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FINAL REPORT

DESTINATION CHOICE MODELLING AND THE DISAGGREGATE ANALYSIS OF URBAN TRAVEL BEHAVIOR

by

Joseph A. Ansah
Graduate Fellow

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16. Abstract

This research postulates a destination choice methodology that can be incorporated in an operational set of models of urban travel behavior. The model formulation presented has provision for making aggregate forecasts of types of travel behavior that the current quality of data can allow.

The belief that disaggregate models developed with traditional sampling designs require smaller samples is not theoretically supported. It is argued that separate sampling, (analogous to stratified sampling) be used to achieve such savings in sample size.

The multinomial logit model was found to be impractical and of low predictive power in modelling the choice of specific shopping destinations.

A multinomial response relation model that is proposed indicated that it is more pragmatic, given current data quality, to predict types of shopping destination choice behavior. Additional market segmentation was found to be worthwhile in model development. There was the indication that only a few attitudinal factors were necessary. Empirical investigations with the methodology yielded encouraging results.

The extension of destination choice modelling as a logistic discrimination problem is also discussed.

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Introduction and Problem Statement

This research develops an operational framework for modelling types of shopping destination choice in home-based shopping travel by automobile. The question of how one can achieve data collection savings in prediction model development without sacrificing the statistical soundness of the models is theoretically discussed.

There has been much criticism of traditional aggregate trip distribution techniques, like the gravity and opportunity models, which are considered to be too gross and insensitive to factors that influence the destination choice behavior of different groups of people. A disaggregate method (the multinomial logit model) that attempts to predict the choice of zonal shopping destinations by individuals has been postulated in recent travel behavior literature. The disaggregate model is so general in its formulation (with respect to the specification of alternative destinations for individuals) that it is not operationally and analytically feasible to obtain aggregate forecasts of destination choices. Its predictive accuracy is also not satisfactory. The objectives of the research were:

1. To investigate the modelling of shopping destination choices for an essentially auto-committed group of households at the disaggregate level.

2. To attempt to include attitudinal considerations in the modelling of the choice of types of shopping destination.

3. To determine how data can be efficiently collected and analyzed for operational transportation planning.

Applications of the multinomial logit model have assumed that shopping attraction and spatial separation (travel time or distance) variables act as continuous variables with a wide range of occurance within a given sample. Figure 1 shows how irregular the effects of zonal retail employment and interzonal distance are in depicting the patronage of zonal shopping destinations. It was the objective of the research to strike a compromise between a generalized disaggregate technique and a gross aggregate procedure for predicting shopping destination choice, recognizing the qualitative nature of controlling variables.

The multinomial response relation (MRR) model that is proposed predicts types of shopping destination choice behavior defined as a classification with respect to the attraction measures of shopping areas (retail employment or retail floor area) and the location of shopping destinations relative to households (in terms of travel time or distance).

In a 1971 survey, respondants were asked to rate the importance of certain descriptors in their choice of shopping destinations. Seven of these attitudinal factors, listed in Table 1, were used in this research. Owing to the small size of the sample, the sample was divided into two parts on the basis of the importance of an attitudinal factor. These groups were called attitudinal market segments. Market Segment 1 represented those to whom an attitudianl factor was considered important in the selection of a shopping destin-

