# Explaining the location decision of moving firms using their mobility profile and the accessibility of locations

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## Abstract

This paper describes the research approach and first empirical results of the estimation of discrete choice models that describe the location decision of moving firms. The model is based on random utility theory and features systematic choice sets to account for the choice context at the highest level of spatial detail (address-level). Firms are analysed categorised to their mobility profile. These mobility profiles are homogenous groups of firms with similar mobility characteristics that are a priori assumed. The models are tested on an extensive revealed preference dataset with firm migration observations in South Holland. To avoid correlations between variables a variety of composed accessibility variables have been constructed that describe the distances to the physical infrastructure or that are an aggregated form of potential accessibility. The location attributes of alternatives have been completed with the business environment type and the rental level.

The results are first of all valuable for the development of a simulation model for firm location but the empirical results also yields insight into the spatial behaviour and location preference of firms. Although further research is necessary, the presented addresses some challenges in modelling the spatial behaviours of firms in an urban environment. Therefore the presented approach holds seems valuable for the development of a simulation model for location decisions of moving firms and offers good possibilities for future research.

# Introduction

Integrated land use and transport models (LUTI-models) take into account the complex interaction between land use and transport: they explicitly model the effects of transport policies on the development of urban land use or on the environment. Reversely land use dynamics influence travel behaviour. For a state of the art overview of integrated land use and transportation models see Miller et. al. (1998) Wegener and Fürst (1999) or Timmermans (2003) more recently. Although much progress has been made in the development of LUTI models, the behavioural and theoretical aspects in these models still are weak (Timmermans 2003). The approach to model the location of economic activities in LUTI-models can be enhanced by accounting for spatial choice behaviour and by applying a high level of spatial detail, preferably address level (micro-level).

To improve the behavioural foundation, the first scientific challenge lies in the decision making unit. The simulation model for the location of economic activities within contemporary LUTI-models, allocates jobs. In other words a job decides to relocate whereas the true cause of the spatial development is the entity of the firm. Modelling concepts that have been developed in other disciplines, such as the demography of firms, might be beneficial in developing advanced choice models for firm location.

The second challenge lies in the level of spatial detail that is used. Most revealed preference examples of simulation models for economic location (Anderstig and Mattson 1991, Shukla and Waddell 1991, Abraham and Hunt 1999, Holl 2003) describe an spatially aggregated location choice for a (aggregated) zone from all possible zones. This level of detail is not sufficient if one wants to describe for certain important phenomenon like the suburbanization of employment which is found in many researches (Shukla Waddell 1991, Louw 1996, Kawamura 2001, de Bok 2003) and the formation of employment clusters due to economies of scale (Waddell Ulfarsson 2003, Bade 2000, van Oort et. al. 2002). The spatial level at which this phenomenon and many other land use dynamics occur, stress the need to model the relocation of individual firms in a spatial disaggregated environment.

This approach tries to overcome these shortcomings by developing a location choice model that first of all represents the firm as the decision making unit and secondly applies a high level of spatial detail. To accurately describe the behavioural context of the location decision an approach has been applied in which an individual firm makes a decision to relocate and chooses a unique location from a limited set of feasible alternatives. Further more it is acknowledged that firms have a large variety in mobility characteristics and hence a large variety in location preferences with regard to infrastructure related location characteristics. To account for this heterogeneity in preference, the concept of mobility profiles will be used to address the mobility characteristics of firms.

# Background

### *Firm migration*

The event which is discussed in this research is the firm migration event. Firm migration is a particular form of location adjustment which can be defined as a firm's change of address from location A to location B. In research history, firm migration has witnessed a broad spectrum of theories and approaches, but one generally accepted theory does not exist. In a contemporary overview Pellenbarg, van Wissen and van Dijk (2002) distinguish three approaches: the neoclassical, behavioural and institutional approach, each with its own strengths and weaknesses. All approaches have in common that they represent the firm as an active decision-making agent: a firm chooses a location from a number of alternatives. In doing so, it takes economic and/or non-economic factors into account. The neoclassical approach is based on the homo economicus and is derived from standard classic economic theories, tracing back to the work of Von Thünen (1826). The neoclassical approach strives for cost-minimizing and has been applied in various LUTI models (Abraham, Hunt, 1999). The behavioural approach, founded by Simon (1955), assumes satisfying behaviour and is based on the idea of decision making in a context with limited information and bounded rationality. Pred (1969) was one of the first to introduce the behavioural approach in location theory. An important argument to apply a behavioural approach is that it can account for non-economic factors and firm internal processes. Although influencing transport costs, the factor accessibility is often assessed in (non-economic) abstract measures, such as the employment potential in the region. Literature further more stresses the need to account for firm internal processes so it seems evident that a behavioural approach offers some advantages in modelling firm migration. The third approach (institutional) focuses assumes that the environment in which the choice behaviour takes place is non-static: the government and real estate market are modelled as an institute influencing the environment. In the presented approach the environment is taken into account to some extend but the decision making of the government or real estate developers is not taken into account explicitly. This research applies a behavioural approach in which the decision to relocate is modelled as a complicated decision making process consisting of multiple stages in which different aspects play a determining role in firm behaviour (Louw 1996).

