SEMINAR ON DEMAND MODELING AND ESTIMATION OF DEMAND

INTRODUCTORY COMMENTS

Raymond H. Ellis

In formulating my introductory comments, I inevitably could not focus only on the problem of estimating demand for a demand-actuated system and ignore the entire problem of estimating the demands for urban transportation. It has become trite to say that the simple impossibility of dealing solely with an urban transportation system based on the automobile forces us to look at other forms of public transportation. During the past few years, we have structured a very rich variety of transportation concepts ranging widely in the technological and institutional innovations required to implement these systems.

I would suggest that there is a problem in the evaluation and demand estimation process to determine the consumer's response to the different types of alternatives, particularly combinations of alternatives. I would like to pinpoint some questions that have been bothering me about demand modeling and the estimation of demand for new systems. I would be very curious to see how the individual techniques and approaches respond to these problems.

Most of the demand work that has been done in the area of urban transportation is focused on what one might call a dual-choice problem—that is, public transit versus the automobile. Yet, when I start talking about a rich array of alternatives ranging from the private automobile to car pools, reserved lanes for car pools, fringe parking, conventional transit, dial-a-bus, taxi, and systems requiring higher degrees of technological innovation, it seems clear to me that in the urban situation we are going to have 3, 4, or possibly more modes operating in competition with one another. It is essential that the process for estimating demand be responsive to competition among the modes, particularly among 3 or more modes. I think the 2-mode problem is essentially where we are now. There are a few n-dimensional models or techniques available for dealing with this particular problem. I think each of them has its disadvantages.

The second type of problem that I see in estimating demand for urban transportation is what one might call the new mode problem for which we have no base-line data that can be used for purposes of calibrating a modal-split model or any sort of model. We really do not have a decent method for coming to grips with estimating the demand for a new mode. In this regard, I am looking forward to hearing some responses or disagreements on this particular point.

Third, I suggest that in many ways the techniques and the ideas that we have used to date have not given us the types of information we need to plan an urban transportation system. Who are the potential riders of the system? Particularly from the techniques that have developed from the highway planning process, we do not know who is using the systems in terms of the social groups, i.e., the elderly, the young, the housewives, and the families with different levels of car ownership and varying economic needs. This sort of information is frequently missing. It is frequently important because this is the way people define the public transportation problem. We have very litttle information on the peaking characteristics and the temporal distributions, yet it is clearly very important. We have relatively little information on the elasticity of demand to changes in the service

levels or the changes in the performance requirements in terms of time or price, yet these also are quite important in designing a system.

Finally, there are factors that we simply have not considered to any high degree. For example, to the best of my knowledge, reliability, safety, comfort, and convenience have not been factored into the demand modeling process.

Perhaps, as one of my associates has suggested, we will not be able to develop techniques for predicting the demand for urban transportation until we have a theory of urban transportation—a theory of demand. Nonetheless, the transportation systems of our cities are in an element of chaos, and I think it behooves us to do something in response to these requirements.

I have outlined several questions for discussion. What type of demand analysis strategies have been used? Have the strategies involved a psychological approach, an econometric cross-sectional type of approach, a behavioral approach, or an approach based on a marketing-type study? What sort of mathematical models have been used? What variables or factors were considered? Did they include transportation variables (for example, time and price), trip variables (the characteristics of the trip), and the trip-maker? Regarding results of analyses, do we have some estimates of the demand curve for demand-actuated systems? What about the sensitivity of the analyses? How many sensitivity analyses were run? Can one begin to draw some conclusions about the nature of the demand for demand-actuated systems?

RESULTS OF RECENT DEMAND ANALYSES

Joseph H. Stafford

I will describe some of the strategy or the philosophy that we were trying to implement at M.I.T. One of the questions relates to data. Did we use attitude surveys, or did we try to use observations on actual behavior and actual choices? We rejected the attitude survey for our particular effort for several reasons. First, we thought it would be more expensive. Second, I did not really feel I had any great capability of doing it, and that is probably the main reason I rejected it. I really felt that the GM people were doing a far better job than we were capable of doing. I am very intrigued with some of the work that Jim Wallace started 3 or 4 years ago on the multi-attribute utility model. We experimented with it a little, and I became convinced that I did not know how to get around the post-decision rationalization kind of phenomonon that one has to come to grips with in attitude or intention surveys. I felt that we might end up with weights on rationalizations rather than with real utilities.