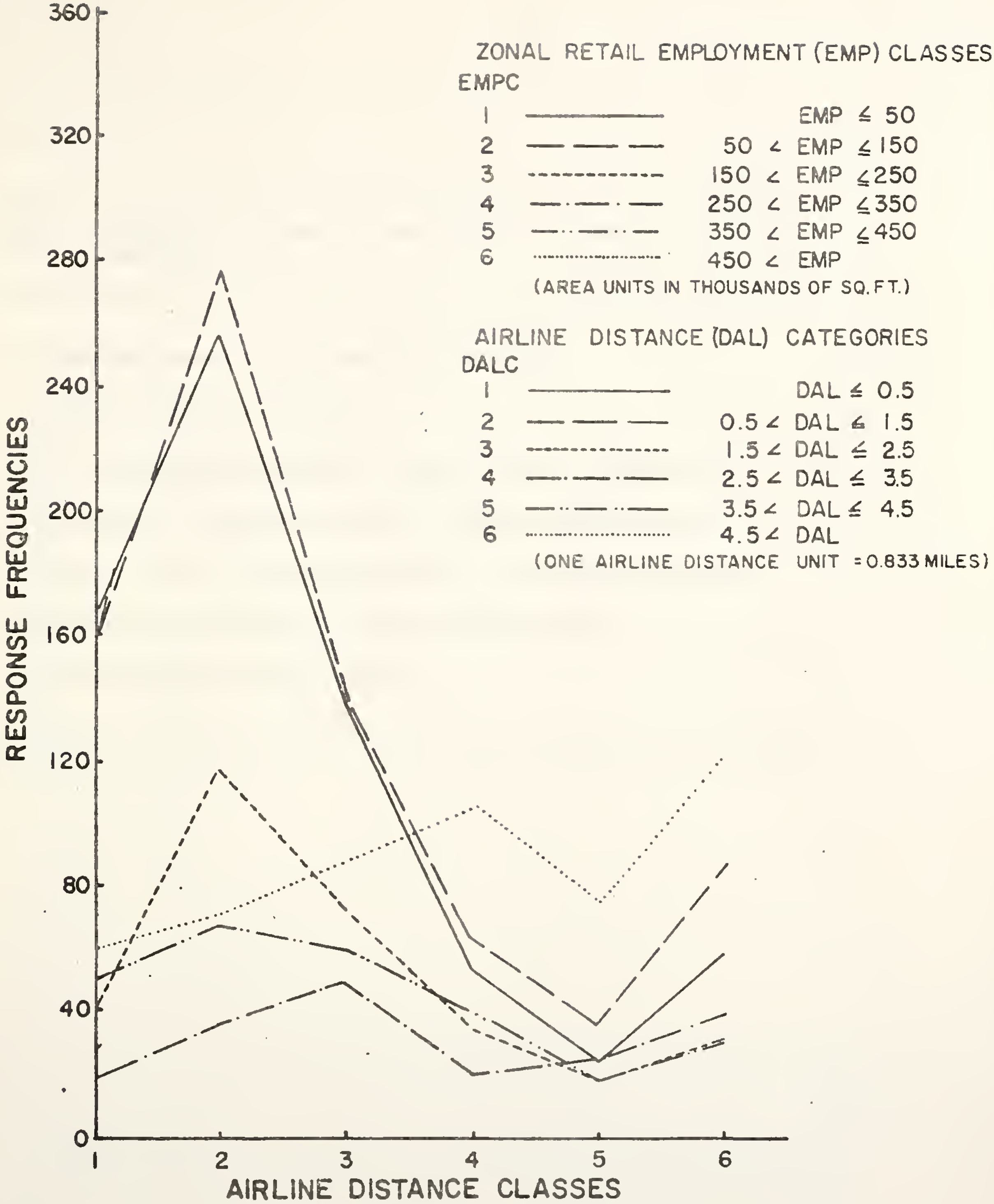

FIGURE 1: RESPONSE FREQUENCY DISTRIBUTIONS FOR ZONAL FUNCTIONAL SHOPPING DESTINATION CHOICE — EMPC x DALC

Table 1 Shopping Destination Choice Factors Considered in this Research

1. Many Employees in Shopping Establishment
2. Wide Selection of Goods
3. Shopping Destination Requiring Shortest Travel Time
4. Uncongested Approach Roads to Shopping Destination
5. Desire to Visit Several Stores at Different Locations
6. The Ability to Quickly Find a Parking Space
7. A Destination Closest to Home

ation. Market Segment 2 included those that did not attach any significance to an attitudinal factor. A model for the prediction of types of shopping destination choice behavior was developed for each attitudinal market segment. Interpretation of model parameters and statistical tests were performed to establish the usefulness of model development for attitudinal market segments.

