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Notes on the State-of-the Art of Benefit-Cost Analysis as Related to Transportation Systems

JOSEPH D. CRUMLISH

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

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FOREWORD

Benefit-cost analysis attempts to help decision makers evaluate the possible consequences of alternative decisions. We present this paper with the aim of informing policy makers on the nature, goals, advantages, and limitations of this kind of analysis. It should be of general interest to those concerned with transport policy and of particular interest to the U. S. Department of Commerce's Office of High Speed Transportation -- sponsors of the Northeast Corridor Transportation Project, for which the National Bureau of Standards is providing a simulation and benefit-cost analysis.

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This review of benefit-cost analysis as a tool for evaluating alternative courses of action describes the technique, discusses a number of benefit-cost studies, and indicates the difficulties inherent in this area of applied economics. The author concentrates on the application of the technique to large scale transport problems, reviews the literature and indicates in his conclusions where the technique can be helpful and where there is little chance for its success.

An accompanying matrix of benefit-cost studies and a commentary thereon is supplied by Marsha Geier, an NBS economist. Miss Geier's literature search failed to produce any analytic methods which were comprehensive, theoretically justifiable, operational or significant. This finding tended to support the views of the author. (Introduction by Alan J. Goldman, Applied Mathematics Division, Institute for Basic Standards, National Bureau of Standards.)

Key Words: Benefit-cost analysis; Transportation economics; Transport systems; Systems Analysis; State of the Art

1. Introduction

Alan J. Goldman

Benefit-cost analysis is not a well-defined set of proven techniques with a widely agreed-upon range of applicability. Rather, it is a currently evolving general approach to selecting from among alternative projects (or programs), or from combinations thereof. Its characteristic feature is a stress on identifying and weighing as many as possible of the significant benefits and costs associated with each alternative.

This may be contrasted with an emphasis on meeting some postulated requirement regardless of cost, or at minimum cost, or with awareness of only a restricted class of costs and benefits (e.g., those only to the users of a transportation system).

Ideally, such an analysis should take into account indirect effects of policy choices, and intangible effects not easily measurable in numerical terms, as well as the more obvious and readily quantifiable consequences. The possibility of achieving such comprehensiveness, and the appropriate methods for doing so, remain topics of lively controversy.

There is also a need to allow for the varying uncertainties and risks of the costs and benefits of different alternatives. Their respective dispersals over time must be considered as well. The feasibility and choice of formulations for these purposes is again a matter of (constructive and stimulating) dispute. Even where numerical costs and benefits are easily ascertainable, there is no real consensus as to what mathematical formulas should be used to convert them to a single "rating number" for each alternative, or to a manageably small set of such ratings. For example, the frequently-used benefit/cost ratio is held by many distinguished practitioners to be seriously inadequate as a rating index.

The fact that benefit-cost analysis exhibits such a high proportion of "topics in ferment" to tested principles may be disturbing; one would prefer procedures of more thoroughly demonstrated ability to produce the "one best answer." Probably the ferment and controversy are basically healthy, in that they focus attention on the interaction between analyst and policy-maker as the latter carries out his key responsibility: setting the criteria by which the choice among alternatives is to be made. The foundational problems just described are of course far from the only sources of difficulty in specific applications; many of the question marks in these studies stem from data deficiencies, and others from current imperfections in our predictive abilities. These too affect profoundly the results and direction of benefit-cost analysis: for example, there is not even agreement on whether current transport choices can affect significantly the path of further economic development of a highly developed region.

2. Transport Studies in General

During a recent visit to the National Bureau of Standards, Benjamin H. Stevens, regional economist from the University of Pennsylvania, said that transportation's greatest need today is for research on how to investigate transportation problems. In his opinion there is no one who knows how to do an economic impact study of the Northeast Corridor. That is, however, only the result of the fact that economics, which he called the most precise of the social sciences, is in reality a highly intuitive art. The metropolitan transport studies, which represent the work most analogous to Corridor research, are still only experimental.

Their underlying theory is yet in the early stages of development, and their models require data that are unavailable or at least unusable in their present form.

Stevens' views update those of the Woods Hole Conference on "System analysis in transport planning from transport design considerations," August 1960, sponsored by the National Academy of Sciences and the National Research Council:

> An assessment of the evidence presented in this study gives emphasis to the necessity for achieving a more precise understanding of transportation, including its relationship to the political, social and economic activities of the nation.

To clarify this relationship is an important aim of transportation benefit-cost analysis. In addition,

> . . . the generation, collection and processing of data are prerequisite to the formulation of practical analytical and conceptual frameworks which in turn give efficient guidance to the kind and extent of data needed.[1]

Available data appear inadequate in a number of respects, to permit meaningful evaluation and projection of performance, cost, and responsiveness to measurable public demands of various transport systems. Data are lacking to describe and evaluate the relationship of transport to such socio-economic factors as urban and metropolitan development,

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[1]Conference on Transportation Research, Report of a Study Group convened by the National Academy of Sciences at Woods Hole, Massachusetts, August 1960 (Publication 840; Washington: National Academy of Sciences-National Research Council, 1960), p. 51.

location of industry, personal safety, defense, etc. Conventional transport cost accounting is inapplicable to this purpose. This deficiency limits public and private ability to make informed choices among transport alternatives, because it forces analyses of present and future possibilities into speculation, and may conceal the full range of possible choices which would be revealed by analyses founded on an adequate information base.

