MODELLING RESIDENTIAL LOCATION CHOICE - A REVIEW OF SOME RESULTS

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ABSTRACT: *Residential location decisions are inextricably linked with transport policy decisions. An understanding of this relationship is necessary if the full ramifications of such policies are to be known.*

Many investigations of the influence of transport policy decisions have concentrated primarily on transport related variables and have neglected to consider more qualitative aspects of the social and physical environment.

This paper reviews microscopic approaches to modelling residential location and, in particular, highlights a multinomial logit approach. It briefly describes a data set which has been collected to allow construction of such a model. Finally, it presents the results of an investigation of the importance residents' knowledge of alternative areas has on the structure of this model.

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INTRODUCTION

It has long been acknowledged that transport policy is inextricably linked with residential location decision. Consequently an understanding of this relationship is necessary if the full ramifications of such policies are to be known and much research over the last couple of decades has been devoted to exploring this relationship. However, much of this research has concentrated primarily on system-wide transport related variables and has neglected to consider the more qualitative aspects of the social and physical environment. While this may be acceptable at an aggregate level, these procedures cannot be used to analyse individual choice processes.

This problem has in part been due to the type of procedures used to analyse the land use/transport interaction and to the availability of certain data sources. Recently, however, procedures have been developed which enable planners to look at the individual decision making process and obtain insights into factors constraining and influencing it. These procedures see the individual decision of where to live and when to move as being constrained and moulded by their knowledge of the alternatives open to them.

This paper reviews the methods available for investigating the choice process and discusses the influence a resident's knowledge of the alternatives has on the factors influencing the choice of where to live.

DECISION PROCESS

A suitable conceptual framework for looking at the decision process is that suggested by Brown and Moore (1970). Using the earlier work of Wolpert (1964) and Adams (1969), they divided the relocation process into two more or less simulataneous processes. The first, the search, is where the decision maker gathers information about the alternatives open to him. The second stage, the decision, combines the information gathered in the first stage into a form suitable for evaluating the alternatives.

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The Search

The search for a new location can take many forms and is influenced by many factors. The media, real estate agents and discussions with other people can contribute as much to people's perception of altenatives as does the overt action of looking at alternative houses.

Brown et al. (1977) explain the search in terms of the migrants 'awareness space'; 'awareness space' is thoseparts of the urban area of which the person has some knowledge. Gould and White (1974) see this 'awareness space' or spatial knowledge as resulting from people's experience and spatial learning. They argue that the discrepancy between people's perception of the characteristics describing an area and the true representatation of these characteristics is a function of the people's knowledge of the area. This discrepancy is greatest when the individual has least knowledge about the area and becomes less as knowledge grows.

Research into the factors influencing the gathering of information has concentrated on the spatial aspects of the search progress. Using Gould and White's concept of a mental map various researchers [e.g. Brown et al. (1977), King (1978), Morris (1976), Humphries (1974), Jones (1969)] have pointed to the directionality of the migration process. People have been found to move outward from the central city or in towards the central city along the transport corridor or sector containing their previous location. The main reason put forward to explain this phenomenon is that people's travel to work, shops and recreation is strongly influenced by the transport network. Since in most urban areas, the transport system radiates out from the central city, the collection of information by people will have a strong directional bias.

The Decision

Given people's level of knowledge of the urban area and their perception of the characteristics describing each area, the next step, according to Brown & Moore's framework is the decision.

The seventies have seen a growing interest in the use of the individual as the basic unit of analysis for choice situations. Initial studies [Ball (1973), Kain & Quigley (1974), Apps (1974a, b), Richardson et al. (1974), Leven and Mark (1977), Borukhov et al. (1978)]

into the factors influencing people's preference for particular location/house type combinations concentrated on the price people were willing to pay for particular amounts of housing. These studies used either the market price of a house or its rated value as measure of the utility people gain from choosing that house. Typically, these researchers built models in which the house price was introduced as the dependent variable in a least squares regression equation and the characteristics describing the house and its location were used as the independent variables. The coefficients of these variables were thought of as implicit prices (i.e. the price people are willing to pay for one unit of that commodity).

