Behavioral Travel Demand Models: Some Basic Considerations

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Travel demand forecasting has probably been subjected to more active and virulent criticism in recent years than any other phase of the transportation analysis process. The reasons for this are numerous but basically stem from a feeling that most existing models are cumbersome and unresponsive to changing analytical requirements.

Some critics have argued, with considerable cogency, that the most pressing current requirement is for a simpler, more aggregate set of models that are less ravenous in their data requirements, are less expensive and time-consuming to apply, and rapidly test a large number of different plans in a timely and responsive manner. Others have argued, with equal force, that a greater understanding of the basic mechanisms underlying travel behavior would lead to a completely new family of modeling techniques, employing varying analytical structures and each oriented toward a particular set of analytical issues and areas of policy concern.

Certainly, simpler, more malleable model structures that lead to more timely and less expensive forms of analysis are required. So too are models that may be used to address particular, relatively narrow issues at some considerable level of detail. Both of these requirements imply the need for a better and more organized understanding of the factors influencing travel behavior than we have at the moment. Both also imply a somewhat different approach to the whole question of travel demand forecasting and travel behavior research than has been embraced in the past.

These points emerged with some considerable clarity from the recent Conference on Urban Travel Demand Forecasting (1). We would like to take some of the initial recommendations of that conference as the starting point for these comments.

Our comments are deliberately eclectic, covering issues that it seems to us should be among those of greatest concern in any future programs of research, development, and application of models. They cover issues of an institutional and organizational nature as well as questions of technique and research orientation. Although the comments are not a comprehensive statement of the issues, we hope they may serve to provoke some fruitful discussion and argument.

RECOMMENDATIONS FOR TRAVEL BEHAVIOR RESEARCH

One of the major purposes of the earlier conference was to develop a set of recommendations for future research in travel demand forecasting. Issues relating specifically to travel behavior were the concern of one workshop, which identified 11 major topics for future research (1, p. 115):

1. Behavioral response to low-capital options;
2. Evaluation of alternative marketing strategies;
3. Behavior of special user groups;
4. Definition, measurement, and treatment of attributes of transportation service;
5. Comparison of attitudinal and conventional forecasting techniques;
6. Monitoring of travel behavior;
7. Process of travel decision-making;
8. Activity patterns and destination choice;
9. Simultaneous estimation of service and demand;
10. Problems of aggregation and scale in travel analysis; and
11. Dissemination of research information.

The orientation, scale, and timing of the research vary considerably. Their total estimated budget comes to more than $4 million over a period of 3 to 4 years. The potential source of this money, perhaps not surprisingly, is not immediately identifiable. A cursory examination of the list suggests a number of themes that are central to several topics.

1. Considerable emphasis was placed on the need to develop a more coherent understanding of travel behavior from a variety of specialized perspectives. Emphasis was placed particularly on developing a better understanding of the potential impact of low-capital options, i.e., options involving relatively small levels of capital expenditures and dealing mainly with incremental changes in the service, supply, pricing, or marketing characteristics of existing transportation systems. Typical examples include car-pool schemes, priority transit schemes, parking and gasoline taxes, enhanced security provisions, improved vehicle design, alternative marketing strategies, short-range scheduling and service modifications, and marginal pricing changes. In a parallel vein, emphasis was also placed on the need to address more specifically the behavior and requirements of special user groups whose needs differ significantly from the norm and who are either ignored in current demand forecasting analyses or else simply lumped together with the rest of the population. Particular stress was placed on those segments of the population, the elderly, young, handicapped, and poor, whose behavior and use of existing systems is subject to identifiable constraints. In both instances, the emphasis was on the analysis of behavior at a highly disaggregate, specialized level rather than at a generic level, at least in the early stages of investigation.

