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THE DATA BASE FOR INTERCITY PASSENGER TRAVEL ANALYSIS: CURRENT STATE AND FUTURE PROSPECTS

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ABSTRACT

This paper discusses the need for improved techniques for the analysis and modelling of intercity passenger travel demand in order to provide an improved factual basis for policy decisions in this area. Improvement of these analysis techniques, however, depends fundamentally on the existence of a high-quality, comprehensive, disaggregated data base pertaining to intercity travel. The current state of Canadian intercity travel data is reviewed and found to be inadequate for this task. The paper then sketches a data collection program designed to remedy this situation.

INTRODUCTION

Intercity passenger transportation policy in this country is currently in a considerable state of flux, as witnessed by the continuing debate concerning future directions for intercity rail passenger services, concerns about the viability of the intercity bus industry in this country, recent initiatives with respect to airline deregulation, etc. Considerations of most, if not all, of these issues would be greatly assisted through the use of demand models which are capable of generating credible, policy-sensitive forecasts of origin-destination flows by mode for the range of economic scenarios and transportation policies under consideration. Unfortunately, such models are rarely available, particularly in cases in which the interaction between two or more modes is of interest. Several reasons exist for this state of affairs, including: intercity passenger travel demand simply has not been as well studied as the corresponding urban travel demand case; the complexity of intercity travel makes it very difficult to model successfully; and the work to date in the area has tended to be largely oriented towards improving methodological aspects of the models, rather than towards improving their behavioural content. These reasons, in turn, all devolve from a more fundamental obstacle: the very weak and limited data bases upon which work in this area has traditionally been based.

In any field of scientific research, credible, useful theories of system behaviour can only be achieved when suitable data concerning the system in question are available to test these theories against, to help the researcher learn about the system in question, and to provide the environment within which improved theories can evolve. Similarly, the translation of such theories into practical quantitative models of system behaviour requires considerable data for model estimation purposes. Finally, data are also required to use such models to forecast future system behaviour. Hence, data -- quantitative empirical information -- lie at the heart of the development and use of any sort of quantitative tool for systems analysis.

The intercity passenger transportation system is no different in this regard than any other system. The basic thesis of this paper, however, is that a suitable data base for the development of credible, policy-sensitive models of intercity passenger travel demand does not exist in this country (or, for that matter, anywhere in North America), that the development of such models is virtually an impossibility until such a data base does exist; and that intercity transportation policy decision-making has suffered and will continue to suffer from this lack of good demand analysis capabilities.

The next section of this paper presents a brief discussion of some of the key modelling issues which must be addressed if improved intercity passenger travel demand models are to be developed. From this discussion comes the identification in the third section of the paper of the desirable properties of a data base which would be capable of addressing these model development concerns. The paper's fourth section then critiques available Canadian data bases in light of these requirements, leading to a discussion in the fifth section of potential approaches towards obtaining an improved data base. The final section of the paper then summarizes the major points of the paper.

TOWARDS IMPROVED MODELS OF INTERCITY TRAVEL DEMAND

Recent reviews of the state-of-the-art of intercity passenger travel demand modelling have criticized this state-of-the-art on a number of grounds.[1,2] Much of this criticism stems from the spatially aggregate nature of conventional intercity travel demand models, which results in the introduction of significant aggregation biases into these models, as well as hinders the specification of sound behavioural relationships within the models. Thus, while important methodological advances concerning such topics as the statistical estimation of these models and the statistical testing of constraints on model functional form and parameter values have occured in recent years,[3,4] it would appear that the major obstacle to improved intercity demand models is not methodological, but rather behavioural, in nature. That is, a number of issues exist concerning our understanding of intercity travel behaviour which must be addressed, if improved models of this behaviour are to be developed.

One such issue relates to the identification of travel market segments. Market segmentation is typically done on the basis of trip purpose. It is almost universal within the literature to disaggregate intercity travel, at a minimum, into business and non-business trips and to calibrate separate models for these two trip types, in recognition of the considerably different processes involved in trip generation and modal choice for the two trip types. In other words, trip purpose is generally viewed as a critical variable in the definition of intercity travel markets.

