Vacancies and Residential Search in an Empirical Equilibrium Search Model
- FIRST DRAFT -

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Abstract

As is well known, housing has a unique set of characteristics which cause the operation of the housing market to be different from that of other markets. Therefore it is not surprisingly that the study of housing and residential mobility forms a recurrent theme in economic research. In this paper a stock-flow housing market model is proposed where households search for a dwelling in an equilibrium framework. Depending on housing market conditions as expressed by the arrival rate of residential offers, and the fastidiousness of households as expressed by the reservation place utility, households move to another dwelling. The model yields a theoretical relationship between vacancies, search and residential mobility. For the emprical analysis we make use of the Dutch Housing Demand Survey (WBO), which contains retrospective data on housing market histories of participants.

1 Introduction

The study of housing choice and mobility forms a recurrent theme in economic research. Nowadays, a vast amount of literature exists on both theoretical and empirical issues on housing. In an earlier contribution Clark and

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Van Lierop (1986) give an interesting overview of the housing choice and mobility literature. They distinguish two different streams of literature. On the one hand they address the literature on housing choice, based on the utility maximizing paradigm, and on the other hand they discuss the literature on residential mobility, based on the notion of disequilibrium. More recently, new developments in microeconomic theory, like imperfect information and search theory, have come to fore. For example, Arnott (1989) and later Read (1997) examined vacancies and rent dispersion in a partial search model of the rental market. Moreover, Van der Vlist et al. (1998) have recently examined vacancies and residential mobility in an equilibrium search model, where housing choice and mobility is the result of both wealth maximizing behavior of the household, and profit maximizing behavior of the landlord. However, up till now no structural empirical equilibrium search model of the housing market exists. It is the purpose of the present paper to formulate and estimate an equilibrium search model for the housing market.

The plan of the paper is as follows. In section 2 we formulate our equilibrium search model of the housing market. Data, empirical specification and estimation issues are discussed in section 3. Results and implications will be given in section 4, which is currently under construction. Conclusions will be drawn out in section 5.

2 The Equilibrium Search Model

2.1 Search for a Dwelling by Households

The demand side of the model is the more or less standard search model for homogeneous households where we assume that every household is continuously searching for a better residence. Initially, households are supposed not to have a dwelling of their own when entering the housing market. Over time households may receive an offer, which is either accepted or rejected. We assume that a dwelling is entirely characterized by its so-called place utility, defined as the net composition experienced in a certain location (Wolpert, 1965) . Following standard practice [1], we assume that the search process of the individuals' maximizing expected wealth can be described as the random arrival of offers by means of a Poisson process, whereby offers are assumed to be identical and independent drawings from a known density function $f(r)$ with associated distribution function $F(r)$, and complement $\overline{F}(r)$ and r place utility. We assume that offers arrive at a constant rate $\lambda \in [\lambda_0; \lambda_1]$,

[1] See Lippman and McCall (1971)or Mortensen (1986) for a discussion of search theory.

whereby λ_0 is the arrival rate of offers for households not yet having a dwelling of their own, and λ_1 for households already having a dwelling of their own. Moreover, we assume that households receive at most one offer per period, whereby no recall is allowed. Upon arrival the household has to decide whether to accept or reject the offer depending on whether the place utility offered is greater or smaller than a certain value respectively. By the stationarity assumption, this value is the same in all periods. If the value exceeds a so-called reservation value, the household will transit to the dwelling. During residence, the household is assumed to experience a constant place utility. We assume households to break up following a Poisson process at a constant rate μ [2]. Moreover, we assume that households can be forced to move due to renovation of the dwelling, whereby they leave the dwelling and return to a situation of not having a dwelling of their own, which happens following a Poisson process at a constant rate η. Finally, let r^o be the baseline utility level of households not having a dwelling of their own, and ρ the discount rate. Thus, for a household to accept a dwelling, the place utility offered should be greater than a minimum value of place utility. The optimal value of the reservation place utility can be obtained by using the principle of dynamic programming, with reservation value r^*

$$r^* = r^o + (\lambda_0 - \lambda_1) \int_{r^*}^{r} \frac{\overline{F}(r)}{\rho + \eta + \mu + \lambda_1 \overline{F}(r)} dr \tag{1}$$

whereas for households having a dwelling of their own the optimal strategy is to accept each offer strictly better than the present one.

