RESEARCH NEEDS IN ECONOMIC AND FINANCIAL FACTORS OF HIGHWAY TRANSPORTATION: IN SEARCH OF IMPROVED STRATEGY

J. H. Boyd, Ohio State University

This report is one part of a study of highway research needs and resources that had the objective of developing a series of mission-oriented research and development programs in highway transportation so that the entire effort on federal, state, and local levels may be managed and coordinated with efficiency, continuity, and clarity toward well-defined goals and problems. As a segment of that larger study, this report describes the scope and content of economics and financial research in highway transportation. The objective of this research is the acquisition of knowledge relevant to optimizing the allocation of resources with respect to highway policy. Three broad aspects of highway economics are distinguished: demand for trips, costs and supply of trips, and interaction of supply and demand. First priority for future research must be given to the specification and quantification of demand for highway trips, both because of its intrinsic importance and because so little has been done in the area. Second in relative marginal importance is research into the wealth distribution effects of highways and highway policies. Third priority should be given to work in applied research on the interface between basic research and policy. Further work on costs is placed last in importance primarily because, of all study areas, this is the best cultivated.

•THE GOLDEN Anniversary of HRB is surely an opportune time to reflect on past research in highway transportation and chart a strategy for future research. This paper is about economic research, as applied to economic and financial problems in highway transportation, and addresses the following questions: What is economic research in highway transportation, and what good is it? What research has been done in the past in the area, and what are its limitations? What kinds of future economic research would be likely to give the most valuable additions to our knowledge? Answers to these questions are a prerequisite to an efficient allocation of future research effort.

The scope of economic and financial research in highway transportation can be defined in terms of the goods and services being analyzed and in terms of the general aims of applied economic research. Highways and roads of all kinds provide flows of valuable services to the members of the economy. Conversely, they also impose costs on these members in that resources used for their construction, maintenance, and operation are thereby not available to be used for alternative valuable goods and services. This is the basic "law of scarcity," as applied to highways. Agencies responsible for the building and operation of highways, recognizing this basic economic fact, are naturally interested in sponsoring economic research in this area. What are the benefits of highways, and how might they be estimated for alternative highway configurations? What are the costs, and how might they be estimated? To which members of society do these costs and benefits accrue? How can optimization criteria for construction, financing, and operation

Sponsored by Committee on Social, Economic and Environmental Factors of Transportation and presented at the 50th Annual Meeting.

of highway networks be made both operational and consistent with other economic and social goals of society? A task of economic research is to provide answers to such questions.

The objective of economic research in highway transportation is to inform policy-makers of the probable consequences of alternative policies by improving the state of knowledge of the workings of the economy in this area. Because "research need" connotes an imperative and indispensable activity, it is probably better to avoid using the term. It is more meaningful to specify which research is likely to be more valuable, and which less valuable, in its resulting increment to the stock of knowledge.

Economic research in highway transportation deals with a commodity, trips. As for any commodity, there are 3 main categories of economic research: demand for trips, cost and supply of trips, and interaction of supply and demand. The demand for trips is derived from an economic agent's willingness to pay for this commodity in terms of actual monetary expenditure and in terms of the expenditures of time, discomfort, and other resources that are valuable to him. Knowledge of the relative marginal values placed on trips and other commodities is, of course, a requisite for ascertaining the benefits associated with trips. The cost of trips, on the other hand, refers to the valuable alternative ouputs that must be sacrificed when resources are devoted to the production of trips. The production of trips differs from the naive textbook economic commodity in that an important part of the inputs in this production process are supplied by the trip-makers themselves in the form of time and other user-supplied inputs. The interaction of supply and demand elements produces the observations of prices and quantities of trips that are the basic data of economic research.

PAST RESEARCH IN HIGHWAY TRANSPORTATION ECONOMICS AND FINANCE

The production and allocation of highway services or trips can be analyzed by using the same concepts and theories that would be applicable to other goods and services. Unfortunately, highway economic research has largely proceeded as if highways were some unique kind of economic asset, to which standard economic theory is inapplicable. That highways possess distinctive physical characteristics, no one would deny. That textbook interpretations of microeconomic theory are often difficult to apply blindly to highway-related allocational problems is incontestable. Yet, the attempt to use ad hoc theorizing leads to its own difficulties because the resulting "engine of analysis" is not subjected to the ruthless examination of the economic theorist. It is, after all, a function of this specialist to check theories for internal consistency, to derive further implications, and to examine their meanings. Past economic and finance research connected with highway transportation has suffered from its isolation from the mainstream of economic theory.

