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Residential choice and household behavior : State of the Art

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Abstract

Modeling households' residential choices is one of the greatest challenges of land use – transport interaction modeling. And although the very structure of UrbanSim conditions to some extent the way those choices may be modeled, UrbanSim remains relatively flexible in this regard, allowing the user to specify its own location choice models.

This report carries out a survey of the representation and analysis of residential choices in the economic literature and in applied modeling (with a special emphasis on UrbanSim). It also examines how these two research fields address the issue that a household consists of various members with potentially diverging objectives regarding the residential choice.

Keywords

Residential mobility, household behavior, UrbanSim

Preferred citation style

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1 Introduction

1.1 Narrowing the scope

Even within the simplified framework of land-use transport interaction models, which focus on said points (and associated environmental issues), there are various points of interest when considering the situation of a household. The main ones are as follows:

- where does it live?
- what is its composition (size, number of children, economically active members,...)?
- what are the workplace locations of its working members?
- what are the travel needs of the various household members and how are they fulfilled (including by which transportation mode)?

All these questions are as many decisions, which may occur at either the individual or household level. For instance, one is not likely to ask his spouse's opinion about which route to use to get to his workplace (at least when commuting alone). Conversely, the number of cars owned by the household is likely the outcome of a collective decision. Furthermore, all decisions do not have the same "temporality", in the sense that households may adapt more or less quickly as well as frequently to changing conditions. Excluding those related to the household composition, decisions represented in land-use transport interaction models may be schematically ordered as follows:

- long-term decisions: residential and job choices;
- intermediate decision: car ownership;
- short-term decision: travel behavior (choice of destination, mode, and route).

This classification mirrors the level of transaction costs and the importance of the stakes associated with each decision. It is fairly easy to change route or switch to public transit when hearing that one's usual itinerary is congested (e.g. due to an accident), and such a decision is unlikely to have lasting influence on the individual or the household's future. Buying a car is a whole different matter, be it in terms of money or time[1] involved. And transaction costs, as well as the stakes at hand (e.g., housing price, permanent income, choice of school for the children), are even higher when changing job or home.

For the sake of brevity, and in regard to contents available in Work Packages 2.4 and 2.5, this report focuses on households' residential choices. Incidentally, it will shed some light on the

[1] Before buying a car you have to pick a brand, a model, negotiate, possibly apply for a loan, etc.

issue of job choice (through the influence of the workplace on the residential choice, mechanisms being symmetrical to some extent), as well as on other choices in general (through the presentation of discrete choice theory).

1.2 Introducing residential choices

The residential choice, defined here as the choice of the place where the household lives, and, when it is dissatisfied with its current home, of when and where to move, is a fairly complex issue. It involves numerous decisions, such as when to move, where to look for, or the choice of tenure, as well as various constraints which may be more or less binding in terms of budget, commuting time, schooling, and so on.

To deal with this complexity, economic researchers and modelers alike have endeavored to **break down the individual process** into a succession of steps, each step representing one elementary decision. Wong's proposition, represented in *Figure 1*, illustrates the sheer difficulty of this task: the decision tree is dense, with a barely comprehensive structure, and includes numerous feedbacks to boot. Yet, this merely mirrors the extremely high level of complexity and singularity of the residential process, and I thus use Wong's attempt to break it down as a basis for the ensuing discussion.

As emphasized in the decision tree, the residential process is generally split into two main components: the **decision to move** and the **residential choice** *per se*. The first element logically seems to precede the other: one chooses a new residence because one wishes to move. Yet the very decision to move may directly depend on the existing alternatives. One might find his or her dream house while wandering along the streets, and decide to buy it and move in at once. Another might wait for the good bargain before moving. Furthermore, it represents an "everyday decision" insomuch that households are constantly assessing their satisfaction with their home as they experience living in it. Although one does not seriously consider the issue of whether or not to move each morning while having coffee, numerous events in the life-cycle provide an occasion to give it some thought, meaning that dynamic behaviors are probably at work.

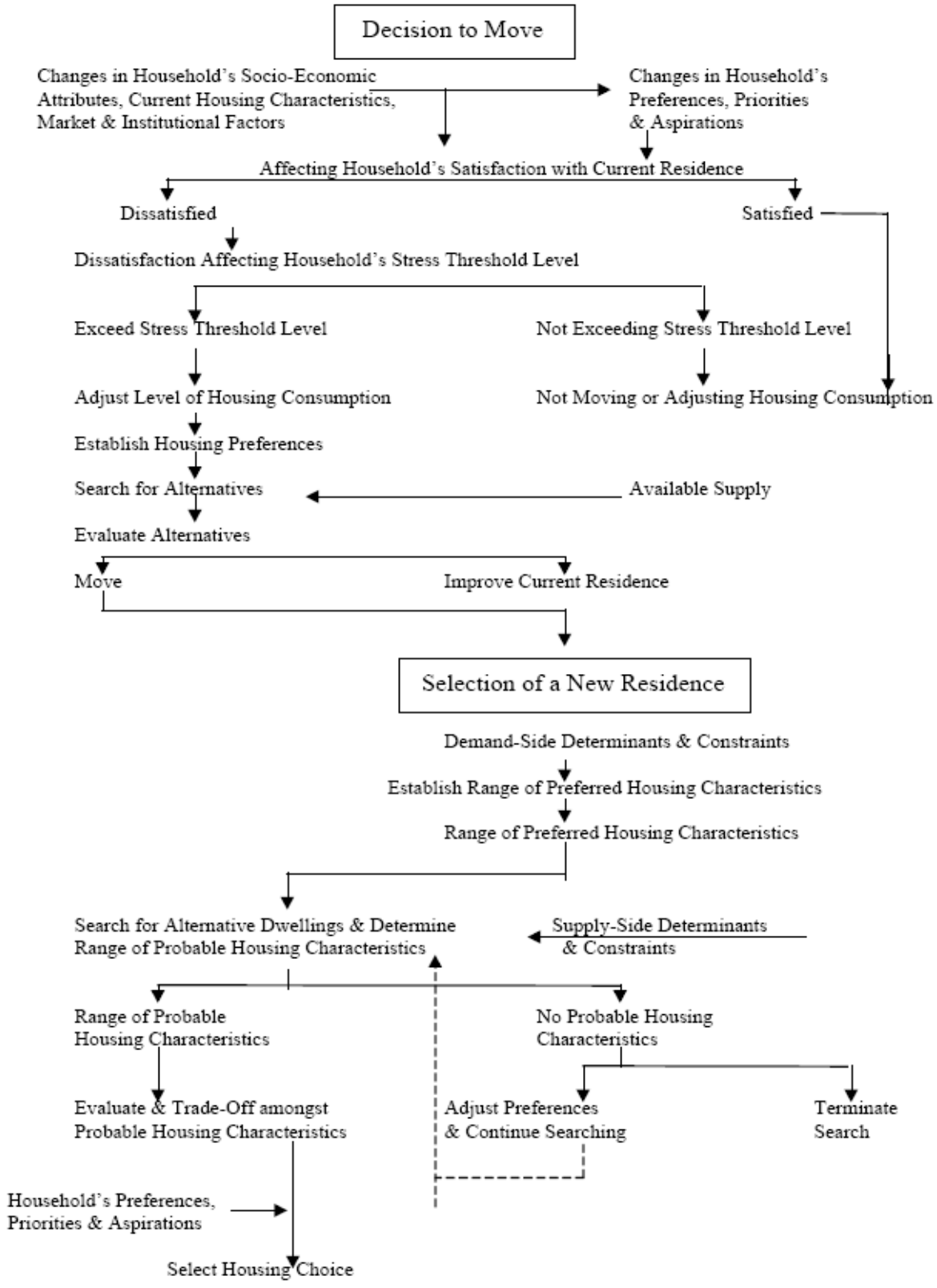
This **two-step structure** is probably the most commonly shared assumption across all approaches presented here. Microsimulation models or discrete choice models of residential mobility typically place special emphasis on the decision to move, which results in either a move indeed (with the ensuing residential choice to be made), or an alternative action (usually stay put and do nothing, home improvements sometimes being an option). On the other hand, long-term equilibrium models, e.g. the monocentric city model, often omit this decision by assuming that households do not wish to move at equilibrium, and jump directly ahead to the

residential choice. Aside from that, there is considerable variety in the way of dealing with the complexity of the residential process. Applied models presented in section *3* strive to represent more and more minutely the decision tree. On the other hand, economic works break the whole process asunder and scrutinize it part by part.

