

A Spatial choice model of consumer behavior : aspects of calibration and application

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A SPATIAL CHOICE MODEL OF CONSUMER BEHAVIOR: ASPECTS OF CALIBRATION AND APPLICATION

*Harry Timmermans and Jan Veldhuisen**

Recently, a number of authors (4, 5, 8, 9, 11, 12, 14) have proposed alternative ways of calibrating spatial choice models of the general form:

$$(1) \quad p(j|D) = \frac{U_j}{\sum_k U_k}$$

$$(1a) \quad = \left[\frac{\sum_g a_g V_{jg}}{f(c_{ij})} \right] / \left[\frac{\sum_k (\sum_g a_g V_{kg})}{f(c_{ik})} \right]$$

where,

$p(j|D)$ = the probability that an individual located at origin i will choose destination j from the total set of destinations D ;

U_j = the utility of destination j as viewed from origin i ;

$f(c_{ij})$ = a function of the total costs between origin i and destination j ;

V_{kg} = the value of destination k on the g -th attribute, contributing to the attractiveness of the destination;

a_g = an empirically estimated coefficient for the relative weight of the g -th attribute contributing to the attractiveness of the destination.

This discussion on the calibration of spatial choice models has been concentrating on the problems of distinguishing the distance-separation effects from the destination effects, on estimating destination effects endogenously from trip distribution data and on problems resulting from different numbers of destinations in the choice set of individuals. The present paper adds a further methodology, in which these three aspects are treated simultaneously, to the existing ones. In addition, the application of the methodology in a study of spatial shopping behavior in South-East Brabant, the Netherlands, will be described.

Methodology

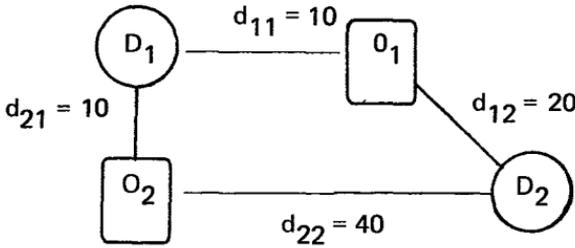
Assume the study area is a closed spatial system, composed of N mutually exclusive residential zones, called origins, and M mutually exclusive shopping centres, called destinations. Each origin generates a certain number of shopping trips, O_i , during some finite observation period. Similarly, each destination receives a certain number of shopping trips, D_j , during some finite observation period. Further, let t_{ij}^S represent the total number of shopping trips

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from origin i to destination j . Then, T denotes the total number of shopping trips within the spatial system and the $N \times M$ matrix of shopping trip frequencies is denoted by $T^S = (t_{ij}^S)$

Our problem is then to derive the relative attractiveness of the shopping centres from observed spatial shopping patterns. Therefore, consider a hypothetical spatial system with only two origins, O_1 and O_2 , and two shopping centres, D_1 and D_2 . The consumers at O_1 and O_2 must choose between shopping alternatives D_1 and D_2 at time-distances d_{11} , d_{12} and d_{21} , d_{22} . Figure 1 gives hypothetical values for the relevant variables.

Figure 1: Hypothetical Spatial System



Assuming the distances between the two origins and two destinations are equal, the relative attractiveness of the shopping centres is given by the ratio of the total number of shopping trips to the first shopping centre and the total number of shopping trips to the second shopping centre. In formula:

$$(2) \quad U_1 / U_2 = D_1 / D_2$$

However, these distances are not equal and this implies that the total number of observed shopping trips is also influenced by the distance separation between the origins and the shopping centres, for example, assume the friction of distance equals d^2 , $O_1 = 700$ and $O_2 = 950$ and the attractiveness of shopping centre 2 is three times the attractiveness of shopping centre 1. This gives the results presented in Table 1.

