Applications of Value of Travel Time to Economic Evaluation of Transport Investment Alternatives

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This review of conventional evaluation techniques and the changing viewpoints and techniques of economic evaluation focuses on the principal techniques applied to transportation investment, the estimation and uses of travel time values, and the value of travel time in cost-effectiveness analyses. The implications of the value of travel time for techniques involving cost-benefit estimation are also examined. The primary constituents of user benefits are reduced travel time and reduced automobile operating costs. This gives rise to the need to convert time savings in minutes to an equivalent monetary value. An attempt is made to establish what time values are relevant for economic evaluation, and it is stated that nonworking time has value and that this value should be used to determine benefits accruing from transport projects that result in time savings. The value of travel time will enter the evaluation process through the procedures for estimating future use and travel times on a new transportation facility. The problems encountered in such use of travel time values are discussed. These include the possible inaccuracies in travel time estimations, the estimation of monetary value of time savings, the problems associated with variations in travel time value, and the estimation of the amount of induced traffic. The value of induced travel time and time savings, together with the issue of consumer surplus are also discussed. An alternative evaluation technique that is superseding cost-benefit analyses is cost-effectiveness. In this technique, which is based on the systems analytic approach to transportation planning and which does not require the conversion of time savings into monetary terms, the achievement of certain time savings may be expressed as a goal of the transportation project. This can be directly assessed for effectiveness. Use of cost-effectiveness will lead to changes in uses of the values of travel time and travel time savings. Such values will assume increased importance in determining goal achievement and in permitting goal modification in an evaluation process that seeks to achieve prespecified goals.

In the process of planning investment in transportation, one can usually find an evaluation phase, designed to assist the decision maker in choosing among alternative plans or in deciding whether to invest money in transportation at all. This evaluation process is intended to answer two basic questions: Is the plan worthwhile? and If the plan is worthwhile, when will it be worthwhile? In transportation investment, these questions are customarily asked of the users of transportation facilities (or the potential users) to estimate how worthwhile the project is in monetary terms. In the last few years, the entire framework of economic evaluation has entered into a state of changing viewpoints and changing techniques. These will be dealt with, however, in more detail, later in this paper. For the present, the concern is with the conventional evaluation techniques.

At least three principal techniques of cost-benefit analysis have been applied to transportation investment: net present worth, cost-benefit ratios, and internal rate-of-return (13). These techniques can be applied with varying degrees of sophistication. From the viewpoint of the economist, the techniques should be applied by estimating costs and benefits for each year of the project life and by appropriately discounting these monetary streams to the present, or a base year. In practice, highway economists estimated costs and benefits for an average year in the life of the project and computed the economic evaluation on the basis of such figures. Implications for the value of travel time will be examined for both procedures of application of the techniques.

In such economic evaluation procedures, the costs and benefits, for each alternative plan, must be determined. The costs associated with highway projects would generally comprise planning, right-of-way acquisition, construction, maintenance and policing of the facility, relocation costs, accident costs, and user travel costs. The total benefits of the project in an economic evaluation have generally included (according to highway economists) the user benefits. Clearly, the above listings of costs and benefits are not irrefutable. Apart from any other questions, costs can be regarded as negative benefits, or benefits as negative costs. In many cases, a clear distinction between costs and benefits does not exist. Yet the evaluation procedures (with the exception of net present worth) call for computations that are clearly sensitive to the definition of costs and benefits. However, Fleischer (5) has shown that, as long as a consistent treatment is used for all elements of costs and benefits for all alternatives, in terms of classification into either costs or benefits, the three methods of economic evaluation will lead to a single ranking of the alternatives.

The primary constituents of user benefits are likely to be reduced travel time and reduced automobile operating costs. For an economic evaluation, such benefits must be expressed in monetary terms, hence giving rise to a need for values of travel time savings to be applied to convert time savings in minutes to an equiv-

alent value in, say, dollars and cents.

ESTIMATION OF TRAVEL TIME VALUES

As noted above, the major context in which travel time is valued is in terms of savings of travel time related to highway or other transportation projects. It should be stressed that travel time cannot actually be saved and, in fact, no form of time can be saved—it can simply be used in an alternative manner. Therefore, the concept of travel time savings refers rather to a diversion of time, which would have been used for traveling, to some other use. It should first be established why travel time, or travel time savings, should have a value. That travel time spent during working time has a value is obvious. Such time is being paid for by an employer and therefore has value or worth to the employer. Similarly, a saving of such time should permit that time to be diverted to more productive uses; this would increase gross national product (GNP) and appear in national income accounting. Any time, other than time spent traveling during working hours, should have a value because of an individual's ability to use that time for some other purpose and thereby to increase his or her total utility. To a large extent, the value that such time will have is related to an individual's perception of what he or she can do with the time that is saved from travel and that is in no way related to the GNP.

