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Destination Choice Models for Shopping Trips In Small Urban Areas†

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ALTERNATIVE shopping destination choice models are examined in this paper. Three research issues are addressed: 1) the comparison of attitudinal and objective models; 2) the transferability of destination choice models across two small urban areas; and 3) whether the Independence from Irrelevant Alternatives (IIA) property holds for attitudinal destination choice models.

The data were collected in Davis and Woodland, California. Probability samples of approximately 200 households were selected in each city. The variables of interest include: 1) destination selection frequencies for grocery and nongrocery shopping trips; 2) objective characteristics of alternative destinations, and 3) respondents' rating of alternative nongrocery shopping destinations on six characteristics (attitudinal variables). For each city, three types of multinominal logit destination choice models are estimated: 1) attitudinal models for nongrocery shopping trips, 2) objective models for nongrocery shopping trips, and 3) objective models for grocery shopping trips.

The results indicate that although the IIA assumption may be reasonable for the attitudinal models, they do not appear to be transferable across cities. The objective models fare better against the transferability criterion, although they do not fit the data as well as the attitudinal models do.

INTRODUCTION

The development of disaggregate models of travel behavior has been a major research activity in recent years. Although the basic theoretical concepts of individual choice behavior (McFadden, 1974; Domencich and McFadden, 1975) can be applied to different components of travel choices, most empirical work has focused on work modal choice. There are relatively few examples of destination choice models. This study develops alternative shopping destination choice models for two small cities in California: Davis and Woodland.

Attention is given to three research issues, which have been addressed in modal choice studies, but which have received little or no attention in previous destination choice studies. First, since both objective characteristics and subject perceptions of destinations are available in the data set, comparison of objective and attitudinal destination choice models can be made. Second, comparison of the models estimated for the two cities can serve as a test of the spatial transferability of destination choice models. Particular attention is given to the relative transferability of attitudinal and objective models. Third, the nature of the destination choice sets included in some of the models allows tests for the Independence from Irrelevant Alternatives (IIA) property of the multinominal logit model (McFadden, et al., 1977).

BACKGROUND

Destination Choice Models

Previous destination models have focused on shopping travel and have usually used the multinominal logit model. The previous studies differ from one another in three important ways. First, different definitions of alternative destinations and of the set of alternatives among which an individual is assumed to choose (choice set) are used. Second, the variables explaining destination choice can be measured objectively, e.g., distance, floor area of a shopping area, or by the use of attitudinal scales, e.g., convenience of location. Third, models can describe grocery shopping trips, nongrocery shopping trips, or total shopping trips.

Early destination choice models were components of shopping tripmodeling systems which also included frequency choice and mode choice components (Domencich and McFadden, 1975; Ben-Akiva, 1974; Adler and Ben-Akiva, 1976). Alternative destinations were defined as the geographic zones used in

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transportation studies. The choice sets faced by an individual included all zones visited by all individuals in the originating zone. The variables used to explain the choice among destinations were measured objectively and typically included size or attractiveness variables, such as number of retail employees, as well as transportation level of service variables such as travel times and costs. The models explained total shopping travel.

More recent studies have been characterized by the use of attitudinal variables in place of objective variables. Attitudinal destination choice models include the nongrocery shopping models developed by Northwestern University researchers (Stopher, et al., 1974; Koppelman and Hauser, 1978), and models of grocery store location choice (Recker and Kostyniuk, 1978; Shuler, 1977). These models usually include specific locations such as shopping centers or grocery stores as alternatives in the choice sets. The attitudinal variables include travelers' ratings of attributes of the shopping destinations.[1] These attributes have included variables describing the price and selection of merchandise; convenience of shopping at the destination; convenience of the location; parking convenience; and satisfaction with service.

Ansah (1977) used both objective and attitudinal variables in his destination choice study. Like the early objective models, his models explained shopping undifferentiated by the grocery, nongrocery classification as a function of a size variable (floor area) and an accessibility variable (distance). Attitudinal variables measuring perceptions of destination characteristics were used to stratify the sample, with separate models estimated for each stratum.

Transferability of Transportation Choice Models

Disaggregate choice models were originally assumed to be transferable over time and space. That is, a model estimated in a particular city at a particular point in time should be reasonably applicable in other cities at other times. The basis for the transferability assumption is the fact that disaggregate models are based upon observations of individual behavioral patterns rather than the zonal averages used in conventional models.

