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THE USE OF MULTINOMIAL LOGIT ANALYSIS TO MODEL THE CHOICE OF TIME TO TRAVEL*

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Ever scarcer public investment capital and the need for greater energy conservation have combined in recent years to force a reconsideration of traditional approaches to the problem of peak-period congestion in medium to large sized cities. Increasingly, the emphasis is shifting away from the construction of new transportation infrastructure and vehicles toward more efficient use of existing facilities, with particular attention being paid to policies designed to spread peak-period travel demand more evenly throughout the day. In this context the individual's choice of time to travel to and from work is of crucial significance: it is also probably the least understood travel decision. This paper investigates the use of multinomial logit analysis to model the time of day choice, using data collected in Hamilton, Ontario during the summer of 1977. The exercise highlights the difficulties involved in using the logit model both as a descriptive and predictive tool, as well as indicating the need for further research into the determinents of the time of day decision. A preliminary finding is that journey time is not a significant factor in the individual's choice of time to travel.

During "rush hours" in most urban areas, transportation facilities are overcrowded, congested, and usually operating less efficiently than at other times of day. Until recently, most efforts to alleviate this congestion have relied on new construction, that is, on creating additional transportation capacity to serve the obvious demand. In order to identify the appropriate size of facility to build, forecasts of future travel demand are required. Geographers and others have been quite active in developing and improving travel demand forecasting models, especially those to predict the spatial pattern of demand and the share of demand for each transportation mode. The temporal pattern of demand (over a single day) has been largely ignored, perhaps because rush hour (peak period) travel in most areas consists mainly of journeys to or from work, the timing of which is largely non-discretionary.

In the last few years, however, providing additional capacity has not always been seen as a good solution for a number of reasons: local opposition to specific proposals; increasing construction costs combined with tighter budgets; and heightened-awareness of the uncertainties associated with long-term forecasts of spatial patterns of travel behavior. In this setting, other approaches to alleviating peak period congestion have been gaining favor. The one which concerns us in this paper is the attempt to spread work trip demand over a longer period of the

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day thereby reducing the size of the peak demand and making more extensive use of existing facilities. As a necessary precursor to the successful implementation of policies designed to this end, we focus on the individual's choice of time to travel home from work and the use of the multinomial logit model to both describe and predict travellers' behavior with respect to this choice. First, the causative structure of the time of day decision is examined by identifying the combination of variables which gives the best explanation of individual choice in a logit model formulation; then the transferability of the calibrated model is tested by estimating a second model, containing the same explanatory variables, on data collected after a change in the transportation system had caused congestion and travel times to increase such that time of day choice could be expected to be different.

The paper begins with a review of some of the key concepts and a discussion of the assumptions and specifications which need to be made in order to use the logit model. The data on which the study is based were collected in Hamilton, Ontario, in what is perhaps a unique situation, as described in the second section. The third section reports on the results of the analysis, and the final section contains the conclusions stemming from this initial exploration of the choice of time to travel.

CONCEPTUAL FRAMEWORK

Capacity of a roadway is defined as the "maximum number of vehicles that have a reasonable expectation of passing over a given roadway in a given time period under the prevailing roadway and traffic conditions" [5, p. 5]. Transit system capacity can be defined analogously, in terms of people. As the number of vehicles (or people) wishing to use a transportation facility approaches the capacity of the facility, travel delays result. During morning and afternoon "rush" hours, most urban areas experience a considerable peaking of travel demand for some period of time, during which the capacity of the transportation system is approached or exceeded. Depending on the size and spatial structure of the urban area, this peak period will vary from as little as 15 minutes to as much as two hours or more.

The standard transportation engineering response to the problem of peak-period congestion (and to the considerable public reaction which almost always accompanies congested travel conditions) has been to attempt to increase capacity, either through operational improvements (one-way street systems, parking restrictions, etc.) or through new construction. This standard approach accepts the magnitude of travel demand as given, which is reasonable, since in most cities the majority of peak period travel consists of non-discretionary work trips. This approach also accepts the timing of travel demand as given, which is not so reasonable. As early as fifty years ago, some large cities recognized that the timing of travel demand need not be taken as given, and, for work trips in particular, it could be altered [8, p. 70]. During World War II, many cities introduced plans to stagger work hours, but most of these subsequently reverted to pre-war work hours. Within the last decade there has been renewed interest in ways to alter the timing of peak period travel demand, an interest which has perhaps arisen because of the rapidly escalating costs of new facilities construction and the increasing difficulties in finding acceptable locations for them. Whatever the reason, non-construction solutions, and non-engineering solutions, are receiving increasing attention from transportation professionals. Staggered hours and flexible hours have been identified as two methods by which to alter the timing of demand.