Table 1: The T^S - Matrix

i	j	Destinations		$\sum_j t_{ij}^S$
		1	2	
Origins		400	300	700
		800	150	950
	$\sum_i t_{ij}^S$	1200	450	$T = 1650$

However, until now we have assumed that the attractiveness of the shopping centres is known *a priori*. In practice, the attractiveness of the shopping centres has to be derived from the matrix of observed shopping patterns, presented in Table 1.

This can be accomplished in the following way: First, assume the friction of distance equals d_{ij}^{-1} . This implies that

$$(3) \quad t_{ij}^s = {}_iA_j * d_{ij}^{-1}$$

Or,

$$(4) \quad {}_iA_j = t_{ij}^s * d_{ij}$$

and,

$$(5) \quad {}_iA_j^* = {}_iA_j / \sum_j {}_iA_j$$

and,

$$(6) \quad A_j^R = \sum_i {}_iA_j^* / N$$

where,

${}_iA_j$ = the attractiveness of shopping centre j as seen from origin i;

${}_iA_j^*$ = the relative attractiveness of shopping centre j as seen from origin i;

A_j^R = the average relative attractiveness of shopping centre j.

Table 2 gives the resulting relative attractiveness of the shopping centres for each origin i.

Table 2: Relative Attractiveness of the Shopping Centres

i \ j	Destinations		$\sum_j {}_iA_j^*$	
	1	2		
Origins	1	.400	.600	1.000
	2	.572	.428	1.000
A_j^R	.486	.514	1.000	

Assuming that the attractiveness of the shopping centres is independent of the distance effects, we can iteratively change the friction of distance parameter β until the sum of variances in the column vectors of the matrix of relative attractiveness of the shopping centres is at minimum. Table 3 gives the results by increasing β from -1.5 to -2.5 with steps of 0.5. Evidently, the optimal results are obtained for $\beta = -2.0$. The corresponding ratio of the relative attractiveness of shopping centre 1 and 2 equals 1:3; the value initially hypothesized.

Until now, we have assumed that the destinations in the choice set of a residence zone are the same for each residence zone. This assumption might be realistic, for example, for outdoor-recreational behavior but, certainly, it is not for spatial shopping behavior. This is supported by many research findings on awareness spaces, activity spaces, information levels, utility fields and so on (15, 19, 20, 22, 33, 34, 36, 36, 41), indicating the spatially and cognitively discontinuous constrained characteristic of spatial (shopping) behavior. The

Table 3. Results for Different Values of β .

i \ j		$\beta = -1.5$		i \ j		$\beta = -2.0$		i \ j		$\beta = -2.5$	
		Destinations				Destinations				Destinations	
		1	2			1	2			1	2
Origins		.320	.680	Origins		.250	.750	Origins		.191	.809
		.400	.600			.250	.750			.143	.857
A_j^R		.360	.640			.250	.750			.167	.833

problem then is that the methodology, outlined above, no longer is applicable under such circumstances. This is illustrated in Figure 2.

Figure 2. Hypothetical Example of Different Destinations in Choice Sets.