The MRR methodology used also enabled the inclusion of interaction effects in model development. Travel behavior models have typically not considered interaction effects (a two-way interaction can be interpreted as the effect of changes in one variable being different depending on the level of the second variable). The MRR model predicts the frequencies of selection of types of shopping travel behavior. These predictions need only be expanded with a sampling ratio to obtain an aggregate forecast of how many people in the total population engage in a given type of shopping destination choice behavior. A discussion is given in the research report on how to predict or simulate the selection of specific shopping destinations, given an improved data base.

A recently developed statistical discrimination approach that admits both qualitative and continuous variables, and named "logistic discrimination," is presented. The advantage of this method over the classical discrimination approach is that it does not assume a multivariate normal distribution for the variables in the discriminant function. This greatly simplifies the model parameter estimation procedure. A separate sampling logistic discrimination procedure is also discussed. This separate sampling method ensures that each sub-population of classification or discrimination is adequately covered in the sampling during data collection, using a reasonable total sample size. It is argued that with the definition of further variables and the standardization of classifications of types of shopping destination choice behavior (referred to as functional shopping destinations), the logistic discrimination can replace the MRR approach. A further advantage with the use of the discrimination approach is the efficient data collection that extension to separate sampling logistic discrimination allows. The effectiveness of further variables depends on prevailing local conditions for a given geographical unit in an urban area. It is also possible that the availability of such variables can lead to the prediction of the choices of specific destinations pertinent to a geographical origin unit, using techniques discussed in the final request.

Summary of the Work Plan

This research used home-interview and attitudinal data collected in 1971 for the first phase of this study for a sample of 357 single-family households in the Indianapolis area. The families had not changed residential location for a period of seven years and ninety-seven percent of them travelled by automobile. Additional data collection and preparation were carried out to check or supplement the available reported information from the 1971 survey. These were done with the aid of various publications, maps, aerial photos and other material from the Indianapolis Department of Metropolitan Development. Various computer programs had to be written to organize and coordinate the data preparation in order to minimize manual work.

The major activities carried out were as follows:

1. Organization and coding of relevant data on shopping travel and responses to a successive category questionaire on factors influencing the choice of shopping destinations. The travel data preparation included the identification of specific chosen shopping destinatons and the direct estimation of travel times to alternative shopping destinations. The establishment of geographic coordinates and the assembly of shopping attraction measures were also conducted.

2. Preliminary work on model development first involved a descriptive statistical analysis of all variables. Test runs were made of logit model programs obtained from MIT and Northwestern University. The development and testing of a multinomial response relation (MRR) computer program were also carried out.

3. The estimation of multinomial logit models for predicting specific shopping destination area choices for a subsample of the available data base were performed.

4. The MRR model was used to reproduce classification patterns formed by shopping destination attitudinal factors. The MRR approach was also used to determine which attitudinal factors acted independtently. Three different attitudinal factor classification schemes were investigated.

5. Various MRR models for predicting functional zonal shopping destination choices were developed. The data used was from a 1964 Indianapolis transportation study data base. The analysis done with the 1964 zonal data was to verify assumptions made about the regularity of the effects of zonal destination choice variables, the adequacy of zonal shopping destination boundaries, and the usefulness of market segmentation in model development. The factors for market segment used in the zonal analysis included the percentage of single-family dwelling units in an origin zone, relative accessibility to retail floor area and average origin zone income.

6. Functional destination choice models using actual shopping areas for defining destination alternatives were also developed. Only travel to major shopping areas that were more likely to attract travel on major road facilities were considered. Models were developed for the total sample and for market segments defined with respect to attitudinal factors on shopping destination choice. Some multivariate statistical testing and interpretation of model parameters were carried out to establish the usefulness of each market segmentation adopted.

Findings and Recommendations

The major findings and recommendations in this research relate to the complexity and practicability of defining alternative shopping destinations, the ability to make aggregate forecasts of destination choice behavior and the effect of traveller attitudes in model development. Recommendations on how to minimize on sample size in data collection, the satisfaction of criteria for good statistical modelling and inference on parameters are also discussed.

The Multinomial Logit Model

A current multinomial logit modelling technique for the prediction of specific shopping destination choices was found to be impractical and of low predictive accurracy. It requires the arbitrary specification of a different number of alternative specific destinations for each individual. This procedure is also tedious in a wide scale application and makes the use of any analytical or rational method for making aggregate predictions of destination choice infeasible.

