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Attributes of Households, Locations and Real-Estate Markets for Land Use Modeling

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Abstract

One of the fundamental tasks of land use modeling is the specification (and estimation) of the models that will define both demand and supply in the real-estate market. From the point of view of the demand, residential location choice models depend mostly on the attributes of the decision-maker (*i.e.* the household) and the set of alternatives that faces (the supply of housing units located in different zones within the city). From the point of view of the supply, the development of new housing units will depend on the demand and on the market conditions that shape or constrain both the type of supply and its location within the city. The proper specification of the sub-models accounting for these elements will affect the general quality of the model outcomes.

In the context of the SustainCity project (www.sustaincity.eu), three European cities (Brussels, Paris and Zurich) will be modeled using the land use microsimulation platform UrbanSim. The aim of this paper is to identify the attributes of households, locations and real-estate markets that can be included in UrbanSim, with an emphasis on the relevance of these attributes or market conditions in the particular case of European cities.

Keywords

Social and Economic Attributes; Households and Housing Units; Location Choice, Real-Estate Markets, European Cities

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1 Introduction

In classical urban economic theory, the location choice of the household is treated as a decision where the main considered variables are accessibility, space and environmental amenities (Fujita, 1989). Accessibility accounts for traveling costs and benefits associated with the different activities that the household's members will perform at different locations in the city. Space refers to the size and quality of the housing unit itself. Environmental amenities include land use attributes like the presence and intensity of different economic activities (commerce, service, industry, education, etc.) and neighborhood quality. A location will be characterized by its attributes in these three dimensions and the household will make a choice by accounting for the trade-off between them at each possible location.

Land use models need to account for these attributes in order to properly model the location choice of the households but, at the same time, need to consider the heterogeneity in preferences between households. The location preferences of a household are related with its attributes which, at the same time, define their basic needs and constraints.

To model in details the land use system, the supply side should also be accounted for. In real-estate markets, supply is understood as the stock of buildings in which households and firms locate (DiPasquale and Wheaton, 1996). In the particular case of the residential real-estate market, supply consists of housing units which are produced by developers at different locations within the city. The supply and location of new housing units is affected both by demand (households looking for a dwelling) and by subsidies or market regulations, usually imposed by the government. The identification of these regulations and subsidies is also fundamental to properly model the supply in land use models.

This paper presents a review of the attributes of households, locations and real-estate markets that can be considered and included in a land use modeling platform. In the context of the Sustaincity project the modeling platform will be UrbanSim (Waddell, 2002) and the case studies will be the cities of Brussels, Paris and Zurich. Considering that UrbanSim was originally developed and tested for US cities, the difference in attributes for households, locations and housing markets between Europe and the United States is analyzed, with an emphasis on the modeling implication of these differences. A preliminary analysis on how these attributes can be included in UrbanSim is also included.

The list of attributes given in this paper, although not exhaustive, attempts to identify those elements that are more relevant in the supply-demand dynamics of a city. Each attribute

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is described in terms of the effects it has in the decision-making process of households or in the real-estate market. The final selection of attributes to include in the models will depend on their availability, modeling feasibility and statistical significance for each case study. Therefore, the attributes listed in this document should only be considered as suggestions of variables to include in the sub-models of UrbanSim.

The paper is organized as follows. Section 2 focuses on household attributes and how they are related with the different stages of the life cycle of the household. Section 3 describes location attributes, understanding that a location is composed by the housing unit and its surroundings (or neighborhood). Access attributes are also included in this section, considering that they are usually location-specific. Section 4 analyzes the market regulation and subsidies that can affect the supply of housing, with a focus on land use planning, housing policies and sustainability issues.

2 Household Attributes

Since Alonso (1964) and McFadden (1978), the choice of residential location has been understood as a household's rational decision. Households either make bids for housing units in an auction or choose the location/dwelling that maximizes their utility, respectively. In both cases, the utility function (or the willingness to pay) depends on the specific preferences of the household. From a modeling point of view, the heterogeneity in location preferences will depend on the households' characteristics or attributes. Therefore, identifying the relevant attributes to characterize the households as heterogeneous decision makers is fundamental in the context of a location choice model.

The attributes of the households are also relevant because they define their basic needs and restrictions in terms of housing (Clark *et al.*, 2006). Most of the time these needs or restrictions are related with capacity or budget issues (McCarthy, 1976). Common examples of these attributes are the household size (determines the needs in housing size) and income (defines the budget constraint).

Both preferences and restrictions of households are largely decisive for what is called the "life cycle" of the household (Kim *et al.*, 2005; McCarthy, 1976; Krizek and Waddell, 2003). The different stages of the life cycle can be identified by milestones like getting married, the birth of children in the household, divorce, change of job, retirement and death of a member in the household. Each stage implies different needs and preferences for the household; for example, households with young children might prefer peripheral locations with better access to the natural environment while single working people might prefer central locations with better access to services, job opportunities and cultural offer. The changes in needs and preferences that come with a change in the life cycle might trigger a relocation of the household and even a change in the housing tenure (ownership, renting) choice (Clark *et al.*, 1997). The different stages in the life cycle can be identified through attributes of the household like number of children, household size, age of the head of the household, etc.

