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AN INPUT-OUTPUT MODEL OF RESIDENTIAL MOBILITY : A SIMULATION OF HOUSING OPPORTUNITIES

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A residential move may be defined as the adjustment of a housing situation to suit, as much as possible, the housing needs and aspirations of an occupant through a change in place of residence (Rossi, 1955). In 1981, a large research project concerned with housing needs in the Netherlands (Regional Housing Needs Survey) revealed that 265,000 households said they would like to move. It thus laid the finger on one of the greatest problems of housing in the Netherlands, the qualitative shortage of housing. More research is necessary to understand the mismatch of households and dwellings, and to develop instruments to resolve this problem. Only short distance moves have to be taken into account, since the purpose of a move as defined above, is to improve the residential situation, and short distance moves do not break the web of contacts, consisting of employment, cultural, and social links.

The field of residential migration comprises a number of research directions. The initial focus was analysis of origin and destination sets and patterns of migration flows between these. Such macro-analytic studies of intra-urban migration tend to concentrate on interrelationships of factors like socio-economic and demographic characteristics of out- and in-migrants and origin and destination areas. However, rather than dealing with housing consumption, most of this research concerns the influence of migration on areas of origin and destination and on the facilities there (De Giovanni, 1983; Everaers & Maas forthcoming). In contrast to the *macro*-analytic approach, the *micro*-analytic approach focuses on the behaviour of the individual migrant. At first, this type of research explored the reasons for moving (Rossi, 1955), but later, in the 1970s, it evolved beyond this point. Examples of such studies are those dealing with the influence of stress on mobility (Brown & Moore, 1970; Clark & Cawallader, 1973); search behaviour of individual households (Barret, 1973; Smith & Clark, 1982); housing choices of individual households (McFadden, 1978; Van Lierop, 1981; Onaka & Clark, 1984); and relationships among household characteristics, housing consumption, and residential mobility (Clark, Deurloo & Dieleman, 1984). Although the micro- and the macro-analytic approaches differ, there is also a high degree of overlap, since individual decisions to move have aggregate effects. This point is the basis on which this article discusses a method for analysis and simulation of residential mobility between various housing types within a housing market.

Up to the present, new construction has been the most important instrument to improve matching of households and dwellings. The addition of a new unit to the housing stock generally leads to residential moves within the existing stock; this engenders the so-called vacancy chains. A vacancy chain may be defined as « ... the sequence of moves made by a vacancy subsequent to its arrival in the system (. . .) where each vacancy is created by the construction of a new unit or by the 'death ' of a family... » (White, 1971). As soon as housing production decreases, the capacity to influence residential mobility within the existing housing stock becomes of greater importance in combatting the qualitative housing shortage. It is then essential to know exactly what effects the construction of each type of dwelling has on residential mobility. In this context, the concept of vacancy chains can be put to good use in analyzing the way a housing market functions, as numerous

applications of this approach have shown (e.g. White, 1971; Adams, 1973; Jones, 1978; Sharpe, 1978).

This article first demonstrates the use of an input-output model to simulate the turnover of housing caused by the primary supply. Subsequently, two important decisions regarding the specification of the model are treated : the delimitation of the spatial and sectoral housing sub-markets, respectively. Then, the relationship between the sectoral sub-markets are described for the period 1978-1981. The data for this study was derived from the one percent sample survey on regional housing needs that was carried out in 1981 by the Netherlands Bureau of the Census and sponsored by the Ministry of Housing.

Vacancy Chain Analysis

The collection of data on vacancy chains usually proceeds as follows : the occupant of a newly constructed dwelling is asked for his previous address; then the present occupant at that address is asked for his previous address, and so on. This approach has a few major drawbacks. A practical problem is that it involves a large amount of travel and therefore time, and it is also highly susceptible to non-response. Theoretically speaking, it is even irrelevant to trace individual chains, because causal interpretation cannot be extended over more than one link. Whether or not a dwelling is vacated depends on the availability of the dwelling to which the household wishes to move. It does not depend on the way in which the latter dwelling was vacated; this fact allows a different approach to vacancy chain analysis.