This report intends to review and, to some extent, compare how the household behavior is represented in the case of the residential choice in the economic literature and in applied modeling (with special emphasis on UrbanSim in the latter case). It focuses on the **household perspective** and **economic mechanisms**. Market equilibrium mechanisms and especially the formation of housing prices do introduce indirect interactions between residential choices, but are not at the core of the analysis. They are however presented when relevant.

Following this introduction, *section 2* starts with an overview of the economic literature, and reviews how the decision to move, the choice of dwelling characteristics, and the location choice are represented and analyzed in it. A last subsection elaborates on how the issue of making individual behaviors transform into a collective decision for the whole household is treated (or not) in this strand of literature. Then, s*ection 3* analyzes how the household behavior is represented in urban models as far as the residential choice is concerned. It draws on the previous section to offer a comparative approach. Lastly, *section 4* provides some conclusions.

Figure 1 A conceptual model of the household's housing decision-making process



Source: Wong (2002)

2 Residential choice and household behavior : the microeconomic approach

The economic literature typically breaks the residential process into small parts and examines them separately. Holistic approaches are seldom, maybe because researchers have acknowledged the high complexity of this process and concluded on the vanity of seeking one integrating approach when so much remains to be done. Regardless, **four key topics** may be identified in the literature:

- residential mobility;
- the level of housing consumption;
- the choice of dwelling characteristics;
- the location choice.

Dwelling characteristics should be understood as intrinsic ones, while the location choice comprehends the issue of location-based amenities. Most works tackle only one or two of these points, sometimes up to three. Addressing all four would surely get you a Nobel price though, as once again it has never been done to the best of my knowledge. Among those, the level of housing consumption is maybe the most recurring subject, sometimes being central in the analysis, sometimes as a co-product. Conversely, there is **a wall separating the issues of location and dwellings characteristics** in academic research, and the interplay between the two is still not fully understood (Hilber 2005). This might represent the most important lack as for now.

One major issue seems missing when comparing to *Figure 1*: the home search.[2] The housing market being characterized by sheer product differentiation, information gathering is crucial yet costly at the same time. Visits, which are necessary to confirm stated characteristics as well as to get the whole picture, require time. As a consequence, households must develop search strategies which condition their residential decision. The way households devise such strategies should constitute a natural field of research. Yet, literature on this specific topic remains scant to the best of my knowledge; the issue of **home search** is thus **not considered in this review**.[3]

[2] Some could argue maintenance to be another missing item in my list. I personally consider maintenance as one among several possible supply-side responses to the willingness to adjust one's housing consumption. This is why it does not appear in this short list.

[3] Some works do consider the search process to account for the phenomenon of vacancy (e.g., Wheaton 1990, Arnott and Igarashi 2000), but they seldom try to specify it, encapsulating the whole process in an effort variable. Among the rare works taking specific interest in the way households search their future home, let us cite the recent contribution of Chen, Lin, and Paaswell (2009).

Bearing this limitation in mind, this section exposes the various contributions of theoretical and empirical economics with respect to the representation and analysis of **the residential choice**, with a special care to the **main microeconomic mechanisms** that are represented. Each of the four above topics is addressed one by one except for the level of housing consumption, which is usually represented jointly with other topics. A last subsection elaborates on how the issue of making individual behaviors transform into a collective decision for the whole household is treated in the economic literature.

2.1 Residential mobility, or the decision to move

Stricto sensu, residential mobility is not a component of housing demand. As a matter of fact, a move is already the outcome of a meeting between supply and demand, which brings us back to the issue of stated vs. revealed preferences. And, to a more or less important extent, the same remark could be made concerning *subsections 2.2* and *2.3*. This consideration is not trivial in the case of the housing market, some households being actually unable to move because appropriate supply does not exist in sufficient quantity. In other words, **residential mobility would be but the visible part of the iceberg**. Notwithstanding, there is considerable data and literature regarding actual residential mobility, much less so regarding the willingness to move, hence the choice of addressing the former rather than the latter.

This survey comprises four parts. First, a simple model is developed as a parable of residential mobility, providing an initial insight into this matter. After stressing next the difference between a move and a migration, the survey on residential mobility is resumed. A review dedicated to the phenomenon of migration concludes this subsection.

2.1.1 Residential mobility: an introduction

a) A parable of residential mobility: Homeworld

To introduce the topic of residential mobility, let us start by a simple tale. Imagine Mister M. who, right after his graduation, leaves home with a suitcase as sole luggage. Once arrived in the city of his choice, he gets a work downtown and decides to settle in a nearby gigantic hotel named Homeworld. Homeworld can provide him with any kind of place, from a luxurious villa with a lovely garden to the simplest room. M. has relatively simple tastes, taking the form of a Cobb-Douglas utility function:

$$U(h,z) = h^{\varepsilon} z^{1-\varepsilon}$$

where h denotes housing services, z is a composite good standing for all other goods in the economy, and ε a random variable taking values in $[0;1]$. The value of ε may change at any

moment, according to how much time M. plans to spend in his room, the weather, his mood, and so on.

b) Why do we move?

Let us start by assuming that M. can freely change rooms. In our rather simple model, M. would do so every time ε varies: this might be a simple bedroom when he worked late, another one when he feels like changing, or a deluxe villa for a week-end with friends. Transposed to the real world, **residential mobility is primarily a response to a change in housing needs** (Gobillon 2008). If one is satisfied with his location, home improvements are also an alternative. Otherwise, a residential move is the sole option. Moreover, if mobility was costless in all regards, one should expect people to constantly adjust their housing consumption, as happens in our tale. Lastly, a residential move can also be imposed by an outside constraint: non renewal of lease, accident at one's place, expropriation, etc.

c) When moving? The role of moving and transaction costs

Because all is not for the best in Homeworld, soon the manager finds that if M. were to stay in the same room, this would make his job easier. As a result, the clever manager enforces a fee for every room change, and as a counterpart adds a carrot to secure the loyalty of his clients: the longer one stays, the less he pays per day. Actually, M. does not mind these new rules for many reasons. Changing room takes time, he cannot leave his suitcase, he needs to get used to his new place, and he also has to tip the groom each time he carries his luggage to another room. Most of all, M. finds it stressful to constantly change places, and longs for stability. All these elements are as many deterrents to mobility, encapsulated in a disutility term δ when changing room.

Considering the new moving costs, M. stops changing room every day. More specifically, he goes and asks the manager for another place if and only if:

$$U(h^*, z^*) - U(h_0, z_0) > \delta$$

where (h^*, z^*) is the optimal bundle given the current value of ε, and (h_0, z_0) his current consumption. Considering that M. has a budget constraint giving z as a function of h and income, the above condition is tantamount to a (S, s) rule: a move occurs if and only if $h^* \notin [h_0 - m, h_0 + M]$, where m and M depend on ε and δ among other things.

In sum, the introduction of moving costs has the following consequences:

- Adjustments of housing consumption become punctual instead of continuous. [4]

[4] Note that one has to assume that the set of discontinuities of h^* has a measure equal to zero to obtain this result. In other words, ε cannot be excessively irregular (punctual jumps are ok though).

- More specifically, a move is triggered when the inadequacy between the current residence and the optimal one exceeds a stress threshold.

This last rule was empirically validated by various works, including Dunn (2003) and Gobillon and Le Blanc (2008).

d) Planning or not planning?

An implicit yet crucial assumption behind the above moving rule is that M. is myopic. He does not know what the future holds for ε, the value of which may change at any time. Only under this assumption is the strategy described above optimal. This position is the one adopted by Venti and Wise (1984), who develop a model of residential mobility based on a **"disequilibrium" approach**. A move is triggered only when a disequilibrium term exceeds a certain threshold, which resets the value of this term to zero. On the other hand, the **"dynamic movement plan" approach** considers that households know their future to a certain extent. In this setting, the existence of moving and transaction costs leads the household to carefully plan its mobility. Amundsen (1985) shows that a disequilibrium measure can actually be at its largest just after a move has taken place, [5] a claim corroborated by the empirical findings of Edin and Englund (1991) in an analysis on recent movers.