The Multinomial Response Relation Approach

An alternative modelling framework, the multinomial response relation methodology, is proposed in this research. It predicts the number of people who select a type of shopping destination choice behavior. Such types of shopping destination choice behavior (functional shopping destinations) are classifications of shopping areas with respect to measures like retail floor area or retail employment and shopping destination location relative to households. Except for a few categories of low frequency, the empirical investigation with the methodology proposed gave very good forecasts of functional shopping destination choices. Only appropriate sampling ratios need to be applied to predicted frequencies of functional shopping destination choice to obtain aggregate forecasts. It was found that some interaction effects had to be incorporated in some of the models developed.

Attitudes on the Selection of a Shopping Destination

It was found that a suitable definition of travel market segments needed to use only two attitudinal factors - one relating to measures of the wide range of goods and services at a shopping area, the other to the convenience of getting to the shopping destination in terms of distance and travel time. A direct behavioral interpretation of the patterns of shopping destination choice produced by models for attitudinal market segments was possible. The need for the market segmentation was also supported with statistical tests.

Future Data Collection and Modelling Requirements

The need to simplify data collection needs and the requirements for good statistical model development often conflict. The finding that few attitudinal factors need to be considered in one model indicated that future attitudinal data collection can be greatly simplified. Large sample sizes are, however, required in order to validate statistical tests that need to be made on model parameters. It is recommended in order to achieve a suitable compromise in data collection and yet cover as many travel market segments as possible, that it is necessary to use separate sampling (analogous to stratified sampling) which is an efficient way of sampling that avoids redundant data collection. Supposing that there are two market segments of interest in a population in the proportion 9 to 1. If a random sample of size 100 is taken, one expects the sample to yield 90 members for the first market segment and 10 for the second. If a reasonable sample size required for each market segment were 40, one would need a total sample size of 400 to just meet the statistical requirement for the second market segment. With separate sampling, one can do a good modelling job by taking a sample of 50 from each market segment and using approximate estimates of the proportion of occurance of the two market segments in the total population. The theory behind model development under separate sampling data collection is also discussed.

Implementation Guidelines

At the end of the first phase of the research project, Dr. E.J. Kannel made the following remarks:

> "Certainly, additional research is required to determine the limits of the sample size necessary for estimating travel and the degree of geographical biases, which exist. Also, consideration must be given to the data requirements of other aspects of travel forecasting, i.e. trip attraction, distribution and assignment."

Much work has been done recently which has suggested that disaggregate travel demand modelling be done within a choice framework. This research has laid a theoretical foundation for attending to Kannel's remarks, incorporating useful aspects of disaggregate modelling approaches. Most importantly, the methods discussed in this research recognize that the data base available is limited and that most of the variables are categorical. They also recognize that such a situation with variables may be around for a long time to come.

Since the modelling approaches developed are for categorical variables, they do not require a sophisticated data base. This can be illustrated by the fact that, whilst complex multidimensional scaling requires complicated attitudinal data collection, any simple attitudinal data collection procedure can be used to define the attitudinal market segments that may be needed for the models discussed in this research.

The finding that only a few attitudinal factors need be considered in defining attitudinal market segments, if verified in further empirical analysis, will greatly simplify attitudinal data collection on shopping travel behavior.

A strong recommendation made in this research is that separate sampling be used for more efficient data collection. The sampling design and analytical techniques presented in this research for such separate sampling modelling are ready to be operationally incorporated in present travel behavioral studies.

With the proper sampling design, variable definition and data collection, the adaptation of the modelling methodology proposed in this research into a complete modelling framework for travel demand forecasting is possible. The perspective of such a modelling framework is illustrated in Figure 2.

The theoretical discussion in this research has indicated that disaggregate modelling is not necessarily synonymous with a saving in the sample size needed for modelling. Given the many questions that disaggregate models are likely to ask, their desire to cover many novel market segments and the requirements of sound statistical modelling, data requirements for ambitious disaggregate analysis are more likely to be complex and massive with respect to sample size. The functional shopping destination choice modelling framework proposed in this reasearch recognizes the theoretical and practical problems associated with fully disaggregate modelling and develops operational models that present data quality can accommodate.