In the following, several attributes that characterize households are listed, and their potential effect in the location choice process is described. The goal of this analysis is to identify which attributes are most relevant to model location choice; however the feasibility and convenience of considering each attribute in a modeling platform will depend on data availability and statistical significance of each attribute in the particular case of study.

- **Income:** The income of the household defines its upper threshold for rent or housing price and determines the choice set of locations and housing types at which the household

has access. Income has also shown to be a spatial segregation/agglomeration variable; indeed households tend to prefer neighborhoods with an average income close to their own (Clark and Onaka, 1983; Clark *et al.*, 2006).

- **Size:** The number of members in a household determines the space needs of the household in terms of housing size (surface, number of rooms). Changes in the household size (that can be correlated with the birth of children) may trigger a relocation of the household (Rossi, 1955) or even a change in the ownership/renting status (Clark *et al.*, 1997).

- **Number of children:** The presence of children triggers specific needs and preferences in terms of location and housing. For example, households with children might give priority to locations with good accessibility to educational or recreational facilities (Kim *et al.*, 2005).

- **Marital Status:** There is evidence that this attribute has an effect on location choice preferences (Gabriel and Rosenthal, 1989). The marital status can be an indicator of stability in the household in terms of the long-term decisions that are usually taken by a couple.

- **Age:** Most of the time the considered variable is the age of the head of the household which, intersected with the household size and the potential presence of children, helps to identify the current life cycle of the household (young family, old couple, etc) (Clark *et al.*, 1997). Different ages yield heterogeneous preferences in location, mobility habits and/or restrictions. For example, old households might prefer to avoid isolation and to locate near to services and commerces (Clark and Onaka, 1983). Furthermore, it is interesting to observe that there exists an inverse relationship between the probability a household relocate and its age (Clark and Onaka, 1983).

- **Sex:** The sex of the head of the household can have a significant effect in location preferences (Gabriel and Rosenthal, 1989). This can be easily explained by the differences between genders but is mostly relevant in the case of single-parent families.

- **Ethnic group:** As with income, race or ethnic origin has proved to be a factor that affects residential location choice (Gabriel and Rosenthal, 1989). Spatial segregation and agglomeration phenomena that are due to this variable are often observed in cities with different ethnic groups of large size (Van Kempen and Ozuekren, 1998; Van Gent, 2010).

- **Number of workers:** This variable affects the internal household dynamics. For example, a family with both parents working will make different decisions regarding commut-

ing and performance of secondary activities than a family with one parent dedicated to household activities. Also, the number of workers in a household (or alternatively the activity status of each member) is likely to affect the location decision, making access to work places more relevant (Horner, 2004; Levy, 2003). In some situations the choice of the residential location can be conditioned to the job location (Waddell, 1993).

- **Education:** Although traditionally not used in land use models, there is evidence that the education level of the head of the household can affect location preferences (Gabriel and Rosenthal, 1989). In recent modeling efforts, the education level has been used as an indicator of lifestyle preferences which could be used in a latent class approach to better model and understand location choice (Walker and Li, 2007).

- **Current tenure status:** A relocating household will have to choose between buying or renting their next dwelling. If this is a higher level decision than the choice of the dwelling itself, it will reduce the number of available alternatives for the household. There is evidence that the current tenure status affects the decision of future tenure status (Clark and Onaka, 1983; Clark *et al.*, 1997), therefore affecting location choice. More specif tenure types, like leasing or subletting, can also be considered for this variable.

- **Number of cars:** The level of car (or any other motorized vehicle) ownership is a decision made by the household as a result of changes in its life cycle. It is not clear if the number of cars affects the residential location by changing the perceived accessibility of locations or if the chosen location determines the needed number of cars (Bhat and Guo, 2007). Regardless the actual cause, there is an observed relationship between car ownership and residential location. For example, well motorized households might choose locations where no public transport is available, while transit-captive households are likely to prefer locations better connected to the public transport network.

- **Public transport subscription:** Also a non-traditional variable in land use models, the public transport subscription or pass is an available alternative in most European cities (Simma and Axhausen, 2001), eliminating the variable cost in transportation by public transport. The presence of this type of subscription in a household is likely to affect the mobility habits of the household, having one or more of its members prone (or committed) to the use of public transport (Simma and Axhausen, 2001). Besides the obvious effects in travel behavior, a subscription to the public transport system should also affect location choice, making more attractive zones that are well served by the public transport system (Bhat and Guo, 2007).

2.1 Implementation in UrbanSim

Most of the previously mentioned attributes can be included in the Household Location Choice Model, particularly as independent variables of the Multinomial Logit Models that predict location probabilities. The household attributes should always be included as interacting with the location and housing unit attributes.

Household attributes are also variables in the Household Relocation Model. In the current version of UrbanSim, the relocation probabilities are calculated from historical relocation rates by attributes like age and income. However, the availability of more attributes (if that is the case) represents an opportunity to model explicitly the probabilities of relocation as a function of a more comprehensive and detailed set of attributes, accounting for the household's life cycle.

The Household Transition Model (which predicts the migration of households from and to the study area) can also benefit from the inclusion of more detailed household attributes. The current version of UrbanSim samples and duplicates existing households until reaching the desired control totals. This could be improved by just increasing the sample variables (*i.e.* generating more types of households). A restriction for the use of more attributes is that this will require the new (yet to develop) demographic models to account for these variables when generating the simulated population for future years.