So after a very short time of trying a few things along that line, using mostly student term papers, we went the other route dealing with data that were essentially behavioral. That is, we tried to infer from choices that people were making, and we used predominantly the Boston home interview survey data. One thing that we did very much agree with the GM people on (we did not disagree with them on the attitude survey but felt that this was their thing and that we ought to wait for their results) was that disaggregation was going to be essential and that cross-sectional data on the zone aggregates were not going to tell us anything. We had to get down to the individual household and individual trip-maker to learn anything. This then suggested to us some sort of discriminant analysis such as probit-logit.

The other thing that I felt fairly strongly about was that we could not look at the trip. Although most of the previous studies had been done in terms of trip prediction, we had to recognize that there was both a long-run and a short-run decision. A person was making not a decision about a trip but a decision about a whole group of trips when he made the decision to purchase a second or third automobile. We might expect the quality of the public transportation service that was available to influence that automobile-ownership decision. Therefore, Paul Hauxy used the discriminant-analysis approach (with what little data we had available on accessibility or average walk times to the transit system) to see what accessibility would explain in automobile-ownership trends

rather than the other approach in which automobile ownership is considered to be completely given exogenously. Not to my surprise, there was some effect on second car ownership, virtually no effect on first car ownership, and most of the effects of the quality of the public transportation system could be washed out with a very minor change in income. I do not have the exact numbers, but I hope this begins to put things into some perspective.

The other kind of approach we were taking is similar to what a number of other people have done on the so-called "value of time" models (Thomas and Haney at Stanford Research Institute, Lisco at the University of Chicago, and a number of others). All of those models have really been restricted to middle-class, rush-hour commuters in major metropolitan areas. We thought that, if we were going to look at a potential market for dial-a-bus, we had to get well beyond that and look at different trip purposes, different times of day, different people, and different income classes to see how people were making their choices in this broader context of trip-making behavior. That study is really just now beginning to get off the ground. We hope Rodney Plourde will be working on it all year.

Another approach that we took was to ask the question, What other kinds of data and observations of behavior choices can we work with in a disaggregate, carefully structured, and controlled experimental way prior to having dial-a-bus in the field? We were fortunate enough to talk Karl Guenther into allowing us to observe the Mansfield project. The Richmond County Planning Commission opened its files to Dennis Kershner, who just finished a master's thesis on using discriminant analysis.

We think that this value of time model that Lisco, Haney, Labe, and others have done makes a lot of sense. Houston Wynn's short-cut mode-split model is another example of this same kind of approach.

What can we do now with this disaggregate framework to build it back up into an aggregation for the whole community? Arnold Soolman, working that kind of an approach and taking the models as already given but plugging back in and deducing it the other way on a value of time framework, has put together some demand curves that seem to be reasonably consistent with our other kinds of observations on taxi cabs and bus systems. This method seems to calibrate reasonably well.

In summary, I can say that we have not settled on one model or one approach. We think it is going to be necessary to get into a very disaggregate kind of analysis where we have some new field observations and new data points. We are going to have to be careful of what we do to those data points to be able to extrapolate from a particular observation into any other situation. If we simply look at the balance sheet after the end of 12 months and decide whether the concept is go or no-go, we will have lost most of the useful information in the experiment.

Richard L. Gustafson

I will go over the methodology and the approach of our study at General Motors toward ridership estimation. We had a specific goal in mind in estimating the ridership for the particular case study community. We employed the attitudinal survey for the purpose of obtaining data for use in statistical analyses for the case study community. We applied the data from the attitudinal surveys to specific information concerning the trip-making behavior of the community. The attitudinal survey was conducted in 2 parts. The first part was in-depth group interviews from which we gained qualitative information concerning the residents' attitudes toward this transportation system. This aided us in preparing questions for the home interview survey. We conducted 5 of them for 5 different groups: retirees, teenagers, male heads of households, no-car households, and females.