In order to inventory significant past research in the area, an extensive search of relevant bibliographies was conducted during the summer of 1968. The findings from this literature search were classified into 6 ad hoc categories: congestion-pricing analyses and planning, finance, costs, traffic forecasting, impact studies, and miscellaneous. The resulting bibliography, omitted here for lack of space, is contained in another report (1). The following is a brief and somewhat impressionistic summary of this literature.

Congestion-Pricing Analyses

In a sense, this category encompasses all economic research in the subject of highway transportation. Its contribution has been to separate explicitly trip supply and demand elements, to construct marginal trip cost functions, and to derive efficiency-promoting tolls or user charges for highways. Although it is motivated by practical considerations and makes use of empirical engineering relationships, the main thrust of this research has up to now been to clarify theoretical concepts with some derivations relating to policy matters. The analyses have so far dealt with the simplified situation encompassing a single highway segment. Empirical relationships between trip time and volume-capacity ratios are used, but values of time and other intangible user inputs are either assumed or crudely estimated. Most important, no empirical data on trip demand

elasticities have yet been incorporated into this research. Peak-load problems have been extensively dealt with, and one conclusion of this research is that a variable pricing system for highway capacity or highway services would lead to substantial gains in efficiency, provided of course that the method of actually collecting these charges is not in itself extremely costly. Crude estimates of marginal-cost user charges have been made, usually resulting in estimates considerably higher than current levels of user charges.

Because of its grasp of the supply-demand-interaction elements of highway transportation economics, this body of research must form the basis for future highway transportation economic research. Put differently, the model seems to be capable of capturing significant variables relevant to the subsystem equilibrium analysis. It should make possible more accurate prediction of behavior and, a related gain, better informed normative policy judgments.

Benefit-Cost Analysis and Highway Planning

The research listed here is designed to be useful to highway planners seeking to evaluate alternative highway configurations. It is addressed to the practice of evaluating highway investments and other expenditures. The attempt to balance benefits gained from highways against alternative benefits foreclosed (that is to say, opportunity costs) is entirely laudable. It represents a significant advance over the "needs-resources" planning framework used in many highway departments. A broadly conceived benefit-cost analysis should certainly be the basis for highway services planning.

Nevertheless, benefit-cost analyses as practiced seem to suffer several methodological flaws. The lack of orientation to a trip cost-price framework results in measuring highway benefits by user cost savings rather than associating them with the utilities gained from the trip itself. That is, shifts of the cost function rather than shifts of the cost function plus the associated changes in equilibrium are being analyzed. To be concrete, suppose one highway investment would lead to substantial trip generation as compared with another highway investment. In this circumstance, user costs for the first highway may actually increase relative to the second highway. Clearly, the benefits from either of these two highways must be computed by algebraically summing the benefits and the costs associated with the total number of trips on those highways. It is unfortunate that the benefit-cost analysis literature is largely independent of the forecasting literature. It is argued later that forecasting methodologies should incorporate both price and quantity data, which would make them useful in benefit-cost analyses.

Double-counting of benefits results from calling transfers of user benefits to property owners land-value benefits and adding them to user benefits. Pervading much of the benefit-cost and impact literature is the notion that the estimation of highway benefits requires a detailed examination of all changes in the economy resulting either from an increment in the highway network or, in some cases, from the actual presence of highways. The validity of this notion depends on the kinds of questions that are being asked. If knowledge of the level of benefits generated by a new highway is desired, then this kind of research is probably not even desirable. However, if the effect of highways on the distribution of real wealth is being investigated, then perhaps some of this detailed information would indeed be relevant. The reasons for the separation of benefit-cost and impact literature are elusive. Nevertheless, it seems that there are indeed two separate bodies of research.