2.2 Comparison Aspects Between Europe and the United States

European households are different compared with United States households and therefore they will have different behaviors and preferences. The following analysis focuses on the differences that could be relevant in terms of location choice modeling. Table 1 on the following page presents a group of indicators that show some aggregated trends for households and population in the United States and in three European countries (the relevant countries for the case studies of this project).

On average, European households are slightly smaller than US households. Europe presents a larger share of very small (one-person) households as well as a smaller share of big (5 or more people) households. Although the number of households with children is quite similar in Europe and in the US, the smaller fertility rate of Europe (which is equal to 1.5) indicates that the number of children per household will be smaller than in the US (where the fertility rate is equal to 2.05). This also means that the average frequency and number

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Figure 1: Selected indicators for household attributes.

		Belgium	**France**	**Switzerland**	**United States**
Average household size	**(1)**	2.4 (2001)	2.4 (2001)	2.3 (1990)	2.6 (2000)
One person households	**(1)**	33.5% (2008)	30.1% (2005)	37.1% (2008)	27.5% (2008)
Households with children	**(1, 3)**	39.7% (2008)	39.5% (2005)	32.1% (2008)	39.6% (2008)
Households with more than 5 people, 2001	**(1)**	7%	9%	7%	10%
Passenger cars per capita, 2002	**(1)**	0.463	0.476	0.502	0.765
GDP per capita in US\$, 2007	**(2)**	42609	41970	56207	45592
Gini index, 2007	**(2)**	33.0	32.7	33.7	40.8

(1) United Nations Economic Commission for Europe (UNECE) Statistical Division, Trends in Europe and North America 2005, http://www.unece.org/stats/trends2005

(2) United Nations, Human Development Report 2009, http://hdr.undp.org/en/statistics

(3) U.S. Census Bureau (2007), Current Housing Reports, Series H150/07, American Housing Survey for the United States, U.S. Government Printing Office, Washington DC, 20401, printed in 2008

of changes in the life cycle of households will be smaller in Europe. This should affect the specific preferences for housing size and the probabilities of relocation of the households.

The larger number of vehicles per person is an indicator of the bigger modal share for car in the United States. In that regard, European cities usually have well irrigated public transport networks and higher population densities (Newman and Kenworthy, 1989). Hence the mobility behavior of the inhabitants in European cities is different. This certainly affects the way in which transportation attributes of the potential location will be perceived by households: the presence of public transport facilities should be more relevant for location choice in Europe than in the United States. Another effect of the smaller modal share for car in Europe is that households might give more importance to the presence of services or commerce at walking distance from their location.

The income distribution within a country or a city has an effect on the potential spatial segregation which can be even more relevant that the ethnic origin (Gabriel and Rosenthal, 1989). The Gini index is a measure of how well the income is distributed in a country (a low value indicates a more equal distribution). The observed values for the Gini index make reasonable to expect less income-explained spatial segregation in European cities than in the United States. In terms of modeling, average income of zones or neighborhood should be less relevant in Europe than in the US.

3 Housing and Location Attributes

Many reasons might yield a household to relocate. Every household possesses its own personal trajectory defined by the different locations it has occupied in its evolution (*i.e.* the life cycle, see Section 2). Different classes of reasons for household relocation can be pointed out (Clark and Onaka, 1983; Rossi, 1955):

1) *Forced move*: loss of housing unit (eviction by public or private action, end of lease, destruction of the housing unit).

2) *Voluntary move*:

    i) *Adjustment move*: specific housing dissatisfaction like change in the housing market, space and cost of the housing stock, quality of the neighborhood and/or accessibility (thus related to location and housing unit attributes).

    ii) *Induced move*: change of employment status, modification of the household formation (thus related to the household attributes).

Considering the household attributes described in Section 2 and observing the above reasons that might imply household relocation, it can be concluded that a change in the attributes of a household might lead to a house moving (Clark and Onaka, 1983). As paradigmatic examples, modifications in the household attributes like *(i)* change in the marital status, *(ii)* birth of new children and/or *(iii)* job change (higher income, retirement) often imply a change of the specific needs of the household. In order to fulfill this updated need status, the only solution for the household is often to find a new and adapted housing stock.

Now, focusing on the decision-making process itself[1] when a household is looking for a new dwelling, two main meta-aspects have to be considered: *(1)* **the housing unit characteristics** and *(2)* **the location characteristics** (Clark and Onaka, 1983; Levy, 2003; Clark *et al.*, 2006). These two meta-aspects, defining a set of possible location attributes, are treated respectively in Sections 3.1 and 3.2.

3.1 Housing Unit Characteristics

A household looks for a location by accounting for its needs and preferences. These needs and preferences will thereafter determine a set of several attributes of the housing stocks they will actually look for. However, as it is pointed out in (McCarthy, 1976), it is important to note that

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[1] when the decision of a household to relocate has already been taken.

updated housing needs must often be accompanied by increased income to effectively enable relocation.

