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Household and housing market dynamics: a simulation model

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Introduction

Household change is the driving force behind the residential mobility process. The number of households in the Netherlands has increased much more rapid than could be expected on purely demographic grounds. Changes in life-styles with respect to living arrangements and associated changes in household composition underly this increase and explain why solely demographic models have failed to predict the trend of increasing numbers of households. Changing household dynamics are especially critical for residential mobility and housing market change. The implications are not limited to the growth of quantitative housing needs that accompanies the increase in number of households. Moves between various types of dwellings, located in a system of spatial sub-markets are determined to a large extent by the (changes) in the composition of the household. Thus, to a large extent household dynamics are the basis of housing market dynamics.

To analyse the effects of demographic change and household evolution on the functioning of the housing market, we have constructed a model (WODYN), which has as its basis a simulation model of households in the Netherlands. This simulation model is the input of a second model in which changes in housing needs, housing supply and the housing distribution can be simulated. This contribution has two main sections: in the first part the general approach of the simulation is outlined, and in the second part it will be sketched how this is linked to a simulation of the residential mobility process. It will be shown that the conclusions with respect to the methodology of modelling household dynamics have repercussions for modelling residential mobility as well.

The WODYN household model

The WODYN-household model is based in part on a previous attempt to develop a simulation of Dutch households, using a multi-state demographic approach, the PRIMOS model. There are, however, some marked differences in the methodology adopted, and we will compare the performance of the models. The discussion of the model covers the general structure of the model, the definition of the household positions (the state space), the way in which transition probabilities have been estimated, the aggregation of individuals to households and the internal consistency of the model.

Household modelling and available data

While a complete record of individual life histories would provide specific timing and duration data on all household events, such longitudinal data sets are rare and not available in the Netherlands. However, there are three viable alternatives. First is the Housing Needs Survey which is repeated every four years among a sample of all inhabitants aged 18 years or over, provides considerable retrospective information, for instance on the timing of leaving the parental home, including the partner relation at that moment. Second we used the Survey on Family Formation, which is held by the Netherlands Central Bureau of Statistics every three years, to obtain data on fertility and on the cohabitation of unmarried women. The data set contains a wealth of retrospective information, recording the exact age at the moment of the start of cohabitation etc. Third, the purely demographic data (fertility, mortality and migration) were derived from the national population forecast, ensuring consistency of the household model with this forecast.

The observation plan was slightly different for each data- set, which required that one rework the data to be able to use it consistently. It turned out to be possible to define the population at risk at the start of observation periods, before events were recorded and thus to deduce transition probabilities.

The structure of the WODYN Household model

Three elements of the household model characterize its structure; the state-space, the nature and estimation of the transitions between states and the aggregation of individuals to households. The individual is the basic unit of analysis and processes of household formation and dissolution are regarded as the result of the transitions of (groups of) individuals between household positions (states). Obviously this introduces the need the aggregate these (groups of) individuals to households in a consistent manner.

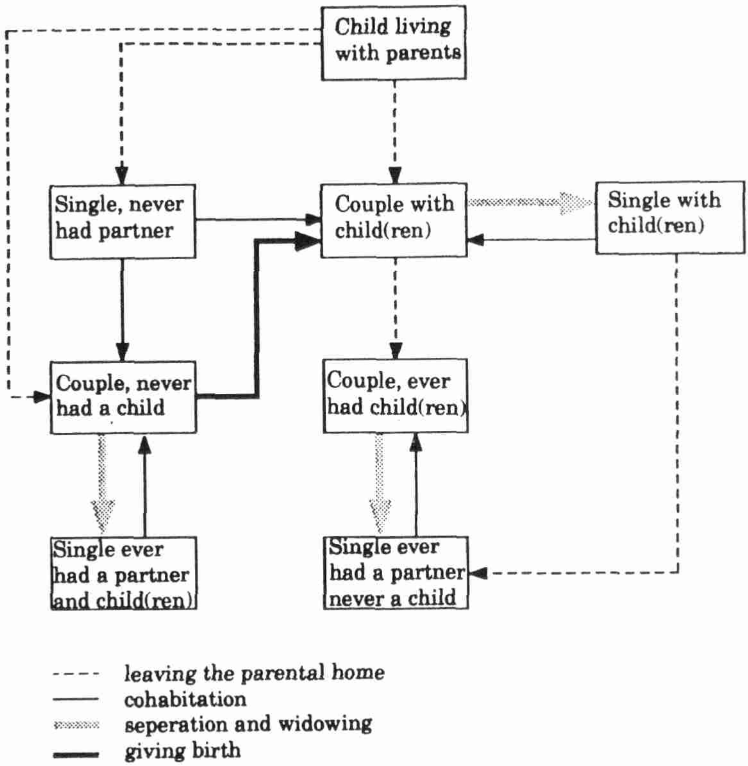

Figure 1 States and transitions in the WODYN-model

The household positions are depicted in Figure 1. The system is limited to the population in households and the arrows indicate transitions from one state to another. In addition, the events by which people enter or leave the system are also modelled. Entering the system can occur as births (entering the system as children living with their parents) or as immigration (entering the system in every possible state). Leaving the system is possible from every state by means of decease, emigration or moving into an institution. The transition probabilities of entering or leaving the system are derived from the national population forecast, except for the moves into institutions which were modelled endogenously. The household position of the migrants were estimated proportionally according to their age.

Only two states can be characterized as being 'single passage' states (Willekens 1983), viz. children living with their parents, and singles not having lived together. The others are transient states, but it is assumed that people do not return to their former position within one estimation interval (one year). Within the system no absorbing states are defined, but it is impossible to return to the system once it has been left (death, emigration and living in institutions are assumed to be absorbing states).