In addition to the problems associated with the actual measurements of benefits and costs, there are shortcomings in the application of benefit-cost analysis. The benefit-cost ratio is still used, rather than the difference between benefits and costs generated, to rank projects. The ratio form, of course, cannot rank projects in terms of desirability. In addition, there seems to be little discussion of appropriate discount rate to use in project evaluation. The practice of benefit-cost analysis of highway improvements would undoubtedly improve if there were greater familiarity with similar analyses of other public works as well as with the kinds of knowledge detailed later in this report.

Some of the "planning" studies and research listed use a benefit-cost methodology, although other criteria are usually employed with unspecified weights. As in many

endeavors where action must be taken in the absence of complete scientific knowledge, transportation planning often relies on rules of thumb, professional judgment, arbitrary standards, and other ad hoc criteria. Perhaps when the current state of the art of benefit-cost analysis is considered, the unwillingness of highway planners to rely exclusively on this tool can be justified. It can be hoped that the economist should in the future be able to furnish the planner with better tools. By the same token, the planning profession will undoubtedly use more explicit analysis and less ad hoc theorizing in the future.

Finance

Highway finance appears as a well-defined category under the supply portion of the theory-suggested conceptual framework. User charges serve the dual function of allocating highway services among competing users and transfering resources from users to the highway administration. Other sources of funds might include property, income, and other general taxes. Conversely, revenues from user charges may be used for non-highway purposes.

Any system of taxes or charges has implications for the distribution of real wealth among members of the economy. In this connection, questions of equity or fairness arise that are not capable of solution on scientific grounds. Only efficiency conditions can be scientifically described. The emphasis of the highway finance literature is on the resource transfer rather than the highway services allocation function of user charges. User charges and other taxes are compared often on equity grounds, almost never on efficiency grounds. "Cost allocation," a pseudonym for setting prices for highway services for the different classes of users or setting the level of user charges versus the other taxes used to finance highways, is also analyzed primarily on equity grounds. The finance literature is not yet integrated with the congestion-pricing literature discussed earlier. Thus, many of the normative policy statements made are without analytic content.

Highways are definitely a capital asset, and a large portion of public expenditures on highways is for construction. There is a body of literature on capital budgeting and investment policy, but this seems to have had little impact on highway planning or programming. One could find no scientific criticism of the "pay-as-you-go" method of matching all construction, maintenance, and operation expenditures to current receipts. The lack of systematic examination of the capital budgeting aspects of highway finance is difficult to explain.

Cost Analyses

Given the fact that so-called benefit-cost analyses are in reality cost function analyses, the existence of a large body of cost analysis should come as no surprise. As stated earlier, costs of highway trips refer to the value of user, nonuser, and highway administration inputs in alternative uses. Some of these costs are relatively easy to measure or forecast, such as those incurred for concrete, motor fuel, or policing. Others, such as noise, air pollution, travel time, or risk-bearing are much more difficult to measure. Some research has been done on time valuation, but it suffers from a failure to ask questions relating to its role in trip-price and equilibrium analysis.

There has been little research designed to quantify the magnitude of other intangible cost elements. Public policy recognizes risk-bearing as a cost in that the government is increasing safety standards for highways and automobiles, but there is little evidence of cost-effectiveness, let alone cost-benefit, analysis of safety features. Costs associated with nonuser inputs, such as noise, vibration, and air pollution, are recognized by highway planners, yet they have available little quantitative information designed to help them make decisions with respect to these costs.

Although individual state highway departments have apparently collected a large body of construction and maintenance cost data, few appear in the literature cited. It is difficult to believe that each state faces unique conditions and would not be able to profit from organized dissemination of this kind of knowledge. Econometric techniques should be used to "explain" cost in terms of imported causal variables so that highway administrators can predict future cost. Only when this is done can economic optimization proceed.

Despite these shortcomings, the state of knowledge is relatively more advanced in this area than in some of the other areas. There is some evidence in the literature of a conscious, systematic attempt to trade off different elements of highway administration costs in highway construction and operation. There is less evidence of conscious trade-offs among these costs and user costs, and almost none of such trade-offs involves nonuser costs.

Traffic Forecasting

An array of impressive mathematical models has been developed to forecast the volume of traffic using given roads, networks, or systems. Sometimes these are erroneously called "demand" studies, even though they seek to forecast one of the results of the interaction of supply and demand, namely quantity of trips taken.

