Critical Evaluation of AASHTO's Manual on User Benefit Analysis of Highway and Bus-Transit Improvements, 1977

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The changing nature of transportation systems and services puts a burden on decision makers. Decision makers are usually presented with alternative uses of scarce resources. To choose among transportation improvement alternatives properly, investment decisions should be based on a process that meets efficiency criteria. Over the last few decades, interest in such a process has generated extensive literature. A Manual On User Benefit Analysis of Highway and Bus-Transit Improvements is one in this series. The book is intended to help to determine "whether the benefits from reduced highway and transit user costs (operating costs, fares, travel time values, and accident costs) exceed the highway or bus system costs required to produce the benefits." The manual presents a methodology and cost factors to estimate these system costs and user benefits. The methodology can be applied to most types of highway and bus-transit improvements. The technique and background information are significant contributions to the literature on economic analysis of transportation improvements. Although it assists in the selection of efficient transportation improvements, several factors reduce its practical utility for the average person involved in the early stages of transportation investment planning. This paper reviews the subject matter, stated purpose, and format of the manual. A summary critical evaluation of the manual is provided.

The problem of choosing among transportation improvement alternatives is fundamental to transportation capital investment planning. The literature on this subject demonstrates widespread interest in such a process. The complex nature of the problem has spawned an extensive collection of articles and books that deal with specific aspects of it.

The American Association of State Highway and Transportation Officials' (AASHTO) A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements, 1977 (1) is one of these specialized references. It is intended to help the reader determine (1, p. 1), "Whether the benefits from reduced highway and transit user costs (operating costs, fares, travel time values, and accident costs) exceed the highway or bus system costs required to produce the benefits."

Economic analysis and cost factors are used to determine the economic desirability of highway- or bus-transit-improvement alternatives by estimating benefits that might be accrued to the users. This methodology excludes consideration of the nonuser social, economic, and environmental effects of highway or bus-transit improvements (1, pp. 1-2).

Most types of highway and bus-transit improvements, including curve elimination, widening or adding of lanes, grade changes, new road construction, installation of traffic control devices, dedication of lanes for buses, and changes in bus routes or schedules, may be analyzed by using this methodology. Chapters 6 and 7 (1) provide examples for this purpose.

The manual is an update, extension, and replacement of the 1960 AASHTO report, Road User Benefit Analyses for Highway Improvements (2), and a replacement for the National Cooperative Highway Research Program (NCHRP) Report 133 (3). It provides (1, p. 1) "short-cut procedures" to deal with problems referenced in NCHRP Reports 96, 122, and 146 (4-6).

The manual is organized into four major components:

1. Methodology, reduced to eight steps;
2. Project description;
3. Cost definitions and cost factors; and
4. Examples to illustrate the applicability of the proposed methodology and cost factors.

These are presented in seven chapters. A discussion of the economic analysis of transportation improvements is introduced in chapter 1. Chapter 2 presents the proposed methodology (eight steps) for analyzing the economy of highway and bus-transit improvements, and project description and project costs are treated in chapter 3. Chapter 4 deals with unit highway-user costs in terms of basic section, accident, transition, and delay costs. Section transition and intersection delay costs are the subject of chapter 5. Chapters 6 and 7 serve to illustrate the applicability of the proposed methodology and cost factors for highway and bus-transit improvements. Tables of compound interest factors, motor-vehicle running cost-factor tables, method for updating cost factors, decision rules for selecting sets of projects and establishing priorities, and research project summary of findings (NCHRP Project 2-12) constitute appendices A-D.

The manual requires that the reader have a basic familiarity with some tools of economic analysis, both theory and quantitative methods.

EVALUATION

Strengths

The main strengths of the manual are its integrated treatment of the economic analysis of user benefits of highway and bus-transit improvements and decision rules for the selection of sets of projects and the establishment of priorities (1, appendix C). These may be viewed as a major contribution to the literature on economic analysis of transportation improvements.

A few innovative ideas are introduced in the manual (e.g., bus-transit improvements, simplified decision rules, and logically sequenced, but cumbersome, methodological procedures).