2. There was considerable debate concerning the role that "attitudinal" analysis techniques may usefully play in the development of an improved understanding of travel behavior. The interest of the workshop members was reflected primarily in topics 4 and 5. The first of these focused on the need for a clearer identification of the salient attributes of transportation service, including the methods to be used in characterizing and measuring them and the mechanisms whereby they may be incorporated in either attitudinal or conventional model structures. Particular concern was expressed with respect to the definition of system-specific and system-common attributes, the stability and transitivity of user perceptions and attitudes toward alternative attributes, and the problems of extrapolating attitudes concerning existing systems to the analysis of new systems. The second focused on a comparison of the efficacy of attitudinal versus conventional techniques when applied to a single (or several) common test cases. Emphasis was placed in this latter case on a careful, comparative analysis of the viability, cost, and utility of attitudinal versus conventional techniques and on identification of those areas where each may be most appropriately applied in an operational context.

The message in this case is simple: There is a well-developed body of analytical techniques, derived mainly from the fields of market and consumer research, that appears to be highly appropriate to certain forms of travel behavior research. To date, its use has been explored only to a limited degree. It appears worthy of much closer examination.

3. One of the most common pleas of the behavioral analyst is for more and better

data. At present we are virtually ignoring one important source of such information, that is, information on traveler responses to the successive changes that are continually being implemented in transportation systems throughout the country. The problem is partly that we simply lack the appropriate mechanisms for collecting such data and partly that the necessary financial support is usually not forthcoming. The workshop proposed that a sample of case studies of existing systems be used to develop a systematic program for monitoring the impact on both long- and short-run travel behavior in response to selected changes in transportation service. The interest here was to capture information on operational changes in existing transportation services rather than to set up a set of explicit demonstration experiments. Particular emphasis was placed on low-capital options discussed above.

4. Existing information on travel decision process is extremely fragmentary largely because of the diffuse and uncorrelated nature of much existing research. To overcome the problem and to provide an effective, concentrated nucleus of research that might then serve as an effective foundation for the development of improved, more responsive demand forecasting models, a comprehensive program of basic research was recommended of the mechanisms underlying the travel decision-making process. This program would focus particularly on issues such as

a. Identification of the basic structure of the travel decision process and its relation to the established activity patterns and the characteristics of different decision units;
b. Development of a coherent, compatible set of behavioral data bases to serve as input to a variety of subsequent forms of analysis;
c. Identification of the sensitivity of travel decision-making to varying service parameters and other controllable factors under situations of at least quasi-experimental control;
d. Examination of the interrelations between long- and short-run travel investment decisions and between long- and short-run behavior;
e. Analysis of the interrelations between destination choice and trip purpose on the one hand, and route and mode choice and time of travel on the other; and
f. Consideration of potential short- and long-run substitution effects that involve the potential substitution of other forms of communication or interaction for current, physical movement.

The thrust of this recommendation was to guarantee (at least conceptually) that sufficient resources be made available, in one time and one place, to permit significant progress to be made in the development of improved behavioral analyses.

The above issues flowed only from one of the several workshops at the conference, but they serve to illustrate the combination of pragmatic and theoretical concerns that should underlie any future research program. We would like to pursue some of these issues in the remainder of this paper.

APPLICATION OF URBAN TRAVEL ANALYSIS RESEARCH

The absence of an appropriately funded urban travel analysis research program in the United States suggests that the priority that many planners associate with research in this area is not shared by decision-makers with the authority to implement such a program. In this context, it is useful to consider the potential justification for an urban travel analysis research program from the decision-maker's viewpoint.

During the past 10 years, the preponderance of the urban travel analysis research effort has been focused on regional planning analyses characterized by relatively coarse representations of the various urban transportation modes and relatively long forecast periods of 15 years or more. Research activity on these types of problems is understandable in the context of an urban transportation planning process that focused on highway capacity issues as it was evolved by the Federal Highway Administration. The crucial issues of urban transportation policy both now and in the future, however, involve concerns such as environmental policy and its transportation interrelations (with

respect to the social as well as the physical effects of transportation), land use policy and its relations with transportation, and energy policy and transportation.