It is interesting to note, however, that while separate models are typically calibrated for business and non-business trips, these models also typically differ only in their calibrated parameter values; that is they possess identical functional forms and identical sets of independent variables. This implies that the same decision structure and the same set of explanatory variables are equally valid for all trip purposes. A trip to visit relatives in Kingston, however, involves a considerably different decision process than a trip to camp in a provincial park or a trip to visit a client in Montreal, and it is not clear that the same set of explanatory variables and/or function forms are equally suitable to characterize these processes, even at the aggregate, correlative level typical of intercity demand models.

A second issue relates to the decision process which is assumed to characterize trip-making behaviour. There is much discussion in the literature of "direct" versus "multistage" demand models. A direct demand model is one in which a single equation "directly" predicts modal travel volumes by origin-destination (O-D) pair. A multistage model, on the other hand, uses two or more equations to arrive at this same result, typically by first predicting the total (all mode) travel volume for an O-D pair and then "splitting" this total volume among the competing modes. The decision processes consistent with these two model formulations are, respectively, a joint process in which the decision to travel to a particular destination and the mode to be used are simultaneously determined, and a sequential process in which the decision to travel to a particular destination is made first and the mode to be used is then determined, given the prior choice of destination.

Neither decision process can be rejected as being a priori unreasonable. Ideally, the analyst should test the relative merits of these two processes rather than assume one a priori. Such an approach, however, presupposes a model structure which, first, can differentiate between the two processes and, second, facilitate the statistical testing of the hypotheses representing these processes within the model. Such a capability does not exist within the current intercity demand modelling state-of-the-art, primarily because the distinction between current "direct" and "multistage" models is artificial in that the two are mathematically equivalent to one another (i.e., one is derivable from the other through a series of simple algebraic manipulations). Thus, current models cannot differentiate between the two decision processes.

A second difficulty with multistage models in general (i.e., urban as well as intercity models) is how to represent a multimodal transportation system at the first stage level, so that total O-D volumes can be predicted. That is, it is reasonable to expect that the ease of travel between two centres will influence the amount of interaction that will occur between them, but this is theoretically and practically difficult to do when mode splits are "unknown" (since destination is postulated to be chosen prior to mode). Conventional intercity demand modes typically handle this "trip induction" issue (i.e., the sensitivity of trip generation levels to transportation level of service) in very ad hoc ways, which are often found to not perform well in forecasting applications (e.g., they often significantly over-predict the amount of travel generated by a system improvement).

The only modelling method currently available which consistently addresses both of these issues (i.e., differentiation between joint and sequential choice processes and representation of modal service levels in the first stage of a sequential choice process) is disaggregate choice modelling. No truly disaggregate choice model has ever been developed for the intercity case, although the only practical reason why this is so concerns data availability. A description of disaggregate choice models is beyond the scope of this discussion, but a brief illustration of how such models might potentially be applied to the intercity case is presented in Rice, et al. (1981, Appendix D).[1]

Finally, a third issue relates to the variables chosen to include in the demand function. These variables obviously reflect assumptions concerning "causal" relationships within the system (or at least strong and stable correlations). Intercity demand models are very consistent in their choice of variables: frequency, time and cost are used to characterize modal service levels; and population, employment, income, etc. (as well as various "compatibility" variables such as "linguistic compatibility indices", etc.) are used to characterize the level of interaction between city pairs.

Perhaps the single biggest obstacle to improving the specification (and the measurement) of variables included in intercity demand models is caused by the extreme spatial aggregation of such models. "Catchment areas" for stations and terminals can be very large, and it is not uncommon for such catchment areas to constitute the zone system for the model. The difficulty in generating meaningful access times and costs under such circumstances is only the most obvious of the problems involved. A less obvious, but possibly more fundamental, result is that this extreme spatial aggregation makes it extremely difficult to think about "causal" factors and inter-relationships affecting inter-city interactions and their attendant travel flows. This, in turn, inevitably results in the use of only the most basic and correlative of factors (population, etc.) within the model. Finally, as has already been mentioned, adoption of such a spatially aggregate approach typically results in the introduction of significant "aggregation" biases in model parameter estimates and hence, ultimately, in model predictions.