Data are needed not only on the physical characteristics of each system considered and the nature of the service it performs, but also on how it is operated, what adjustments can be made, and how well different modes can be integrated within it functionally.

Any appraisal of a particular mode's performance or of the transport system as a whole requires data measuring capacity and use as well as data bearing on the operational factors which influence these quantities. With the exception of information on major equipment items, most of these data are not available.

Perhaps the greatest deficiency of past benefit-cost analysis is the inadequate identification and treatment of quantitative factors which are fundamental but which are not usually expressed in dollar terms. These include social costs, such as smog, deterioration of the city and countryside, and improper use of land. They also include social benefits.

Looking at the environmental and institutional framework of transportation,[2] Harvey S. Perloff of Resources for the Future points out the need for a fruitful interchange among the social sciences, natural sciences, and technology to help bring about a more precise description of the values of urban living, clarify the interrelationship of transport and urban development, and aid in devising models to simulate the interaction of public policy with known social and economic forces in the society. To achieve these ends, however, extensive work is needed to establish analytical principles, gather and examine data, and develop necessary mathematical formulae and computer programs.

Perloff and Lowdon Wingo, Jr. represent one viewpoint in a continuing transport debate. They maintain that a transport system cannot be judged only on its ability to meet existing demand, because the system will itself contribute to molding future transport activities, thus shaping future demand. In evaluating developmental plans, they contend, our first and most important concern is to state the long-run developmental objectives for the region which the system serves. We then ask how a given system contributes to these objectives.

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[2]Conference on Transportation Research, Report of a Study Group convened by the National Academy of Sciences at Woods Hole, Massachusetts, August 1960 (Publication 841; Washington: National Academy of Sciences-National Research Council, 1961), p. 103.

[3]Lowdon Wingo, Jr. and Harvey S. Perloff, The Washington transportation plan: technics or politics (Reprint no. 34; Washington: Resources for the Future, 1962), p. 5.

Benjamin Chinitz, Deputy Assistant Secretary of Commerce for Economic Development, expresses another point of view:

> . . . I see very little leverage left in transport in fashioning the path of development. The corollary is obvious: our main concern in the realm of public policy is to provide the most efficient possible transport system for a growing and changing economy. We can no longer change the map; we can only adjust to it.[4]

The issues in this debate are so fundamental that they require explicit consideration by planners of future transport systems.

Melvin Webber adheres to the Perloff-Wingo point of view in saying that transport effectiveness comes from contributing to the successful functioning of the social order and to the production of that most intangible and most important commodity, social welfare:[5]

> It would seem, as a minimum, that an evaluation of long-term consequences deserves at least equal consideration to a transportation facility's capacity to carry expected traffic loads and its impacts on users' operating costs.

The need for this kind of comprehensive, welfare-oriented, benefit-cost analysis is particularly great in transport planning, Webber concludes. Yet in no regional transport plan so far has any systematic attempt been made to weigh costs and benefits on such a comprehensive basis.[6]

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[4]Transportation Research Conference, loc. cit., p. 107.

[5]Melvin W. Webber, "Transportation planning models," Traffic quarterly, (July 1961) p. 385.

[6]Transportation Research Conference, loc. cit., p. 162.

Why have such large-scale evaluations not been undertaken in the crucial field of transport planning? In a summary review of major metropolitan area transportation studies, Richard M. Zettel and Richard R. Carll[7] suggest that evaluation studies have been minimized, having traditionally been thought of as a final major step in transport planning, whereas most major transport studies have been concerned with problems of preceding phases such as simulating transport systems, determining modal split, and predicting demand. In addition, it is a far more complex task to frame benefit-cost models than to frame predictive models, because benefit-cost analyses include non-scientific institutional considerations.

Zettel and Carll found little systematic use of economic tools of any kind in the 23 urban transport studies they reviewed. And it is Lyle Fitch's conclusion that transport planning typically neglects to examine all the alternative transport systems which could accomodate user needs. In those it does examine, transport planning to date has used benefit-cost analysis and other analytical tools partially and imperfectly.[8] Much of the benefit-cost analysis which has been used has employed questionable methodological procedures.

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[7]Richard M. Zettel and Richard R. Carll, "Summary review of major metropolitan area transportation studies in the United States" (Berkeley: Institute of Transportation and Traffic Engineering-University of California, 1962), p. 63.

[8]Lyle C. Fitch and Associates, Urban Transportation and Public Policy (San Francisco: Chandler Publishing Company, 1964), p. 118-119.

> Nowhere has benefit-cost analysis been applied to whole new transportation layouts, such as those proposed by the National Capital, Pittsburgh, and other urban transportation studies. Little attention has been given to such basic questions as how much of the travel in an urban community is sufficiently important to justify the cost of providing additional facilities to handle it. To be sure, the technique for such global analysis has yet to be developed. . . . . nonetheless, the question is crucial and needs to be attacked with all available tools and any new ones which can be invented.[9]

Implicit in this is the point that not all desire for transport is a "demand" in the sense of an imperative which must somehow be catered to. The variety of performance expectations is an important aspect of the problem.

