Influence of accessibility on residential location choice

Barry Zondag
Department of Transportation & Planning
Faculty of Civil Engineering and Geosciences
Delft University of Technology
PO Box 5048
NL-2600 GA Delft
phone: +31 (0)15-2784977
fax: +31 (0)15-2783179
e-mail: B.Zondag@CiTG.TUDelft.nl

RAND *Europe*
2333 CP Leiden
The Netherlands
phone: +31 (0)71-5245042
fax: +31 (0)71-5245191
e-mail: Zondag@RAND.org

Marits Pieters
RAND *Europe*
2333 CP Leiden
The Netherlands
phone: +31 (0)71-5245151
fax: +31 (0)71-5245191
e-mail: Pieters@RAND.org

Paper submitted for presentation at the 84th annual meeting of the Transportation Research Board, January 2005, Washington and for publication in the Transportation Research Record

Submission dates:
First: July 29, 2004
Second: November 13, 2004
Third: March 23, 2005

Number of words:
Abstract: 230
Total text: 5,156
Tables + Figures: 1,250

ABSTRACT

There has been substantial discussion among planners about the influence of transport in residential location choices. The purpose of this paper is to analyze the importance of accessibility in explaining residential location choices. The paper addresses this issue by presenting and analyzing findings from the literature and results of a housing market estimation study in the Netherlands. The research findings for the Netherlands illustrate that the transport system influences residential moves at three stages:

- Move/Stay choice, estimation results show that it is less likely that households are going to move away from a more accessible location;
- Travel time variables are significant for all household types and therefore changes in the transport system will affect the size of the housing market and search area of the households;
- The model estimation results suggest that accessibility of a specific location is for many household types not a significant variable in their location choice.

Overall the empirical results suggest that the role of accessibility is significant but rather small compared to the effect of demographic factors, neighborhood amenities and dwelling attributes, in explaining residential location choices. The empirical findings are confirmed by findings in the literature, the present results are located at the lower end of findings reported in the literature. An important factor contributing to this result is that accessibility changes between regions in the Netherlands are rather small.

BACKGROUND

Observations on the historical development of transport and spatial patterns in the Netherlands illustrate the strong impacts of transport on spatial development. The most common way of public transport in the 15th to 17th century was transport over water. The main cities in the Netherlands were connected to each other by waterways and the urban growth was centralized in the nodal points of the water transport network. In 1839 the first railroad connection between Amsterdam and Haarlem became operational and in the following period until 1870 all the provinces in the Netherlands were connected to the rail network. Up to the 2nd World War spatial settlement (population, industry) adapted to the mobility offered by the railway network. Following the 2nd World War the private car has become the dominant transport mode and especially the accessibility of the rural areas has been improved.

An interesting constant factor in transport behavior, according to the law of Hupkes (or Zahavi), is the average time people spend per day on traveling (1-1.5 hour). According to this law the introduction of a new transport mode with a higher travel speed results in an increasing distance span for spatial interactions. As a result of widespread car use residential settlement has dispersed out of the main cities into various new satellite towns.

The above serves to illustrate the apparent strong causal relationship between changes in the transportation system and spatial developments. It contributes to the widely recognized relationship between transport and land-use. While long term effects from rather dramatic technology changes may be easily observed, it is an other matter to prepare for day-to-day policy making. This requires to address relatively small incremental land-use effects of particular projects (e.g. new road, railway station, etc). It is then a challenge to detect the relationship between transportation and land-use for relatively small differences in accessibility. The present paper focuses on te estimation of transport accessibility as a determinant of residential location choices. This estimation has been carried out as part of te preparation of a new land-use transport interaction model.

RELATIONSHIP BETWEEN ACCESSIBILTY AND RESIDENTIAL LOCATION CHOICE

In general, accessibility of a location, determined by the transport system and land-use pattern, is indicated as an important determinant of the development potential of a location. Many different actors, such as households, shops and industrial firms, value accessibility in their choice of location. Especially the location of offices and shops seems to be sensitive to accessibility. It can be observed that these functions are usually located at the more accessible locations.

It should be noted that accessibility is a rather general concept and every household has its own perception. For example, a household with two workers, two children and two cars will value the accessibility of a location very differently from a household with two retired persons without a car. Most determining is that these two households have a very different activity pattern. The household with two workers and two children will be interested in the accessibility of schools and workplaces. The household with two retired person will most likely be interested in accessibility of services in the neighborhood and accessibility of their social contacts. Car ownership or not is also an important characteristic, households without a car are likely to base their accessibility measures largely on the performance of the public transportation system. It follows from the above that changes in the transport system will have a very different impact on the residential location choice for different types of households, based on the actor specific accessibility attributes.