- Households have to decide between looking for a **flat or** for a **house**. In urban areas with high density profiles, to live in a personal house (or single-family unit) is often a luxury and is thus not affordable for the majority of households. For that reason, we observe in many situations that households who want to live in a house might have to locate in suburban areas, yielding suburbanization phenomena[2]. Following the previous fact, the decision to favor a personal housing stock is also based on the willingness of the household to live near green spaces and on the desire to benefit from a garden (for example for the children to play on). For example, it can be observed that families with young children often tend to favor gardens instead of balconies, because of their potential danger. On the contrary and as already emphasized in Section 2, it is more likely that singles and young couples prefer flats in urban areas. Hence, there is a relationship between the present attribute and household attributes like the income, the number of children and the age.

- **Space** is a dominant factor within the household decision-making process for relocation (Clark and Onaka, 1983). The needed space is usually determined by the household in function of its size and its income (NBHBP Sweden and MRD Czech Republic, 2005; Clark *et al.*, 2006). One might naively think that every household always tries to increase its available **floor area** (by satisfying at the same time a fixed limit in terms of cost), as it could mean more luxury for the inhabitants. However, some households rather tend to favor smaller housing stocks for practical issues like a reduced maintenance cost.

- Besides the floor area, the **number of rooms and bathrooms** is obviously an aspect that is considered (NBHBP Sweden and MRD Czech Republic, 2005). When it is likely that a household composed from one to three persons will mostly favor the comfort provided by (a small number of) spacious rooms, larger families will rather prefer a large number of rooms such that each inhabitant possesses its own personal space. This last consideration is of greater importance in occidental countries.

- The **age of the housing stock** is also an aspect that is taken into account in the decision-making process (NBHBP Sweden and MRD Czech Republic, 2005; Clark *et al.*, 2006). Indeed, newer housing stock means, in most situations, better heat insulation (and hence lower heating costs) as well as better sound insulation. For households in the process of buying a housing unit, choosing a newer dwelling implies that less maintenance work will have to be carried in the future. On the other hand, it is interesting to note that for

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[2]Suburbanization is when a city expands outwards and starts to engulf some of the villages or hamlets residing around the rural-urban fringe.

housing stocks older than fifty years old, the age might sometimes become a positive attribute because of cachet considerations[3].

- The **quality and design of the housing stock** is also taken into account in the decision-making process (Clark and Onaka, 1983). However, these are often secondary attributes in comparison with space or cost considerations and they are moreover hard to quantify. For example, aspects like the luminosity, view to open spaces or architectural design are difficult to measure. In discrete choice models, the exclusion of this type of attributes might generate price endogeneity (Guevara and Ben-Akiva, 2006). This means that the parameter for price in the estimated models results is positive, since this variable is explained mostly by unobservable quality attributes. If quality attributes are not explicitly included, methods to correct for endogeneity in choice models should be implemented.

- The **cost** (rent, mortgage or buying price of the housing unit) is definitely an important issue (Clark and Onaka, 1983). The part of the household income that can be attributed to housing has often to be limited. For example, in the United States, the National Low Income Housing Coalition (NLIHC)[4] promotes a guideline of 30% of household income as the upper limit to be used for housing. In Europe, the share of the total household consumption dedicated to housing lies between 20 and 30% depending on the country (MIIR, 2006). It is important to note that rent and mortgage are not the only costs related to housing. When relocating, besides the costs of moving (usually related to furniture transport) there might also exist, depending on the country, transaction costs which can make moving, selling or buying less attractive.

- The **tenure condition of the housing unit** (*i.e.* available to rent or buy) is an important aspect in the household location choice and is given by the household specific expectations (for example, a household might want to move from a rental to an owned unit) (Clark and Onaka, 1983; Clark *et al.*, 1997). This attribute can also consider more specif tenure types, like leasing or subletting (which sometimes can be illegal and, hence, hard to observe in official data sources)

- In most European countries, people are more and more aware of the importance of sustainable development and of the underlying environmental friendly behaviors. For this reason, the **sustainability index of the housing stock** might enter into the decision-making process. This includes various aspects like the availability of solar or heat pump heating, a good heat insulation or even air quality and the presence of good tap water, etc.

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[3]The age of a building might be in certain cases seen as a mark or quality, as of distinction, individuality or authenticity.

[4]http://www.nlihc.org

3.2 Location Characteristics

Besides the specific needs of a household, which define some attributes for the desired housing unit that have to be fulfilled (and that can often be represented as hard constraints), preferences aspects, concerning the location or the neighborhood, also enter into the decision-making process (Levy, 2003). These location attributes can be classified in three categories: those related to land use (Section 3.2.1), those related to socio-economic considerations (Section 3.2.2) and those related to transportation (Section 3.2.3).

3.2.1 Land Use Attributes

For their convenience, households often tend to favor neighborhoods with good local facilities and infrastructure (Clark and Onaka, 1983; Levy, 2003). Such kind of land use attributes can be categorized by their type of economic activity.

- **Commerce**: the presence of commerce is a basic need for households. Availability of retail is likely to make a location more attractive for residential location. However very high densities of commerce are likely to discourage the location of households, considering the externalities that this might produce (congestion, crowds, noise, etc.). Therefore this variable should not be treated in a linear way.

- **Services**: availability of services (hospitals, post offices, banks, libraries, theaters, sports facilities, etc.) is also likely to increase the attractiveness of a location for households.

