45TH Congress of the European Regional Science Association
23-27 August 2005, Vrije Universiteit Amsterdam

THE IMPACT OF ACCESSIBILITY ON RESIDENTIAL CHOICE: EMPIRICAL RESULTS OF A DISCRETE CHOICE MODEL

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ABSTRACT

Transport in general, and accessibility of people, jobs and services in particular, is assumed to have an important impact on the residential choice behavior of households. After all, the amount of activities that can be deployed by the household members, whether labor, leisure or socially associated, is determined by the accessibility of a location.

The past decades the residential location choice of households has been subject of study in many researches. Nevertheless, the relation between accessibility and residential choice has shown to be hard to verify empirically. Such (empirical) knowledge, however, can help address many of the problems that urban regions are facing nowadays, like the (re-)location of residential areas and jobs, the planning of new infrastructure and predicting the amount of traffic generated by commuting and leisure activities.

The first part of this paper gives an overview of the literature on residential choice behavior, with an emphasis on research that studied the relation with accessibility. In the second half a theoretical model for residential choice will be presented, followed by the estimation results. The model is estimated on revealed data derived from the National Housing Survey, in which over 75 thousand Dutch households were inquired on their current and previous housing situation. Different aspects of the residential choice decision are incorporated in the model, like the dwelling type, the location of the dwelling, the characteristics of the household, and the influence of accessibility.

The results show that so-called individual accessibility measures, like migration distance, commuting distance and access to public transport for households without a car, have a significant influence on the residential choice behavior of most of the household types we constructed. Nevertheless, dwelling characteristics and social neighborhood qualities are very influential as well.

KEYWORDS: Residential choice, housing market, accessibility, discrete choice.

1. INTRODUCTION

The past decade major changes have occurred in the Dutch housing market, both in terms of the demand, quantitative as well as qualitative, and the supply side of the market. The new demand is mainly a result of demographic processes: phenomena like ageing of the population and the individualization of people increased the demand for more (smaller) dwellings. Furthermore, altered compositions of households and welfare situations lead to different preferences for housing type and attributes. The housing supply faces difficulties to match this (new) demand. This is mainly caused by the lack of available land in urbanized areas and the small profits that can be achieved by building firms. This situation is also acknowledged by the Dutch government (Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, 2004).

The changing housing market increases the need for a household to be flexible when searching for a dwelling in terms of the location and the dwelling type. The relatively well-developed transport system in the Netherlands is partly able to facilitate this flexibility. On the other hand, increasing congestion problems or the absence of good public transport may make a location less attractive to settle. The choice to which dwelling a household finally relocates is determined by the residential choice behavior.

The residential choice behavior is an import issue in the housing market. We define this behavior as the choice for a dwelling on a location by a household. We assume that this behavior is determined by three types of characteristics, namely aspects of the dwelling, the location of the dwelling and the household that is relocating. To understand the consequences of changes and (policy) interference in the housing market, we need to know more of this behavior.

This paper describes the results of an empirical model that explains residential behavior. The central goal of this paper is to reveal the influence of accessibility on residential choice behavior, while controlling for other relocation issues. In this study we define accessibility as the relative ease that is takes to reach certain functions, in terms of time and/or money (Geurs & Ritsema van Eck, 2001). In order to do this, we estimated a discrete choice model on revealed preference data (i.e. a large survey on housing demand in the Netherlands).

The notion of a central role of accessibility in residential behavior is motivated in the second paragraph of this section. Nevertheless, as we will see from in the literature review, accessibility is not often a very strong explanatory variable in residential choice models, at least not in terms of classical, more generic accessibility measures, like the number of inhabitants or jobs within a particular amount of travel time. This is why we want to focus on so-called individual accessibility matters, which comes closer to the actual household's perception of accessibility, namely the ease that (frequently conducted) activities can be deployed.

2. BACKGROUND

Numerous methods have been developed and applied to derive the determining factors of the residential choice behavior of households. Even the traditional models, like Alonso's residential location model (Alonso, 1964), reserve a dominant place for accessibility. That is, the choice where to settle in an urban area was determined by the combination of income, the costs for housing and the distance to employment (located in the central business district). Since then many varieties have been made on the Alonso's work and it took until the mid-seventies that researchers employed new techniques for this topic.

The overview that Clark and van Lierop made in 1986 gives a good insight into the best practice of residential choice modeling at that time. From this research and several other publications, it shows that the most applied techniques are the hedonic price method, which calculates the effect of housing attributes on the price paid for a dwelling, and the random utility theory. The latter theory is based on the notion that a human is trying to maximize its utility when choosing a dwelling. Next the chance that an alternative is chosen from a set of alternatives can be derived from these utilities. Classical examples of the application of the hedonic price method and discrete choice modeling in the residential choice context can be found in, respectively, Rosen (1974) and McFadden (1978).

More recent examples of techniques for residential choice modeling are discussed in Dieleman (2001). In this article he describes the new challenges in residential choice modeling and how they can be faced. He expects a lot of new research topics like joint decision making

(Molin,1999) and decisions when the preferred dwelling is not readily available (Gärling and Friman, 2001). However, Dieleman stresses that the frontier in the research field of residential relocation seems to lie in how circumstances in local and national housing markets affect the decision making and whether changes over space and time influence the choice behavior. For this last subject, longitudinal studies into the housing careers of people could give new, interesting insights, like Feijten has shown in her dissertation (Feijten, 2005) .

For this research we have chosen to use the discrete choice method, since it has proven to be a sound approach to investigate which attributes have a significant influence on the residential choice behavior, even compared with other methods (Clark en van Lierop (1986); Follain and Jimenez (1984)). However, the final decision to carry out this research with discrete choice modeling is based on two issues: data availability and the preferred disaggregated level of detail. The first issue will be clarified in chapter 4: "Data used". The second issue is support by Miller et al. (2004), where the authors stress out that discrete choice modeling can be applied to study the effect of the choice maker's characteristics on a micro level. This gives us the possibility to study the role of individual accessibility measures in the household's relocation decision. The next paragraphs discuss the results of previous research on discrete choice models for residential choice location.

2.1. Residential choice modeling with discrete choice

This section discusses some of the outcomes of residential choice models, carried out with discrete choice models. Since these models all have the same theoretical background, we do not make a distinction between the different modeling techniques that were applied, like Multinomial Logit, Nested logit or Probit. For a methodological description of these methods we refer to Train (2003).