A key question is about the significance of the changes in the transport system to explain locational choices of residents. Are changes in the transport system a key driver of sub urbanization or are other factors, such as demographic developments, local amenities or dwelling characteristics, more dominant factors? If the latter is the case then transport policies are not expected to be very effective in regulating spatial developments and it is questionable whether residential land-use effects should be incorporated in the transport project evaluation. An analysis addressing the importance of accessibility in residential location choices needs to include all key explanatory variables of residential location choice.

The analysis of the relationship of transport with land-use becomes even more complicated when many actors are considered, such as landowners, project developers, different tiers of government and residents and firms. The behaviour of these actors can influence the significance of accessibility in the residential location choice. It is then important to separate land, objects (houses) and residents to understand the influence of the various actors. Furthermore it is important to classify the market situation, e.g. supply or demand dominated, to determine the market power of each actor.

The behavior of the actors can significantly influence the accessibility parameter. For example, a reduced effect can easily result from government policies which restrict residential development to certain locations and create a housing supply shortage. In this case the market situation will drive residents to settle in less accessible locations. In an empirical analysis it is difficult to isolate such influences and to incorporate the effect of government policies in the historical data series.

LITERATURE REVIEW OF EMPIRICAL STUDIES

The number of empirical studies about transport impacts on land-use is quite limited. This is especially so when compared with the large body of empirical studies on the reverse impact of land-use on transport. Some reasons for the limited attention from empirical researchers may be:

- An observed relatively low significance of the accessibility factor: in developed nations current transport policies do not result in dramatic changes in accessibility and therefore in large changes in land-use. The relative difference in accessibility within a country or study region has an important effect on the significance and size of accessibility parameters. For example, the structuring land-use effects of a new road are likely to be larger in an area with a sparse road network than in an area with a dense road network. An example of this phenomenon is the strong influence of highways in the greater Jakarta region on land-use developments, see (1). It should be mentioned however that the relative difference in accessibility within a country or study region has an important effect on the significance of accessibility parameters.
- Difficulties with the estimation: the time lag between a transport measure and land-use change is rather long. Land-use changes occur much slower than, for example, changes in transport behavior. This time lag puts high demands on the required data: data collection over a long time period (e.g. 10 to 20 years) is needed. This further requires to adjust for all other relevant developments, which might influence land-use changes, in this relatively long period. According to Miller et al. (2) none of the empirical studies has succeeded in meeting these problems so far. Miller notes that in there is virtually no study which has case did the study design provided an adequately controlled ‘experiment’ to properly isolate the impacts of transport investments from other evolutionary factors at work in the urban region.

Although the difficulties are clear and methodological questions remain, a number of studies should certainly be mentioned. One of the first persons illustrating the relationship between land-use and transport has been Hansen (3). He analyzed the Washington DC area and found that locations with a good accessibility had a higher chance of being developed, and at a higher density, than remote locations. A study of Giuliano (4) for the San Francisco area resulted in the conclusion that the impact on land-use of transit developments after five years of operation was insignificant.

Most of the empirical studies have limited their scope to transit developments; this is counter-intuitive with the expectation that a larger land-use impact will result from road transport measures. Miller et al (2) made an extensive review of studies of the impacts of transit projects in the US and Canada. The key observation is that land-use impacts of transit developments, if observed, tend to be small and concentrate around the stations.

Several research projects have focused on the relationship between transport and urban form, and more specifically on the tradeoff between housing type (residential densities) and accessibility. Hunt (5) concludes, based on Stated Preference research in Edmonton, that very dramatic improvements in travel times to work would be required to compensate the typical household for a move into higher density dwelling forms. A Stated Preference study for six cases in Belgium and the Netherlands of Molin and Timmermans (6) confirms these findings. They concluded that regardless of the study area and the model specification accessibility considerations are significantly less important than housing attributes and attributes related to the neighborhood.

A study of Weisbrod et al. (7), based on revealed preference data, emphasizes that available transport policies only have marginal influence on residential preferences. Factors beyond the scope of public policy, such as the desire for single-family, detached homes among families with children, and reduced moving rates for older persons and families with several children, all affect mobility and location patterns more than other factors related to public expenditures.

This study of Weisbrod also highlights the importance of housing costs in residential location decision. It is often suggested that transport policies have a strong impact on house prices. A study of Pagliara and Preston (8) suggests that transport changes appear to have relatively modest impacts on house prices.