- **Education**. This attribute is particularly relevant for households with children. However, quality can play a more important role than quantity. For example, high quality schools availability might enter in the household location decision-making process as a necessary condition (Clark *et al.*, 2006).

- **Industry**. Industry is usually a big source of jobs and therefore households will prefer to have access to it. However, the presence of industry usually generates negative externalities that make nearby locations unattractive

Besides the classical land use categories, other characteristics of the location, like the presence of **public infrastructure**, can have an effect on residential location choice. In urban areas, for example, proximity to high quality green public spaces gives more attractiveness to a housing unit (Clark *et al.*, 2006; Lo and Jim, 2010). This notably helps to explain suburbanization processes where we observe population movement from within towns and cities to the rural-urban fringe. Indeed, many residents of metropolitan areas no longer live and work

within the central urban area, choosing instead to live in satellite communities and commute to work via automobile or mass transit. In that regard, they favor openness of the landscape and low-density environments, that they consider to be more pleasant than the inner-city (Caruso *et al.*, 2005). A collateral effect of this phenomena is that, in some cases, lower income residents are observed to stay in the inner city. Such suburbanization processes mostly occur in more economically developed countries, especially in Europe and in the United States, which is believed to be the first country in which the majority of the population lives in the suburbs, rather than in the cities or in rural areas.

As it is testified in (Loechl and Axhausen, 2009), **environmental services** such as sunshine exposure, views, lakes, river fronts also enter significantly in the household location choice. However, it is hard to identify if these are location-specific or dwelling specific attributes. For example, only a fraction of the dwellings in a location near a lake can have a clear view to it; this will depend on the orientation of the housing unit (this is also likely to affect sunshine exposure).

3.2.2 Socio-Economic Attributes

- The **average income** of a neighborhood is important regarding its attractiveness. Indeed, households, when relocating, tend to look at the social marker of the population living in the area of interest. In particular, the median neighborhood income is predominant in the household location choice (Clark and Onaka, 1983). As already emphasized in Section 2, this aspect might lead to social segregation and hence to gentrification[5] and suburbanization phenomena (Van Gent, 2010; Clark and Onaka, 1983; Levy, 2003).

- Considerations about **race and ethnic group** are also likely to be part of the relocation decision-making process. Especially for immigrants, living in communities might be facilitating the process upon the arrival into a new country. As pointed out in Section 2, this aspect might in the end yield ethnic segregation effects (Van Gent, 2010; Musterd and Ostendorf, 2009) which are clearly visible in many European and American metropolis. As emphasized just above, such type of segregation phenomena might be due both to race and socio-economic considerations.

- **Safety** aspects become more and more visible and hence considered nowadays (EFILWC, 1997; Clark *et al.*, 2006). For that reason, urban safety is an attribute that might be taken into account (for example using crime rate indicators) within the household relocating

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[5]Gentrification is the restoration and upgrading of deteriorated urban property by middle-class or affluent people, often resulting in displacement of lower-income people.

process.

- **Neighborhood familiarity** is also considered in the household location choice (Levy, 2003). Indeed, in correlation with some of the attributes described above, it has been widely observed that, when relocating, most of households (this proportion can be estimated at around 60% in France for example) tend to stay in the same residential area (Levy, 2003). This can be notably explained by the fact that people might prefer to stay close to their social network (family and friends).

3.2.3 Transportation Related Attributes

The transportation system affects the perceived quality of a location because of the need of the household members to perform different activities at different locations in the city. The location of the household in the city will determine their travel time or travel cost to the different possible activities, ultimately affecting their perceived travel-benefit. At the same time, the transportation system generates externalities that might affect the perception that a household has on a particular location. The possible transportation related attributes to be included in a land use modeling framework are listed in the three following categories.

(a) **Access**

The link between land use and transportation has traditionally been modeled through the concept of access, understood as the economic benefits derived from the interaction (contact) between two activities (Martinez, 1995). Access can be categorized in two different types of benefit:

– *Accessibility*: the benefit obtained from visiting other locations in the city to perform activities.

– *Attractiveness*: the benefit obtained from being visited from other locations.

In the context of location choice, accessibility affects residential location (the members of a household need to travel to perform activities at different locations) while attractiveness is usually related with non-residential location (*e.g.* commerce is visited by shoppers, industry in general is visited by workers).

Traditionally, in the classical 4-stage transportation models (Ortuzar and Willumsen, 1994), access measures were obtained as a function of the balancing factors of the trip-distribution (entropy) models. This provided the measure with a rigorous mathematical and statistical interpretation but, at the same time, limited the interaction between

transportation and land use to an aggregated variable. Aggregate travel measurements, such as the economic definition of access, are unable to account for the complex spatial behavior of individuals and to respond to sophisticated travel demand management measures.

Other measurements, like travel time or cost, can be used as indirect measurements of access (Ben-Akiva and Lerman, 1979), and are nowadays the standard for location choice modeling, especially in agent-based and microsimulation models. They provide a much more specific and explicit measure of the quality of the transportation system at each location but, at the same time, lack the comprehensiveness of the benefit measure. We analyze this type of variables below.