Zettel and Carll see signs of hope in new techniques for evaluation, and particularly those developed in the areas of regional planning and water resource use (see section 3.1.).

3. Benefit-Cost Analysis in Particular

Perloff and Wingo, Melvin Webber, and Henry Fagin (Executive Director, Penn-Jersey Transportation Study) have all expressed dissatisfaction with narrow benefit-cost calculations based mainly on direct-dollar outlays and direct-dollar receipts or savings--calculations common enough to transport studies. They believe meaningful evaluations must sail beyond charted seas. Some explicit and quantitative ways of appraising non-monetary values do exist, and many others appear to merit study. Let us briefly survey the limits and capacities of benefit-cost analysis as they appear to those who use it.

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[9] Ibid.

Benefit-cost analysis can be characterized as the collecting and organizing of data in accordance with a system of values, or "criteria," by which alternative courses of action are to be assessed. Essentially, this kind of analysis attempts to do explicitly what people do implicitly every time they make a decision about the future. Whereas private firms aim to maximize profit, the decision rules of benefit-cost analysis seek to maximize public benefits or general welfare. And, as John Krutilla points out,[10]

> The application of criteria for improving welfare cannot be a mechanical or a compellingly logical activity. Rather, it requires more intimate knowledge of the economy, experience, and highly developed intuitive sense than analysts commonly possess . . .[11]

Benefit-cost analysis can help the decision maker with the following kinds of decisions: (1) Should money be spent for a given purpose? If so, (2) is this the most profitable way to spend that money? To reach these decisions, the analyst must be able (1) to assess the economic characteristics of a particular project or program, (2) to determine which of a number of projects designed to serve a given purpose achieves the purpose at least cost, and (3) to determine which of a number of projects (or combinations thereof) designed to serve different purposes confers the largest net benefit on the people of the area it serves.

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[10]John V. Krutilla, "Welfare Aspects of Benefit-Cost Analysis" (Reprint no. 29; Washington: Resources for the Future, 1961), p. 233.

[11]Ibid.

A great deal of data describing components of each alternative project and various project sequences must be examined in order to give a clear idea of what overall plan is best, or which contenders ought evidently to be candidates for a subsequent selection stage.

The set of viewpoints from which the project or program effects are examined is of basic importance. The viewpoint of the community at large can differ from those of the operator and user. Projects which are large in scope necessarily require a comprehensive approach to the evaluation of benefits and costs, since at this level a greater variety of effects present themselves. Needless to say, whatever viewpoint is taken should be stated clearly in the analysis.

Roland McKean of the RAND Corporation says benefit-cost analysis consists of five elements: (1) desired objectives, (2) alternative systems to meet objectives, (3) costs entailed by each alternative, (4) models to help trace out costs incurred and achievements provided, and (5) criteria to identify the best system.[12] Included in analyses should be gains and costs measured in monetary units, other commensurable effects, effects that can be quantified but not in terms of a common denominator, and non-quantifiable effects.

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[12]Roland N. McKean, "The economics of defense," Encyclopedia of the social sciences (manuscript), unnumbered.

The process necessarily involves subjective judgments in groping for an operational statement of the objectives, finding alternative ways of attaining the capability, making preliminary cost estimates, testing the impact on other objectives, and redesigning in the light of these impacts.

Benefit-cost analyses are less possible in applications where uncertainties are great or where incommensurables are highly significant. However, as aids to decision these analyses can sometimes point with considerable clarity to improvements, even though neither they nor any other techniques can identify truly optimal choices. They can help eliminate really bad choices. They can provide a useful framework for aiding decision makers to organize evidence and clarify their thoughts and intuitions about alternatives.[13]

Otto Eckstein of the President's Council of Economic Advisers finds the most important use of benefit-cost studies to be negative: It provides an antidote to the "requirements" approach, which does not consider costs. (There is always some cost the requirement is not worth.) In addition, it focuses attention on the margins, where decisions are made. It does not ask, "Is defense worth its cost?" but rather, "Would an extra billion dollars of defense yield an important enough increase in our strength to be worth the cost?"[14]

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[13]Ibid.

[14]Otto Eckstein, Public Finance ("Foundations of Modern Economics;" Englewood Cliffs, N.J.: Prentice Hall, 1964), p. 25.

Can the benefit-cost principle serve to determine the proper allocation of resources for most public expenditures? "Unfortunately not," Eckstein replies. The monetary returns expected from investment in facilities such as education, improved housing, and highways have not so far yielded to reliable measurement. This is because their benefits, in addition to being partly non-monetary, are diffused over both time and space in a way that is difficult to trace, let alone measure. Thus, Eckstein concludes, benefit-cost analysis can be useful mainly in evaluating expenditures for operations which have fairly concentrated and quantifiable effects, such as those for flood control, electric power production, postal operations, and some transportation and recreation facilities. Most of these expenditures are in the public works field where benefits are primarily economic, tangible, and measurable.[15]

To this conclusion are opposed the views of those who say that benefit-cost analysis must also account for intangible and non-quantifiable effects. Eckstein maintains that benefit-cost analysis is too limited a tool to deal with these broader effects. Though his view is not poles apart from the Roland McKean approach, it helps us to understand better the dilemmas confronting practitioners of the art.