In general it can be stated that accessibility seems to have a modest positive influence on residential location choice. This makes accessibility an explanatory variable for residential location choice. However demographic developments, neighborhood amenities and especially housing attributes seem to be more dominant explanatory variables. This increases the problem of empirically identifying the relatively smaller influence of accessibility.

It should be noted that these findings vary for different study areas or research methodologies. In the literature studies Stated Preference as well as Revealed Preference research methods have been used. Another distinction can be made between cross-section and dynamic analysis. The amount of empirical research work is too limited to address the impact of research methodology on study results. A complicating factor is that most of the studies have been executed for different regions and so far little is known about how transferable these results are.

HOUSING MARKET MODULE ESTIMATION

Structure of the housing market module

The housing market module is part of the TIGRIS XL system, this is a new land-use and transport interaction model of the Transport Research Center in the Netherlands. Figure 1

presents the main relationships between the modules, for a more extensive description reference is made to RAND *Europe* (9). Two spatial scale levels are differentiated within Figure 1, namely the regional level (COROP 40 regions in the Netherlands) and local transport zones of the National Model System (NMS sub-zones, 1308 zones covering the Netherlands).

Figure 1: Functional design of the prototype TIGRIS XL model

The TIGRIS XL model follows a system approach and all modules have dynamic interactions. Changes in the outcomes of the housing market module, another spatial distribution of residents, have a significant impact on other modules like the transport market, land market and labour market. In the labour market module the population following economic activities, like the retail sector, are especially affected by changes in the housing market. Ongoing reserach work in the Netherlands highlights that the largest uncertainties in transport demand result from uncertainties in the future spatial distribution of jobs and residents. A change in the transport system affecting the residential settlement pattern will have a long term impact on transport demand. The text here above illustrates that transport measures affecting residential settelement patterns have wider impacts on the whole land-use and transport system. In this paper we will limit ourselves by only addressing the influence of accessibility on the housing market.

The remainder of this section will describe the structure of the housing market module. The main purpose of the housing market module is to model supply, demand and the allocation process for houses. Housing supply is calculated in the real estate market module and includes demolished houses and newly constructed houses. The number of vacant houses in a zone depends on changes in the number of houses and factors influencing their occupancy such as household dissolution and migration.

Figure 2 presents the various steps at the demand side of the housing market. First a household makes a decision to move or to stay. Once a household decides to move this household enters the residential location choice module. The residential location choice module consists of a nested structure, first a household chooses a region and second a specific zone within a region.

Figure 2: Structure of the housing market module

The national housing market survey, so-called WBO-survey 2002 (10), in the Netherlands was used as primary data source to estimate both the move/stay module and the residential location choice module. The national housing market survey taken every fourth year, contains over 100 thousand records. The survey contains Revealed Preference as well as Stated Preference information for the move/stay decision. The households were asked whether they have made a move in the last two years, and if so from which location to which location, and the households were asked if they were planning to make a move in the next two years. The residential location choice is only addressed in the Revealed Preference part of the survey. In this research we have only used the Revealed Preference information from the WBO-survey.

The great advantage of the WBO 2002 survey, in comparison with previous surveys, was that the records were coded at a very detailed spatial level of four digit postal zones. For the TIGRIS XL model it meant that it was possible to estimate the housing market module at the level of transport zones. In this way the geographical dimension of the land-use model coincides with the transport model and the impact of accessibility at the zonal level on move/stay and location choice could be tested.

The accessibility measures for TIGRIS are derived from the National Transport Model of the Netherlands. This is a discrete choice type of transport model based on micro economic utility theory. Well-known references for such type of models are McFadden (11), Ben-Akiva and Lerman (12) and Daly and Zachary (13). With such models it is possible to generate the logsum value, an aggregate value expressing the utility of diverse alternatives such as modes, destinations and time-of-day options. In the housing market module estimation household type specific logsums have been included as accessibility indicators. The transport model contains a lot of detail in its social-economic segmentation and therefore household type specific logsums, consistent with the activity pattern of the household members, were generated for six household types in the residential location choice module.

A wide set of other explanatory variables were included in the move/stay and residential location choice model estimation to determine how important accessibility is among other variables. The other variables address household characteristics, neighborhood characteristics and resistance to move over long distances. Due to time and data restrictions the research does not classify different dwelling types and this is considered to be a serious limitation.

ESTIMATION RESULTS

Model estimation results for move/stay

The move/stay decision of households is mainly influenced by dynamic changes such as change of job/study or changes in the household composition (e.g. marriage, birth of child). In the WBO data set it is not possible to link the move/stay decision to this type of dynamic changes and therefore in the model estimation static variables age or household size were used.