(b) Trip Variables

The use of explicit trip variables such as travel time and cost allows to understand the location preferences of households regarding observable attributes of the transportation system. This type of variable becomes particularly relevant when the transport/land use model incorporates an agent- or activity-based transport model (due to the potential disaggregation of the data). Travel time or travel cost can be disaggregated (depending on the capabilities of the available transport model) in the following dimensions:

- Purpose

- Period of the day

- Mode

The selection of the purposes, periods or modes to be considered in the location choice model becomes relevant when we want to account for travel behavior of individuals in an activity-based fashion but will finally depend on the available transportation model.

In general, existing land use models consider only trips to work or only trips during the morning peak-hour (Wegener and Lerman, 2005). The inclusion of more dimensions in these variables may represent an advantage in terms of model quality but at the same time increases the complexity of the interaction between the transportation and the land use model.

(c) Transportation Networks and Infrastructure

The presence of infrastructure and transportation networks affects location choice beyond their effect on the accessibility of a location (Bhat and Guo, 2007). The distance to highways or public transport stations may be correlated with other access measurements

but they also may generate added value or negative externalities that are not necessarily related with travel cost or travel time. Examples of this are the noise or pollution generated by a highway or an airport, or the added value that a neighborhood acquires when improved bike or pedestrian facilities are implemented. A list of possible attributes of this type is given next:

- Distance to (or presence of) public transport networks

- Distance to (or presence of) highways

- Distance to attractive points in the city like the central business district, airports, train stations, etc.)

- Presence of other transport facilities (bike lanes, facilities for pedestrians, etc.)

3.3 Implementation in UrbanSim

Location and housing-unit attributes should be included as dependent variables of the Household Location Choice Model (interacted with the household attributes) and the Real Estate Price Model. It is particularly relevant to account for the possibility of price endogeneity in the location choice model, which means that the included dwelling unit's price variable is correlated with the model's error term. In discrete choice models this problem is caused principally by the omission of attributes correlated with price. Therefore, this can be solved by including this type of attribute (typically those of quality or age) or by using methods to correct endogeneity (Guevara and Ben-Akiva, 2006).

Other models using location and housing attributes are the Development Project Transition Model and the Residential Development Project Location Choice Model. The current version of UrbanSim samples new residential developments from previously built units and then distributes them using a Multinomial Logit Model. Using more specific and detailed attributes requires to have historical data on previously built units for the sampling procedure.

Regarding the interaction of UrbanSim with a transport model (in the context of this study MatSim or Metropolis), the selection of the transportation-related or access attributes must be done carefully, in order to ensure the compatibility between the land use and the transport model.

3.4 Comparison Aspects Between Europe and the United States

In part as the result of a different type of demand (see Section 2.2) the housing supply in Europe is, in general, different from the one observed in the United States (general indicators for this are shown in Table 2 on the next page). Smaller households and higher land values explain the considerably smaller size of the housing units in Europe. Also due to higher land values (and less available land), an important part of the housing supply in Europe is concentrated in "multi-family buildings" (usually apartment buildings) and in dense neighborhoods. This should be reflected in a different (smaller in relative terms) relevance of attributes like the size and the type (house or apartment) of a dwelling.

High land values also affect the relative expenditure dedicated to housing, making this a bigger item in the budget of European households, probably making this a more sensible variable when looking for a dwelling (with the probable exception of Switzerland).

While the age of the buildings is an important factor everywhere, the assumptions of linear decay with age usually made in the United States are irrelevant for the three case studies of this project and for Europe in general. For example, hedonic rent models estimated for Zurich (Loechl and Axhausen, 2009) have shown that an older building can be more attractive than a newer one, therefore yielding a higher rent or price.

In terms of neighborhood attributes, the higher density and the smaller housing units observed in European cities make the quality of the neighborhood more relevant (Fujita, 1989). Therefore access to parking lots, commerces, services and other public access amenities should have a stronger effect in the attractiveness of a location in Europe than in the US. Higher density also makes location externalities (noise, pollution, neighborhood quality) more easily perceived (Fujita, 1989). This should be taken into account when estimating location choice models.

Europeans cities usually have better public transport, fewer parking spaces and less available roads than US cities (Newman and Kenworthy, 1989). This makes the presence of public transport much more relevant for location choice generally in Europe. For car-owning households, the availability of a parking lot (something that cannot be taken for granted in Europe) will be very relevant when choosing a dwelling. In general, the restrictions, perceptions and preferences in terms of transport attributes of locations should be treated differently than in the US.

Figure 2: Selected indicators for housing unit attributes.

		Belgium	France	Switzerland	United States
Housing units in multi-family buildings	**(5, 6, 7)**	-	44% (2004)	43.8% (2000)	26.4% (2000)
Average household consumption spent on housing	**(5, 6, 7)**	25.9% (2004)	23.5% (2000)	26.4% (2007)	21.7% (2000)
Homeownership	**(5, 7, 8)**	68% (2001)	56% (2002)	35% (2000)	66.2% (2000)
Average dwelling size in m^2	**(5, 6, 7)**	-	70 (2004)	101 (2000)	167* (2000) *median value

(5) U.S. Census Bureau, http://www.census.gov

(6) Federcasa Italian Housing Federation (2006), Housing Statistics in the European Union 2005/2006, Synthesis Report, Ministry of Infrastructure of the Italian Republic

(7) Swiss Federal Statistical Office, http://www.bfs.admin.ch

(8) Norris, M. and P. Shiels (2004), Regular National Report on Housing Developments in European Countries, Synthesis Report, Heritage and Local Government, Department of the Environment, Ireland

4 Government Regulations, Housing Policies and Housing Markets

Thanks to the implementation of regulations and subsidies, European governments have an important influence on the behavior of real-estate markets.

