TYÖVÄEN TALOUDELLINEN TUTKIMUSLAITOS
LABOUR INSTITUTE FOR ECONOMIC RESEARCH

TUTKIMUSSELOSTEITA 22
DISCUSSION PAPERS 22

HEIKKI LOIKKANEN

A LOGIT MODEL OF INTRA-URBAN MOBILITY

HELSINKI 1982

TYÖVÄEN TALOUDELLINEN TUTKIMUSLAITOS
LABOUR INSTITUTE FOR ECONOMIC RESEARCH

TUTKIMUSSELOSTEITA 22
DISCUSSION PAPERS 22

HEIKKI LOIKKANEN

A LOGIT MODEL OF INTRA-URBAN MOBILITY[1]

[1] The results of this paper were presented at "Economists' Days", March 4-5, 1982, in Turku, Finland.

Helsinki 5.5.1982

CONTENTS

A LOGIT MODEL OF INTRA-URBAN MOBILITY

by

Heikki Loikkanen

Abstract

In this paper we present results of a logit model which is used to explain the mobility of new Finnish housing allowance recipients during the three years after becoming eligible. As our theoretical framework we use a search model developed by the author elsewhere. In that model the household faces an imperfect market for rental housing and a perfect market for non-housing. The imperfections of the housing market include rent dispersion, imperfect information, search and transaction costs, availability uncertainty etc. In that framework household equilibrium can be expressed as a set in housing quality and rent space. If the household's present unit belongs to its equilibrium set it does not search (and vice versa). The optimal policy of a disequilibrium household (searcher) can be expressed by its acceptance set in housing quality and rent space. In our empirical application we first solve what is the best stochastically attainable housing size (instead of quality) and rent combination for each household. Then we construct a distance measure from that point to each household's initial housing size and rent combination. By using our distance measure in explaining mobility we get as a result estimates of the boundaries of the equilibrium sets, and of how the probabilities of moving develop outside the equilibrium set.

1. INTRODUCTION

There are two alternative ways of undertaking major changes in the single most important component of consumer expenditures, namely housing. One is to invest (or disinvest) in the present dwelling. The other, and the far more important one, is to change housing consumption by moving. Understanding of households' mobility behaviour is important not only for housing demand analysis, however, since the aggregate outcomes of residential mobility are of interest e.g. for urban planners and transportation economists.

The purpose of present study is to estimate the probabilities of moving for a sample of Finnish housing allowange recipients. The housing allowance involved can only be obtained by renter households who have very limited possibilities of changing the characteristics of the dwellings they occupy. Accordingly, the realization of one object of the housing allowance system, improving the recipients' housing conditions, crucially depends on their mobility behaviour.

The decision on what kind of empirical analysis to employ in mobility analysis should be related to an underlying model of household behaviour. Next, we survey alternative theoretical frameworks used in past analyses. First we refer to standard "textbook" demand theory which has been used to analyze housing demand. There, assuming perfect markets for all commodities involved and no transaction costs, the optimal housing consumptions are derived as if moves took place "over-night" as responses to changed initial conditions.

Here, the mobility aspect has no explicit role to play. The empirical counterpart for our housing allowance case, corresponding to this approach, would be the following. Assume that the housing allowance only changed the price of housing faced by the recipients. Then, one could use existing evidence on price elasticities of housing demand to estimate changes in housing consumption. Implicitly this procedure assumes that all households which get the allowance also move.

A second approach is to concentrate on the mobility aspect by describing average moving probabilities for households with varying characteristics without any explicit underlying behavioural model. Most of the literature on intra-urban mobility seems to be of this type since the basic argument of Quigley and Weinberg /1977/ in summarizing the material of more than one hundred studies is that (p. 42) "there are many inconsistent findings on the correlates of residential mobility in urban areas. Surprisingly, however, this ambiguous evidence is not inconsistent with the current state of the theory of mobility - suggesting the largely tautological nature of theory itself". Later, commenting on the theoretical perspectives of the mobility studies surveyed they note (p. 49) "these theories provide little in the way of specific hypotheses or variable propositions - indeed, it is hard to conceive of how a household's choices about residential mobility could fail to be consistent with the a priori descriptions in the literature".

At the end of their article Quisley and Weinberg themselves offer a "synthesis model" the idea of which is to derive income equivalents of disequilibrium for individual households which then are used to explain mobility behaviour. The basic idea is summarized by the following: if the dollar value of the benefits derived by moving to a new dwelling unit exceed the costs associated with a move, a household will be more likely to move. Although the authors discuss housing market imprefections and related transaction costs, they hoever do not present any explicit behavioural model. Instead in deriving their income equivalent of disequilibrium they use an equilibrium demand function which assumes e.g. equilibrium housing prices ruling out the possibility of rent dispersion.

The approach suggested in Quigley and Weinberg /1977/ is applied by Friedman and Weinberg /1978/ to analyze mobility in the data of the Housing Allowance Demand Experiment (HADE) in the United States. There, estimated income equivalents of disequilibrium, cost measures related to out-of-pocket moving costs, expected search time and current tenure discount, are used in a logit model to explain household mobility. The benefit measures related to moving (income equivalents of disequilibrium) are derived from separate demand equations which are estimated using control households of HADE as observations. The cost measures, respectively, are estimated using actual costs of mover households. First demographic characteristics (etc.) of mover households are used as independent variables in a regression equation to predict search costs, moving costs and losses of rent discounts. Then, these equations are used to derive the cost estimates for all households.

In the logit models estimated by Friedman and Weinberg the disequilibrium measures used turn out to be significant only for one site (Pittsburg) in the data consisting of percent-of-rent and control households in Pittsburg and Phoenix at two years after enrollment to the experiment. As for the cost measures current tenure discounts have explanatory power at both sites, whereas expected search costs are significant in Phoenix, only. Expected out-of-pocket moving costs do not work well in either site.

An alternative approach to predict mobility behaviour is to use solely sociological-demographic explanatory variables in a qualitative response model. MacMillan /1978/ uses this analysis strategy in estimating logit models of mobility with HADE's data. On the basis of previous literature and a loose theoretical framework explanatory variables are chosen and used in logit estimation of the probability of moving and searching during the two years after enrollment to HADE using the same independent variables, respectively. The independent variables include life-cycle factors (age, number of children, change in number of children, change in marital status), other household characteristics (race, years of education, number of moves in three years before the experiment, income), and attitude factors related to housing and neighbourhood quality, social bonds, and willingness to move if more money were available for rent.

The author concludes that the direction of the relationships, as well as the significance levels of coefficients are generally similar for the probability of searching and the probability of moving. The explanatory power of the logit equations, as indicated by the coefficient of determination is somewhat higher for the probability of searching than for the probability of moving. In both models age of family head and having positive feelings towards neighbours have a negative effect on the relevant probability. Lack of basic facilities, high previous mobility, change in marital status, perceived crowding and predisposition to move variable affect the probabilities of moving and searching positively. Related to the experimental variables in HADE, the probability of moving for housing allowance recipients was 0.10 (0.05) higher than that of control households in Phoenix (Pittsburg). The average probability of moving during the two years after enrollment among all households was 0.36 in Phoenix and 0.57 in Pittsburg. Finally, we note that the overall explanatory power of MacMillans model is better than that of Friedman and Weinberg /1978/.

Finally, we refer to the model of intra-urban mobility by Hanushek and Quigley /1978/. Their analysis is actually analogous to Friedman and Weinberg's /1977/ model in that they also explain mobility behaviour within a qualitative response (probit) model using a different disequilibrium measure. Instead of using income equivalents of disequilibrium they estimate the gap between equilibrium demand and actual consumptions. They note that for given distributions of search and transactions costs one expects a monotonic relationship between "mobility activity" and their disequilibrium gap measured in terms of monthly rent. The equilibrium demand functions are estimated using the subsample of recent movers in the HADE samples for each city, i.e. those who moved to their dwelling units within past 12 months before enrollment to the experiment. In probit mobility analysis the data consists of the control households in the HADE sample. In addition to using a gap measure for total disequilibrium they also decompose it into initial annual disequilibrium and to a change in disequilibrium between two periods. The variables are further disaggregated by distinguishing them by their algebraic sign.

All alternative disequilibrium measures are estimated for control households in the HADE sample for the two years following enrollment. Finally, they also estimate a trichotomous choice (probit) model which has as an additional category the possibility of searching without a move. In all the estimated models the single most powerful explanatory variable is the annual increase in equilibrium level of housing demand. Measures of initial disequilibrium or decreases in equilibrium housing demand do not get significant coefficients in either city. Finally, the models working with a single (non-disaggregated) disequilibrium measure are the worst ones.

After our short literature survey we note that our analysis will be closely related to the abover analyses in several respect. First, Friedman and Weinberg /1977/, MacMillan /1978/ and Hanushek and Quigley /1978/ all use data which is related to the analysis of the effects of housing allowances, and we shall use housing allowance recipient data, too. One major difference in this respect is that our data, unlike that of others, is not experimental which makes the estimation of net effects of allowances on mobility difficult when no control group is available. On the other hand, in this paper we do not aim at estimating such net effects, the purpose here is only to explain mobility among housing allowance recipients. Confinement to mobility in rental stock is also a common denominator. As for the theoretical backgrounds all cited studies discuss imperfection related to the (rental) housing market. Transactions costs including search and moving costs are recognized as relevant factors. Further, housing price dispersion and uncertainty related to getting offers are noted, too. In spite of verbal discussions on these elements none of the above studies presents a well formulated consumer choice model including these elements in deriving their key concepts for empirical analysis.