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[15] Ibid.

Eckstein and McKean are both well-known for their benefit-cost work on water resource development. Indeed, the benefit-cost principle itself was established in the Flood Control Act of 1936, in which the Corps of Engineers was authorized to survey the payoffs and costs of alternative programs. (Today, many studies later, when the federal government alone spends nearly two billion dollars annually on water resource development, confusion and controversy still persist.)

3.1. Water Resource Development Studies

The benefit-cost bible in this area, Proposed Practices For Economic Analysis of River Basin Projects, is known as "The Green Book." It distinguishes between primary and secondary benefits, a distinction accepted as valid by Robert Dorfman of Harvard, another leading benefit-cost economist, but rejected by McKean and others as leading to confusion and over-counting. Water resource agencies join in this controversy: the Bureau of Reclamation counts secondary benefits; the Corps of Engineers and the Department of Agriculture do not.[16] (A similar battle rages in highway benefit-cost studies.)

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[16]The Green Book distinguishes between the two concepts as follows: primary benefits are the value of the immediate products or services resulting from the measures for which project costs and associated costs were incurred. In the irrigation project illustration, the primary benefits are the value of the wheat produced by the farmer. Secondary benefits are the values added over and above the value of the immediate products or services of the project as a result of activities stemming from or induced by the project. The value of the bread over and above the value of its wheat content would be a secondary benefit.

In bringing "The Green Book" up to date, the President's Water Resources Council defines benefits as

> . . . increases or gains, net of associated or induced costs, in the value of goods and services which result from conditions with the project as compared to conditions without the project. Benefits include tangibles and intangibles and may be classified as primary or secondary.[17]

Among the primary benefits to which water resource development may lead, the Council includes these examples:

(1) Domestic, municipal, and industrial benefits (the amount users would be willing to pay for such improvements in lieu of foregoing them).

(2) Increases in net income from agricultural production.

(3) Net contributions to public health, safety, economy, and effectiveness in use and enjoyment.

(4) Recreation benefits, including the intangible values of preserving areas of unique natural beauty and of scenic, historic, and scientific interest.

(5) Net economic effect of changes in transport capability, and in the productivity of forest, range, mineral, and other resources.

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[17]U.S., President's Water Resources Council, together with a statement by Sen. Clinton P. Anderson, Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources, Document No. 97, 87th Congress., 2nd Sess., 1962, p. 9.

The council also calls for inclusion of measures of "redevelopment" benefits: the value of labor and other resources required for project construction which can be used in project operation, maintenance, and added area employment during the life of the project, to the extent that such labor and other resources would otherwise be unused or underused; and the contribution which a project makes toward alleviating problems and promoting economic growth and well-being, toward increased national income and welfare, and toward regional growth and stability.

The above listing of possible benefits indicates the inability of benefit measures fashioned thus far to quantify the full effects of large-scale projects. For this reason one cannot make sweeping generalizations about the potential aid that analyses can provide or about the formulation of analyses in connection with particular choices. So far, there are no clear-cut rules for determining the list of actions that should be considered or the scope of the systems into which the actions should be fitted, just as there are no clear-cut rules for devising appropriate criteria.[18]

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[18]Roland N. McKean, Efficiency in Government Through Systems Analysis: With Emphasis on Water Resources Development ("RAND Corporation Study;" New York: John Wiley and Sons, Inc., 1958), p. 96.

Eckstein accepts the Green Book's ratio of benefits to costs as the recommended basis for comparing projects, but McKean criticizes this commonly used test on grounds that benefit-cost ratios reveal nothing about the absolute scale of gains or costs. A Brookings Institute study supports McKean's view as demonstrating conclusively that a simple benefit-cost ratio test will often prescribe investments which do not produce the largest net benefits. The study notes that since some items could well be considered as either a negative cost or a positive benefit (reduced maintenance, for example), the way they are introduced into the ratio may substantially affect the final ratio but still may not succeed in measuring the gap between benefits and costs. Also, ratios are not as meaningful as absolute value figures. A benefit-cost ratio for one project could be 10:1 and for another 1.3:1, yet the increase in real output could still be far greater for the second project.[19]

The Brookings study also supports McKean's decision rule based on the difference between the discounted present value of future benefits and costs as one which invariably points to that project which will make the maximum contribution to benefits under the same circumstances. Where V^0 is the net present social value, B^0 the discounted present value of the future stream of benefits, and C^0 the discounted present value of costs,

$$V^0 = B^0 - C^0 .$$

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[19]Brookings Institute, The preparation and evaluation of transport projects (not for publication), Washington: February 1965, pp 37-38.

Questions often overlooked are, "How long will the benefits be expected to last, and over what time period are costs to be incurred and at what rate of interest?" Since we know that a dollar spent today is worth more than a dollar spent in the future, the difference between the undiscounted and the discounted present value of future benefits and costs cannot be ignored.[20]

Just as the economist's approach to benefit-cost analysis is broader than the highly specialized approaches of the accountant and the engineer, the systems analyst's interdisciplinary point of view is often broader than the economist's. This may account, in part, for the slightly divergent viewpoints of Eckstein and McKean.[21]

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[20]Eckstein and McKean also differ in their choice of discount rates to maximize present worth for a given investment budget. The distinction between the two viewpoints is brought out clearly in McKean's Efficiency in government through systems analysis (loc. cit., p. 117). In all of the issues discussed thus far, it is our belief that McKean's is the better view. Both Eckstein and McKean agree, however, that alternative benefit-cost schemes must each be reduced to a single number, such as present worth, and further, that there is now no fully acceptable means of handling benefits and costs over time.