From the point of view of housing supply, government regulations constrain the development of new housing projects by defining the city limits and specifying physical thresholds (*e.g.* maximum density, maximum altitude, minimum surface of green public areas, etc.). The government can also have an active participation in the supply of housing, acting as a developer when it decides on the construction of social housing or by stimulating the development of real estate through subsidies.

From the demand point of view, government regulations affect the land use attributes of the different zones or neighborhoods in a city by defining the types of economic activities that are allowed in each of them. As explained in Section 3, the location choice of the household is affected by these attributes. Other government decisions, like housing policies or development constrains, affect the vacancy rates in the housing markets. Low vacancy rates affect the feasibility of relocation for households, by reducing the available housing supply (Murie, 1974).

A list of government regulation and policies that affect both the real-estate market and (as a consequence) household location choices is presented next. The list attempts to identify the more relevant regulations and policies that can be found in general in cities in Europe. However, particular cases of policies or regulations that could be relevant for the Sustaincity case studies might be omitted here.

(1) **Land Use Planning**

Land use planning is the public policy the aim of which is to order and regulate the use of land in an efficient and ethical way. It encompasses many aspects and disciplines, including the following ones:

– **Zoning**: there often exist legislative regulations that divide a city or a county into zones, specifying the allowed uses for the property in these areas. For each zone, these regulations fix in particular the target urban density and the type of allowed activity (housing, industrial, commercial, agrarian, etc). This affects directly the supply of new housing, by restricting the development of new projects to particular zones or by constraining the number of housing units that can be supplied at different locations in the city. Zoning also has an effect on location choice, by con-

straining the land use attributes of an area and, therefore, by affecting the perception of households on the neighborhood quality. For example, zones were industry is allowed to locate are less attractive for residential location because of the negative externalities generated by this activity.

– **Landscape architecture**: government actions might decide on the design of outdoor and public spaces to achieve environmental, socio-behavioral and/or aesthetic outcomes. The quality of a neighborhood is highly correlated by the presence and quality of public spaces, therefore affecting location choice and, in the long term, increasing land prices.

– **Conservation and aesthetics**: national, regional or city laws might exist to regulate the design of buildings (height, type, material, etc.), notably to achieve aesthetic uniformity within a specific area. Conservation laws allow to classify buildings and thus to prevent from their possible demolition. This type of policy affects the type of housing supply that can be provided. Also, aesthetics are relevant for the perceived quality of a neighborhood, therefore affecting location choice.

(2) Housing Policy

According to (Donner, 2000), the primary aim of a housing policy is to assure that every household has access to housing adequate in size and in quality and at reasonable expenditure effort. Hence, a housing policy is the set of government actions, interventions and regulations the outcome of which yields a particular form of housing market. Generally speaking, a housing policy must ensure at the same time economic competitiveness, social cohesion and environmental sustainability (EFILWC, 1997). Different housing policies might lead to forms of housing market that can be very specific since it involves owner-occupied housing stocks (full ownership, co-ownership or shared ownership) as well as rented housing stocks (Donner, 2000). Moreover, in case of non-ownership, public (social) and private rental housing have to be distinguished (Donner, 2000; Norris and Shiels, 2004; European Parliament, 1996; NBHBP Sweden and MRD Czech Republic, 2005). Even if the ultimate goal to be reached is almost the same everywhere, housing policies might strongly differ from country to country (Donner, 2000). For example, when governments promote home ownership in Belgium and France, the policy in Spain is to increase the proportion of rented dwellings (Donner, 2000; European Parliament, 1996; NBHBP Sweden and MRD Czech Republic, 2005). Because of the heterogeneous housing policies implemented in the different European countries, the ratio between rented and owner-occupied housing strongly differs from country to country (see Table 2). In the following, we give a non-exhaustive list of the indicators on which housing policies are likely to focus on.

– **Rate of homeownership** (Norris and Shiels, 2004). Government might provide tax subsidies (*i.e.* lowering housing taxes) to homeowners in order to promote home-ownership (European Parliament, 1996). As already emphasized above, it can be observed that the rate of homeownership is very heterogeneous in the different European countries (Norris and Shiels, 2004). The access to homeownership can notably also be correlated with the type and the detailed nature of available mortgage systems (European Parliament, 1996; NBHBP Sweden and MRD Czech Republic, 2005). A difference has to be made between freehold and leasehold ownership, depending on the length of time (indeterminate or fixed) during which the household has the right to occupy land or a building.

– **Ratio of rented housing stocks** (NBHBP Sweden and MRD Czech Republic, 2005). Rented housing units have to be categorized in three groups: public rental housing, non-profit or limited-profit rental housing and private rental housing (Donner, 2000; European Parliament, 1996). Note that, in some cases, rented housing can also include legal or illegal subletting.

– **Social housing** includes government supported accommodations for people with low to moderate incomes. This includes direct housing subsidies as well as public housing (Donner, 2000).