Interpretation of the reservation equation reveals that if the offer arrival rate for households not having a dwelling of their own is smaller than that of households having a dwelling, then the reservation value r^* will be lower than r^o. So in a housing market having great difficulties for newly formed households to obtain an offer, dwellings which yield a lower utility than the baseline utility level r^o will be accepted. The reason is that when newly entered households are discriminated, such that $\lambda_0 < \lambda_1$ it is attractive for the household to first accept a dwelling with a low place utility level and subsequently move to one with a higher place utility, than wait for another offer while not having a dwelling of their own. On the other hand, if offer arrival rates for both states are the same, a household with no dwelling of their own will set the reservation value equal to r^o. If the housing market is such that the arrival rate for households having a dwelling is smaller than

[2] As a first attempt to model finite lifetime we assume lifetime to be exponential.

that for households not having a dwelling of their own, then the reservation value will be higher than r^o.

Since we expect o¤ers to be di¤erent from the place utility actually experienced, we distinguish between the o¤er distribution $F(r)$ and the distribution of place utility experienced $G(r)$. Moreover, we distinguish between households who experience at most a place utility r, and those which experience more than r. Our stock-‡ow representation of the housing market in Figure 1 shows that households may move to one of the three states depending on housing market conditions.

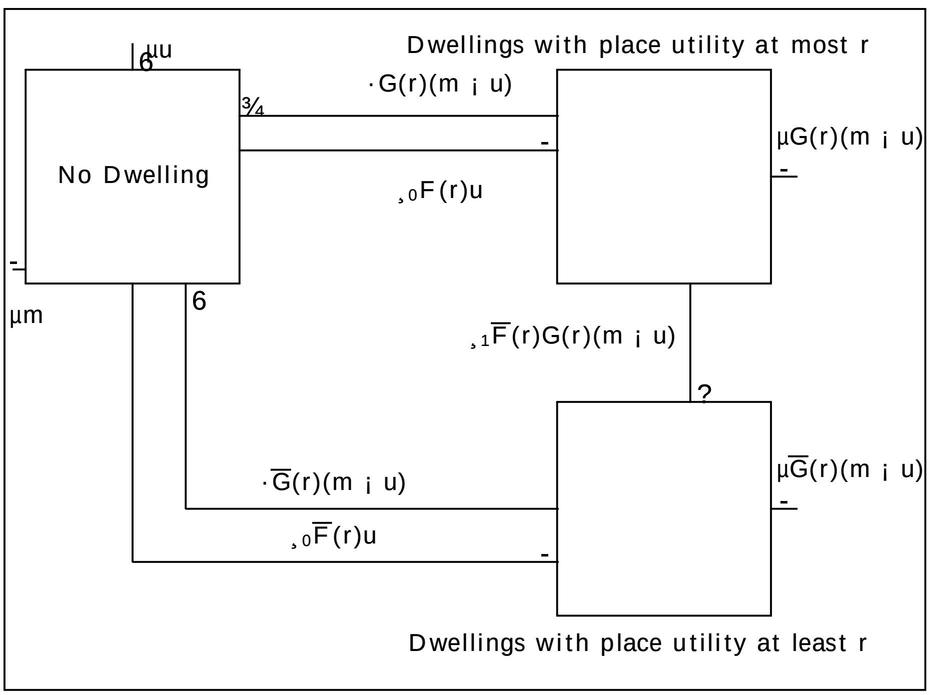

Figure 1: A Stock-Flow Scheme of the Housing Market

Figure 1 shows that households not having a dwelling of their own may move to a dwelling of either the housing stock with place utility at most r, or to one of the stock with place utility at least depending on the housing market and as long as they are alive. If dwellings with place utility of at most r are o¤ered more frequently, households may move to dwellings with this lower place utility more frequently. In addition, since households continuously search for better dwellings, households may subsequently move to dwellings with place utility of at least r. As such the model captures housing career where households start in a less preferred dwelling and subsequently move to a dwelling with higher place utility. As a result of the residential move, a dwelling with lower place utility becomes vacant, which subsequently will be offered on the market, thus creating a vacancy chain. As a result, residential mobility is higher if households start in dwellings with place utility at most r, than when households start in dwellings with place utility at least r. Moreover, as Figure 1 reveals, due to urban renewal households might be forced to move. However, as can be seen, households are assumed not to move from high to low- utility dwellings.