Weaknesses

Organization

The manual does not read well. It contains too much detail and excessive background information. Numerous tables and figures distract the reader. Some figures are reduced to a size that makes them difficult to read. These figures and tables could have been consolidated and presented at the end of the appropriate chapter or a change could have been made in the manual's format to accommodate them. The organization and layout of the manual contribute a great deal to this distraction. Chapters start at the middle of pages. The flow of the text is often interrupted by pages of figures (1, pp. 50-61) and tables (1, pp. 126-135).

The methodology that is provided could have been more concise, with necessary detailed and relevant explanation (reduced to a minimum) referenced in the appendices, as in the cases of procedures for updating cost factors (appendix B), decision rules for selection of sets of projects (appendix C), and research project (appendix D). The manual does not contain an index to facilitate references to the major subject areas dealt with in the text. An index is a very useful device, especially for inexperienced practitioners.

The inclusion in the main body of the text of contradictory statements that justify the limitation of the book to user benefits and costs only and of a lengthy discussion regarding consumers' surplus and its controversial adaptation to explain induced and diverted traffic does little to improve the readability of the manual and to enhance the understanding of the principles of cost/benefit analysis for the average analyst. Indeed, in some cases, it creates confusion.

These difficulties may reduce the usefulness of the manual to many practitioners who are relatively inexperienced in transportation economic analysis (7). More than 60 percent of the states prefer a simple but accurate methodology to assist them in their transportation investment programs (7).

Concepts and Approaches

In general, the manual deals thoroughly with major theoretical concepts that underlie transportation economic analysis and presents logical approaches for applying them. In a few instances, statements are made that are questionable and contradictory and approaches are taken that do not totally reflect today's transportation conditions. For instance, in defining the scope of the manual, it is stated that (1, p. 2), "For developed countries, the economic elements of the SEE trilogy--social, economic, and environmental impacts--is largely covered by highway and transit user impacts." This is offered as the basis for focusing on the effects of highway and transit improvements on transportation costs. According to the book, this practice is consistent with (1, p. 2) "current economic theory."

The statement referenced above is true only as long as all of the SEE costs, including all of the transportation costs, are internalized by the highway and bus-transit users. This is not the case in today's transportation system. This is indirectly recognized by the authors for the case of SEE, since in the next paragraph the reader is reminded of the "crucial importance" of the SEE trilogy, and later the exclusion of SEE is cited as one of the manual's limitations (1, p. 176).

Another justification given for restricting the manual's scope to the user economic effects is that (1, p. 2) "...such analysis is limited to readily costable benefits and costs." However, the authors readily adapt the concept of consumers' surplus to explain the inclusion of induced and diverted traffic. The concept of consumers' surplus is basically derived from "willingness-to-pay", which is a value that is not readily measurable. Such statements, although few are dealing with fundamental concepts, may create misunderstanding and confusion among practitioners--the very persons that the manual is trying to assist.

For the analysis of improvement costs for highways and bus systems, the authors present only a listing of types of project cost estimates (1, pp. 37-40) and brief discussions on analysis period (1, p. 20) and residual value (1, p. 29) of the improvements. These are not only loosely connected but are presented as separate components conceptually as well as organizationally.

A more comprehensive discussion, similar to the discussions about user costs (1, pp. 40-75), that involves these three components would have provided the reader with useful insights into the highway and bus system improvement costs (project costs) and the interdependence of these three components. For example, lifetime or service life of a highway facility is a determinant of residual value of the facility. The analysis period may very well be influenced by the surfacing design life option. Project cost estimates depend on the design alternatives adopted, and this in turn impacts the cost of a project.

Major policy issues in transportation investment planning evolve around these components. The development of strategies for pavement management is one of them. These strategies cannot be properly developed without a good understanding of the interdependence of these components and the various alternatives based on current conditions (e.g., changing vehicle mix or increasing axle load). These alternatives determine the project cost estimates, including maintenance costs. The development of these alternatives includes determination of design life alternatives, coupled with the economic analysis of each alternative and its effect on the highway system.

Such a comprehensive, but concise, discussion would provide the decision maker with potential options from which to develop pavement-management strategies based on current conditions. Improvement projects could then be evaluated, by using cost/benefit analysis, based on these strategies.