To an economist, the most notable feature of these models is their ignorance of trip-price variables. It is not surprising, therefore, to find them consistently underestimating travel volume when trip prices are reduced, as by the expansion of the capacity of the road network or the construction of better capacity in the form of freeways. Second in importance is inadequate attention to the influence of highway policy on the location of economic activity. This is, of course, merely another aspect of the failure to take into account price elasticity in the demand for trips. The long-run demand for trips is likely to be quite a bit more elastic than the short-run demand. In the long run, economic agents are able to move the location of their economic activities, for example, to take advantage of changes in relative trip prices. The same can be said of other short-run demand parameters, such as automobile ownership or manufacturing or commercial technologies.

A failure to correctly forecast travel volume may not of itself be very serious because the number of trips is not per se the relevant objective of highway policy. The optimization process does depend crucially on knowledge of the relationship of both price and quantity in trip consumers' demand function, however. Proper specification of forecasting models by including trip price as an explanatory variable could and should make them tools relevant to economic optimization.

An implication often erroneously drawn from current forecasting studies is that there is a "need" or "requirement" to accommodate a certain volume of future traffic. Necessity in this context refers literally to an inelastic demand for trips, whereas there is considerable evidence that travel demand is highly elastic, especially in the long run. Needless to say, the examination and quantification of elasticities and cross-elasticities for trips along network segments remain to be attempted. Perhaps existing forecasting technologies can be adapted to this task.

Impact Studies

A large fraction of the projects listed in Highway Research in Progress under "Economics" falls into this category. These are primarily descriptive studies of phenomena such as the effect of a new bypass highway on retail sales in the bypassed community or new economic activity along a new freeway. In addition, there are more general studies attempting to discover nonuser benefits, over and above user benefits from highways. Double-counting of benefits is implicit in many of these studies. The "impact" of highways on every person in the economy need not be estimated to measure the total benefits flowing from highways.

The importance of distinguishing between purely pecuniary and technological externalities has been established in the economics literature since at least the 1930's. Purely pecuniary externalities operate through changes in relative prices and result in shifts in welfare from one group to another. They have implications for wealth distribution but not for efficiency. An example cited earlier is the shifting of some highway benefits to owners of property near highways. Technological externalities, on the other hand, represent the use of some economic service without taking into account its scarcity value, usually because no price is charged for the service under present private property institutions. An example is the noise resulting from the operation of a freeway, which is not typically economized by either highway builders or users. The large sample of impact literature examined in connection with this study invariably confuses these

two concepts of external effects. As descriptions of often dramatic changes of the landscape, these studies are net contributions to our knowledge, even though they typically ignore the effect on distant land values due to the changes in the relative supply of accessible land. It is also possible that they may contribute to our understanding of the transferring of benefits and costs through changes in relative prices. An explicit reorganization of these studies toward this end would undoubtedly improve their scientific respectability.

Miscellaneous

The miscellaneous category encompasses many references that did not seem to be immediately relevant to economic analysis of highway services and the optimization process carried out by the highway administration. Included under this category are things such as analyses of Interstate Commerce Commission regulations, traffic flow theory, transportation textbooks, articles on public transit, statistics on the movement of freight, and other topics too numerous to list in detail. Many of these references would undoubtedly be useful to research along the lines to be suggested in the next section.

STRATEGIC PROGRAM FOR OPTIMIZATION OF FUTURE RESEARCH EFFORTS

A research optimization program should ideally consider both the marginal value and the marginal costs of different kinds of additional knowledge. The focus of this section is on the former aspect and perhaps is justified on the basis of a fairly high elasticity of substitution in production among different kinds of economic knowledge. We should reject, as stated earlier, the notion that there is any such thing as a "need" or "requirement" for a certain kind of economic research or even for any research at all.

The program is based on the hypothesis that highway administrators are interested in both efficient allocation of resources and in an "equitable" distribution of wealth with respect to the effects of their policies and actions. That there are abundant examples of suboptimal behavior and that the findings of past research are too often ignored can perhaps be regarded as evidence against the hypothesis. Continued interest in and willingness to fund research on the part of those involved in building and operating roads, however, should be regarded as evidence in favor of the hypothesis. In any event, it is not clear what economic research would have to contribute if the goal were not optimum use of scarce resources with respect to highway transportation.