These models, although adopted by many researchers, have the drawback that it is difficult to incorporate several constraints influencing the location decision process. Ball and Kirwan (1975) have argued that the inability of these models to incorporate the constraints of the household budget and the spatial distribution of the supply of housing limit their usefulness in understanding the forces underlying the housing market. MacLennan (1977) adds to these criticisms by pointing out that the models have refrained from incorporating people's knowledge or perception of the alternatives available to them and have taken refuge in the economic assumption of a perfect market.

Such models set the scene for a number of more recent studies which have called upon the behavioural models developed in the transport planning field for the analysis of transport related decisions and have applied these to the choice of residential location. These models have their base in consumer choice theory and take the general from:

$$p(i : A) = e^{V_i} / \sum_{j=1}^{j} e^{V_i} \quad (1)$$

where $p(i : A)$ = probability of choosing alternative i from set of alternatives A;

V_i = utility gained from alternative i

j = number of alternatives.

Lerman (1975) used the multinomial logit model (Equation 1) to analyse the relationship between transport related decisions and home ownership. He considered the choice of house (tenure and house-type), level of car ownership, mode of travel to work and location as being carried out simultaneously within a multinomial logit framework. Lerman's empirical

results proved disappointing, but this was more because of the unsuitability of his data than the unsuitability of his approach.

Hensher (1978) also investigated the application of this model type to residential location choice. He defined the consumers choice of housing options as consisting of four decisions.

Decision 1 - which location
Decision 2 - which type of dwelling
Decision 3 - which occupancy status
Decision 4 - how residentially mobile are the people.

These decisions were seen to fit into a sequence with each stage modelled by the multinomial logit model.

The sequential model discussed by Hensher (1978) took the form

$$P(\ell,e,o,r) = P(\ell)\ P(e/\ell,e)\ \ P(r/\ell,e)\ \ P(r/\ell,e,o) \qquad (2)$$

where $P(\ell,e,o,r)$ = the probability of choosing location ℓ, establishment type e, occupant status o, and residential mobility level r.

$P(\ell)$ = probability of choosing location ℓ from choice set L

$P(e/\ell)$ = probability of choosing establishment type e from choice set E given choice of location ℓ,

$P(o/\ell,e)$ = probability of choosing occupant status o from choice set O given choice of location ℓ and establishment type e,

$P(r/\ell, e,o)$ = probability of choosing residential mobility level r from choice set R given choice of location ℓ, establishment type e and occupant status o.

Young et al. (1978) suggest that in the light of peoples search behaviour and the probabilistic nature of choice set determination, a sequential model in which the location choice process is divided into two steps is preferable.

i.e. $$p(\ell) = p(s,a) = p(s)\ p(a/s) \qquad (3)$$

where $p(s)$ = probability of choosing sector s from choice set S

$p(a/s)$ = probability of choosing area a from choice set A given choice of sector s.

Ben-Akiva and Koppelman (1975) in justifying simultaneous models state that with the sequential model, the problem arises of defining a generally acceptable sequence which can be used to model the entire population. However, the problem of limiting the number of alternatives* in a simultaneous model to an acceptable and realistic level make the sequential model a more feasible option.

Although these models have only recently been applied to residential location choice, their development in the mode choice and destination choice areas has been based on sound behavioural assumptions (McFadden (1978)). This, associated with these models' ability to treat people's budgeting constraint and limits on the supply of housing in a rational manner, make this approach more attractive than the implicit price approach outlined earlier. It is therefore used in the empirical section of this study.

A third modelling approach has also been used by some researchers. This questions the non-hierarchical approach of introducing characteristics into the logit model and its assumption of independence of alternatives. This approach known as elimination by aspects, defines a choice by progressively eliminating unsuitable alternatives due to their unsuitability with respect to certain characteristics. Brown and Moore (1970) applied this model to residential location choice by allocating upper and lower limits of acceptance to particular characteristics. The decision maker then orders these characteristics according to their importance and proceeds to eliminate those areas which are unacceptable for each of the characteristics in decreasing order of importance. Tversky (1972 a, 1972 b) made the model more behaviourally sound by changing the Brown and Moore model from a deterministic into a probabilistic one.