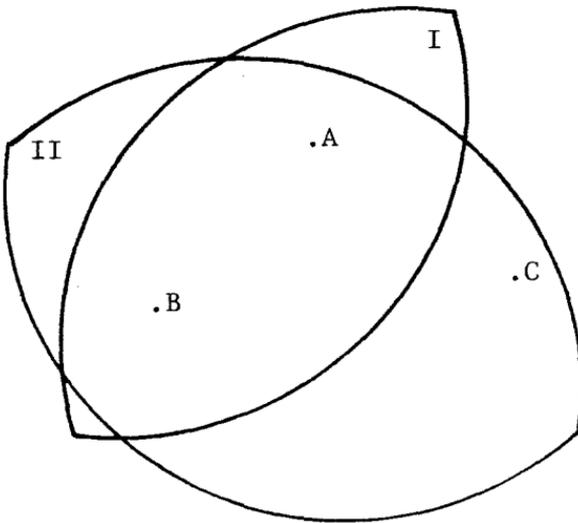


Figure 2 shows that choice set I consists of two shopping alternatives, A and B and that choice set II consists of three shopping alternatives, viz. A, B and C. Assuming the attractiveness of the three shopping alternatives is equal, the relative attractiveness of shopping alternative A in choice set I will be 0.5, whereas the relative attractiveness of shopping alternative A in choice set II will equal 0.33. Evidently, using the objective function of minimizing the sum of variances in the column vectors of the matrix of the relative attractiveness of the shopping alternatives for each residence zone will lead to uninterpretable or even wrong results in this situation. Therefore, we will have to specify an objective function which does give interpretable values for the relative attractiveness of the shopping alternatives under these circumstances. One possibility is to minimize the sum of variances in the ratios of the relative attractiveness of the shopping alternatives for all relevant combinations of shopping alternatives. Using this objective function, the ratio of the relative attractiveness of shopping alternatives A and B in choice set I (0.5 : 0.5) will be equal to the ratio of the relative attractiveness of shopping alternatives A and B in

choice set II (0.33 : 0.33): an interpretable and theoretically correct result.

In practice, however, we will probably not get a perfect fit of the model, this leading to different values for the relative attractiveness of the shopping alternatives from each residence zone. Therefore, we will have to derive an average relative attractiveness measure for the shopping alternatives. Given the objective function, the most useful way of deriving the average relative attractiveness of a shopping alternative is to compute the geometric mean of the relevant values for the relative attractiveness of a shopping alternative.

The fact that the geometric mean gives better results in the context of different destinations in the choice sets of the residence zones is illustrated in the next example. Let the attractiveness of shopping alternative A in choice set I be two times the attractiveness of shopping alternative B in choice set I and let the attractiveness of shopping alternative B in choice set II be two times the attractiveness of shopping alternative A in choice set II. For example,

$$\begin{aligned} 1 A_A^* &= .6 & 1 A_B^* &= .3 \\ 2 A_A^* &= .2 & 2 A_B^* &= .4 \end{aligned}$$

The best decision a researcher can make in this situation is to consider the attractiveness of the two shopping alternatives as equal. However, this is not reflected in the values of the arithmetic mean, which was computed in our initial example, since these values are respectively .4 and .35. Computing of the geometric means, however, results in respectively .346 and .346. That is, the geometric means indicate that the average relative attractiveness of shopping centre A equals the average relative attractiveness of shopping centre B.

Summarizing the methodology, the starting point is a spatial choice model of the general form:

$$\begin{aligned} (7) \quad p(j | D) &= \frac{A_j}{\sum_{g=1}^M A_g}, \quad g \in U_i \\ & \quad j \in U_i \\ (7a) &= \left[\sum_{k=1}^r \gamma_k V_{jk} / f(d_{ij}) \right] / \left[\sum_{g=1}^M \left(\sum_{k=1}^r \gamma_k V_{gk} / f(d_{ig}) \right) \right] \\ & \quad j \in U_i \\ & \quad g \in U_i \end{aligned}$$

The solution is obtained by minimizing the objective function:

$$(8) \quad \sum_{j=1}^{M-1} \sum_{k=j+1}^M (\text{var} (A_j^* / A_k^*)), \quad \begin{aligned} & j \in U_i \\ & k \in U_i \\ & i=1, \dots, N \end{aligned}$$

with

$$(9) \quad {}_iA_j = t_{ij} * f(d_{ij})$$

and

$$(10) \quad {}_iA_j^* = {}_iA_j / \sum_g {}_iA_g, \quad \begin{array}{l} g \in U_i \\ j \in U_i \end{array}$$

The average relative attractiveness of the shopping alternative is derived as:

$$(11) \quad A_j^R = \left(\prod_{i=1}^N {}_iA_j^* \right)^{1/N}, \quad j \in U_i$$

where,

${}_iP(j|D)$ = the probability that a consumer located at i selects shopping alternative j from the total set of shopping alternatives D ;