Most of the available strategies were established under conditions and policies that prevailed 20 years ago or longer. Some of these conditions have changed, or at least are operating in a different direction from the one assumed previously. For example, nationally, registration of heavy vehicles (buses and trucks) increased at much higher rates than registration of passenger cars. Between 1970 and 1977, registration of heavy vehicles grew by about 57 percent, but the increase for passenger cars was only 27 percent during the same period. For the same period, the vehicle miles of travel for heavy vehicles rose by about 51 percent as opposed to about 26 percent for passenger cars (8). Moreover, the axle load of heavy vehicles has been steadily increasing for the past decade.

Without these strategies, the reduced costs for highway users due to improvements may be short-lived. In fact, the rapid deterioration of much of the highway system and the increasing costs of resurfacing, rehabilitation, restoration, and reconstruction may be partly viewed as a direct result of the current lack of such sets of strategies.

Concepts and Illustrations

In general, the manual gives complete and detailed suggestions, guidelines, and examples. However, some of these suggestions and guidelines (rules of thumb) are offered with no explanation or reason, and in certain cases they are ambiguous and inappropriate and perhaps they should not be followed (or at least they should have been presented as optional) due in part to the set of assumptions implicit with their use.

For instance, in relation to the user cost factors, the book recommends updating them (1, p. 14) "when the relevant price levels...change by more than 20 percent." Why 20 percent and not 10 or 15 percent? The currentness of cost factors is sought, in part, to account for the effect of inflation on price levels (including the relevant ones) as reflected by the change in the consumer price index (CPI) or other price level change indicators. The

market rate of interest and the current dollar discount rate (the market or nominal rate of interest used to discount future streams of benefits and costs expressed in current dollars) are subject to inflation. The market rate of interest is one of the components of the CPI. CPI and interest rate change at different rates and not necessarily at the same time.

There is a direct relationship between market rate of interest and change in relevant price levels (e.g., an increase in interest rate would be reflected in higher cost of an automobile). When outdated cost factors are used to calculate future user benefits and costs in current dollars, the projected user benefits and costs would be underestimated by an amount, in percentage, approximately equal to the percentage change in the relevant price levels.

The decision to keep cost factors current is then a function of how much underestimation of user benefit and cost the analyst or decision maker is willing to allow. A rule of thumb that emphasizes the relation between relevant changes in price level and the market-rate-of-interest, on the one hand, and the amount of the underestimation of future user benefits and costs on the other hand, would be more helpful than a mere specific figure of relevant price level change. Such a suggestion might read as follows: When relevant price levels change at a higher rate than that of the market-rate-of-interest, efforts should be made to update cost factors unless the analyst or decision maker decides otherwise.

Similar suggestions are made with respect to (a) vehicle mix (1, p. 42), (b) changes in highway user costs due to change in bus-transit patronage (1, pp. 102-103), and (c) others [e.g., residual value (1, p. 29) highway section definition, variations in volume/capacity ratios (1, p. 35), calculation of present values of benefits and costs, and accurate calculation versus practical applications (1, p. 20 and p. 30)]. Only the first two are considered here.

Regarding the vehicle mix, the book states (1, p. 42), "If the percentage of trucks in the traffic stream is relatively small (less than 5 percent), basic section costs may be calculated as if the entire stream consists of passenger cars." This statement, specifically the less than 5 percent, is misleading and does not reflect the complete picture of vehicle mix when considered in conjunction with the design standard (design life), and construction and maintenance costs of certain improvements (e.g., curve elimination as given in the book on page 78).

For example, take a basic section that has an average hourly traffic of 1000 vehicles. First, assume, as in the manual, that the entire stream consists of passenger cars that weigh about 3800 lb each. This is equal to about 500 equivalent single-axle load (ESAL). Second, assume that the vehicle mix is made up of 95 percent passenger cars and 5 percent trucks. There would be 950 passenger cars and 50 trucks (29 trucks of typical 18-wheeler 3-S2 configuration that weigh about 54 000 lb each and 21 single-unit trucks that weigh 12 000 lb each). This vehicle mix amounts to about 21 700 ESAL (475 for passenger cars plus 21 225 for trucks).

With the homogeneous stream, only passenger cars, the ESAL is 500 as opposed to 21 700 ESAL for the heterogeneous stream. This is a ratio of 43:1. The variation in the construction and maintenance cost may be significant; thus, the variation in cost/benefit results of the improvement. The variation in maintenance cost may be translated into shorter life of the improvement due to the increased ESAL. This may become crucial for those states that have an increasing proportion of 3-S2 trucks or segments of the road heavily traveled by 3-S2 trucks.