Staggered hours programs involve "shifting fixed, standard, 5-day work schedules to earlier or later time periods without changing the length of the workday. Employees must still be at work by a specified time and leave at a specified time" [8, p. 68]. There is, therefore, no element of traveller choice involved in such a program. The only behavior to be modelled to predict the results of a staggered hours program is the behavior of the decision maker in each firm who approves the change to a revised work schedule. This has usually been treated as a marketing problem by transportation professionals [7, pp. 180, 182], and is probably best left as such.

Flexible hours programs, on the other hand, allow each employee some freedom in determining work schedules in that "employees are permitted to set their own daily starting and quitting times within pre-established limits" [8, p. 69], as long as they work the required total weekly hours. Such a program offers much greater scope for altering the daily pattern of travel demand since the final travel decision rests with the individual employee. If travellers make sufficient use of flexible schedules, work trip demand may be spread over a long enough time period to reduce peak demand significantly with the immediate benefit of increased efficiency in vehicle use. In the long-term, the change in the pattern of demand may reduce the need to invest increasingly scarce public funds in new facilities. Flexible hours programs thus appear to have considerable potential as a transportation policy in an increasingly fiscally and energy conservative era.[1]

A flexible work hours program is, however, difficult to implement for all employees in a city. Moreover, because of the element of individual choice which it incorporates, there can be no guarantee that it will induce sufficient spreading of demand to justify its implementation in all instances. In many cases, therefore, it would be useful to be able to predict the consequences of such a program for travel demand before investing in it. Modelling the choice of time of day to travel is a necessary precursor to an effective use of a flexible hours policy since it is essential in order to gain an understanding of the determinants of time of day choice and to be able to predict travellers' behavior with respect to this choice.

Given that a model of the choice of time of day to travel may have practical significance, what form of model should be tried? The simplest approach is to consider travel by periods (e.g., peak or off-peak) rather than by actual clock time. With this formulation, the dependent variable is represented by discrete, mutually exclusive choices, and previous work in disaggregate behavioral travel demand modelling can be brought to bear.

This is the approach followed in this paper, using the multinomial logit model for individual choice behavior. Given a situation in which a traveller faces a set of discrete, mutually exclusive choices (such as mode of transportation or time of day to travel), the probability that a particular individual will select alternative i is given as:

$$P_i = \frac{exp(\sum_k \beta_k X_{ki})}{\sum_j exp(\sum_k \beta_k X_{kj})} = \frac{1}{1 + \sum_{\substack{j \\ j \neq i}} exp(\sum_k \beta_k (X_{kj} - X_{ki}))} \qquad (1)$$

where: P_i = probability that alternative i is selected;

X_{ki} = attribute k of alternative i; and

β_k = the k_{th} parameter of the model.

This model has been derived from both

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[1] It would appear, from a recent study of 500 personnel administrators in the U.S., that most firms which have adopted a flexible hours program are pleased with the results. One conclusion of that study is "that the use of rearranged workweeks is increasing generally, and that the trend is away from compressed workweeks and toward flexible systems" [4, p. 41].

microeconomic utility theory and Luce's axiomatic choice theory and is founded upon a number of assumptions about the nature of choice, the form of individual utility functions, and the statistical distribution of the error term in measuring utilities. Probably the most concise yet thorough treatment is that by Domencich and McFadden [*3*].