${}_iA_j$ = the attractiveness of shopping alternative j as viewed from residence zone i ;

${}_iA_j^*$ = the relative attractiveness of shopping alternative j as viewed from residence i ($\sum_j {}_iA_j^* = 1.0$);

U_i = the utility field of residence zone i ;

V_{jk} = the value of the k -th attribute of shopping alternative j ;

$f(d_{ij})$ = a function of the distance separation between residence zone i and shopping alternative j ;

t_{ij} = the total number of shopping trips from residence zone i to shopping alternative j ;

A_j^R = the average relative attractiveness of shopping alternative j ;

M = the total number of shopping alternatives;

N = the total number of residence zones;

r = the total number of attributes, contributing to the attractiveness of a shopping alternative;

γ_k = an empirically estimated coefficient for the relative weight of the k -th attribute, contributing to the attractiveness of a shopping alternative.

An Application

The model and calibration procedure, outlined in the foregoing paragraph, was used in a study of spatial consumer behavior for durable goods in South-East Brabant, The Netherlands. Within the study area, 33 residence zones and 62 shopping centres were identified.

The input data for the model on observed spatial shopping behavior were collected in two separate surveys. The first survey was undertaken in the summer of 1975 by interview and included 1024 respondents (25), and the second survey was undertaken in the summer of 1978, also by interview and including 771 respondents. These interviews represent about 10 percent of the total number of households in the study area. Although there is a difference of three years between the two surveys, this was not considered problematic since there were no important changes in the retailing structure of the study area in this period. Thus, the two surveys were added together and re-weighted proportional to the relative number of households in each residence zone. The matrix of shopping trips from the residence zones to the shopping centres was constructed by asking each respondent to mention the shopping centres visited as well as the frequency of these visits during a one month time period for a number of durable goods. The purpose of the study then was to model the resulting aggregate spatial shopping behavior patterns in mathematical terms.

The specific form of the spatial choice model used in this respect was:

$$\begin{aligned}
 {}_i p(j|D) &= {}_i U_j / \sum_{g \in U_i} {}_i U_g, \quad g \in U_i \\
 &\quad j \in U_i \\
 &= \left[\sum_{k=1}^r \gamma_k V_{jk} / \left\{ (d_{ij} - d_{ij}^*)^a \cdot e^{\beta(d_{ij} - d_{ij}^*)} \right\} \right] / \\
 &\quad \left[\sum_{g=1}^M \left(\sum_{k=1}^r \gamma_k V_{gk} / \left\{ (d_{ig} - d_{ig}^*)^a \cdot e^{\beta(d_{ig} - d_{ig}^*)} \right\} \right) \right] \\
 (12) \quad &j \in U_i \\
 &g \in U_i
 \end{aligned}$$

where,

$$d_{ij}^* = \min_{j \in U_i} \{ d_{ij} \} + 1, \quad j = 1, 2, \dots, M;$$

α, β = calibrated distance parameters

and the meaning of the other symbols is the same as in the preceding paragraph. Notice that the model describes consumer behavior in terms of the difference of the distance to the shopping centres and the distance, necessary to pass the nearest shopping opportunity. The distances, a consumer has to travel in order to reach the nearest shopping opportunity, are therefore not included in the model. The distance from a particular residence zone to the nearest shopping centre is assumed to represent one unit of measurement. This transformation was thought to be necessary to yield more realistic input data for the choice model. The inclusion of observed distances would imply that the choice set of consumers located in the periphery of the study area is treated differently from the choice set of consumers located in the centre of the study area solely due to the geometry of the study area. In reality, however, consumers located at the periphery of the study area will probably discount the distance to the nearest shopping opportunity and then view the distances to

the more distant shopping opportunities. By taking the difference between the distances to the shopping centres and the distance to the nearest shopping centre the input data for the model reflect more correctly the underlying decision making process of consumers and are partially independent of the specific geometry of the study area.