Vehicle mix is never assumed to consist entirely of passenger cars, regardless of truck proportion, in the design and in the estimates of construction and maintenance costs of an improvement. A possible exception would be bus-transit exclusive roadway improvement. There is no apparent reason to do so when calculating basic section costs.

The manual defines annual user benefits of bus-transit improvements as the reduction in transit user costs and highway user costs. For the highway user costs, these include changes in vehicle running (operating) costs and travel time. The manual asserts (1, p. 103), "These changes are typically a small fraction of total motor vehicle costs and travel time, yet, they are often worth considering when a sizeable change, say over 10 percent, is caused in the vehicular traffic...."

This 10 percent figure is probably intended as a shortcut suggestion. It is inappropriate. A more comprehensive method should have been provided to deal with the analysis of these changes regardless of the amount of reduction in the highway user costs.

The economic analysis of bus-transit improvements may be sought for reasons other than reduction in the highway user costs; although it is to be recognized that reduction in these costs is important, so is the cost reduction in maintenance of highway facilities. The limitations placed by this figure will truncate the availability of additional information that may be acquired about the proposed bus-transit improvements, especially when they are independent of highway improvements or proposed as alternatives to highway improvements.

These considerations, although cited in the manual, are not dealt with appropriately. The manual could have provided examples that deal with bus-transit improvements as alternatives to highway improvements, as well as cases that show relationships between number of buses needed to serve additional person trips, operating axle weight of the needed buses, and additional maintenance and construction costs of the city streets due to buses. These would have enhanced the understanding of much of the literature on bus-transit improvements and increased the usefulness of the manual to its intended users.

CONCLUSION

Although the narrowness of the manual's scope is perhaps justifiable, given the complexity of the problem of selecting among transportation-improvement alternatives, the reason that is advanced for limiting the scope of the manual is not theoretically rigorous.

The book does provide usable tools in the form of procedures to evaluate user benefits and costs. These may be useful to transportation-investment analysts and policymakers. Several illustrations and shortcuts should be viewed as optional and some should not be followed in certain instances. The analyst finds little assistance from the book in dealing with some aspects of bus-transit improvements and improvement cost estimation.

The manual can be a valuable reference document for analysts who are familiar with economic and traffic engineering principles. However, the fundamentals found in elementary textbooks on principles of economics or traffic engineering are lacking.

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The views expressed in this paper are ours and do not necessarily reflect those of the Policy and Planning Section or the Oregon Department of Transportation.

Discussions

Douglas S. McLeod

Kimboko and Henion's critical evaluation of AASHTO's A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements (1) is well based and timely. To a lesser degree, I concur in nearly all of their criticisms. The authors, however, do not present many of the manual's strengths and major weaknesses. The paper is timely because it provides useful comments and further exposure to the most-widely accepted highway and bus-transit economic-analysis methodology. My comments will address Kimboko and Henion's evaluations and will further discuss strengths and weaknesses of the manual.

The authors state four strengths of the manual:

1. Integrated treatment of economic analysis of user benefits of highway and bus-transit improvements,
2. Decision rules for the selection of projects,
3. Establishment of priorities, and
4. Thorough treatment of major theoretical concepts that underlie transportation economic analysis and a logical approach to apply them.

I agree with the authors' assessment of these four strengths. However, other aspects of the manual also contribute significantly to transportation economics literature. First, simply because it is the AASHTO guide, the manual's assumptions and methodology are elevated to the standard to base economic analyses. Second, the manual fulfills one of its major purposes by providing users a means for updating cost factors over time. The updating procedure is comprehensive and relatively easy to implement. Third, the manual is comprehensive and covers greatly diverse highway projects. From personal experience, the methodology has been useful on such a great scale as a large highway network analysis (9), a safety study, and to a lesser extent, on a bus study.

The manual makes two positive breaks with conventional transportation economic analysis. First, the methodology is based on a willingness-to-pay approach (1, p. 154), rather than a conservation-of-resources approach [i.e., 10)]. However, as pointed out by the authors, the manual at times philosophically deviates from the willingness-to-pay approach. Second, the manual recommends a 4-5 percent discount rate (1, p. 15) rather than more traditional higher rates. As stated in the manual, these higher rates inappropriately reflect inflation.