As the theoretical background for our analysis we use a search model developed in Loikkanen /1982/ which considers the consumer choice problem of a household facing an imperfect market for housing and a perfect market for non-housing. In this paper we only present the central elements of a basic model in order to apply it later to our empirical problem. The basic outcome of the theoretical model is that household equilibrium can be expressed as a set in the space of housing quality and rent. If a household's present unit belongs to that set it does not search in order to move and vice versa. Parameter changes, like those resulting from a housing allowance, change the position of the equilibrium set and possibly (depending on the system) the location of the household, too, allowing for many types of reactions. The criterion for accepting randously received offers in our model defines an acceptance set in the space of housing quality and rent. It size affects the probability of moving of searching (disequilibrium) households.

As a result of our theoretical considerations, we also end up with the problem of constructing disequilibrium measures related to undertaking search and moving. Despite the generality of our theoretical framework our operationalization will be somewhat specific due to the nature of available data and the fact that it is related to Finnish housing allowance recipients. Namely, we use the properties of the allowance system to derive our disequilibrium measures in a very simple way. We define target housing size (m^2) for each household to be the size at which the housing allowance is greatest according to the allowance system. Then we calculate the difference of actual and target sizes, group these into intervals and finally construct dummy variables on the basis of this disequilibrium measure. To take into account the existence of rent dispersion, we use the relation of actual to fair rent, the latter being calculated by housing allowance authorities for each recipient's rental unit. The basic hypothesis is that the further each household's pre-allowance rental unit is from the target size, the more probably it will be out of equilibrium, i.e. it searches in order to move facing a stochastic opportunity set consisting of rental units which define points in housing quality (here m^2) and rent space. Similarly, the more expensive the present unit (given its quality) the more probably the household is in disequilibrium. Some other variables are used in addition to our disequilibrium measures in our logit model, too.

The plan of this paper is the following: In section 2. we present the key elements of Loikkanen's search model of intra-urban mobility and discuss some of its implications for empirical mobility analysis. In section 3. we discribe our data basis and the Finnish housing allowance system. The operationalization of the theoretical considerations to emprical analysis of mobility behaviour of housing allowance recipients is carried out in section 4. A Short introduction to qualitative choice models is given in section 5. Empirical results of our logit mobility model are presented in section 6. Finally, some conclusions are offered in section 7.

2. SUMMARY OF A SEARCH THEORETIC MOBILITY MODEL

The purpose of this chapter is to summarize the central results of a search theoretic model of intra-urban mobility presented in Loikkanen /1982/. We confine ourselves to the results of the infinite horizon version of the basic one-move-model of that study. Unlike in the original model, we assume here only one area which comprises the whole city.

Consider a representative consumer (or household) in a two commodity case. Let the commodities be rental housing and non-housing (or other consumption). Denote the quantity of non-housing by Z. Assuming that the price of non-housing is normalized to unity, Z measures non-housing expenditures simultaneously.

As for housing, we shall denote housing quality index by H and assume that the household's partial preference ordering over multidimensional housing units is independent of other elements of its consumption bundle. Then, the housing quality of any single dwelling can be expressed by

(1) $H = \Phi(x_1,...,x_n)$

where $x_1,...,x_n$ are quantities of physical characteristics of the housing unit and $\Phi(.)$ represents the partial preference ordering. Our H is not a natural scale. Any monotonic transformation of the quality scale is still a valid scale. Finally, assuming that housing quality and the respective service flow per unit of time are proportional to each other, we can denote both by H without ambiguity.

The household's objective is assumed to be the maximization of expected discounted utility stream during its infinite decision horizon. More specifically, it is the discounted "sum" of inter-temporally separable instantaneous utilities where the latter are defined at time-point t by an utility indicator

$$(2) \qquad u(t) = u(H(t),Z(t))$$

where H(t) is housing quality and Z(t) is non-housing expenditures at t. The instantaneous utility function is assumed to be continuous, differentiable and unique up to a linear transformation. Both commodities are assumed to have positive marginal utilities.

The household's instantaneous income, Y(t), is constant over time and there is no saving. If the household's present rental unit is characterized by rent R_0 and quality H_0 and it does not search in the imperfect rental housing market in order to move, its discounted utility stream during an infinite horizon is

$$(3) \qquad (1/\alpha) \cdot u(H_0, Y - R_0) = \frac{u_0}{\alpha}.$$

where α is the subjective rate of time preference. According to (3) all income beyond rent is used in the perfect market for non-housing, i.e. $Z = Y - R_0$.

If the household wants to change its housing consumption it has to search in an imperfect rental housing market. The imperfections include rent dispersion at each housing quality level and availability uncertainty as transactions take place through a stochastic matching process. In the following we shall consider the stochastic process from the household's view-point assuming that search takes place through newspaper ads[1)].

If the household searches during a short interval of time, it places an ad to a local newspaper. The ad specifies imperfectly the target type of housing in terms of key physical characterisitcs. On the basis of its ads the household expects to get offers as a Poisson process. As for the quality of offers, the household has a subjective conception of the joint distribution of physical housing characteristics and rents of offers which are random draws from the relevant distribution. But then, through (1) and u(H,Y-R), it also has a conception of the distribution of instantaneous utilities of offers.

If the household searches and gets an offer it visits the offered unit to find out its true characteristics and whether it is acceptable or not. If the visited unit is acceptable, to simplify exposition, the move is assumed to take place instantaneously with associated lump-sum moving costs.

The household's acceptance criterion in our case is a reservation utility level which is denoted by U. To see how this concept works, assume that a visited unit is of quality H_i and its rent is R_i. Then, if $U \leqq u(h_i, Y-R_i)$ the offer is accepted and a move takes place. Alternatively, if $U > u(H_i, Y-R_i)$ the offer is rejected and search is continued[2]. The acceptance set, A, consists of (H,R)-combinations given by

(4) $$A = \{(H,R) \mid u(H,Y-R) \geqq U\}.$$

In our infinite horizon, stationary and non-adaptive case the reservation utility level is a constant over time. Omitting its derivation here, it suffices to point out that it is based on an indifference relation. Namely, the reservation utility level defines the set of worst acceptable offers (or (H,R)-combinations) such that the expected discounted net utility that follows from accepting such an offer is equal to what can be achieved as an expected value by rejecting it and continuing search. The set of "marginally" acceptable offers, A', is defined by (4) when equality holds on the RHS, i.e.

(5) $$A' = \{(H,R) \mid u(H,Y-R) = U\}$$

A' defines a bid-rent curve in (H,R)-space. In general bid-rent curves map (H,R)-combinations in which utility is constant, assuming a fixed income, too[3].

In Figure 1 the expected minimum and maximum rent spectrums are $R^0(H)$ and $R^1(H)$, respectively. Assume that our household's present rental unit is of type (H_0, R_0) such that it is located at point A

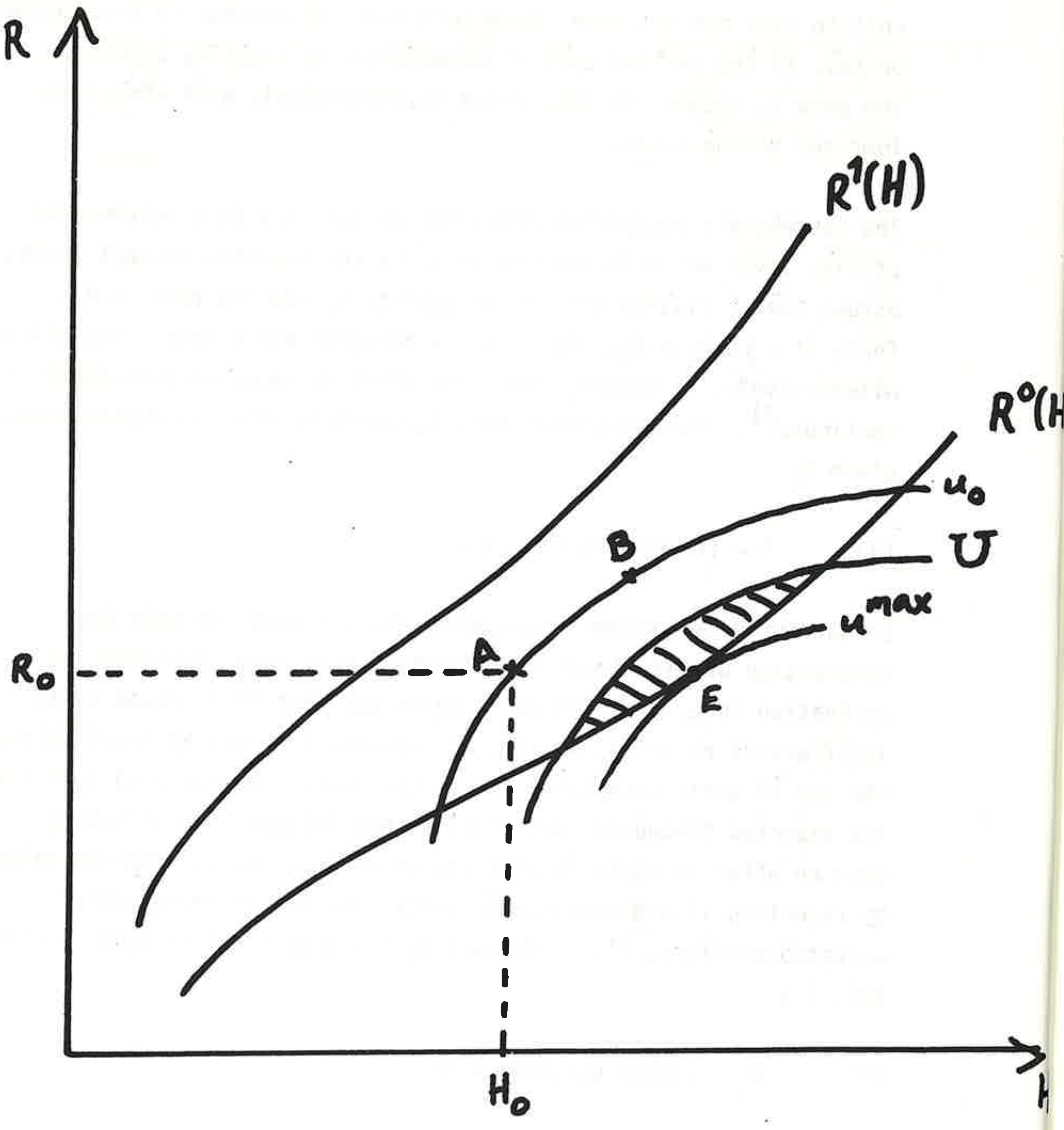

Figure 1: The dashed acceptance set of a household located at point A, i.e. its present rental unit is of quality H_0 and of rent R_0. The upper boundary of the acceptance set is a bid-rent curve corresponding to utility level U.

where it gets utility u_0 if it does not search. Accordingly, a bid-rent curve labelled by u_0 passes through point A. The household may try to better its position by searching in the housing market. The best stochastically attainable rental unit is given by point E in Figure 1 through which bid-rent curve u^{max} passes. Assuming here that search from point A is profitable, the figure illustrates the household's dashed acceptance set which is bounded from above by bid-rent curve U.