This model is often seen as a method by which decision makers reduce many of the possible location choices available to them to an acceptable level. However, the reliance on particular aspects may be a simplification of the problem. Decision makers may group a number of characteristics together and use these factors as a basis for eliminating alternatives using a similar decision process as has been outlined in equation 2. Such considerations require further investigation as does the elimination by aspects model.

* Lerman included six possible locations, three levels of car ownership, two choices of mode and four house types in his model thus making the respondents compare 144 alternatives.

The final decision rule to be considered here states that people, rather than trying to obtain the best solution, only look for a satisfactory solution (March & Simmons (1958)). Decision makers are thought to accept the first alternative which provides a given level of satisfaction. This model appears to fit people's observed search behaviour well. The short search period (usually 1-2 months) and the limited area covered could not provide any decision maker with the complete knowledge required to make the best possible choice.

Possibly the main problem with applying this model within a mathematical framework is the difficulty of determining what is an acceptable level of satisfaction. One approach may be to use the logit model to determine the utility function using only the alternatives considered in the search. Since only the alternatives looked at are incorporated into the model the utility function is a measure of the acceptable level of satisfaction. The task of determining each of the alternatives considered in the search by enough people to result in the required overlap of alternatives, is an onerous task and unlikely to be attempted in the near future.

Each of the four approaches to determining the decision rule offer some attractive features. However, the logit model because of its theoretical basis and strong empirical grounding, has been used in the empirical section of this paper.

NATURE OF DATA

As has been mentioned earlier, one of the main problems facing individual choice modellers is the lack of suitable data. To make this problem even more acute, there has been much debate among choice modellers as to what determines a suitable data set.

Two distinct fields of thought have developed. The first opts for the use of traditional macroscopic measures such as travel time, cost, etc., while the second view is that people's perceptions of system attributes offer more insight into the choice process. For the first side Hartgen (1974) found that perceptions accounted for only 20% of the explained variance in travellers modal choice while income and automobile ownership explained the remaining 80%. Dobson and Kehoe (1974) reported similar findings.

Perceptions have however, been used by many researchers (Hensher (1972) Brown (1976) Dobson & Ticher (1976) Nicholadis (1977) and have been found to enhance the prediction obtained.

In the residential location studies outlined in the previous section none of the studies have incorporated attitudinal variables. This severely limited the number and variety of the factors which could be investigated by the models and made it impossible to investigate variations in people's perception with respect to their knowledge of the alternatives.

This study was designed to investigate the influence certain characteristics have on the decision to locate within the urban region. Since people's knowledge of the alternatives available to them has been deemed an important determinant of this choice process the measures incorporated in the models must be sensitive to people's perceptions of alternative locations. Perceptual measures have therefore been used in this study.

THE EMPIRICAL STUDY

The general model developed in equation (2) and (3) of this study used the directional bias of people's knowledge to suggest that the choice of a location in which to live should be considerd in two stages. The first is the selection of a suitable sector, while the second is the choice of an area within the sector. In the empirical section of this paper an investigation of the decision rule used by people who are familiar with the alternative areas in a sector is compared with the decision rule used by people who are not familiar with all the alternative areas in order to investigate the influence that knowledge has on the factors influencing the decision.

Measurement of Attitudes

Models combining people's attitudes towards the characteristics describing a "good" have been the subject of many studies in the transport planning field. Brown (1977), Hensher & Currell (1975), Fishburn (1967) have shown preference for a linear additive function where the attitudes towards a particular characteristic is given by the combination of the peoples value structure (the importance they place on a certain attribute) and their evaluation of the quality of the characteristics as offered by the good (in this case, their satisfaction with the quality of attribute provided in an area):

$$V_i = \sum_{k=1}^{m} I_k \; S_{ik} \qquad (4)$$

where I_k = the importance of characteristic k in choice process.