Housing type attributes

Many researches studied the choice of merely the type of dwelling, disregarding its neighborhood and location (Börsch-Supan (1987), Rouwendal (1989) and Tiwari, P. and Hasegawa, H. (2004)). The outcomes of these researches are reasonable and quite similar: larger families prefer more bedrooms, while the income of the household determines the type of tenure and (monthly) housing costs.

Neighborhood attributes

In other studies the characteristics of the neighborhood are incorporated. This can be done as a dummy-variable for a certain area (Dökmeci, V. and L. Berköz (1999)), but also with characteristics of the neighborhood. Social-economic aspects of the neighborhood like average income, local expenditures for education, racially equivalence with inhabitants and crime rate seem to be a good explanatory variable (Boehm, 1982; Quigley, 1985; Columbino, 2001).

Accessibility attributes

The role of "general" accessibility, like the mass of labour, people or services within 30 minutes, seems difficult to quantify in residential choice models. (Molin and Timmermans, 2003). Waddell (1996) even finds a negative, or in other cases insignificant relation between residential location choice and accessibility of jobs and inhabitants. This is probably due to the fact that in this case these measures indicate more or less to the preference for the amount of urbanism or urban density. Srour et al. (2002) observe a positive influence of a (logsum) accessibility of jobs on residential location choice, although they have only incorporated accessibility measures, so nothing can be said about substitution effects with other residential choice factors.

On the other hand, commuting distance is observed several times as an influential factor (Weisbrod e.a., 1980; Quigley, 1985; Evers, 1990; Molin and Timmermans, 2003), also in combination with the availability of public transport (Ortuzar, 2000). Recently, new insights look more at a household's individual situation, by taking along personal, spatial relations (e.g. work location, position of the kids' school) and how these relate to daily activity patterns and long-term location choices (Axhausen e.a., 2001).

2.2. Conclusions

The literature examined shows that the influence of accessibility on residential choice behavior is not easy to grasp. Moreover, it seems that dwelling attributes and the social status of a neighborhood have (far) more influence on the relocation decision. Nevertheless, the prospect of (new) directions into a more individual approach of accessibility, like commuting distance or distance to frequently visited locations, seem to add new perspectives to the research field. We will use this knowledge in the next chapter, when we formulate the theoretical model for residential choice.

3. THEORETICAL MODEL FOR RESIDENTIAL CHOICE

We have designed a theoretical model to estimate the effect of accessibility on residential choice behavior by households. The model is roughly based on the one presented by Brown and Moore in 1970. This choice behavior is part of a bigger migration process, which consists of three steps: residential mobility, residential search and residential choice. Our focus, however, is on the last two steps. The theoretical model we used for this research is depicted in figure 1 and described in this chapter. First we will clarify the total migration process.

Residential mobility is defined as the decision when and on which grounds to move. The choice whether to migrate is mostly caused by demographic reasons or household internal processes that occur in the life-cycle of a household (Clark and Dieleman, 1996). Since this type of relocation mostly caused by dissatisfaction with the current dwelling or the (local) living environment, the migration distance is often very small: according to our survey, 80% of these relocations are made within 10 km.

There is also a strong relation between the housing career and other types of events in the life of a household or person. These are associated with household formation and dissolution and the educational and job career. These relocations often yield a longer migration distance, since the household wants to decrease its (new) commuting distance or move towards or from a certain household situation (Mulder and Hooimeijer, 1999).

When the household has a propensity to move, it starts searching for suitable, alternative locations to form a choice set. The formation of the choice set is based on the awareness of space, which is a result of the household's information on the current housing supply by different media, a real-estate agencies or own sources (Brown and Moore, 1970). Other aspects of the residential choice, like dwelling price and size, can restrict the choice set as well. Later on in this paper we will show how we generated the choice set for this research. Finally, when the choice set has been composed, the household makes a selection based on utility maximization. The theoretic background behind this is discussed in the next section.

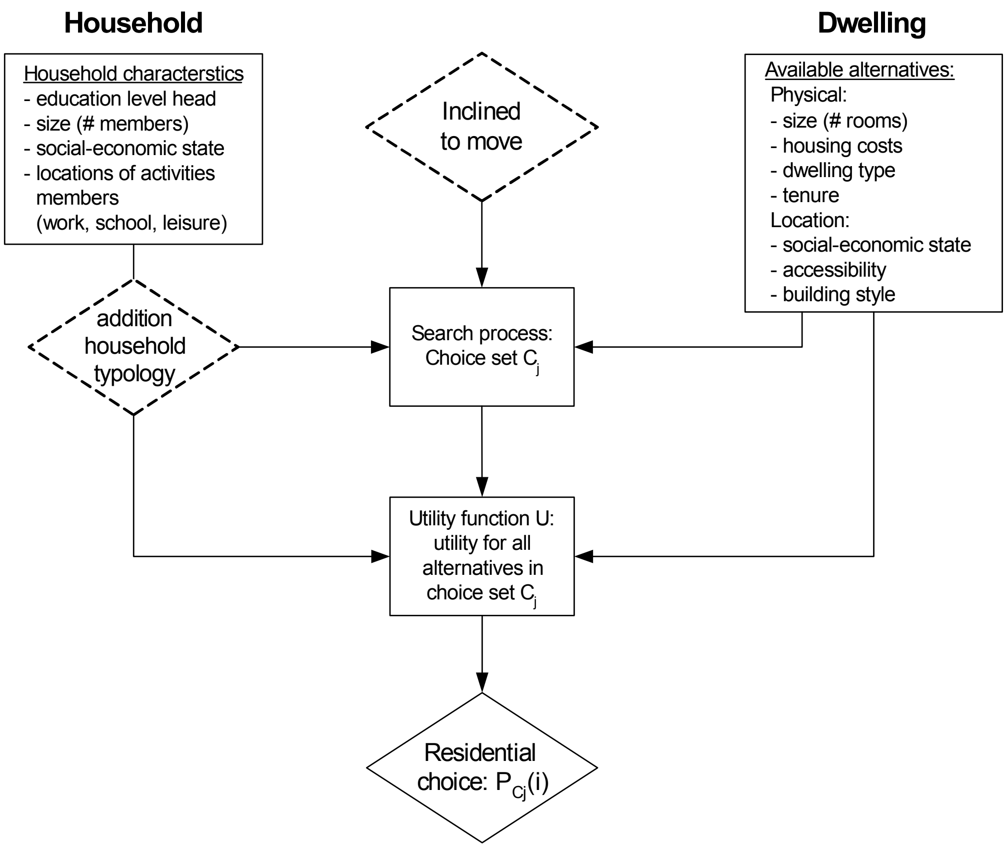

Figure 1: Scheme of theoretical model

3.1. Residential choice

The choice for a dwelling from a set of alternatives is a conditional decision which will be modeled in the form of an multinomial logit (MNL) model, based on random utility theory (McFadden, 1974). According to this theory we assume that a household attaches a utility to each alternative in a subset of alternative locations that are considered. Subsequently, the dwelling with the largest utility also receives the largest chance to be chosen. The utility of dwelling *i* is composed of an observed and a random, unobserved part:

$$U_i = \mu V_i + \varepsilon_i$$ Equation 1

with:

U_i	:	the utility of location i
V_i	:	the observed utility of location i
ε_i	:	the random, unobserved utility of location i
μ	:	model specific scale factor

If we assume that the random component of utility is Gumbel distributed, it can be discarded from the probability function (McFadden, 1974). The remaining multinomial logit model describes the probability that household *j* chooses dwelling *i* from a subset C_i with *K* alternative dwellings:

$$P_{C_j}(i) = \frac{e^{\mu V_i}}{\sum_{k \in c_j} e^{\mu V_k}}$$ Equation 2

The observed utility function in the presented model has the form of a linear additive utility function (equation 3). For each household type a separate choice model has been estimated.

$$V_i = \sum_{n=1}^{N} \theta_n \cdot x_{ni}$$ Equation 3

With:	θ_n	:	utility coefficient of attribute n
	x_{ni}	:	generic attribute *m* for location *j*

The attributes in the utility function reflect various aspects that contribute to the utility of a dwelling for household. These consist of, above all, accessibility measures, but also of characteristics of the dwelling and its neighborhood. A more detailed description of the attributes used in this model will be given later on.

3.2. Household typology

In our search for adequate household types, we performed a sensitivity analysis on the migrated households' characteristics and the attributes of the chosen dwelling. It appeared that the number of persons, the education level of the head[1] of the household, the age of the head and the migration reason were the most distinctive dimensions. The most important are summed up and motivated below:

- Household size: It turned out that the number of household members not only determines the choice for dwelling type and size, but also the choice of neighborhood. In comparison with singles, families (especially with children) move more frequently to quieter and more spacious neighborhoods (Faessen, 2002).
- Education of the head: Although this household characteristic is very closely correlated with the income of the household, education seems more discriminating than income in terms of the distances to migration, workplace, and urban centers. The latter can be explained by the interest for areas with cultural, recreational and retail services. Another reason to prefer education to income is that due to privacy matters survey questions regarding income are often not or incorrectly answered. Of course, income is still a guiding matter for the choice of tenure and housing costs. We plan to enter this in the model with interaction variables.
- Age of head: Especially elderly (~ people aged over 60 years) show a different choice behavior in terms of dwelling type and neighborhood. Moreover, they have special needs for services (healthcare) and public transport.
- Work instigated migrations: Migrations made due to work reasons are a subject of their own. Research showed that a household that migrates for work reasons undertake a large migration distance to decrease its commuting distance (Mulder & Hooimeijer, 1999). Furthermore, the first move is made primary to live closer to the workplace: other attributes seem of lesser importance. In a follow-up relocation, which is often made

[1] The head of a household is defined as the person with the highest monthly net income, regardless of gender and age.

relatively shortly after the first one, the household has more information on its new living environment and is able to search better for a dwelling and a neighborhood with more utility.

These distinctive household characteristics lead to the following household typology:

Household type	Description
1L	Single household, low educated (lower than college degree)
1H	Single household, highly educated (college degree or higher)
2+L	Household with two or more persons, with a low educated head.
2+H	Household with two or more persons, with a high educated head.
60+	Household with a head with age 60 years or older
WORK	Households whose migration is work-related

3.3. Choice set generation

Ideally, we want to estimate the choice behavior on the actual, regarded choice set of alternative dwellings. However, this information is almost never available in revealed data sets. This is why we have chosen to generate a systematic choice set. This choice set is a random sample taken form the full set of available alternatives in the period of migration. We use a sample because the full set would be too large to estimate the model on, since we work on the lowest level of detail, namely (physical) dwellings on a location. A full set in this case would mean thousands of alternatives, which makes it impractical (and illogical) to apply. However, McFadden (1978) has proven in his estimation of a discrete model for residential choice that a random sample drawn from the full set of available alternatives yields consistent estimates.

The choice sets for each household is generated according to the approach which is often used in route choice modeling and described by Bovy and Stern (1990). They describe a stepwise formulation of subsets:

- Set of existing alternatives: all existing dwellings in the Netherlands.
- Set of available alternatives: alternatives that were available in the period of migration.
- Set of feasible alternatives: all available dwellings in a constructed search area. Since migration and commuting distance are dominant aspects in the search behavior, we constructed a search area for each household type around these locations. From this area

a random set of alternatives can be drawn to form a choice set. The search area is depicted in figure 2, the measures of the area for each household type in table 6. Exploration of the migration data showed that all household types occur in all dwelling types so we did not have to make a distinction in dwelling characteristics, like costs or size, in generating the choice set.

- Choice set: the chosen alternative and 59 other alternative dwellings, which are drawn randomly from the search area. The (relatively) large number of alternatives is chosen because it improves the performance of the model, in terms of significance levels of the parameters, without overloading the estimation software.