## *Mobility profiles*

Individual firms have a large variety in size, nature of its activity, region of origin and spatial relations. This large variety has to be accounted for: it is very likely that that these features influence the preferences of firms. Especially the variance in spatial relations is important when analysing infrastructure related aspects in location analysis. To account for these relations the mobility characteristics of firms can be used as dimensions for categorising all firms in groups with similar mobility characteristics (*mobility profiles*). This research approach assumes that these mobility profiles are at least to some extend of influence on the location preferences of a firm. In other words: if a firm has a high car dependency for its activities it is likely that this firm has a preference for a location well accessible by car. If these spatial interdependencies are accounted for explicitly, it might improve the insight into the relative importance of accessibility as a location factor.

The main interest when defining these mobility profiles for firms are the spatial relations with employees, customers and suppliers. Furthermore of influence are the distance at which these relations occur, the intensity of this relation and the modality that is used. The mobility characteristics of firms have been analysed extensively by Verroen et. al.(1990) in previous research. These analyses were conducted to support the formation of the ABC location policy. This policy has been introduced in the fourth policy document on spatial planning in the Netherlands (VROM, 1990). It aims to match the mobility needs of businesses and amenities with the accessibility of different locations, also referred to as 'The right business at the right place' (Verroen et. al., 1990). By locating businesses at the 'right' location, the mobility behaviour of employees can be affected considerably as is demonstrated by van Wee (1997). Despite the possible positive effects which can be gained with this policy, the successfulness of the policy was limited due to the large amount of business areas which remain unaffected by the policy (Martens, 1999). As a consequence, the fifth policy document on spatial planning evaluates the effect of the ABC location policy as limited (VROM, 2001).

Despite the limited success of the ABC location policy the conducted mobility studies and the resulting mobility profile definitions have been applied in this research. The presented mobility profiles in table 1 are a result of a cluster analyses on a number of mobility characteristics for all industry branches (Verroen et.al. 1990). These mobility characteristics were derived from extensive datasets such as the National Travel Survey (in Dutch: 'Onderzoeks Verplaatsings Gedrag') and the Labour Force Counts (in Dutch: 'Arbeidskrachten tellingen').

**Table 1: Mobility profiles (adapted from Verroen et. al. 1990)**

| | Mobility variables | | | | | | | | Transport of goods | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mobility profile | Labour intensity | Car dependency | Car share | Public transport share | Slow traffic share | Distance commuting | Visiting intensity | Visiting car share | Road | Rail | Water |
| 1. Space extensive industry | - | - | ++ | - | - | + | - | ++ | + | 0 | 0 |
| 2. Agriculture and Mineral extracting | -- | - | + | - | - | 0 | -- | ++ | + | 0 | 0 |
| 3. Offices trade and industry | + | - | ++ | - | - | + | 0 | ++ | var | var | var |
| 4. Utility and transport companies | - | ++ | + | - | + | + | - | -- | 0 | 0 | 0 |
| 5. Offices with high car-dependency | + | ++ | ++ | 0 | - | + | 0 | ++ | var | - | - |
| 6. Space intensive industry with high share public transport | + | - | 0 | + | 0 | 0 | - | ++ | + | - | - |
| 7. Offices business services | + | - | + | + | - | + | + | ++ | - | - | - |
| 8. Offices government | + | -- | + | 0 | - | + | + | + | var | var | - |
| 9. Social services | + | -- | -- | + | ++ | -- | 0 | ++ | var | - | - |
| 10. Public services | 0 | -- | 0 | + | 0 | - | ++ | 0 | var | - | - |
| 11. Medical and sports facilities | 0 | - | - | ++ | + | - | + | + | - | - | - |

++ = very high resp. very large
+ = high resp. large
0 = average
- = low resp. small
-- = very low resp. very small
var = variety among firms within profile

This paper describes model estimates for relocating firms on the office market. Because the analysis focuses on the office market the dataset is reduced to firms in mobility profiles 3, 5, 7, 8 and 9. Mobility profile 3, the offices trade and industry, consists for instance of firms in the graphical industry or for instance administrative activities of firms in the industry-, construction- or trade sector. Firms that are regarded as offices activities with a high car dependency mainly come from business services: for instance. lawyers, accountants, ICT-services, advertising agencies, economic consultants. Profile 7 consists of the other firms in business services, such as financial services, insurance, real estate agent, notaries, engineering office, news agencies, employment agencies etcetera). Profile 8 consists of government firms: public services, administrative and public activities of public utility firms or public activities from the communication industry. Profile 9, social services, consists of firms with administrative activities for social work, or administrative and public activities for the service industries.