Two broad classes of basic research can be distinguished, corresponding to the twin components of the welfare maximization goal of economic policy. These components are efficiency in the utilization of scarce resources and equity in the distribution of net benefits from highways. The efficiency component may be thought of as the size of the "pie" of net benefits from highways, the equity component as the size of the slices going to each person. Basic research is concerned with the discovery of laws of behavior, with the ultimate aim of discovering the impact of alternative policies on behavior.

Policy analysis and specification, in contrast with basic research, are concerned with using knowledge for the purpose of deriving optimal policies. The distinction between basic research and policy analysis is meaningful because action must be taken and policies specified even in the face of imperfect or erroneous knowledge. The ultimate motivation for the acquisition of new knowledge should be the specification of new and better policies; and policies should, of course, make use of the best available knowledge.

Each one of these study areas will be discussed in this section in rather general terms, with more specific examples only for purposes of clarification. In the report on which this paper is based (1), some suggested specific projects were outlined for each study area, indicating the types of questions that the researcher might fruitfully pose.

Study Area 1 (Basic Research): Efficient Allocation of Resources

Demand—The measurement and causal explanation of the joint demand for trips on various segments of the highway network should be regarded as the first priority of highway transportation economic research. Without a doubt, this is the most serious gap in our knowledge. Demand, in the technical economics sense as used here, should not

be confused with "demand studies" that fail to isolate supply and demand elements. Trips should be regarded as objects of constrained consumer (or business) choice. In order to understand the choice process, we must first know what else the chooser is giving up, at the margin, to take a given trip. This, of course, is the key reason that price variables must be explicitly entered in the demand analysis.

Demand is most usefully broken down into long-run and short-run components. Determinants of trips such as location, habit, population, income, motor vehicle ownership, and others are fixed in the short run, but not in the long run. (In a formal sense, the short run is defined in terms of the fixity of some of these elements.) Short-run demand analysis should proceed along the lines of present forecasting models, except, of course, trip prices must be taken into account. As explained earlier, the price of the trip is the sum of the expenditures for user charges, time, and other intangible user inputs, and gasoline, automobile, and other tangible user inputs. The trip-time component, at least, is dependent on the volume of traffic.

Long-run demand analysis depends on the prediction of the adjustment of these factors to changes in relative trip prices. Because of the nature of the market in which trips are sold, this process of adjustment itself has impacts on relative prices. For example, a new highway leads to a lowering of trip prices because congestion is lessened relative to the old highway. This lowering of price leads to, in the short run, an increased number of trips along any part of that highway. In the long run, people change their locations, car ownership patterns, habits, and the like, leading to the consumption of even more trips, which in turn leads to higher prices for trips along the highway.

Because this adjustment process takes place over time and because at any moment in time the future can never be predicted with certainty, a dynamic adjustment model would undoubtedly contribute to our understanding of the movement of the system between successive short-run equilibria. As time unfolds and future uncertain events are determined, what before was a probability distribution of outcomes will become, with certainty, one of the possible outcomes. Future probabilities, however, are now conditional on this additional information and usually will be different. Economic agents adapt to the "mistakes" (viewed ex post) of the past. Given the longevity of buildings and transportation facilities, a better understanding of this mechanism would be a very valuable contribution to the understanding of the long-run demand curve for trips and for the adjustments it implies.

Within the long-run and short-run framework, demand might be broken down usefully by time of day or by day, month, or secular trend; by type of user such as household, business, or government; by type of vehicle; by trip purpose; or by socioeconomic characteristics of trip-makers. As with any econometric problem, stochastic elements should be explicitly dealt with.

Costs—Rational highway policy requires the trading off of different components of the costs of trips plus the determination of equilibrium quantities of trips on the highway system. The state of our knowledge of costs is relatively more advanced than the state of our knowledge of demand, even though much fertile unplowed ground remains in the cost area.