Further positive aspects of the manual are that it is based on well-researched data. Although, as pointed out by Kimboko and Henion, the methodology at times is cumbersome, there are numerous cross references (i.e., 1, p. 12 and in the examples). Finally, the manual is truly a guide for economic analysts rather than a cookbook approach to be followed. Data and basic steps are provided, but significant decisions are left to the economic analysts or decision makers.

Numerous weaknesses of the manual's organization are addressed. Although I agree with each point made, none of them should seriously limit the manual's effectiveness. An index would be useful to inexperienced practitioners, but at least as stated above, there are numerous cross references. My major concern about many of the manual's figures is not where they lie in the text, but their small size. Values obtained are subject to too much error due to the figures' small scale. Larger-scale figures should be provided, or at least be available, for order.

Kimboko and Henion point out convincingly the questionable and contradictory statements concerning

1. The relation between highway and transit user impacts with social, economic, and environmental impacts and
2. The willingness-to-pay approach.

They are correct in stating that the manual's statements dealing with these fundamental economic concepts may create confusion among the manual's users.

Kimboko and Henion in their daily work are obviously very concerned about design aspects of highways and more specifically the interrelationship between heavy vehicles and pavement-management strategies. They criticize the manual for not devoting adequate attention to project costs. I find the manual's discussion on project costs quite adequate. Nevertheless, project costs are important and the manual's final form reflects considerable improvements on this subject compared with initial drafts. Most users who view the manual as a guide for conducting detailed economic studies have probably wished for more-detailed or less-detailed treatments in certain areas under study. From my own experience, I have needed more detail in such areas as initial bus costs, bus salvage values, and highway type-traffic speed relationships. On the other hand, for highway network analyses, a simplified method to aggregate costs of intersection delay was desired. However, after other sources were consulted and professional judgments made, the analyses proceeded. Certainly, I prefer to have guidance from the manual in these important areas; however, given the scope of the manual and wide range of projects to which it can be applied, I cannot find fault with the document for not including these items that were important to me. The manual relies heavily on its users' judgments for determining appropriate considerations in a study. Kimboko and Henion make a strong case for the importance of increased attention to vehicle-mix and pavement-management strategies; however, I do not find fault with the manual for lack of a detailed analysis in this area.

The authors criticize the manual for suggestions and guidelines (rules of thumb) that they feel are inappropriate and ambiguous at times. They point to the manual's treatment of changes in price levels, vehicle mixes, and the reduction of transit user costs and highway user costs from bus-transit improvements. I agree with all three of their assessments; I update costs at the beginning of each study and use appropriate vehicle mixes. However, I do not find fault with the manual for presenting such shortcut methods to users who feel they are reasonable for the type of study they are conducting.

I disagree with the authors' position that the manual's examples are complete and detailed. Quite the opposite, I find the examples replete with simplifying assumptions and no example reflects a majority of the manual's methodology. Note, however, that the manual stated that the examples reflect only specific parts of the methodology (1, p. 78).

Though I agree with the authors' concept of user benefits and costs subject to underevaluation due to inflation, I find their presentation confusing. The interchanging of market-rate-of-interest and discount rate, and the use of current costs throughout the discussion lead to the confusion and the inappropriateness of their possible suggestion for cost updating. I prefer to obtain updated user costs and project costs at the same time to reduce the underestimation of one type of cost versus the other. In any case, the manual's 20 percent price-level-change

criterion is too great. A 10 percent level appears more reasonable, and this underestimation will at least be partly offset by lagging project cost estimates. The Florida Department of Transportation updates values yearly but allows analysts the option of updating at any time if desired.

Many weaknesses of the manual were not pointed out by Kimboko and Henion. In my opinion, the two most significant weaknesses of the manual's methodology to its users are the number of calculations required by its users and probable inconsistencies of simplifying assumptions (9). The immense amount of hand calculations for a complex project greatly increases the probability of a computational error. To reduce the probability of error, the manual's methodology needs to be computerized. This need was recognized in the manual (1, p. 176). Florida (9) and Colorado (11) have already developed computer programs based on the manual's methodology. Thus, this weakness is at least being partly corrected.