The input-output model, which is introduced below by means of a simple example, simulates flows of vacancies among housing sub-markets from the registration of individual links, which means that cross-sectional data can be used. (Table 1 presents this type of data.) Information on present and former dwellings is collected in a hypothetical sample of 600 recent migrants. Transition probabilities can be derived from this data by dividing the cell entries by the appropriate row total. The matrix of transition probabilities (Table 2) consists of two parts. The first part, indicated by the symbol Q, contains the

Table 1
Absolute numbers of moves

Dwelling of destination	Vacated dwelling			
	Rental	Owner	Newcomer	Total
Rental	120	40	240	400
Owner	60	80	60	200

Table 2
Relative numbers of transition probabilities

Dwelling of destination	Vacated dwelling			
	Rental	Owner	Newcomer	Total
Rental	.3	.1	.6	1.0
Owner	.3	.4	.3	1.0
	Q			

probabilities for households leaving a dwelling behind. The second part represents the newcomers to the (regional) housing market. Suppose a primary supply of 100 rental and 100 owner-occupier dwellings is offered (e.g. as a consequence of new construction). Table 2 shows that 60 rental and 30 owner-occupier dwellings will be occupied by households leaving no dwelling behind. The remaining 40 rental and 70 owner-occupier dwellings produce a secondary supply of 60 rental and 50 owner-occupier dwellings. This can be computed by multiplying the vector of primary supply $\bar{a}$ with the matrix Q ($\bar{a} \cdot Q$). Of course this secondary supply leads to new vacancies. These can be computed by multiplying this secondary supply ($\bar{a} \cdot Q$) again by the matrix Q, which makes $\bar{a} \cdot Q^2$. This can be repeated infinitely, implying that the total supply can be represented as

$$\bar{a} + \bar{a} \cdot Q + \bar{a} \cdot Q^2 + \bar{a} \cdot Q^3 \ldots =$$
$$\bar{a} \cdot (\bar{I} + Q + Q^2 + Q^3 \ldots) =$$
$$\bar{a} \cdot (\bar{I} - Q)^{-2} =$$
$$\bar{a} \cdot M = b$$

The resulting M is the matrix of multipliers. These multipliers are equal to the part of the chain provided by each type of vacated dwelling which results from a primary supply of one dwelling of a specified type. Summation of the columns yields the total mean chain length. Not only do these multipliers provide a quantitative measure of the relations among sub-markets, but they can also provide a simulation of the total supply of housing opportunities resulting from alternative construction programs. Table 3 shows that in this example a shift in the construction program towards the owner-occupier sector leads to extra total supply. This approach can only be applied if the transition probabilities do not change along with changes in the position of the link in the chain.

Table 3.a.
Total supply as a result of 100 vacancies each :

$$\overset{\bar{a}}{\begin{bmatrix} 100 & 100 \end{bmatrix}} \times \overset{M}{\begin{bmatrix} 1.538 & 0.256 \\ 0.759 & 1.795 \end{bmatrix}} = \overset{\bar{b}}{\begin{bmatrix} 231 & 205 \end{bmatrix}}$$

Table 3.b.
Total supply as a result of 60 rental and 140 owner vacancies :

$$\overset{\bar{a}}{\begin{bmatrix} 60 & 140 \end{bmatrix}} \times \overset{M}{\begin{bmatrix} 1.538 & 0.256 \\ 0.759 & 1.795 \end{bmatrix}} = \overset{\bar{b}}{\begin{bmatrix} 199 & 267 \end{bmatrix}}$$

This condition is met, since as mentioned above, the links are independent of each other.

Determination of the Spatial Level for Analysis

The spatial level at which an equilibrium of supply and demand is reached may be indicated by the term 'housing market area'. This is the areal extent within which a residential move does not entail an unacceptable loss of social and cultural contacts and

does not necessitate a change in place of employment. Only moves between housing types within these functionally separate regions should be the subject of analysis. We took the subdivision of the Netherlands in 51 housing market areas, as defined by the Directorate General of the Ministry of Housing, as the spatial level for our analysis. However, we may assume that a similar pattern of mobility may be observed in housing market areas that show a high degree of similarity in regard to the structure of their housing types and households. In two recent studies (Clark, Deurloo & Dieleman 1984; Scholten & Hooimeijer 1984), housing market areas were clustered on the basis of variables concerning the state of supply and demand, and characteristics defining the housing stock and those describing the households, respectively. These two categories of variables, supplemented by the administrative criteria used by the Ministry of Housing, allow a division of the Netherlands into four regions (see Fig. 1). It should be emphasized that within the cluster, the combined housing market areas are considered as separate units; this is important for identifying the group of in-migrants in the housing market areas. Each household that moves within the region from one housing market area to another will be considered as an in-migrant in the destination area, and thus as a newcomer in its housing market. Its arrival terminates a vacancy chain.

