LOCATION BEHAVIOUR AND THE JOURNEY TO WORK

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SUMMARY

The journey to work arises as a result of two basic location decisions (where to live, and where to work), yet most mathematical models of commuting journeys concentrate on describing the journeys rather than the location decisions that give rise to them. This lack of a behavioural basis in conventional models of trip distribution may give rise to rather weak predictive ability.

In the paper, it is argued that the main factor affecting the spatial relationship between home and work-place, and hence the pattern of journeys, is the definition of the search space for a home (for those with a job), or for a job (for those with a home). The absence of travel time or cost as an important factor in choosing where to live leads to the proposition that an individual's choice of home (of a given type) is in effect random (ie, independent of location), within his or her search area. There are three main research issues arising from this proposition. The first is to define the extent of the search area for individuals of different characteristics, and the relationship between the characteristics of the worker (and family) with characteristics of the houses. The second is to investigate evidence for the basic hypothesis that, within the search area, "distance is no object". The third is to bring these two strands together to form a coherent model for the journey to work.

On the first two research issues, the authors present findings from an exploratory study of the search process for those buying a home in the Humberside region. The concept of a "tolerable range" of travel times is used to define the search area. The tolerated range is shown to be dependent on certain characteristics of the household. A follow-up survey enabled the tolerated travel time to be compared with the travel time that was realised for the home eventually chosen. For tolerated travel times less than 30 minutes, it was found that the realised travel times were broadly consistent with our hypothesis (ie, that, within the tolerated range, the final choice of home is approximately random). For tolerated travel times greater than 30 minutes, it was found that the realised values were approximately equal to the tolerated values.

On the third research issue, the basic structure is given of a new form of model for the journey to work that is based on the above proposition.

1. INTRODUCTION

The journey to work is an outcome of two basic location decisions - where to live and where to work - yet most mathematical models of the journey to work concentrate on describing the journeys rather than the locations decisions. Indeed, to the author's knowledge, the only model used in practice that is presented from the latter perspective is that of METRA (ca 1967). In this, the population of employed people were regarded as consisting of three groups:

(i) a proportion, α, who were selecting a home having got a job

(ii) a proportion, β, who were selecting a job having got a home

(iii) a proportion, $1-\alpha-\beta$, who were selecting home and job simultaneously.

The first and second of these groups were assumed to have their location choices represented by a distance decay effect, expressed in two singly constrained gravity models. The third group was assumed not to be influenced by distance in its choice, but was distributed in proportion to the numbers of homes and jobs in each zone in such a way as to ensure that the numbers of home-work trips beginning and ending in each zone were consistent with the numbers of employed residents and jobs.

However, the METRA model limits its recognition of the differences in location behaviour to this structural disaggregation; it shares with the gravity model the general defect of not having any empirically supported behavioural rationale.

It is contended in this paper that a useful and perhaps more realistic journey to work model might be evolved by:

(A) distinguishing between different types of location decision

(B) considering the search processes involved.

For (A), METRA's categorisation of home/workplace decision-making is insufficiently refined for our purposes. Ignoring transitional or *pied à terre* arrangements, the 'journey to work' can arise from different sequences of location decisions, thus:

(i) change in work place, but not as a consequence of changing house

(ii) change in work place, consequent upon a change of house

(iii) change in home location, but not as a consequence of a change in job

(iv) change in home location, consequent upon a change in job.

Note that we do not regard a 'simultaneous' choice of home and work place as being a realistic proposition: one or other will always be chosen first, though of course the changes might occur very close in time to one another. Also, for a household with two or more employed, more than one of the above home-work relationships may be operating at the same time. In the rest of the paper we consider the distribution that arises for relationships established by changes of types (iii) and (iv). Equivalent formulations based on job search hypotheses will be more difficult to formulate, since the issues involved are more complex.

The basic hypothesis for a new model, and the contribution that the migration and residential mobility literature can make to this hypothesis, are briefly reviewed in

Section 2 with the model being explained with an example in Section 3. Section 4 reviews some of the literature on search behaviour, and Section 5 presents the results of an empirical study that investigated the basic hypothesis. Section 6 concludes by raising some points for further consideration.

2. BASIC HYPOTHESIS AND BACKGROUND STUDIES

Our basic hypothesis is that, for transport planning purposes, the home-work trip distribution pattern for those householders whose house choice comes after their job choice may be described by the combination of two factors:

(i) the area over which they decide to carry out their search

(ii) the distribution of houses of a suitable type in this area

such that, on average, the outcome of the actual choice of house within the search area is random; that is, within the search area, travel distance (or time or generalised cost) on the return journey to work is no object.