– **Vacancy rate** (NBHBP Sweden and MRD Czech Republic, 2005). A low vacancy rate might imply for example that it could be difficult for households to find a housing unit fulfilling all their needs and preferences. As a consequence, households could be forced to lower their expectations on the location attributes they are looking for.

– **Rent values**. To avoid excessive rent values in cities with high land values and high demand, governments can constrain the liberty of the landlord to fix the rent (a measure known as rent control). This regulation affects the housing market, by making it less competitive and generating artificial prices (Arnott and Igarashi, 2000). Rent control also affects the supply side, making the construction of new housing less attractive for developers. This finally affects the consumer (*i.e.* the household) by reducing the available housing supply and increasing the cost of searching for a new dwelling. Rent control policies are particularly relevant regarding land use models where, usually, the rent prices are assumed to be competitive.

(3) Sustainability

Public policies concerning sustainable development are more and more important and widely implemented nowadays. To reach such goals regarding environmental sustain-

ability, governments try to act on the following set of indicators (EFILWC, 1997).

Global environment: global climate, acidification of the environment, toxification of the ecosystem, water consumption, energy consumption.

Local quality of life: air quality, local disturbance, waste management, urban mobility.

4.1 Implementation in UrbanSim

Clearly, regulation policies like land use planning enter in the Residential Development Project Location Choice Model as restrictions to the placement of housing units in specific zones. From the point of view of non-residential demand, the location of firms (Employment Location Choice Model) is also affected by land use planning policies.

Housing policies are harder to implement in a modeling platform. For example, rent control should affect somehow the Real Estate Price Model but it is not clear how the rent thresholds affect the prices in general in the real-estate market. Social housing can be included as forced developments of a particular type of housing unit in the Development Project Transition Model; however this must be exogenously defined by the analyst.

It is not clear how sustainability policies could enter the model, however, global or general regulations should affect the quality of the new housing stock. This could be implemented in an improved version of the Development Project Transition Model.

4.2 Comparison Aspects Between Europe and the United States

Western Europe countries play a more interventionist role within the housing market compared with United States, Van Gent (2010). As a consequence, the market is in average less regulated and hence more liberalized in the United States than in Europe. While the housing policies are very heterogeneous in the different European countries, it is not surprising that the one implemented in the United States has also its own specificities. Social housing in the United States include, as it is the case generally in Europe, direct housing subsidies as well as non-profit housing and public housing. However, as social housing is highly decentralized in the United States, there are almost no national statistics quantifying its nature and importance. Concerning the rate of homeownership, while it was equal in 2000 to 66% in the United

States[6], this rate was strongly varying in European countries from 35% in Switzerland[7], 56% in France to 68% in Belgium (Norris and Shiels, 2004). The percentage of homeownership might notably be correlated to the average dwelling price, to the rent level as well as to the mortgage interest rate (Clark *et al.*, 1997; MIIR, 2006).

Regarding rent control, there are cases of application of this type of policies in both Europe and the US. Examples of this are the cities of New York and Paris, both characterized by high land values and low vacancy rates. Nevertheless, the literature reports little on how these policies are applied in different cities (Arnott, 1988). Therefore, in the modeling effort, it will be necessary to detect if this type of policy is being applied in each case study and in that event it will be mandatory to identify the particular mechanisms used to control rent values.

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[6]U.S. Census Bureau, http://www.census.gov
[7]Swiss Federal Statistical Office, http://www.bfs.admin.ch

5 Conclusion: Towards Integration / Summary and Synthesis

In this paper, we have provided a list of possible attributes characterizing households and locations that are relevant in household location processes. All these attributes might enter, at different degrees, into the location decision-process of households. Obviously, feasibility and convenience of considering each of these attributes in a modeling platform will depend on data availability and statistical significance of each of these attributes in the particular case of study. Sometimes, these attributes might be hard to quantify and to consider into the modeling framework and might hence provoke price endogeneity phenomena. We have seen that income has to be considered as a dominant and limiting factor and should hence be treated with special care, especially in Europe where the expenditures dedicated to housing are large. On a different note, it can be observed that the relatively small modal share for car in Europe indicates that detailed attention has to be paid on attributes related to accessibility, in particular those concerning public transportation. As emphasized in this paper, several household or location attributes might yield to spatial segregation or suburbanization phenomena in large cities and should hence be treated carefully. Besides the typical attributes defined by location preferences, we have pointed out in this contribution a list of attributes which are related to environmental sustainability. Due to the increasing trend regarding these concerns nowadays, these attributes should be somehow considered with particular attention. Another important consideration is the relevance that rent control policies might have in the process of determining the real state values in European cities; the assumptions and structure of the Real Estate Price Model should take this issue into account.

The relocation decision of a household is a major subject in the reviewed literature. Land use models usually focus more in the location choice process than in the elements that trigger relocation. The relevance (and complexity) of modeling the relocation decision process should be addressed carefully, maybe accounting more explicitly for the changes in the household's life cycle or identifying relocation triggers (like changes in land price or neighborhood quality of the current location of a household).

Finally, an important question will be to decide to what extent one wants to account for the long-term investment strategies of the households (like buying a house). In that case, the income trajectory of the households will have to be modeled in order to consider housing as part of their savings strategy and to derive their willingness-to-pay/ability-to-pay information.

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