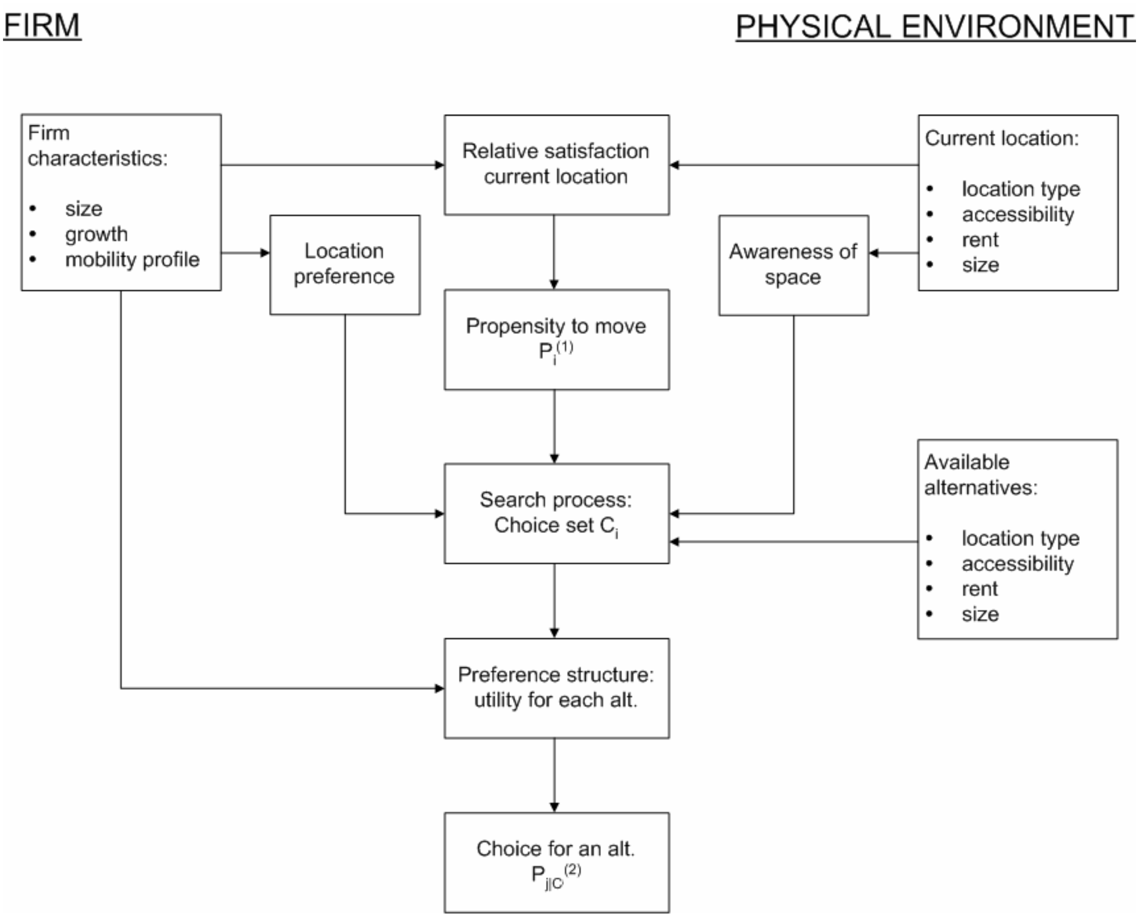
Because it is expected that the mobility characteristics of a firm influence its preference regarding the accessibility of locations, they can be used to form hypotheses about the preference of each mobility profile regarding the accessibility of locations. Table 1 indicates that firms in business services and from the government (profile 7&8) both have a high visiting and labour intensity and a large car share for commuting. Firms in business services appear to be visited by car mainly so for these firms we expect an orientation on road accessibility. Governmental firms appear to be less dependent on car use compared to business services. So for this mobility profile we expect a more evenly preference for road and public transport. Firms in profiles 3 and 5 both have a large car share for visiting as well as commuting. A strong focus on road transport is expected. Firms in social services (profile 4) have an exceptional low car use and low visiting intensities which might imply a preference for inner city locations well accessible for the population by slow traffic or public transport.

# Theoretical model

The theoretical model is based on a behavioural approach describing the spatial decision making of individual firms in a disaggregated physical environment. At a certain point in time this firm has various characteristics that determine their preferences, such as its size, the firm's growth or its mobility profile. The firm is located at a unique location in the physical environment in which multiple alternative locations are available. The location alternatives in this physical are described by real estate characteristics such as the size of the real estate object and the location characteristics, such as location type and accessibility. The firm migration behaviour of an individual firm within this physical environment is regarded as choice process that consists of a sequence of considerations and decisions as visualised in figure 1.

First of all the decision to move is a result of the relative satisfaction at the current location. The factors influencing this satisfaction are referred to as *push factors*. These push factors influence the propensity of a firm to move. Researches described in literature observed that on a yearly basis seven to eight percent of all firms move (Pellenbarg 1996). Furthermore firms appear to move over relatively short distances, plausibly because firms are dependent on existing spatial relations with employees and customers or suppliers, also referred to as *keep factors* (Pellenbarg 1996). The decision to relocate is mainly determined by firm internal factors relating to the life-cycle of firms and to a lesser extent by site related factors (Louw 1996, van Dijk and Pellenbarg 2000). Especially the growth of firms and the demand for more space appears to be an important *push factor* for firms to move. Other determining factors are the size and age of the firm (Brouwer et. al 2002). The tendency to migrate furthermore shows large differences between sectors: firms in business services show the highest share of movers.