An important consideration in any attempt to model travel choice is one regarding the sequence in which travel related choices are made. In general, the fundamental travel choices are those of trip origin, destination, mode, time of day, and frequency. For work trips, which are the only trips we are considering, it is reasonable to assume that the trip origin, frequency, and destination are fixed. This leaves, in addition to time of day choice, only mode choice to be considered; and the only question of sequence then is whether the commuter chooses the mode first, and then the time to travel, or vice versa, or both simultaneously. Under the assumption of a simultaneous decision, individuals are regarded as choosing among alternatives such as, say, travelling by bus in the peak and travelling by car in the off-peak. Arguments have been advanced elsewhere concerning the implausibility of such a decision process [*2*] while available empirical evidence suggests that models based on an assumption of a sequential decision process fit data better than so-called "simultaneous" models [*1*]. For this reason the simultaneous decision structure will not be considered further. Of the two sequential or separable decision structures the easier to deal with is that in which mode choice precedes time of day choice; in this case the appropriate values to use to describe the transportation system for a particular time of day alternative are those of the chosen mode at that time of day. On the other hand, if the choice of time to travel is made prior to the mode choice, then the theory of sequential choice modelling requires that attributes of all the modes available, weighted by their respective mode choice model coefficients, be included in the time of day model in order to specify fully the utility of a particular time of day to travel [*3*, p. 43]. An analysis based upon the latter decision structure requires, therefore, the estimation of a mode choice model before time of day choice can be considered.

In order to throw some light on the question of decision sequence, a number of mode choice models were calibrated. The results from these estimations indicated that most (68%) of the variation in mode choice could be explained simply by whether or not the individual possessed a driver's license: travel time and cost contributed relatively little explanation. This finding is not due to the presence of non-licensed captive transit riders in the sample since all individuals reported the availability of both car and bus. Instead, the result reflects the fact that almost all of those who had a license chose auto. These data, then, seem to indicate that mode choice may be largely predetermined by such things as the possession of a driver's license or, more probably, auto ownership. To the extent that this is true, mode choice is not so much a short-term frequently made travel decision but rather an infrequent, long-term phenomenon which is reflected in decisions such as those to get a driver's license or buy a car. Consequently, it is much more likely that the time of day choice is made conditional upon a fixed preceding mode choice rather than vice versa. For this reason the present analysis is based on the assumption of a mode-time choice sequence.

DATA COLLECTION

An unusual and perhaps unique opportunity to develop and test a model of the choice of time to travel was provided in Hamilton, Ontario, during the summer of 1977. As a result of a set of relatively severe geographical barriers, the western exits from the central business district are very limited, consisting primarily of 4 lanes on King Street (one-way westbound) and 2 lanes on Aberdeen-Longwood, with roundabout secondary routes along York Boulevard or Mohawk Road (Figure 1). Three lanes of King Street were closed from June 27 until October 25 for sewer and road reconstruction. This severe capacity reduction was expected to cause traffic conditions equivalent to a doubling in demand for the corridor, which otherwise was not anticipated until 10 to 15 years into the future. The research design for this paper entails using data collected before the lane reduction to calibrate a model of time of day choice for trips home from work, and then testing the stability (or transferability) of this model by recalibrating it on data collected during the closure. By comparing variable coefficients across the two models we can learn something not only about the determinants of time of day choice but also about the predictability of changes in the timing of travel demand which might be expected to result from the introduction of flexible hours programs.

With the financial support of the Transportation Development Agency of Transport Canada, we were able to carry out a coordinated data collection effort surrounding the partial closure of King Street, including home interview surveys of the usual travel diary variety, traffic volume, occupancy, and classification counts, and travel speed and delay studies. These data were collected both before and during the closure.

For the home interview surveys, the same households were interviewed at the different stages of the project, since the focus was on changes in travel behavior. The number of interviews completed in the first survey represents, therefore, the maximum sample size for the other phases of the project. The population of interest consisted of those households most likely to use the affected corridor during the afternoon peak, namely all those in West Hamilton, Dundas, Ancaster, and western Wentworth County. A clustered random sample was drawn from those households.[2] In addition, to improve the likelihood of interviewing people actually affected by the work on King Street, a license plate survey was used to identify households using King Street during peak periods before the closure. Also, people were interviewed at bus stops (to be followed up at home in subsequent phases). To meet confidentiality requirements, households selected randomly and those selected through the license plate survey were treated identically in subsequent interviewing, although it is possible to separate responses for the two groups for statistical purposes during analysis.