Comparison of the coefficients of choice models estimated with data from two or more different locations can serve as a test of spatial transferability. The comparison could involve all coefficients in the models or all coefficients excluding alternative specific constant terms. The latter, and less stringent, test is probably more realistic in most cases because the alternative specific constants may account for unspecified location-specific factors, which would lead to different constant terms in different locations.

Recently, the transferability of work mode choice models with objective independent variables has been tested, with conflicting results. Atherton and Ben-Akiva (1976) tested the transferability of work mode choice models by comparing the coefficients of models estimated in three cities: Washington, D.C., Los Angeles, and New Bedford, Massachusetts. They interpreted their results as validating the transferability assumption. Talvitie and Kirshner (1978) concluded that models similar to those of Atherton and Ben-Akiva were not transferable based upon estimations for Washington, D.C. (the same data set that Atherton and Ben-Akiva used), the San Francisco Bay Area, and the Minneapolis area. Further, they also concluded that models were not transferable within regions based upon comparison of models estimated for different parts of the San Francisco region.

The Independence from Irrelevant Alternatives Property (IIA)

The IIA property of the logit model states that the relative preference for two alternatives is independent of the presence or absence of additional alternatives. If the IIA property holds, there are two important benefits. First, a choice model can be estimated by including only a subset of the available alternative in the data set. Second, a model estimated on a smaller set of alternatives can be applied to a larger choice set, e.g., after the introduction of a new alternative.

McFadden, et al. (1977) have developed tests of the IIA. These tests are important because violation of the IIA may make the multinominal logit model inappropriate. The test that is applied in this study involves the comparison of the coefficients of a model estimated with a particular choice set with the coefficients of a model estimated with a subset of the original choice set (the conditional choice test). It should be noted that McFadden et al., and Horowitz (1980) have developed several other tests. Therefore, conclusions based upon the single test used in this study should be viewed as suggestive rather than definitive.

STUDY DESIGN

Data Collection

Data from a household survey on

household energy consumption and travel behavior are the main information source for the analyses of this study. Probability samples of about 200 households were selected in Davis and Woodland, California, with one person per household responding to a self-administered questionnaire. Data were collected from September to December 1976. Details of the sample selection procedures and the questionnaire design are discussed elsewhere (Tardiff and Scheffler, 1979).

Davis and Woodland are in the Sacramento region, and are close to each other. They are also similar in size, with 1975 populations of 31,832 and 25,389 for Davis and Woodland, respectively (Yolo County, 1975). Two distinguishing characteristics of Davis are the presence of the University of California and the emphasis given to energy and planning issues by the local government and citizenry.

The data usesd in this study contain information on shopping destination choice. For each city, the shopping destinations include the downtown area of several peripheral shopping centers. In addition, information on out-of-town shopping is available. The out-of-town destinations include Sacramento, the San Francisco Bay Area, and the other city, i.e., Davis respondents considered Woodland as an out-of-town destination and vice versa.

Respondents reported the frequency of nongrocery shopping visits to in-town and out-of-town destinations (measured as annual frequencies). Weekly grocery shopping frequencies to stores within town were also obtained.

Respondents were also asked to rate the quality of the shopping destinations on six characteristics: 1) convenience of location, 2) convenience of parking, 3) convenience of shopping in stores, 4) variety and selection of merchandise, 5) price of goods or items, and 6) attractiveness of stores, pleasant environment. A five-point scale ranging from very poor to very good was used. The characteristics used in this study are quite similar to those used in the studies reviewed in the previous section.

Data on the objective characteristics of shopping areas and grocery stores were also collected. Local data sources, e.g., planning departments, were consulted for information on the floor area and the number of stores for each shopping area. The number of employees was obtained from a telephone survey of local businesses. Finally, the city block distance between each respondent's home and each shopping destination were measured with the aid of planning maps. Objective data were obtained for in-town destinations only.

Methodology

For each city, several multinominal logit destination choice models are estimated. The transferability of the various models is tested by comparing the coefficients of the model estimated with Davis data to the coefficient of the corresponding Woodland models.

First, the ratings of destination characteristics are used to explain destination choice for nongrocery items. Models are estimated with the choice set containing both in-town and out-of-town destinations and with the choice set containing in-town destinations only. Comparison of the models estimated with alternative choice sets serves as a test of the Independence from Irrelevant Alternatives Property.

Second, models of nongrocery destination choice are estimated using objective explanatory variables. Alternative specifications involving 1) distance (measured in miles) and 2) an attraction variable (floor area [in square feet], number of stores, or number of employees) are tested. The choice sets include in-town destinations only.