There has been a lengthy controversy over the existence of a value for travel time that is incurred during nonworking time. Numerous viewpoints have been put forward relating to travel time values of nonworking time. There is a strong segment of opinion that maintains that leisure time can in no way be traded for goods or services, and therefore has no economic value (12). Another opinion holds that, since savings of nonworking time are not reflected in GNP, they should not be considered in an economic evaluation of a public project. In my opinion, the latter statement demonstrates a shortcoming of national income accounting rather than a valid argument for the exclusion of travel time savings of nonworking time in the economic evaluation of alternative transport projects.

The existence of overtime rates of pay has led at least two writers to diametrically opposite opinions about the existence, or nonexistence, of a value of nonworking travel time. Bellis (2) states that

> Some authorities like to equate vehicle time to earning power. This seems acceptable for commercial vehicles but not for passenger cars. A man's leisure time is worth more than his working time as evidenced by the one-and-one-half time and double time for overtime.

On the other hand, Glassborow (6) says that

> In practice, both the eagerness shown by workers to obtain their share of overtime, and the insistence in agreements to reduce working hours that the weekly wage shall be unchanged, attest that little value is placed on leisure and high price on effort.

In general, however, prevailing opinion among transportation planners and highway economists is to accept the idea that nonworking time has value and that this value should be used to determine benefits accruing from transport projects that result in time savings.

The concepts and mechanics of placing values on travel time savings are discussed by Reichman and Hensher in papers in this Record and will not be discussed here. It is sufficient for the purposes of this paper to establish what time values are relevant for economic evaluation.

USE OF VALUES OF TRAVEL TIME IN EVALUATION

In standard economic evaluation procedures, value of travel time may potentially enter the calculations in two roles. An important factor in the evaluation procedure is the estimation of future travel on the facility under study. This forecast of travel will provide estimates both of the number of users of the facility and of the travel times on the facility, the latter being determined through speed-volume-capacity relationships. For computing future travel volumes, a set of travel demand models should be used. Reichman and Stopher in a paper in this Record point out that it is becoming increasingly apparent that value of travel time is an important constituent of travel demand models. Hence, it is possible that value of travel time will enter the evaluation process through the procedures for estimating future use and travel times on a new transportation facility.

A major constituent of the benefits of a transport investment has frequently been travel time savings. Such savings are estimated by the technique discussed in the previous paragraph. So that such benefits can be entered into a cost-benefit procedure, the travel time savings must be expressed in monetary terms. This monetary conversion is accomplished by the use of the value of travel time. Hotchkiss and Hensher (8) estimate that 25 percent of all economic benefits from urban road works in Australia were attributable to travel time savings. Of the benefits from the U.S. Interstate Highway System, it has been estimated that between 72 and 81 percent are derived from travel time savings (4). Clearly, the determination of time savings and the conversion of time savings to monetary measures are no mere academic exercise but are rather an extremely important part of the execution of an economic evaluation. It is also clear that, since travel time savings appear to have such a prominent place in total transport benefits, misestimation of the benefits accruing in monetary terms, from travel time savings, will have a serious effect both on the determination of the economic viability of a particular transport project and on its ranking among other alternatives.

The problems of the methods for determining values of travel time and the estimation of reliable values have been dealt with elsewhere [(7) and in a paper by Stopher in this Record] and will not be discussed here. Assuming that reliable and correct values have been determined for the present values of travel time, many problems yet exist for applying these to an economic evaluation. It is these latter problems that are the main concern of the remainder of this paper.

Future Values of Travel Time

Since any transportation project will be accompanied by costs and benefits over a period of time into the future, future time savings must be estimated and converted to monetary terms. This requirement gives rise to two problems. The first problem is estimating future travel time savings. For economic evaluation, future travel time savings should be estimated at least at yearly intervals. The procedure for this will involve the estimation of traffic volumes and, hence, travel speeds for the facility under consideration. Present travel forecasting techniques are inadequate for predicting travel for a single point in the future and involve an extremely cumbersome procedure to provide such a prediction. Estimation of yearly travel volumes would therefore require

excessively expensive computation, yielding forecasts of doubtful accuracy and usefulness. For estimates of travel speeds and, hence, time savings, the estimated travel volumes must be substituted into a speed-volume relationship. Differences of speed from one year to the next are likely to be small, and the estimation of them will be subject to considerable inaccuracy. This inaccuracy will be compounded by the errors generated in producing the forecast travel volumes. Thus, the estimation of future travel time savings is fraught with inaccuracies and problems, and the estimates obtained must be handled circumspectly.