During the first phase (prior to closure) 520 households were interviewed. Unfortunately, because of difficulties in following-up individuals during mid-summer, the second data collection includes interviews from only 200 households, in addition to the traffic counts and speed and delay studies. Both of these figures represent upper limits on the numbers of cases with usable information. As we shall see later, the actual sample sizes used for model calibrations were considerably smaller for both surveys.

ANALYSIS

The first step in applying the logit model to time of day choice is to identify the time periods which constitute the choice alternatives. They are not quite so obvious as, say, modal alternatives, and accordingly a number of different time of day categorizations were tested. The first of these was based upon the standard notion of peak and off-peak and resulted in two alternatives only. In Hamilton, the peak is usually defined as 4:30–5:30 p.m.,

[2] Boundaries for the study area were determined primarily on the basis of the known commuter-shed for Hamilton's employment areas. Only those subareas likely to use the affected transportation corridor were included. Thus the sample is not a random sample of the urban area population. (In particular, socioeconomic status for the study area is in general higher than the Hamilton average.) Estimated parameter values are therefore probably not applicable to the population in general. This limitation does not of course affect the present longitudinal analysis.

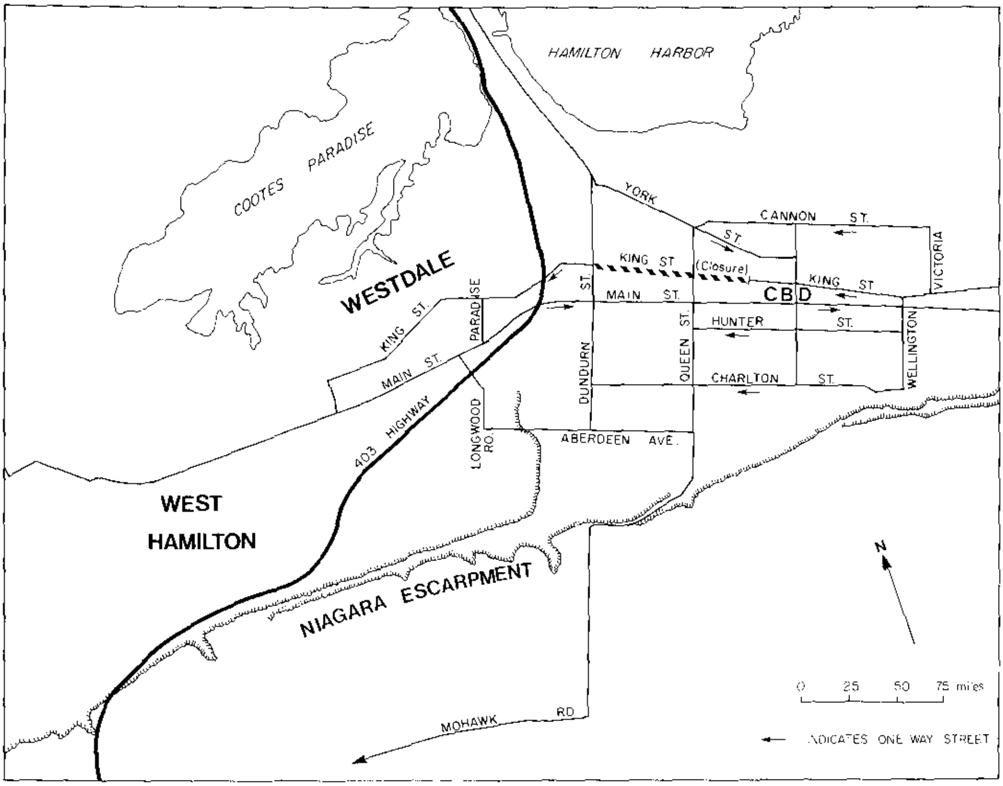

Fig. 1. Routes Selected for Travel Time Collection in Hamilton.

and that definition was used here initially. The second categorization decomposed off-peak into pre-peak (3:45–4:30) and post-peak (5:30–6:15), on the intuitively plausible grounds that workers do not perceive the utility of post-peak travel as being identical to pre-peak travel, even though the travel characteristics of the two may be the same. The third and final categorization tested drew upon traffic volume counts made before closure and was based on identification of periods of relatively homogeneous traffic volumes and travel times. Three such periods were identified and were labelled as peak (4:30–5:15), shoulder (4:00–4:30 and 5:15–5:30), and off-peak (3:45–4:00 and 5:30–6:15). Models using each of the three categorizations of time to travel were calibrated on the first survey data set and results indicated that the pre-peak/peak/post-peak scheme gave the most predictable description of time to travel. It would appear that the simple chronological element which the other two classifications fail to incorporate is an important one; accordingly, all subsequent model estimations are based upon this definition of alternatives.