The home interview survey was then implemented. In order to gain quantitative information concerning the particular subgroup, we established certain quotas. The marketing group that conducted the survey interviewed 100 households that did not have an

automobile available to them. We required a quota of 1,000 households, and we needed 200 housewives, 150 males, 100 females who work, 100 teenagers (male or female), and 100 heads of households with no cars available. We divided the housewives, males, and females that work into no-car, one-car, and multi-car households to obtain quotas. We had 400 multi-car households, 550 one-car households, and 100 no-car households—a quota of 1,050. The actual results were, I believe, about 1,080 for the attitudinal survey. Then, in the data analysis section of our questionnaire, we asked the individual, What percentage of trips that you are now making would you divert to the demand jitney system that has been explained to you by the interviewer? With the help of the interviewer, the person was told to enter a certain percentage. As the interviewee got more and more specific about what particular trips he would divert, the interviewer continued to question him. If he showed no interest at all in the system, the interview was completed at that point.

We also had questions concerning the latent demand. The intent of this survey was to get microlevel data concerning the potential ridership in the case study community. We divided the groups into particular subgroups and classified the data by person type and by trip type. There is a modal split for each person type and trip type in the case study community. We developed these modal splits and then aggregated them to get total aggregate modal split for the community.

We took the disaggregated information and applied it to a survey of the community that had been taken previously by another organization. It had trip-generation behavior by household and by trip purpose and origin and destination information on all trips made in the community. We applied our modal-split data to the demographic information for each respondent to determine how many trips would be made by each person type and by each trip type in the case study community. There were 175,000 eligible trips in the case study community. These were factored to estimate the number of trips in each category and then aggregated by hour because we also had the time of day that the trip was made. We could make this information very detailed. In aggregating it, we came up with the total distribution of trips to be made on the demand jitney for the particular system we discussed. We used 3 parameters—person type, trip type, and system configuration—and described system configuration by 3 attributes—maximum waiting time, minimum travel time ratio, and fare. We had 16 system configurations, 6 person types, and 6 trip purposes.

The latent demand estimates were calculated and are available in another paper. From the questions that we entered on the survey, latent demand was found to be of little significance. In addition, we investigated the potential school trips to be made on the demand jitney system. First of all, we found that the community had an excellent busing system and that none of the to-school and from-school trips would be made on the demand jitney because the school bus is free. We calculated potential trips after school and found that they would have little influence on the total demand distribution of the demand jitney. Therefore, at that point, we discounted it for out total feasibility analysis. The figures will be made available as soon as clearance is received.

Karl Guenther

The problem in Mansfield was similar to a fire drill in that a private operator and a planning agency came to us at Ford Motor Company and asked us to wind up an experiment. Very frankly, there was not much thought on their part for an a priori prediction of the demand for a new service. On the other hand, in our own program we had made a value judgment that was perhaps not totally justified but that seems today to have been a wise decision. The work that had been going on, particularly at M.I.T., appeared to be reasonably promising, and a parallel effort was not warranted. We carry a fairly strong conviction that a field test is probably the only sure way to predict demand. It is not a prediction of demand a priori, but it does give you points on the demand curve. We also capitulated to GM very much for the reasons that Joseph Stafford talked about. So, we thought that, for the particular Mansfield test, it was not ridiculous to go into the field to measure the demand and report our findings. It

was the cheapest and probably the most reliable thing that we could do at that point. We also have some modal-split models running that we are not at all pleased with, and we hope we will be applying our data findings to those. Any of the more elegant demand model formulations appear to be out of the question for calibration for an unknown mode at this point, at least with our available resources.

This is a 2-way street. We have fed data back into model development from our field experiment and plan to continue to do this as much as is possible. It is very difficult to get implementation-oriented operators and agencies to hold still while certain things are measured. Many times we had to go down to Mansfield to keep them from changing parameters or doing some wild things that would have, in our point of view, upset the limited experimental value of what we have done. They would want to run something for a week and then change it, and we had a hard time convincing them that it had not stabilized. So, we are feeding data back into the demand model building effort. We do not have a very elegant effort of our own, and we have completely ignored the survey approach.