**Figure 1: conceptual model of individual firm in a physical environment**




Once the decision to move is made the firm will search for alternative locations. This search process will lead to a choice set with limited satisfactory alternatives. First of all the search process is limited to a set of *available* locations. Furthermore the set of available alternatives can be reduced to *known* alternatives by assuming an awareness space of this firm, similar to residential migration (Brown and More 1970). This space includes locations that the firm has knowledge about through direct contact, through the media or specialised agencies. Finally the search process is restricted to alternatives that are *feasible*, or in other words that are compatible with the preference of a firm (for instance a minimum size of a location). Once a limited set with feasible alternatives is created the firm will determine its expected utility based on the attributes of each alternative (*pull factors*) and the preference structure of the firm. From these alternatives, the firm will choose the alternative with the highest expected utility as its new location. McFadden (1978) has proven that consistent estimates can be obtained when the full choice set is replaced with a subset containing the observed choice and a random sample from the possible alternative choices.

The approach consists of two decisions and the formation of a choice set. The decision to relocate is modelled separately from the location decision for a new location, an approach also applied by van Wissen (2000) in the micro simulation SIMFIRMS. The actual decision for an alternative location in a choice set $P_{j|C_i}{}^{(2)}$ is a conditional decision which will be modelled using a spatial preference model in the form of a multinomial logit model. The joint decision $P_{ij}$ of firm $i$ to move and to relocate to location $j$ is the product of the probability $P_i^{(1)}$ firm $i$ will move and the conditional probability $P_{j|C_i}{}^{(2)}$ of firm $i$ choosing location $j$ from a subset of alternatives $C_i$ :

$$P_{ij} = P_i^{(1)} x P_{ij|C_i}^{(2)}$$

The influence of accessibility can be of importance in each decision, but from literature it seems that accessibility mainly expresses itself as a pull factor rather than a push factor. The focus of this paper is therefore on the estimation of the choice model for moving firms. This model, as well as the formation of the choice set will be addressed subsequently.

## Location choice

The location decision of each individual moving firm $i$ is modelled with a multinomial logit model, based on random utility theory (McFadden 1974). This implies we assume that firm $i$ attaches some utility $U_{ij}$ to each alternative $j$ in a set of alternative locations that are considered. Furthermore the firm will choose the alternative that yields the highest expected utility. In the presented model we assume a linear additive utility function of the form:

$$U_{ij} = V_{ij} + \varepsilon_{ij} = \beta_{0ij} + \beta_{1i} x_{1ij} + ... + \beta_{ni} x_{nij} + \varepsilon_{ij}$$

Where $U_{ij}$ is the expected utility of location $j$ and $V_{ij}$ is the deterministic part of the expected utility of location $j$. The deterministic component of utility is specified as a function of alternative specific variables ($x_{1j}$,…,$x_{nj}$) multiplied by estimable coefficients ($\beta_{1i}$,…, $\beta_{ni}$). And because we apply a labelled experiment an alternative specific constant $\beta_{oij}$ is added to the utility function for the business environment of the location. If the random unobserved component of utility $\varepsilon_{ij}$ is assumed Gumbel distributed, it can be eliminated from the utility function (McFadden, 1974).The resulting multinomial logit model describes the probability $P_{ij|C_i}{}^{(2)}$ of choosing location $j$ from a unique subset $C_i$ with $k$ alternative locations:

$$P_{ij|C}^{(2)} = \frac{e^{V_{ij}}}{\sum_{k \in C} e^{V_{ik}}}$$

where $V_{ij}$ is the deterministic part of the utility.

## Choice set definition

The presented location choice model describes the location decision at the level of unique real estate objects, the lowest level of detail possible. This implies that a large number of alternatives are available. In this approach the search process is simulated by constructing systematic choice sets for each relocation observation. This choice set is a group of alternative firm locations, out of all possible available firm locations from which the firm will make his choice.

The choice situation in route choice modelling and location choice shows large similarities concerning the large number of alternatives. In spite of these similarities, the methodology of constructing individual choice sets seems much more developed in route choice modelling (Fiorenzo-Catalano et. al. 2003). Unfortunately few empirical examples exist in which revealed preference data of firm relocation is combined with the formation of systematic choice sets. The only contemporary example of an analysis on revealed preference data in which systematic choice sets are applied is given by Waddell and Ulfarsson (2003). They estimated a multinomial logit model for employment location based on revealed preference data. Within their approach the choice set consisted of the chosen alternative and nine randomly selected location alternatives, although no further details are given about the choice set algorithm.