In Loikkanen /1982/ it is shown that if households' information (ad), visiting and moving costs are constants in terms of utility and independent of present consumption bundle[4)], then the reservation utilities, U, of all similar households located along the same bid-rent curve (like at A and B in Figure 1) are the same. I.e. their acceptance sets are the same.

If the ad cost or the visiting cost is fixed in terms of money, its utility value may vary depending on present consumption bundle (or present housing unit). By making an additional assumption about utility function (1) which guarantees that housing quality is a normal good, the utility cost of a fixed money cost is an increasing function of H along each bid-rent curve[5)]. In this case households which would enjoy the same utility without search (like those at A and B) have different reservation utilities if they search (lower at B than at A).

Given the consumption bundle of the household and assuming that search is profitable (as an expected value) we have the following comparative statistics results. The household's reservation utility level, U, is

a) a decreasing function of the advertisement cost, the visiting cost, the moving cost and the subjective rate of time preference,
b) an increasing function of the probability of getting offers and the probability that a visited rental units is "available". Finally, assuming that all search and moving costs are constants in terms of utility, U is also an increasing function of present utility level.

Up until now we have assumed that either the household is in equilibrium (doesn't search) or in disequilibrium (searches) without stating more explicitly the condition for being in one of these two states. It turns out that each household can be classified into either class on the basis of its (H,R)-combination. In (H,R)-space we can derive a boundary which separates equilibrium and disequilibrium households. If the household's rental unit is located exactly at a point on the boundary, then it is indifferent between searching and not searching, as its expected net returns of search are equal to zero.

As for the nature of the "equilibrium boundary", if information (ad), visiting and moving costs are constants in terms of utility and independent of the contents of consumption bundles, the boundary becomes a (constant utility) bid-rent curve like the one labelled by u_E in Figure 2. The respective equilibrium set is dashed vertically. In this case we get the following comparative statics results concerning the bench-mark utility level u_E. Namely, it is

a) a decreasing function of the probability of getting offers and the probability that a visited units are "available" and
b) an increasing function of the advertisement cost, the visiting cost, the moving cost and the subjective rate of time preference.

If, on the other hand, the ad cost or the visiting cost is fixed in terms of money and housing quality is assumed to be a normal good, then the equilibrium boundary is no longer a (constant utility) bid-rent curve. Instead, the boundary becomes a curve like DD in Figure 2 which has at each point a greater slope than the respective bid-rent curve. The respective equilibrium set becomes asymmetric relative to the best stochastically attainable point E as compared to sets defined by bid-rent curves. This implies that more over-consumption and less under-consumption of housing quality (relative to H_B in Figure 2) is tolerated in the former than in the latter case, without getting into disequilibrium.

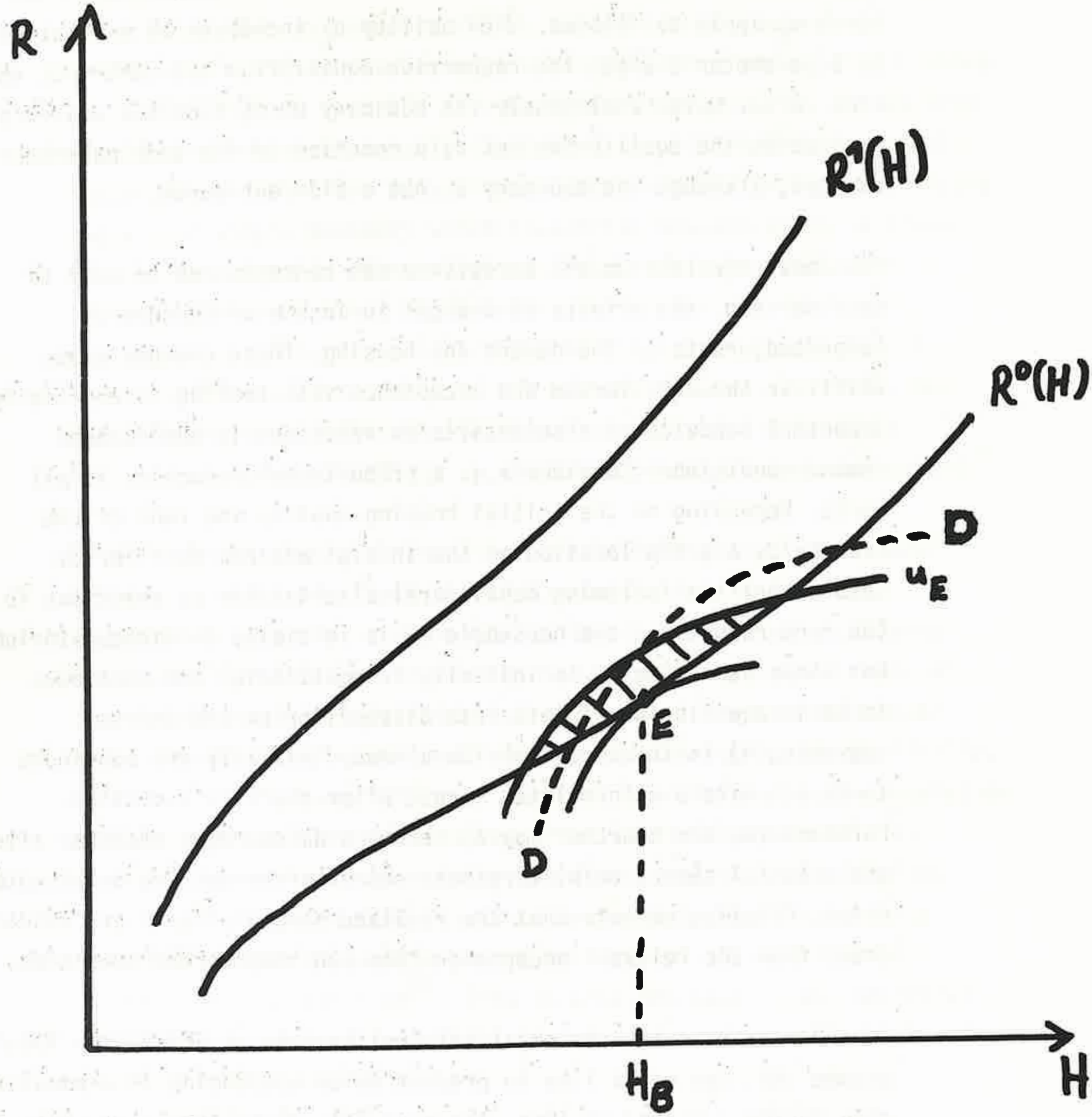

Figure 2: The dashed equilibrium set of the household is bounded from above by a bid-rent curve corresponding to utility level u_E if search and moving costs measured in terms of utility are independent of present consumption bundle. If these utility costs increase along each bid-rent curve as H increases, the upper boundary of the equilibrium set is DD which is not a bid-rent curve.

As for comparative statics results concerning a boundary like DD in Figure 2, we only note that the above results concerning bid-rent curve u_E apply as follows. When utility u_E increases as a reaction to a parameter change, the respective equilibrium set contracts and vice versa. Quite analogously the boundary DD of Figure 2 contracts or expands the equilibrium set as a reaction to the same parameter changes, although the boundary is not a bid-rent curve.

The above equilibrium and acceptance set concepts can be used to consider e.g. the effects of changes in income or changes in (expected) rents on the demand for housing. These changes cause shifts in the equilibrium and acceptance sets leading to emprically important behavioural alternatives as reactions to the changed demand conditions. Consider e.g. a proportional reduction in all rents. Depending on the initial housing quality and rent of the household, and the location of the initial and new equilibrium sets we get the following behavioural alternatives as reactions to the rent reduction: the household 1) is initially in disequilibrium but stops searching 2) is initially in equilibrium and continues to be in equilibrium 3) gets into disequilibrium and starts searching 4) is in disequilibrium already initially and continues to search with a reformulated target after the rent reduction. Furthermore, the searcher may a) become a discouraged searcher after unsuccessful search or b) terminate search after getting an acceptable offer. Finally, we note that the realized demand effects are random draws from the relevant acceptance sets and they spread over time.

In order to move towards empirical implications of the search model assume that one would like to predict which households in a population move during a period of time. Assuming that moves take place only as a result of active search the task can be partitioned into two predictions. First, to predicting who are in disequilibrium (search) during the interval of time. Second, to predict mobility among searchers.