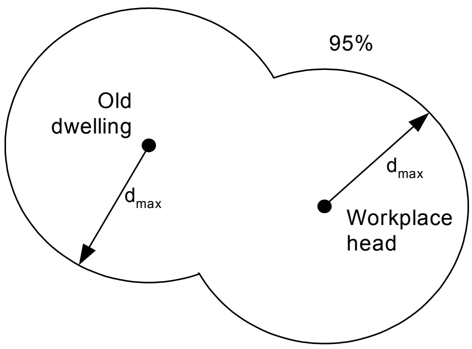

Figure 2: Construction of search area

	Single, low educated	Single, high educated	Two +, low educated	Two +, high educated	60+ yrs	Work instig.
d_{max} 95%	40 km	40 km	30 km	40 km	70 km	70 km

4. DATA USED

The residential choice model is estimated on revealed data from the Housing Demand Survey (in Dutch: Het Woningbehoefte Onderzoek (WBO); Ministerie van Ruimtelijke Ordening and Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer (2003)). This is a large survey held under approximately 75,000 households. About 11,000 migrated households were derived from this survey, providing information on the new and previous dwelling type and residential location. We have only information on the migration between 2000 and 2002. The level of detail of residential location are 4-digit postal zones, which have an average size of nine square kilometers, varying from a few square kilometers in urbanized areas to $100km^2$ in rural environments. This relatively low level of spatial detail gives the possibility to add detailed data to the migration, like accessibility measures, social-economic status and general neighborhood characteristics.

The accessibility measures used in the model can be divided into two groups: travel times and the accessibility of locations. The travel times are derived from the National Model System (in Dutch: Landelijk Model System, LMS) and are used to add migration and commuting distance to the relocations. The second group of measures provides information on the local accessibility situation, like the distance to railway stations, highway on-ramps and the quality of public transport. The latter is a score between minus and plus one, representing the availability of public transport.

As we could see in the literature review, the social-economical state of a neighborhood is also an important explanatory factor in residential choice. We have gathered data on social economic issues from several sources. The Social and Cultural Planning Office of the Netherlands calculated a social status score. This factor score varies between minus 3 and plus 6 and is a combination of education level, employment, income situation and crime rate of a neighborhood (for a description, see: (SCP, 1998)).

Concerning the percentage of non-western foreigners in a neighborhood, we had to construct a measure due to the high correlation between the “plain“ percentage and the housing density. This is the difference between the actual percentage and the “expected” percentage of non-western foreigners per density class (i.e. the median of the percentages). In practice this means that scores around zero (i.e. no difference) indicate a percentage of foreigners, which is close to the expected value for a neighborhood with that density.

Finally, the Living Environment Database provides us general neighborhood characteristics like the dominating building area, the percentage of single-family houses, and a classification of five living environments, varying from central urban to highly rural and is an indicator for the degree of urbanization and nearness of urban services.

The choice set of available dwellings is drawn from the SYSWOV database (Housing Supply System, in Dutch: Systeem Woningvoorraadgegevens). This database holds the amount of vacant dwellings on four-digit postal zones and is a simulated supply, based on two-annual (measured) figures. There is only limited information available about the vacant dwellings. This relates to classifications of size, dwelling type, tenure and price (see table 1). A combination of all classifications leads to 24 dwelling types. The abbreviations are used to refer to a specific type of dwelling. For example: BUMISFSM stands for a small, single-family middle-priced owner-occupied house.

Table 1: Dwelling characteristic classes

<table>
<tr><td>Attribute</td><td colspan="24">Classification (abbreviations in brackets)</td></tr>
<tr><td>Tenure</td><td colspan="12">Buy (BU)</td><td colspan="12">Rent (RE; net rent per month)</td></tr>
<tr><td>Costs (€)</td><td colspan="4">Low (LO)
<= 136134</td><td colspan="4">Middle (MI)
136134 - 170167</td><td colspan="4">High (HI)
> 170167</td><td colspan="4">Low (LO)
<= 340</td><td colspan="4">Middle (MI)
340 - 430</td><td colspan="4">High (HI)
> 430</td></tr>
<tr><td colspan="25"></td></tr>
<tr><td>Type</td><td colspan="6">Multifamily (MF)</td><td colspan="6">Single-family (SF)</td><td colspan="6">Multifamily (MF)</td><td colspan="6">Single-family (SF)</td></tr>
<tr><td>Size (number of rooms)</td><td colspan="3">Small (SM)
<= 3</td><td colspan="3">Large (LA)
> 3</td><td colspan="3">Small (SM)
<= 4</td><td colspan="3">Large (LA)
> 4</td><td colspan="3">Small (SM)
<= 3</td><td colspan="3">Large (LA)
> 3</td><td colspan="3">Small (SM)
<= 4</td><td colspan="3">Large (LA)
> 4</td></tr>
</table>

5. RESULTS

We have used the Nlogit software package to estimate the parameters of the logit model (Greene, 2002). The results of the estimated residential choice models are displayed in tables 2 through 6, in the back of this paper behind the references. The tables show the estimated coefficients, indices for significance levels and the standard errors. We have normalized the coefficients and standard errors to the parameter coefficient of the migration distance (presented in table 2a). In this way the estimations for the different household types can be compared easier. Before we discuss the most important outcomes, we will first look at the interaction variables we created and the reference values of attributes we have used.

In order to add more information about the household to the model, we created several variables that are interactions of household characteristics with attributes of the dwelling or neighborhood. Similar to Tiwari & Hasegawa (2004), we interact the household income with a combination of dwelling price and tenure, and household size (number of members) with dwelling size and type. Furthermore, to account for interaction with neighborhood attributes, we combined car ownership with the proximity of on-ramps highway and railway stations, and the relative quality of public transport. Analogous, we looked at the distance to primary schools for households with and without a child under 13 years. Finally, we also included two variables that represent the similarity of the ethnicity of the head with the neighborhood concerned.

The household income is measured in units of 1.000 euros per month (Keuro). To make the coefficients for dwelling types (dummies) easier to interpret and compare, we used an adjusted household income. This is the difference between the modal income of all households in de survey and the income of the household (1.7 Keuro). The dummy coefficients now show the utility for a dwelling type in comparison with a household with a modal income. The coefficients for the interaction variables represent the change in utility derived from the dwelling type according to the difference between the household income and the modal income. The parameters also indicate how much extra utility a household receives from investments in the dwelling, i.e.: how much it appreciates a more expensive (and probably more luxurious) dwelling in comparison with other consumer goods.

In a multinomial regression model like the one we applied in this study, perfectly correlated (groups) of alternatives need to be avoided. This is why we introduced reference points for some of the variables. The estimated coefficients give the difference of utility with respect to the reference value. For example: the reference dwelling type is a cheap, multi-family small rented house. The estimated coefficients for the dwelling type dummies and the interaction variables now indicate the extra utility that a household derives from choosing this dwelling type. In general, we have chosen the most common (i.e. most chosen or most available) value as reference point. Reference points of other variables are the rural living environment and the building area 1960-1995.