Although this last element could seem to invalidate the "disequilibrium" approach, **the existence of unpredictable hazards** which may lead to forced moves **limits the household capacity to plan its residential mobility** (Nordvik 2001). More specifically, Nordvik finds in an endeavor to merge the two above approaches a result previously shown by Muth (1974) in a more simple setting, which states that "*the willingness to accept overconsumption or underconsumption early in a planned stay decreases with the probability that an exogenous move should take place*" (Nordvik *supra*, p.523). In sum, the truth would lie somewhere between the two approaches.

e) Some simple comparative statics

Let us derive a few more findings from our model. First, **moving and transaction costs** hinder mobility. Indeed, the greater δ, the higher the stress threshold, hence this result. [6] **Search costs**, including both time and money dedicated to the home search, logically have a similar impact (Wheaton 1990, Debrand and Taffin 2005). Secondly, because part of the monetary costs of moving do not vary much with income, high income households should display a higher propensity to move. Böheim and Taylor (1999) and Debrand and Taffin (2005) both confirm the **role of income** empirically, when Gobillon (2001) finds that it is the

[5] Cf. Muth (1974) and Goodman (1995) on this point.

[6] Refer once again to Amundsen (1985) for a demonstration of this point in a rigorous theoretical framework. Van Ommeren and Van Leuvensteijn (2005) validate this result empirically.

perception of one's own financial situation that affects mobility decisions rather than income itself. Lastly, the more ε varies (in frequency and/or in amplitude), the shorter M.'s expected length of stay in a given room will be. In other words, **the more frequently your housing needs (significantly) change, the more you move**. Versatile people or those having an aversion to stability should accordingly move more often than the others. Conversely, Kan (2003) shows risk aversion to reduce residential mobility, though to a modest extent. Still in this line of thought, changes in household structure will often trigger a residential move as they significantly change the value of h^*, a point that I discuss at length in *2.1.3a)* .

2.1.2 Is it a move or a migration? Long- vs. short-distance mobility

a) On the importance of distance in residential mobility

Before proceeding further, it is paramount to acknowledge differences between short- and long-distance mobility. Indeed, motives underlying residential moves greatly differ between from one category to the other. **In long-distance residential mobility**, **the link to employment is primary**, the move being frequently coupled to a job change. [7] Such is not the case in short-distance mobility, to the point that Dieleman (2001, p. 253) states that "*it is generally supposed that the residential location can be chosen without reference to the location of the job, at least if the commuting distance is not too large*". To be more specific, the **adjustment of housing consumption** (including tenure, home size, and housing type) is usually the **primary motive behind a short-distance move** (Gobillon 2001).

This duality is partly reflected by the very structure of the economic literature. A specific literature exists on migration, including both theoretical and empirical works, when short-distance mobility is on the other hand more seldom considered alone. [8] In sum, the economic literature basically draws a distinction between migration and residential mobility as a whole, rather than between short- and long-distance mobility. Although there are sometimes cogent reasons to do so (e.g., when space is clearly not an issue it is relevant to consider all residential moves together), this undermines findings insomuch that the influence of various factors may vary depending on whether one considers long- or short-distance mobility (Gobillon 2001, Debrand and Taffin 2005, Kan 2007).

[7] Retirees and other inactive people represent a non negligible exception to this rule, but do not undermine our argument. In point of fact, one could easily substitute the notion of labor market by that of social network (mainly family for retirees). Because metropolitan areas define the natural space for daily travel practices, labor-and-housing markets roughly coincide with "social spaces" (in other words, metropolitans areas define who you can "easily" visit). Other exceptions include people taking advantage of rapid transit systems to live in different metropolitan areas than they work in; such instances are much less numerous, however.

[8] The fact that there is a specific word for long-distance mobility, "migration", and none for short-distance mobility, is quite interesting in this regard.

b) Defining the term "migration"

The fact that one can draw a line between long- and short-distance mobility is, as implied above, a widely acknowledged fact in the economic literature. There is still no clear consensus however over how to define this line precisely, resulting in a variety of considerations based on political jurisdictions, co-occurrence of a job change, and so on. In fact, the term "migration" itself is fraught with ambiguousness, and the economic literature abounds with multiple and inconsistent uses of this term (Zax 1994). [9]

Among all explicit as implicit suggestions, Zax offers to my view the best definition of migration when he says that "***a move is a migration when the worker leaves one housing-and-labor market to relocate in another***" (*ibid.*). This definition is more appropriate than others for it is grounded on the notion of regional markets, instead of, for instance, distance thresholds or administrative boundaries which might not reflect the reality of real estate markets. In operational terms, the closest translation of this definition would be the notion of residential **moves exiting a metropolitan area**.

The choice of placing the market at the center of the definition of a migration is motivated by the postulate that housing-and-labor markets are the natural framework of reference for job/housing decisions, as they are characterized by specific wage and housing price functions. The latter are the product of various factors, such as population, employment, local amenities, access to markets, and production technologies (among other things). In other words, **housing-and-labor markets would define expectations for wages and housing prices, setting the framework in which the household thinks and takes its residential decision, in conjunction with its job decision** (including keeping the same job). This links this definition to the works of urban economics,[10] as one must assume that housing-and-labor markets and their associated wage and housing price functions exist and are consistently defined. The monocentric city model actually represents the ideal analytical framework in this regard: it provides a theoretical basis to justify the existence of these wage and housing price functions and derive them. The situation could be more complex in case of polycentric metropolitan systems, however. Additionally, the issue of the interstitial space, namely the rural area, is not addressed by this definition at all. This might explain why politico-administrative divisions are still often preferred in practice. Regardless, Zax's proposal provides a clear and consistent basis to converge towards a uniform definition of migration, which would constitute a significant step forward in residential mobility analysis.

[9] To the best of my knowledge, the situation has not changed much since then, and later works still remain unclear or inconsistent about this notion (e.g., Dieleman 2001, Gobillon 2001, Debrand and Taffin 2005).

[10] Note that this *rapprochement* is explicitly proclaimed by Zax (1994).

c) Few facts about short vs. long distance mobility

The empirical literature confirms and specifies the above statements. First, all works on residential mobility report or find that **long-distance moves are relatively infrequent** in comparison to short-distance ones. In the case of France, inter-regional mobility only accounted for 21% of all residential moves during the period 1999-2002 (Debrand and Taffin 2005). As mentioned above, long-distance mobility is also generally accompanied by a job change (Zax 1994). Conversely, **residential and workplace relocations are substitutes within a same region**, meaning that they are much more frequent alone than together (Linneman and Graves 1983, Zax 1991). Once again, this is consistent with the previous statements.

2.1.3 Residential mobility 2

Considering the fact that there is little literature dedicated to short-distance mobility, the reviews first keeps on addressing residential mobility as a whole. On the other hand, issues and factors specific to migration are presented separately in *2.1.4*.

a) The influence of life-cycle and household composition

Since the seminal work of Rossi (1955) which gave the initial impulse, there is now considerable history concerning the study of the influence of the life-cycle on residential mobility, and several regularities were observed across the globe. First, there is a strong relation between the propensity to move and the **stage in the life-cycle** of an individual. In all developed countries, young adults aged between 20 and 35 are by far the most mobile population segments, and residential mobility typically falls as one gets older.[11] Secondly, **changes in the personal, educational, or employment domains** are common triggers of a residential move (Dieleman, Clark, and Deurloo 2000). Among other things, this encompasses leaving home, changes in household composition (e.g., getting married, birth of children, divorce), or getting a new job. Given that most of those triggering events are concentrated at the beginning of adulthood, this partly explains why mobility decreases with age. In addition, Dunn (2003) finds that the size of the (S,s) band is broader for older households, which implies that the **psychic cost of moving increases with age**. This provides another explanation to the lower propensity to move of this household category.

Considering what was just said, it seems pretty clear that **household composition** is to impact residential mobility in various ways. First, living as a couple automatically entails a move from either one or the two partners. On the other hand, an employed spouse hampers mobility (Böheim and Taylor 1999, Gobillon 2001, Debrand and Taffin 2005). If a move occurs

[11] See Long (1992) for an international analysis, Debrand and Taffin (2005) for French data.

anyway, the longer the distance, the higher the probability of the spouse becoming unemployed or inactive (Courgeau and Meron, 1995). The impact of children is relatively complex as they tend to increase mobility at first, but ultimately decrease it (Gobillon 2001). Indeed, once the family has settled in a sufficiently large and comfortable home, a residential move would cause the children to lose contact with most of their friends (Long 1972), and potential troubles to adapt to their new school might affect their future school results (Long 1975).