Inasmuch as the focus of national interest has shifted to issues associated with the environment, land use, energy utilization, and public transportation, there should be a corresponding refocusing of urban travel analysis research activities. If support is to be secured for an effective and meaningful urban travel analysis research program, it must be demonstrated to decision-makers that the results of this research will enable them to make better decisions with respect to these important and complex issues.

That an urban travel analysis research program is important to the achievement of national objectives can be illustrated by considering one specific research area. Partially in response to the critical issues identified above, national urban transportation policy has emphasized the development of an effective urban public transportation program for American cities. This emphasis is based on the belief that the environmental, social, and economic benefits are such that the general community should contribute to the development and support of the program. In other words, the rationale for developing an effective urban public transportation program stems from its contribution to the overall development of the community's objectives and not solely from a profit motive. The success of public transportation will, however, be ultimately judged on one overriding criterion: its ability to penetrate the urban travel market. The consequence of this observation is ineluctable: The marketing of public transportation cannot any longer be overlooked or deemphasized in a competitive environment in which the number of transit captives is increasingly diminishing.

Important elements of a public transportation marketing program include identification of target markets for public transportation—population segments that represent high potential sources of business; identification of the features and the stimuli most likely to influence the target markets; and assignment of priorities in the redesign of the public transportation service product.

Thus, one justification for conducting an urban travel analysis research program is based on the need to market public transportation more effectively. Unless an urban travel analysis research program is justified in this or similar terms, there is a strong danger that urban travel analysis research program proposals will be dismissed as irrelevant to national goals and merely reflecting the desire of researchers to conduct research in an area that they enjoy.

This perspective provides, in fact, an opportunity for an even broader urban travel analysis research program than was provided by the requirements of system level planning analyses. Many urban travel analysis research projects could be defined within this framework of marketing public transportation. Areas that are of particular importance include automobile car-pooling and increased automobile occupancy, vehicle equipment and terminal design, passenger's perception of personal security, schedule reliability, and image projected by transit operating personnel. Research projects should be designed to assess not only the impact of a given factor on the utilization of public transportation but also the normative issue of how the public transportation product should be designed.

IMPLEMENTATION OF URBAN TRAVEL ANALYSIS RESEARCH RESULTS

Perhaps more important than the identification of priorities for future research is the assessment of the results of the research that has been accomplished to date and the degree to which these research results have been implemented. Even if a research program were clearly related to national priorities, the program would not be sustained if the research results were not implemented. Nearly 5 years after the work of Lisco, Quarmby, and Stopher, behavioral, stochastic, disaggregate models are—with few exceptions—not being employed in operational planning studies and are largely discussed in research rather than operational planning contexts. Although aspects of behavioral, stochastic, disaggregate models do require further research, they can be usefully employed in modal-split and automobile occupancy analyses.

Thus, some of the research into behavioral, stochastic, disaggregate models has been completed and is available for implementation in operational planning projects, and there are distinct economic and technical justifications for using these techniques. Why then has the introduction of these techniques into operational planning practice been so limited, and what can be done in the future to encourage more rapid dissemination and implementation of research results? These are difficult issues that are not easily analyzed or resolved. Factors that contributed to the slowness with which these techniques have been implemented include the unavailability of a well-documented and efficient computer system, the general unavailability of well-qualified and trained personnel, and the absence of a professional consensus regarding the research findings to date.

If the urban travel analysis research program is to have any opportunity to be funded at an appropriate level, it should clearly include major elements relating to the implementation of research results. The following projects would contribute significantly to increasing the probability that these research results would be implemented:

1. A well-documented and efficient computer system that can be used in conjunction with behavioral, stochastic, disaggregate models (assuming that a professional consensus regarding the design of this system can be achieved) and that includes a calibration program, programs to assist in the preparation of a calibration data set, and programs to effectively apply the calibrated models;
2. Training programs that include short courses oriented to current practitioners and courses within the graduate programs of universities;
3. A program of demonstration planning projects that is specifically designed to field test the latest planning techniques—including new urban travel analysis approaches—within an operational planning environment and to demonstrate that these techniques can be effectively used to increase the quality of the transportation planning product; and
4. Techniques for applying behavioral, stochastic, disaggregate models that will exploit their advantages during the alternative-evaluation phase of a planning effort.