The second problem is to estimate the monetary value of these travel time savings. It has been customary to apply a single value of travel time, based on present measurements, to estimate the monetary value of future travel time savings. However, several studies have suggested that the value of travel time is related to the individual's income level (1, 9, 11). If this is the case, then values of travel time will change as real income changes; this introduces a requirement to estimate values of travel time for each year of the project life, based on forecast real income increases.

Given the past importance of travel time savings in the benefits of transportation projects, it is clear that the problems described here should be the concern of some major research effort. Clearly, the adoption of the present value of travel time will lead to an underestimate of benefits (with a growing economy) and, thus, more cautious investment decision making. However, the effects of the misestimation of the travel time savings cannot be easily categorized as leading to underestimation or overestimation of benefits. The conclusion to be drawn here is that the primary research should be to improve estimates of future amounts of travel and future travel speeds, rather than to improve value of travel time estimates alone. It is also relevant that time savings are real benefits generally only for rural projects and for public transit investments. Urban highway projects may generate reduced travel times for a short period of the investment life, but the prime benefits of such projects are in increased capacity and therefore increased mobility. In both cases, benefits will be closely related to future travel amounts, but will be less closely related to value of travel time per se. In that value of travel time may play a major role in estimating future travel (as discussed by Reichman and Stopher in a paper in this Record), then value of travel time still plays an important part in providing estimates of the benefits of proposed transportation investment.

Multiple Values of Travel Time

Recent work has suggested both empirically (11) and theoretically (3) that a number of values of travel time may exist. Specifically, it appears that value of travel time is likely to vary with traveler income, trip purpose, and amount of time saved (11). If such variations in value of travel time are of any significance, then it would seem necessary to incorporate the separate values in the estimation of benefits from transportation projects. Such a procedure clearly compounds the problems of benefits calculation as discussed in the previous section.

First, the use of multiple values of travel time will require that future values of each travel time value be estimated for the project life. Second, it will necessitate that traffic flows on a projected facility be determined by trip purpose, income, and amount of time saved so that monetary travel time savings can be estimated. Furthermore, this breakdown of traffic flows would need to be estimated at yearly intervals for the entire project life in a strictly correct economic evaluation procedure.

Given the present inadequate ability to make annual predictions of traffic flow on a facility, particularly on a planned facility, whether the complexity of computation described here has any justification is questionable. The first question for research to answer is whether this degree of detailed estimation of traffic flows can possibly be achieved. If it can be achieved, then the next question is to determine if the detailed estimation of time savings will likely lead to different decisions than would be made based on a more gross estimation procedure. If the answer to either of these questions is negative, then research is needed to determine what, if any, separate estimation of travel time savings and values of travel time are required and how aggregate values of travel time should be estimated. For instance, if it is determined that one value of travel time should be used for time savings of less than 1 hour, one must still specify how a value, for all time savings less than 1 hour, should be calculated.

Induced Traffic

The discussion of the estimation of benefits has thus far been concerned primarily with benefits from time savings. However, many of the benefits from transportation projects, particularly urban highway projects, may accrue from the provision of increased capacity that is used by travelers making trips not made before, i.e., induced traffic. So far, attempts to estimate the amount of additional travel that will occur as a result of an improvement in a transportation facility have met with little success. Thus, the first problem in this area is to be able to estimate the amount of induced traffic. It is, of course, most probable that the estimation technique will involve the use of values of travel time, since demand for travel will be related to such values.

The second problem relates again to the specific values of travel time. The discussion thus far has focused on values of travel time savings. In the case of induced travel, however, the appropriate value is the value of travel time, not just that of travel time savings. As has been discussed by Stopher, in a paper in this Record, travel time savings and total travel time quite likely will be valued differently. At present, no values have been put forward for total travel time nor has any theoretical work been done to show how such values should be derived.

Apart from the fact that distinctions between induced travel and other travel and between the value of total travel time and travel time savings will lead to different estimates of benefits for specific alternatives, they may also lead to radically different transportation policies. Based on a traditional highway economics approach, if total travel time is valued more highly than travel time savings, then projects that provide considerably increased capacity and are likely to induce large amounts of additional travel are likely to be favored over projects that would speed up present travel movements. In fact, because of the difference between total travel times and possible time savings, if total travel time has positive value, greater benefits will probably always accrue to one induced trip than to one trip on which a time saving is possible.