The second major weakness stems from two of the manual's major strengths. Because the manual covers small-to-immense projects and is a guide rather than cookbook approach methodology, results may be subject to great variability according to what assumptions are made. For instance, one analyst may use the manual's 4 percent discount rate, and another may use the U.S. Office of Management and Budget's 10 percent rate; users may use significantly different accident cost values; or, for a large network study, costs for intersection delay may be included or treated in a general way. Groups of users, say by states, should define more precisely what major assumptions will be used in order to obtain greater uniformity of results.

In addition to the suggested improvements sited by Kimboko and Henion and those above, further improvements to the manual should be made. First, Figure 3 (1, p. 24), which deals with peak-hour traffic characteristics, is inappropriate for all of the manual's examples. The 30th and 100th peak traffic hours are important design parameters but are not relevant to the manual. For example, by using the example on page 24 (and assumptions on page 23) of the manual, there would be 618 one-way peak hours and 1236 two-way peak hours. To use the 30th peak-hour misrepresents traffic peaking characteristics. An hourly curve closer to 618 should be used. As an improvement, hourly traffic curves well beyond the 100th hour should appear in Figure 3.

Further improvements include the following:

1. Change the calculation of a present-worth factor for a stream of benefits (1, p. 31) to a present-worth factor for a stream of costs that involve a specific cost component (9);
2. Change the inaccurate definition of discount rate on page 7 to reflect the appropriate discussions on pages 7, 14, and 15; and
3. Bring back all values to the time of decision (year 0) rather than to the year construction is completed (1, p. 20).

In conclusion, Kimboko and Henion point out valid weaknesses of the AASHTO manual. An understanding of these weaknesses will assist the manual's users. Additional weaknesses are presented, the most significant of which is the number of hand calculations required and the inconsistency of results among users. Positive aspects of the manual also are addressed in this discussion. Despite the weaknesses presented above, the manual is a most important and useful tool to economic analysts and administrators.

Willard D. Weiss

The authors have provided a comprehensive and useful critique of the publication, A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements. A number of their criticisms, however, deserve further comment. Three of these are discussed below.

SEE IMPACTS

The authors apparently take exception to the manual's assertion that (1) "current economic theory" concludes that "for developed countries, the economic element of the SEE trilogy--social, economic, and environmental impacts--is largely covered by highway and transit user impacts". The authors state that it "is not the case in today's transportation system" that all the SEE costs "are internalized by the highway and bus-transit users."

As a general statement, either position could be argued, but what is more important is whether or not for any specific project evaluation the SEE impacts are adequately included in the user cost analysis. To the extent that the SEE impacts of a given improvement are reflected in induced or diverted traffic, those impacts should be measured by the consumer surplus approach presented in the manual. This measure, however, may be quite inaccurate if the induced traffic benefit represents a large share of the total user benefit (i.e., if triangle KLM in Figure 4 of the manual represents a large portion of trapezoid U_oKLU_1).

Thus, in some situations, the procedures in the manual may be adequate for measuring SEE impacts but may be quite inadequate in others. It is currently up to the analyst to decide whether additional SEE analysis is required for any given project. A useful addition to the manual may be some guidelines for making this determination. This could be presented as an appendix, which outlines specific SEE impacts with an indication of the adequacy of their measurement by the procedures given in the manual.

ALTERNATIVE PROJECT DESIGNS

The authors have suggested inclusion in the manual of a discussion of the interdependence of project design (initial cost), service life, and residual value. An example was given for alternative pavement designs, which generate different values of initial cost, annual maintenance cost, and service life. They suggested that procedures be included in the manual for developing pavement management strategies and similar facility designs on an optimum basis.

Determination of the optimum design of a given project is a process highly amenable to application of engineering economy. However, a set of working procedures for optimization of highway design would be necessarily extensive and its inclusion in this manual would probably not be feasible. It may be more suitable as a separate, companion document.

In any case, the evaluation of alternate designs for a given project can, of course, be done by using the manual, by considering each design as a separate, mutually exclusive alternative. The procedure is given in appendix C of the manual.