In summary, key behavioural issues in intercity model building include:

1. obtaining a clear understanding of the travel markets which exist within the intercity transport system;
2. obtaining a clear understanding of the decision processes (factors and relationships) at work within each of these markets; and
3. working at a level of analysis that is sufficiently disaggregate to enable one to hypothesize and test "causal" factors and inter-relationships.

These issues all appear to point towards the need for a more disaggregate, behavioural approach to thinking about and modelling intercity travel demand, if improvements in the current state-of-the-art are to be achieved. They also clearly point to the need for a comprehensive, dissaggregate data set upon which to base the development of such models.

IMPLICATIONS FOR DATA REQUIREMENTS

Key attributes a data base which would be suitable for addressing issues such as the ones raised in the previous section include comprehensiveness, consistency, and spatial disaggregation. Each of these attributes is discussed in turn.

The data base should be comprehensive in several senses. It should cover the four major modes used in intercity travel: auto, air, bus and rail. It should cover the range of trip purposes involved in intercity travel: business, vacation, visit friends and relatives, etc. It should include a wide range of variables characterizing the trips made (by mode, purpose, origin, destination, duration, etc.), the service characteristics of both the chosen mode and other available but unchosen modes (travel times and costs, service frequencies, etc.), and the characteristics of the trip-makers (age, sex, income, occupation, etc.). Ideally, the data base should also include "attitudinal" information concerning trip-makers' perceptions, preferences, and decision processes.

One of the key points implicit in the items just listed is that trip data must be collected in terms of true origin-destination linkages. Much Canadian travel data, however, typically exists in the form of either link volume counts or ticket lifts. The former case provides little direct information about origin-destination movements, while the latter provides information about the origin and destination of the "trip link" represented by the ticket in question, but does not necessarily define the true origin and/or the true destination of the overall trip. In addition, neither case provides any opportunity to link observed trips with the characteristics of the trip-makers -- a necessary prerequisite for any attempt at explaining the observed travel behaviour in a systematic way.

The data should be consistent in that the data for each mode of travel should be collected using consistent methodology (e.g., essentially the same questionnaire is used in all cases, samples are selected in consistent ways, etc.) and consistent definition of terms and variables (e.g., trip purposes, socio-economic characteristics of the trip-makers, etc.). Ideally, the data for each mode should be collected simultaneously to ensure temporal consistency.

Finally, service characteristics should be defined and collected in a consistent fashion across modes.

"Spatial disaggregation" of the data set simply means that the basic unit of information is the individual trip, made by an individual trip-maker (as opposed to spatially aggregate data concerning flows of trips between cities or zones). A disaggregate approach is fundamental to the analysis of travel behaviour, since clearly it is at the level of the individual trip-maker which travel decisions are actually made and hence it is at this level that such decisions can best be analyzed. While this observation may not seem to imply particularly new needs in data or data collection techniques, since many data bases are constructed by surveying individual travellers, it does, in fact, mean that such surveys must be carefully designed to ensure that they are maximally useful in a disaggregate analysis -- something which is not true for existing data bases which were typically constructed for aggregate analysis purposes.

Ideally, this data base should be time-series in nature. In practical terms, this might mean a fairly large-scale cross-sectional data collection effort to initiate the data base, followed by periodic, smaller-scale "updates". One rarely has the opportunity to exploit time-series data in transportation analysis (intercity or urban), but the availability of such a time-series data base could immeasurably improve the overall utility of the data themselves and of the models which are ultimately derived from them. In particular, time-series data facilitate the identification of shifts in modal preferences over time, adjustment in modal choices in response to system changes, and so on, in ways which generally are simply not possible with cross-sectional data alone.