The d_{ij} and d_{ij}^* -terms were measured in travel-time units. Firstly, a transportation network, covering the study area, was constructed. Secondly, on the basis of the spatial distribution of the households within the residence zones, the speed of the various transport modes on the links of the network and the distribution of the transport modes for each residence zone, the 33 x 62 matrix of representative travel-times between the residence zones and the shopping centres were derived.

The identification of the utility fields was based on the observed spatial shopping behavior patterns in the study area. That is, the utility field of a residence zone includes the shopping centres, which are patronized from the residence zone. An alternative and theoretically more valid way of identifying the utility fields is to derive them from questions in the survey about the willingness to travel in order to purchase a particular good and the information levels of the respondents. However, such questions were not included in the survey of 1975. Therefore, it was not possible to employ this alternative procedure.

Apart from data on observed spatial shopping behavior patterns, utility fields and travel-time distances, the spatial choice model requires input data on the attributes of the shopping centres, contributing to their attractiveness. In the literature (6, 10, 21, 23, 29, 32, 43) numerous attributes, ranging from the price of the goods and the functional complexity of a shopping centre to the reputation of the shopping centre and window display, are mentioned. Clearly, not all these attributes are strictly relevant in a planning context. Therefore, two criteria were established for the reduced set of attributes to be included in the model. Firstly, each attribute had to have a direct physical meaning and secondly the set of attributes selected should encompass the most important aspects of the physical planning of shopping centres. The reduced set of attributes consisted of 8 attributes. The list of attributes is given in Table 4.

Table 4: The List of Attributes.

Identification Meaning

X_1	Number of parking lots
X_2	Total parking space
X_3	Number of shops
X_4	Number of branches (functional complexity)
X_5	Number of employees
X_6	Number of super-stores
X_7	Number of shops per parking facility
X_8	Index for range of choice per branch

The second part of the study involved the calibration of the spatial choice model. Using the 'sequential linear search' -method (1, 2, 3) the model was calibrated on the basis of the objective function of minimizing the weighed sum of variances in the ratios of the relative attractiveness of the shopping centres. The calibrated parameters for the distance function were respectively $\alpha = .2486$ and $\beta = .1510$. The model accounted for 74.3 percent of the variance in the observed shopping trips and accounted for 99.2 percent of the variance in the number of arrivals in the shopping centres.

The calibration of the time-distance function resulted in a 33 x 62 matrix with the relative attractiveness of the shopping centres as viewed from the residence zones. This matrix was input for the computation of the geometric means, denoting the average relative attractiveness of the shopping centres. The average relative attractiveness of the shopping centres is given in Table 5.

Table 5. The Average Relative Attractiveness of the Shopping Centres (x10).

Id. no.	Name	Average relative attractiveness
1.	Eindhoven, city centre	6.722
2.	Woensel	1.457
3.	Woenselse Market	0.117
4.	Strijp	0.315
5.	Geldrop	0.297
6.	Valkenswaard — centre	0.983
7.	Woenselse Heide	0.122
8.	Heezerweg	0.473
9.	Tongelre	1.398
10.	Vaartbroek	0.166
11.	Hendrick Staetslaan	0.115
12.	Son	1.486
13.	Breugel	0.185
14.	Waalre	0.211
15.	Aalst	0.421
16.	Leende	1.642
17.	Nuenen	0.774

18.	Best	0.071
19.	Veldhoven	0.168
20.	Valkenswaard-Willibrordlaan	0.012
21.	Heeze	1.530
22.	Oirschot	0.195
23.	Geldrop-Coevering	0.067
24.	Best-Wilhelminaplein	0.257
25.	Bergeijk	0.312
26.	Bladel	0.144
27.	Casteren	0.098
28.	Duizel	0.034
29.	Eersel	0.290
30.	Hapert	0.141
31.	Hoogeloon	0.129
32.	Luyksgestel	0.028
33.	Reusel	0.171
34.	Steensel	0.088
35.	Vessem	0.278
36.	Westerhoven	0.093
37.	Wintelre	0.159

Table 5 gives the results for only 37 shopping centres. The remaining shopping centres were not important for the purchase of durable goods. These shopping centres were, therefore, not included in the final analysis.