INSTITUTIONAL CONSIDERATIONS AND AN URBAN TRAVEL ANALYSIS RESEARCH PROGRAM

Implementation of a national urban travel analysis research program requires institutional changes at the federal level. To argue that the problem of implementing a research program would be solved if only the appropriate funding were available overlooks what may well be an important aspect of the problem, namely, that the federal government is not currently well organized to manage an urban travel analysis research program. The urban travel analysis research effort of the U.S. Department of Transportation is fragmented among various groups within the department (e.g., the Federal Highway Administration, the Urban Mass Transportation Administration, and the Office of the Secretary) and the National Cooperative Highway Research Program. Further, many of the issues that should be addressed within such a program are of major concern to a number of agencies outside the department, particularly the Environmental Protection Agency and the U.S. Department of Housing and Urban Development. Although a significant amount of coordination with respect to urban travel research does take place among these groups, the organization of an effective urban travel analysis research program requires a more developed institutional structure.

Thus, there is a need within the federal structure for an institution that would fund and manage a multimodal urban travel analysis research effort. This institution should clearly be designed to avoid even the suspicion of having a modal bias and for this reason should not be lodged in either the Federal Highway Administration or the Urban Mass Transportation Administration. Although multimodal research and policy studies related to urban travel analysis might be directly funded and managed by this new institution, this would not preclude the conduct of more mission-oriented urban travel analysis research efforts within the modal agencies. For example, the Urban Mass Transportation Administration might continue research projects specifically oriented to the

problems of the transit industry such as the impact of the travelers' perceived security on their attitudes toward public transit. For those projects that continued within the operating administrations, this new institution would serve as a formal coordination point rather than as the program manager. The very applied nature of an urban travel analysis research program suggests that it should be placed within an operating department—probably the Department of Transportation—and not lodged in a more research-oriented environment where the perspective of the application of the research may be lost.

DISTINCTIONS BETWEEN MODELS FOR PREDICTION AND EVALUATION

In formulating mathematical models to estimate travel demand and especially the behavioral, disaggregate models, we need to bear in mind that different models may be appropriate depending on whether the primary aim of the analysis is prediction, evaluation, or design. The models may be different with respect to their structure or specification, their data requirements, the statistical estimation procedure used, and the method of their application.

If the primary aim of the model is predicting or forecasting some present or future level of travel demand, a 2-stage procedure is involved. At the first stage the model is specified and "estimated" (to use the terminology of the econometrician) or "calibrated" (to use that of the engineer) from a data set of observations on both the dependent and explanatory variables included in the model. The results of this first stage are best estimates of all the parameters of the model (i.e., the model coefficients) together with measures of the statistical significance that can be attached to the coefficients. At the second stage the model is "run" by inputting observed or predicted values for the explanatory variables to give predicted value or values for the dependent variables. The "goodness" of the model is assessed principally in terms of its overall explanatory power, that is, its ability to duplicate the values of observed dependent variables at the second stage. The estimates of individual model parameters derived at the first stage need not necessarily be of concern, provided that overall predictive ability of the model is acceptable.

If on the other hand the primary aim of the model is to aid processes of evaluation or design, the estimates of the structural parameters of the model and the errors of estimate associated with them are important. In the context of models to explain travel behavior and travel demand, the processes of evaluation and design may be considered to be much the same. In evaluation we are concerned with placing "values" on reductions in travel time and other transport system improvements; in design we are concerned with assessing what specific transport improvements will be most successful in effecting some desired objective. In both cases we are attempting to estimate the relative value or importance (however defined) of different transport system attributes. That being the case, the application of the model is essentially a 1-stage process in which we are interested only in interpreting the model coefficients in ways that are useful in evaluation or design. The second, predictive, stage is not necessarily of concern; but, in any case, in assessing the goodness of the model, predictive efficacy is secondary to the model structure and the significance of the individual structural coefficients.