A script has been developed to generate choice sets for each firm migration subsequently. This choice set generator determines stepwise subsets of alternatives, using concepts similar to route choice modelling (Bovy and Stern 1990). For each observation the following procedure is followed:

- **existing alternatives**: all chosen firm locations in the dataset;
- **available alternatives**: select alternatives that were available in the corresponding period;
- **feasible alternatives**: select those alternatives that are of corresponding property type: office, commercial property (shop) or industrial property;
- **choice set**: consists of chosen location completed with nine random alternatives from all feasible alternatives.

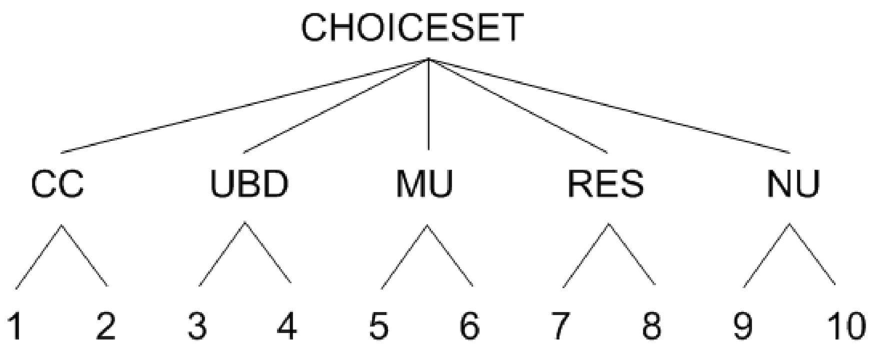
The choice set procedure will be further advanced in future research by adding size criteria for the feasibility of alternatives and adding the distance to the original location to operationalize the awareness space concept.

**Table 2: types of business locations (source: WMD / edited)**

| Business environment |
|---|
| City Centre (CC) |
| Urban Business District (UBD) |
| Mixed Urban (MU) |
| Residential (RES) |
| Non-urban (NU) |

To facilitate a labelled experiment, the business environment of each location is added as an alternative specific constant to the model. This business environment is derived from an environment typology, originally consisting of 15 categories (sourse: Living Environment Database 2002, in Dutch: ‘WoonMilieuDatabase 2002’). These categories are reduced to five business environments each accounting for a representative share of business locations (table 2). The locations are distinctive in land use density and to the degree of mono-functionality. City centre locations for instance lie in urban districts with a high land use density and a mixed land use. Urban business districts are mono-functional business locations. The remaining urban districts are categorised as mixed urban or mono-functional residential locations. To secure the variability in the choice set the choice set algorithm selects a fixed number of alternatives (two) from each business environment (figure 2). Besides the chosen location, the choice set procedure randomly adds alternatives to the choice set, while securing that from each business environment two alternatives are represented in the choice set.

**Figure 2: Choice set composition**



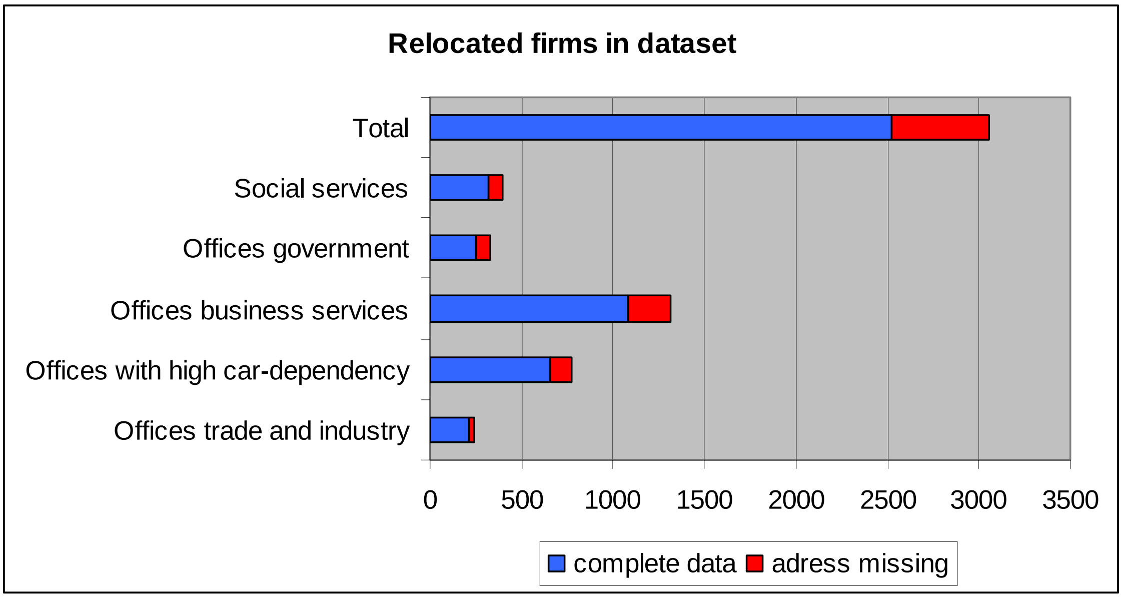

## Dataset

The presented theoretical model will be tested on a research area which consists of the province of South Holland, a highly urbanised area (see figure 3). With a population of 3,4 million persons in the year 2001 it has the largest population of all provinces in The Netherlands. The province counted almost 1,5 million jobs and 130 thousand firms. The area measures over 3000 square kilometres. In our first analysis we focus on the office market but in future estimations we will make model estimations for all industry sectors.