S_{ik} = level of satisfaction with characteristics k for alternative i.

m = number of characteristics.

Golob (1972), and Golob and Dobson (1974) have reviewed the pyschological scaling techniques useful in quantifying these attitudes. These articles and the work of others (Brown, 1977; McLeod 1975)have pointed to the use of semantic scaling techniques as a useful method of measurement.

Survey

As has been highlighted in an earlier section of this paper, data suitable for testing models of residential location choice has been unavailable. No model as yet has been calibrated using attitudinal data. The present study therefore set out to collect such a data set

The study focused on three outer suburban area in Melbourne (Figure 1.). They were chosen so as not to be vastly different in physical and social space as well as being located along the same major transport link (for further details see Young et. al. (1978)

New residents from each of these three areas were then interviewed and measures of their perception of the suitability of each area as a possible location were obtained. The respondents were asked to rate on 100 point semantic scales, how satisfied they thought they would have been with each of the factors shown in table 1, had they located in each of the three areas. They were also asked to rate on 100 point semantic scales how important they thought each of these factors was in their decision to locate.

As well as the respondents perception of the areas it was necessary to obtain a measure of their knowledge of the areas in question. Several methods have been used to measure knowledge. Gould and White (1974) and many researchersfollowing them asked the respondents to draw maps of the area of interest and the number and type of errors found in these maps was used as measure of the accuracy of people's knowledge.