We knew that the potential users of the system in Mansfield would probably be based on present transit ridership because the system exists and this is merely a modification of the transit system. It does not, in and of itself, represent implementation of a new service. We were not at all surprised to find that, in fact, that is what happened. We do feel that we got a little bit more into the serve-passenger market. This is based on the response to the question on our ridership surveys: What alternate mode would you have taken had you not been using the fixed route or route deviation Woodland bus for this trip? We found that the answer categories with the highest percentages are either "walk" or "ride with another person." So, we are getting into a potential serve-passenger trip market. I regret that I do not have those numbers.

In terms of setting the fare, this was a very simple process. The base rider fare in Mansfield was 35 cents, and we felt that it was very important to establish a differential price for the doorstep service rather than to offer it at exactly the same price. The question then became, What would the traffic bear? In this case, it was not what would the user bear but what would the city council approve, because it had to approve any fare increase. We arrived at a magic number of 50 cents, which seemed to all concerned to be some sort of a reasonable kind of differential for this kind of service. The fact that we do have 2 points on the demand curve leads us to believe that one of the things that we would like to do when we finish some more neighborhoods in Mansfield is to offer some alternative fare policies, if we can get the city council to agree.

There is another kind of demand, though, that is not addressed by demand for ridership. That is the demand for the particular vehicle that we designed for Mansfield. I suppose now I will have to be a little bit defensive and suggest that operators seem to want the kind of vehicle that we have. We had no intention of marketing it when we started out, but this particular Econoline, with some modifications to it, seems to be very appealing to private operators. That is a type of a demand that many transportation researchers are not too interested in, but it happens to be one that the person who signs my paycheck is very interested in. We are quite frankly a little bit surprised that it turned out that way, but William Howard made some interesting improvements on our Mansfield design.

William T. Howard

If I had to spend 5 minutes discussing the demand modeling that we did in Toronto on dial-a-bus service, I would have to stretch the words "none of" for 5 minutes. If I give you a little history, you can realize why we did this the way we did it. We did a very extensive market survey in 1965 or 1966 to estimate the demand for our commuter rail service. Things turned out very well but not the way the market survey showed it was going to turn out. One just cannot place too much emphasis on what people say they are going to do. Our market survey showed that on the rail system we would probably carry approximately 15,000 passengers a day, and this was practically right. However,

it also told us that our heaviest demand would be from the innermost stations to the CBD, and this was 100 percent wrong. As I said earlier, we had to expand the size of a parking lot almost immediately after we went into service because we based our parking lot capacity on the market survey that was carried out. What we had estimated to be $1.8 million in revenue actually became $3 million in revenue because we were getting maximum fare from more people than we had anticipated. It worked out quite well after a rush job to extend parking lots at the most distant suburban stations.

On our dial-a-bus program we thought that we could probably operate for a year at the same price it would have cost us to do a survey. So here we are ready to nod to an after-survey without the before-survey and to find out some facts rather than fiction. We do plan to do a complete survey later this month and to include such things as income levels. It will certainly be available to anybody who is interested.

Karl Guenther

As long as we have people like William Howard doing our uncontrolled experiments, I think we are not in too bad a condition.

Kenneth W. Heathington

A lot of work can be done in planning. I realize surveys cost a lot, but we should figure out a way to get the same data without having to spend a lot of money for surveys. What I think we are missing is a theory of estimating demand. When systems like these and those being considered by the Urban Mass Transportation Administration are installed, we can begin to calibrate a model to find out whether our theory is any good. It seems to me that there is absolutely no correlation between implementation of projects and what we are doing in the way of theoretical modeling for demand.