Third, models of grocery shopping destination choice with objective explanatory variables are estimated. The specifications are similar to those of the objective nongrocery shopping models.

Two estimation methods are used. Since the data for weekly grocery shopping trips typically contain zero frequencies for a number of destinations in the choice set, standard maximum likelihood models are estimated. However, for the nongrocery shopping frequencies, the variables are constructed so that all annual frequencies are nonzero. Therefore, least square can be used. McFadden (1974) describes these alternative estimation methods.[2]

Least squares analysis is used for the nongrocery models for two reasons. First, it is much more computationally efficient than is maximum likelihood estimation. Second, the construction of the frequency variable as annual frequencies is consistent with the assumption that there are 365 observations per respondent. They would lead to an effective sample size of $365 \times N$ for the maximum likelihood estimation.[3] The statistical precision resulting from an effective sample size of this magnitude is probably greater than that justified by the measurement of the frequencies. Least squares analysis does not inflate sample sizes in the same manner;[4] hence, the resulting statistical precision is probably more realistic.

In assessing the similarity (or differences) between coefficients in the IIA and transferability tests, two statistical tests have been applied in previous studies. First, the equality of the entire set of coefficients can be tested (Atherton and Ben-Akiva, 1976; McFadden, et al., 1977; Talvitie and Kirshner, 1978; and Horowitz, 1980). Second, the coefficients of particular independent variables can be examined separately by calculating t statistics (Atherton and Ben-Akiva, 1976). Specifically, the difference in coefficients for two models is divided by the square root of the sum of the variances for the respective coefficient estimates. The second type of statistical test is used here. It should be noted that in the case of the IIA tests, the conventional significance levels associated with the values of the test statistics do not strictly apply, because the samples used to estimate the models are not independent.

RESULTS

The results are presented in three subsections, according to type of model: 1) attitudinal destination choice models for nongrocery trips, 2) objective models of nongrocery shopping destination choice and 3) objective models of grocery shopping travel.

Attitudinal Destination Choice for Nongrocery Shopping Trips

In addition to the six attitudinal variables, a full set of alternative specific constants, which are not reported, are used. Table 1 presents the models. For each model, the number of cases includes respondents who gave a complete set of ratings for all alternatives in the choice set.[5]

Comparison of the coefficients of the alternative models within each city tends to validate the IIA assumption. In most cases, the coefficients for the same variable are quite similar. There is also very little difference in the alternative specific constants (not shown). Further, none of the test statistics for the comparisons of coefficients are close to the magnitude for standard levels of statistical significance (the largest such statistic approximates the 80 percent level). These results suggest that the IIA assumption may be reasonable for attitudinal destination choice models estimated for particular cities. The fact that the out-of-town destinations are rather crudely defined (entire cities) suggests that the IIA is a robust property, in this case.

The comparison of models between cities suggests that these models are not transferable. The most important factors in the Davis models are location convenience, and convenience of shopping within the stores. Variety and selection of merchandise and attractiveness of the stores are statistically significant in one of the two models. Neither parking convenience nor price attain statistical significance.

The importance of the location variable is interesting in light of the fact that the Davis city government has a policy of locating shopping opportunities so that the downtown is enhanced and the peripheral shopping centers mainly serve nearby residents. The goal of the policy is to minimize shopping travel. The strong location coefficients suggest that shopping preferences within Davis are consistent with this planning policy.

In contrast to the Davis models, the location variable is highly insignificant in the Woodland models. All other variables are statistically significant at $p < .05$ with a two tail test. However, the negative coefficient on the variety and selection variable is anomalous.

In addition to the qualitative observations of the structures of the models for the two cities, comparison of the coefficients for particular variables also suggests important differences between cities. In most cases, the coefficients differ in magnitude and/or sign. The differences in the coefficients of location convenience, parking convenience, and variety and selection of merchandise are all significant well beyond the .01 level in both models. In the models containing both in-town and out-of-town destinations, the difference in the coefficients of the price variable is significant at the .05 level.

Objective Destination Choice Models For Nongrocery Shopping Trips

The objective destination choice models for each city are similar to the objective models reviewed earlier, particularly Ansah's (1977), in that an accessibility variable and an attraction variable are hypothesized to be the important independent variables. In addition, alternative specific constants are used. Since the attraction measures do not vary across individuals, it is not possible to specify a full set of alternative specific constants.[6] Therefore, only a CBD constant is specified in each model.[7] Again, the coefficients of the alternative specific constants are not reported.