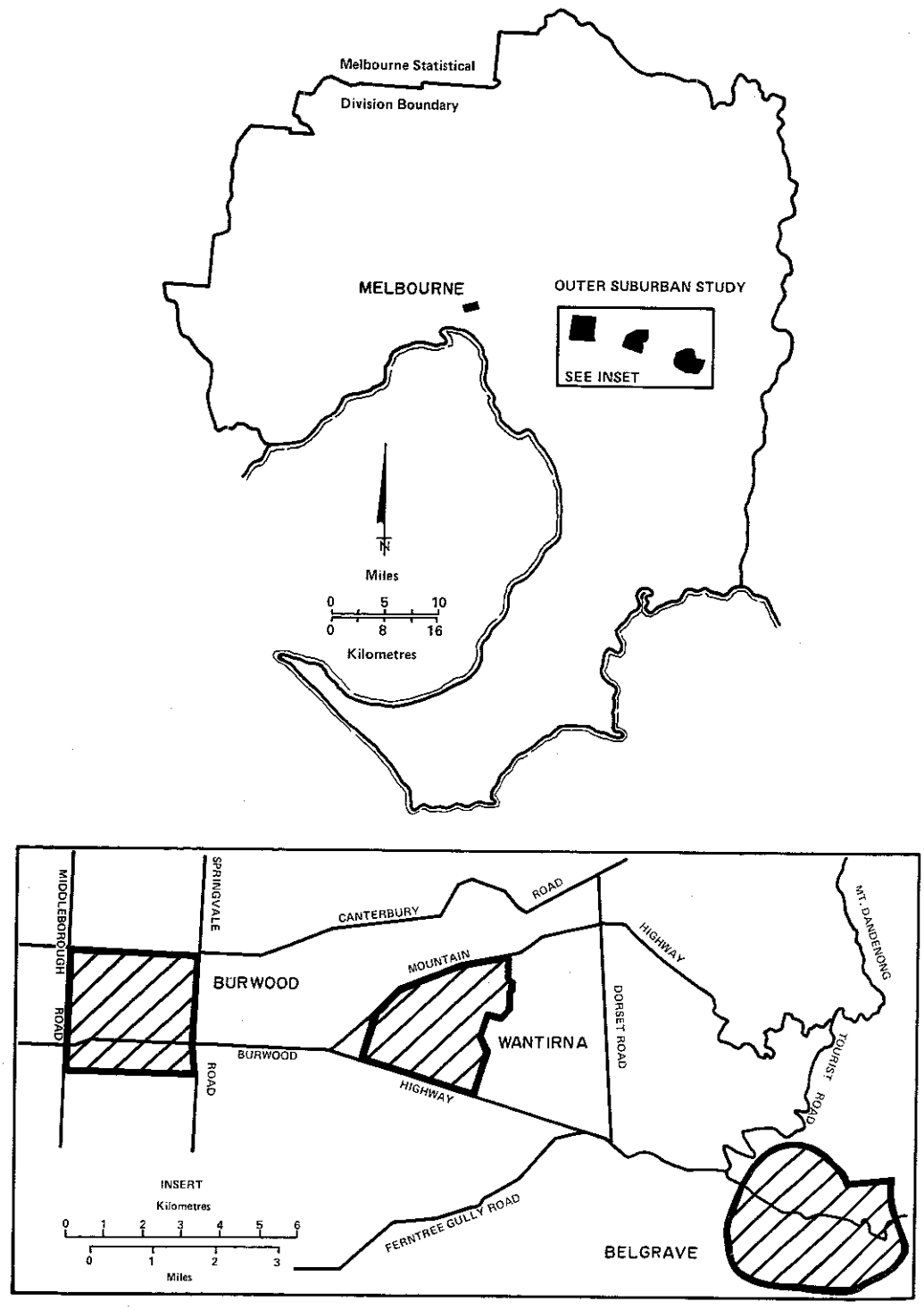

Fig 1 — Location of the study areas

Brown et al (1977) asked people to list the areas they knew in a given region and used this as a measure of their awareness space. In this study, a measure was obtained by asking people to rate their level of knowledge on a hundred point semantic scales with the extremes described by the words "very well" and "not at all".

In general discussion with many of the respondents it became evident that people were unwilling to say they knew an area if they had not had a great deal of contact with it. Comments like "I've only driven through the area a few times, how am I to know what it is like?" were not uncommon. However, these people still considered to have a view of the area whether it be collected by hearsay, comparison with perceived similar areas, newspapers or the few trips they had made to the area. It was therefore important in the survey that even if the respondent claimed to be unfamiliar with the area, they were still to indicate what they thought the area was like. Hence the study population consisted of people who thought they were familiar with the areas as well as those who thought they were not.

A total of 400 questionnaires were administered in the survey. This sample represented all the people who have moved into each of the three areas in the period September 1977 - June 1978. Information was collected for both the husband and wife in a typical family unit, but for purpose of the empirical section of this paper only the husband will be considered. Later analyses will investigate the interrelationship present in the household decision making process. This paper presents results for only part of the overall study, namely the importance of residents knowledge of the alternative areas on the structure of the model.

Results

Resident's knowledge of areas

A comparison of the people who rated their knowledge of the areas studied as "good" (a score of between 51 and 100 on this knowledge scale) and "bad" (a score between 1 and 50 on the knowledge scale) is shown in table 2. It showed that 29% of the people choosing to live in an area said they did not know the area very well. These people were primarily in the East Burwood and Wantirna areas. In general, the people who decided to live in Belgrave said they had

a better knowledge of the three areas than did the people who decided to live in the other two areas. This may be the result of the Belgrave region being on the outskirts of the city, hence requiring people to travel through the other two areas in order to get to or from Belgrave.

FACTOR	ABBREVIATION
Closeness to present workplace	Work
Closeness to open country	Country
Closeness to entertainment	Enter
Closeness to friends	Friends
Closeness to relatives	Relatives
Closeness to people of same age	Age
Closeness to people of same social level	Social
Closeness to people of same nationality	Nation
Availability of suitable shops	Shops
Availability of suitable schools	Schools
Public transport	Trans
Traffic noise	Noise
Tidiness of area	Tidin
How well buildings are maintained	Maint
How clean the air is	Air
Presence of trees, shrubs, grass	Shrubs
Dwelling type in the area	Dwell
Type of dwelling you can afford	Afford

Table 1. Factors included in study of residential preference.

To test the influence of knowledge on the decision rule, it was necessary to isolate a sample of people who had the required knowledge levels. The total study population was therefore divided into groups depending on whether they knew none, one, two or three of the areas.