William T. Howard

I would like to clarify our particular situation. I should not give the impression that we proceed haphazardly with everything we do. We have a very, very strong group in our transportation planning division. We were recently formed as a Research and Transit Systems Branch of the Department of Highways. As well as having transit planners in our own branch, we work very closely with the overall transportation planning group, and we develop sophisticated models for our overall transportation system. We are not working in isolation, although it appears so when we throw these programs in without much in the way of planning or estimating demands. It is not our intention to do so. We, as I stated earlier, are certainly planning to expand our dial-a-bus operation, whether in the form it is in now or in some other form; and the experience we are getting now can be applied in other areas. It also can be fed into our overall transportation planning techniques to ensure that we are going in the right direction.

Joseph H. Stafford

May I react just a moment with regard to this theory of transportation demand? I do have one doctoral candidate, Eduardo Aldana, who is working on something that I think might be characterized as the theory of demand. He is trying to put together much disaggregate information, in both a long-run and short-run context, into a microanalytic simulation. I think it is closely related to some of the reaggregation of the disaggregate data that GM has done. I think we are approaching a point on a theory of demand that is rich enough for us to begin to test some of these new concepts. I do not believe the picture is as bleak as Raymond Ellis and Kenneth Heathington may be suggesting that it is.

OPERATOR REQUIREMENTS FOR DEMAND ANALYSES

Fred Tumminia

It is hard to say how accurate demand estimates have to be for decision-making. Actually I am in a unique position. I am a researcher that escaped and went into the transit

industry to try to do something there; and, of course, I have been meeting all kinds of obstacles. However, I do have an opportunity at this time, thanks to one of Joseph Silien's research projects, to disaggregate the market data by using an old survey and to start reaggregating it on the basis of data needed to plan a system. I have discussed transit planning that is concerned with conventional bus, conventional rail, new modes, and new systems of bus.

We are about 8 percent complete. We have a lot of problems disaggregating the data, and we are having a lot of problems reaggregating it. We are doing this from 2 points of view: One is the theory of good analytical procedures; the other is the decision theory of the transit operator. He has to be able to take this information from my group and make sensible decisions. He is going to put his political risks on the line. I hope I am not going to take half of the political risks to the point where he gets fired and I get fired.

There has not been that much good marketing work going on in the transit industry. The few marketers who have had experience with conducting a survey and with the actual behavior when a new service was introduced are still available to us. Unfortunately, the tendency of people to talk loosely tends to affect the quality of the survey. We need to have more information on the relationship between the responses in a survey and actual behavior. This problem becomes even more acute if the data are disaggregated.

Quite a few people have said that there is a lack of theory. I have not felt that in my experience. There are quite a few pieces of theory around in terms of decision-making, model making, and demand projections. Possibly what we need to do is synthesize them. The first theory relates to how people desire their life styles and what their self-images are in relation to the world. This theory treats people's activities—how they choose to live and how they make their day-to-day decisions. The second theory is the theory of the system itself as it relates to linking people's opportunities. That theory was available quite a few years ago. Essentially, the elements are available, although it would take a 3- to 4-year work program to develop a comprehensive theory.

Raymond H. Ellis

Did demand estimates have any influence on the selection of Haddonfield as a choice for a demonstration site?

Arthur Schwartz

Haddonfield was chosen partially because it is a very adjustable site. It is possible to expand the size of the area. If we find from our initial surveys that we should expect a relatively low demand per person per household, we would have to cover a larger area. We did not do any specific presite selection demand surveys.

We did, however, have some criteria for choosing Haddonfield. We were looking for a community where we might expect the following "demand indicators": (a) a combination of a central area that has some commercial content, and (b) a rail service to a major activity center, either New York or Philadelphia, that draws substantially large numbers of people and has a real parking shortage. If anyone wants to know the definition of parking shortage, it is when people start climbing curbs in the morning trying to find places to put their cars. Add that to your theory of demand.

GENERAL APPLICABILITY OF DEMAND-ESTIMATION PROCEDURES

Raymond H. Ellis

Is it possible to take the General Motors model and use it in Haddonfield?

H. J. Bauer

I think that in some respects it could be used there.