There are, unfortunately, only a narrow range of variables available for analysis, in large part a reflection of the paucity of existing knowledge of the determinants of time of day choice. The variables included in the analysis (Table 1) are those for which plausible hypotheses could be identified relating to time of day choice.

The first variable considered is flexibility in the time to leave work, which was used not as an explanatory variable but to define the sample for model estimations. All workers who indicated that they did not have a choice of time to leave work were deleted. Although this stratification resulted in a considerable diminution of sample size, it is a sine qua non condition for the analysis since it is meaningless to consider non-choice travellers in a choice-based model of behavior.

Even among travellers who do have a choice of time to leave work there are likely to be varying degrees of flexibility. The variable "MODE" is based on the hypothesis that auto drivers have a greater amount of freedom in choosing a time to start home than bus riders. In addition, it was hypothesized that the greater the number of work trips per week ("NWT"), the greater the probability of a trip maker having evolved a more rational travel pattern. Specifically, it was felt that more frequent travellers would make a greater effort to avoid peak-period congestion. The number of pre-school children was used to give some indication of domestic constraints on travel behavior, while the combined annual income of the household was used as a surrogate for occupational status to test a hypothesis that higher status workers have greater freedom in choosing when to leave work.

TABLE 1

INDEPENDENT VARIABLES FOR THE TIME OF DAY MODEL

VARIABLE NAME	DESCRIPTION
FLEX	A dummy variable with values: 1 if the worker can choose when to leave work 0 otherwise
MODE	Assumes values: 1 if auto is the chosen mode 0 otherwise
NWT	The number of work trips per week
NKIDS	Number of children aged 5 years or younger in the household
INCOME	Combined annual income of household
TT	Travel time at each alternative time of day

Travel time is the only generic variable tested, i.e., the only one which has values specific to *each* alternative time of day: to enter the model all other variables have to be made specific to *one* of the alternatives. Two specifications of the travel time variable were tested. The first of these consisted simply of the total (one-way) journey time for the chosen mode and route at each alternative time of day. Since the structure of the model implies that the choice process is based on a comparison of the values of each attribute across the alternatives (only the differences matter in (1)), this specification implies that, ceteris paribus, an individual gains as much utility from a saving of 5 minutes on a 30-minute trip as from a similar saving on a 10-minute trip. The second specification takes into account the intuitive difference between those two situations by using as the values of the travel time variable the ratio of journey time at each time of day to the journey time at the chosen time of day. Preliminary analysis indicated that the latter definition of travel time performed better in explaining choice; consequently, this is the version used in all the estimations reported here.

The first part of the analysis, conducted to determine which combination of the independent variables gives the best explanation of the time of day choice, calibrated a series of models on the first survey data set. The best model obtained (Table 2) contains only two explanatory variables—travel time and income—in addition to a peak-specific constant.[3] The signs of the coefficients of these variables are all as expected and indicate that the greater the travel time at a particular period of the day the lower the probability of an individual travelling in that period. The positive value of the peak-specific constant indicates a bias toward travelling in the peak, while the coefficient on income bears out the hypothesized effect of this variable. Specifically, the result indicates that workers from households with an annual income in

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[3] One interpretation of an alternative-specific constant such as this is to view it as a way of including within the model the effects of variables for which data were not available but which are nonetheless important determinants of the time of day choice.

excess of \$20,000 (valued at 1977 prices) are, ceteris paribus, more likely to travel pre-peak than others. However, only the coefficient of the peak constant is significantly different from zero at conventionally accepted levels of significance, and the overall fit of the model is low, as indexed by a ρ^2 of 0.25. Looking at the t-statistics, it would appear that most of what explanatory power there is in the model is contributed by the peak constant. To some extent, the magnitude and significance of the constant are to be expected, given the special nature of the time of day choice. This arises from the fact that whereas in any city peak travel times can be expected to be larger than off-peak times, most individuals, by definition of the peak, choose these longer travel times. The implication for the modelling effort is that before we can get a negative and significant coefficient on travel time, we first have to explain these peak choices. Unfortunately, the other variables in the analysis failed to provide this explanation so that a constant had to be used instead to account for the peak bias.