Household composition also influences the decision-making process itself. According to Molin (1999), households of more than one person tend to use two higher-order constructs to come to a joint statement of their residential preferences. More specifically, housing characteristics are divided into two main groups:

- Dwelling characteristics: the key considered elements are tenure, dwelling type, the number of rooms, and price or monthly rent.
- Location characteristics: households are mainly concerned with the type of neighborhood, the general accessibility to activity places (including workplaces, schools, etc.), and the frequency and proximity of public transit.

Although this provides first clues as to how families and more generally households take joint decisions, significant work remains to be done on this topic (Dieleman 2001).

b) Is commuting an issue?

The **influence of commuting** on residential mobility is **highly controversial**, and many antagonistic points of view coexist on this topic. [12] In new urban economics, commuting costs are central in the location choice (→ *2.3.1*). Thus, one might expect this variable to also exert a significant influence in the decision to move (for instance, if the commute gets longer due to congestion, or in case of job change), an opinion shared by Zax (1994). On the other hand, Simmons concludes following a review of early literature on intra-urban mobility that "*all studies reject job location as an important reason for moving*" (Simmons 1968, p.637), although conceding that "*the place of employment may act as a constraint when it comes to selecting a dwelling*" (p.646). Indeed, it is quite obvious that commuting is at some point an issue, as one cannot live in one continent and work in another (at least not with our current technology). The question is thus: to what extent?

A key issue when studying the link between employment location and residential mobility is that when facing costly commute (be it in time or money), two options arise: **moving or quitting**. The existence of a strong connection between the two processes is a well-established fact, theoretically and empirically (Zax 1994, Böheim and Taylor 1999, Gobillon 2001). The

[12] Quigley and Weinberg (1977, p.54) had already noted in their time that "*there is no consensus on the effects of accessibility, workplace location, and workplace change on subsequent* [residential] *mobility*".

disagreement lies in the precise nature of this interaction. Böheim and Taylor (1999) are probably the most radicals in this regard, as they find commuting time to exert no significant influence on residential mobility. When Zax and Kain (1991) conclude that the longer the commute, the less likely moves are and the more likely quits are, implying that households would mainly resort to the "quit" strategy, Van Ommeren *et al.* (1999) find in the same case that moves and quits are both more likely. In the case of workplace relocation, Zax and Kain show the probability of a residential move to increase significantly with the distance between the new workplace and the old residence (Zax and Kain 1996). In short, this brief overview has, if anything, underlined the current lack of consensus over this topic, meaning that this case is not closed yet.

c) Housing tenure

Housing tenure represents with age and household composition one of the dominant correlates of the propensity to move (Dieleman, Clark, and Deurloo 2000, Debrand and Taffin 2005). According to the first source, private renters are in general three to four times more likely to move than home owners. This ratio is relatively accurate in the case of France, where tenants of the private sector, and of the social sector to a lesser extent, are much more mobile than home owners (Debrand and Taffin 2005).

Several elements account for these differences. First, search costs and transaction costs are typically higher in the case of ownership. [13] In the case of the social sector, the fact of enjoying lower rent represents a disincentive to mobility, especially to the long-distance one (Debrand and Taffin 2005). There is also strong basis for **self-selection**, as households with long expected lengths of stay tend to opt for ownership, and conversely (Haurin and Gill 2002). This phenomenon is related to the above indicated search and transaction costs, but also to the fact that ownership provides the greatest freedom as to how to maintain and improve your dwelling, especially in the case of detached housing. Households willing to invest in their dwelling would therefore logically buy instead of renting (Hubert 2006).

d) Additional factors

Length of housing tenure

The length of housing tenure is often cited as a deterrent to mobility. The rationale is that people **accumulate a specific type of capital with time spent in a given location**. This includes among other things the knowledge of the neighborhood, the development of a social network (Schwartz 1973, Kan 2007), or the investment in decorating and furnishing the dwelling. All these elements contribute to increase the costs of moving, monetary and non-

[13] Note that while the acquisition of a new home involves substantial search and transaction costs (Hubert 2006), this is also the case when willing to sell your former home (Coulson and Fisher 2009). In sum, home owners willing to move and buy a new residence are doubly handicapped.

monetary alike. In the case of the private rental sector, regulations favorable to tenants regarding rent increases, or similarly discounts given by landlords to avoid costly changes of tenants might also account for lower mobility (Hubert 1995).

As a consequence, most empirical works find the length of housing tenure to decrease the household propensity to move (Böheim and Taylor 1999, Gobillon 2001). Let us highlight two limitations though. First, the length of housing tenure might capture part of the effect of job tenure if this last variable is not considered in the regression, as these two variables are significantly correlated (Bartel 1979). This point could explain why Gobillon (2001) finds the length of housing tenure to have an influence on long-distance mobility but not on the short-distance one. Were it not for the argument of Bartel, this result would be difficult to account for. Secondly, it is quite likely that households have **idiosyncratic tastes for stability**. Given this postulate, some households are willing to move and change jobs frequently, while others long for the greatest possible stability as discussed in *2.1.1e)* . Length of housing tenure would in this case be strongly correlated with the household type, leading to biased estimates.

Borrowing constraints

Besides altering tenure structure (→ *2.2.1*), borrowing constraints also exert a significant influence on residential mobility. Indeed, those prevent part of potential moves toward the homeownership sector from occurring. The overall impact on residential turnover is not straightforward though, for at least three reasons:

- Constrained households may move within the rental sector instead. Consequently, lower mobility toward the ownership sector are compensated for by higher mobility toward the rental sector (Ioannides and Kan 1996).
- Borrowing constraints might merely delay the move.
- Residential turnover could rise through a structure effect, as borrowing constraints result in a higher share of tenants, who are the most mobile category (→ *c)*).

In spite of the first point, Zorn (1989) and Gobillon and Le Blanc (2008) both find that **borrowing constraints hinder mobility**. However, as it is not clear to which extent they address the last two issues in their model, their results remain subject to caution.

Unemployment

Unemployment is found to have **mixed effects** in the literature: at the individual level, unemployment experience increases the likelihood to proceed to a residential move, especially a migration (Pissarides and Wadsworth 1989, Debrand and Taffin 2005). Unemployed individuals have fewer incentives to stay and might expect better job opportunities in other regional labor markets. On the other hand, the overall unemployment level exerts a negative influence on mobility (Debrand and Taffin 2005). The effect is more

significant for unemployed people, whom bad economic prospects discourage to move (Pissarides and Wadsworth 1989).

Government interventions

According to Strassmann (1991), government interventions have a "*strong side effect of* ***lowering residential mobility***". In an international analysis of residential mobility rates, he finds this element to be a better predictor of housing turnover than tenure structure. Notwithstanding, this has to be considered as a general rule, and specific policies might obviously facilitate residential mobility.

2.1.4 Theoretical and empirical analyses of migration

After presenting the main theoretical frameworks to study migration, including meso- and micro-models, a survey of the main determinants of migration is proposed based on an overview of the empirical literature.

a) Meso-models of migration and the constant utility principle

Although differing in various regards, most recent theoretical models of migration are based on the utility maximization principle. Under this assumption, households wish to settle in the region yielding the highest utility. Like potential differences create electric current between two points, **utility differences generate flows of households directed from low-utility to high-utility regions**. In this setting, a network of cities (or regions) is characterized at equilibrium by a constant utility for all mobile households.

A first and well-known application of this framework is the monocentric open-city model. This model basically assumes that the level of the city population adjusts itself to equate household utility with a national equilibrium level, which is exogenous.[14] The underlying mechanism is as described above: a higher population increases competition for land, thereby reducing utility and ultimately driving part of excess households away (and conversely). In sum, congestion acts as a back-pulling force ensuring the stability of the equilibrium. However, the constant utility principle is in this context an elegant way to close the model rather than a premise to study migration patterns.