Richard L. Gustafson

We could have applied particular concepts in the model that we used to survey a particular community for developing some sort of idea of demand. There are obviously other aspects of the theory that were brought out in this particular attitudinal survey that might also be applicable to the problem of selecting that sort of area for a demonstration project.

Raymond H. Ellis

Would you have recommended this expensive data collection effort in Haddonfield in order to use this approach? Would you have had to reproduce all of your surveys in Haddonfield?

Richard L. Gustafson

We would not have had to do as extensive a survey as we did. One of the objectives of our research was to develop the tools and techniques for determining ridership as well as other aspects of user preferences.

Kenneth W. Heathington

I think one thing that is not firm at the present time is that the city selected by General Motors for the survey work will necessarily have the same preferences or scales of value as Haddonfield. The model formulations might work quite well, and I believe they would, but I am not sure that one can take the results from this particular city and transfer them directly to Haddonfield.

Richard L. Gustafson

I did not say that; I said only that it did not have to be as extensive.

Kenneth W. Heathington

This is what we do not have much information on and where we are really deficient in theory. We do not know how much is transferable from one area to another.

Arthur Schwartz

I want to point out that the example the General Motors people have already used is the one very serious shortcoming of all attitudinal surveys. When we confront someone with something that they have not experienced, how do we, in the short interview, try to make real to some person the concept that we are trying to evaluate. For example, the GM survey revealed a negative reaction by the people to zone fares. I do not think any of those people had ever seen a zone fare. They had no idea what the question meant.

Joseph S. Silien

We think General Motors has made a radical contribution in conducting this series of surveys. We are conferring with them, asking for their help in designing or commenting on, at least, the survey that we plan to take in Haddonfield, and using some of the techniques to get an estimate of demand. We started with the known demands of the number of people passing through the turnstile at a station on the rapid transit line. We also know the number of parking spaces available. We can predict with some certainty that more people want to go to that station than can get there. In that sense, the demand was considered in choosing Haddonfield as opposed to some other place along the line.

Raymond H. Ellis

Would you say that some of the discriminate models and logit models could be generalized with additional data for another city?

Joseph H. Stafford

We deliberately tried to do that in the work that Arnold Soolman did in Manchester, New Hampshire. We tried to develop reasonable estimates of the demand potential for that community of 100,000 by using data from the Chicago Skokie-Swift and the San Francisco Bay area. We did it on the basis of what I might call willingness to pay for a minute spent in a particular kind of activity or an environment. We used this sort of willingness to pay, in cents per minute, for the environment of the automobile in commuting trips or the environment of home, that is, getting home quicker or time spent walking and waiting versus being in the vehicle. Some of this same kind of data and some things that Lamb did in the Toronto parking garage selection were used. We built a reasonable estimate of what people would be willing to pay for dial-a-bus service that offered door-to-door travel to the member of the household who had the family car available, the member of the household that would need a second car in order to make these trips, and the potential serve-passenger trip-maker (a person who does not have a driver's license and who would have to rely on somebody else in the household). Clearly, there are weaknesses to this kind of deduction from all these other pieces of research that have been done. However, it did not look all that bad when we got it back together in terms of the aggregate and checked it out against what was actually going on with the fixed-route system there now. So, yes, I think we do feel reasonably comfortable about generalizing to other cities, but there is a difference between being reasonably comfortable and being sure.

Raymond H. Ellis

There is a question here of how much reliability we can place on our estimates. I want to offer one piece of evidence that I was struck by—a comparison of our work and the General Motors work. We looked at the demand for a demand-actuated system in a new town. Using essentially a technique that dealt with the attributes of the system, particularly the fare level, overall travel time, and waiting time that a person is going to encounter, we estimated the diversion to a demand-actuated system. The attributes were a 20 cent fare versus the 50 cent fare used in the General Motors study, roughly 2.3 times the overall travel time, a little higher than the number used in the General Motors study. On the other hand, the waiting time was somewhat smaller than the General Motors study. Overall, we roughly estimated that between 16 and 17 percent of those trips remaining within the community, equivalent to the definition used in the General Motors study, would be made on the new system. I was struck that this was fairly close, considering that these 2 approaches involve fairly different viewpoints. Our fare was lower, and waiting time was lower also. However, travel time was somewhat higher.