Results: Accessibility

The coefficients for migration and commuting distances of the head and partner (if present) have the correct sign and are (very) significant for all household types. Notably the migration distance has a very large impact on the residential behavior. This indicates a strong bond with the neighborhood, caused by relations with family, friends and other social activities. Furthermore, households are also better informed about the local housing market then other markets. This relationship is often recognized in other studies (Clark & Dieleman, 1996). The presence of one or more children often leads to an even larger sensitivity towards migration distance, which is probably caused by the activity network of the children, i.e. school, sports and leisure.

However, there are differences in sensitivity towards migration distance between household types: higher educated households are willing to commute further and migrate further. The larger commuting distance is a well-known phenomenon with higher educated people (Schutjens e.a., 1998). The reason for the difference in migration distance probably lies in the smaller importance they attach to social and family contacts and the fact that most households with a high educated head also have a high educated partner with a job. This means that they have to compromise between both work locations, often resulting in larger migration distances (van Ommeren, 1996).

The results for the preference of transport facilities are varied. The nearness of an on-ramp to households with a car is a positive attribute for households that are considered more mobile, namely the highly educated singles and the households that migrated for work related reasons. On the other hand, higher educated people without a car choose significantly more a neighborhood with good public transport facilities. The distance to the nearest railway station is only important for households with a car who moved because of work reasons. Finally, there is no significant prove that households with a child aged six to 12 are relocating closer to primary schools than households without children. A plausible reason for this is the Dutch policy regarding primary services. This prescribes that every residential are with enough inhabitants should have a primary school.

Households that have indicated they move was work related show a significant different sensitivity towards migration and commuting distance. As could be expected, the distance to the workplace is far more important than it is for other household types (with other migration reasons). Nevertheless, according to our estimation results, it seems that this influence is not larger than that of the migrations distance. This is probably caused by the relative subjective way the question is interpreted by the households: some migrations can be work instigated but still are made over relatively short distances, for example when a household has its workplace at home (e.g. a doctor or artist) and needs more space. This phenomenon also occurs in our survey.

Results: Social-economic attributes

Households with two or more persons tend to relocate to a neighborhood with inhabitants of a similar ethnical background. This causes (and has caused) ethnical segregation in the Netherlands, primary in urbanized areas. Next to this preference, these household types (2+) have a significant preference for areas with a higher social status score, probably inflicted by the search for a quieter and better neighborhood to raise children in.

Results: General attributes

Almost al household types, except single highly educated, prefer a neighborhood with a relatively high amount of single-family homes. These areas are assumed to be more quiet and spacious. Next to that these household types also choose to relocate to areas with new housing development, which were very popular in the 2000-2002 period, when migrations were made. The dummies for residential environment almost never have a significant influence. This could mean that either household types do not share a common preference in comparison with rural areas (the reference environment), or that the other variables in the model like dwelling type, ethnical and social status, amount of single-family homes and building period already cover many of the environmental preferences.

Results: Dwelling attributes

The coefficients that concern dwelling characteristics, the dummies as well as the interaction variables, all have the expected sign and are almost always significant. That is to say: the chance that a household relocates to a more expensive, owner occupied house is determined by its income. A similar logical relationship is found for the number of household members and the size and type of the dwelling. This is in line with other research into the residential preferences of households.

6. CONCLUSIONS

Regarding the influence of accessibility, the most important results are the sensitivity of households for the migration and commuting distances for head and its partner. In addition, the combination of car ownership and the proximity of on-ramps, railway station and public transport quality is significant with the expected sign for some of the households. Although car ownership is related with wealth, we believe that in this model it also stands for a lifestyle that is environmentally aware, because we also added other, social-economic variables in the model. The results show that people who do not own a car significantly relocate to neighborhoods with better public transport facilities.

The overall influence of accessibility measures, apart from migration and commuting distance, is very small, whether or not interacted for household specific characteristics. This is probably caused by the relative high quality of the Dutch transport system and the spatial distribution of services, which has resulted over years in a homogenous (high) level of accessibility. This is probably the reason why empirical research on revealed residential behavior in the Netherlands (as described in this paper) is not able to find a significant and/or large influence of accessibility.

Moreover, we did not find a strong preference for the residential living environment; it seems that the dwelling type is of more importance. Of course, the relation between dwelling type and neighborhood is strong: some types only occur in some neighborhoods, but when a dwelling type is chosen, the environment of the dwelling seems not very important. Only social neighborhood aspects like status and ethnicity issues have impact.

The preference for dwelling type is very strong, also in terms of the maximum perceived utility. In practice this implies that people are willing migrate or commute over longer distances, when they can have the dwelling type they long for. This has implications for the (Dutch) housing and transport policy. After all, unless traveling has become such a burden in terms of time (congestion) and costs (extra taxes and peak-hour charges), households will tend to relocate further away from their previous residential location and workplace when the preferred dwelling is not available in the direct vicinity. This could result in more car traffic. This process is enhanced by the tightness on the housing market in Dutch urbanized areas like the Randstad, the western part of the Netherlands.

Future planners and/or policy makers will have to keep the strong influence of housing type in mind, because it could obstruct plans that want to stimulate smart growth and reduce car mileage. Future research plans to follow up this study include therefore the construction of a simulation model to examine the outcomes of various (policy) scenarios, like the effect of allowing rural living, discouraging car-usage and revitalizing the city centers.

7. ACKNOWLEDGEMENTS

The presented research is made possible by the support of other parties. We would like to thank the following institutes for their contribution in means of knowledge, data and software:

- The Netherlands Institute for Spatial research (Ruimtelijk Planbureau), Den Haag, Netherlands.
- ABF Research, Delft, The Netherlands
- Geo-Database Management Centre from the department Geodetic Engineering of Delft University of Technology, Delft, The Netherlands.

8. REFERENCES

Alonso, W. (1964) *Location and land use: toward a general theory of land rent*, Harvard University Press, Cambridge, Massachusetts.

Axhausen, D.M., Scott, A. König & Jürgens (2001) Locations, commitments and activity spaces, Presented at the Survive Workshop, Bonn, December 2001, *Arbeitbericht Verkehrs- und Raumplanning* **96**, IVT, ETH Zürich.

Boehm, T. P. (1982) A hierarchical model of housing choice. *Urban studies* **19** (1) pp. 17-31.