The New Economic Geography, founded on the twofold keystone constituted by Krugman (1991, 1993), provides a more enlightening insight in this regard. It is a branch of neoclassical economics which aims to explain size differences between regions. The standard model takes place in a two–region setting, with either part or the whole population being mobile. Centripetal and centrifugal forces are modeled, and utility is *in fine* a function of regional

[14] → *2.3.1* for a presentation of the monocentric model.

population. In this general analytical framework, **migrating to the other region can be the result of agglomeration forces or on the opposite the consequence of excessive congestion or competition in the region of origin**. Once again, regional utilities are equal at equilibrium. Although several equilibrium patterns are possible (including a symmetric allocation), the only stable one would typically consist of a central region and a satellite one.[15] The strong appeal of this theory is that unlike the basic open-city monocentric model, where migration boils down to equating population across regions, it accounts for regional disparities: regions are more or less attractive, and this **attractiveness is at the core of migration patterns**.

A SIMPLE EXAMPLE OF A MODEL OF REGIONAL MIGRATION: ANAS (1992)

Anas (1992) offers a simple two–zone model which illustrates the above framework tellingly. In his model, an increase in population brings about an increase in per–capita output (*via* localization economies), but a decrease in per–capita land consumption. This results in an inverted U–shaped utility function $V(n_i)$, n_i standing for the population of city *i*. In addition, a dynamic adjustment mechanism operates migration from the lowest to the highest utility location. In Anas' model, the agglomeration force is thus the economies of scale, while the competition for land acts as a repulsive force.

b) The decision to migrate: an individual perspective

Parallel to the previous literature, another strand has focused on the decision to migrate from an individual perspective. The gist of this literature is to **identify the costs and benefits of migration**, and reflect upon how these two elements vary with individuals. An important though indirect contribution in this field is provided by Sjaastad (1962), who casts the migration issue into a basic allocation problem, resulting in migration being considered as an investment increasing the productivity of human resources. Migrating involves private costs on the one hand, including out of pocket moving expenses and the psychic costs of changing one's environment. On the other hand, monetary returns to migration take the form of a positive or negative increment to the stream of real earnings, the increment depending on the changes in nominal earnings, costs of employment, and prices. Although the private and

[15] The purpose of this subsection is not to present in detail the findings of the New Economic Geography, rather to focus on its contribution in accounting for the phenomenon of migration. This is why drastic simplifications are made. In particular, the role of the level of transportation costs in determining the stable equilibrium pattern (symmetric vs. asymmetric) is deliberately not addressed here. Similarly, while a classic issue is that of optimal city size, it is once again not exposed here. See Combes, Mayer, and Thisse (2008) for more on this topic.

public spheres are strongly intertwined in Sjaastad's work, [16] the **Cost-Benefit Analysis** clearly takes shape.

Following this line of thought, Puig (1981) carries the analysis further and models the migration decision as a **trade-off between future earnings and location preferences**. In addition, there is imperfect information, implying that individuals, who are risk-averse, base their decision on future expectations. A first consequence is that **information and risk-aversion both exert a significant influence on the migration decision**. Individuals are less reluctant to migrate when they know what they will get, even more so when they have strong risk aversion. Secondly, young households logically value discounted wages over a longer term than old households. As a result, the former are chiefly concerned by employment prospects (including real wage differentials), while they care less about the uncertainty about their future environment than old households for whom location preferences are paramount.

c) The main determinants of migration

While previous models provide a sound theoretical background to explain migratory movements, they are obviously unfit to derive structural models, since it is extremely hard, if possible at all, to measure the utility of living in one city compared to another. On the other hand, it is fairly easy to track flows of population between regions, and the empirical literature has thus focused on uncovering the main determinants of this variable, mainly using simple linear regressions (with possible sophistications).

Let us briefly present **incentives and hurdles to migration** based on the survey made by Ghatak, Levine, and Price (1996) for a start. The main driving forces of migration that are identified are:

- real wage differentials;
- unemployment differentials;
- **attractive amenities** (public goods, climate,[17] etc.);

while the two main hurdles to migration are:

- the **costs of migration** (which may be pecuniary, social, etc.);
- **risk aversion** of potential migrants.

[16] The issue of migration is *a priori* considered from a public perspective, the question being what is the best spatial allocation of human resources considering a starting position and the costs and benefits of migration. However, it is private considerations that *in fine* underlie the decision to migrate or not.

[17] See Rappaport (2007).

This short list is fairly consistent with the theory, and most elements previously cited appear. One can first note that the influence of various factors should vary by age bracket according to Puig (1981), nonetheless. Furthermore, several significant issues are omitted, including:

- **The role of information**: according to Wasmer and Zenou (2002), distance to job opportunities has a negative influence on information gathering. A first way to cope with this difficulty is to migrate first and search onsite, which implies that the migrant already has optimistic expectations about employment prospects. Otherwise, regions providing readily available information about job opportunities (good websites, national press, etc.) should be more attractive.
- **Educational attainment**: in the same line of thought, because better educated people can make easier use and analyze sophisticated sources of information, they should show a higher propensity to migrate. Another important factor in this regard is that as a general rule, the higher the qualification of a job, the higher the recruitment area (Schwartz 1973).
- **The presence of family or friends**: first, getting closer to one's family can be the primary motive of a migration, especially for older people (Gobillon 2001). Regardless, the presence of family or friends at the zone of destination mitigates the cost of migration, monetary (it provides solutions as to where to stay for the first few days) and psychic alike, and makes the job hunt from afar easier (Bauer, Epstein, and Gang 2000). Conversely, the development of a social network at the zone of origin is a hindrance to mobility as was discussed before, a hindrance which proves even more important in the case of migration (Kan 2007).
- **Job tenure**: as job tenure usually involves the acquisition of specific experience, status, and wage, one might expect it to have a negative influence on the propensity to migrate, a hypothesis corroborated by Bartel (1979).

The last two factors cannot be readily considered in aggregate models. One would have to resort to disaggregate modeling (such as logit models) to take those into account. Lastly, most factors having an influence on residential mobility as a whole should logically have to some extent an influence on the propensity to migrate.

2.2 Choice of dwelling characteristics

The housing market is characterized by the fact that it offers **heterogeneous goods**. In fact, each housing unit is unique to a certain extent. Because dwelling on this consideration precludes any kind of research, researchers have progressively endeavored to represent the heterogeneity of housing and study it.

Concerning housing demand, this involves first determining which characteristics matter in the residential choice, and to what extent. There are two ways to tackle this issue, which are to use either stated preferences (e.g. Louviere 1979) or revealed preferences. Considering limitations inherent to the first method, including the paucity of dedicated surveys, the review focuses on methods based on revealed preferences. Except for a few exceptions, including the

2.2.1) or the location choice (for which exist alternative theories exposed in *subsection 2.3*), most works dealing with the choice of residential characteristics use either one of the two main theoretical frameworks, namely discrete choice theory and hedonic analysis. These two main strands are presented in *subsection 2.2.2* and *2.2.3*, respectively.

2.2.1 The choice of housing tenure

a) Standard approaches to the tenure choice

The issue of tenure choice holds a specific place in housing economics, as it gives birth to a prolific literature. It may be divided into three main branches.

Housing: an asset like any other?

A first strand focuses on the notion of housing as a **financial investment**, and makes use of the standard tools of portfolio analysis. A housing unit is an asset, which is risky due to the uncertainty on future prices and potential rents. As cleverly highlighted by Kain and Quigley (1972), housing plays a specific role in the dynamics of wealth accumulation of low- and middle-income families for at least two reasons. First, other forms of investment such as the stock market "*require far more knowledge, sophistication and discipline*", and secondly "*low- and middle- income households have more leverage available in the real estate than in other investment markets*" (op. cit.). Consequently, **home equities have a dominant position in the asset portfolios of these income brackets**.