Consider the problem of predicting equilibrium vs. disequilibrium. Assume that the way of mesuring housing quality is solved in a way or another. The next steps would be to derive the minimum rent spectrum ($R^0(H)$) and the best sotchastically attainable point E since our model suggests that the "further" each household is located from its E-point the more probably it is in disequilibrium[6]. For similar households which differ only with respect to their (H,R)-combinations there is a single boundary which classifies households to be either in equilibrium or in disequilibrium. From an econometric point of view the problem is that the boundary is unobservable or latent. Furthermore, it is not necessarily a bid-rent curve such that if an explicit utility function of the households were available, the relevant differences between (H,R)-points and point E could be measured in terms of utility or the corresponding income equivalent[7].

As for mobility among disequilibrium households, the search-model implies that the "further" the (H,R)-combination is from the equilibrium boundary, the greater is the corresponding acceptance set and the probability of moving, too. Given a "distance measure" from point E, the probabilities of moving may increase at unequal rates to different directions from the equilibrium boundary. Finally, we note that the same "distance measure" is relevant in the prediction of both the equilibrium vs. disequilibrium dichotomy as well as move vs. no move dichotomy among searchers. But this also implies that one can use the same "distance measure" to explain mobility among all households and to get an estimate of the equilibrium boundary at the same time[8]. This is also the case in our empirical efforts as we have no separate information on being in disequilibrium (a searcher) or not.

Above we have loosely discussed the "distance measure" regarding it as a gross measure of disequilibrium. If e.g. search or moving costs among otherwise similar households differ this has to be taken into account. Provided that household specific estimates of these costs can be obtained (like in HADE, c.f. Friedman and Weinberg /1978/) one may either construct "net distance measures" or use the cost estimates as separate variables. With no direct information on differences in search and moving costs among households proxy variables can, of course, be used.

In the following section we shall first consider our data and the housing allowance system which applied during the follow-up period. Thereafter we shall discuss how we can end up with an easy but case-specified solution to the problem of determining point E and constructing a "distance measure" from that point.

3. DATA AND THE HOUSING ALLOWANCE SYSTEM WHICH APPLIED TO NEW RECIPIENTS

The households in our panel data began to receive housing allowance after the middle of 1975 when a new allowance law became effective, too. Our data basis consists of 442 households from three biggest cities in Finland (Helsinki, Tampere and Turku) and it was gathered from annually filled housing allowance forms. The households fulfilled the following conditions:

- they had not received housing allowance before mid 1975
- they began to receive allowance according to the new law beginning from mid 1975
- they received housing allowance continuously from mid 1975 till (at least) mid 1978.

A more detailed description of the construction of data can be found from Loikkanen /1982/. Further, because a detailed formulation of the new housing allowance law to "economists' language" can be found from Loikkanen /1980/, it suffices to point out, here, how it affects the rent spectrum of an eligible household without going into details.

As the relevant law contains "quantity constraints" which measure (rental) housing services in terms of living areas (square meters) of dwellings, we shall use the same measuring rod here, too. To simplify exposition, assume that there are two commodities, rental housing (H) and non-housing consumption (Z) with unique prices. Further, the price of non-housing is normalized to unity. Then, in Figure 3 line AB is the household's rent spectrum before it becomes a housing allowance recipient. After becoming eligible for the allowance, respectively, the relevant budget constraint is ACED. Referring to the figure we note that if the household's present rental unit is smaller than H_1 it cannot get allowance in that unit at all. If the prsesent rental unit is larger than H_2, the allowance scheme is equivalent to a cash transfer ($= \Delta Y^+$). When the size of present rental unit is within the interval from H_1 to H_2 the

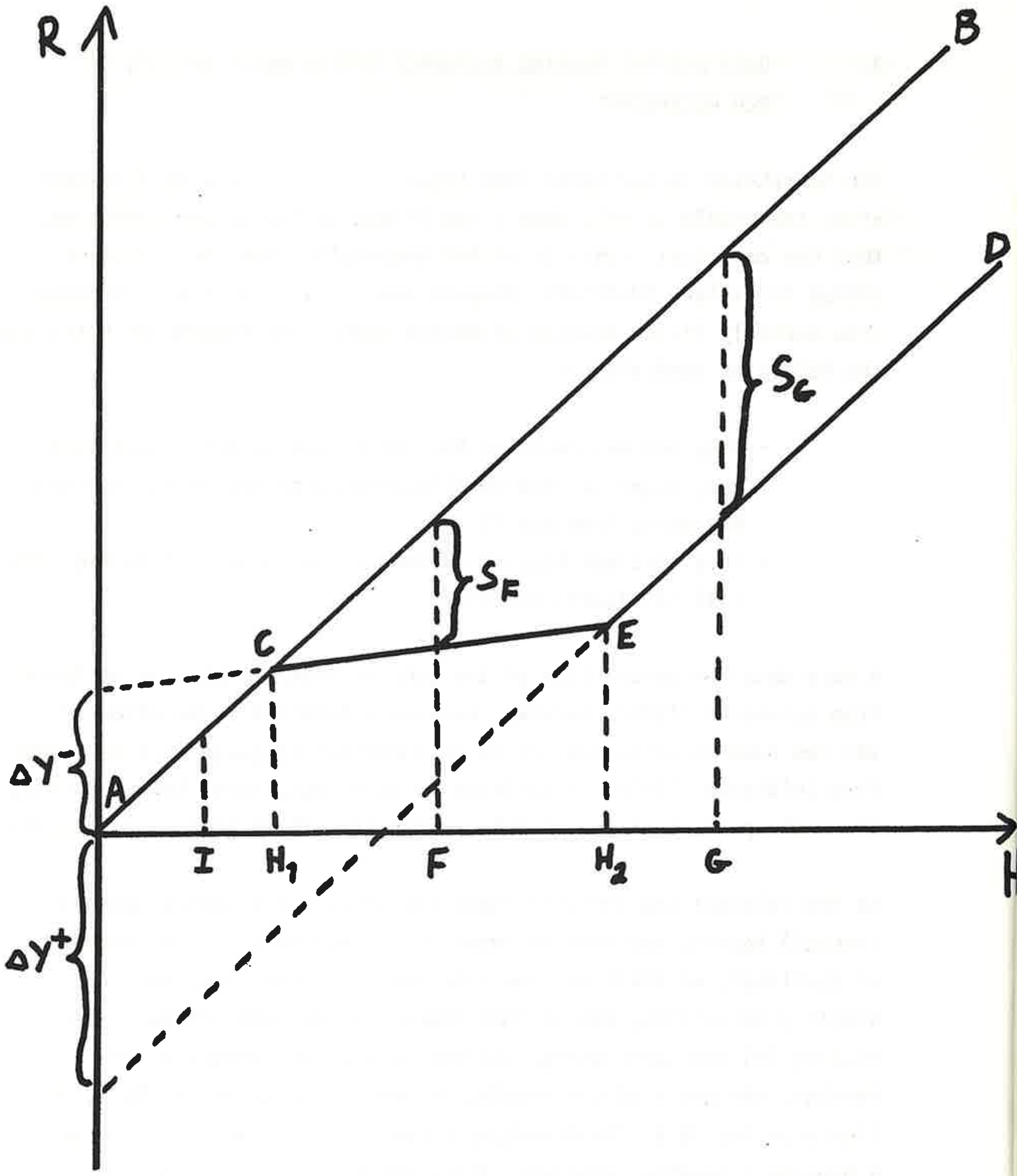

Figure 3: The household's pre-allowance rent spectrum (or rent line) is AB. After becoming a recipient of the allowance it is ACED. If dwelling size is F the amount of the allowance is S_F and for size G it is S_G. If dwelling size is I no allowance is received.

allowance scheme stands for a combination of a reduction of housing price (= 100 s precent) and an income reduction or an implicit tax ($= \Delta Y^-$). Both ΔY^+ and ΔY^- are also explicitly described in Figure 1, whereas the effect of the housing price reduction manifests itself as the decreased slope of the rent spectrum in the interval (H_1, H_2), only.

As for the parameters of the allowance scheme, corner point E is determined via housing size limit H_2 which is an increasing function of family size. In 1975 H_2 was e.g. 75 m^2 for a family of four members. Parameter s increases with family size and decreases with income whereas the implicit tax parameter, ΔY^-, behaves in exactly opposite manner. Finally, corner point C and the cash transfer, ΔY^+, relevant for large rental units, are determined "endogenously" via the other parameters.

To see how great incentive to move the allowance system creates, it is important to note its unconditional nature. By this we mean the fact that moving is not a necessary condition for becoming a recipient. Referring to Figure 3 assume that the pre-allowance dwelling sizes of two households are F and G. If they don't move, their non-housing consumptions will increase by the amounts of the allowances, S_F and S_G, after becoming eligible. Instead, a household with dwelling size I will not receive any allowance after becoming eligible unless it moves to a larger rental unit.

As for magnitudes, we note that on the average the housing allowance payments are approximately 40 % of rent in our population in mid-1978. Accordingly one may say that the housing allowance constitutes a major change in the demand conditions of an average eligible household.

To conclude this section, we note that in addition to the housing allowance, there was another institutional feature related to the functioning of the rental housing markets which affected the households' opportinities. Namely, our panel data is related to years

1975-78 and rents have been regulated during this period. More exactly, we have had strict rent control from 1968 till 1973 such that nominal rents were fixed to a level which prevailed at the end of 1967 in old rental units. Since 1973 we have had rent regulation in Finland such that the government has decided annually on the acceptable maximum rents in different kinds of private rental units. Non-private (i.e. municipal or otherwise at least partially publicly financed) rental units are beyond rent control or rent regulation, as rents in such units are determined via a cost calculation based on the downpayment structure of mortgages and running costs.