The figure does not display the complete detail of the model effort. For instance, singles who have lived together were divided into those who were separated and those who were widowed. Obviously the events leading to these stages are different, but also the probability of re-entering the position of living together turned out to vary between these groups. The decision as to which household states had to be distinguished, was based on a careful analysis of the heterogeneity in the transition probabilities. For instance it turned out that the probabilities of cohabitation differ between those living with their parents and those living alone (this can be grasped intuitively, a lower probability of cohabitation means a higher probability of becoming single after the leaving of the parental home). Additionally, the probability of separation is higher among those not having children. (For a full overview of these analyses, see Hooimeijer & Linde 1988).

Apart from the attributes defining the household position, other attributes, viz. age (by one year intervals), sex and birth cohort (by five year intervals) were used to estimate the transition probabilities. These probabilities were calculated as follows:

$$mij(x,y,z)=Oij(x,y,z)/Li+(x,y,z) \quad (1)$$

in which:

- i and j are the position attributes of individuals at time t (i) and t+1 (j) respectively;

- mij the probability to go from position i to position j;

- Oij the number of transitions during the interval of one year exactly;

- Li+ the number of persons in position i at time t;

- x, y and z are the age, sex and birth-cohort.

This leads to a very large matrix, encompassing over 15,000 transition probabilities. Obviously some form of generalization is needed to estimate these probabilities. The shape of the empirical distributions of the age-specific transition probabilities, showed that these distributions exhibited the shape of some well-known mathematical functions (e.g. the lognormal, the positive exponential, etc.). We used an iterative least-square method to fit these mathematical curves to the observed probabilities according to age, for each sex and birth- cohort separately. In Figure 2 an example of this procedure is shown. The figure depicts the probabilities of leaving the parental home for women in the birth-cohort 1940-1944.

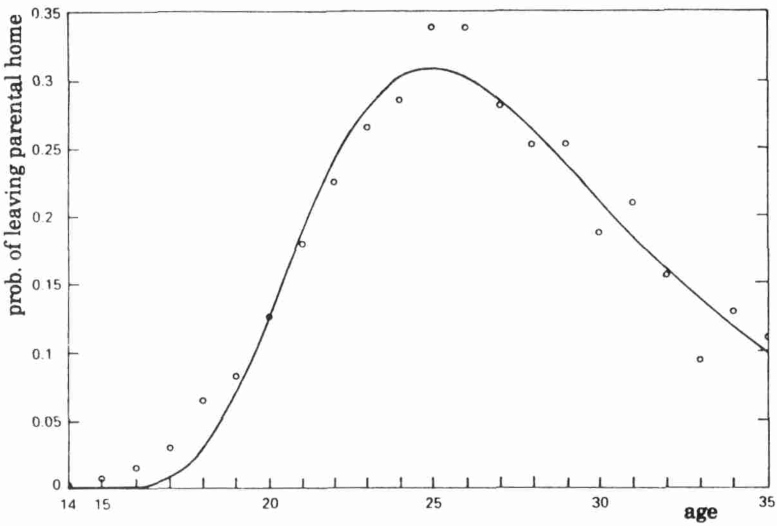

Figure 2 Observed and estimated probabilities of leaving the parental home by age (females, birth-cohort 1940-1944)

While the transition probabilities for females were estimated in the way described above, for the males, only part of the probabilities were estimated in this way. The reason for this restriction is related to the way in which the consistency problem between males and females occupying complementary household positions has been solved.

The consistency problem is a well known issue in household modelling. Many transitions made by woman are dependent on the transitions made by their (male) partners and vice versa. For instance if a cohabiting male dies, the females makes the transition from couple to single (widowed). The decision was to model the transitions which affect both men and woman explicitly for the woman. The transitions of the man were derived from these transitions by means of an age-relation matrix. In this matrix the age distribution of the males per age of the females is fully specified. Multiplying the vector of transitions made by females with this matrix renders the age-specific transitions of the males. For instance the number of males changing from living alone to cohabitation could be derived in this way. But also the number of widowed persons can be derived in this way from the mortality rates of the opposite sex. As we have chosen the woman as the 'marker' of the household, this also solves the problem of 'marker' changes. The age of the new marker can be estimated directly. In this way consistency is assured in the following elements:

- the number of men living together equals the number of women living together.

- the number of transitions of males from single to couple in a given period equals the number of transitions between these positions made by females.

- the number of males who separated equals the number of females.

- the number of widowed males widower equals the number of deaths of cohabiting females.

Apart from the assurance of consistency, the method also reduces requirements on data-collection. This is a preferred methodology even if data are available for both man and women. In many household models the male and females are treated separately until the moment of aggregation. Then one has to correct for the differences between for instance the married males and the married females. This correction overrides the carefully specified parameters.

A second aspect of the consistency problem relates to leaving the parental home and the transition to the 'empty nest' state for the parents. This has been solved by specifying the age distribution of the mother over the age of her youngest child. This matrix is adjusted on the basis of two demographic processes. First, when a child is born, the mother makes the transition from a couple without children to a couple with child(ren). In the age-relation matrix the youngest child is now zero. Every year the age of both the child and the mother is updated. When the next child is born however, its older brother or sister (estimated on the basis of the distribution of birth intervals) is deleted from the matrix and the youngest child is again aged zero. When the youngest child grows older, its reaches the age at which it leaves to parental home. By multiplying this probability with the probability that its mother has a specified age, the probability of transitions to the empty-nest state can be estimated directly.

This matrix is dynamic in two ways. Changes in the age (and order) -specific birth-rates are translated into the matrix, as well as changes in the age at which people leave their parental home. In this way the decrease in elderly families with children and the increase in elderly couples in the near future, due to the drop in the birth-rates in the past can be estimated accurately. This leads us to a very important aspect of the model structure, the way in which the dynamics in household formation and dissolution is modelled.