Table 3 shows the proportion of people who had a given level of knowledge. It shows that 40% of the respondents said they knew all three areas, 20% knew only the areas they had chosen to live in and 19% said they knew none of the areas at all.

Chosen Location	East Burwood			Belgrave			Wantirna		
Knowledge Level	good	bad	total	good	bad	total	good	bad	total
Area rated by respondent									
East Buwood	75	33	108	73	59	132	55	55	110
Belgrave	37	71	108	98	34	132	50	60	110
Wantirna	37	71	108	70	62	132	75	35	110

Table 2: Respondents rating of thier knowledge of study areas.

People who knew	Total
- all three areas	139
- none of the areas	67
- only area located in	75
- others	69
	350

Table 3: Level of knowledge of study areas.

For investigating choice models, a sample size in order of 140-160 had been used as a lower limit (Lisco (1967), Lee & Dalvi (1970) Hensher & Currel (1975)). The sample population obtained in this study allowed only two models to be calibrated. Hence the respondents were grouped into those people who said they knew all of the areas (the know-all group), while those people who knew only the areas they had located in were grouped with those who said they knew none of the areas (the know-none group).

Model Calibration

Previous attempts to include measures of people's knowledge of the alternatives available to them (Brown et al. 1976) have attempted to do so by incorporating a measure of knowledge into the model as an independent variable. This approach assumes that people who have a reasonable

knowledge of the area will see each of the independent variables in the model in the same light as those who do not know the area. That is to say, the coefficients of the independent variables are influenced by people who know the area as well as people who do not know the area. Hence these coefficients do not represent either group but are indicative of some complex mix of people with varying degrees of knowledge. A more satisfactory approach is to segregate the population into groups with similar levels of knowledge and perception of the alternatives.

The approach used here was to build two models, one for each of the groups considered in the study, and then to compare the model coefficients. The form of the model used has been discussed earlier.

The model (Table 4) shows that the coefficients of most of the factors in the know-all group were insignificantly different from zero at the 5% level. Only closeness to work, schools, friends, dwelling type in the area, presence of trees and shrubs and traffic noise were found to be significant.

In comparison the know-none group had no coefficients which were significantly different from zero at 5% level and had only two coefficients, those of closeness to entertainment and friends which were significant at the 10% level. The low significance of the coefficients and the evidence that people tend not to include such a large number of variables in their choice (Miller, 1956)) resulted in a new model being constructed with included only the seven most significant factors present in either model.

For the second set of models (Table 5) most of the coefficients were significant (5% level). Only closeness to entertainment in both models and presence of trees and shrubs in the know-none model were insignificant. These models demonstrate that although accessibility variables have a significant influence on the location decision process non-transport variables; dwelling type in the area and presence of trees and shrubs in the area, influence the decision process and should be included in studies of residential location choice.

Factor	know all		know none	
	Coefficient (10^{-3})	T. Value	Coefficient (10^{-3})	T. Value
Work	.65	3.02 *	9.66	1.47
Country	.06	.24	3.40	1.45
Enter	.33	1.24	6.15	1.70
Friend	.68	2.10 *	2.57	1.70
Relatives	.46	1.66	0.80	.95
Age	- .02	- .07	- 4.34	- 1.34
Social	.63	1.41	0.84	.42
Nation	.19	.68	4.65	1.29
Shops	.05	.21	2.04	1.36
School	.42	2.22 *	0.83	.87
Trans	.17	.92	- 0.89	- .18
Noise	.44	1.90	3.33	1.47
Tidin	- .39	- 1.38	0.74	.86
Maint.	.16	.58	- 0.42	- .68
Air	.22	1.00	- 0.10	- .31
Shrubs	.78	2.69 *	0.71	1.36
Dwell	.77	2.77 *	8.83	1.39
Afford	.41	1.17	6.58	1.63
Const.	- .36	- .96	- 1.44	.85
- 2log λ	84.51	(18 degrees of freedom)	91.05	(18 degrees of freedom)
no. respondents.	139		142	

* Coefficients significant at the 5% level

Table 4: Choice of location as a function of 19 Variables.