Research is clearly needed in the prediction of induced traffic and in the evaluation of the value of total travel time. The first of these research topics is the determination of the demand and supply schedules for travel. Induced travel is simply the effect of a shift in supply for a given demand schedule. The fact that current estimating procedures do not provide adequate

estimates of induced travel is largely a reflection of the fact that current so-called travel demand models are not demand models in the sense of estimating the demand schedule for travel.

Finally, the estimation of benefits from travel time savings constitutes an estimation of the increase in consumer surplus for existing travelers. On the other hand, the estimation of benefits from increased travel, although some consumer surplus is included, is largely an estimate of increased consumer expenditure on travel. It has been argued (13) that consumer surplus should not be included in estimating the benefits from transportation projects. If one accepts such arguments, then the benefits from transportation projects are total consumer benefits minus consumer surplus. Such benefits also, like induced travel, require estimation of the value of total travel time. Thus, consumer surplus changes can be estimated by using the value of travel time savings, although net consumer benefits require the use of the value of total travel time.

VALUE OF TRAVEL TIME IN COST-EFFECTIVENESS

The emphasis in the paper has thus far been on the value of travel time as a means to convert the travel time savings, resulting from a proposed transportation project, to monetary terms for use in a cost-benefit analysis. An alternative evaluation technique, which is, to some extent, superseding cost-benefit analyses, is that of cost-effectiveness analysis (10). This technique is rooted in the systems analytic approach to transportation planning, in which a primary task is to specify goals to be met by any transportation project. The cost-effectiveness approach then assesses the degree to which each goal is met by a potential project and the cost at which goal achievement is attained. The analytical stage of the evaluation terminates when the information on costs and goal achievement has been arrayed. The decision maker is then able to select a project on the basis of the information provided by the analyst. It should be noted that, unlike traditional cost-benefit analysis, cost-effectiveness analysis does not aim at rank ordering alternative projects, nor does it usurp the role of the decision maker.

More important for this paper, the cost-effectiveness approach does not require the conversion of time savings to monetary terms so that an evaluation can be carried out. Rather, the achievement of certain time savings may be expressed as a goal of the transportation project and, thus, can be directly assessed for effectiveness. Furthermore, careful specification of goals that relate to travel time can remove many of the problems generated by the more traditional valuing of time savings in cost-benefit analysis. Problems relating to equity, whose travel time should be considered, and times of day when travel times should be affected can all be handled adequately by goal formulation. Conversion of time savings to monetary savings is clearly no longer required.

It might be concluded from this that the replacement of cost-benefit analyses by cost-effectiveness analyses would lead to the disappearance of the need for values of travel time, at least in what has traditionally been the major application area for such values. However, a consideration of the requirements of cost-effectiveness analysis shows such a conclusion to be misleading. Although the role of values of travel time savings as converters of time to money may disappear with the adoption of the cost-effectiveness technique, values will still be required to determine the effectiveness of a transportation project. The assessment of the effectiveness of a project in achieving various goals, including but not limited to travel time goals, will generally require estimation of the travel volumes that will occur if that project is adopted. As discussed by Reichman and Stopher in a paper in this Record, values of travel time savings are likely to play an important part in travel forecasting processes. In fact, if current travel forecasting trends are maintained, values of travel time are likely to play an increasingly important part in the travel forecasting process.

Finally, a planning process that seeks to achieve prespecified goals is not necessarily irrevocably tied to a single set of prespecified goals. The goals set may be such that achievement of all goals is not possible within the available (or any reasonable) budget or under any possible transportation project. Under such circumstances, some modification of goals is likely to be undertaken to permit the planning process to generate some alternative projects. This may frequently happen when goals are mutually exclusive, and the modification may be to set lower levels of achievement for one or more goals. For example, goals of increased mobility and reduced environmental pollution are likely to be jointly unattainable under present technology unless one is careful to specify by how much mobility is to be increased and pollution reduced. The modification of goals in this manner is, effectively, based on a value judgment. The analyst, or the decision maker, is placed in the position of determining which goals to hold unmodified and which ones to modify and by how much. Knowledge of values of travel time could be instrumental in assisting such goal modification by making explicit the value of one goal, against which modification of another goal could be assessed. In the earlier example, for instance, a reduction in the mobility goal could be determined as being equivalent to a certain penalty in travel times. Such a reduction might allow the pollution goal to remain unmodified. The cost of retaining the pollution goal could thus be determined.

In summary, the use of cost-effectiveness as an alternative evaluation procedure to cost-benefit analysis will lead to significant changes in the uses of values of travel time in evaluation, but will probably not lead to any diminution of their importance. Instead of being used as a conversion mechanism for travel time savings, values of travel time and travel time savings will assume an increased importance in determining goal achievement and in permitting goal modification in an evaluation process that seeks to achieve prespecified goals.

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