TABLE 2

COEFFICIENTS AND STATISTICS FROM BEST TIME OF DAY CHOICE MODEL FOR FIRST SURVEY DATA SET

VARIABLE	COEFFICIENT	t-STATISTIC
TT	-1.05	0.50
PEAK CONSTANT	1.86	3.60
INCOME (Pre-peak specific)	0.66	1.39
ρ^2	0.25	
χ^2	46.99	

Sample Size 86

On a more substantive level, the poor performance (non-significance) of travel time, in conjunction with the strong peak constant, raises some doubt as to the efficiency of flexible hours programs. The immediate implication of the present results is that the implementation of such programs may not achieve the desired goal of spreading demand for transportation facilities over longer time periods. Clearly, there is a strong bias towards apparently irrational peak-hour travel which economic considerations alone fail to explain. It is not clear at this point what the variables are which cause this pattern of behavior, but it is likely that they derive from fairly deep-rooted social and/or institutional forces. In this respect the performance of income is notable and suggests that flexible work schedules may be more successful if aimed at certain population sub-groups rather than others.

However, caution is necessary in evaluating these results in view of the small sample size. With so few observations it is not possible to state categorically whether the present finding accurately reflects the role of travel time in the choice of time to travel, or whether the result is due simply to peculiarities of the present data set. In this respect it is worth noting that travel time differences between the various times of day were quite small, covering a range of from 1 to 8 minutes on journeys for which the reported travel times range from 10 to 30 minutes. The poor performance of this variable may therefore be due simply to the fact that the differences between alternative times of day (expressed as a ratio of actual travel time) may have been too small to include anything other than purely random choice behavior. People may be very sensitive to travel time differences once they exceed, say, 10 minutes, but be substantially indifferent among alternatives differentiated by lower stimulus levels. Clearly, confirmation of the ideas suggested above awaits analysis based upon larger data sets which cover a greater range of variation in the explanatory variables.

The pattern of travel time changes brought about by the King Street closure is a complex one. Travel times increased on most routes. In some cases the time for the journey from the CBD to the 403 Expressway tripled. On some routes the major increase in travel times occurred during the peak-period; in other cases, however, off-peak times increased more sharply leading to more uniform travel times and smaller time of day variations.

Whatever the direction of the changes, the pattern of peak/off-peak travel time differentials changed, in some cases quite drastically, on all routes.

Given the change in the stimuli facing individuals, two different types of adaptation are possible. First, individuals may change their *behavior* in response to the changes in the attributes of the alternatives and in accordance with their preferences for those attributes as revealed by the logit model coefficients: in this case the model will continue to describe preferences accurately after the closure. This is the response which is assumed in any attempt to use models such as that calibrated here to predict the results of system changes. Alternatively, the individuals may alter their *preferences* and either maintain their behavior patterns or change them in some direction other than that predicted by the model. Of the latter two courses of action, the first (unchanged behavior) is more likely and has a strong psychological basis in learning-theoretic ideas, such as that of habitual behavior. Clearly, if adaptation of this type occurs, then predictions from logit and other models of individual choice will be useless.

The second part of the analysis is designed to test the stability of the logit model calibrated on the first survey data set, so as to explore the nature of the changes, cognitive or behavioral, caused by the road closure. For purposes of comparison, the model calibrated on the second survey data set was constrained to contain the same explanatory variables as that derived for the first data set. The estimation results (Table 3) indicate that although the coefficients again have the intuitively "correct" sign, only the peak constant is significant, and the overall fit to the calibration data set is very poor. The coefficient of travel time and its associated t-statistic are larger in absolute magnitude, indicating more rational behavior with respect to this variable. There is also less of a tendency to travel during the peak, while the income effect on choice of time to travel is weaker. Assuming that the coefficient estimates are independently distributed in the sub-populations for the two surveys, we can calculate t-statistics to measure the significance of these differences in model coefficients. The results (Table 4) indicate that none of the observed differences is significant. Ostensibly, therefore, the stability of the logit model of time of day choice is confirmed, and the evidence of the present study is that individuals' revealed preferences for attributes of the alternatives remains unchanged. However, given that none of the four coefficients of interest (those of income and travel time in the two models) are significantly different from zero, and in view of the small sample size upon which both estimations are based, it is probably wiser to withhold judgement. Under the circumstances the best conclusion is probably to state that any *instability* of the model coefficients remains unproven.