Börsch-Supan, A. (1987) *Econometric Analysis of Discrete choice – with applications on the demand for housing in the U.S. and West-Germany*. Heidelberg: Springer, Berlin.

Browm, L. A. & E.G. Moore (1970). The intra-urban migration process: a perspective. *Geografiska Annaler series B* **52**, pp. 1-13.

Clark, W.A.V. & F.M. Dieleman (1996) *Households and Housing: Choice and Outcomes in the Housing Markets*, CUPR Press, Rutgers University, New Jersey.

Clark, W.A.V. & .F.J. Van Lierop (1986), Residential mobility and household location modeling, *Handbook of regional and urban economics*: Volume I (ed. P. Nijkamp), Elsevier Science Publishers.

Colombino, U. & M.L. Biey (2001) *Modelling household choices of dwelling and local public services.* Centre for household, income, labour and demographics, Italy.

Dieleman, F.M. (2001) Modelling residential mobility; a review of recent trends in research, *Journal of housing and the built environment* **16**, pp. 249-265.

Dökmeci, V. & . Berköz (1999) Residential-location preferences according to demographic characteristics in Istanbul. *Landscape and urban planning* **48** (1-2), pp. 45-56.

Evers, G.H.M. (1990) The residential location and workplace choice: a nested multinomial logit model. *Spatial Choices and Processes* (ed. M.M. Fischer, P. Nijkamp and Y.Y. Papageorgiou) Elsevier Science Publishers, B.V. (North-Holland), pp. 313-329.

Faessen, W.B.M. (2002) Present and preferred housing of one-person households in the Netherlands,1998 *Journal of housing and the Built Environment* **17**(3) pp. 337-350.

Feijten, P. (2005) *Life events and the housing career: A retrospective analysis of timed effects*. Eburon, Delft.

Follain, J.R. & E. Jimenez (1984) Estimating the demand for housing characteristics: Survey and Critique, *Regional Science and Urban Economics* **15** pp. 77-107.

Gärling, T. and Friman, M. (2002) A Psychological Conceptualization of Residential Choice. *Residential Environments: Choice, Satisfaction, and Behavior* (ed. J. Aragonés, G. Franscescato & T. Gärling), Greenwood, Westport, CT.

Geurs, K.T. and Ritsema van Eck J.R. (2001) *Accessibility measures: review and applications*, RIVM Report 408505006, National Institute of Public Health and Environment, Bilthoven.

Greene, W. H. (2002) *Nlogit version 3.0 Reference guide*. Econometric Software Inc, Plainview, New York.

McFadden, D. (1978) Modelling the choice of residential location, in A. Karlquist et al. (ed.), Spatial interaction theory and residential location, North-Holland, Amsterdam, pp. 75-96.

Miller, E. J., J. Douglas Hunt, J.E. Abraham, P.A. Salvini (2004) Microsimulating urban system. *Computers, environment and urban systems* **28** (1-2), pp. 9-44.

Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer (2004) *Nota Ruimte: ruimte voor ontwikkeling*. Sdu Uitgevers, The Hague.

Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer (2003) *Beter Thuis in Wonen – Kernpublicatie WoningBehoefte Onderzoek 2002*. The Hague.

Molin, E. (1999) *Conjoint Modelling Approaches for Residential Group Preferences*. PhD dissertation, Technische Universiteit Eindhoven, Faculteit Bouwkunde, Eindhoven.

Molin, E.J.E., and H.J.P Timmermans (2003), Transport considerations in residential choice decisions: accumulated evidence from the Benelux, in: *Proceedings of the 82-th Annual Meeting of the Transport Research Board*, Washington, D.C..

Mulder, C.H. & P. Hooimeijer (1999) Residential Relocations in the Life Course. *Population issues, an Interdisciplinary Focus* (eds. L.J.G. Van Wissen and P.A. Dykstra), Kluwer academic/Plenum Publishers, New York, NY.

Van Ommeren, J.N. (2000) *Commuting and Relocation of Jobs and Residences*, Aldershot: Ashgate.

Ortuzar J. De D., F.J. Martinez & F.J. Varela (2000) Stated Preferences in Modelling Accessibility. *International planning studies* **5** (1), pp. 65-86.

Piet H. L. Bovy and Eliahu Stern (1990) *Route Choice: Wayfinding in Transport Networks*. Studies in Industrial Organization, Kluwer Academic Publishers.

Quigley, J.M. (1985) Consumer choice of dwelling, neighborhood and public services. *Regional Science and Urban Economics* **15**, p. 41-63.

Rouwendal, J. (1989) *Choice and allocation models for the housing market*, series: Studies in operational region sciences, Kluwer Academic Publishers, Dordrecht.

Schutjens, V.A.J.M., R. van Kempen & B. Wiendels (1998) *Werk-geïnduceerde migratie over lange afstand: een vooronderzoek*. Faculteit Ruimtelijke Wetenschappen, Urban Research centre, Utrecht.

Sociaal en Cultureel Planbureau (1998) *Van hoog naar laag; van laag naar hoog*, Cahier Sociaal en Cultureel Planbureau 152, Elsevier bedrijfsinformatie, Den Haag.

Srour, I.A., K.M. Kockelman and T.P. Dunn (2002) *Accessibility Indices: A Connection to Residential Land Prices and Location Choices*, Presented at the 81st Annual Meeting of the Transportation Research Board, Washington.

Tiwari, P. & Hasegawa, H. (2004) A discrete choice model of housing demand in Tokyo, *Regional Studies* **38** (1) pp.27-42.

Waddel, P. (1996), *Accessibility and Residential Location: The Interaction of Workplace, Residential Mobility, Tenure, and Location Choices*, presented at the 1996 Lincoln Land Institute TRED Conference, Cambridge, Massachusetts.

Weisbrod, G.E., Lerman, S.R. & Ben-Akiva, M. (1980), Tradeoffs in residential location decisions: transportation versus other factors. *Transport Policy and Decision Making* **1**, pp. 13-26.