As our empirical results are affected by rent regulation we point out its effects by referring to theoretical considerations. First, rent regualtion decreases real rents causing a shift in the equilibrium set towards larger units. The other effect is that rent regulation increases excess demand. This is equivalent to a decrease in the arrival rate of offers and tends to increase the equilibrium set. The above two effects affect mobility to opposite directions. As a result of the first effect some households in "small" units would get into disequilibrium (begin search) whereas some searchers in "too large" units initially would get into equilibrium. As the reduction in "availability" expands the equilibrium set, it is quite possible that none of those in "small" units get into disequilibrium after all. Furthermore, more households living in too large units get into equilibrium. If rent control decreases the supply of rental housing as one would expect, the availability of vacancies gets worse expanding the equilibrium set further. The overall effect is reduced mobility.

4. CHOICE OF KEY EXPLANATORY VARIABLES

The dichotomous dependent variable in our empirical analysis will be move or no move during the three year period after becoming a recipient of the housing allowance. In this section we discuss the choice of the key variables to be used in our empirical analysis.

In the previous section we described the nature of the housing allowance system through pre- and post-allowance budget constraints assuming that unique prices for both housing and non-housing existed. In Figure 4 we consider the post-allowance stochastic rent spectrum allowing for rent dispersion around average rent spectrum ACGD. Boundary AFEI is based on the lowest expected rents, and boundary AJKL on the highest expected rents, respectively. The values of H at kink points F, C and J differ whereas the abscissas of kink-points E, G and K are the same H(N), being based on the family size (N), only.

In section 2 we pointed out that we would want to construct a benefit of moving (or disequilibrium) indicator which would measure the "distance" between the stochastically best attainable consumption point and the initial post-allowance (H,R)-combination. Whatever "distance" measure one uses, the best stochastically attainable consumption point has to be determined first.

The best point in Figure 4 must lie on boundary AFEI. The pre-allowance housing size of all households in our data is greater than that implied by point F. To see what the pre-allowance housing sizes, H_i, are relative to $H(N_i)$ implied by kink-point G we calculated

$$(6) \qquad D_i = H_i - H(N_i)$$

for each household ($i = 1,\ldots,442$). In (6) we used N_i such as it is the family size at the end of the follow-up period, i.e. three years after becoming eligible. On the average D is -6.6 m^2, i.e. the average household is located between the abscissas of points F and E and their average pre-allowance dwelling size is 58 m^2.

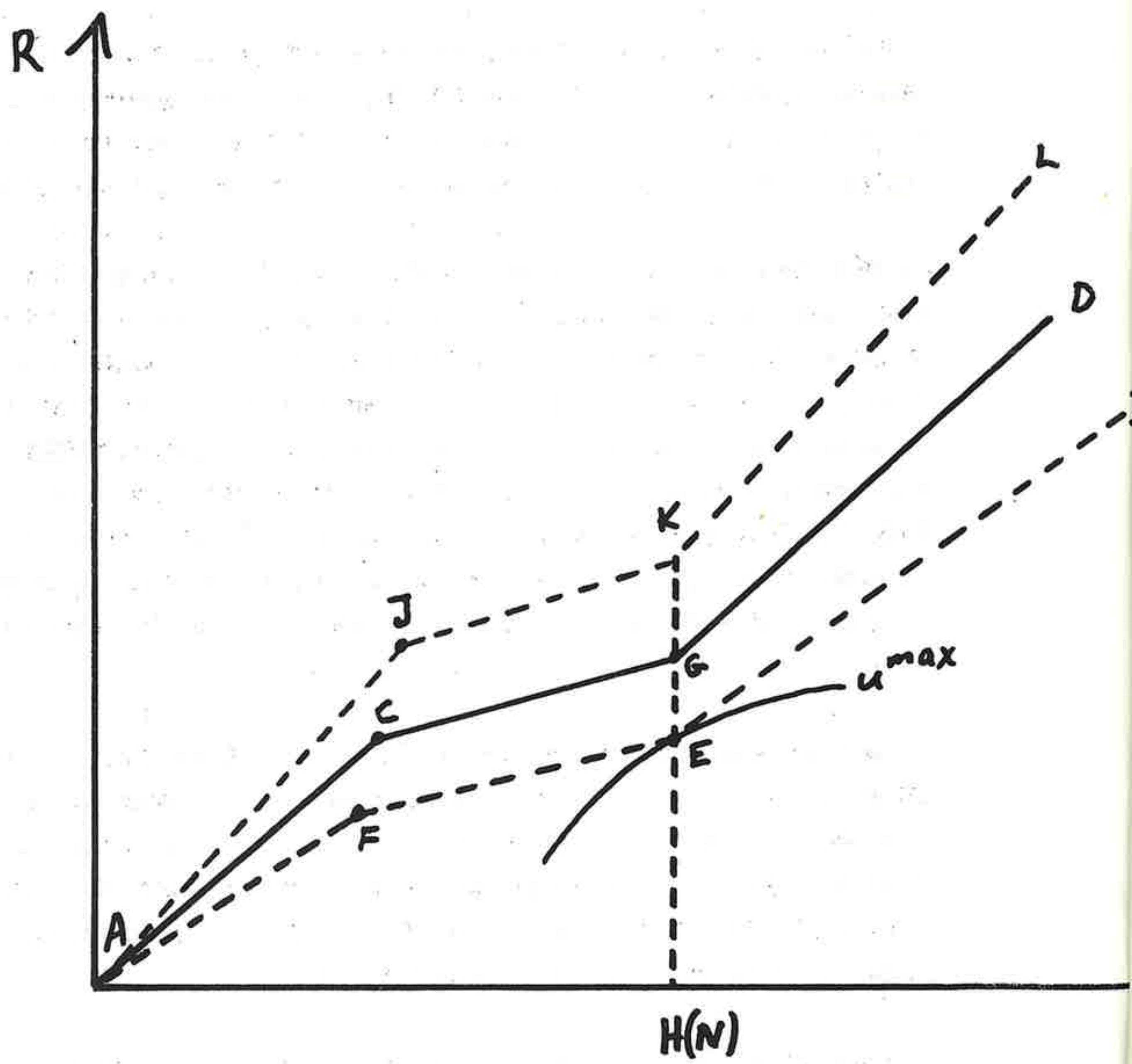

Figure 4: The household's post-allowance stochastic rent spectrum. The best stochastically attainable point is E at which the minimum rent spectrum kinks.

In this connection we note that in Loikkanen /1980/ we estimated equilibrium demand-for-m^2 functions with data on housing allowance recipients by a special procedure[9)]. The log-linear specification gave a price eleasticity of -0.17. and an income elasticity of 0.36. By applying the average housing price reduction on segment FE which is 75 % and the respective implicit tax, ΔY^-, which is on the average 6 % of income we get an estimate of housing demand increase of 10.6 %. When this figure is applied to average pre-allowance size 58 m^2 we get an average desired increase of 6 m^2 which is almost the same as average D (6.6 m^2), above.

On the basis of the above calculations based on average figures one would expect the desired dwelling sizes to be close to relevant H(N) sizes even if segment FE continued beyond point G to the right in Figure 4. Given that the marginal subsudy rate becomes zero for sizes beyond H(N), it is not unconceivable to take the $H(N_i)$ values as "best sizes" associated with the minimum rent spectrum, too. Accordingly, to avoid estimating the best stochastically attainable points for each household separately, we think there is fairly good ground for assuming that highest attainable bid-rent curves pass through kink-point E in Figure 4. As the slope of EI is typically much greater than that of FE, point E can be expected to be the best point for a variety of preference structures and income levels.

If we wanted to construct a distance measure between each initial post-allowance (H,R)-combination and point E we would need to use some estimate of minimum rents. To avoid that and to allow for eventual asymmetries we shall classify initial post allowance (H,R)-combinations with respect to their "cheapness" and size relative to H(N) into "cells".

The housing allowance authorities calculate a fair rent on the basis of the characteristics of each recipients dwelling and we denote it by R_i^F for household i. The household's actual rent is denoted by R_i. Now obviously at any given size the greater is R_i/R_i^F, the more probably one expects household i to move. We use this ratio to classify rental units into "cheap" ($R_i/R_i^F \leq 1$) and "expensive" ($R_i/R_i^F > 1$) ones. Secondly, we use the values of D_i as defined in (6) to locate the rental units into size classes relative to $H(N_i)$. The class limits of D_i and the distribution of households into the classes appears in Table 1.

In our setting we expect the probability of moving to be zero (or very small) for households located in the class "cheap&($-5 \leq D < 5$)" which contains point E in Figure 4. If the equilibrium set consists of "cells" other than that around point E, we expect the probability of moving to be the same from these as from that around point E. Otherwise, we expect the moving probability to be greater from expensive than from cheap rental units given the D-class. On the other hand, given the rent class we expect the probability to move to grow the further the class is from that around point E.

In addition the the above variables related to the gross benefits of moving, one would like to have variables related to search and moving costs. Unfortunately we do not have such direct information. On the other hand our households are fairly homogeneous in many respects, e.g., they are families with at least one child. Expecting that families living a later stage of their life-cycle have greter moving costs (and equilibrium sets) we construct a life-cycle variable on the basis of the birth year of the mother of each family (c.f. Table 1).