Sectoral Housing Sub-Markets

The definition of sectoral sub-markets is of crucial importance to the study of residential mobility. Sectoral sub-markets are distinguished by classifying dwelling types; moves between these types are the subject of our study. The classification determines how adequately the structure of the redistribution process can be represented by the model. Two structuring elements may be isolated. The first one combines the factors of the demand side, namely the housing needs and the housing aspirations of the households. The second important element combines the various dimensions of supply. The numerous empirical studies of migration (e.g. Rossi 1955; Speare et al. 1975) demonstrate that a limited number of key variables suffice to classify the dwellings :

1. tenure (rental/owner-occupier)
2. type of structure (single-family/multi-family)
3. size
4. price.

On the basis of these variables, a classification was produced consisting of 19 housing types. For three types of owner-occupier housing, the difference between existing and new construction is explicitly included in the classification. The reason for this is that the allocation of these dwellings is different due to government intervention, which is legitimated by its role in financing the construction of certain categories of dwellings (see e.g. Van Weesep 1984). The 22 resulting types, as listed in Table 4, turn out to have significantly different recruiting patterns. The nature of these recruiting patterns is discussed in the following section.

Vacancy Chains in the Netherlands

To analyze the flows among the sectoral sub-markets, a hierarchy of dwelling types was constructed, based on the preferences of households in the earlier stages of their life-cycle. The moves of these households make up the bulk of the total residential mobility (Clark, Deurloo & Dieleman, 1984). Their preferences are scaled as follows : owner-occupier housing is preferred to rental housing; single-family dwellings are preferred to units in multi-family structures; large units are preferred to small units; and expensive

Fig. 1

dwellings are preferred to cheap ones (Table 4). Starting households have limited access to the sub-markets that are higher up in this hierarchy, partly because their incomes are, on the average, rather low, and partly because of the effect of housing allocation rules (Van Weesep, 1982). Wherever they start within the hierarchy, they try to filter up with every subsequent move. Although moves in the opposite direction do occur (e.g. after retirement, separation, or a sudden drop in income), the dominant trend is that dwellings left behind are located lower in the hierarchy.

Table 4 shows the multiplier matrix M, generated by the model run on ± 13.000 moves in the Netherlands in the period 1978-1981. A multiplier of .10 indicates that a total supply of 10 dwellings (specified in the column) becomes available as a result of a primary supply of 100 dwellings (specified in the row). Only multipliers larger than .05 are shown. The diagonal represents the moves within the same sub-markets, including the ones to dwellings in the primary supply. The empirical results shown in the table confirm the theoretical expectations regarding the hierarchical nature of housing sub-markets. Only two multipliers larger than .05 appear in the top right-hand side. The lower left-hand side too clearly demonstrates the process of filtering up. The largest flows occur from cheaper dwellings to more expensive ones and from small dwellings to larger dwellings.

Table 4
The matrix of multipliers

			Multifamily rental							Single-family rental									Owner-occupied existing		
			Small			Large				Small		Average			Large						
			C	M	E	C	M	E	L	C	M	C	M	E	C	M	E	L	C	M	E
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Multifamily																					
Small	Cheap	1	1.09																		
	Moderate	2	.11	1.05																	
	Expensive	3	.07		1.04																
Large	Cheap	4	.14			1.07															
	Moderate	5	.11			.08	1.08														
	Expensive	6	.07		.06		.07	1.04													
	Luxerious	7		.06			.06		1.08												
Single family																					
Small	Cheap	8	.07							1.06											
	Moderate	9	.07				.08				1.02										
Average	Cheap	10	.10			.08	.08			.06		1.09									
	Moderate	11	.06			.08	.10					.07	1.06								
	Expensive	12	.08	.06		.07	.14							1.02							
Large	Cheap	13				.07						.06			1.05						
	Moderate	14	.09			.07	.13					.10	.09			1.06					
	Expensive	15				.07	.15						.07				1.03				
	Luxerious	16					.17											1.04			
Owner occupier																					
Existing	Cheap	17																	1.11		
	Moderate	18					.06												.15	1.08	.06
	Expensive	19																	.12	.14	1.19
New	Cheap	20	.08	.06		.06	.12						.07						.08		
	Moderate	21	.07				.13						.08						.12		
	Expensive	22											.07						.13	.18	.17

Table 4 also shows that the effects of vacancies in existing stock and in newly built owner-occupier housing entering the market differ. The supply generated by existing housing is almost entirely concentrated within the owner-occupier sector. Newly built dwellings, on the other hand, produce larger numbers of vacancies in the rental sector. This is a result of the government's policy to stimulate home-ownership. Mortgage supplement payments are granted to households with lower incomes that buy newly built dwellings. The transition from rental to the owner-occupier sector is therefore easier when people move into new dwellings.