In a seminal work, Henderson and Ioannides (1983) have set the basis for the analysis of tenure choice and of the household investment behavior. Based on the consideration that partial-ownership arrangements are hardly feasible, the crux of their housing investment-consumption model is an **investment constraint** that requires home owners to own at least as much housing as they consume. While their model does not consider other risky assets besides housing, Brueckner (1997) has successfully filled this lack by carrying out the same reasoning in the presence of multiple risky assets. Flavin and Nakagawa (2008) study for their part the investment behavior of households in the presence of both durable (housing) and non-durable goods, as well as adjustment costs for the housing good. [18]

A "micro" approach to tenure decision

Another approach is presented and discussed in Kain and Quigley (1972), and more recently in Magnan and Plateau (2004). It bases the tenure decision on a meticulous **financial analysis of the different options**, using the standard indicators in this field. Typically, the costs of

[18] Other works on this topic include Fu (1991), Flavin and Yamashita (2002), or Arrondel and Lefebvre (2001).

renting and owning are assessed on a yearly basis, according to a baseline investment plan for the ownership case (acquisition then reimbursement of the mortgage) which incorporates loan conditions. These costs are then used in an actuarial calculus taking various parameters into account, such as taxation, transaction costs, or expected length of tenure. Compared to the previous one, this approach is primarily intended to evaluate a small number of options, and sort them according to various financial indicators.

Statistical approaches

Lastly, a large body of literature has adopted a more neutral approach, based on sheer statistics with little economic founding, [19] to try and uncover the many variables exerting influence on the household decision. Probit or logit models are especially rife in this strand. At first, the stress was put on four categories of factors:

- **Household socio-economic characteristics**, which include race in the U.S. case.[20] Gyourko and Linneman (1996) underline for this country the growing influence of labor market conditions as compared to demographic factors such as marital status or family type.
- **Household life–cycle attributes**: in particular, the odds of ownership drastically rise as the head of the household gets older and the household gets bigger (Li 1977).
- **Permanent income**, which was shown to be more reliable indicator than yearly income (Kain and Quigley 1972). Wealth also exerts significant influence on the tenure choice, in particular due to borrowing constraints (see below). Data on this topic are seldom available however, and few studies include this variable.
- The relative cost of owning versus renting (Hendershott and White 2000).

Later works have underlined other factors influencing tenure choice, such as:

- **Path dependence**: homeowners rarely revert to renting unless their household splits up (Michelson 1977).
- The **tax system** (Brueckner 1986): in the U.S., home ownership is usually less costly than renting due to tax exemptions on capital gains (Hendershott and White 2000).
- **Transaction costs** and expected length of stay (Haurin and Gill 2002). [21]
- **Borrowing constraints**: following the seminal works of Linneman and Wachter (1989) and Zorn (1989), this issue stimulated numerous papers, reviewed in Gobillon (2008). Because borrowing constraints may prevent households from choosing their optimal value of housing stock, it has a negative impact on the ownership rate.

[19] I argue that this literature has little economic founding since it seldom seeks to explain why renting or owning yields different utilities for the various household categories.

[20] While this issue has largely been addressed in the U.S. (e.g., Kain and Quigley 1972, Li 1977, or Gyourko and Linneman, 1996), such works are less frequent in France since ethnicity remains a “hot topic”.

[21] In the second-hand property market, transaction costs represent 14% of the transaction amount in France, 12% in the U.S. (Laferrère and Le Blanc 2006). In the rental market, they typically add up to one month worth of rent.

- The **risk** carried by housing prices (Turner 2003), income (Diaz-Serrano 2005), or rents (Sinai and Souleles 2005). In the first two cases, risk reduces the odds of home ownership for risk-averse households. Inversely, uncertainty on rents increases them. When two of these elements carry uncertainty, risk insurance mechanisms may arise. This is the case when income is correlated with rents (Ortalo-Magné and Rady 2002) or housing prices (Davidoff 2006). In the latter (former) case, the propensity to home ownership (tenancy) increases because housing prices (rents) serve as an insurance mechanism against income shocks.

b) Limitations of standard approaches and unaddressed issues

Despite the significant advances made concerning the ins and outs of the tenure choice, four limitations must be highlighted.

Firstly, Gobillon (2008) illustrates in the case of borrowing constraints that some factors may have a more important impact in hindering residential mobility rather than in altering the household tenure decision (→ *2.1.3d)*). Consequently, it is important to **consider the decision to move and the tenure choice simultaneously**.

Secondly, the choice of applying for **social housing** has yet to be properly addressed by this field of research. Most of the literature gives little attention to social housing,[22] and only considers owner-occupiers and private renters. As far as France is concerned, social housing is characterized by eligibility rules and a potentially long waiting period before the acceptance of the application. Besides, while the household enjoys cheaper rents than in the unregulated market, it has to choose among a limited number of options, barring any precise pick of dwelling characteristics.[23] Lastly, social housing units are often located in lower quality environments. All these aspects differentiate social housing from the private rental market and render current models irrelevant, at least in the French context. Among the few works on this subject, Magnan and Plateau (2004) and Laferrère (2008) underline the low incentives for social tenants to move towards the property market considering the low level of rents they benefit from. But they fail to analyze how these households ended up in social housing in the first place.

Thirdly, there exist several other factors which may influence the household decision and are difficult to test in practice. This includes the role of ownership as an **edge against inflation** (Kain and Quigley 1972), or the freedom it provides as regards the way to accommodate, decorate, and do works in one's home (Hubert 2006, Coulson and Fisher 2009). Moreover, while most of the models are based on sound financial and economic mechanisms that affect

[22] Anas and Cho (1985) is one exception. However, being an extension of the applied model CATLAS to include the various forms of social housing in Sweden, it is closer to urban modeling than to housing economics.

[23] That is unless you have connections with your city mayor…

the household decision, tenure choice may stem from less pragmatic reasons.[24] Households could excessively fear being homeless, especially after their retirement, which drives them to acquire their own home. Ownership also has an **affective dimension** in our societies based on consumption and indeed ownership, inclining individuals towards this form of tenure. Lastly, many households consider rents as "money wasted" in a simplistic but widespread way of thinking (since rents are but the counterpart of monthly payments of home loans). While the significance of these rationales has yet to be assessed, it is clear that the tenure choice is generally more than just the outcome of a complex financial analysis.

Lastly, **available housing supply** is seldom considered in the literature on tenure choice. This is detrimental to the quality of results inasmuch as household may opt for ownership because the rental market does not offer dwellings matching their needs (Taffin 1987). The **role of space** is another shortcoming, as stressed by Hilber (2005) when he claims that "*research about the role of location specific factors as determinants of the homeownership status of properties is a widely underdeveloped area*".[25]

2.2.2 A disaggregate approach to the choice of dwelling characteristics: discrete choice theory

Following the pioneering work of Luce (1959), completed by the equally seminal one of McFadden (1973), the use of discrete choice theory has quickly spread to various fields of research, such as the analysis of travel demand (cf. Ben-Akiva and Lerman 1985). As far as housing demand is concerned, the early contributions of Quigley (1976), Lerman (1977), and McFadden (1978) have set the basis for the analysis of residential choices in this theoretical framework, which I am now going to present. [26]

a) Basic theoretical set-up

Discrete choice theory owes its name to the fact that it addresses the situation where an individual must choose among a **finite number of well-identified options**. Each of the N options yields a different utility, which is given in the case of option i by:

[24] Le Blanc and Lagarenne (2004) argue that were it not the case, household portfolios would be more diversified than the way they are now. See also Magnan and Plateau (2004) on this point.

[25] While Hilber (2005) constitutes a noteworthy exception by tackling the role of various urban amenities on the home ownership rate, the analysis focuses on uncertainty issues (more precisely on the relationship between the neighborhood externality risk and housing price volatility, and its impact on the homeownership rate). The extent of neighborhood externality risks and their influence on housing prices have yet to be confirmed, however.