These models were then used as a basis for comparing the decision rules for varying levels of knowledge. Three tests of the interchangeability of the models were undertaken. The first test compared the rank order of the significance of the co-efficients of each model. Spearman's rank order correlation showed that there was a significant variation (5% level) between the two rankings obtained, hence inferring that the influence of each factor was different for each of the decision processes. However, a second test was carried out to investigate if there were a significant difference in the magnitude of the coefficients. This t-test showed that the magnitude of the coefficients was not significantly different suggesting the opposite conclusion to that of the rank order test.

The final test used compared the prediction made by the two models when the data used to calibrate it and the alternate data set were both input into the models. A comparison of the the prediction from each of the four possible combinations (Table 4) showed that there was little difference in the predictions made by each model when either data set was used.

Hence the models show that the decision rule used by each of the groups was not significantly different. Therefore, notwithstanding that people were unfamiliar with the alternatives in their sector of interest, their perception of what they thought they were like enabled them to compare the alternatives using a similar decision criterion. The need for segregation of people by their level of knowledge of alternatives when comparing alternative in their sector of interest, therefore, seems unnecessary.

	KNOW ALL			KNOW NONE		
	Coeff. (10^{-3})	T. Value	Rank Order	Coeff. (10^{-3})	T. Value	Rank Order
Work	.311	2.19 *	6	.542	2.62 *	4
Enter	- .104	- .54	7	- .041	- .12	7
Friends	.834	4.09 *	1	1.029	3.63 *	4
School	.546	3.52 *	2	.442	2.41 *	5
Noise	.622	3.44 *	3	.527	3.15 *	3
Shrubs	.479	2.75 *	5	.185	1.67	6
Dwell	.642	2.86 *	4	1.230	4.05 *	1
- 2 log λ	-54.01	(6 degrees of freedom)		- 45.81	(6 degrees of freedom)	
no. respondents	139			142		

* coefficients significant at the 5% level

Table 5: Choice of location as a function of 7 factors.

CHOSEN AREA	DATA USED	KNOW ALL					
	MODEL	KNOW ALL			KNOW NONE		
	ALTERNATIVE AREA	BUR	BELG	WANT	BUR	BELG	WANT
BUR	Correct		27	25		28	26
	Incorrect	-	(4)	(6)	-	(3)	(5)
BELG	Correct	57		58	49		50
	Incorrect	(10)	-	(8)	(18)	-	(16)
WANT	Correct	36	36		36	38	
	Incorrect	(5)	(5)	-	(5)	(3)	-
	DATA USED	KNOW NONE					
	MODEL	KNOW ALL			KNOW NONE		
	ALTERNATIVE AREA	BUR	BELG	WANT	BUR	BELG	WANT
BUR	Correct		39	39		41	40
	Incorrect	-	(6)	(6)	-	(4)	(5)
BELG	Correct	53		51	51		49
	Incorrect	(4)	-	(5)	(6)	-	(8)
WANT	Correct	29	33		28	35	
	Incorrect	(11)	(7)	-	(12)	(5)	-

Table 6: Comparison of prediction of models using both data sets.

CONCLUSION

Behavioural choice models have been found to throw considerable light onto people's choice of mode of travel and destination choice. This paper has discussed another application of these models - residential location choice - and has investigated the choice process in the light of research in the areas of urban geography and transport planning. the model proposed enables investigation of the level of knowledge decision makers have of the urban environment, as well as providing a framework for investigating the part non-transport variables play in the location decision.

The model was first used to investigate if respondents with different levels of knowledge of the alternatives available used different factors to determine the suitability of alternate locations. It was found that both the people who thought they knew each of the areas, used the same decision rule. That is, even though the respondents were unfamiliar with the alternatives in their sector of interest, their perception of each area enabled them to compare the alternatives in a manner similar to the respondents who had a good knowledge of the alternatives.

The model also pointed to non-transport related variables such as dwelling type and the presence of trees and shrubs in the area as influencing the location decision, highlighting the need to include such variables in analyses of the residential choice process.

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