To allow for eventual differences on the basis of whether the initial (mid-1975) dwelling is private or public we construct a related dummy (1 = private). As for how the dwelling type affects moving probability we note that Loikkanen's /1982/ model implies that if private and public units differ such that the probability of being expelled is larger for the former, then the respective equilibrium set is larger for public units as compared to private ones. If living in buildings consisting of public rental flats is considered to be an inferior alternative as compared to private dwellings, this

Table 1: Means of variables

		All Cities	Helsinki	Tampere
Mobility (dummy)				
- move (= 1)		0.167	0.104	0.240
- no move		0.833	0.896	0.760
City (dummies)				
- Helsinki (0-case)		0.543	1.000	0.000
- Tampere		0.357	0.000	1.000
- Turku		0.100	0.000	0.000
Unit type (dummy)				
- private (= 1)		0.133	0.146	0.139
- public		0.867	0.854	0.861
Birth year of mother (dummies)				
- 1950		0.238	0.179	0.285
- 1941-1950		0.557	0.579	0.538
- 1941 (0-case)		0.205	0.252	0.177
Rent and size class of unit (dummies)1)				
cheap unit &	$D < -25$	0.038	0.042	0.038
	$-25 \leq D < -15$	0.120	0.104	0.146
	$-15 \leq D < -5$	0.176	0.154	0.215
	$-5 \leq D < 5$ (0-case)	0.242	0.242	0.253
	$5 \leq D < 15$	0.113	0.129	0.089
	$15 \leq D$	0.059	0.025	0.108
expensive unit &	$D < -25$	0.031	0.042	0.025
	$-25 \leq D < -15$	0.063	0.088	0.025
	$-15 \leq D < -5$	0.090	0.117	0.057
	$-5 \leq D < 5$	0.050	0.042	0.044
	$5 \leq D < 15$	0.007	0.008	0.000
	$15 \leq D$	0.007	0.008	0.000
Number of observations		442	240	158

1) The rental unit is cheap (expensive) if actual/fair rent is at most (more than) one in the pre-allowance dwelling. D is the difference in size of pre-allowance unit and H(N) (c.f. Figure 4) when the latter is obtained using the family size of mid-1978.

affects moving propensity oppositely, however. Finally, we note that under conditions of rent regulation (excess demand) it may be easiest to move from one public unit to another as this does not affect the number of vacancies in the public rental stock which is the main interest of housing adminstrators.

In addition to the variables discussed above we use city dummies. The means of our variables are reported in Table 1. Referring to our dependent variable we note that only 16.7 % of the households in "all cities" (Helsinki, Tampere and Turku) moved during the three years (from mid-1975 to mid-1978) after becoming recipients of housing allowance. The means of the 44 observations from Turku are not reported separately as the sample is too small for city specific modeling.

5. TOWARDS ECONOMETRIC SPECIFICATION: MODELS OF QUALITATIVE CHOICE

Our dependent variable is a binary response variable: move or not move during the three years after becoming a recipient of the allowance. In this section we shall shortly discuss the specification of three qualitative choice (or response) models - the linear probability model, the probit model and the logit model - although we shall concentrate in the last alternative in our empirical analysis[10]. The reason for this short introduction is that logit and probit models have not been applied by economists in Finland despite their fastly increasing application alsewhere[11]. The reader familiar with these techniques may skip this section and continue with our empirical results in section 6. Furthermore, we shall confine ourselves, here, to the consideration of binary qualitative response models, only, although the models can be extended to consider more than two response alternatives.

5.1. The Linear Probability Model

Assume that we have independent observations $(Y^i, X_1^i, X_2^i, \ldots, X_m^i)$ concerning k households $(i = 1, \ldots, k)$. Assume further that the dependent variable, Y, is a binary response variable such that

$$(6) \qquad Y^i = \begin{cases} 1 \text{ (move)} \\ 0 \text{ (no move)} \end{cases} \quad (i = 1, \ldots, k)$$

whereas the independent X- variables may be either of continuous or discrete type.

One possibility to model the quantal response to the values of the explanatory variables would be to formulate a linear probability model. This interpretation appears if we describe the probability distribution of Y by letting $P^i = \text{Prob}(Y^i = 1)$ and $1 - P^i = \text{Prob}(Y^i = 0)$. Then, as $E(Y^i) = P^i$, we can write the linear probability model in the following form

$$(7) \qquad P^i = \alpha + \sum_{j=1}^{m} \beta_j X_j^i + e^i \qquad (i = 1,\ldots,k)$$

where α and β_j are parameters and e^i is the error term. Assuming that the X_j^i's $(j = 1,\ldots,m;\ i = 1,\ldots,k)$ are fixed and e^i is an independently distributed random variable with 0 mean, the probability distribution of e^i must be equivalent to the probability distribution of Y^i. But then we also have

$$(8) \qquad \mathrm{Var}(Y^i) = \mathrm{Var}(e^i) = P^i(1-P^i)$$

suggesting that the error term is not constant for all observations, and implying that heteroscedasticity becomes a problem. Another problem arises from the fact that the error distribution is not normal, hance one cannot apply the classical statistical tests to the estimated parameters. Thinking of simple estimation methods, by using weighted least squares instead of OLS, one can correct for heteroscedasticity when the variances of each Y^i are used as weights. In addition to the problem of simple test statistics, there are other difficulties, too. Namely, there is no quarantee that the predicted values of Y^i will lie in the (0,1) interval. Leaving other problems and their eventual corrections unconsidered, we conclude by noting that very often one would not expect the probability of reacting (moving) to be linearly dependent on the stimuli (disequilibrium measures etc.). Rather, around some threshold level of stimuli one would expect the marginal effect of the level of stimuli to be great and small elsewhere.

5.2. The Probit and Logit Models

Referring to the difficulties of the linear probability model discussed above, one would like to have a specification which would i.a. allow for non-linear response to stimuli and for which all probability predictions would lie in the (0,1) interval. Accordingly, one would like to use a specification which translates the values of independent variables, X_j, which may range in value over the entire real line, to a probability which ranges from 0 to 1. Further, one would like the response probability to be a monotonic (either increasing or decreasing) function of each X_j.

At this stage let us denote the level of stimuli by Z^i for observation i $(i = 1,\ldots,k)$. Now Z^i can be viewed as an unobservable latent variable or index which summarizes the effects of all independent variables affecting the willingness to react, i.e.

$$(8) \qquad Z^i = g(X_1^i,\ldots,X_m^i) .$$

Assuming that the probability of reacting is an increasing function of our latent variable Z, the use of the cumulative probability function provides a transformation which satisfies the requirements related to the probability range.

By denoting a cumulative probability function by F, the probability of reacting to stimuli can be written as

$$(9) \qquad P^i = F(Z^i) .$$

By making assumptions concerning the functional forms of g(.) in (8) and F(.) in (9) one ends up with different types of qualitative response models. Assume that g(.) is linear, i.e.

$$(10) \qquad Z^i = \alpha + \sum_{j=1}^{m} \beta_j X_j^i$$

and assume furthermore that each decision maker has a critical value, $\bar{Z}^i$ of Z^i such that

$$(11) \qquad \text{If} \begin{cases} Z^i > \bar{Z}^i & \text{react (move)} \\ Z^i > \bar{Z}^i & \text{don't react (don't move).} \end{cases}$$

On the assumption that $\bar{Z}^i$ is a normally distributed random variable, the probability that $\bar{Z}^i$ is less than equal to Z^i can be computed from the cumulative normal probability function. This specification gives the probit model in which the probability of reacting becomes

$$(12) \qquad P^i = F(Z^i) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Z_i} e^{-s^2/2}\, ds$$

where Z^i is given by (10) and e is the base of natural logarithms.

The logit model is obtained, if instead of the cumulative normal, one assumes F(.) to be the cumulative logistic probability function. In this case we have

$$(13) \qquad P^i_i = F(Z^i) = \frac{1}{1 + e^{-Z^i}} \left(= \frac{e^{Z^i}}{1 + e^{Z^i}} \right)$$

where e is the base of natural logarithms and Z^i is assumed to be a linear function of the observable independent variables as defined by (10). Clearly (13) implies that

$$\lim_{Z^i \to \infty} P^i = 1 \quad \text{and} \quad \lim_{Z^i \to -\infty} P^i = 0$$

By substituting the RHS of (10) for Z^i in (13) we get the equation in the form

$$(14) \qquad P^i = \frac{e^{\alpha + \beta_1 X^i_1 + \ldots + \beta_m X^i_m}}{1 + e^{\alpha + \beta_1 X^i_1 + \ldots + \beta_m X^i_m}}.$$

Having information on the binary response (move = 1, no move = 0) of decision makers and on the independent variables (X^i_j; i = 1,...,k; j = 1,...,m), the parameters and β_j of (14) can be estimated by the maximum likelihood method for which there are nowadays several computer probrams available also in Finland. McFadden /1977/ has shown that the maximum likelihood estimates are asymptotically efficient and normally distributed.

The logit coefficients α, $\beta_1,\ldots,\beta_m$ have no direct interpretation as a reflection of the effects of independent variables on the response probability. As a nonlinear function, logit has the property that the marginal effect of any independent variable on the response probability varies depending on the initial (or starting) probability of responding. This becomes evident when we calculate the derivative of response probability w.r.t. independent variable X_j from (14) getting

$$(15) \qquad \frac{\partial P^i}{\partial X_j^i} = \beta_j P^i(1 - P^i)\,.$$

By differentiating (15) w.r.t. P^i we get

$$(16) \qquad \frac{\partial P^{i^2}}{\partial X_j^i \partial P^i} = \beta_j(1 - 2P^i)$$

which implies that the marginal effect of any independent variable X_j on the response probability is the greatest when the initial probability level is $P^i = 1/2$.

As another sensitivity measure one may want to use the elasticity of response probability w.r.t. X_j which becomes

$$(17) \qquad \frac{\partial P^i}{\partial X_j^i}\,\frac{X_j^i}{P^i} = \beta_j X_j^i(1 - P^i)\,.$$

According to (17) the elasticity depends on both the initial response probability and the level of independent variable involved in addition to parameter β_j.

Especially when the explanatory variables are of discrete type with only a few classes the best alternative to get an idea of how levels of variables and their changes affect response probabilities is to calculate them from the model. We shall use this alternative when presenting results of our model in addition to commenting their statistical properties.

6. EMPIRICAL RESULTS BASED ON LOGIT MODELS

The results of estimating our mobility model as a logit model with the maximum likelihood method with observations from all cities are presented in Table 2. In addition to the estimated coefficients we report the asymptotic t-statistics. When the t-statistics are significant in a two-tailed test at the 0.10, 0.05 and 0.01 levels, they are marked with *, ** and ***, respectively. The likelihood ratio which is asymptotically chi-square distributed is used to evaluate the goodness of fit of the estimated models.