Modelling household dynamics

The dynamic nature of the processes determining the transitions between household states is represented in the model by allowing the transition probabilities to vary over time (one of the main advantages of simulation methods over for instance headship rate methods is, that the dynamics in each proces can be analyzed and modelled separately). The causes of these dynamics can be twofold. In the first place it can be a compositional effect; within the group on which transition probabilities are applied, subgroups can be distinguished having varying probabilities. If the share of these subgroups varies over time, then the probabilities will change accordingly. Heterogeneity leads to temporal instability. This can be solved by splitting up the original group into more homogeneous subgroups. The second possibility is that the behaviour of the groups which are homogeneous changes over time due to changes in the context, say as a result of changes in attitudes towards marriage, having children, etc.

The nature of the dynamics can also have two facets. It can be a case of more (or less) people participating in a proces, or of changes in the age-specificity (a change in localization). For instance a drop in the age-specific birth rates at a younger age can either mean that people have fewer children, or that people have children when they are older. In modelling household dynamics, it is crucial to differentiate between these two effects. We will distinguish two ways to measure changes in transition probabilities, viz. cross-sectional and longitudinal. Cross-sectional measurement implicitly assumes that the age specific transition probabilities can be estimated without reference to the survival function of the group involved. However, this assumption is violated if the age-specific probabilities are dynamic. These probabilities are calculated by dividing the number of transition in a given time-interval by the size of the population at risk at the beginning of that period. The size of the population at risk is determined by the pace at which the process has evolved until that moment, because every transition reduces this population by one person. Cross-sectional measurement ignores the fact that the survival functions of successive cohorts differ. Applying the transition probabilities means that these are multiplied with a population at risk, which differs from the one used to determine the probabilities.

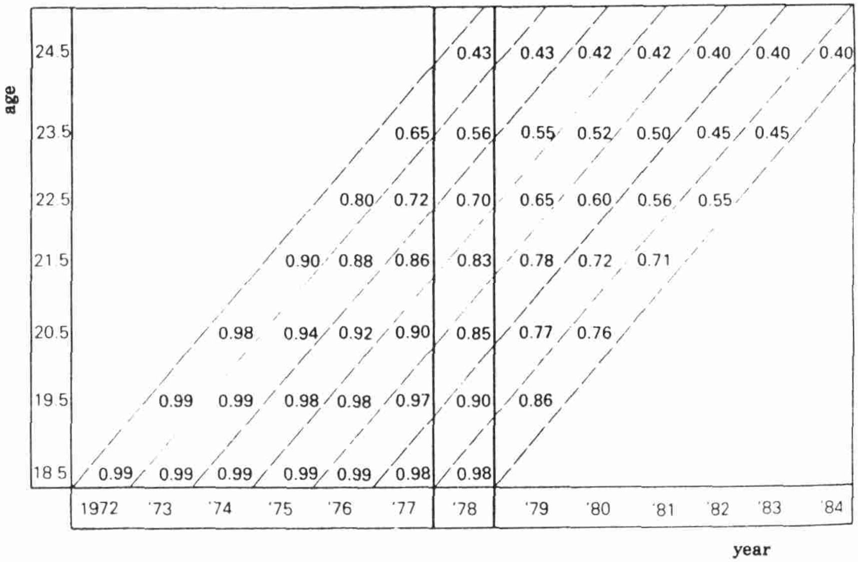

Figure 3 The Lexis-diagram

The error which is introduced by cross sectional methods is illustrated in Figure 3. In the Lexis-diagram cohort-specific survival functions are depicted on the diagonals. The cross-section, indicated at the year 1978 in this figure, is a combination of various survival functions at a certain point in time. A comparison of successive diagonals shows that the survival functions of later cohorts decreases at a higher pace than those of earlier cohorts, but that the level is about the same at the age of 25. Clearly people do not participate in greater numbers in this process over the life-course, but they participate at an earlier stage in life; the rapid decrease of the survival function at an early age is compensated by a slower decrease at older age. In the cross-sectional method this compensation does not occur, because the transition probabilities at higher age are determined on the basis of the survival functions of earlier cohort, which showed a rapid decrease at higher age. Applying these probabilities on later cohorts causes an overestimation of the number of transitions at higher age and the total survival function will be estimated incorrectly. Frinking (1981) postulated that the number marriages ending in a divorce will be overestimated if cross-sectional data are used, due to the fact that divorces occur at an earlier age.

The difference between the longitudinal (cohort) and the cross-sectional (period) approach is particularly relevant for making projections. Within the longitudinal approach it is possible to formulate assumptions about the future development of the process on the basis of the development of the survival function up to the present moment (Veys 1981). We analysed the dynamics in the various processes of household formation and dissolution, by comparing the survival functions of successive birth-cohorts. If these turn out to be the same then the future (unknown) parts of later cohorts will probably be the same as those of earlier cohorts. However if they differ at an early age, various hypotheses can be developed about the future development of the survival function of later cohorts. We will illustrate this with two examples.

Two empirical examples

The first example is the one we used before; leaving the parental home. We fitted lognormal curves for five successive birth-cohorts (see table 1).

Table 1 Parameters for leaving the parental home

	Males			Females		
Cohort	LMAX	WMAX	SIGMA	LMAX	WMAX	SIGMA
'35-'39	27.44	.219	.345	25.72	.277	.394
'40-'44	26.40	.253	.330	24.96	.310	.403
'45-'49	25.62	.254	.367	24.07	.329	.415
'50-'54	25.34	.255	.386	23.37	.332	.470
'55-'59	25.25	.254	.394	23.16	.331	.492

The changes in the parameters turned out to be large for the first three cohorts. The maximum probability (WMAX) increased and was reached at an earlier age (LMAX). At the same time the shape of the curve became flatter (SIGMA increases). The last two cohorts show only minor changes however. Apparently the age at which people leave the parental home has stabilized over the past ten years. In this example only the age-specific distribution is changing, because everybody leaves his or her parents, and the survival function will decrease to zero for every cohort. To illustrate the magnitude of the changes represented by these shifts in parameters, the survival functions of staying with the parents of the first and the last cohort are depicted in Figure 4.