The ultimate goal of this research project is to simulate the total supply resulting from a primary supply brought about by a specified construction program. To perform the simulation, the transition probabilities must be stable both in space and time, which can

only be achieved at the regional level; the spatial sub-markets which are delimited above meet this condition. In one of these sub-markets the model proved to be stable over a period of 4 years. However, more tests will have to be carried out — on other sub-markets and over a longer period of time — to assess the stability of the model and its relevance in a policy context.

Research Directions

The application of this model as a simulation technique is a statistical approach and is thus similar to the application of time series analyses. The simulation uses historical information only, whereby it demonstrates the advantage and disadvantages characteristic for time series analyses. The advantage is obvious : the model is simple to use and its application in policy analysis is not very time-consuming, which is rarely the case with micro-analytic approaches. Yet the disadvantages are also evident. No theoretical explanation has been incorporated into the model; therefore, its application as a simulation model remains purely statistical. To remedy this, the model could be complemented with a causality model. Another possible adaptation is to use not only information on actual moves in the past but also on the expressed aspiration to move in the future. A first application of the model using this type of information is now on record (Scholten & Hooimeijer, 1984b).

The model should be applied to each one of the spatial sub-markets, since significant differences exist between sub-markets. At present, the Ministry of Housing is subsidizing a research project that does just that. For a simulation study, a demand profile should be available for the distinct sub-markets, as should some idea of the number of migrants and starters expected. These points lead to our suggestion that the model should be incorporated in a general spatial interaction model whereby residential moves generated by new construction and those due to factors such as employment opportunities, attractiveness of residential environment, public facilities, etc., can be estimated. The integration of this type of information in the model has been achieved on a preliminary basis, but it requires further elaboration (Scholten, 1984).

Conclusion

Residential mobility is a crucial factor in the adjustment of housing situations to the needs and aspirations of households. A recent critique of the conceptual models employed in research on residential mobility expresses concern over their tendency to concentrate on the demand side and argues that housing opportunities deserve more attention (Graham, 1984). From the point of view of the policy-maker, research on the supply side of the housing market is far more interesting, because, on the one hand, the Dutch government plays a decisive role in the supply of new housing and, on the other hand, it significantly influences the allocation of vacancies within the existing stock.

Vacancy chain analysis is a promising approach to the study of housing opportunities, but it proves to be very cumbersome in practice. The input-output model described in this article is not only very efficient, but it also provides, at the aggregate level, detailed and quantitative estimates of the total supply that becomes available within sub-markets as a result of a specified primary supply. Although the preliminary results are very encouraging, much work remains to be done to test and improve the model.

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RESUME : UN MODELE D'ENTREES-SORTIES POUR L'ETUDE DE LA MOBILITE RESIDENTIELLE : SIMULATION DES OPPORTUNITES DE LOGEMENT

Le montant total des constructions nouvelles aux Pays-Bas diminuera dans l'avenir en fonction des modifications démographiques. De plus en plus, le marché du logement existant devra répondre aux demandes du logement. En conséquence, la redistribution des programmes de construction sera de toute première importance. L'analyse des « chaînes de logements vacants » est utilisée pour la succession de locataires par habitation. La reconstitution des « chaînes de logements vacants » prises individuellement est cependant très aléatoire et manque d'appui théorique. Le modèle basé sur l'étude des arrivées et des départs, qui est décrit dans cet article, fournit une alternative et peut être utilisé pour évaluer le montant total et la composition du roulement qui résulte d'une différenciation

spécifique des programmes de construction. Un pas décisif a été fait dans l'élaboration du modèle — il s'agit de la délimitation spatiale et sectorielle de sous-marchés du logement. La délimitation spatiale des sous-marchés est réalisée au moyen d'une analyse de regroupement. C'est par l'analyse loglinéaire qu'on réalise la délimitation sectorielle des sous-marchés et qu'on évalue les liens existant entre ces sous-marchés.

MOTS-CLEFS :
Logement; Modèles; Chaînes de Markov; Pays-Bas.

KEY-WORDS :
Housing; Models; Markov Process; Netherlands.