For predictive purposes a perfectly satisfactory model might exclude any cost variable; but if a monetary value of time is required from the model to allow evaluation of alternatives, a cost variable must be included. Similarly, the form in which explanatory variables are entered in a model to allow good prediction (whether as differences, ratios, or whatever) may not allow meaningful interpretations to be placed on the coefficients. Consequently, for design purposes—for estimating the relative value of 2 specific attributes, for example—a model that is less good in a predictive sense is more appropriate if it allows useful inferences to be drawn from the coefficients.

In terms of the statistical estimation procedures employed, the distinction between predictive and evaluative models may be relevant to the extent that there are problems of misspecification and multicollinearity that give rise to unreliability and inconsistency

in parameter estimates. If the model is purely predictive, low statistical significance levels associated with coefficients are likely to be of much less concern than if the coefficients themselves are the required output of the model.

These comments are not meant to imply that predictive and evaluative models should be different on theoretical grounds. Indeed quite the opposite is true. Ideally, one would expect a model that is a perfect predictor of behavior to contain all the factors that determine travel decisions in such a way as to reflect the relative values placed on them by the traveler. Further, to the extent that a model allows the outcome of any course of action to be predicted perfectly, it might be considered a perfect evaluation model. However, we are still a long way from developing perfect models. Moreover, even if one day perfect model constructs are available to us, practical and economic considerations such as data availability will always present constraints. The fact is that, practically speaking, we need to develop specific models to address specific problems and will often be required to adopt less than perfectly structured behavioral models. Certainly we should always be wary of predictive models that do not bear some recognizable and convincing relation to travel behavior; but, having said that, the distinction between models where prediction is the primary objective and models where coefficient interpretation is the primary objective is still a useful one to bear in mind.

In considering predictive models that involve a 2-stage process of estimation and application, we need to remember that, as inputs to their application, predictions must be made of all the exogenous variables included in the model. This being the case, we need to guard against the development of overly sophisticated models that can only be used in prediction if elaborate and expensive surveys are undertaken to predict the exogenous variables. This caution is made particularly with regard to the inclusion of psychometric, attitudinal, and perceptive data as explanatory variables of behavior in predictive models. Although it will probably often be true that the inclusion of such variables allows improved understanding and explanation of travel behavior, the difficulties of predicting the variables for other travel-choice situations may be so great as to invalidate the model in prediction.

DEMAND MODELS IN A CONSTRAINED TRAVEL ENVIRONMENT

Transportation planners have in the past been largely concerned with improving the transportation system so as to persuade travelers who have choices available to them to travel in a certain way. The obvious example is the attempt to persuade those with automobiles available to use public transport. Behavioral travel demand models have reflected this concern by concentrating on the modal- and route-choice decisions of travelers who are free to make such decisions.

However, we are now entering a period when policies to control travel will be increasingly pursued and when more and more travelers will find their mode and route choices much more limited by restraints on the use of private cars through legislation and pricing, by fuel prices and availability, and by other environmental pressures. Such constraints imply the need to produce estimates of travel demand in situations where travelers are faced with sets of choices rather different from those they have been faced with in the past. What this means for behavioral modeling is not altogether clear, but is something with which we should be concerned. Certainly the ways in which behaviorally based approaches to trip generation, attraction, and distribution modeling deserve attention. The estimation of how much traffic is generated by improved facilities and, on the other side of the same coin, the estimation of how much travel will be suppressed as travel choices are limited are important problems that have nowhere been satisfactorily tackled. However, in tackling these problems and others we have mentioned, we need to beware of directing all our energies to the development of improved and new models and neglecting the application of the models we have already developed.

Clearly, a great deal of research effort is required in many directions, but as transport planners we are being asked to help solve today's problems and to advise on policy decisions that cannot wait for the results of next year's research projects. Imperfect

as they are, many of the behavioral models we have already developed can be of assistance in making better decisions, and we need to see to it that what knowledge we have already gained is put to practical use.

REFERENCE

1. Urban Travel Demand Forecasting. HRB Spec. Rept. 143, 1973.