The explanatory variables in the move/stay model are household characteristics, neighborhood characteristics, vacant houses in the region and accessibility. Table 1 summarizes the explanatory variables and presents a brief description; a few variables perhaps need an explanation:

- *Neighborhood types*, five different types of neighborhoods are identified and each zone in the model has been coded by this definition. The neighborhood classification consists of the following five classes: 1 urban center, 2 urban, 3 local village center, 4 local village green neighborhoods and 5 countryside (14). Each neighborhood class has its own characteristics for residential density, services, etc.
- *Vacant houses*, this explanatory variable addresses the opportunities in the surroundings of the current location of a household. The variable expresses the percentage of vacant houses in the region where the household resides.
- *Accessibility,* a logsum variable is used to express the accessibility level of the current location of a household. The logsum variable is an aggregated variable summarizing the accessibility for all purposes and all households at that location.

Table 1 presents the estimation results and only significant variables have been included. The results show that older (lft) and larger households (hh) are less mobile and confirm the expectations. Two_worker households (werk2) and higher income households (inc) are more mobile. The neighborhood variable illustrates that households are more mobile in an urban environment (wmt1/2) than in a more rural environment, wmt-5 (rural area) has the lowest mobility.

Table 1: estimation results explanatory variables move – stay choice model

Overall the annual percentage of households moving to another house is around 9 percent in the Netherlands. Significant differences in percentage of households moving exist between regions in the Netherlands mainly because of differences in population segmentation and types of residential locations. Interesting outcomes of specific interest for policy makers are the estimation results for the variables vacant houses in the region and accessibility. It can be concluded that the percentage of vacant houses in a region has a significant impact on the dynamics of the housing market. This finding confirms an ongoing discussion in the Netherlands that supply side restrictions in the housing market seriously affect the dynamics of housing and labor market. Accessibility has a significant impact on the willingness of people to move from a location, less people are willing to move away from easily accessible locations than from less accessible locations. This finding confirms the hypothesis that people are moving away from less accessible locations in the periphery of the country.

Model estimation results for residential location choice

The location choice preferences of the household have been estimated following a nested structure (see figure 2) and therefore the model includes regional as well as zonal variables. Another difference from the move/stay estimation is that here individual models are estimated for the various household types instead of incorporating household characteristics as explanatory variables. In this structure it is possible to estimate the parameters of household type specific logsum accessibility indicators.

The final model consists of six different household types, earlier estimation results were based on 13 household types. Several household types were aggregated because of similarity of the parameters or lack of observations. The move/stay model was estimated on 74 thousand records and the residential location choice model was estimated on a small sub set of households making a move of almost 12 thousand records. The estimation result of the individual household types are discussed in the appendix, the six types are:

A Non-employed households under 65
B Employed, one-person household under 65
C Employed, 2/3+ persons household under 65 with a low income
D Employed, 2/3+ persons household under 65 with a medium/high income
E One-person household above 65 (non-nested structure)
F 2/3+ persons household above 65 (non-nested structure)

The explanatory variables in the residential location choice model are summarized in table 2 and include type of neighborhood, local amenities, social-economic indicators, average price of houses in a zone, vacant houses, accessibility and travel time between current location and new location. A _C behind the variable means that this is a regional variable (COROP regions in Netherlands or NUTS 3 level according to European classification) and all other variables in the table are zonal.

Table 2: Explanatory variables residential location choice model

All variable are briefly described in table 2, but the transport related variables are explained hereunder in more detail.

- *Travel time variables* (1_time, logtime, 1_time_C, logtime), the travel time variables express the travel time between location of origin and new location. A combined

function of logtime and 1/time addresses the spatial behavior of household moves in the best way. The coefficients of the travel times variables are different for intra-regional moves and inter-regional moves.

- *Accessibility variables,* household type specific logsum variables have been tested for all six household types. For each household type purpose specific logsums, such as work, education, other and all purposes, have been tested to select the variable with best fit.

Table 3 presents the parameters and t-values for the residential location choice of all households by household type.

Table 3: estimation results residential location choice model, by household type

For all household types the most dominant variables in the model estimations were the number of vacant houses and travel time between current location and new location. Even within a region itself household moves are mainly a quite local process and the majority of households settle down in the same municipality. This variable captures various factors such as imperfect information about alternatives, social-networks at the old location and location of employment. The parameter for the nesting coefficient is between 0 and 1 and this confirms that the nested structure for household types A, B, C and D is consistent with utility maximization.