EFFECT OF VEHICLE MIX ON USER COSTS

As an alternative to estimating user costs separately for different vehicle types, the manual suggests (1): "If the percentage of trucks in the traffic stream is relatively small (less than 5 per-

cent), basic section costs may be calculated as if the entire stream consists of passenger cars." The authors have objected to this simplification and demonstrated that the effect of a small percentage of trucks on roadway construction and maintenance costs may be significant.

The authors may have misinterpreted the term, "basic section costs," in the above quotation. These are defined in the manual as the time value and unit running costs on the analysis section and do not include construction or maintenance costs. Hence, the simplification suggested applies only to the calculation of these user costs and are not intended to be applied to construction and maintenance costs, as the authors have implied. For calculating the basic section costs, the small error introduced by this simplification would appear to be acceptable.

Apart from these comments on the authors' evaluation of the manual, a separate criticism of the manual itself may be raised: The manual does not suggest a procedure for ensuring optimum timing of a project even if its benefit/cost ratio is favorable. Sometimes, especially in a situation where a high traffic-growth rate is projected, even though the total (present-worth) benefits exceed costs, the benefits for the initial year are low and a postponement of the project implementation proves to be more economical than immediate implementation. This may be determined by considering different project timings to be mutually exclusive alternatives (e.g., alternative A is the basic project constructed in year 1; alternative B is the same project constructed in year 2; and so on), and evaluating the alternatives as described in appendix C of the manual.

A simpler approach, which is usually as accurate, is the so-called first-year-benefit analysis. The basis of this analysis is that the economic effect of postponement of the project by one year is represented by the loss of the first year's benefit plus the gain due to the foregone interest for one year on the capital investment. The foregone interest is simply the investment times the interest (or discount) rate. Thus, successive postponements can be tested until the initial year's benefit is reached that just exceeds this foregone interest. That point in time represents the optimum timing; that is, implementation at that time will be more economical than implementation any time earlier (or later).

Determination of the optimum timing of a project does not necessarily ensure a favorable overall benefit/cost ratio for the project, depending on the nature of the future benefit stream. However, for continuously increasing benefits it usually does, and this fact permits another useful application of the first-year-benefit analysis: evaluation of projects in which future benefits are difficult to assess because of traffic congestion conditions. This conceptual problem was addressed in the manual (1, chapter 4 and example 4 in chapter 6), but the solution suggested is somewhat arbitrary and inexact.

An alternate approach is to apply the first-year-benefit criterion and when the optimum timing is determined (which may be immediate implementation), it is generally true that the project is economically feasible as well (favorable benefit/cost ratio). Exceptions to this rule can occur, but only if the traffic growth rate is small, in which case the congestion problem is not likely to arise anyway.

Authors' Closure

Our paper and the subsequent reviews of it by Douglas S. McLeod and Willard D. Weiss should provide the users of the AASHTO manual with insights as to its major strengths and weaknesses. That was and still is our intent.

We appreciate the efforts of the discussants in this process, who, in their reviews of our paper, pointed out additional strengths and potential weakness of the manual. Certainly, some users may also find (if they have not already) many other strengths and weaknesses in the manual.

In general, we concur with the results of the discussants, McLeod and Weiss. However, several areas of their review deserve further comment on our part. We will address: (a) discount rate, interest rate, and related expressions; (b) basic section costs and vehicle mix; (c) shortcut methods; (d) SEE impacts; and (e) interdependence of residual value, analysis period, and cost of improvements.

The proper use of expressions such as market rate of interest, market or nominal rate of return, current and real costs is partly explained on pages 14-15 of the manual (1). A relatively simple definition of discount rate is provided on page 7 of the manual. We disagree with McLeod's assertion that this definition is inaccurate. The manual's definition of discount rate is sufficient and conveys the basic notion of the discount rate, in that money has a time value. A borrower of money (capital) pays interest and a lender of money (capital) expects a return.

Expressions used in our discussion of changes in price level are consistent with the manual's use of these expressions. The effect of change in price level on the interest or discount rate is easily understood. The purpose of our discussion is to suggest an alternative to the 20 percent figure. This alternative would be partly based on the intrinsic characteristics of CPI rather than on an arbitrary figure.

We do not consider the manual's recommendation of a 4-5 percent discount rate to be "a positive break with conventional transportation economic analysis", as reported by McLeod. However, the discussion provided by the manual about what a discount rate ought to represent is important. This discussion leads to the distinction between market or nominal rate of return and rate of return that represents solely the real cost of capital.