[21]McKean, Efficiency in Government. . . loc. cit., pp. 76-92. There are two other commonly proposed criteria: equivalent annual net benefits and internal rate of return. Both are more difficult to use than discounted present value of future benefits and costs.

McKean offers some general guidelines for choosing criteria.[22] Criteria at each level should be consistent with higher level criteria, i.e., benefits and costs to users must be correlated to benefits and costs to the system and the community. In addition, the criteria chosen should not obscure spillover effects (effects on gains and costs of other operations -- also called external economies and diseconomies, social costs, or indirect effects). Finally, since costs are a sacrifice entailed by use of existing resources, the analyst should guard against erroneous concepts of costs or gains which may affect adversely his choice of criteria, such as penalizing an alternative for costs incurred in the past.

[22] Ibid., p. 96.

Discussing particular criteria, McKean notes that utility--the label for whatever should ultimately be maximized--depends on a vast number of variables. Since functional relationships among variables, and indeed many of the variables themselves, are not fully known, the analyst cannot devise any perfect, complete criteria for judging utility. What he can do is to specify a variable on which utility is believed to depend, say the level of real income, and then try to find what would happen to that variable under alternative courses of action.

Failing that, he can seek a good index (such as maximum net profit or maximum performance of defined tasks at a given cost) of what would happen, under each alternative, to that variable. He may in some cases be able to demonstrate that a certain relationship exists between this index and the specified variable, such as between a transport system's net profit and a region's real income. In other cases, he may be able to offer only inconclusive evidence and make a rather weak probabilistic statement which rests largely on judgment. But even given more conclusive evidence, his criterion is valid only in terms of that variable.

McKean also presents some suggestions for judging the usefulness of various criteria for an analysis. If there is widespread agreement or persuasive evidence that a variable specified is the most important one, then the criterion associated with it takes on added significance. The ability to measure in several kinds of units the effects of alternatives on variables increases the value of an analysis. Still, criteria do not provide a complete test of a course of action, but only a partial test: a comparison in terms only of selected consequences, knowledge of which are expected to be helpful to decision makers.

McKean offers these guidelines on other aspects of benefit-cost analysis:

On appropriate alternatives

(1) Decide on the scope of the systems to be examined, the scales for examining them, and combinations of measures for assessing them.

(2) Watch out for possible interrelationships such as the effects of adopting one policy on the costs or gains from other policies, especially if they are to be ranked.

On intangibles

(1) Try to show the value implicitly assigned to intangibles by preference for one course of action over another.

(2) Devise indicators of the nature and magnitude of intangibles.

On uncertainty

(1) Explore ranges of outcome to which roughly the same degree of confidence can be attached, even if subjective.

(2) Examine the possible effects of various innovations on the gains or costs of the systems being compared. Examine the effects on the systems supposing the budget were altered or certain other relevant contingencies occurred. (A range of results, not a unique outcome, is thus associated with each alternative course of action.)

(3) Consider the game aspect of choosing one's course of action. When we move, others adjust their policies accordingly, which may affect the payoffs or costs of our move.

(4) Estimate costs of insuring against the more important unfavorable contingencies.

(5) Look for "dominance" -- cases in which the same course of action is best in all relevant circumstances (i.e., the occurrence of major unfavorable contingencies, or modification of the task or budget). Dominance occurs when course of action A_1, for example, is superior to course of action A_2 for all scoring criteria.

(6) Consider statistical uncertainties due to imperfect data or estimation techniques. Have possible results of an action emerge as a frequency distribution, not as a single outcome.

(7) If other types of uncertainty do not dominate and if a comparatively detailed model seems advisable, use Monte Carlo techniques to make repeated calculations to reflect the change elements in various events.

In applying his experience with comparisons of military systems to non-military problems, McKean has made a significant contribution to benefit-cost analysis. That is why so much attention has been paid in this paper to his findings. We now turn to an area in which formal benefit-cost analysis has been going on for about 15 years.

3.2. Highway Benefit-Cost Analysis

Just as water resources people look to their "Green Book" for guidance in the economic analysis of a project, highway organizations look to their "Red Book."[23] This publication of the American Association of State Highway Officials is used to justify needed expenditures and to examine the comparative worth of proposed improvements in rural areas. The book's major premise is that the economic desirability of any highway improvement can be determined by calculating its effect on passenger car operations.

Consideration is given to seven principal factors:

(1) Solvency of a system or group of systems of highways

(2) Land and community benefits from highways and their improvements

(3) Costs of construction or improvements of highways

(4) Costs of maintenance and operation of highways and their appurtenances

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[23]American Association of State Highway Officials, Road User Benefit Analysis for Highway Improvement (Washington: American Association of State Highway Officials, 1960), p. 10.