The final part of the study concerned the determination of the relative contribution of the selected attributes of the shopping centres to the derived average attractiveness of the shopping centres. That is, a least squares solution to the attractiveness component of equation (12) is sought in terms of the eight selected attributes of the shopping centres. One way of obtaining these relative contributions is to use stepwise regression analysis. However, due to the problem of multicollinearity, it becomes difficult to sort out the separate relative contributions of the attributes selected.

One possible way out of this problem is to use the ridge regression technique (16, 17, 18, 24, 30, 31). The ridge regression is an estimation procedure based upon

$$(13) \beta^* = (X'X + kI)^{-1}X'Y$$

where,

$\hat{\beta}^*$ = the ridge estimates of β ;

X = matrix of standardized independent variables, i.e. attributes of a shopping centre;

Y = vector of dependent variables, i.e. derived average attractiveness values;

k = a nonnegative parameter ($0 \leq k \leq 1$).

Since the estimates $\hat{\beta}^*$ are not unbiased least squares estimates for $k > 0$, the error sum of squares associated with $\hat{\beta}^*$ will be larger than the error sum of squares associated with the ordinary least squares estimates. However, the mean square error of the ridge estimates is smaller than the mean square error of the least squares estimates. The choice of a value for k can be accomplished by inspection of the *ridge trace*, a plot of k against the values of the ridge estimates.

Both stepwise and ridge regressions were run on the data for all 37 observations, with the average attractiveness of a shopping centre as the dependent variable and the eight selected attributes of a shopping centre as the independent variables. Table 6 gives the results for the stepwise regression analysis.

Table 6. Results of the Stepwise Regression Analysis.

Iteration	Regression Equation	R ²	F-test of entire regression	Partial F-tests	Degree of freedom
1.	$Y = 0.28138 + 0.00058 X_1$	0.85	192.9	$X_1: 192.9$	1 and 35
2.	$Y = 0.16225 + 0.00031 X_1 + 0.00073 X_5$	0.87	109.1	$X_1: 5.7$ $X_5: 4.7$	2 and 34
3.	Variable X_8 was entered. Its partial F-value was 0.27 with 3 and 33 degrees of freedom. The critical F-value at $\alpha = 0.05$ is 2.90, so variable X_8 was not accepted, and the procedure was terminated.				

Table 6 shows that only the first two variables entered, contribute significantly to an increase in the multiple correlation coefficient. These two variables are the number of parking lots and the number of employees. Both variables are positively associated with the derived average attractiveness of the shopping centres. Together they account for 87 percent of the variance in average attractiveness scores. Although causal interpretation might be misleading, these results suggest that consumers prefer the larger shopping centres with

good parking facilities for the purchase of durable goods.

The ridge regression results are given in Table 7. Figure 3 portrays the ridge trace. Table 7 again indicates the relative importance of variables X_1 (the number of parking lots) and X_5 (the number of employees) in explaining the derived average attractiveness scores of the shopping centres.

Table 7. Results of the Ridge Regression Analysis.

k-value	Regression coefficients								R ²
	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	
0.0	0.190	0.071	-0.318	0.044	1.000	-0.062	0.004	0.058	.867
0.1	0.333	0.034	0.077	-0.024	0.266	0.226	-0.014	-0.034	.838
0.2	0.295	0.042	0.100	-0.016	0.245	0.231	-0.022	-0.028	.815
0.3	0.273	0.048	0.110	-0.007	0.235	0.227	-0.026	-0.027	.795
0.4	0.258	0.051	0.114	-0.000	0.223	0.221	-0.029	-0.028	.776
0.5	0.245	0.054	0.116	-0.007	0.218	0.216	-0.031	-0.029	.758
0.6	0.235	0.056	0.116	-0.012	0.210	0.210	-0.032	-0.031	.741
0.7	0.226	0.058	0.117	-0.016	0.203	0.203	-0.032	-0.032	.726
0.8	0.218	0.059	0.116	-0.020	0.200	0.200	-0.033	-0.033	.710
0.9	0.211	0.060	0.116	-0.023	0.192	0.192	-0.033	-0.034	.700