**Figure 3: Research area**


The research has been conducted on a revealed preference dataset containing firm migrations in the Netherlands. Because of the usage of coordinate information in this dataset, information about the accessibility of locations is added with a high level of spatial detail. The data on individual firm migrations are derived from the National Information System of Employment (LISA) for the years 1988 to 1997. For each firm move in the dataset the 6-digit postal zone of the original location and the new location is known. Firm characteristics further include firm size (number of jobs) and business sector or mobility profile. To avoid any irregularities from small (not existing) firms, the observations will be limited to firms with more than five employees. Finally this yielded a dataset consisting of more than 3000 relocated firms, of which 2500 were usable (see figure 4). For some observations it was not possible to determine its coordinates because the 6-digit postal zone at the new location either the original location was false (non-existing). These observations are left out of the analysis.

**Figure 4: Distribution of firms in the dataset**




Datasets containing location characteristics, such as accessibility measures, are linked to each individual firm migration and business real estate object, based on their coordinates. For the reason that accessibility is a complex phenomenon a set with a variety of accessibility measures have been tested for its explanatory value. First of all for each firm location a set of distance attributes have been computed denoting the distance to motorway onramps and train stations. These attributes are calculated in GIS, using coordinate information. It appeared that the distance attributes were highly correlated. This was solved by translating the distance measures into a composed distance location type describing the position of a location in relation with the physical infrastructure. The definitions are similar to the ABC location types introduced in the ABC location policy (Verroen et. al. 1990).

**Table 3: Definitions of αβγ-locations**

| Location type | Definition |
|---|---|
| α | distance to intercity station less then 800 m. |
| β | distance to train station less then 800 m. and distance to onramp less then 5000 m. |
| γ | distance to onramp less then 2000 m. |
| ρ | all other locations |

Besides measures accounting for the transport infrastructure itself, a set of potential accessibility measures have been used that describe the transportation system as well as the land use. These so called contour measures (Geurs and Ritsema van Eck, 2001) denote the number of opportunities (for instance jobs or customers) that are within reach. These accessibility are derived from the Living Environment Database (WMD) and are added as an attribute to each firm location. To avoid the problems with correlations between the accessibility variables a factor analysis has been used as a technique to reduce the number of variables but to maintain the information in the data. The factor analysis using varimax rotation yielded 4 uncorrelated components with an eigen value higher than 1,0.

**Table 4: Factor loadings accessibility components**

| | Component | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| population within 15 minutes by car | 0,316 | 0,308 | 0,811 | 0,266 |
| total number of jobs within 15 minutes by car | 0,359 | 0,331 | 0,792 | 0,251 |
| jobs in agriculture within 15 minutes by car | -0,270 | 0,137 | 0,382 | 0,771 |
| jobs in industry within 15 minutes by car | 0,341 | 0,171 | 0,809 | -0,262 |
| jobs in commercial services within 15 minutes by car | 0,386 | 0,337 | 0,794 | 0,160 |
| jobs in public services within 15 minutes by car | 0,285 | 0,327 | 0,669 | 0,491 |
| population within 30 minutes by car | 0,272 | 0,748 | 0,534 | -0,049 |
| total number of jobs within 30 minutes by car | 0,209 | 0,800 | 0,455 | 0,009 |
| jobs in agriculture within 30 minutes by car | 0,200 | 0,721 | 0,479 | 0,249 |
| jobs in industry within 30 minutes by car | 0,334 | 0,665 | 0,550 | -0,176 |
| jobs in commercial services within 30 minutes by car | 0,168 | 0,825 | 0,411 | 0,017 |
| jobs in public services within 30 minutes by car | 0,191 | 0,776 | 0,441 | 0,085 |
| population within 45 minutes by car | 0,088 | 0,972 | 0,083 | 0,083 |
| total number of jobs within 45 minutes by car | 0,018 | 0,946 | 0,002 | 0,239 |
| jobs in agriculture within 45 minutes by car | 0,220 | 0,810 | 0,209 | -0,313 |
| jobs in industry within 45 minutes by car | 0,212 | 0,893 | 0,191 | -0,176 |
| jobs in commercial services within 45 minutes by car | -0,033 | 0,912 | -0,039 | 0,328 |
| jobs in public services within 45 minutes by car | 0,008 | 0,932 | -0,023 | 0,265 |
| population within 15 minutes by train | 0,828 | 0,098 | 0,062 | 0,314 |
| total number of jobs within 15 minutes by train | 0,878 | 0,161 | 0,090 | 0,243 |
| jobs in agriculture within 15 minutes by train | 0,043 | 0,026 | -0,025 | 0,670 |
| jobs in industry within 15 minutes by train | 0,727 | 0,116 | 0,141 | -0,063 |
| jobs in commercial services within 15 minutes by train | 0,873 | 0,146 | 0,107 | 0,164 |
| jobs in public services within 15 minutes by train | 0,818 | 0,172 | 0,045 | 0,388 |
| population within 30 minutes by train | 0,943 | 0,064 | 0,129 | 0,057 |
| total number of jobs within 30 minutes by train | 0,948 | 0,115 | 0,188 | 0,021 |
| jobs in agriculture within 30 minutes by train | 0,338 | 0,081 | 0,061 | 0,821 |
| jobs in industry within 30 minutes by train | 0,908 | 0,021 | 0,129 | -0,159 |
| jobs in public services within 30 minutes by train | 0,891 | 0,164 | 0,168 | 0,233 |
| population within 45 minutes by train | 0,921 | 0,108 | 0,266 | -0,079 |
| total number of jobs within 45 minutes by train | 0,897 | 0,140 | 0,268 | -0,028 |
| jobs in agriculture within 45 minutes by train | 0,634 | 0,171 | 0,131 | 0,589 |
| jobs in industry within 45 minutes by train | 0,902 | 0,069 | 0,259 | -0,222 |
| jobs in commercial services within 45 minutes by train | 0,890 | 0,130 | 0,267 | -0,066 |
| jobs in public services within 45 minutes by train | 0,874 | 0,177 | 0,264 | 0,101 |
| | | | | |
| Extraction Method: Principal Component Analysis with varimax rotation | | | | |
| 4 components extracted with eigen value > 1.0 | | | | |