(5) Direct benefits to road users in the form of reduced vehicle operating costs and savings in time on improved highways

(6) Benefits to road users in the form of increased comfort and convenience

(7) Benefits to road users in the form of over-all accident reduction.

The manual finds it possible to treat only items (3), (4), (5), and (6)[24] in detail, thus concentrating on relating road user benefits to capital costs. The costs analyzed are direct costs in the narrowest sense, thus showing the book's orientation to engineering rather than to economic analysis.

A review of the field indicates that present practice among highway departments varies widely with respect to the extent of reliance upon economic analysis in decision making.[25] There is a "shocking gap" in the literature when one looks for guidance in studying the economic and social consequences of expressways.[26]

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[24]Positive identification of values for assignment to degrees of comfort convenience is not possible. Assumed confort and convenience values are included in the vehicle operating costs in direct relation to the type of operation.

[25]R. G. Hennes, "Criteria for highway benefit analysis," presented at the 44th annual meeting of the Highway Research Board, Washington: January 1965, p. 7.61.

[26]Ibid., p. 7.73.

The works of Mohring and Harwitz,[27] Kuhn,[28] and Winch[29] have been cited as three outstanding contributions to the literature dealing with highway benefits. Mohring and Harwitz examine in some detail the many changes in the functioning of society which are brought about by highway improvement. Kuhn emphasizes project and system analyses. Special attention is paid to "external and internal values," to "cost and gains," and to "the importance of pursuing high-level criteria." Although Kuhn concedes the reality of political constraints which limit road decisions to a set geographical area, he holds that

> . . . a highway department--of whatever scope--which concerns itself solely with transport by motor vehicles, excluding all other considerations, cannot consistently act in the general public interest of its jurisdiction.

In the opinion of Robert G. Hennes, Professor of Civil Engineering at the University of Washington,

> [t]his trilogy [Mohring and Harwitz, Kuhn, and Winch] constitutes the most impressive exposition of thinking on highway matters that has appeared since the internal combustion engine transformed and personalized transportation in our society.

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[27]H. Mohring and Mitchell Harwitz, Highway Benefits (Evanston: Northwestern University Press, 1962), pp. 1-209.

[28]Tillo E. Kuhn, Public Enterprise Economics and Transport Problems (Berkeley: University of California Press, 1962), pp. 1-243.

[29]David M. Winch, The Economics of Highway Planning (Toronto: University of Toronto Press, 1963), pp. 1-166.

On comparison with the sophisticated techniques discussed by McKean (above), this does not speak well for the state of the art of benefit-cost analysis in the highway area. Hennes goes on to say that the authors are proponents of a philosophy not yet current in highway policy, namely, that the public interest is paramount in highway policy, and not the interests only of the users. Hitherto, our highways have been built and operated on the principle that the users are the ones whose interests highways serve because they pay the full costs. He concludes that the works of these authors provide a theoretical foundation for a more broadly based highway policy.[30]

In addition to user studies, a body of over 600 research reports, critical articles, books, etc., has appeared on the subject of non-user or community consequences of highway development. Differing methodologies and lack of uniformity in the variables preclude anything but a descriptive evaluation of the studies. It seems clear that highway impact studies tend to double-count gains. Savings in fuel, time, and vehicle wear-and-tear, and added user convenience and comfort (partly as measured by user charge revenues) are put down as user gains from a highway project. Gains such as land-value increases and lower costs of production are listed as external benefits from the project. However, R. M. Zettel has convincingly pointed out that almost all of the external gains (general economic benefits) from highway projects looked at so far

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[30]Hennes, loc. cit., p. 7.76.

are basically user benefits which have been passed on to other sectors of the economy. In this way they are counted twice.[31]

Also, while increases in land value near new highways are typically noted, possible decreases in land value elsewhere are hardly ever considered. That highway projects may merely create compensating positive and negative effects has been obscured by long-term land-value increases caused by postwar population growth, family formation, rising personal incomes, and other general trends.

The greatest number of these studies analyzes the effects of bypasses. There are also urban radial freeway studies and a few beltway studies, the most famous of which is the study of Route 128 around Boston. The 128 study ascribes primarily to highway improvement, the migration of industry into the freeway areas, and ignores many other factors of possibly greater relevance. The location close to Route 128 of major research centers such as Harvard and MIT, for instance, and the burgeoning of entire new space-related industries, imply economic causes that are at most only partly associated with the beltway.[32]

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[31]Richard M. Zettel, "The incidence of highway benefits," in Economic Analysis in Highway Programming, Location, and Design (Special Report No. 56, Highway Research Board; Washington: October 1960), p. 150.

[32]Edgar M. Horwood, Carl A. Zellner, and Richard L. Ludwig, "Community consequences of highway improvement." Unpublished report, National Cooperative Highway Research Program, University of Washington, Project 63-2-2, 1964, p. 4.