That the approach might be worth developing was suggested by the fact that nearness to work was not very often cited in the literature as an important factor affecting home location, and neither is it an important factor affecting people's decisions to move home. (For example, the General Household Survey in Great Britain showed that, whilst some 14 percent of householders move house because of a change in job, only two percent of householders move in order to be nearer work.)

Although there is a considerable literature on migration and residential choice, comparatively little relates to these questions. This is mainly because the focus of interest is different, namely:

(a) the factors affecting the decision to move

(b) the factors affecting the choice of new home

(c) the relation between the location of the new home and the location of the old home (ie migration flows),

whereas the focus of this paper is on

(d) the relation between the location of the (new) home and the location of the (old or new) job

from the perspective of (a) or (b).

Studies of intra urban migration have tended to concentrate on investigating how residential mobility (that is, the propensity of individuals or groups to move house over a given period of time) varies with such factors as household size and composition, income, occupation, and type of tenure.

Studies of inter urban migration (and of labour migration, in which both job and home change), have tended to concentrate on analyses of the change in job rather that the change in home location.

Studies of factors affecting the new home location have distinguished between: the household's aspirations; the search behaviour; and the decision process, given the various constraints and trade offs possible, but have tended to concentrate on the first

and last of these, studying the influence of such factors as size and condition of house.

However, for transport planning purposes, such detailed considerations may not be needed to formulate an adequate destination choice model. We contend that this choice process is effectively represented by self-imposed limits on:

(a) the range of house prices (and possibly types) a mover is prepared to consider

(b) the geographic extent of the area of search;

and that the final outcome is, within these constraints, effectively random, being dictated by a whole host of issues whose individual outcomes are random in nature. These include: what houses come on the market; whether information is acquired about them; the condition of the house; its neighbourhood; its relation to work place, shops, schools; the type, size and condition of garden; the purchase price; other related purchases; competition from other prospective purchasers; availability of finance; success in selling own house etc.

This approach thus recognises the effect of the constraints on the choice of a home in part by expressly incorporating them, and in part by averaging them out. In this respect, we therefore avoid some of the strictures that Lyon and Wood (1977) have made concerning more detailed approaches to the study of housing choice.

The basic concept that people's search behaviour is limited in extent was put forward by Brown and Moore (1970), who supposed that the migrant's knowledge of the possibilities was the principal constraint on the search pattern. (This set of possibilities they termed an 'awareness space'). Knowledge of these would be derived both from previous direct contact with relevant locations, and indirect contact as a result of acquiring information from acquaintances, newspapers, estate agents, advertisements etc. Within this awareness space, the actual search for vacancies would be undertaken only for those locations which the migrant perceived as likely to satisfy his aspirations for a new home (the search space). Thus, by considering houses of a certain type or price and a search area of a certain extent, we have a mechanism that corresponds to the Brown and Moore framework; it also relates to the "elimination by aspects" framework of Tversky (1972). Related work includes that of Weibull (1978), Phipps and Meyer (1985) and Smith (1985).

At this point we clarify the ideas developed so far by an example, and postpone to Section 4 a further review of the concept of the search area.

3. OUTLINE OF THE MODEL

Suppose that a group of workers are searching for homes within a certain range of their job-locations. The range will vary amongst them, and the kinds of house that they are likely to consider purchasing will be dependent on both the income associated with the new job, other household income, stage in the family life cycle etc. We make the simplifying assumption that the workers can be grouped by their income, or by socio-economic group, such that this grouping characterises the kinds of house they

wish to move to, and characterises their search behaviour.

Thus workers in group n whose jobs are located in a zone j search for a suitable house from amongst all those on the market of housing type n. We assume their search is conducted in principle in any direction from zone j (their *actual* patterns of search being of course influenced by the spatial distributions of the sort of home they want to live in); and that they consider housing opportunities only up to a range r from their jobs, this range having a probability density distribution for workers of type n given by the 'range function' $p_n(r)$.

An interpretation of the meaning of the range function can lie anywhere between two extremes:

(i) the probability of each individual of type n choosing a house up to a range r from his home is given by $p_n(r)$ (the same function for all individuals of this type)

(ii) each individual has a specific range within which he confines his search, but this range is different for different individuals in the group of type n, such that the proportion of individuals of type n who confine their search to a range r is given by $p_n(r)$.