DISCUSSION OF ESTIMATION RESULTS BY HOUSEHOLD TYPE

This section discusses estimation results for each household type. In this section the estimation results, significant variables by household type (see table 4), are compared and analyzed. In table 4 all insignificant variables and correlated variables have been removed. The correlation between variables has been checked for each household type.

Household type A: Non-employed households under 65
All significant variables for household type A, time between origin and destination, vacant houses, price, services, public open space, residential densities have the expected sign of the parameter. A disadvantage is that household type A combines all incomes classes and household sizes, although the majority of the households in this class will fall into the low-income group. These two household characteristics are especially distinctive for the variables type of neighborhood and average income in the zone.

Household type B: Employed, one–person household under 65
An important difference between one-person households and larger households is the preference of small households for an urban environment (see parameters for wmt1 and wmt2). The accessibility variable is significant and the parameter value is positive conform expectations.

Household type C and D: Employed, 2/3+ persons household under 65 with a low income and Employed, 2/3+ persons household under 65 with a medium/high income
Income is the only differentiating characteristic between household type C and D, however this difference has a large impact on several parameters. The average housing price variable (Price_WOZ) has a negative parameter for lower income households of type C but the variable is insignificant for the medium and high income households of type D. Furthermore households with a low income are attracted to neighborhoods with medium income

households and households with medium and high incomes are attracted to neighborhoods with a high percentage of high income households (everybody wants to move upwards!).
The parameters for neighborhood type and residential densities seem to be connected to income as well. Larger households (both C and D) have a preference for a more suburban /rural environment with low residential densities. For household type D the parameters have the expected sign and significance, but for household type C these variables are insignificant. An explanation is that households with a low income are not capable of realizing their preference.
The parameter values and t-values of the accessibility variables are not confirming expectations. For household type C accessibility is insignificant and for household type D accessibility has a negative influence on location choice. A possible explanation is that these household types have a preference for less accessible non-urban locations. In theory other variables should address this preference and accessibility could still be positive and significant. An option is to extend the model with more detailed alternatives, a potential extension is the inclusion of dwelling types.

Household type E and F: One-person household above 65 and 2/3+ persons household above 65
The nested model structure did not fit for household type E and F and a multi-nominal logit model has been used for these two household types. The nested structure did not work because of the small number of interregional movements of these household types. Households of type E have a high preference to move to a new dwelling within the same zone. The accessibility variable has an expected significant and positive parameter. Other positive variables are services in the local zone and a rural environment.
Household type F has quite similar estimation results to household type E. Only the preference for a certain type of neighborhood does not exists for household type F. The local zone (intrazone) variable is again very dominant and it illustrates that elderly don't want to make a new start in another environment.

OBSERVATIONS AND CONCLUSIONS

The above results, both from the literature review and model estimation, represent the influence of accessibility on residential location choices. The quality of the results is certainly influenced by the complicating conditions for empirical analysis on accessibility as have been elaborated in this paper. However the results of the present study illustrate that with a sufficient data base it is possible to tackle many of these complications. A further strong point of the housing market estimation, compared to other studies, is the inclusion/testing of many explanatory variables. The main omission, due to spatial scale level and research restrictions, of the research is that it does not include different dwelling types.

The results show a significant but further modest positive influence of accessibility on residential location choice. Demographic developments, neighborhood amenities and especially housing attributes seem to be more dominant explanatory variables. These findings are within the band width of findings in the literature. The literature is unfortunately not rich enough to analyze the impacts of different research methods, for example Stated Preference versus Revealed Preference, or to draw conclusion about how transferable findings are between different regions.

The results for the housing market module will be further used as part of the total TIGRIS.XL model package to analyse policy implications for various transport and land use measures. Some explorative test runs with the whole system illustrate that large transport measures do have a significant but modest effect on the spatial distribution of residents.

However the tests also illustrate that such change in the distribution of residents has a significant effect on the distribution of jobs as well.

The context, spatial structure and network structure, has a large impact on the findings. For example, accessibility differences in the Netherlands (a rather homogenous network and spatial structure) are rather small compared to larger countries and therefore their expected impact on spatial structure is relatively low. Another important feature of the Netherlands is that the housing market is strongly regulated. This feature influences the model estimation results and should be addressed when applying the model. In general it can be stated that an empirical analysis on accessibility, analysis conditions and choice of variables, necessarily has to deal with a significant amount of specific characteristics for the region.