Table 2: Model characteristics

	Single, low ed.	Single, high ed.	Work instig.	Two +, low ed.	Two +, high ed.	60+ yrs
N	848	475	807	3573	2015	1045
Initial log-likelihood:	-3472.004	-1944.814	-3304.136	-14629.093	-8250.104	-4278.590
Final log-likelihood:	-1600.953	-975.956	-1484.494	-7111.073	-3755.801	-1440.575
Rho-square:	0.538	0.497	0.550	0.514	0.545	0.663

Table 3a: Coefficients for migration distance

	Single, low ed.	Single, high ed.	Work instig.	Two +, low ed.	Two +, high ed.	60+ yrs
Migration distance	-2.835	-2.673	-1.750	-2.595	-2.409	-2.867

Table 3: Estimated coefficients for accessibility and social neighborhood attributes

Variable	Single, low ed.		Single, high ed.		Work instig.		Two +, low ed.		Two +, high ed.		60+ yrs	
	coeff.	st.e.	coeff.	st.e.	coeff.	st.e.	coeff.	st.e.	coeff.	st.e.	coeff.	st.e.
Accessibility attributes												
Migration distance (natural logarithm off-peak travel time (minutes) by car)	-1.000 **	0.026	-1.000 **	0.035	-1.000 **	-0.042	-1.000 **	-0.018	-1.000 **	-0.023	-1.000 **	-0.023
- additional value for hh. with one or more children under 17 years	-				-0.082	-0.073	-0.041	-0.026	-0.106 **	-0.040	0.175	-0.172
Commuting distance head of hh. (natural logarithm peak-hour travel time (minutes) by car)	-0.286 **	0.041	-0.220 **	0.054	-1.000 **	-0.044	-0.227 **	-0.022	-0.123 **	-0.030	-0.330 **	-0.148
Commuting distance partner (natural logarithm peak-hour travel time (minutes) by car)	-				-1.027 **	-0.060	-0.397 **	-0.024	-0.466 **	-0.030	-0.664 **	-0.169
Quality of public transport:												
- for hh. without a car	0.185	0.117	-0.099	0.220	0.016	-0.328	0.061	-0.093	0.448 **	-0.193	-0.103	-0.116
- for hh. with a car	-0.193	0.151	-0.047	0.249	-0.019	-0.345	-0.078	-0.099	-0.480 **	-0.198	0.049	-0.140
Distance[ln] to on-ramp highway:												
- for hh. without a car	0.073 *	0.038	0.213 **	0.069	-0.035	-0.100	0.049	-0.034	0.056	-0.055	0.081 **	-0.041
- for hh. with a car	0.132 **	0.054	-0.194 **	0.080	0.182 *	-0.107	0.056	-0.037	0.049	-0.058	0.033	-0.051
Distance[ln] to railway station:												
- for hh. without a car	-0.033	0.041	-0.093	0.070	-0.261 **	-0.117	-0.010	-0.038	-0.077	-0.059	-0.045	-0.050
- for hh. with a car	0.035	0.062	0.028	0.084	0.272 **	-0.129	0.047	-0.042	0.075	-0.062	0.024	-0.063
Distance[ln] to primary school												
- for hh. without a child under < 13 years	-				0.039	-0.078	0.000	-0.027	-0.031	-0.034	0.062	-0.048
- for hh. with a child under < 13 years	-				0.461 **	-0.168	-0.087	-0.063	-0.037	-0.094	-1.032	-0.830
Social neighborhood attributes												
Index for percentage of non-western												
- for hh. with a head with western ethnicity	-0.299	0.214	-0.444 *	0.265	0.147	-0.363	-0.404 **	-0.130	-0.350 **	-0.175	-0.200	-0.237
- for hh. with a head with non-western ethnicity	1.165 **	0.357	0.557	0.671	1.397	-0.905	1.670 **	-0.197	1.141 **	-0.389	1.170	-0.867
Score for social status of the neighborhood	0.014	0.023	0.042	0.029	0.029	-0.038	0.085 **	-0.014	0.030 *	-0.018	0.052 **	-0.026

NB: All coefficients and standard errors are normalized to the coefficient for migration distance

[ln] : Natural logarithm of the Euclidean distance **: significant at 5% level *: significant at 10% level

Table 4: Estimated coefficients general neighborhood attributes

Variable	Single, low ed.		Single, high ed.		Work instig.		Two +, low ed.		Two +, high ed.		60+ yrs	
	coeff.	st.e.	coeff.	st.e.	coeff.	st.e.	coeff.	st.e.	coeff.	st.e.	coeff.	st.e.
General neighborhood attributes												
Residential environments												
Rural	<reference>		<reference>		<reference>		<reference>		<reference>		<reference>	
Rural village	0.032	0.081	0.158	0.124	0.148	-0.105	-0.072 **	-0.033	-0.098 **	-0.049	0.077	-0.068
Green urbanized	0.024	0.088	0.192	0.130	0.106	-0.123	-0.088 **	-0.039	0.007	-0.054	0.107	-0.079
Urbanized	0.005	0.083	0.145	0.124	0.141	-0.117	-0.092 **	-0.037	-0.100 *	-0.051	-0.022	-0.076
Central urbanized	-0.049	0.094	0.244 *	0.133	0.301 **	-0.142	-0.186 **	-0.049	-0.152 **	-0.065	0.045	-0.092
Percentage of total number of houses per postal zone												
built between 1995 and 2003	0.197	0.137	0.462 **	0.174	0.567 **	-0.173	0.544 **	-0.055	0.642 **	-0.075	0.406 **	-0.114
built between 1960 and 1995	<reference>		<reference>		<reference>		<reference>		<reference>		<reference>	
built between 1945 and 1960	-0.246	0.170	-0.082	0.246	0.137	-0.311	0.008	-0.095	-0.008	-0.144	-0.219	-0.185
built before 1945	-0.146	0.095	0.135	0.118	-0.244	-0.155	-0.488 **	-0.058	-0.085	-0.073	-0.545 **	-0.108
single-family	0.314 **	0.105	0.225	0.138	0.590 **	-0.183	0.471 **	-0.063	0.180 **	-0.084	0.668 **	-0.112

NB: All coefficients and standard errors are normalized to the coefficient for migration distance
**: significant at 5% level
*: significant at 10% level

Table 5: Estimated coefficients for dwelling attributes, interacted with household characteristics.