For generality, we suppose the range to be expressed in units of generalised cost, although it is possible that detailed investigation may reveal that time alone is sufficient to characterise people's search behaviour. A single range function is used, whatever means of travel is considered in the determination of the search area.

Essentially, all that the model requires is the following aggregate data:

E_{jn} = number of persons of group n newly employed in jobs in zone j

H_{in} = number of houses (in total) of type n in zone i

C_{ij} = the generalised cost of travelling to work at j from a home in zone i by the mode which the worker expects he may (have to) use.

Prediction in which the function $p_n(r)$ is known, is a straight forward process, and is best illustrated by the following example (in which subscripts n are dropped for clarity).

Prediction example

We are given the zone to zone cost matrix:

Work Zones	Home Zones			
	Zones	L	M	N
	A	5	10	15
	B	10	5	15
	C	15	10	5

and numbers of houses and home-seeking workers:

Zones	L	M	N	E_j
A				100
B				100
C				300
H_i	200	50	250	500

The range function has p(r) = 0.4 for $cij \leq r = 5$
= 0.5 for $cij \leq r = 10$
= 0.1 for $cij \leq r = 15$

Consider workers with a job in zone A. A fraction 0.4 consider houses up to 5 units away; only houses in zone L are that close, so all are considered. A fraction 0.5 consider houses up to 10 units away; this includes houses in both L and M, and of these a fraction 200/(200+50) are in zone L; by our hypothesis of random choice, therefore a further 0.5x200/250 of the 100 workers in A try to find a house in zone L. Finally, a fraction 0.1 consider houses up to 15 units away; these include zones L, M and N, and so a further fraction 0.1x200/(200+50+250) try to find a house in zone L.

The results of similar calculations give:

$.4x1 + .5x\frac{200}{250} + .1x\frac{200}{500}$	$.5x\frac{50}{250} + .1x\frac{50}{500}$	$.1x\frac{250}{500}$	x100
$.5x\frac{200}{250} + .1x\frac{200}{500}$	$.4x1 + .5x\frac{50}{250} + .1x\frac{50}{500}$	$.1x\frac{250}{500}$	x100
$.1x\frac{200}{500}$	$.5x\frac{50}{300} + .1x\frac{50}{500}$	$.5x\frac{250}{300} + .1x\frac{250}{500} + .4x1$	x300

that is:

Zones	L	M	N	Sum	E_j
A	84	11	5	100	100
B	44	51	5	100	100
C	12	28	260	300	300
Sum	140	90	270	500	
H_i	200	50	250		500

This describes the basics of a new model. In this form, it is only a singly constrained model. The basic hypotheses are such that it is possible that a model could be so formulated as to satisfy both home and job constraints simultaneously. It would however need a dynamic framework to achieve this.

Note that we do not assume that the means used for travelling to work after the move is the same as that which conditioned the definition of the search area. For example, a suitable house might be found very near the work place, so enabling the worker to walk to work; but the search may have been conducted on the supposition that the individual might have to drive to work.

4. DEFINING THE SEARCH AREA

Brown and Holmes (1971) appear to have been the first to study the search behaviour of the intra urban migrant. They suggested that studies of urban awareness space (*ie* the places people knew about) and urban activity spaces (*ie* the places people went to) would give some insights, and investigated the directional, distance and sectoral biases in such 'spaces'. The biases in distance perception that occur (Day, 1976; Pocock, 1978) have given rise to the concept that different people have different mental maps of their locality; the role of such mental maps in influencing search behaviour needs to be understood. However, it is the biases in people's perception of time rather than of distance that is important in transport, and unfortunately little has been written from this viewpoint. Moreover, since some directional biases encountered in distance perception are accounted for by differences in travel times, interpretation of the literature on 'cognitive distance' is difficult in the absence of speed information.

An investigation of the vacancies actually considered by a group of movers was carried out by Barrett (1976), who attempted to quantify the concept of search area by studying the distances between the vacancies actually considered. His results suggested that the vacancies inspected were very close; only about two per cent of the trial group of movers had search clusters of more than five miles. However, his approach had its limitations, since the vacancies were of those *actually* inspected, which might therefore define a smaller (and possibly biased) area compared with that defined by the vacancies that one could inspect (ie those in the 'search space' of Moore and Brown). Davey (1978) did ask respondents for information on all the areas they considered, and reported that 35 percent considered areas beyond five miles from their chosen house.