Many of these studies have been criticized as being motivated by the desire for public acceptance of the projects studied. Others were initiated by state governments solely for the purpose of inquiring into the question of special tax assessment districts.[33] The studies show no advance in methodology or broad understanding of the impact of highway development on the community (see Table 1). The theoretical economist could well dismiss virtually all of the highway economic impact literature as lacking in significance.[34]

As a first step in filling in our knowledge about the community consequences of highway development, Robert M. Pashek has urged a study of the effects of changes in fixed assets, such as land use, on the income and employment of the community. Such a study is being conducted by the Pennsylvania Regional Analysis Group at Penn State.[35]

Professor Edgar M. Horwood's survey of community impact studies concludes with this comment:

> The community consequences studies at some point merge into the general regional highway planning studies and will further merge into the overall urban region studies that will characterize the coming decades. The spatially localized studies, although limited in objective, must be conducted with a greater sophistication to protect the reputation of highway agencies.

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[33] Ibid., p. 106.

[34] Ibid., p. 14.

[35] Robert M. Pashek, "Community consequences of highway improvement," (presented at the 44th annual meeting of the Highway Research Board, Washington 1965), p. 7.

TABLE 1

GAPS IN KNOWLEDGE

I. Gaps in Knowledge Recognized by Interest Groups

The impact of highway development on

A. Local employment
B. Tourism
C. Wholesale trade area change
D. Agricultural production
E. Relocation of residents
F. Economic base of the community
G. Urban renewal (slum elimination)
H. Public service district area (schools, fire districts, library service, etc.)

II. Methodology Needs Perceived by Analysts

A. How to evaluate impacts of highway change apart from other economic effects
B. Design or identification of control study areas
C. Possible electronic data processing methods
D. Standardization of research approaches for data comparability
E. Evaluation of air and ground rights over and under freeways
F. Assessments of noise damages

III. Gaps in Knowledge Recognized by Officials

A. Economic justification of frontage roads
B. Impact of billboard legislation on highway-oriented businesses
C. Impact of route adoption announcements on right-of-way costs
D. Economic justification for rural cattle underpasses
E. Land use impacts at interchanges (and logical controls)
F. Impact of urban area development on freeway service (i.e., congestion)
G. Impact of highway development on regional economic development

In his opinion, a new research program must be written which can lead to a broader concept of community consequences.[36]

The U. S. Agency for International Development has sponsored a number of benefit-cost studies for proposed highways in developing countries. A Brookings Institute review found every such study to be fallacious. The outstanding weakness of benefit-cost analyses in the studies reviewed was overestimation of benefits and underestimation of costs.[37] Benefit-cost ratios in virtually every study reviewed turned out to be 1 or greater than 1. The result was a pseudo-scientific justification of every proposal. Other major weaknesses included: (1) failure to define benefits precisely, (2) failure to distinguish between financial benefits (e.g. monetary value which a banker would consider in making a loan) and economic benefits (those which allocate resources correctly), (3) failure to distinguish between intangible and other indirect benefits and to evaluate them accurately, and (4) failure to consider project interdependence (spillovers).

The report concludes that no definitive, explicitly formulated set of criteria now exists by which capital projects on transportation can be judged. Such guidelines as do exist are too general and are actually fallacious in some respects. Criteria are needed[38]

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[36]Horwood, Zellner, and Ludwig, loc. cit., p. 115.

[37]Brookings Institute, loc. cit., p. 18

[38]Brookings Institute, loc. cit., p. 42.

(1) To provide for consideration of a number of feasible alternative solutions to any transport problem for a range of explicitly stated assumptions which are broad enough to encompass both the most and least favorable forecast of the behavior of the major variables. The sensitivity of the variation of these assumptions should be determined.

(2) To supply techniques for relating a proposed transportation improvement to the natural resources and to the agricultural, industrial, and investment plans of the economy within which it is to take place, and for assessing its likely impact on the economy.

In a recent study of urban transportation benefit-cost analysis,[39] Lyle Fitch has concluded that though the complications of such techniques are (and probably always will be) subject to wide margins of error, the technique should not be eschewed on that account:

> At the least, the attempt to evaluate all the factors bearing on an investment decision from the standpoint of overall community welfare will help guard against leaving important factors out of consideration [as has been the case with most transportation planning]. Benefit-cost analysis should not be deprecated on grounds of fallibility: its purpose is to lead to more informed judgments than would otherwise be possible.

These statements complete the circle and conclude this review of benefit-cost analysis as an art. With all its conceptual and practical difficulties some progress has been made. In learning the lessions of the past, we hope to deal more effectively with the tasks of today and tomorrow.

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[39]Lyle C. Fitch & Associates, loc. cit., pp. 109-110.

4. Summary

These are major conclusions on the present state of benefit-cost analysis which can be drawn from the literature.

(1) Data deficiencies limit ability to make informed choices among transport alternatives.

(2) The largest conceptual difficulty is the identification and measurement of social benefits and costs.

(3) Among the first and most important questions to be considered in evaluating a transport system is, "What shall be the long-run regional development objectives?"

(4) In no regional transport plan known to the author has any systematic attempt been made to weigh benefits and costs on a comprehensive scale.

(5) Benefit-cost analyses are less helpful where uncertainties are great or where incommensurables are highly significant. Nonetheless, areas in which extensive uncertainty exists may be the ones in which careful and explicit assessment of ranges of possible actions offer the most potential. Incommensurables often can be dealt with qualitatively in a fashion that is at least partially satisfactory.

(6) There are no clear-cut rules for determining the list of actions that should be considered or the scope of the systems into which the actions should fit.

