could lead to an inflated view of benefits. The issue becomes complicated, however, because land may change in value because of other effects of transit not related to user time and cost savings. Land values may increase because of better visibility, better pedestrian access to retail at stations or economies of scale. Thus, a portion of land value increments could be legitimately added to time savings benefits, while the remainder should not.
Double counting cannot be totally avoided. The simplest way to overcome many of the problems with double counting is not to add benefits together. Consequences of transit can be displayed for each alternative, and these consequences need not be combined. The information can then be interpreted and compared by decision makers who are making tradeoffs in their minds to reach a conclusion. Some factors will be ignored while others are given high value as these decisions are reached. It is essential not to over-represent a given benefit by providing several redundant measures.

Venn diagrams, or similar graphical techniques, can be used to show double counting where it exists.
Success Should be Consistent with Positive Benefits

Benefit measurement must be intuitively correct. Intuitively correct answers may not always come from some measurement techniques. For example, shifts of trips from automobile to transit could lead to counter-intuitive results when only time savings are used as the benefit indicator. More travel by transit may show up as a negative benefit, because transit trips generally take more time than automobile trips. Thus a transit alternative that attracts large numbers of automobile trips could do poorly in a benefits evaluation if total travel time is used as a measure of success. A negative time savings benefit is counter to the goal of increasing transit use and misrepresents what will happen. Other effects, such as changed automobile ownership costs and reduced parking difficulties, may have been ignored and should be identified, as well.

Better and more intuitively correct measurement techniques are available. Later, this report will discuss an enhanced consumer surplus measure that more realistically expresses user benefits and accounts for behavior factors in travel choice.
Beyond the issues raised earlier in this chapter there are technical issues that affect how the benefits are interpreted and affect the underlying validity of their measurement. Three of the more general technical issues relate to the size of the universe, aggregation of benefits and standardization.

Size of the Universe

The universe is defined by the limits of the system, usually delineated by geographical boundaries. The size of the universe can make a big difference to the perceived magnitude of benefits. The definition of the universe is especially important when relative measures are used, such as percentage reduction in air pollution or energy use or the percentage change in trips to a locale. If the size of the universe is large, the relative magnitude of transit induced change will appear to be small. Measures of this sort can be misleading since there would be larger impacts in smaller areas or different time periods. It is better to simply report the magnitude of the effects and allow comparison between alternatives rather than putting them on a relative scale. Different individuals can then interpret whether or not they are significant, based on their magnitude rather than on the choice of the size of the universe.

Aggregation of Benefits

If non-monetary benefits are to be combined, the choice of the mathematical formulation will affect results. Generally, benefits are combined using a linear function, by adding individual benefits put in some common set of units such as dollars or time. The use of a linear function assumes that each benefit is independent (unrelated) of all other benefits. Since some benefits are invariably related to others a simple linear sum could seriously misrepresent the
overall effect of an alternative. Other mathematical forms can be used. For example, weights can be used as exponents with the combination of benefits being the product of each benefit raised to its power. This formulation has a different effect on the combination, since it tends to emphasize differences—magnifying high scores and diminishing low scores.\(^3\) The resulting nonlinear preference function may be more consistent with intuitive preferences than a linear form. Reasonable arguments can be made for either approach (linear or multiplicative), and it is sometimes difficult to make a choice. Sensitivity analysis should be used to determine the differences.

A second, and perhaps better, approach is to avoid aggregation except in cases where the decision to combine factors is obvious. Tradeoff analysis can be used to provide a basis for decision without the need for aggregation.

**Standardization**

Benefits are measured on different scales and need to be placed on a standard scale if they are to be combined. Several standardization methods exist. Examples are standardization by range, standardization by mean, and standardization by mean and standard deviation. Standardization by range sets the upper and lower limits of all indicators on the same scale, say 0 to 100. Standardization by mean sets the mean values at the same point, say 50, while use of standard deviation also standardizes the dispersion of data. Since the nature of data may differ for each indicator, choice of a method may affect the outcome. Sensitivity analysis can help reduce the effect of a given standardization method on the aggregate benefit measure.

E. INTERPRETATION

Once a set of benefits has been identified and measured, they should be interpreted to build confidence in the analysis. The process of benefit measurement always involves a series of simplifications, omissions and assumptions that must be examined to determine their effects on the results. The interpretive phase could involve several activities.\(^4\)

Break-even Analysis

Break-even analysis tells how much better the best alternative is over the second-best. Such an analysis is often easy to perform. An important question is addressed: Are the differences between the best and second-best alternatives significantly large so that they are not within the range of differences that might be expected from the data and procedures used? Such an analysis would be conducted by comparing marginal costs versus gains. The marginal gain of the best plan over the second-best plan should be examined in relation to the process used to delineate the differences in the plans. If the differences are beyond the range of variance due to the forecasting techniques, there should be a greater degree of confidence in the best plan.

Measurement of Transit Benefits

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directed at the alternatives themselves or at the data processing effort. In the first case, the sensitivity of the choice of the best alternative to the procedure used to define a benefit measure is examined. In the second case, the sensitivities of the forecast to the data used and parameters of the forecasting techniques are examined. Obviously, the latter case would involve considerably more effort that the former. Data and parameter sensitivity would usually involve the following steps: (a) identify the parameters used in the forecasts; (b) examine the range of values used; (c) review the process used to set parameter values for the forecasts; (d) estimate the possible range of values the parameter could have as the result of statistical, conceptual, or assumption errors; and (e) determine how these errors would be carried through the process and how they might have a differential effect on the various alternatives.

Analysis for Contingencies

A contingency is an event whose occurrence is possible but not probable. For example, the effects of severe long-term shortages in petroleum-based fuels, the effects of major changes in population growth, or the effects of major shifts in land-use patterns might be viewed as contingencies. Because of the uncertainty of the future, it is desirable to examine how well the best alternative performs under contingent situations. Such an analysis would usually involve the following steps: (a) identify the contingent situations, (b) develop scenarios as to how they would occur, (c) forecast the performance of the best alternative under the contingent situations, and (d) compare the performance of the best alternative under normal and contingent situations.
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Impact and Incidence Analysis

The impact (upon whom) and the incidence (at what period in time) of the costs and gains associated with the best alternatives should be examined. The costs and gains for two plans may be very similar in the aggregate but very dissimilar in their effects on those who receive them or the times in which they occur.

Implementation Feasibility

The relative ease with which a plan can be implemented should be examined. A superior plan with a low probability of successful implementation might be rejected in favor of a lesser plan with a higher probability of successful implementation. In addition, plans might be combined to increase implementation probabilities, or efforts might be made to reduce barriers to implementation (when barriers can effectively be identified).

Qualitative Analysis

Qualitative analysis is a catchall that would include a careful examination of the best choice considering factors omitted in the analysis, assumptions made, factors that could not be quantified, uncertainties, and the results of the other phases of interpretation.