4.1 Possible shape of a search area

Of course, the concept of range as described in Section 2 and used in 3 is only a reasonable one if there is a single point which acts as the focal point of the search area. Inter urban or labour migrants are those who are most likely to have such a monocentric search area, since for many of these the area will be unfamiliar, and so the site of the work place will be the one which is most likely to be taken as the reference

point in the search process. Assuming the range is defined in terms of units of time, isochrones about a given job location will not of course be circles unless the speed distribution is radially symmetric about the centre. Intra urban migrants are likely to have a more complex search area, perhaps one which reflects their more detailed knowledge of parts of the town; and this will almost certainly have more than one focus, such as the present home and job. Elliptical or ovoid shapes may arise in the case of a uniform speed distribution. Brown and Holmes (1971) fitted ellipses to describe search patterns in their study.

5. AN EMPIRICAL STUDY

In his study of accessibility preferences in residential location decisions, Raji (1987) adopted an approach which enabled the appropriateness of these concepts to be explored. He supposed that, when searching for a new home, people had critical thresholds of travel-time which they did not wish to exceed. He investigated what these 'tolerable limits' of travel time might be for accessibility to three different activities (work, shops and schools). Thanks to the co-operation of a firm of estate agents, 1332 questionnaires were distributed between July 1984 and February 1985 to those registered as seeking homes in the Humberside region. Overall, a response rate of 33 percent was obtained. For the hypotheses explored here, the key question was:

> "What is the *maximum acceptable travel-time* that the appropriate members of your household would be prepared to spend to reach each of the following from your new home? Please *indicate in minutes* under the one main particular means of transport expected to be used regularly."

Only 258 questionnaires could be used, since many did not answer this key question.

Other questions on factors that might affect the search process covered:

- type of accommodation, preferred locality, and distance from present home
- whether any member of the household was changing jobs
- importance of proximity to work, shops and schools; and the respondent's interpretation of accessibility
- car availability, and the use of public transport and of cars to work
- household composition: number of employees, school children, pre-school children, retired person etc.

The information from the questionnaire was supplemented by information from the estate agents own records, covering:

- target price of a house (including maximum and minimum)
- minimum number of rooms.

The approach taken had the advantage over previous studies in that it was undertaken whilst people were actively searching for a new home rather than afterwards. Thus it provided an indication of behavioural intention, and avoided the risk of retrospective justification of choices made. It also enabled a follow-up study to

be made.

A follow-up study was conducted in January and February 1986, primarily to enable the actual travel-times 'realised' upon choice of a home to be compared with the tolerated travel-times. A total of 48 returns were received, from the 258 in the first study. (A large proportion, 60 percent, were returned by the Post Office as "gone away".) Given such a small sample from the follow-up study, the question arose as to whether it is representative of the original sample. To investigate this, the distributions of the tolerated travel times in the two samples were compared, and are illustrated below.

5.1 Findings

From the point of view of the hypotheses discussed in this paper, the main findings of interest were the information obtained on the probability distribution of tolerated travel-times, and the relationship between these and the realised travel times, for accessibility to work. (See Raji 1987 for accessibility to shops and schools.) The complementary probability distributions for the tolerated travel times are shown in Figure 1. These decline with travel-time, as one would expect. (The closeness of agreement between the original sample and the follow-up study are also apparent here.)

The relationship between realised and tolerated travel times is shown in Figure 2. Neglecting the three people who worked at home, the plot shows that, as one would expect, realised travel time is generally less than tolerated travel-time, but only up to about 30 minutes. Beyond that, the realised time is approximately equal to the tolerated time. This suggests a difference in pattern of behaviour. Those who tolerate a high travel-time, seek it. Perhaps members of this set had a non-zero value for their *minimum* tolerated travel times; but this aspect was not investigated in the study.

Clearly, for tolerated times greater than 30 minutes, the empirical evidence does not support the hypothesis that, within this threshold, people's actual choice of home may be treated as random. For times less than 30 minutes, the proposition appears to be more tenable. This was tested in the following way. Suppose that potential homes are uniformly distributed about one's new work-place, up to a tolerated value T. Then the hypothesis that a home is chosen independently of travel-time would imply that the expected value of travel-time realised is $2T/3 = 0.67T$. Hence, for $T<30$, a linear regression of realised time, R, against tolerated time, T, was undertaken. In the relationship $R = \mu T$, the coefficient μ was estimated as 0.75 ± 0.08. Hence, the results were not inconsistent with the basic hypothesis (under the simplifying assumptions.)