In general our results are encouraging. The model as a whole works statistically well. As for individual coefficients, the city dummies are positive and significant for both Tampere and Turku. Our result imply that the mobility rate in Helsinki is lower than that of Tampere and Turku which most probably results from a greater excess demand at regulated rents in Helsinki.

The private-public dummy variable gets a negative coefficient significant at 0.01 level. Accordingly, if the rental unit at the time of becoming a recipient of the allowance was a private one, the probability of moving during the next three years is smaller than in the case of a public rental unit. As for our original hypothesis, we noted that there are opposing forces related to the propensity to move from private and public units. The fact that our empirical analysis resulted in such a clear difference emphasizing the greater mobility from public units is surprising.

Our trichotomous life-cycle measure, modelled by using two dummy variables gives the result that younger families are more mobile than older ones although the coefficient for the youngest ones (mother born later than 1950) is significant only at the 0.10 level. These results give limited support to our initial hypothesis of lower mobility rates in later stages of the life-cycle.

Table 2: Logit estimation of the probability of moving; all cities

Independent variable		Coefficient	Asymptotic t-statistic[1)]
Constant		-4.548	-6.97***
Helsinki		(the 0-case)	
Tampere (city dummy)		1.549	4.38***
Turku (city dummy)		1.071	2.23**
Private rental unit (dummy)		-3.935	-3.61***
Birth year of mother			
- Later than 1950 (dummy)		0.971	1.91*
- During 1941-1950 (dummy)		0.990	2.09**
- Before 1941		(the 0-case)	
The difference (D) between actual and "target" size is in the interval (dummies)			
cheap unit &	$D < -25$	2.358	3.21***
	$-25 \leq D < -15$	1.953	3.56***
	$-15 \leq D < -5$	1.593	3.07***
	$-5 \leq D < 5$	(the 0-case)	
	$5 \leq D < 15$	-0.255	-0.30
	$15 \leq D$	-0.025	-0.03
expensive unit &	$D < -25$	4.387	4.84***
	$-25 \leq D < -15$	3.483	4.98***
	$-15 \leq D \quad -5$	2.239	3.32***
	$-5 \leq D \quad 5$	2.080	2.85***
	$5 \leq D < 15$	-31.575	-0.21
	$15 \leq D$	2.999	1.95*

Likelihood ratio	102.23 (16 degrees of freedom)[2)]
Sample size	442
Mean of dependent variable	0.167

1) t-statistic (in a two-tailed test) significant at the 0.10, 0.05 and 0.01 levels are marked with *, ** and ***, respectively.

2) $\chi^2(16df, 0.01) = 32.0$.

Finally, we shall comment our "disequilibrium variables" which measure the households' location relative to point E in Figure 4. We shall interprete our results so that the rent & size classes in which the probability of moving does not differ significantly from the class aroung point E (the 0-case) belong to the equilibrium set[12]. Using this interpretation the equilibrium set consists of four rent & size classes. Outside these classes the estimated coefficients are very significant for all classes where D is negative. Furhter-more, the coefficients grow the smaller is D implying that the probability of moving grows to that direction, too. We also note that it is asymmetric around point E consisting only of "too large" units in addition to the 0-case class.

We also note that in each D-class the coefficient is greter for expensive than for cheap units just as we expected. Finally, as for "too large" units, the coefficients become significant only for expensive units in the open class of $D > 15\ m^2$.

In order to find out eventual differences among cities we estimated the model with the observations of Helsinki and Tampere, too. The sample from Turku was too small for separate estimation. The results appear in Tables 3 and 4.

There seem to be clear differences among the two cities. First, the average mobility rate is only 10.4 % in Helsinki whereas it is 24.0 % in Tampere (and 25 % in Turku). Second, the private/public dummy is very significant in Tampere and totally insignificant in Helsinki. As for our life cycle variables based mothers' birth year, the situation is the opposite. In Helsinki these variables support the hypothesis about greater mobility among younger households but in Tampere the variables get insignificant coefficients.

There are also differences in the working of our disequilibrium measures in the two cities. In Helsinki the equilibrium set is larger than that of Tampere. This is not in discord with the conception that, due to rent regulation and inter-regional mobility, excess

Table 3: Logit estimation of the probability of moving; Helsinki

Independent variable		Coefficient	Asymptotic t-statistic[1)]
Constant		-4.735	-4.31***
Private rental unit (dummy)		-63.784	0.00
Birth year of mother			
- Later than 1950 (dummy)		2.496	2.58***
- During 1941-1950 (dummy)		1.527	1.70*
- Before 1941		(the 0-case)	
The difference (D) between actual and "target" size is in the interval (dummies)			
cheap unit &	D < -25	2.238	2.20**
	-25 ≦ D < -15	1.581	1.74*
	-15 ≦ D < -5	-0.493	-0.39
	-5 ≦ D < 5	(the 0-case)	
	5 ≦ D < 15	-32.903	0.00
	15 ≦ D	-32.371	0.00
expensive unit &	D < -25	3.952	2.98***
	-25 ≦ D < -15	3.232	3.32***
	-15 ≦ D < -5	1.676	1.78*
	-5 ≦ D < 5	1.200	0.92
	5 ≦ D < 15	-32.191	0.00
	15 ≦ D <	-35.084	0.00

Likelihood ratio 57.53 (14 degrees of freedom)[2)]
Sample size 240
Mean of dependent variable 0.104

1) t-statistic (in a two-tailed test) significant at the 0.10, 0.05 and 0.01 levels are marked with *, ** and ***, respectively.

2) $\chi^2(14df,0.01) = 29.1$.

Table 4: Logit estimation of the probability of moving; Tampere

Independent variable		Coefficient	Asymptotic t-statistic[1)]
Constant		-2.517	-3.07***
Private rental unit (dummy)		-3.749	-2.78***
Birth year of mother			
- Later than 1950 (dummy)		-0.156	-0.22
- During 1941-1950 (dummy)		0.184	0.29
- Before 1941		(the 0-case)	
The difference (D) between actual and "target" size is in the interval (dummies)			
cheap unit &	$D < -25$	2.377	2.06**
	$-25 \leqq D < -15$	2.258	3.00***
	$-15 \leqq D < -5$	2.100	2.98***
	$-5 \leqq D < 5$	(the 0-case)	
	$5 \leqq D < 15$	-0.173	-0.14
	$15 \leqq D$	-0.363	-0.30
expensive unit &	$D < -25$	5.069	2.67***
	$5 \leqq D < -15$	3.200	2.38**
	$5 \leqq D < -5$	3.571	2.47**
	$5 \leqq D < 5$	2.858	2.23**
	$5 \leqq D < 15$	(no observations)	
	$15 \leqq D$	(no observations)	

Likelihood ratio 43.76 (12 degrees of freedom)[2)]
Sample size 158
Mean of dependent variable 0.240

1) t-statistic (in a two-tailed test) significant at the 0.10, 0.05 and 0.01 levels are marked with *, ** and ***, respectively.

2) $\chi^2(12df, 0.01) = 26.2$.

demand for rental housing is relatively greater in Helsinki resulting in smaller availability of vacancies and smaller mobility, too, than in Tampere. If such differences among the two cities are true, then, as our theoretical model also suggests, diminished availability leads to enlarged equilibrium sets.

Above we have discussed the statistical properties of our logit models and the signs of coefficients. As noted before, the coefficients themselves do not directly give any idea of the magnitudes of the probabilities of moving. To give a better picture of our results, we have calculated a number of probabilities from our models in different cases to explicitly illustrate how their absolute levels depend on levels and changes in the levels of independent variables. We concentrate on probabilities which have been calculated from city specific models from which the statistically insignificant variables have been omitted.

From Table 5 we see e.g. how marked difference there is in the probability of moving between public and private units in Tampere. From Table 6, respectively, we see that the life cycle variable is important in Helsinki. Finally, referring to both tables we note that the probabilities of moving in the equilibrium classes (circled) are close to zero. E.g. because of involuntary moves due to notices which have not been eliminated from our data, we cannot expect to get zero probabilities in these classes.

Table 5: Probabilities of moving in Tampere

	D<-25	-15≦D<-25	-5≦D<-15	-5≦D<5	5≦D<15	D<15
Public units						
- cheap	0.49	0.44	0.39	0.05	0.05	0.05
- expensive	0.95	0.67	0.79	0.64	no observations	
Private units						
- cheap	0.01	0.01	0.01	0.00	0.00	0.00
- expensive	0.19	0.03	0.05	0.02	no observations	

Table 6: Probabilities of moving in Helsinki

	D<-25	-15≦D<-25	-5≦D<-15	-5≦D<5	5≦D<15	D<15
Old family in						
- cheap unit	0.08	0.03	0.01	0.01	0.01	0.01
- expensive unit	0.09	0.08	0.03	0.01	0.01	0.01
Middle-aged family in						
- cheap unit	0.24	0.11	0.02	0.02	0.02	0.02
- expensive unit	0.26	0.25	0.09	0.02	0.02	0.02
Young family in						
- cheap unit	0.53	0.31	0.07	0.07	0.07	0.07
- expensive unit	0.55	0.54	0.27	0.07	0.07	0.07

7. CONCLUSIONS

The purpose of this paper has been to construct a model which makes it possible to predict the mobility behaviour of new housing allowance recipients during the next three years after becoming eligible. As our theoretical background we have utilized a search model developed in Loikkanen /1982/. Household equilibrium of that model can be expressed as a set in the space of housing quality and rent. If a household's present rental unit belongs to the relevant set it does not search in order to move and vice versa. Parameter changes, like those resulting from becoming a recipient of housing allowance change both the position of the household and the relevant equilibrium set allowing for alternative reactions to the allowance. There include a) starting search b) continuing search c) stopping search, and d) continuing to be its equilibrium. The outcome depends on both the initial position and the change in demand conditions.