TABLE 3

COEFFICIENTS AND STATISTICS FOR SECOND SURVEY DATA SET

VARIABLE		COEFFICIENT	t-STATISTIC
TT		-1.66	1.20
PEAK CONSTANT		1.25	3.72
INCOME		0.15	0.25
ρ^2	0.12		
χ^2	17.15		

Sample Size 64

TABLE 4

STATISTICS FOR DIFFERENCES IN MODEL PARAMETERS BETWEEN FIRST AND SECOND SURVEYS

VARIABLE	t-STATISTIC
TT	0.24
PEAK CONSTANT	1.00
INCOME (Pre-peak specific)	0.67

CONCLUSIONS

This paper has documented an initial attempt to model the choice of time to travel and to assess (indirectly) the predictability of changes in this choice.

Whereas the results pertaining to the tests of parameter stability are encouraging, these are overshadowed, if not called into doubt, by the failure to derive a model of the time of day choice offering satisfactory explanatory power. Though disappointing, this failure does provide some insights into the nature of the problems involved in successfully modelling this particular travel choice.

First, and perhaps most obviously, the multinomial logit model may not be the best modelling technique for this situation because of the ambiguities inherent in the specification of discrete alternatives. Retaining time of day as a continuous variable might prove more satisfactory. In particular, it may be possible to use a linear regression model to predict the time chosen, in minutes from the peak. This would circumvent the problems involved in using a categorized dependent variable and still provide the researcher with the flexibility of being able to aggregate the individual data to obtain demand estimates for whatever time periods are of interest—without having to specify these periods beforehand. The major difficulty with the regression approach is the need to be able to specify travel times as a function of time of day, continuously. It is the difficulty (impracticality) of this task which led us to identify discrete time periods, and to use the logit model, and which we feel still makes the logit approach the most practicable method of analysis. It is unlikely that the lack of explanatory power is due solely, or even largely, to the use of this particular modelling technique.

A more probable explanation of the poor results concerns the data available for model calibration. It is likely that the failure to calibrate a reasonably good model of time of day choice is due in part to the fact that the differences in the characteristics of travel at each time of day were too small to produce non-random behavior. This difficulty is not due to sampling problems, nor is it a peculiarity of the present data set. The problem will arise in any situation where it is required to predict the results of a change (perhaps drastic) in the attributes of a particular alternative, when existing conditions show little variation across alternatives. In such situations the only solution may ultimately be to conduct laboratory-type tests in which individuals are confronted with hypothetical rather than actual situations and which allow the researcher to control the levels of important variables [*2*; *6*].

Finally, the present results indicate that travel time and socioeconomic variables do not appear to be significantly related to the choice of time to travel. This finding persists through the two data sets collected before and after a major change in the transportation system had affected the characteristics of travel at each time of day. One of the more surprising findings is that even among individuals who reported having a choice of time to leave work, there is a strong bias towards travelling in the peak, as indexed by the magnitude and significance of the peak-specific constant. This suggests that the familiar peaking of traffic volumes in rush hours is not simply a function of fixed work schedules but is perhaps due to other less obvious constraints on the choice of time to travel. For example, the time of day decision is obviously only one of a number of decisions to be made, daily, about the sequence of activities, and one which quite possibly may be subject to other more important decisions. In turn, activity-sequencing decisions are likely to be subject to constraints imposed by the individual's life style or stage in the life cycle.

In conclusion, we would suggest that further attempts to model the choice of time to travel need to move away from attempts to explain this choice in purely "economic" terms, and to look more closely at the constraints on the timing of demand. The evidence of the present study is that flexible hours programs which consider only work schedule constraints on the time of day choice may not significantly alter the temporal pattern of travel demand.

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