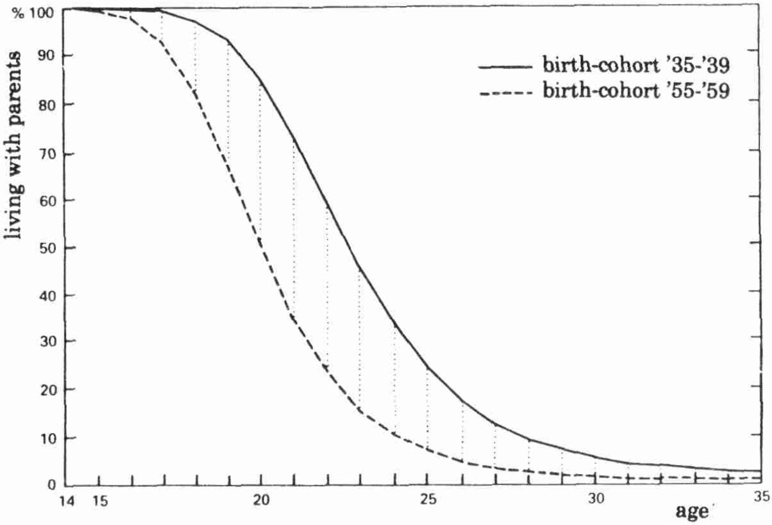

Figure 4 Percentage living with parents of two birth-cohorts

Of the women in the first birth-cohort (1935-1959) 75% lived with their parents at the age of 21. In the last cohort (1955-1959) this percentage had dropped to less than 40%. For the future no specific changes can be expected and the parameters of the last cohort were used to estimate future behaviour of later cohorts. The advantage of the longitudinal approach in this case is the correct estimation of the parameters. A cross-sectional approach would have overestimated the age-specific transition probabilities, due to the past dynamics. This will be shown in the next paragraph.

The second example relates to the process of cohabitation. In the past transitions to the married state have decreased considerably. In the Netherlands this has been compensated, until recently, by people who cohabit without being married. However, the cumulative percentage of people living together is lagging behind for the last cohort. Of the earlier cohorts eventually more than 90% lived with a partner at some point in life. The question is whether the latest cohort is postponing the decision to start living together or whether they will remain single for a larger proportion all their lives. We postulated three hypotheses as to the future development:

- the first specifies that only the age-specific distribution is changing, future transition probabilities are increased in such a way as to end up with more than 90% having lived together at least once before the age of 36.

- the second postulates that only the known part (early age) is changing and that transition probabilities at higher age will remain the same.

- the third indicates a decreased propensity to live together over the life-span.

The consequence for the estimation of the number of households in the future is large. In 2000 the difference between the first and the last hypotheses amounts to 170,000 households out of a total of 6,5 million. We will next examine the question whether the longitudinal approach also has advantages over the cross sectional approach, in the sense that it leads to better predictions.

Longitudinal or cross-sectional: a test on performance

As we noted in the introduction, the WODYN-model has a lot in common with the PRIMOS-model. However they differ in a number of respects, one of them being the way in which transition probabilities were measured. In the PRIMOS-model this was done cross sectionally. We ran each model, starting in 1982 for a period of 4 years. Then we compared the outcomes with the results of the Housing Needs Survey from 1986 (WBO1985/1986). We limited the test to people living at home, and singles, who never have cohabitated. The reason for this restriction is that these are single passage states, the survival function is determined by one process only. Differences in the survival function can therefore be attributed to the modelling of the process.

With respect to estimating leaving the parental home, both models differ only in the way the probabilities were estimated. The lognormal curve in the PRIMOS-model gave similar parameters except for the standard deviation, which was larger. (PRIMOS 0.50 and 0.59 for males and females respectively, WODYN 0.39 and 0.49). This is in accordance with the expectation that overall probabilities are higher due to the mixing of successive survival functions. The result should be an overestimation of the percentage of people having left the parental home. This is shown in table 2.

*Table 2 Percentage of females living with parents 1986 (*1000)*

Age	Observed	PRIMOS	Diff.	WODYN	Diff.
18	91	92	+1	95	+4
19	84	80	–4	84	0
20	65	63	–2	70	+5
21	49	46	–3	53	+4
22	41	31	–10	36	–5
23	28	20	–8	24	–4
24	17	13	–4	15	–2
25	11	9	–2	9	–2
26	8	6	–2	6	–2
27	6	4	–2	4	–2
28	4	4	–1	3	–1
29	4	3	–2	2	–2
30	3	2	–1	2	–1
31	3	2	–2	1	–2
32	3	1	–2	1	–2
33	2	1	–1	1	–1
34	1	1	0	1	0
35	2	1	–1	1	–1
Total	526.6	458.0	–68.5	500.7	–25.9

In the beginning of 1986 some 525,000 women aged 18 or over lived with their parents. In the WBO living with parents is defined as a transient state; women that have left but afterwards returned for some reason (e.g. separation) are also included (approximately 10-15 thousand). The models treat this as a single passage state.

The differences between the model results are telling. The PRIMOS-model overestimates the number of women who have left by almost 60.000, the WODYN-model by only 15.000. However, the WODYN-model does not provide a perfect fit. At early ages the number of women leaving is underestimated. This is compensated by a slight overestimation at higher age. This is probably due to some heterogeneity at age 18 and 19 when many children leave the parental home to go to a university somewhere else in the country.

To test for cohabitation was similar, although again the model results and the data from the WBO are not completely comparable. Being single in the WBO is again a transient state; it includes a number of persons who have been living with a partner before. Moreover the PRIMOS and WODYN results are less comparable, and therefore we present the pattern, rather than absolute numbers. The results are depicted in Figure 5.