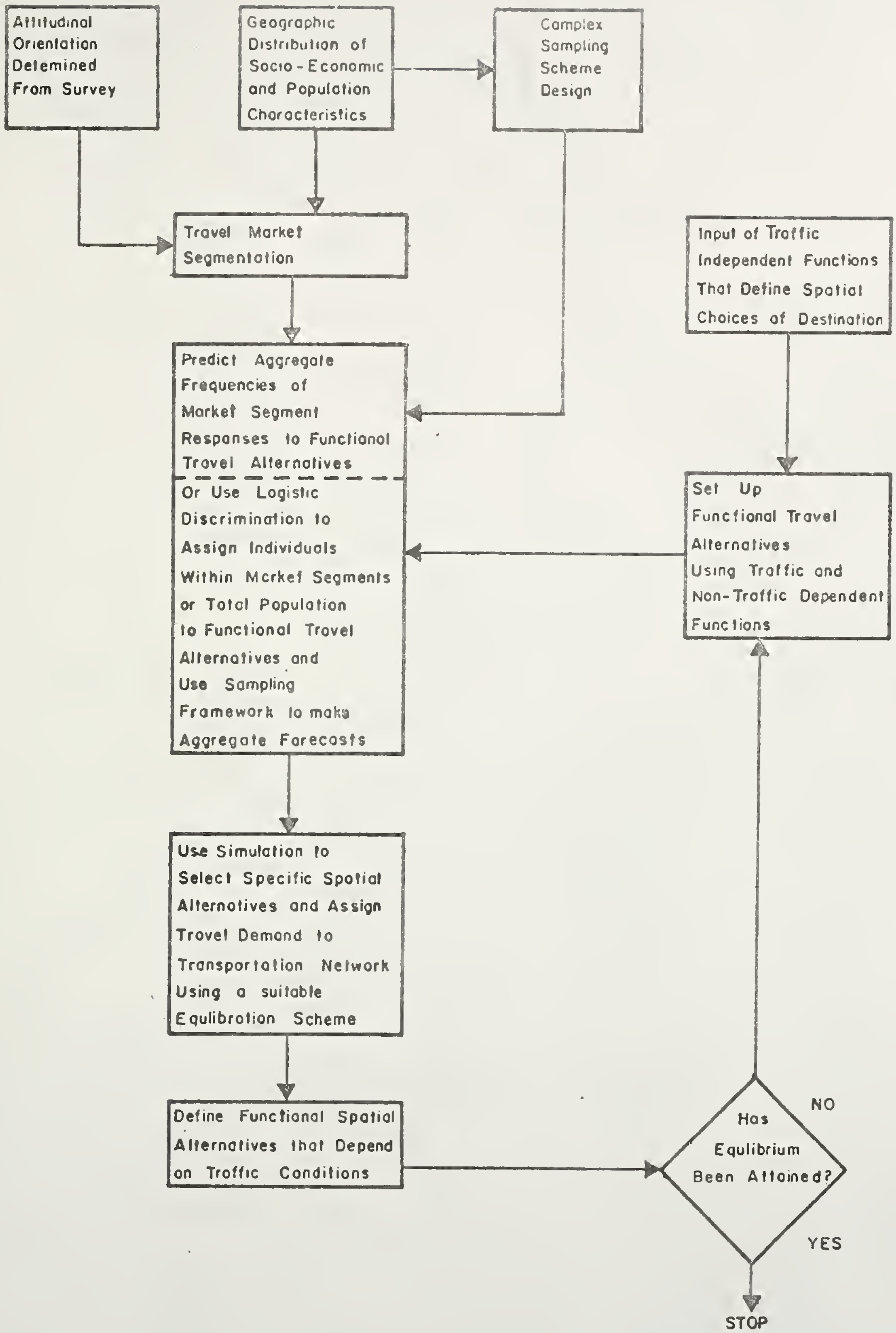

FIGURE 2: PERSPECTIVE OF AGGREGATE TRAVEL DEMAND PREDICTION CONSIDERING A BROAD RANGE OF FACTORS