(7) The commonly-used benefit-cost ratio is a misleading basis for comparing projects. A better test is the difference between the discounted present values of future benefits and costs.

(8) Current procedures for highway benefit-cost analyses are too narrow in scope to be useful in Corridor studies, except in a limited sense.

(9) The literature now available for guidance in studying the economic and social consequences for expressways contains "shocking gaps." The theoretical economist could well dismiss virtually all highway impact literature published thus far as basically inadequate.

(10) There seems to be no definitive, explicitly formulated set of criteria for judging capital projects on transportation.

On the positive side:

(11) Benefit-cost analyses can provide an appropriate framework for decision makers to use in organizing the evidence and clarifying their thoughts and intuitions regarding alternatives.

(12) Benefit-cost analysis should not be deprecated on grounds of fallibility: its purpose is to lead to more informed judgments than would otherwise be possible.

5. Appendix

Commentary on a Matrix of Benefit-Cost Studies

Miss Marsha Geier undertook an investigation of recent benefit-cost studies in order to assess the analytic procedures currently in use in such studies. She was particularly interested in

1) how comprehensively the method tried to measure a given cost or benefit,

2) how adequate the theory was which underlay the model, and

3) how easily data could be fitted to the model, if the model were theoretical in exposition.

The literature search was not exhaustive because of a lack of time; yet it was broad enough to yield some useful generalizations. The results are summarized in the matrix given as Table a.

The row entries identify the author or source of a particular benefit-cost study. Complete references are given at the end of the Appendix. About half a dozen are articles published by economists in the professional journals; five are books; another five were published under the auspices of the Highway Research Board; and the remainder are studies published by various organizations, institutes, and individuals.

The columns are divided into three main categories: system, user, and community. Each of these is subdivided into several relevant subcategories, such as capital costs for the system, the value of travel time to users, or the growth of the economic community.

For each article or book shown in the matrix, a reference symbol appears under each column heading which is discussed in that study. All major categories considered in each book or paper are so indicated. Thus, an entry $[m_{ij}]$ indicates that the j^{th} cost or benefit appears in the i^{th} study. Symbols used are N, Q, T, or V.

An "N" indicates a numerical and monetary example, which may or may not be based on a theoretical model. The actual values used in the example may either be given or else derived in another model. A "Q" means that the values presented are quantified but are non-monetary. An example would be the results of interviews. "T" means that a theoretical model only is presented; a "V" indicates that the discussion is entirely verbal, i.e., no model is presented.

There are 119 entries in 351 cells (27 studies and 13 columns), but this small number may be misleading. Many studies were intended to discuss only a particular benefit rather than to present a balanced and complete benefit-cost analysis. Only N's and T's are analytically interesting. And of the 119 entries, only 10% are T's and 46% are N's. Furthermore, many of the N's designate studies which arbitrarily assume a value in the numerical example and thus fail to derive one in an analytical fashion.

Many of the theoretical studies are non-operational, in that they require non-existent or unreliable data; some become unrealistic by using many simplifying assumptions for the sake of a neat mathematical solution. More than a quarter of the N's involve the use of assumed values. Thus relatively few of the studies involve actual data or operational models and in very few indeed are analyses presented. From the point of view of the advancement of research techniques the literature search failed to produce any analytic methods which were comprehensive, theoretically justifiable, operational or significant. This tends to support the views given in the body of this report.

TABLE A	SYSTEM				USER						COMMUNITY		
	Capital (Construction, Rolling Stock)	Operation and Maintenance	Fares	Other Revenues	Operation and Maintenance	Value of Time	Cost of Accidents	Comfort and Convenience	Aesthetics and Scenery	Congestion Taxes or Tolls	Land Values	Business, Community Income	Air Pollution
AASHO	N	N			N	N	N	N					
Arizona Highway Dept.	N												
Beckmann					T	T				T			
Bevis	N	V			N	N	N						
Brenan and Rothrock	V	V			V	V	V	N					
Campbell	V	V											
Chicago ATS					N	N	N						
Economic Associates (1)	V	V	V	V	V		V		V	V		V	
Economic Associates (2)	N	N	N	N							V	V	V
Foster and Beesley	N	N			N	N		N					
Hewitt					N	N				N			

Johnson					N	N				N			
Kuhn	V	V	V	V		V	V	V	V		V	V	V
Lockheed			Q	Q		Q	Q	Q	Q				
Mgmt. Science Center			V			V		V					
Mohring	V				N	N	N	T		T			
Mohring and Harwitz						T				V	T		
Moses and Williamson					N	N							
Reynolds							N						
St. Clair and Lieder					T	N	T	T		N			
Stanford RI (1)						T[1]							
Stanford RI (2)					Q	Q	Q	Q	Q				
Stanford RI (3)	N	N			N	N	N						
Vaswani	N	N				N							
Walters					N	N				N			
Winch	V	V			V	T	V					V	
Winfrey	N	N			N	N		N					

Legend: N: operational model (numerical) with or without theoretical model; assumed or derived values
Q: quantified, but non-monetary
T: theoretical analysis only
V: verbal discussion only

Footnotes:
[1]Also gives a table of various values for value of time which have been used in the literature

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