The highway administration acquires resources by purchase and by expropriation from nonusers, with purchased inputs probably dominating. The method of finance for these purchased inputs has implications for both the size and the distribution of the net benefits from highways. The focus advocated under this study area is on the former aspect of highway finance. There is certainly a high payoff to further research along the lines of existing congestion-pricing literature. Better determination of marginal trip costs is undoubtedly called for. Of course, much more has already been done on the cost side than on the demand side.

Our understanding and quantification of "tangible" inputs, such as concrete and gasoline, along with their causal determinants are relatively well advanced. Our understanding and quantification of "intangible" inputs, such as travel time valuation or valuation of noise by those near a highway, are relatively less well advanced. The difficulties surrounding the quantification of so-called intangible inputs are due primarily to the fact that they are typically not exchanged directly in easily identified markets. The task of the researcher is to discover situations in which individuals are indeed confronted

with choices between well-identified alternatives. Examples include the choice between toll roads or free roads, between public transit or automobile travel, or between different roads or streets. It may be that nonuser evaluations of noise that streets bear can be inferred on the basis of changes in property values near highways because, other things equal, home owners or renters are willing to pay more for quieter surroundings. It should be clear that the identification and quantification of the value of these intangible inputs are formidable tasks.

Study Area 2 (Basic Research): Determinants of Real Wealth Distribution With Respect to Highway Transportation

The process of constructing demand functions for highway trips should, in addition, yield information as to the persons making these trips. For purposes of providing information relevant to the choice among alternative distributions of real wealth, these demand functions should be specified along individual or group lines relevant to this ethical choice. Of course, this is not the end of the benefit-incidence story, but only the beginning, because it is likely that at least some benefits are not shifted. The identification of primary benefit recipients is probably necessary before the results of the operation of the benefit-shifting mechanism can be predicted.

Analysis of the mechanism by which highway benefits are transferred from persons who use a highway to those who do not directly use a highway should not be confused with double-counting of benefits. Very little has been done to analyze this transferral mechanism. Basic research in the form of general equilibrium highway-related models would be valuable in this context. Caution should be exercised in the interpretation of existing highway impact studies because of their partial nature. As an example, the often dramatic land value gains near new highway interchanges are often cited as an extra benefit from freeway construction, over and above user benefits. Yet, some site-value models of the von Thuenen type predict that a transportation improvement should lower aggregate land values, even though land near the improvement should increase in value. Land incorporated in highway rights-of-way, insofar as the payments made leave the former owners and occupiers no worse off than they were before in terms of their own preferences, shows up as a cost in conventional highway administration accounts. That relocation, construction noise, dust, and vibration, followed by traffic noise, air pollution, and vibration exact from hapless bystanders uncompensated real costs seems apparent. Quantification of these costs, needed for efficiency analyses, is also a prerequisite for equity impact analyses.

Highway finance policy can be viewed as the beginning of a process of shifting costs, in this case, from the highway administration to users or others. The analysis of the shifting and incidence of general taxes, such as property, income, and excise taxes, is in the hallowed, if not hoary, tradition of public finance economics. In any event, if urban land for highways is very scarce (in inelastic supply, to be more precise), the congestion-pricing models in the literature imply that marginal cost tolls of the highways would more than cover total costs. This would mean that imposing marginal cost tolls to allocate efficiently the capacity of existing and future highways would yield revenues far greater than the costs of these roads, possibly allowing reductions in other taxes, thereby reducing the dead-weight losses associated with these taxes.

Because cost shifting and benefit transfers work through changes in relative prices, the resulting price changes cause both welfare gains and losses to specifiable individuals or groups. For example, the increase in property values due to improved accessibility along new highways may leave some property renters or buyers in the area worse off than they were before the new highway. An increase in traffic causes the rents accruing to gasoline stations to increase, resulting in gains to gasoline station owners. Increased construction activity causes rents accruing to union membership or construction skills to rise, thus benefiting those fortunate enough to belong to unions or to possess construction skills. In spite of its importance, little research has been done to trace and quantify these wealth-transfer effects.

Study Area 3 (Applied Research): Policy Analysis

Institutions and Organizations—Institutions and organizations serve an important economizing function: They reduce uncertainty and economize on calculation, information, and transactions costs. Examples of highway institutions are the pay-as-you-go construction system, the formula that allocates funds to political subdivisions, and the division of responsibility for road construction and maintenance between political levels. Organizations include the various administrative structures that formulate and implement highway policy.