H. J. Bauer

Your net result was, from the user's point of view, probably a slightly better offer than the one we used.

VALUE OF TIME DIVERSION MODEL

W. Donald Goodrich

I have a different application of the value of time approach from that discussed by Joseph Stafford. At United Aircraft, we used a value of time analysis to do a demand estimate from the standpoint not of the operator but of the manufacturer. We did it primarily because it was expedient. The project is the helicopter access to San Francisco International Airport. Naturally, the corporation was interested because there was a potential customer, a company, incidentally, that has gone bankrupt since that time. We based our model on the characteristics of the operation itself: the flight time, the fare level, and the waiting times for the 8 heliports that were in existence in San Francisco. Also, we did some disaggregation of the 9-county Bay area in the sense that a matrix was overlaid, a demographic description was made of San Francisco to the extent that

we identified where air travelers would be, and the income attributes were identified of those neighborhoods in which we inferred a value of time. Then we had a bimodal-split model, which we were bemoaning but which we were fortunate enough not to have to go beyond, wherein the air traveler could use the road system to gain access directly to the airport or he could use the road system in some way to gain access to the heliport and fly to the airport. By some quirk of fate, and somewhat to my distress because I have not put much credence in the value of time approach before this, 7 of the 8 heliports came within a tolerance of ± 1 percent of the actual demand in 1968. For the eighth heliport, San Jose, our predicted demand far exceeded the actual demand, and we did not know why. We still do not know why; and, of course, then the project lapsed, and we may never know why.

Arthur Schwartz

I would suggest that it might be the alternative air service available in San Jose.

W. Donald Goodrich

Much of this was taken into account in distributing the total air traffic in the Bay area among the 3 airports. We did a time lapse analysis in both 1968 and 1970 in allocating this total traffic. This research is reported in another paper. A simple approach was used to compare these actual data and, interestingly enough, it did come fairly close to reproducing what actually happened in that year.

Clark Henderson

What kind of values did you use?

W. Donald Goodrich

We did an income survey for 81 cities in 9 counties throughout the Bay area and developed a probability distribution on income, which we specified as having the characteristics of a log normal distribution. We had 91 distributions and, in fact, 783 points that were populated and accessible by road. The 91 distributions were spread over those 783 points. The distributions represented the income distributions of the total population of the Bay area. We wanted to know the income distributions of the air travelers, a subset of the total population, of course. Using some University of Michigan data, we arbitrarily factored the hourly income data (equal to annual income divided by 2,000) by a factor of 1.6. We used that as the distribution of the value of time, so that those having that value of time or greater represented the percentage of the air travelers from that mode who would select the high-priced but high-speed service. I cannot tell you the number from any mode because it depended on the relationship of the access time and cost by automobile and the access time and cost by the automobile and helicopter combination, as read on that distribution.

DIRECTIONS FOR FUTURE RESEARCH

Joseph H. Stafford

The question regarding where we are going in terms of type of demand work ought to be divided into 2 parts: Where are we going from here? and Where do I wish we were going from here? Where we are going from here is that Rodney Plourde and Eduardo Aldana are going to finish their theses, and I do not see anything else happening on the horizon. Where I would really like to go from here is to be able to get some more data of the sort we were able to get from Mansfield. These were very disaggregate kinds of data on choices people actually made for systems having attributes somewhat different from anything we have observed before. We could then begin to infer back from these data and gather new sets of information on willingness to pay to be in different environments and different activities by different people at different times of the day. I frankly do not see that happening soon.

Karl Guenther

In my point of view, the first thing that we would like to do is to continue to do what Joseph Stafford has suggested—providing more data to people who know how to use it. I might mention that we have a whole analysis department associated with our Transportation Research and Planning Office. I do not pretend to speak for what they are doing in transportation demand, but we do have 2 very capable people addressing the problem from a general point of view, that is, the new-mode problem, as earlier phrased.