These components can be interpreted by their factor loadings. Considering the high factor loadings for the variables regarding the accessibility by train, especially for travel times of 30 and 45 minutes, the first factor can be interpreted as a regional accessibility by train. Similarly the second and third component can be interpreted as a regional accessibility by car and a local accessibility by car respectively. The fourth factor has high factor loading for the accessibility of jobs in agriculture, but has not been used in further analysis due to its limited value for the firms on the office market.

In discrete choice analysis it is assumed that an individual makes a trade off between multiple complementary attributes: better accessibility is traded off against higher rental levels. From this theoretical perspective it seemed reasonable to add the rent level of each location to the location choice model. This rental level is derived from a large dataset with information of real estate transactions, including a variety of characteristics of the real estate transaction, such as type (industrial location, office, retail), size and location (source: VastView dataset, included in the Real Estate Monitor of ABF Research). The average rental level (€/$m^2$) of all observations at a location is used as a proxy for the rental level.

# Results

The estimation results for each mobility profile are presented in Table X. The preference structure of each mobility profile can be derived from the estimated parameters ($\beta_1,\ldots,\beta_n$) and the alternative specific constants $\beta_o$. The models are estimated with the freeware program BIO GEME, which have been developed by Michel Bierlaire at the École Polytechnique Fédérale de Lausanne. An effect coding scheme has been applied for the location types in order to derive the parameter value for the α–locations from the parameter values for the other location types.

The estimation results will first of all be discussed for the observed preference for business environments. The business environment type of locations are modelled as alternative specific constants and proved to be significant. As might be expected all mobility profiles show to have a preference for the urban business environments. But there can also be observed some taste differences between profiles. The offices trade and industry appear to have the strongest preference for locations that lie in urban business districts. The offices business services and offices government appear to derive the highest utility in the city centre. The relocated firms in social services appeared to have the highest utility for locations with mixed urban land use.

**Table 5: Estimation results for mobility profiles**

| Variable | Offices Trade and industry | | Offices high car dependency | | Offices business services | | Offices government | | Social services | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Value | t-test | Value | t-test | Value | t-test | Value | t-test | Value | t-test |
| City Centre | 1,31 | 2,57 | 0,82 | 2,09 | 1,31 | 3,29 | 2,75 | 5,62 | 0,76 | 1,49 |
| Urban Business District | 2,68 | 6,73 | 1,51 | 4,48 | 1,26 | 3,40 | 2,02 | 4,40 | 1,01 | 1,94 |
| Mixed Urban | 1,68 | 3,56 | 1,03 | 2,56 | 0,58 | 1,44 | 1,86 | 3,47 | 1,35 | 2,58 |
| Residential | 0,55 | 0,90 | -0,92 | -2,02 | -0,94 | -2,26 | 0,37 | 0,65 | -1,30 | -2,58 |
| Non-urban | 0 | (fixed) | 0 | (fixed) | 0 | (fixed) | 0 | (fixed) | 0 | (fixed) |
| α-location (from effect coding) | 1,47 | | 0,22 | | 0,20 | | 1,02 | | 0,33 | |
| β-location | -0,69 | -2,38 | 0,20 | 0,93 | 0,41 | 2,10 | 0,53 | 1,91 | -0,11 | -0,35 |
| γ-location | -0,68 | -2,48 | -0,30 | -1,31 | -0,04 | -0,29 | -0,81 | -2,79 | -0,65 | -2,71 |
| ρ-location | -0,09 | -0,32 | -0,12 | -0,74 | -0,57 | -3,37 | -0,75 | -2,56 | 0,43 | 1,70 |
| Regional accessibility by train | -0,03 | -0,16 | 0,12 | 0,92 | 0,37 | 3,86 | 0,06 | 0,49 | 0,14 | 0,90 |
| Regional accessibility by car | 0,18 | 0,86 | 0,19 | 1,12 | -0,05 | -0,48 | 0,44 | 1,96 | 0,33 | 1,97 |
| Local accessibility by car | -0,07 | -0,42 | 0,30 | 1,62 | 0,19 | 2,07 | 0,19 | 1,41 | 0,29 | 2,47 |
| Rental level | -0,94 | -1,88 | 0,36 | 1,11 | -0,90 | -2,23 | 0,40 | 0,66 | 0,49 | 1,07 |
| N | 214 | | 662 | | 1079 | | 252 | | 320 | |
| Init log-likelihood | -18869,7 | | -48398,0 | | -124393,0 | | -50396,7 | | -38701,9 | |
| Final log-likelihood | -14076,9 | | -41122,3 | | -103746,0 | | -34022,4 | | -32199,0 | |
| Rho-square | 0,254 | | 0,150 | | 0,166 | | 0,325 | | 0,168 | |