Information for the attraction variables is only available for the in-town destinations. Therefore, models using the smaller choice set are estimated for

TABLE 1

ATTITUDINAL DESTINATION CHOICE MODELS FOR NONGROCERY SHOPPING TRIPS

(Standard errors are in parenthesis below regression coefficients)

Independent Variables	Davis I	Davis II	Woodland I	Woodland II
Location Convenience	.446* (.064)	.364* (.050)	.013 (.073)	-.032 (.061)
Parking Convenience	-.089 (.061)	-.087 (.046)	.260* (.075)	.294* (.067)
Shopping Convenience	.274* (.091)	.247* (.063)	.232* (.087)	.177** (.077)
Variety and Selection of Merchandise	.247* (.091)	.090 (.075)	-.246* (.083)	-.249* (.081)
Price	.128 (.105)	-.0015 (.071)	.253** (.099)	.226** (.088)
Attractiveness of Stores, Environment	.136 (.085)	.152** (.063)	.218** (.086)	.310* (.078)
N	116	98	69	60
R^2	.25	.19	.16	.15

*Regression coefficient significant at $p < .01$.

**Regression coefficient significant at $p < .05$.

Note: For each city, Model I contains in-town destinations only, and Model II contains both in-town and out-of-town destinations. The models contain alternative specific constants, which are not shown in the table. R^2 measures the proportion of variance explained by the independent variables after the effects of the alternative specific constants have been explained.

each city and tests of the IIA property are not made. The small number of destinations within each city and the fact that nonvarying attraction measures are used inhibits IIA tests based upon subsets of destinations within cities.

The models for the two cities are presented in Table 2. In all cases, coefficients are highly significant statistically and are constant in direction with prior expectations and previous empirical findings. That is, the likelihood of selecting a particular destination increases as the attractiveness measure increases, and decreases with distance.

Although the objective models exhibit lower goodness of fit than do the attitudinal models, in general, they appear to have a higher degree of transferability. For each of the three alternative models, the distance coefficients are similar across cities (the differences are highly insignificant, statistically). Also, the coefficients of the attractiveness variables are very similar in magnitude (again, differences are highly insignificant) in the first two models. The coefficients of the attraction variable (number of stores) in the third model are not as similar across the cities, with the difference significant well beyond the .01 level. However, even in this case, the difference is not as large as the significant differences generally found in the comparison of attitudinal models.

Objective Grocery Shopping Destination Choice Models

Since respondents did not rate indi-

TABLE 2

OBJECTIVE DESTINATION CHOICE MODELS FOR NONGROCERY SHOPPING TRIPS

(Standard errors are in parentheses below regression coefficients)

Independent Variables	Davis I	Davis II	Davis III	Woodland I	Woodland II	Woodland III
Distance	-.426 (.0881)	-.500 (.0868)	-.460 (.0868)	-.403 (.132)	-.407 (.126)	-.363 (.130)
Area	.0000164 (.00000303)			.0000161 (.00000291)		
Employees		.0135 (.00177)			.0132 (.00148)	
Stores			.0650 (.00903)			.161 (.0267)
N	158	158	158	118	118	118
R^2	.08	.12	.11	.05	.11	.05

All coefficients are significant at $p < .01$.

Note: The models contain alternative specific constants, which are not shown in the tables. R^2 measures the proportion of variance explained by the independent variables after the effects of the alternative constants have been explained.

vidual grocery stores, only objective models are estimated. For each city, the choice set consisted of in-town grocery stores: six stores in Davis and five stores in Woodland. The structure of the models is similar to the previously discussed objective models. Distance and an attraction variable are the independent variables. Since the destinations are single stores, area and number of employees are the only relevant attraction variables. Since, unlike the case of the nongrocery shopping models, there is no natural way to assign alternative specific constants, the models are specified without constants.

Table 3 presents the grocery trip models for Davis and Woodland. Both distance and the attraction variables are highly significant in the expected direction. Further, there is a very high degree of similarity among the distance coefficients both across alternative model specifications and cities. There are no significant differences in the distance coefficients across cities. The coefficients of the attraction variables are less similar across cities. In both cases, the coefficients in the Davis models are roughly twice the corresponding coefficients in the Woodland models. The differences are also highly significant, statistically. This fact and the fact that the Davis models have higher goodness of fit measures suggests that there may be unspecified variables affecting destination choice which are especially relevant in Woodland.

SUMMARY AND CONCLUSION

In this paper, three issues were empirically explored: 1) comparison of attitudinal and objective destination choice models, 2) the transferability of destination choice models across small cities in the same metropolitan area, and 3) whether the IIA property appears to hold for attitudinal destination choice models.