Concentrating on the number of households experiencing at most r, the time rate change equals inflow minus outflow:

$$\frac{d\left(G(r)(m-u)\right)}{dt} = \lambda_0 F(r) u - \left(\kappa + \theta + \lambda_1 \overline{F}(r)\right) G(r)(m-u) \qquad (2)$$

In a steady-state situation inflow must balance outflow, so that the steady-state distribution of place utility equals

$$G(r) = \frac{F(r)}{\kappa + \theta + \lambda_1 \overline{F}(r)} \frac{\lambda_0 u}{(m-u)} \qquad (3)$$

Using the steady-state homelessness rate, the steady-state distribution of place utility reduces to

$$G(r) = \frac{(\kappa + \theta) F(r)}{\kappa + \theta + \lambda_1 \overline{F}(r)} \qquad (4)$$

This equation is the structural relationship imposed by the steady-state equilibrium between the distribution G of actual place utility experienced and the distribution F of offers. It reveals that the fraction of households experiencing at most r goes to zero, as either $\kappa + \theta$ goes to zero, or λ_1 tends to infinity; that is, all households will experience the highest place utility in the limit. To determine the equilibrium distribution G of actual place utility, we first have to determine the equilibrium distribution F of offers by the supply side of the housing market, which is the topic of the next section.

2.2 Supply of Housing

On the supply side, homogeneous suppliers post a dwelling with an advertised price p, which maximizes a profit function

$$\pi = (p - c)\, l(p) \qquad (5)$$

with $l(p)$ the occupancy level, p the revenue, and c the operating costs of housing provision. We may now relate the advertised price to the households place utility r by

$$r = \alpha - p \tag{6}$$

with α a place utility index depending on certain dwelling characteristics.

It is assumed that each supplier has one vacant dwelling. We assume that at a certain time a certain number of dwellings is occupied, and a given number of dwellings is vacant. The total number of dwellings is fixed in the short run. We assume that there is no bargaining over the advertised price. The number of occupied dwellings is then determined by the offered place utility, the reservation place utility level of the households, and the offers of other suppliers, as represented by $F(r)$. Competition for a household by suppliers to let them occupy the dwelling eliminates discontinuities in the offer distribution. To see this, we notice that households continuously search for better dwellings [3]. As a result of continuous search, the supplier knows that if he offers a dwelling with a slightly higher price no one will accept the offer. If on the other hand, he offers the dwelling with a slightly lower price, all want to have the dwelling, and the supplier can attract all households, which implies a larger profit. As a result, each supplier chooses a different price that will maximize his profits. Given these offers, the number of households per supplier who occupy a dwelling with place utility less than r can be defined as

$$l(r; r^{*}; F(r)) = (m - u)\frac{dG(r)}{dF(r)} = \frac{m\lambda_0(\delta+\theta)(\delta+\theta+\lambda_1)}{(\delta+\theta+\lambda_0)\left(\delta+\theta+\lambda_1\overline{F}(r)\right)^2} \tag{7}$$

Having described demand and supply, we now turn to the housing market equilibrium, which is the topic of the next section.

2.3 Equilibrium

Using the steady-state occupancy level for the supplier offering the lowest acceptable place utility level $\underline{r}$ [4], we can derive the equilibrium profit level. In equilibrium, every offer must yield the same steady-state profit which

[3] It is clear that if search and moving costs are introduced households will not necessarily move to a dwelling with higher place utility, because the gain in place utility should exceed a certain threshold level to overcome these costs (see also Van Ommeren, 1996).

[4] The lowest place utility level is assumed to correspond to the highest acceptable price.

equals $(\alpha - \underline{r} - c)\, m\lambda_0(\kappa+\theta)/(\kappa+\theta+\lambda_0)(\kappa+\theta+\lambda_1)$. As a result, the unique equilibrium offer distribution for $r \in [r^*; \bar{r}]$ is

$$F^*(r) = \frac{\kappa+\theta+\lambda_1}{\lambda_1}\left(1 - \sqrt{\frac{\alpha - r - c}{\alpha - \underline{r} - c}}\right) \tag{8}$$

Using the fact that the highest place utility offered ($\bar{r}$) satisfies $F(\bar{r})=1$, i.e.

$$\begin{aligned} 1 &= \frac{\kappa+\theta+\lambda_1}{\lambda_1}\left(1 - \sqrt{\frac{\alpha - \bar{r} - c}{\alpha - \underline{r} - c}}\right), \qquad (9)\\ \bar{r} &= \left(1 - \left(\frac{\kappa+\theta}{\kappa+\theta+\lambda_1}\right)^2\right)(\alpha - c) + \left(\frac{\kappa+\theta}{\kappa+\theta+\lambda_1}\right)^2 \underline{r} \end{aligned}$$

as well as the fact that households will not accept any offer with place utility less than their reservation value, i.e.