Even though institutions and organizational arrangements serve an important function, it is important to recognize that they also represent constraints that prevent the attainment of the kind of optimum that might be possible in a world of perfect information, and absence of calculation and transactions costs. However, as the state of our knowledge improves, presumably the institutions relevant to the optimization of highway services should also change. For example, a frequently mentioned "rationale" for the establishment of the Department of Transportation was to provide a broader focus to transportation planning and policies.

Although economists have made contributions to the understanding of the functionings of large organizations, this field of study lies outside the mainstream of economic analysis. The development of behavioral theories for highway administrations, under different institutional constraints, would be a valuable addition to our knowledge.

Operational Performance Criteria—The economists' exhortation to "maximize net social benefits flowing from highways" is like the command to "do good." It is a laudable injunction but, by itself, hardly a useful guide to action. Lower level criteria, consistent with this higher goal but cast in terms relevant to the action at hand, would seem to be desirable.

It is difficult for an outside researcher to specify concretely the form such criteria should take. Nevertheless, the following examples may help to clarify the point at issue even though they may not be specified in the optimal form:

1. A bypass of an intercity route should be constructed around a town when conditions A, B, and C are met.
2. Roads should be cleared of snow in the following order: ....
3. Benefit-cost analyses of particular projects should use the following methodology to deal with intangible costs, until further information is developed: ....
4. Engineering standards S_1, S_2, and S_3 respectively should be used for road types T_1, T_2, and T_3.
5. The following "accounting statement," analogous to a corporation's income statement and balance sheet, shall be used to evaluate the performance of the highway department during the past year: ....

The research advocated here comes under the general heading of the economic theory of the "second-best." In other words, given that public servants in the highway administration at all levels are cursed with imperfect or inadequate knowledge as to the total consequences of all their actions, and given that the acquisition of this kind of knowledge would be uneconomic even if possible, objective standards capable of being understood and applied both by the actor and by those evaluating his actions must be devised. It is probable that both the form and the content of these performance evaluation criteria will be different at different administrative levels. Economic theory would seem to be useful in the analysis of the relationship of these criteria to the broader goal of welfare or net benefit maximization with respect to highways.

The importance of this study area cannot be overemphasized. Bridges between theory and practice can prevent the irrelevance of good theory, on the one hand, and the guidance of actions by poor theories, on the other. Indeed, this area more than any other was emphasized during interviews with Personnel of the Ohio Department of Highways and the Federal Highway Administration in the course of acquiring background information for this study. Of course, the value of these operational criteria, measured in terms of their contribution to the welfare maximization goal of highway policy, must depend on the state of our basic knowledge, as outlined earlier.

SUMMARY AND SUGGESTED PRIORITIES

First priority for future research must be given to the specification and quantification of demand for highway trips, both because of its intrinsic importance and because so little has been done in the area. Second in relative marginal importance is research into the wealth distribution effects of highways and highway policies. Third priority should be given to work in applied research on the interface between basic research and policy. Further work on costs is placed last in importance primarily because, of all study areas, this is the best cultivated.

These suggested priorities are based on this economist's evaluation of the relative benefits from increments in knowledge in each area. They are not meant to suggest concentration in one to the exclusion of another; rather, they are intended to advocate increasing the investment of research resources in the former areas, relative to the latter. As new knowledge is acquired, the relative priority of each area will undoubtedly shift.

ACKNOWLEDGMENT

This paper is based on research completed during the summer and fall of 1968 and published as Appendix B, Research Needs in Economic and Financial Factors of Highway Transportation, in a report by Hong, Schwar, and Talbert (1). The entire project was sponsored by the Ohio Department of Highways and the Federal Highway Administration. The opinions, findings, and conclusions expressed or implied in this paper are those of the author and not necessarily those of the sponsoring agencies.

REFERENCE

1. Hong, H., Schwar, J. F., and Talbert, L. O. A Study of Highway Research Needs and Resources. Eng. Exp. Station, Ohio State Univ., Columbus, Rept. EES 229, Dec. 1969.