Although the attitudinal destination choice models tend to fit the data better than do the objective models and the IIA assumption appears to be reasonable, comparison of the Davis and Woodland models suggests that they are not transferable. Since the particular attitudinal variables used in this study are similar to those used in previous studies, the results suggest that this type of attitudinal model is not transferable across cities.

It would be premature to rule out the possibility of developing transferable attitudinal models, however. One interpretation of the results is that the Davis and Woodland samples constitute crude market segments. Previous work on mar-

TABLE 3

OBJECTIVE DESTINATION CHOICE MODELS FOR GROCERY SHOPPING TRIPS

(Standard errors are in parentheses below coefficients)

Independent Variables	Davis I	Davis II	Woodland I	Woodland II
Distance	-1.124 (.0390)	-1.105 (.0386)	-1.112 (.0517)	-1.199 (.0537)
Area	.0000496 (.00000384)		.0000200 (.00000245)	
Employees		.0211 (.00137)		.0132 (.00109)
N	202	202	191	191
NOBS	1010	1010	764	764
ρ^2	.15	.16	.08	.09

All coefficients are significant at $p < .01$.

Note: ρ^2 is the likelihood ratio index defined by McFadden (1974). NOBS is the total number of observations, i.e., the sum of repeated observations over the sample.

ket segmentation in the context of attitudinal mode choice modeling indicates that segments can exhibit different choice processes (Recker and Golob, 1976; Nicolaides, et al., 1977). It could be the case that although models estimated with unsegmented samples are not transferable, sets of models for distinct market segments are. Although sample size limitations prevent this type of inquiry with the present data, this might be a fruitful area of future research.

The differences between Davis and Woodland also suggest that location might be an important factor in attitudinal modeling. That is, different characteristics of alternatives may generally be perceived to be more or less important in different areas. A good example is the convenience of location characteristic in the present models. Its importance in the Davis models is consistent with the importance given to location factors in land-use planning policies.

The objective models fared better with respect to the transferability criterion. The models for the two cities were qualitatively similar in structure. Further, the coefficients of the distance variable were quite stable across both alternative specifications and cities. The simple structure of the models makes the rather encouraging conclusions regarding transferability even more noteworthy. These results also suggest that market segmentation may be less important for objective models relative to attitudinal destination choice models.

Again, these conclusions must be viewed as tentative, however. The small number of destinations in small cities limits flexibility in specifying independent variables. Larger choice sets would allow the use of more destination characteristics which do not vary across individuals and/or alternative specific constants. Larger choice sets would also facilitate IIA tests for the objective models. Future research using data with larger choice sets (larger cities) would indicate whether the tentative conclusions on the transferability of objective destination choice models persist or are even strengthened when less restrictive specifications are considered.

FOOTNOTES

1 Although there is a high degree of similarity among the studies, they do differ somewhat in their definitions and measurement of specific attitudinal variables.

2 When the model is fully specified, least squares estimation is asymptotically equivalent to maximum likelihood estimation. When the model is underspecified, the estimation techniques can differ asymptotically, although the relative importance of the coefficients will be the same (Tardiff, 1979). Since this study focuses on the relative importance of coefficients and does not develop models for purposes of prediction, possible differences between alternative estimators are not crucial.

3 The multinomial logit model treats N repeated observations for the same individual the same as 1 observation for N individuals. (McFadden, 1974).

4 The least squares procedure essentially generates J-1 observations per individual, resulting in an effective sample size of (J-1) $\times$ N, where J is the number of alternatives (McFadden, 1974).

5 The choice set for the Davis in-town model contains the CBD plus four peripheral shopping centers. The Davis in-town/out-of-town model has a choice set with the five in-town locations plus Woodland, Sacramento, and the San Francisco Bay Area. The Woodland in-town model choice set contains the CBD plus six peripheral shopping centers. These seven in-town locations plus Davis, Sacramento, and the San Francisco Bay Area are included in the in-town/out-of-town model for Woodland.

6 The number of variables which do not vary across individuals is limited to (J-1) where J is the number of alternatives in the choice set (McFadden, 1974). The full set of (J-1) alternative specific constants exhausts the available degrees of freedom. Therefore, when nonvarying attraction characteristics are used, the set of constants must be restricted. This problem is similar to the degrees of freedom problem for auto choice models discussed by Lave and Train (1979).

7 A CBD constant was used in the models developed by Ben-Akiva (1974) and Adler and Ben-Akiva (1976).

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