In this paper we have measured housing by living area (square meters) and we have solved in a simple way the best stochastically attainable housing size of each household using the properties of the housing allowance system. The difference between this "target size" and the size of dwelling at the time of becoming a recipient of the allowance is used together with an actual/fair rent ratio to classify observations into "cells". As the "distance" of these cells varies relative to the best stochastically attainable point, they constitute a disequilibrium measure. The idea here is that the more expensive the present unit is or the further it is from the target size, the more probably the household is in disequilibrium and searches in order to move. Furthermore, as the "distance" from the best stochastically attainable dwelling type increases, the household's acceptance set becomes larger such that the probability of moving increases, too.

By using dummy variables corresponding to the "cells" we estimate a logit model explaining the probability of moving of 442 new

Finnish housing allowance recipients in three cities. In the model also life-cycle variables, city dummies and a private-public dummy are used.

In general the estimated models work satisfactorily. The results indicate that there are marked differences in the mobility behaviour of households in different cities. Not only do the sizes of equilibrium sets differ by city, also life-cycle variables operate differently according to our results. Furthermore, the mobility rates from private and public units differ in one city being the same in another. Finally, the hypothesis of the utilized search model that the further a disequilibrium household (searcher) is from the best stochastically attainable housing type, the greater is the probability of moving, is supported by our results. In addition; our results also support the hypothesis that "too large" rental units are tolerated to a greater extent than "too small" ones as the equilibrium sets tend to be asymmetric towards large units around the best conceivable point.

FOOTNOTES

1) By reinterpreting the parameters of the original model it can be applied to other search technologies like answering landlords' ads, visiting housing agencies etc. The general nature of our results carries over to such cases.

2) This type of decision criterion corresponds to the optimal policy rule of standard search models. For an extensive survey concerning search models, see Lippman and McCall /1976/.

3) Bid-rent curves can be derived graphically for a household of income Y as follows: working in a diagram with H on the horizontal axis and Z (with its price normalized to unity) on the vertical axis, draw a horizontal line at the level of $Z = Y$ and also draw the usual indifference curves into the figure. Then, a bid-rent curve in (H,R)-space corresponding to some fixed utility level is obtained as the vertical distance between horizontal $Z = Y$ level and the corresponding indifference curve at each value of H. Obviously higher bid-rent curves will correspond to lower utility levels. Furthermore, if income is changed, the map of bid-rent curves becomes different. As for applications of bid-rent approach in housing market analysis, see e.g. Wheaton /1977/ and Braid /1981/.

4) If the input to get housing information, make visits to see offered rental units and to move is time out of leisure and the utility of leisure is additively separable from other consumption for the household which is assumed to work fixed hours (an to get fixed income), then the utility costs are constants.

5) If our household faced a unique equilibrium rent spectrum, housing quality would be a normal good (its demand would increase with income) if the following condition were true for utility function (2): assuming that $\partial(-u_H/u_Z)/\partial Z < 0$ where u_H and u_Z are partial derivatives, quarantees the normality of housing quality or H (see Braid /1981/).

6) The most common procedure to measure housing quality is to use rent predictions from a hedonic equation, i.e. to explain market rents in a regression by housing characteristics and use the estimates for each dwelling as quality indices. The statistical properties of the hedonic equation can be used to get some estimate of the minimum rent spectrum. The standard error of estimate gives already an idea of the extent of rent dispersion. With an estimate of minimum rents, one needs a separately estimated demand function to predict each household's demand at point E.

7) Assuming that the housing demand function used in the prediction of demands at E (c.f. footnoge 6) is derived from a utility function, the latter can be used to derive the distance measures in terms of utility or income equivalent. In effect Friedman and Weinberg /1978/ use this type of procedure in their analysis although their concepts were not derived from an explicit consumer choice model. Corresponding to our point E they estimated equilibrium demands at average rents and differences from that point. Rent rebate variables were used separately, however.

8) This explains why MacMillan /1978/ gets the result that the direction of the relationships and the significance levels of coefficients are generally similar for the probability of searching and the probability of moving. Related to the disequilibrium measures of Hanushek and Quigley /1978/, neglecting (as the authors do) housing price dispersion, the measures based on the differences between equilibrium demand (at t+1) and actual demand (at t) disaggregated into two variables according to the algebraic sign of the differences would seem most appropriate from our view-point. The authors estimate a model with this specification but it does not work well. Their best model is a "fully disaggregated specification" which includes initial (at t) positive and negative disequilibriums and changes (positive and negative) in equilibrium demands from t to t+1. The variable based on positive increases in equilibrium demands turns out to be the only invariably significant variable. On the basis of this equation, the authors

draw the conclusion that the results "strongly support the underlying theory, suggesting that households whose equilibrium level of housing demand increases are far more likely to move.." We suspect the generality of this result on two grounds. First, the fact that the key variable works well in the population must be at least partly due to the feature that majority (58 % in Phoenix and 70 % in Pittsburg) of the households were underconsuming housing initially. Furthermore the average amount of underconsumption was almost twice the average amount of overconsumption. Second, our search model (and common sense) suggests that if a household is overconsuming initially, it may be in disequilibrium searching for a smaller unit, and now an increase in equilibrium demand (if not very large) locates it to the new equilibrium set, i.e. the change reduces mobility. Hence the key variable of Hanushek and Quigley is theoretically questionable.

9) To estimate equilibrium demand-for-m^2 functions we used a questionnaire technique. First, note that because of the nonlinearity of the housing allowance system rents per m^2 vary even among similar households when their dwelling sizes differ (being outcomes of a random process). Secondly, they vary because of rent dispersion. These elements generate price variability necessary for the estimation of price elasticities. Through our questionnaire we asked housing allowance recipients would they want to move if rental units were easily available at the net rents they were paying. Those unwilling to move were used as observations in estimating "equilibrium demand functions".

10) Presentation of probit and logit models is becoming a standard procedure in textbooks on econometrics. Chapters concerning qualitative choice (or quantal response) models can be found e.g. from Goldberger /1964/, Goldfeld and Quandt /1972/, Maddala /1977/, Pindyk and Rubinfeld /1981/ and Theil /1971/, An excellent survey article on these methods has been written by Amemiya /1981/.

11) For a Finnish application of the Domencich and McFadden /1975/ urban travel demand model, see Tigerstedt /1978/.

12) Note that this interpretation of the equilibrium set is strictly correct only if the set is the same for all households in our population. As can be seen from the estimated model, in addition to our rent&size dummies also other variables are significant in explaining the probability of moving. Hence, e.g. the acceptance and equilibrium sets of "old" families are larger than those of "young" families. But then the size of the equilibrium set which consists of cells in which the probability of moving is the same as in the class around point E is determined by the households which have the smallest equilibrium sets. If more data were available, the sizes of the equilibrium sets of each household type could be estimated. In the following, only differences among cities become evident as separate models as estimated with data from Helsinki and Tampere. Then we see that the equilibrium set of the pooled data is actually the same as that of Tampere, both of them being smaller than the equilibrium set of Helsinki.

BIBLIOGRAPHY

Amemiya, T. /1981/: Qualitative Response Models: A Survey. Journal of Economic Literature, Vol. XIX, No. 4, Dec.

Braid, R. /1981/: The Short-Run Comparative Statics of a Rental Housing Market, Journal of Urban Economics, Vol. 10.

Domencich, T.A. and McFadden, D. /1975/: Urban travel demand. Amsterdam: North-Holland.

Friedman, J. and D. Weinberg /1978/: Draft Report on the Demand for Rental Housing: Evidence from a Percent of Rent Housing Allowance. Abt Associates, Cambridge, Massachusetts.

Goldberger, A.S. /1964/: Econometric theory. New York: Wiley.

Goldfeld, S.M. and Quandt, R.E. /1972/: Nonlinear methods in econometrics. Amsterdam: North-Holland.

Hanushek, E. and J. Quigley /1978/: An Explicit Model of Residential Mobility. Land Economics, Vol. 54, No. 4, Nov.

Lippman, S. and J. McCall /1976/: The Economics of Job Search: A Survey. Part I in Economic Inquiry, June 1976, Part II in Economic Inquiry, Sept. 1976.

Loikkanen, H. /1980/: Elasticities of Demand for Rental Housing: Evidence from Finland. Discussion and Working Papers Nr. 138, Department of Economics, University of Helsinki.

Loikkanen, H. /1982/: Housing Demand and Intra-Urban Mobility Decisions: A Search Approach. Commentationes Scientiarum Socialium 17/ 1982. Societas Scientiarum Fennica. (In printing-press).

MacMillan, J. /1978/: Draft Report on Mobility in the Housing Allowance Demand Experiment. Abt Associates, Cambridge, Massachusetts.

Maddala, G.S. /1977/: Econometrics. New York: McGraw-Hill.

McFadden, D. /1974/: Conditional Logit Analysis of Qualitative Choice Behaviour. An article in P. Zarembka (ed.): Frontiers in econometrics. New York: Academic Press.

Pindyck, R.S. and Rubinfeld, D.L. /1981/: Econometric models and economic forecasts. Second edition. New York: McGraw-Hill.

Quigley, J. and D. Weinberg /1977/: Intra-Urban Residential Mobility: A Review and Synthesis. International Regional Science Review, Vol. 2, No. 1, Fall.

Theil, H. /1971/: Principles of econometrics. New York: Wiley.

Tigerstedt, R. /1978/: En modell för valbeteende i trafiken. Master's thesis, Department of Statistics, University of Helsinki, 1978.

Wheaton, W. /1977/: A bid rent approach to housing demand. Journal of Urban Economics, Vol. 4.