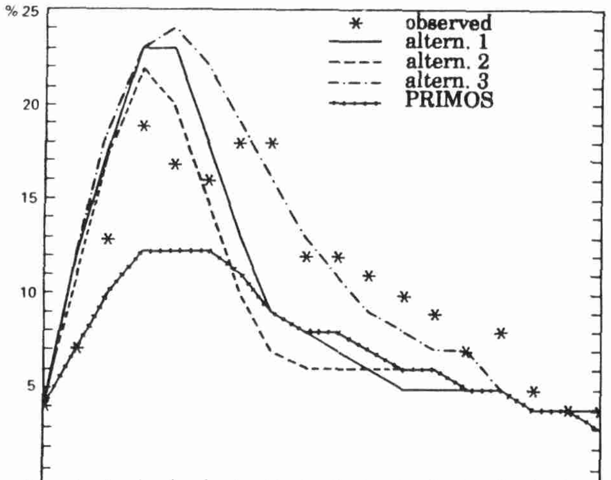

Figure 5 Percentage of singles in 1986

The PRIMOS-model underestimates the number of single people by almost 100.000. In alternative 1 of the WODYN-model this is 80.000, alternative 3 only 8.000. However, even though the results can not be compared directly, from a visual inspection it is apparent that the WODYN-alternatives reflect the pattern in the number of singles better, than the PRIMOS results.

Apparently the longitudinal approach is superior to the cross sectional approach, both in terms of conceptualisation of the processes at hand and in predictive performance. The essential difference between the two methods is, that the longitudinal approach takes the history of the households into account in predicting future behaviour. In the next sections we will explore the ramifications of this conclusion on modelling one of the major effects of household dynamics, viz. changes in housing market dynamics.

The WODYN housing market model

The modeling effort is based on the assumption that changes in the household composition constitute the most prominent factors driving residential mobility. Some changes, viz. leaving the parental home, cohabitation and separation actually imply a move. They are assumed to be the dominant cause of so-called 'induced moves'. Other changes, like the birth of a child or the decease of the partner, can lead to a shift in housing needs and preferences and therefore to a revaluation of the present housing situation. They are assumed to be the predominant cause of so-called 'adjustment' moves (Clark & Onaka 1985).

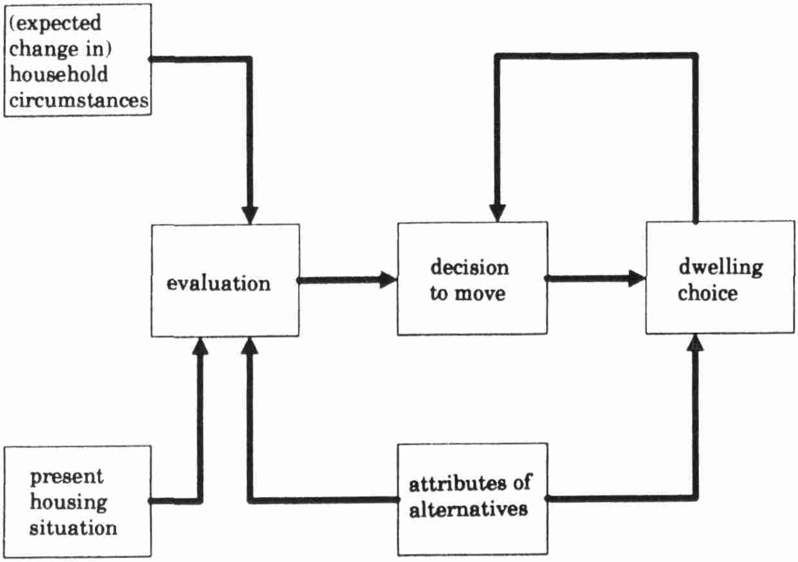

Figure 6 The housing adjustment process

As residential mobility results from the interaction between the characteristics of the household and its housing situation, future demand can not be determined unless both sets of characteristics are known. Therefore, the housing allocation model will have to simulate the future housing distribution of households. Two problems can be identified in estimating the future housing distribution:

The first problem is identical to the problem of household dynamics. The cohort effects discussed in part one are also present in the housing market. The future housing distribution is dependent on the housing career of households over past years. Successive cohorts will have experienced diverse career paths. Owner-occupancy for instance, has become increasingly popular in the sixties and seventies among households of middle age. As a result future generation of elderly households will be home-owners to a far greater extent than the present generation. This calls for an approach in which the future distribution is estimated by starting from the present housing situation and estimating the successive changes in this situation by modelling residential mobility. This leads to the second problem.

The residential mobility process is not fully demand-driven. Moves made by households should be modelled on the basis of the interaction between preferences, opportunities and constraints. A propensity to move is a prerequisite for residential mobility but not a sufficient condition. A vacancy must be available before the move can be made. Even if households exert demand for a certain dwelling type and suitable opportunities are available, the household will still be faced with constraints in trying to occupy the preferred dwelling. A major constraint is the competition of other households exerting demand for the same type of dwelling. However, opportunities arise not only through new construction and household dissolution, but also through the vacancies left behind by households which move to another dwelling. The problem is that the creation of these opportunities depends on whether the demand of households is being satisfied. Next, the creation of opportunities depends on the reaction of households to competition. Households may substitute their original preferences by either postponing the move or by adjusting their preferences towards a sub-market in which competition is less fierce.In the first case the probability of a vacancy decreases to zero, in the second case the probability increases. The housing allocation model will have to simulate this complex interaction.

The state space of the housing market model

The starting-point of the housing allocation model is the occupancy matrix in which the distribution of households over eight dwelling types (sub-markets) plus one category for dwelling substitutes (like house boats, bed-sitters, etc.) is contained. Households are disaggregated according to the age of the marker (the female) and their composition. Sub-markets were delimited on the basis of tenure, construction type and number of rooms. The eight sub-markets can be described as follows: small rental apartments, large rental apartments, small single-family rental dwellings, middle-sized single-family rental dwellings, large single-family rental dwellings, small owner-occupied dwellings, middle-sized owner-occupied dwellings, large owner-occupied dwellings.