Variable	Single, low ed.		Single, high ed.		Work instig.		Two +, low ed.		Two +, high ed.		60+ yrs	
	coeff.	st.e.	coeff.	st.e.	coeff.	st.e.	coeff.	st.e.	coeff.	st.e.	coeff.	st.e.
Dwelling attributes												
Interaction variables with household attribute Interaction hh. income (Keuro, difference with modal income) with …												
- cheap rented house	<reference>		<reference>		<reference>		<reference>		<reference>		<reference>	
- medium-expensive rented house	0.571 **	0.101	0.513 **	0.132	0.553 **	-0.125	0.280 **	-0.034	0.277 **	-0.061	0.321 **	-0.080
- expensive rented house	0.616 **	0.109	0.973 **	0.123	0.884 **	-0.111	0.477 **	-0.035	0.550 **	-0.055	0.597 **	-0.073
- cheap owner-occupied house	0.839 **	0.096	0.891 **	0.112	0.903 **	-0.107	0.631 **	-0.030	0.636 **	-0.049	0.608 **	-0.075
- medium expensive owner-occupied house	1.120 **	0.135	0.902 **	0.161	1.075 **	-0.112	0.717 **	-0.034	0.723 **	-0.052	0.633 **	-0.080
- expensive owner-occupied house	0.984 **	0.146	1.055 **	0.127	1.139 **	-0.109	0.739 **	-0.033	0.818 **	-0.051	0.710 **	-0.076
Interaction household size (number of members) with …												
- a small multi-family house	-		-		<reference>		<reference>		<reference>		<reference>	
- a large multi-family house	-		-		0.380 **	-0.095	0.267 **	-0.031	0.331 **	-0.072	0.266 **	-0.083
- a small single-family house	-		-		0.430 **	-0.081	0.201 **	-0.029	0.365 **	-0.065	0.119 *	-0.067
- a large single-family house	-		-		0.711 **	-0.084	0.377 **	-0.029	0.604 **	-0.064	0.300 **	-0.089

NB: All coefficients and standard errors are normalized to the coefficient for migration distance
**: significant at 5% level
*: significant at 10% level

Table 6: Estimated coefficients for dwelling type attributes.

Variable	Single, low ed.		Single, high ed.		Work instig.		Two +, low ed.		Two +, high ed.		60+ yrs	
	coeff.	st.e.	coeff.	st.e.	coeff.	st.e.	coeff.	st.e.	coeff.	st.e.	coeff.	st.e.
Dwelling types												
REMFSMLO	<reference>		<reference>		<reference>		<reference>		<reference>		<reference>	
REMFSMMI	0.391 **	0.084	0.553 **	0.093	0.705 **	-0.164	0.426 **	-0.056	0.424 **	-0.099	0.522 **	-0.074
REMFSMHI	0.576 **	0.093	0.836 **	0.102	1.327 **	-0.159	0.677 **	-0.062	0.642 **	-0.099	1.044 **	-0.074
REMFLALO	-0.210 **	0.068	-0.180	0.124	-0.525 **	-0.258	-0.395 **	-0.101	-0.324 *	-0.193	-0.606 **	-0.160
REMFLAMI	0.249 **	0.118	-0.011	0.186	-0.069	-0.289	-0.077	-0.104	-0.269	-0.203	-0.318 *	-0.185
REMFLAHI	0.443 **	0.116	0.488 **	0.170	0.498 *	-0.272	0.190 *	-0.105	0.127	-0.194	0.170	-0.175
RESFSMLO	-0.281 **	0.058	-0.215 **	0.103	-0.860 **	-0.230	-0.181 **	-0.088	-0.590 **	-0.173	-0.341 **	-0.118
RESFSMMI	0.060	0.103	0.366 **	0.133	-0.314	-0.253	0.216 **	-0.091	-0.246	-0.179	-0.079	-0.142
RESFSMHI	0.125	0.149	0.498 **	0.160	0.359	-0.231	0.247 **	-0.097	-0.027	-0.179	0.110	-0.159
RESFLALO	-0.426 **	0.107	-0.275	0.212	-1.243 **	-0.293	-0.658 **	-0.098	-1.271 **	-0.200	-1.256 **	-0.232
RESFLAMI	-0.275 *	0.158	-0.020	0.213	-1.485 **	-0.372	-0.463 **	-0.099	-1.140 **	-0.200	-0.996 **	-0.277
RESFLAHI	-0.001	0.182	0.281	0.200	-0.478 *	-0.248	-0.248 **	-0.100	-0.921 **	-0.184	-0.649 **	-0.239
BUMFSMLO	0.379 **	0.083	0.701 **	0.082	0.495 **	-0.156	0.262 **	-0.056	0.288 **	-0.082	0.364 **	-0.083
BUMFSMMI	-0.423	0.369	0.319 *	0.192	-0.029	-0.341	-0.008	-0.134	0.060	-0.150	0.617 **	-0.120
BUMFSMHI	-0.047	0.215	0.513 **	0.152	0.240	-0.273	0.127	-0.117	0.004	-0.133	0.351 **	-0.135
BUMFLALO	0.338 **	0.123	0.582 **	0.122	0.149	-0.270	0.004	-0.104	-0.252	-0.191	-0.219	-0.206
BUMFLAMI	-0.284	0.366	0.273	0.296	0.218	-0.344	-0.554 **	-0.162	-0.505 **	-0.224	0.172	-0.208
BUMFLAHI	-1.392	33.904	0.094	0.278	-0.235	-0.333	-0.585 **	-0.148	-0.697 **	-0.215	-0.246	-0.216
BUSFSMLO	0.096	0.082	0.351 **	0.095	0.016	-0.200	0.091	-0.086	-0.211	-0.165	-0.331 **	-0.142
BUSFSMMI	-0.137	0.133	0.061	0.163	-0.364	-0.225	-0.152	-0.093	-0.433 **	-0.172	-0.269 *	-0.148
BUSFSMHI	-0.379 **	0.160	-0.146	0.172	-0.604 **	-0.232	-0.185 **	-0.094	-0.612 **	-0.171	-0.296 **	-0.151
BUSFLALO	-0.259 **	0.125	0.235 **	0.118	-0.681 **	-0.226	-0.237 **	-0.090	-0.681 **	-0.167	-0.868 **	-0.195
BUSFLAMI	-0.462 **	0.170	-0.319	0.250	-0.863 **	-0.238	-0.531 **	-0.095	-0.845 **	-0.171	-0.747 **	-0.208
BUSFLAHI	-0.568 **	0.163	-0.250	0.159	-0.911 **	-0.230	-0.611 **	-0.093	-0.947 **	-0.168	-0.635 **	-0.191

NB: All coefficients and standard errors are normalized to the coefficient for migration distance
**: significant at 5% level
*: significant at 10% level