Variable X_6 (the number of super-stores) is now also a relatively important variable. Table 7 and Figure 3 also illustrate that the initial values of the regression coefficients alter rapidly as k increases. Variables X_3 , X_4 , X_6 , X_7 and X_8 even experience a change in sign. Moreover, variable X_4 (the number of branches) does not hold its predictive power and could, therefore, be removed from the regression equation. The value of the regression coefficient of the other variables tend to stabilize between $k=0.1$ and $k=0.3$. Hence, we can select a particular value of k within this range; the regression equation then accounts for about 80 percent in the variance of the derived average attractiveness scores of the shopping centres.

Discussion

The basic objective of this article was to present an alternative approach to the problem of calibrating spatial choice models. Current research on this topic has consistently indicated the problem of the effect of the spatial structure of the study area on the calibrated parameters. That is, the parameters of spatial choice models — and also of spatial interaction and entropy-maximizing models (e.g. 40) — do not describe the spatial behavior of individuals (45, 46). Instead, they simultaneously reflect the spatial behavior of individuals and the spatial structure of the area under investigation.

One possible way out of this problem is to develop alternative models which are calibrated independently of the spatial structure of the study area and therefore truly reflect the spatial behavior of individuals. Rushton's preference scaling model (13, 26, 27, 37, 38, 39, 42), the information integrating / multi-attribute theory approach (29, 44) and the purely behavioural interaction models (7, 28) have been relatively successful in this respect and surely may become increasingly relevant when formulated explicitly on the basis of a number of planning conditions. However, these approaches still demonstrate certain disadvantages, the most important of which seems to be the fact that

the destination effects must be defined *a priori* and can only be small in number.

A second possible way out of the problem is to concentrate on the discrimination of distance-separation effects and destination-attractiveness effects. The methodology, presented in this article, represents an example of such an approach. Given the assumption of a distance independent attractiveness of destinations, the average attractiveness of destinations may be derived endogenously from trip distribution data. Thus, in this way distance effects are separated from destination effects. In addition, the variables, reflecting certain dimensions of the attractiveness of the destinations, are not *a priori* assumed to be important but are statistically proven to contribute significantly to the attractiveness of the destinations. In this respect, the present methodology is equivalent to the one, presented by Ewing (11) in a study of interstate migration flows in the United States. However, unlike Ewing's approach, the present methodology does not suffer from problems of different destinations in the choice set of the origins and may have some practical advantages. As to the more recently proposed calibration methods for spatial choice models (4, 5, 9), the present methodology might be a possible alternative while it certainly is superior to these methods in that it treats explicitly the problem of a large proportion of zero cells in the trip distribution matrix.

Nevertheless, the methodology, outlined in this article still has some associated problems. One critical aspect of the methodology is the assumption of a distance-independent attractiveness of destinations. Concentrating on the distance an individual has to travel in order to pass the nearest opportunity, implies that the value of the attractiveness of the destinations is the result of the fitted distance function. Therefore, the average attractiveness of the destinations is based on the choice situations of individuals, located in the periphery of the study area as well as on the choice situations of those, located in the central parts of the study area. The question remains whether these different situations form a theoretically sound basis for fitting a distance function. Another problem, associated with the presented methodology is that the statistical properties of some of the parameters are unknown and that the model is calibrated in two successive stages. Considering these comments, it seems desirable to compare the methodology's performance with the other methodologies in specific choice situations.

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