$$\underline{r} = r^*$$

we consequently obtain the equilibrium value for the reservation place utility [5]

$$r^* = \frac{(\kappa+\theta+\lambda_1)^2 r^0 + (\lambda_0 - \lambda_1)\lambda_1(\alpha - c)}{(\kappa+\theta+\lambda_1)^2 + (\lambda_0 - \lambda_1)\lambda_1} \tag{10}$$

The equilibrium value for the occupancy level, and the distribution of the place utility experienced equals then:

$$l^*(r; r^*; F(r)) = \frac{m\lambda_0(\kappa+\theta)}{(\kappa+\theta+\lambda_0)(\kappa+\theta+\lambda_1)} \frac{\alpha - r^* - c}{\alpha - r - c} \tag{11}$$

$$G^*(r) = \frac{(\kappa+\theta)}{\lambda_1}\left(\frac{1}{\sqrt{\frac{\alpha - r - c}{\alpha - \underline{r} - c}}} - 1\right) \tag{12}$$

which completes the formulation of our model.

3 Data, Specification and Estimation

3.1 Data

For the empirical analysis we make use of a Dutch Housing Demand Survey (WBO)(cf. CBS, 1995a,b). In the WBO, a random sample of all officially

[5] For simplicity, we assume ρ to be small relative to the offer arrival rate (see also Mortensen en Neumann, 1988).

registered individuals in the Netherlands of 18 year and older is asked to participate in the survey. Reasons for asking individuals rather than using households or dwellings as the sample unit are (i) to acquire information on potential new households, and (ii) to acquire information on individuals occupying part of a dwelling, or who do not have a dwelling of their own. From a total of 11,739.174 individuals of at least 18 years old, 84,326 are asked in the 1993/94 WBO to participate, of which 74.5% actually participated. From this we select only those observations for which the participant is the principal occupant of the dwelling, which leaves us with 56,597 observations.

In this survey extensive information on housing and households is collected. It contains information on aspects of the current occupied dwelling, the former occupied dwelling, and of the household, like the number of household-members, employment-status, commuting distance, dwelling type, tenure, rent or mortgage, and income. In addition, subjective information is collected with respect to satisfaction with the current dwelling, perceived safety of the neigborhood, reasons of moving, and preferred location and dwellingtype when moving.

Though the WBO does not follow individuals over time, we do have information about housing market histories, since households are asked about recent moves, and the former occupied dwelling. In the WBO, individuals were asked about the number of transitions over the last five years, the associated spell of occupation, and the associated dwelling characteristics. As such, we have retrospective information on the housing-market history of the household. Figure 2 shows different types of duration data contained in the WBO.

For the first type of observations, 40,251 observations, we know the time of entrance, and the elapsed duration but not the residual duration, which is referred to as right-censored spells. For the second type of observations, 13,474 observations, we have both a left-censored spell of which we do not know the elapsed duration but do know the residual duration, and a right-censored spell of which we do know the elapsed duration but not the residual duration. For the case of two transitions, 2,354 observations or three transitions, 518 observations, we have a left-censored, one or two completed spells, and a right-censored spell. Unfortunately, examination of the data reveals that we only have sufficient detailed information for the first and the second type of observations. For the third and the fourth type of observations, we do have information on the different spells, but however do not have information on the dwelling-characteristics..