More detailed conclusions of the present study on the role of accessibility in residential location choice are:

- The model estimation results suggest that accessibility is a significant variable in the Move/Stay choice. It is less likely that households are going to move away from a more accessible location than from a less accessible location. This finding confirms that households are more likely to move away from remote areas than from central areas;
- The model estimation results suggest that accessibility of a specific location is for many household types not a significant variable in their location choice. The findings confirm that demographic factors, neighborhood amenities and dwelling attributes are more important variables to explain residential location choices. The context of the Netherlands, as described above, is an important factor which helps to explain the findings;
- The model estimation results for the travel time variables illustrate the important role of the transport system in defining the sizes of the housing market. Travel time variables are significant for all household types and therefore changes in the transport system will affect the size of the housing market and location preferences of the households.

ACKNOWLEDGEMENTS

TIGRIS XL is a new land-use and transport interaction model owned by the Transport Research Center of the Dutch Ministry of Transport, Public Works and Water Management. A consortium of RAND Europe, BureauLouter and Spiekermann & Wegener has developed this model in commission for the Transport Research Center. The authors of this paper would like to express their gratitude to the members of the TIGRIS XL project team and in particular to the Transport Research Center for their approval to use the estimation results for the purpose of this paper.

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Table 1: estimation results explanatory variables move – stay choice model

Variable	Description	Coefficient	t-value
Cstay	Constant stay coefficient	0.473	4.7
HH2	2 – person households	0.212	7.1
HH3	3 – person households	0.759	21.7
HH4	4 – person households	1.07	29.1
HH5	5 > person households	1.08	23.6
Werk1	One person employed	0.0824	2.4
Werk2	Two persons employed	-0.509	-12.1
Inc2	Household income between €12639 and €20220	-0.101	-3.2
Inc3	Household income between €20221 and €30330	-0.177	-5.1
Inc4	Household income between €30331 en €42969	-0.230	-5.6
Inc5	Household income €42970 >	-0.244	-5.2
Lft2	Age of head of household between 35 and 65 years	1.27	56.0
Lft3	Head of household older than 65 years	1.93	42.2
WMT_1	Neighborhood type 1	-0.0036	-5.8
WMT_2	Neighborhood type 2	-0.0029	-5.8
WMT_3	Neighborhood type 3	-0.0026	-4.3
WMT_4	Neighborhood type 4	-0.0019	-3.2
WMT_5	Neighborhood type 5		
PVW_cor	Percentage vacant houses at regional level	-0.829	-2.0
Lszone	Logsum, accessibility current house	0.0172	5.7

Table 2: Explanatory variables residential location choice model

Variable	Description
Price_WOZ	Average price of houses in a zone
VacWon	Number of vacant houses in a zone
WMT_1	Neighborhood type 1
WMT_2	Neighborhood type 2
WMT_3	Neighborhood type 3
WMT_4	Neighborhood type 4
1_time	Travel time measure between origin and destination
Log_time	Travel time measure between origin and destination
Water	water per zone (hectares)
Groen	green per zone (hectares)
Voorz	Services in a zone
Werkg	Employment in a zone
Dicht	Residential density in a zone
Inc_med	Percentage households with middle incomes
Inc_high	Percentage households with high incomes
Acc_tot	Logsum for all travel purposes, accessibility indicator
Acc_wrk	Logsum for commuting, accessibility indicator
Acc_oth	Logsum for purpose other, accessibility indicator
Acc_ced	Logsum for purpose education, accessibility indicator
VacWon_C	Number of vacant houses in a region
PWOZ_C	Average price of houses in a region
1_timeO_C	Travel time measure between origin and destination, regional variable
LogtimeO_C	Travel time measure between origin and destination, regional variable