As noted in the manual (1, pp. 14-15), the discount rate, which represents solely the real cost of capital (to be used when discounting future benefits and costs estimated in constant dollars), is generally lower (between 4 and 5 percent) than the current market rate of interest (to be used when discounting future benefits and costs projected in inflated or current dollars). The manual notes that this latter rate (i.e., current market) commonly ranges between 8 and 12 percent in recent economic studies of public projects. The discount rate of 10 percent suggested by the U.S. Office of Management and Budget is within that range. The definitional distinction between these two types of discount rate is more important than the mere order of magnitude of these figures.

The complete definition of the expression basic section costs is provided in the manual (1, p. 40). The manual defines it as "consisting of the unit cost (time value and vehicle running costs) associated with vehicle flow and the basic geometrics (grades and curves) of the analysis section". The association is clear in our discussion of this subject. The vehicle mix is used in the estimation of basic section costs as well as in the calculation of project costs of certain improvements (e.g., construction of new freeways or expressways, widening of existing roads or reconstruction to higher geometric standards, straightening or eliminating

curves, and grade changes). For a given analysis section the same vehicle mix figure ought to be used in both instances in order to minimize the overestimation of benefits by underestimating the costs.

A case was made by McLeod that the users of the methodology provided in the manual may encounter numerous hand calculations. This, he contends, constitutes a significant weakness of the manual. The large number of hand calculations is not as significant a weakness as is the use of shortcuts suggested in the manual. These shortcuts, with implied assumptions, may lead to inconsistent and varied results, even if the hand calculations are replaced by computer calculations. These shortcuts should be carefully assessed.

With respect to SEE impacts, we reiterate that it is quite inaccurate to assume that SEE impacts are covered by highway and transit user impact if all the transportation costs are not internalized by the transportation users.

Finally, the discussants disagreed with our discussion regarding the need for inclusion in the manual of the interdependence of analysis period, residual value, and cost of improvements (and subsequent reference to the development of pavement management strategies). We still contend that the manual should have addressed these issues or at least alluded to them. Several states have shown interest in these issues. A review of the NCHRP Report 215 (12) [and to some extent NCHRP Report 58 (13)] may provide some insights into the essence of our discussion of these issues.

REFERENCES

1. A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements, 1977. AASHTO, Washington, DC, 1978, 189 pp.
2. Road User Benefit Analyses for Highway Improvements. AASHO, Washington, DC, 1960.
3. Procedures for Estimating Highway User Costs, Air Polution, and Noise Effects. NCHRP, Rept. 133, 1972, 127 pp.
4. E.N. Thomas and J.L. Schofer; Northwestern University. Strategies for Evaluation of Alternative Transportation Plans. NCHRP, Rept. 96, 1970, 111 pp.
5. Summary and Evaluation of Economic Consequences of Highway Improvements. NCHRP, Rept. 122, 1970, 324 pp.
6. F.F. Frye; Creighton, Hamburg, Inc. Alternative Multimodal Passenger Transportation Systems: Comparative Economic Analysis. NCHRP, Rept. 146, 1973, 68 pp.
7. M. Roddin and D. Andersen. Current Highway User Economic Analysis. TRB, Transportation Research Record 550, 1975, pp. 20-25.
8. Highway Statistics, 1970-1977. FHWA, 1970-1977.
9. D.S. McLeod and R.A. Adair. Benefit-Cost Analysis Based on the 1977 AASHTO Procedures. TRB, Transportation Research Record 747, 1980, pp. 43-49.
10. R. Winfrey. Economic Analysis for Highways. International Textbook Company, Scranton, PA, 1969, 923 pp.
11. A. Ruth. Cost-Effectiveness Analysis: The Program of the Colorado Department of Highways. TRB, Transportation Research Record 747, 1980, pp. 40-43.
12. W.R. Hudson, R. Haas, and R.D. Pedigo; Austin Research Engineers, Inc. Pavement Management System Development. NCHRP, Rept. 215, 1979, 32 pp.
13. Scenic Easements: Legal, Administrative, and Valuation Problems and Procedures. NCHRP, Rept. 56, 1968, 174 pp.

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