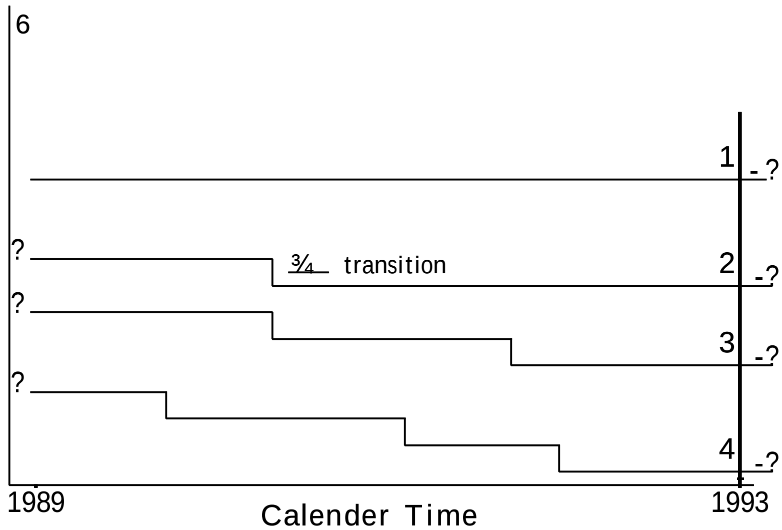

Figure 2: Duration Data

3.2 Empirical Speci…cation

In order to estimate our model and to obtain empirical equilibrium values for (8), (10), (11) and (12) we parameterize the place utility index ®, the baseline utility level r^0, and the operating cost c, and measure the housing price p. Our parameters of the model are ®, · , ¸$_0$, ¸$_1$, ½ and r^0, and c. Following Phipps and Carter (1984) we parameterize the place utility index by separate and independent components of the residential environment. These orthogonal components are attributes of the dwelling unit, the neighborhood, the neigborhood people, and the dwelling's accessibility[6], and are de…ned in the Appendix.

Assuming place utility to be additive in the attributes, we can specify our place utility index ® as

$$® = x¯_1 + " \tag{13}$$

where the vector of the residential and neigborhood attributes x is orthogonal on ", and " is i.i.d. normal $(0; ¾^2)$. Our baseline utility level is found by[7]

$$r^o = \min(®) \tag{14}$$

[6] See also Clark and Van Lierop (1986) for a discussion of the literature on these attributes.

[7] This has been done by Kiefer and Neumann (1993) to …nd the reservation value. In

In addition, operating expenses for the supplier consists of taxes, insurance and costs for maintenance like repair and replacement costs. The operating cost index c depends on the residential attributes[8] x_1, with $x_1 \subset x$

$$c = x_1\beta_2 + \varepsilon \tag{15}$$

Moreover, the renovation parameter κ depends on both residential and neigborhood attributes, so that

$$\kappa = x\beta_3 + \varepsilon \tag{16}$$

In addition, values for the offer arrival rate λ_0 and λ_1 depend on current residential and neigborhood attributes, such that

$$\lambda_0 = x\beta_3 + \varepsilon \tag{17}$$

$$\lambda_1 = x\beta_4 + \varepsilon \tag{18}$$

In our analysis, we impute different values[9] for the discount rate ρ, since most empirical studies fail to estimate the time preference rate because of numerical problems [10]. Our estimation procedure is discussed in the next section.

3.3 Estimation [11]

Using Poisson processes as the stochastic process generating a sequence of events, it can be shown[12] that both the waiting time until the first event, and the times between events in a Poisson ($\lambda\overline{F}(r^*)$) process has an exponential distribution with parameter $\lambda\overline{F}(r^*)$: As is well known[13], the probability distribution F of duration t for the exponential distribution is

$$F(t) = 1 - \exp\{-\lambda\overline{F}(r^*)t\} \tag{19}$$

relation to this, Van den Berg and Ridder (1993) argue that, within certain bounds, the way in which the baseline level is calculated does not substantially matter.

[8] See also De Leeuw and Ekanam (1971), Eubank and Sirmans (1979) and in particular Rosen and Smith (1983).

[9] More appropriately, as observed by Tony Lancaster in a private consultation, we could specify a distribution for ρ

[10] See for estimation of the subjective rate of time preference in job search models, Nadrendranathan and Nickell (1985) and Van den Berg (1990).

[11] For empirical issues in estimating equilibrium models we refer to Van den Berg and Ridder (1993), and Kiefer and Neumann (1993).

[12] See Lancaster (1990) for a discussion of Poisson processes in duration analysis.

[13] See Kiefer (1988) for an outstanding introduction to duration data and hazard functions.

with survival function $S(t)$

$$S(t) \equiv 1 - F(t) = \exp\{-\lambda\overline{F}(r^*)t\} \tag{20}$$

and probability function of duration $f(t)$

$$f(t) \equiv \frac{dF(t)}{dt} = \lambda\overline{F}(r^*)\exp\{-\lambda\overline{F}(r^*)t\}. \tag{21}$$

and hazard rate for leaving homelessness $\varsigma(t)$

$$\varsigma(t) \equiv \frac{f(t)}{S(t)} = \lambda\overline{F}(r^*) \tag{22}$$

This relation between the hazard function and the duration in a particular state will be used in the sequel, since we are interested in the distribution of duration (t) for the different states, and how these distributions are related to the density function of prices (p), and of place utility (r).