Finally, the spatial extent of the proposed intercity travel data base has not yet been discussed. "Intercity travel" can mean many different things to different people. To a national air carrier, for example, it may imply travel between all major and medium-sized urban areas in Canada (if not the world). To a provincial government, it may mean generalized regional travel between urban centres of all sizes. With respect to many current transportation policy issues, however, the appropriate spatial context is typically a relatively linear intercity travel corridor, defined in terms of a sequence of large and medium-sized cities (e.g., the Calgary-Edmonton travel corridor or the Windsor-Quebec City travel corridor). It is this last type of problem definition which is the focus of this paper, for three reasons. First, as mentioned, many of the most important current issues in intercity transportation (e.g., passenger rail options; the state of the intercity bus industry) are essentially "corridor issues" and can be best thought of and analyzed in those terms. Second, intercity corridor travel is the best studied of all types of intercity travel and hence constitutes an appropriate starting point for the development of improved models of intercity travel demand. And third, corridor travel is relatively well defined in terms of the modal networks involved and the data required for its analysis, and hence, again, constitutes the most fruitful starting point for any data collection and analysis effort.

CURRENT STATE OF CANADIAN INTERCITY TRAVEL DATA

Major data bases relating to intercity passenger travel in Canada have been documented and/or reviewed in a number of reports.[1,5,6,7,8,9,10,11,12] These data bases include:

1. 1969 CTC on-board survey of common carrier (air, bus, rail) passengers in the Windsor - Quebec City corridor.[5,12]

2. 1976 Transport Canada intercity travel data base.[11]

3. 1976 Southern Ontario Multimodal Passenger Studies (SOMPS) data base.[6,11]

4. 1977-1980 Canadian Travel Survey, conducted by Statistics Canada as a supplement to their Labour Force Survey.[7,8,9,10,12]

The second and third of these data bases were both constructed from a variety of sources and do not contain detailed data concerning individual trips or trip-makers. Hence, while they have proved suitable as a basis for the development of conventional aggregate models of intercity travel demand, they simply are not suitable for the sort of detailed disaggregate analyses which are required for significant model improvements to be obtained. This leaves the 1969 CTC common carrier survey and the 1977-1980 Canadian Travel Survey as the most promising of the existing data sets for future analysis and modelling efforts.

The CTC data are attractive because they contain detailed, consistent data concerning trip-making behaviour in the Windsor-Quebec City corridor for the air, bus and rail modes. At the same time, however, the data base is seriously deficient for current purposes due to its age, its lack of information on the automobile mode, its lack of information concerning non-travellers, and its restriction to a relatively few (albeit major) links within the corridor.[12]

The attractive features of the Canadian Travel Survey, on the other hand, are that it was a home-based survey (as opposed to the "on-board" nature of the CTC survey) and hence able to collect information about trips by all modes, as well as information about the rate at which households make intercity trips (including the observation of households which made no intercity trips during a given time period), and it is a time-series national data base. Its major limitations with respect to disaggregate analyses are a lack of some key socio-economic variables (e.g., income levels of households not making intercity trips during the observation period), difficulties in the way personal, household and trip information are coded, and the relatively gross spatial scale at which trips are recorded.[10,12]

The general conclusion to be drawn from this brief review, therefore, is that no one data base, or combination of data bases, is suitable for the type of detailed analysis and modelling work described in this paper. This is not to say, of course, that the data sets listed above have not proved to be of value in past analyses or that they may not still prove to be of value in particular applications. But the fact remains that suitable modelling capabilities have not been developed to date based upon these data, and it is very unlikely that such capabilities could ever be developed with these data as the starting point. Thus, it would seem that significant improvements in our intercity travel demand analysis capabilities must await the development of a new, detailed, appropriately designed data base.

ELEMENTS OF A DATA COLLECTION PROGRAM

From the foregoing discussion, a general picture of intercity travel analysis data requirements has emerged, in terms of the need for a comprehensive, consistent, disaggregate data base (ideally time-series in nature). Given that such a data base does not exist, it appears that a relatively major new data collection effort would be required if such a data base is to be established. The detailed design of such a data collection effort is well beyond the scope of this paper. Nevertheless, it is possible to identify at least some of the major elements which are likely to be involved in such an undertaking.