Table 3 The housing typology in 1981

Type of Dwelling	Number	Perc.
Rental, Multi-Family, 3 Rooms or less	776.7	15.8
Rental, Multi-Family, 4 Rooms or more	602.5	12.2
Rental, Single-Family, 3 Rooms or less	247.0	5.0
Rental, Single-Family, 4 Rooms	710.1	14.4
Rental, Single-Family, 5 Rooms or more	527.0	10.7
Owner-Occupied, 3 Rooms or less	273.4	5.5
Owner-Occupied, 4 Rooms	735.5	14.9
Owner-Occupied, 5 Rooms or more	1053.9	21.3
Total	4926.2	100.0

The ordering in this typology is not coincidental, but is designed to reflect patterns of segmentation, substitutability and dominance in the interaction among these sub-markets, measured by the moves from one dwelling type to another. Sub-markets adjacent in the typology should portray a high degree of substitutability, many moves each way, while sub-markets at opposing ends of the typology should portray a high degree of segmentation, very few moves each way. Dominance relations imply that younger households tend to move up from the lower end of the typology (small apartments) towards the upper end (large owner-occupied dwellings). The typology was tested using loglinear analysis and proved to represent these patterns very well (see Hooimeijer & Magnusson 1989 for an example). This typology was used to measure the present housing situation and the preferences of households.

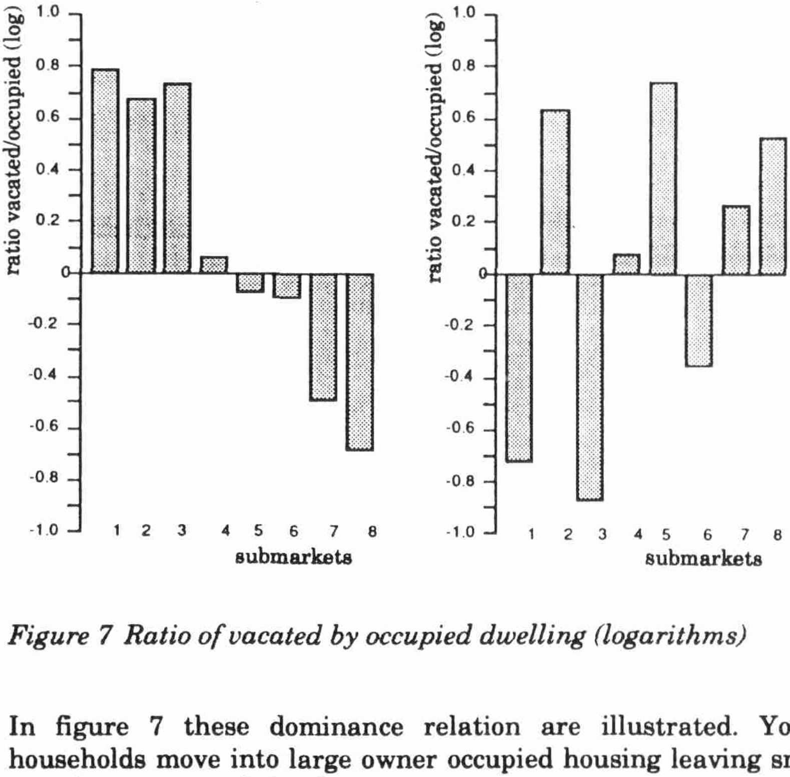

Figure 7 Ratio of vacated by occupied dwelling (logarithms)

In figure 7 these dominance relation are illustrated. Young households move into large owner occupied housing leaving small rental apartments behind.

The general structure of the housing market model

In the first part of the housing allocation model the occupancy matrix is updated with the demographic changes resulting from the household model (see figure 8). This pertains to three kinds of information. In the first place the number of new households are given. These are defined as households which are in need of a dwelling or dwelling substitute. Apart from immigrants, these are split-offs from existing households, people separating from their partner or leaving their parental home. In the second place existing households are described. They occupy a dwelling or dwelling substitute already. The characteristics of these households may have changed. For instance a male living alone may have started to live together with a female leaving her parental home. The result is an existing household containing two-persons, while the age of the marker changes from the age of the male into the age of the female. The third kind of information pertains to household dissolution, defined as the 'death' of a household leaving a dwelling or dwelling substitute vacant. This includes among others the death of a person living alone, transitions to homes for the elderly, but also the vacancy created by someone who moves in with another person. This results in direct estimates of the number of dwellings and dwelling substitutes which are vacated in the stock. The quantitative need for new housing can be derived directly from this information. It is the number of new households minus the number of household dissolutions.