Recognizing that the process of movement by a household from state to state is a three-state[14] continuous-time Markov Chain[15], with constant transition probabilities only depending on the current state, the transition intensity matrix of the process for $r \in [\underline{r}, \overline{r}]$ is

$$Q = \begin{pmatrix} -(\lambda_0 F(r) + \lambda_0\overline{F}(r)) & \lambda_0 F(r) & \lambda_0\overline{F}(r) \\ \delta & -(\delta + \lambda_1\overline{F}(r)) & \lambda_1\overline{F}(r) \\ \delta & 0 & -\delta \end{pmatrix}$$

The transition probability matrix then would be

$$\Pi = \begin{pmatrix} 0 & \frac{\lambda_0 F(r)}{\lambda_0 F(r) + \lambda_0\overline{F}(r)} & \frac{\lambda_0\overline{F}(r)}{\lambda_0 F(r) + \lambda_0\overline{F}(r)} \\ \frac{\delta}{(\delta + \lambda_1\overline{F}(r))} & 0 & \frac{\lambda_1\overline{F}(r)}{(\delta + \lambda_1\overline{F}(r))} \\ 1 & 0 & 0 \end{pmatrix} \tag{23}$$

The total individual likelihood function is made up of the individual likelihoods for the case the individual does occupy a dwelling of their own, and for the case the individual does not occupy a dwelling of their own at the time of the interview. Let (t, p) denote an observation, with t either left censored (t_r), complete (t_c or simply t) or right-censored t_e, and p the price.

[under construction]

[14] Actually, the model is a four-state model since we assume households to be dissolved at rate θ, which is however irrelevant, since the data is retrospective.

[15] See Chapter 5 of Lancaster (1990) for a discussion of the Continuous Time Markov Chain model.

4 Results

[under construction]

5 Conclusion

[under construction]

This paper has formulated an empirical equilibrium search model for the housing market. Starting from individual's optimal behavior, expressions for the equilibrium reservation place utility and the equilibrium offer distribution has been obtained. For the empirical analysis we have made use of the Dutch Housing Demand Survey, which contains retrospective data on the housing market histories of households.

Table 1.Exogeneous Variables

Variable	De…nition	Classes
Dwelling characteristics		
TYWON	dwellingtype	5
BJAAR	year of construction	20
TUIN	lot	2
GARCARP	garage / carport	3
OPPHFDWV	surface livingroom	7
KAMERS	number of rooms	Numeric
ISOL	insulation	3
OWONING	appropriateness of the dwelling	8
TWONING	satisfaction with the current dwelling	6
Neigborhood		
TWOONOMG	satisfaction with the neigborhood	6
LANDGEB	urban/rural area	2
BRTBWPER	year of construction	5
BRTHUKO	ternure in the neigborhood	4
BRTTYPW	dwellingtypes	3
Neigborhood people		
BRTINKOM	income	4
BRTBUREN	noise of neighbors	3
Accessibility		
BRTCENTR	distance from a center	3
BRTHALTE	public transport available	3
HBWWRP	commuting distance	Numeric
Cost of Housing Provision		
ONDERHD	maintenaince cost	Numeric
Price		
HUUR	rent	Numeric
IHS	rent assistance	Numeric
ERFPACHT	long lease	Numeric
KOOP	potential salesprice	30
HYPLAST	mortgage	Numeric
PREMIE93	ownership assistance	Numeric
OZBL	real estate taxes	Numeric

Table 2. Transitions

Variable	De…nition	Classes
Transitions		
AANTVERH	number of moves during (1989-1993)	2
VESTPRD1	date …rst move	9
VESTPRD2	date second move	9
VESTPRD3	date third move	9
VESTPRD4	date fourth move	9
VESTPER/ VERSTPRD	date to current place	14
VSORTWO1	dwellingtype disposed of at the time of the …rst move	18
VSORTWO	dwellingtype disposed of at the time of the last move	18
VGROOTHH	number of family-members at the time of the last move	Numeric
VREDHUSA	reason for last move	3
VREDEN	reason for chosing the current dwelling	31
VHUKO	tenure last dwelling	3
VKOOP	salesprice of lastest disposed of dwelling	30
VHUUR	rent last dwelling	Numeric
VIHS	rent-assistance last dwelling	Numeric
VTYPWON	type of the last dwelling	5
VBJAAR	construction year of the last dwelling	19
VKAMERS	number of rooms last dwelling	Numeric
VGROTER	is current dwelling bigger than last one	3

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