The first such observation is that the data collection effort should probably focus its initial efforts on a single, well-defined major intercity travel corridor. The Calgary-Edmonton corridor is a strong candidate for these initial investigations due to its simple network structure, as well as due to the strong competition which exists between the various modes operating within the corridor.

Second, the data collection effort itself might well consist of a coordinated set of surveys, of both an on-board and a home-interview nature. On-board surveys are by far the most efficient means of obtaining sufficient numbers of observations for statistical analysis of common carrier (air, bus, rail) travellers. These surveys, however, should be supplemented with home-interview surveys (probably of a mail-back variety) conducted in the urban centres contained within the study corridor, in order to obtain information about intercity trip rates, household decision-making, etc. In addition, detailed information about auto travellers in the corridor might best be collected through a license plate survey of vehicles on major corridor highways, combined with a mail-back survey of the owners of the vehicles observed.

Third, these surveys (in whatever form they finally take) should be developed in an entirely consistent way with one another, should be designed with anticipated disaggregated analysis needs specifically in mind, and, ideally, should be administered simultaneously (or as simultaneously as is practically possible) so as to maximize their compatibility.

Fourth, a detailed survey of modal service characteristics and link volume flows should be undertaken at the same time as the travel behaviour surveys. The first type of data is, of course, of fundamental importance to the analysis of travel behaviour; while the second is required to ensure that the sample data from the travel surveys can be weighted appropriately to yield unbiased population totals.

Fifth, while the importance of time-series data has been stressed throughout this paper, there is no need to leap immediately into an ambitious time-series data collection program. A staged approach is definitely preferrable, in which a good cross-sectional data base is obtained for a single corridor and exhaustively analyzed. Based on the experience gained from this "first pass", a cross-sectional survey and analysis of a second major intercity travel corridor may well be the most productive second step. Once both corridors have been studied in detail, then the design and implementation of an efficient, on-going time-series data collection program should be possible.

Finally, the combination of modern survey techniques[13] and the inherent efficiency of disaggregate analysis techniques in their use of data[14] imply that high-quality, reliable surveys of intercity travellers can without question be successfully and cost-effectively constructed. In particular, properly designed and executed mail-back surveys can achieve very high response rates, while significantly reducing the cost associated with home interview surveys. At the same time, a disaggregate analysis approach implies the capability of performing unbiased, efficient statistical analyses based on smaller sample sizes than are required for conventional aggregate analyses.

SUMMARY

Effective intercity passenger transportation policy analysis depends in no small measure upon the ability to produce credible forecasts of intercity origin-destination flows by mode as a function of alternative policy options. Current intercity passenger demand modelling capabilities have generally proven to be inadequate to this task, thus rendering decision-making in this area a more difficult and uncertain undertaking.

Improvement in the intercity demand modelling state-of-the-art appears to depend in a very fundamental way on first improving the "factual base" upon which we construct our analyses and build our models. Existing data are simply inadequate to the task at hand, particularly given the need to adopt a more explicitly behavioural, disaggregate approach to intercity travel. Such an approach does, indeed, seem to be required in order to achieve better insights into intercity travel patterns, which, in turn, will presumably lead to improved model and variable specifications.

There does not appear to be any major limitation to the collection of a high-quality data base suitable for the proposed research and development work, aside, of course from the questions of institutional commitment to the project (on the part of provincial and federal govenrments, as well as the common carriers involved) and of project funding. In particular, an appropriate mix of on-board and home-interview surveys, employing state-of-the-art survey and questionnaire design principles can undoubtedly be designed to provide a cost-effective, high-quality data collection program.

Finally, the cost-effectiveness of this proposed data collection effort would appear to be very high, despite the fact that it could ultimately cost hundreds of thousands of dollars. VIA subsidies amount to hundreds of millions of dollars annually. The Canadian intercity bus industry has revenues and costs of hundreds of millions of dollars annually. Some Windsor - Quebec City corridor rail options which have been suggested could cost billions of dollars to implement. Presumably the expenditure of less than a tenth of one percent of these sums of money to improve significantly decision-making capabilities concerning these vast sums is a price well worth paying.

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