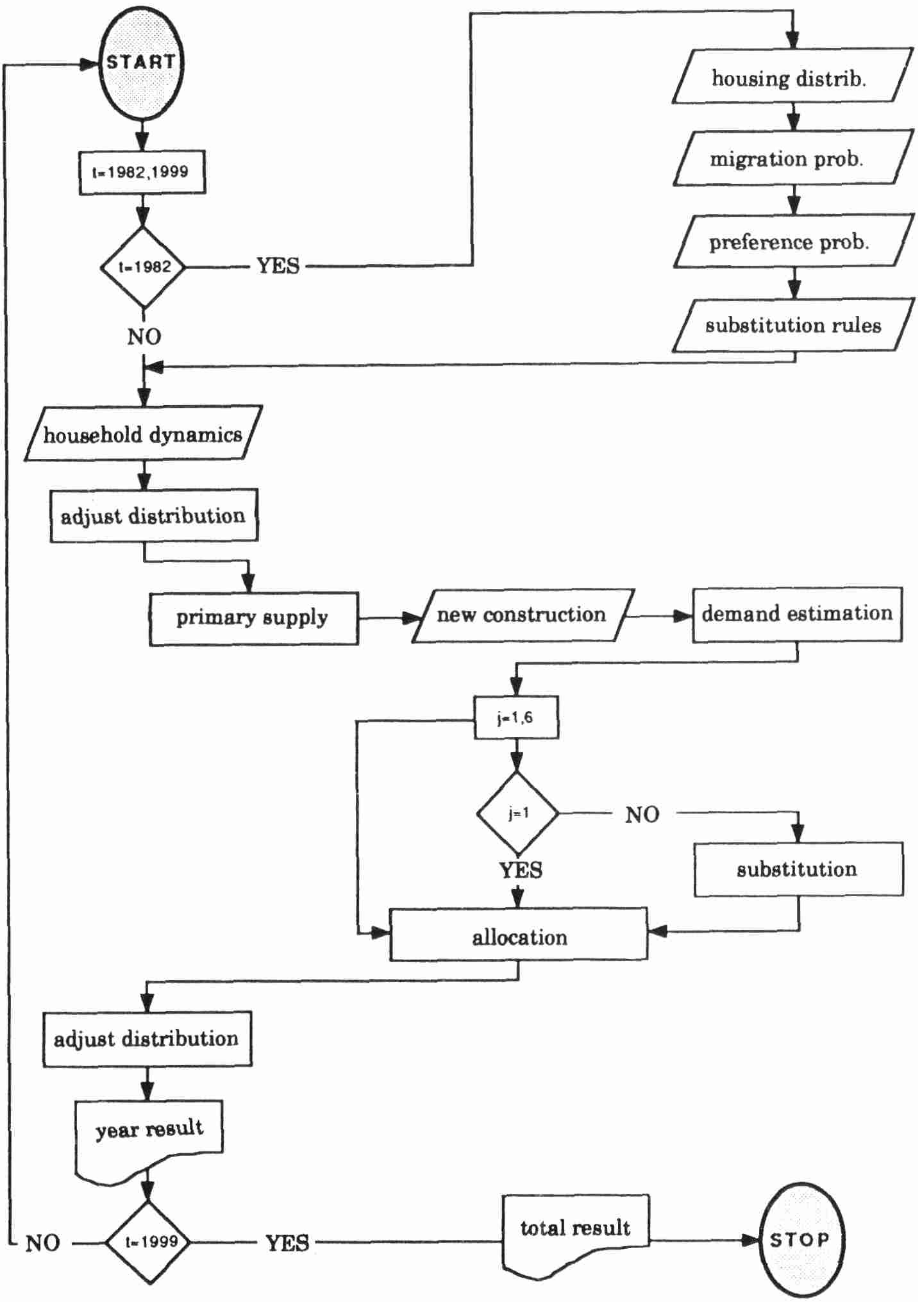

Figure 8 Generalized flow-chart of the housing market model

After this step demand is estimated. The preferences of new households are determined on the basis of the age of the marker, the new household composition and the former household position. For existing households the willingness to move and the preference for another dwelling was determined on the basis of the present dwelling type, the age of the marker and the household composition. A major distinction within the group of existing households is between households in the expansion and the reduction stage of the extended life cycle (viz. under 47 years of age and 47 years and over). These groups appeared to move in almost opposite directions, so we therefore treated them separately in the model. A formal test using logit models showed that the probabilities describing these preferences had a satisfactory level of homogeneity, for each group. An analysis of the dynamics in housing preferences however, showed a fair amount of non-stationarity in these probabilities, notably a sudden drop in the preferences for owner-occupancy in the early-eighties. Testing showed that this drop was only temporary, and that the preferences measured in the late seventies provided reasonable estimates of those in the middle of the eighties.

In the second part of the model the primary supply arising within the housing stock due to household dissolution is estimated by applying the dissolution probabilities derived from the household model to the occupancy matrix. The primary supply due to new construction is read from a separate file. In this way various building programs can be fed into the model. Together with the vacancies within the stock which exist at the start of the simulation, these dwellings form the total primary supply which triggers-off vacancy chains.

The third part of the model simulates the vacancy chains in six iterations per year. This simulation is done by allocating supply to households who demand particular types of dwellings. After each iterations the dwellings occupied are subtracted from to supply and the secondary supply created by households moving from one dwelling to another is added to the supply. In the first iteration allocation occurs proportionally to the share of a particular group in the total demand for each dwelling type. After the first iterations substitution of preferences occurs according to predefined quantitative behaviour rules. Households which already occupy a dwelling, substitute by postponing the move, as long as demand exceeds supply. In each iterations on average 10% of the preferred moves are postponed. Postponement is higher among households occupying dwellings at the lower end of the typology and decreases moving up the hierarchy. New households substitute their preferences by choosing another type of dwelling, which is positioned lower in the typology (those in favour of rental dwellings can not move into owner-occupancy, those preferring a small dwelling can not get large ones, those wanting an apartment can not opt for single-family housing). Substitution is highest towards the sub-market adjacent in the typology and decreases linearly moving away from the sub-market of the original preference. On average substitution among new households equals 5% in each iteration, as long as demand exceeds supply.

After this, the occupancy matrix is updated for the changes in the housing distribution. Households occupying a dwelling, which have not been allocated another, remain in their previous position. New households which have not been allocated a dwelling are added to those living in dwelling substitutes. Each cycle lasts exactly one year. The simulation starts in the beginning of 1982 and ends in the beginning of the year 2000.

Predictive performance of the housing market model

It follows from this description that the model tackles the two problems identified above. Future behaviour is modelled on the basis of the present housing situation which is a result of the housing career over the past years. The model incorporates the history of the household and this history might well be very different for successive cohorts. Residential mobility is not only dependent on the characteristics of the household, but also on the housing market context in which they operate. This specification is very uncommon in modelling residential mobility and a test of empirical result in predicting the process could therefore indicate the viability of the specification.

Starting from an occupancy matrix measured in 1982, we ran the model producing forecasts over a period of four years and test them against data collected in 1986. The model overestimated the total mobility by only 22.000 (5%). Also per sub-market the model-results proved to be satisfactory.