	Household A		Household B		Household C		Household D		Household E		Household F	
Variable	Coef	T	Coef	t	Coef	t	Coef	t	Coef	t	Coef	t
VacantWon	0.543	8.2	0.429	7.3	0.524	9.0	0.654	20.1	0.401	3.9	0.838	8.4
Price_WOZ	-0.0026	-2.0	-0.0047	-4.0	-0.0025	-2.2						
WMT_1			0.0084	5.8			-0.0015	-2.0	-0.0101	-2.4		
WMT_2			0.0040	3.2					-0.0080	-2.3		
WMT_3			0.0035	2.4					-0.0087	-2.4		
WMT_4	-0.0038	-2.8					-0.0025	-4.3	-0.0084	-2.6		
c_water			4.0E-4	2.0	4.1E-4	2.5						
c_voorz	0.0017	2.2	0.0019	2.8	0.0017	2.7			0.0028	2.5	0.0036	3.3
c_groen	1.0E-4	2.6	1.1E-4	2.6			6.5E-5	3.7				
c_werkg							6.3E-4	4.4				
c_dicht	-0.0024	-2.1	0.0018	2.0			-0.0023	-3.5				
inc_med					0.0763	4.6	0.0742	6.8	0.142	4.8	0.254	7.9
inc_high			-0.0151	-2.3			0.0228	5.8				
1_time	-4.07	-2.7	-7.25	-4.8			-6.5	-5.7	8.71	5.6	5.79	3.0
Logtime	-2.63	-16.5	-2.84	-18.6	-2.21	-32.1	-2.7	-24.3	-1.12	-10.9	-1.76	-13.2
Acc_tot							-0.0137	-5.6	1.03	5.2		
Acc_wrk												
Acc_oth			1.98	4.3							0.154	2.4
Acc_ced												
Intrazon					3.06	4.6	2.49	4.8	12	8.7	14.6	9.4
VacWon_C	0.383	4.2	0.320	4.2	0.327	4.7	0.699	17.1				
PWOZ_C	-0.0122	-6.3	-0.0064	-4.2	-0.0081	-5.3	-0.0046	-5.0				
1_time_C	-26	-2.9	-26.1	-3.7			-13.9	-3.6				
logtime_C	-2.44	-10.1	-3.28	-15.0	-2.47	-13.9	-3.57	-23.2				
Nestcoefsz	0.736	10.4	0.736	14.7	0.818	12	0.649	23.4				
Nestcoef	0.794	5.0	0.469	6.4	0.527	6.1	0.603	10				