Richard L. Gustafson

We also have our expert, but in our model we are developing attributes attaching an importance vector to these attributes, and moving from this line with an importance estimation model. This, of course, would be done for an abstract mode. Moving along those lines, we have been working with the mathematics department on some complicated problems with this. We have come up with a new method just recently, which is presented in another paper. We hope with this new technique that we may be able to program and come up with some reasonable and viable method of measuring abstract attributes and the importance of these attributes for estimating demand for an abstract mode or a third hypothetical transportation mode. This is the major work on demand models that we will be doing.

Kenneth W. Heathington

We start collecting data this month, and we are going to do a little modeling. We are at an advantage because many of the system attributes that other studies have found are not important. We have been able to eliminate and thereby reduce the costs involved in the demand modeling aspects. We are looking at levels of service and flexibility of pricing. Another project that we will begin later includes looking at more behavioral, very disaggregate models in terms of forecasting demand for specific trips or activities.

Daniel Brand

Just to counterbalance all the emphasis on data collection—experiments of our demonstrations of dial-a-bus—I think we need a theory of consumer behavior in the travel demand field. We need to develop hypotheses on the important variables that influence behavior from the standpoint of the trip-maker, the trip purpose, the characteristics of the trip itself, and the characteristics of the choices that are available to consumers, in this case the trip-makers when they make trips. We need to try to characterize the attributes in all these areas, form hypotheses as to these attributes, and collect the right kinds of data to test these hypotheses as opposed to perhaps congratulating ourselves, with all due respect, that we have dial-a-bus experiments going and that we are going to collect perhaps a limited subset of after data. We should be collecting the appropriate kinds of before-and-after data in line with the hypotheses. This is the scientific method. This is really the route that we should follow.

Raymond H. Ellis

I would like to second this. I know of only one fairly large-scale before-and-after study that has been undertaken in the country and that was the one for airport access when the rapid transit line was extended to Cleveland airport. Having that sort of information as a base does allow one to do things that one simply would not otherwise be able to do because of methodological problems.

Arthur Schwartz

I would like to bring us back down to scale with essentially William Howard's comment that it is cheaper to run the experiment than it is to run the survey. In this particular area of public transportation experimentation, unlike many that require substantial initial investment, the costs are relatively modest and the unrecoverable capital costs are even more modest. I would say that we are dealing here with an area where there

is a large incentive to risk experimentation rather than to spend all our efforts on pre-analysis.

William T. Howard

In spite of the fact that I did get a scattering of applause when I made a certain statement, I would not think it was unanimous by any means. I just wanted to assure people that we do not intend to continue with this shotgun approach. I am sure that a lot of the work that has been done in demand modeling will certainly be used.

Joseph H. Stafford

I would like to react briefly to the comment that it is a low-cost thing and that it makes sense to experiment rather than to take a great many surveys. In any one specific case, I quite agree with that. The additional information we gain from many surveys could not help us make a much better decision in that specific case. However, one of the real beauties of this kind of low-risk experimentation is that, if it is done correctly and we set up the hypotheses, as Danield Brand suggested, and test them carefully, we can gain a lot of information that will be very useful to us in high-risk things like automated guideways, dual modes, and moving platforms. That, I think, may be the much more crucial issue in terms of our surveys and our demand modeling efforts.

Kenneth W. Heathington

I think that most of us who are familiar with traditional modal-split analysis and things of this nature can look at what has been done and almost argue that any first-year student of numerical analysis can fit the data. That is no problem. All one has to do is to plug in some control cards and data that will fit and one can make it come in within 1 percent, if one really wants to fudge it. It looks like there is absolutely no causation or causality or anything to this effect in the methodological formulations. There is very little sound theory. We come in after the fact and we begin to build models and say this describes the phenomenon. Does it really? It does in one sense describe the phenomenon. However, to be able to use that to forecast what will happen in another situation is completely different, and I think we are foolishly risking our attempts by looking at the effects afterward. We need to look at them before, and we need to calibrate the models and look at them afterward. Otherwise, I do not really have much confidence in the methodology.