Table 4 Predicted and observed number of moves in 1984 (x1000)

Dwelling type	1	2	3	4	5	6	7	8	Tot
Model result	126	62	30	71	40	26	65	41	461
Observed	128	61	32	55	34	22	6	147	439

However, to show the implications of the alternative specification, it is necessary to look at the results in the longer run, examining the predictions for the year 2000. The cohort-effect are particularly strong among the elderly households. This is shown in table 5. Among the elderly two-parent families, owner-occupancy rises from 50% in 1982 to 64% in 2000, for the other household types the increase is just as marked.

Table 5 Owner occupancy among elderly households 1982-2000

	1982	2000
Two-parent families	50%	64%
Two-person households	38%	55%
One-parent families	35%	42%
One-person households	24%	34%

A marked shift occurs in the composition of the households. On the one hand, the number of two-parent families is estimated to drop by half a million to 1.89 million in 2000. On the other hand, the number of people living alone, more than doubles, from 1.17 million in 1982 to 2.54 in 2000. The growth of the number of two-person households is less marked, but still equals 0.68 million households, resulting in nearly 2 million of these households in 2000. The process of individualization generates a continuous growth in the number of households, exceeding population growth to a large extent. Meanwhile household size will be greatly reduced. The total number of households in 2000 is estimated to be 6.67 million. The implications for the housing market are wide ranging. If new construction does not exceed the numbers which are scheduled by the Ministry of Housing up to 2000, then the number of households which have to live in dwelling substitutes will be twice as high by the end of the century (400,000). As the number of these substitutes is already in short supply, the housing shortage will become a very important political issue. A new generation conflict is bound to emerge in that case. Young small households looking for a small apartment will have to compete with elderly singles for a very limited supply. The chances of acquiring a preferred dwelling will be less than 30% for these groups. Total demand for small dwellings is expected to rise from 340,000 in 1982 to 540,000 in 2000. In the second half of the nineties construction will be limited to only 67,000 dwellings per year. The number of vacancies arising through household dissolution will increase, but half of it will consist of larger dwellings, many of them in the owner-occupier sector. This is a result of the increase in owner-occupancy. In 1982 70% of the elderly couples occupied a rental dwelling. In 2000 this will have decreased to 50%.

One of the effects of the growing housing shortage will be that the housing market will become very inert. The number of new entrants into the market for independent dwellings will increase every year due to the housing shortage. Vacancy chains will become shorter, due to this pressure of new entrants. A result the filtering process, bringing about the redistribution of households over the housing stock will be hampered.

There is however a way out of these problems. In the model we simulated the effects of enlarging the numbers of dwellings by new construction by about 20% per year from 1989 onward. This extra construction is assumed to consist of small rental dwellings. Simulation on the basis of this building program shows that the average vacancy chain length in 2000 can be enhanced from 2.76 to 3.13. This means that building 200,000 extra dwellings would enable an extra 800,000 households to move and adjust their housing situation to their needs. Two factors account for this increased residential mobility. In the first place the proportion of new entrants will be lower and vacancy chains will be extended accordingly. In the second place the filtering process can profit from the complementary character of the housing market behaviour of households in the expansion stage and in the reduction stage. By building more small dwellings the latter will be able to realize their housing preferences, leaving large (owner-occupied) dwellings behind. These dwellings will be occupied by household in the expansion stage, leaving a smaller dwelling behind which is occupied by a younger household or a new entrant to the market. This sheds some new light on the 'filtering controversy'.

The filtering policy usually encompassed building large owner-occupied dwellings, hoping that the supply created by the households moving into these dwellings could satisfy the housing needs of those who can not afford to occupy new dwellings. A common criticism is that the supply created in these vacancy chains will be limited to the upper price-segments of the housing market. By building for the elderly, large dwellings in both the rental and the owner-occupied sector will be vacated. As these dwelling were occupied a long time ago, this supply will be cheaper than newly constructed supply. The resulting secondary supply will also be more 'down-market'. As most of the housing stock in the Netherlands is of good quality, this could create opportunities for those in need of (better) housing. However to really measure these effects, the model presented in this book should be elaborated, including price in the housing typology and income among the household characteristics.

Conclusion

Household change is the driving force behind the residential mobility process. The intention of this paper was to show that both the processes of household evolution and of residential mobility are inherently unstable over time. The reason for this instability is, that successive cohort behave differently over their life-paths. Their progression through the life-cycle varies due to changing attitudes towards having children, cohabitation, separation etc. The development of their housing careers varies because housing market conditions change over time. The implications for the modelling of the residential mobility process are pervasive. Repeated cross-sectional migration analyses do not offer realistic insight into the dynamics of the process. Model based on this kind of analysis will fail in predictive power. In this paper a longitudinal approach has been suggested to overcome these problems. Modelling residential mobility also implies modelling the complex interaction among preferences, opportunities and constraints. Neither discrete choice model, nor vacancy transfer models can handle this interaction. Macro-simulation models offer a viable alternative.

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References

Clark W.A.V and J.L Onaka (1985) " An emperical test of a joint model of residential mobility and housing choice", *Environment and Planning A* 17:1-16

Frinking, G.A.B (1981) "De invloed van recente veranderingen in de wetgeving og het aantal echtscheidingen in Nederland", *Bevolking en Gezin* 2:163-178

Hooimeijer P and M Linde (1988) *Vergrijzing, Individualisering en de Woningsmarkt: Het WODYN-Simulatiemodel* (Demographic Change, Household Evolution and the Housing Market: The WODYN-Simulationmodel). Utrecht: Geografisch Instituut, Rijksuniversiteit Utrecht

Hooimeijer P and L Magnusson (1989) "Stability and Interaction in the Housing market: Log-linear and Vacancy Chain Models", *Scandinavian Housing and Planning Research* 6:31-43

Veys D (1981) "De sterftetafels, transversaal en longitudinaal in België", *Bevolking en Gezin* 2:205-227

Willekens F.J (1983) "Multistate life table analysis of marriage and family. Paper presented at IUSSP workshop on family demography: Methods and their applications, New York