Table 3: estimation results residential location choice model, by household type

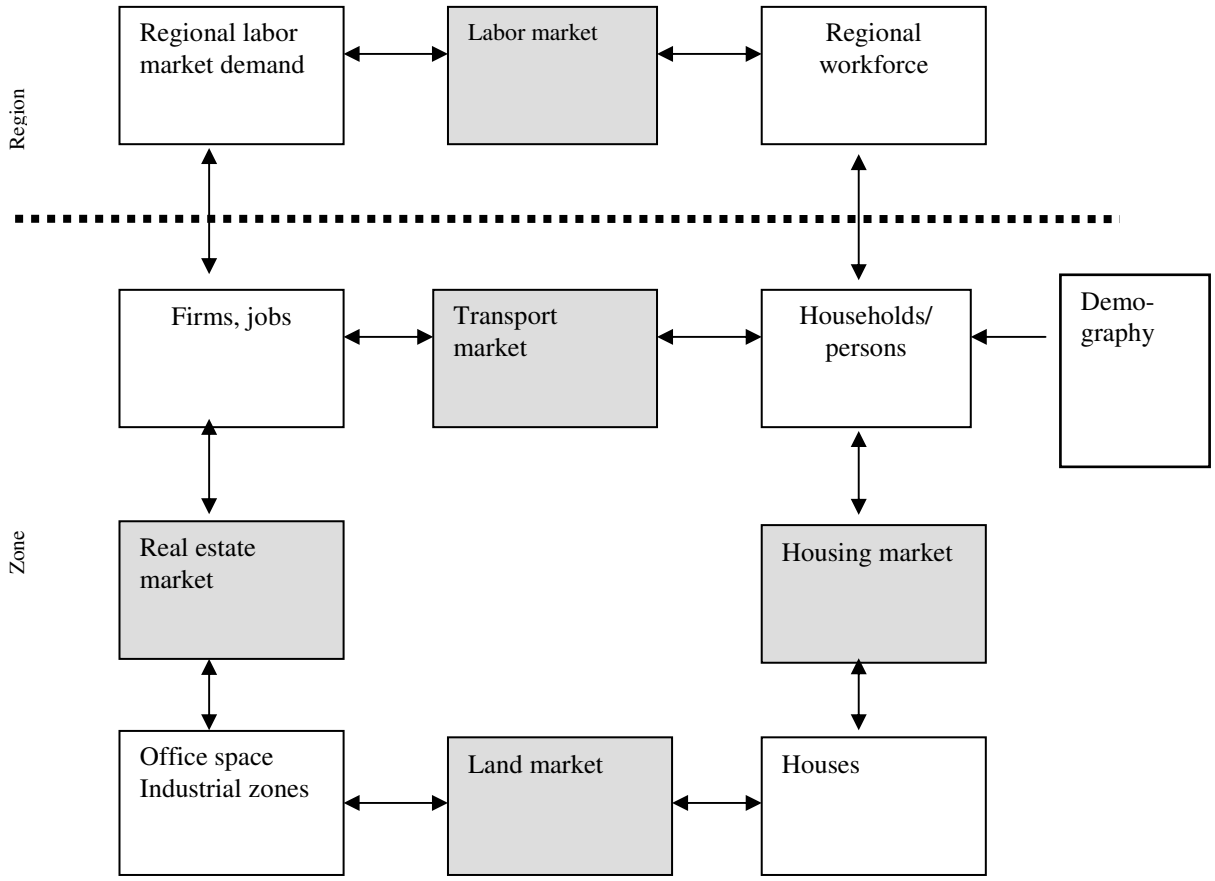
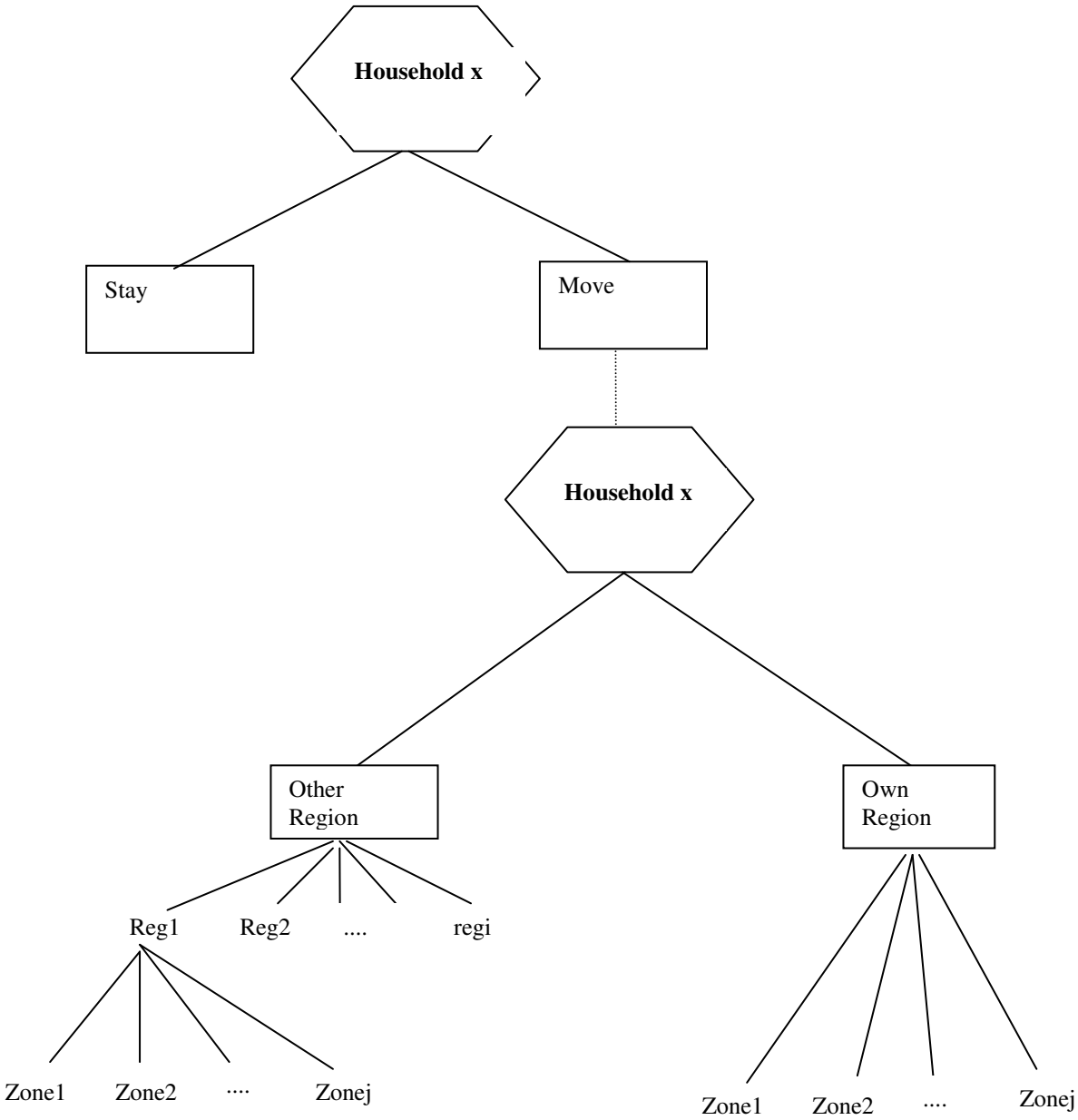


Figure 1: Functional design of the prototype TIGRIS XL model



i = number of regions (40)
j = number of zones in a region , total NL is 1308 zones

Figure 2: Structure of the housing market module