Further estimates were obtained by disaggregating the data. This showed no difference in the estimates of μ for those choosing a home south of the river Humber from those choosing a home north of it. A difference was however found between households with two or more employees, for which $\mu = 0.64 \pm 0.13$, and households with one employee, for which $\mu = 0.86 \pm 0.09$. The latter group had lower tolerated values than the former, and their thresholds may have been unrealistically low in the first place.

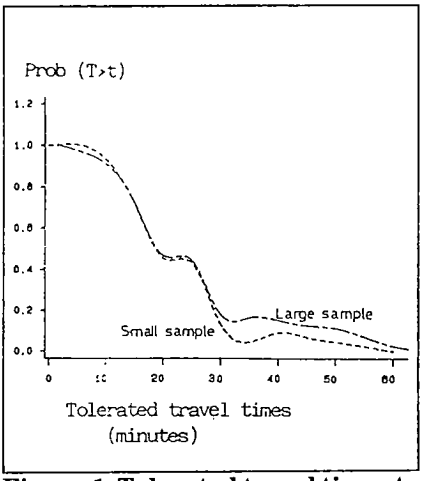

Figure 1: Tolerated travel times to work

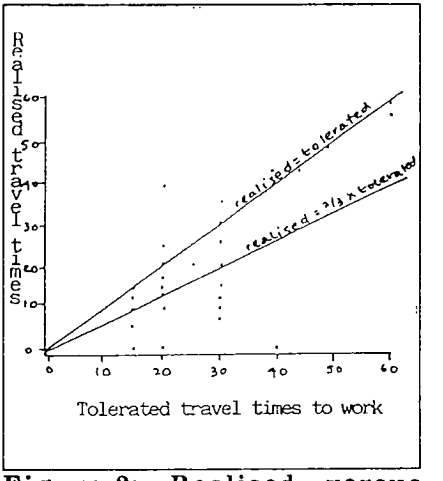

Figure 2: Realised versus tolerated times

6. CONCLUDING REMARKS

We have presented a new, aggregate-level but behaviourally based approach to modelling commuter journeys. It is based on the recognition that these derive from location decisions. The approach requires a method for defining the search area. In this respect, it has similarities with the concept of "choice sets" in disaggregate (individual) models of destination choice. Unlike these models, it is formulated directly for operation at the aggregate level, which is the level at which results are required for transport planning practice. Its hypothesis that, within the search area, people are indifferent to the actual travel times, is not dis-similar to the postulate put forward by O'Sullivan and Ralston (1978), that differences between different destinations at varying distances were only perceptible when they exceeded some tolerance level. Stetzer and Phipps (1977) advocated similar hypotheses to those used here, but from the point of view that, under certain simplifying assumptions, they gave rise to the gravity model. Our own results, however, are presented not from the point of view of attempting to justify an existing model but of suggesting a fresh examination of the appropriate modelling strategy.

The empirical study that was undertaken showed how the maximum acceptable travel-time to various activities varied amongst house-hunters and provided estimates for the way the frequency distribution of the critical threshold reduced as the time increased. The most important empirical findings were the evidence that:

- those with a higher travel time tolerance (> 30 mins), went up to that limit;

• those with a lower travel time tolerance, were indifferent to the actual travel time. The latter finding supported the main contention of the model: that, within the search area, "distance is no object".

The model outlined in Section 3 may be developed in a number of ways. For example, it is only a singly constrained model. It might be possible to derive a doubly constrained model from a behaviourally reasonable rationale. Disaggregation of the housing type/price data may be necessary to reflect housing choice in particular local circumstances. The method of allocating movers over the available houses in their search area (*ie* in proportion to the numbers of houses) may be quite inadequate in a static model, because competition from different job zones will affect the rate at which vacancies are filled, and thus the chances of any one individual buying a house in a given period of time. The approach might therefore be better formulated as a dynamic model. This would enable mobility rates to be used to estimate the proportion of different types of household who move house in a given time period. The length of time for which houses are on the market, and the length of time spent searching for a home, are all complicating factors which can probably only be treated adequately in a dynamic model.

Further evidence for the shape of the search area and for the values of the range function needs to be sought. If it is assumed that a simple range function, centred on each job zone, suffices for a given type of worker, it may be possible to estimate appropriate values for the range function by calibrating it to home-work data. It is possible that, for large sparse matrices, a model of the type outlined may be more efficient in its use of data and/or less demanding in computational terms, compared with conventional trip distribution models.

Whether in the simpler form introduced in Section 3, or in a more complicated and possibly dynamic framework postulated above, the approach has the merit of having a sounder behavioural basis than existing aggregate models of the journey to work, without the demerits associated with disaggregate models of destination choice.

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