With respect to the accessibility variables fewer parameters proved to be significant. Offices trade and industry show to value β- and γ-locations negatively. Combined with the found preference for urban business district these firms are likely to prefer typical business locations near intercity stations. The offices business services appear to have the most significant accessibility parameter of all mobility profiles. With regard to the location type they appear to have a preference for α- and β-locations. Unfortunately by its definition it was not possible to make a distinction between α-locations that are close to motorways or at larger distances what complicates the interpretation. But by the parameters it can be seen that the distances to transport infrastructure are important and that locations at a considerate distance from train stations as well as motorways (ρ-locations) are not preferred. These firms appear to derive a positive utility from the regional accessibility by train and the local accessibility by car. This latter is in line what might be expected regarding agglomeration effects for firms in business services can be assumed to be most dependent on face to face contacts with other firms. The offices with a high car dependency largely stem from the regular business services industry sector, but in spite of their name these firms do not seem to have a strong preference for a specific accessibility. Firms in the government sector appear to attach add a negative utility to alternatives that are located at γ- or ρ-locations. This might indicate that offices for the government are located within reasonable distance from a train station. With respect to the accessibility parameters the firms in social services only show a negative significant preference for ρ-locations (distant form stations and motorway).

The importance of the rental level of a location varies between the mobility profiles. The rental level of locations only turned out to be significant for the firms in business services. The rental level parameter is similar for the offices trade and industry and nearly significant. The estimated parameters of the other mobility profiles are not significant which might indicate that for these firms, the rental level is not an important location factor.

Besides this empirical insight into the location preference structure of firms, the estimated parameters can be used to develop a simulation model that describes the spatial behaviour of firms in a dynamic spatial aggregated environment.

## Conclusions and further research

The objective of the research is to develop empirical choice models for firm behaviour which can be applied in LUTI models. This paper describes the research approach and first empirical results of the estimation of discrete choice models that describe the location decision of moving firms. The estimation results are first of all valuable for the development of a simulation model for firm location but the empirical results might also yield some improved knowledge into the spatial behaviour and location preference of firms. Future research will focus on the development of a simulation model for the framework presented in figure 1, but some preliminary conclusions and observations regarding the location decision of moving firms can be made.

A condition for the research was a disaggregated approach which is generic and can be applied for all types of firms. The models that have been estimated are based on random utility maximising discrete choice behaviour. The choice context of the location decision is defined by alternatives at the address level. A limited set of feasible alternatives is assumed to compose the choice set of a relocating firm.

An extensive dataset on firm migration has been used: besides the population size of the sample, the data is available for a large time period: from 1988 to 1997. To our knowledge no approaches that use choice sets with revealed preference data are available in The Netherlands. With regard to the estimated parameters, the method yields plausible results. The explanatory value of the estimated models is modest, but similar to those found by Waddell and Ulfarsson (2003) on revealed preference data in the United States. Therefore the estimation results seem valuable for the development of the simulation location decisions.

Because revealed preference data is used we measure behaviour which is the result of a firms preference and the influence of spatial planning policy. A near extension of the analysis is to extend the dataset with observations from 1998 to 2003. By estimation choice models for two periods with distinct spatial planning policy, the question to what extend these policies have influenced the choice behaviour of firms might be addressed.

Another important aspect of the research is the usage of mobility profiles to classify firms in groups with a priori homogenous mobility characteristics. These profiles might improve the estimation results of the location choice models. Future research also includes model estimations for all mobility profiles. Furthermore these estimates will also be made for the traditional industry sectors to address the question to what extend these mobility profiles indeed lead to firm categories with more homogenous preferences.

The algorithm that generates the choice set will be further elaborated in future research. First of all criteria will be added for the size of the alternatives to make a further distinction between feasible alternatives. Another enhancement will lie in the application of criteria that describe the likeliness that an alternative is known by using the coordinates of the original location.

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