[26] This subsection only intends to give an overview of discrete choice theory and focuses instead on applications to the housing market. For more on this topic, see the reference book by Anderson, de Palma, and Thisse (1992).

$$\boldsymbol{U_i = \bar{U}_i + \varepsilon_i} \quad \text{(DC1)}$$

where ε_i is a centered random variable and $\bar{U}_i$ the **strict** (or deterministic) **utility** of option *i*. Assuming a linear utility function, (*DC1*) can be rewritten as:

$$\boldsymbol{U_i = \sum_{k=1}^{K} \beta^k X_i^k + \varepsilon_i} \quad \text{(DC2)}$$

where $\left(X_i^k\right)_{k\in[1,K]}$ is the vector of the characteristics of option *i*, and $(\beta^k)_{k\in[1,K]}$ the set of parameters of the utility function measuring how individuals value each one of these. Given the assumption that individuals are rational and seek to maximize their utility, this leads to the following maximization problem:

$$\boldsymbol{\max_{i\in[1,N]} \bar{U}_i + \varepsilon_i} \quad \text{(DC3)}$$

When ε_i follows a **Gumbel** or **type I extreme value distribution** with variance σ^2, one can show that the probability π_i of choosing option *i* is:

$$\boldsymbol{\pi_i = \frac{e^{\theta \bar{U}_i}}{\sum_{j=1}^{N} e^{\theta \bar{U}_j}}} \quad \text{(DC4)}$$

where $\theta = \pi/\left(\sqrt{6}\sigma\right)$. This specific case is called the **multinomial logit model** (MNL). It is likely the most frequently used specification among those allowed by discrete choice theory. Let us note one last important finding, which is that the expected utility is given by the following formula, named log-sum:

$$\boldsymbol{\mathbb{E}\left(\max_{i\in[1,N]} U_i\right) = \frac{1}{\theta} ln \sum_{j=1}^{N} e^{\theta \bar{U}_j}} \quad \text{(DC5)}$$

b) Assumptions and extensions

The MNL specification holds several assumptions which are discussed at length in Skaburskis (1999). Among these, the assumption that the random error terms $(\varepsilon_i)_{i\in[1,N]}$ are independent and identically distributed (i.i.d.) and follow a Gumbel distribution is probably the most often discussed. As a matter of fact, a corollary of this assumption is what Luce calls the "***independence from irrelevant alternatives***" (Luce 1959) or IIA, meaning that "*the relative*

odds of two alternatives are independent of the attributes, or even the availability, of any other alternative" (Mc Fadden 1978).

Besides the IIA, another direct consequence of the above assumption is that the random error terms are uncorrelated. This point entails a serious shortcoming, first enounced by Debreu under the form of the **blue bus/red bus paradox** (Debreu 1960). Alternative specifications enable one to overcome this difficulty (e.g., nested models, network GEV models), but often at the cost of greater complexity.[27]

c) Application of discrete choice theory to the housing market

Discrete choice theory can be applied to a vast amount of issues, ranging from the sole choice of tenure (Li 1977) to the complete choice of all housing characteristics as is done in urban and LUTI modeling (→ *section 3*). Besides this last specific case, it is generally used to **analyze the choice of a small number of characteristics**, for instance, tenure, tenure plus building type (Cho 1997), or the decision to move completed by the tenure choice (Gobillon 2008).

A recurrent issue is to understand the process of the household residential choice. In particular, several researchers have **tested whether households establish a hierarchy between the various alternatives** by testing nested models against simple MNL models. Intriguingly, an initial overview of the literature reveals that MNL models fare better or as well as nested models (Tu 1994, Skaburkis 1999), which could stem from the limitations inherent to the nested formulation (Daly 1987). However, when alternatives are numerous, as it is the case in applied modeling, the assumption that the random error terms are uncorrelated is dubious at the least and should be thoroughly tested.

Lastly, let us note that discrete choice theory is often preferred to hedonic analysis to study individual choices, based on the claim that "*hedonic price functions provide limited information about consumer behavior*" (Cho 1997 based on Ellickson 1981). Notwithstanding, both methods provide meaningful insights into household residential preferences, and a more systematic comparative analysis of the two has yet to be done.[28]

2.2.3 Picking a bundle of housing attributes: hedonic theory is the key

Following the seminal work of Rosen (1974), a large body of literature has tackled the issue of household preferences *via* the study of housing prices. The main premise of hedonic

[27] See Garcia-Castello and Leurent (2007) for a recent review of the various specifications currently in use at the international level.

[28] See de Palma *et al.* (2009) for a first endeavor in this direction.

analysis is that households value goods for their various characteristics, and that the real estate market reflects these valuations through the formation of prices. The **housing attributes** can be intrinsic (number of rooms, home size, presence of a parking lot, etc.) or extrinsic (view, quality of the neighborhood, etc.).

Once again, this subsection only aims at a brief introduction to hedonic analysis. Presentation is mostly based on Cavailhès (2005), who offers a thoughtful survey of works on this topic.[29]

a) Basic theoretical set-up

In the framework of hedonic analysis, a household *j* with characteristics α_j maximizes a utility function including among its arguments the set of characteristics $H = (x_1, \dots, x_n)$ of the housing unit. This is formally translated as:

$$\max_{z,H} \boldsymbol{U(z, H, \alpha_j)}$$
$$\boldsymbol{s.t.\ p(H) + p_z z = Y_j} \qquad \text{(HP1)}$$

where $p(H)$ is the price of the home, Y_j the household income, and z a composite good standing for all other goods in the economy. z can be taken as the *numéraire*, meaning that its price p_z can be arbitrarily set to 1 without affecting the results.

b) The two steps of the hedonic analysis

The hedonic analysis consists in **two successive steps**:

- The first one is the estimation of **implicit prices**, i.e. the function $p(H)$.
- The second one is to estimate for any given characteristic *i* the **demand function** $x_i(p, Y_j, \alpha_j)$.

The second step is extremely rarely performed, first because of its technical complexity, secondly because it involves specific data requirements (Cavailhès 2005). Yet, this step provides the most interesting results as far as household preferences are concerned, inasmuch as it gives the price and income elasticities of any housing characteristic.

While cases of naïve estimations of the hedonic price function are rife, the first step also involves **substantial methodological difficulties**, discussed at length in Sheppard (1999). In particular, the use of linear specifications for the function $p(H)$ is frequent, even though it is not methodologically sound due to endogeneity issues (Sheppard 1999).

[29] See also Sheppard (1999) for another excellent introduction to hedonic analysis, in English to boot.

c) Applications to the housing market and discussion

The scope of issues that may be tackled using the hedonic analysis is unbelievably vast. Any amenity can be examined as long as it is correctly reported in the chosen database, which has brought about the analysis of the impact of elements such as the view afforded by the location, the climate, or even the presence of jails in the neighborhood. Hedonic analysis also allows one to test one of the main predictions of the monocentric city model, which is the decrease of housing prices with distance to the CBD (→ *2.3*). [30]

Contrary to discrete choice models which are best used when dealing with a small number of options, the quality of a hedonic model is highly dependent on the level of detail, and more especially on the **inclusion of all relevant variables**. On the one hand, this leads toward a comprehensive analysis of the housing market, and the hedonic framework appears as a powerful approach to integrate all kind of housing attributes. On a more practical note, this has led to hardly comparable studies as each one has its own list of variables, which implies in turn extremely contrasted results. This point is well illustrated in Cavailhès (2005). Added to the fact that any form of misspecification, inconsistency in the data, or bad instrument can substantially undermine the quality of the estimation, this highlights all the difficulties associated with hedonic analysis.

2.3 Determinants of the location choice

Prior to the above works based on discrete choice theory or hedonic analysis, another section of the economic literature had already begun to investigate the location choice. These works generally disregard any intrinsic housing characteristics besides home size, and focus on the residential location and its connection with job location (*2.3.1* and *2.3.2*), segregation mechanisms (*2.3.3*), and all kinds of "location amenities" in general (*2.3.4*).

2.3.1 Tell me where you work, I will tell you where you live: the monocentric city model

The canonic model of urban economics, namely the **monocentric city model**, studies the **connection between employment and residential location**. The premise of this literature is that commuting is costly and thus affects the household residential choice. After exposing how this is modeled, borrowing the formalism developed in Fujita (1989), I present the main

[30] See Deschamps (2008) for a good survey of this topic

characteristics of housing demand in the monocentric urban model, and lastly discuss the assumptions and then the model in general.[31]

a) Theoretical set-up: the household maximization problem

In the "basic" version of the monocentric model, as exposed in Fujita (1989, chapter 2), housing demand is actually a **demand for land**, households being assumed to build their own home. Demand is derived from the household utility maximization problem, which takes the following form:

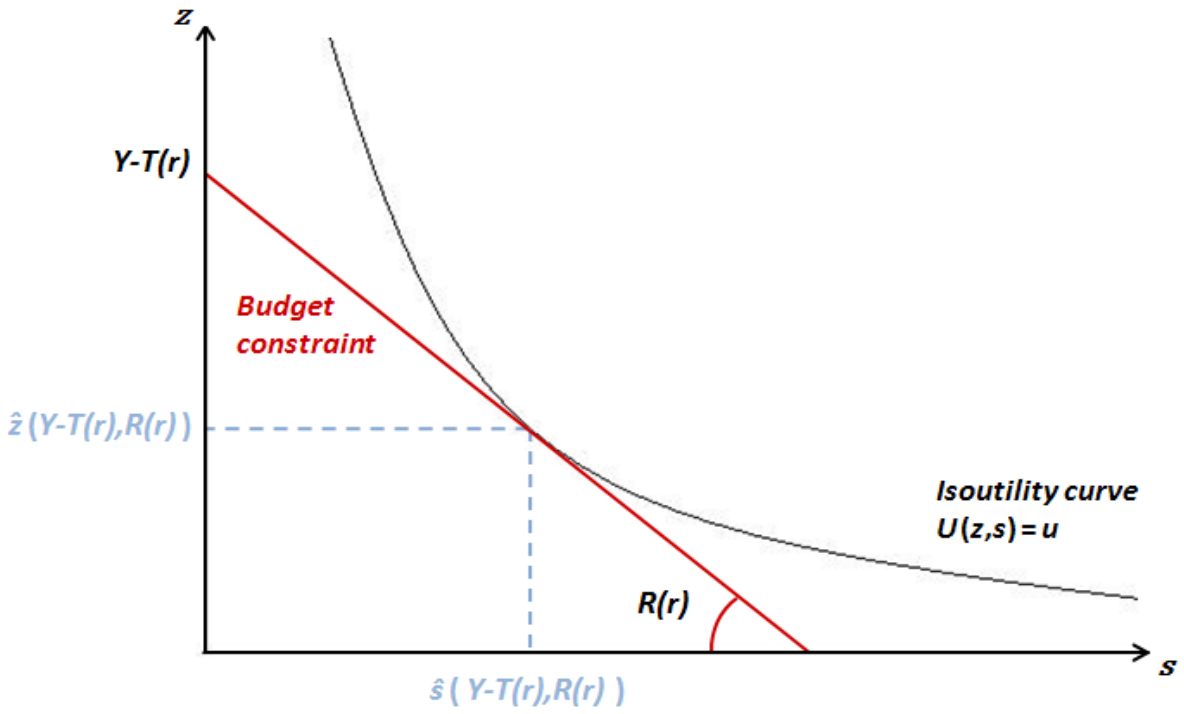
$$\max_{z,s,r} \boldsymbol{U(z,s)} \quad \boldsymbol{s.t.\ R(r)s + z + T(r) = Y} \qquad (M1)$$

Given a location r, households proceed to a trade-off between two goods: **land**, s denoting land consumption or lot size, and a **composite consumer good** standing for all other goods in the economy, the consumption of which is measured by z. This composite good is taken as the *numéraire*. Relative income and relative land price at location r are denoted by Y and $R(r)$, respectively. In this simplified version of the monocentric model, **demand for accessibility** is encapsulated in the budget constraint, which incorporates a commuting cost $T(r)$ to the Central Business District (CBD).

When *r* is fixed, the household maximization problem is equivalent to the standard case of consumer theory. It can be solved graphically using the budget constraint line and indifference curves (*Figure 2*).

[31] Presentation of the monocentric model owes much to Fujita (1989) and Fujita and Thisse (2003).

Figure 2 The household maximization problem



At location r, household disposable income is $Y - T(r)$ *and land rent* $R(r)$*. This leads to the red budget constraint line. Utility is maximized when the isoutility curve is tangent to the budget line, with the corresponding solution (ŝ,ẑ).*

Analytical derivation gives the Marshallian demand for land as a function of disposable income $Y - T(r)$ and land rent $R(r)$: [32]

$$\hat{\boldsymbol{s}}\big(\boldsymbol{Y}-\boldsymbol{T}(\boldsymbol{r}),\boldsymbol{R}(\boldsymbol{r})\big) = \underset{\substack{\boldsymbol{z},\boldsymbol{s} \\ \boldsymbol{R}(\boldsymbol{r})\boldsymbol{s}+\boldsymbol{z}=\boldsymbol{Y}-\boldsymbol{T}(\boldsymbol{r})}}{\operatorname{argmax}} \boldsymbol{U}(\boldsymbol{z},\boldsymbol{s}) \qquad (M2)$$

The household then chooses its location by maximizing the optimal utility solution to the previous problem over feasible locations. This is formally translated as:

$$\max_{\boldsymbol{r}}\left\{\max_{\substack{\boldsymbol{z},\boldsymbol{s} \\ \boldsymbol{R}(\boldsymbol{r})\boldsymbol{s}+\boldsymbol{z}=\boldsymbol{Y}-\boldsymbol{T}(\boldsymbol{r})}} \boldsymbol{U}(\boldsymbol{z},\boldsymbol{s})\right\} = \max_{\boldsymbol{r}} \boldsymbol{V}\big(\boldsymbol{Y}-\boldsymbol{T}(\boldsymbol{r}),\boldsymbol{R}(\boldsymbol{r})\big) \qquad (M3)$$

where $V(Y,p)$ is the indirect utility function.

[32] Disposable income generally refers to household income net of tax. The use of this term in this context makes sense insomuch that transport costs are an expense over which households hold no control (besides through the location choice).

THE MONOCENTRIC CITY MODEL, A SHORT HISTORY

The paradigm of urban economics, namely the monocentric city model, aims to explain household residential choices in a metropolitan area through three main elements:

- a major spatial heterogeneity, materialized by a central point where all jobs are located, the **Central Business District**, and associated with isotropic **commuting costs**;
- a **trade-off** between three elements concerning the residential choice *per se*: **accessibility**, **space**, and a composite good;
- competition for land between city residents and the agricultural sector.

The monocentric city model originates from **Von Thünen's seminal work** on the location of agricultural activities in a plain, which he explains by the existence of a market place and the ensuing transportation costs (Von Thünen 1826). The market place, which is where farmers gather to sell their production, is assumed one to be unique, two to be in a fixed location. Transportation costs vary from one good to another and are borne by farmers.

The first main finding of the model is that activities the most sensitive to transport costs and the least land consuming are located near the market at the equilibrium land-use, when activities less sensitive to transport costs and requiring more land are located further. The second one is that **land rent decreases with distance to market place**. This stems from the increase of transport costs with distance which reduces farmers' capacity to pay for land.

Following the pioneering works of Isard (1956), Beckmann (1957), and Wingo (1961), **Alonso (1964)** developed the first monocentric city model integrating the same notion of bid rent curves as in Von Thünen's works. Various researchers have then greatly contributed to improve the monocentric city model, primarily Muth (1969), Mills (1972), and Fujita (1989), which is now a reference book concerning the theoretical aspects of the model.

b) Main characteristics of housing demand in the monocentric city model

Two elements characterize household housing demand in the monocentric model:

- location;
- **quantity** (here lot size).

Once more, the model simultaneously addresses two of the four main issues identified in introduction. The two elements are simultaneously determined, with the underlying assumption that households are **perfectly informed**. They consider all feasible options and select the optimal one in accordance with their utility function. On the other hand, the household decision to move and the choice of housing characteristics are seldom represented in this strand of literature. Few exceptions are presented further. However, the crux of the

monocentric model lies in the formation of the equilibrium rent curve, which rules over the choices of both location and lot size.

To provide more specific results about housing demand in the monocentric model, an additional assumption is necessary: the **normality of land**.[33] Given this assumption, one can show that land consumption $\hat{s}\big(Y - T(r), R(r)\big)$:

- decreases with transport costs;
- decreases with the level of land rent.[34]

The household location choice results from the trade-off between these two items. It is a trade-off, indeed, as at equilibrium land rents capitalize the accessibility of a location, and thus decrease with respect to distance to CBD (Fujita 1989).

To be thorough, let us point out one particular aspect concerning housing demand in the monocentric city model. Demand is continuous and not discrete, households being assumed to be of negligible size relatively to the whole population.[35]

c) Model assumptions: those that matter and those that do not

The monocentric city model makes various assumptions, being a simplistic yet powerful representation of reality. These are structured around key topics as a guideline for the following discussion. When an assumption is of small or moderate importance, it is explained why that is so. Otherwise, the review of the main model extensions (→ *2.3.2*) highlights to what extent results depend on each of the remaining assumptions.

Transportation system

(*T1*) The transportation network is assumed to be dense,

(*T2*) and "unimodal".

---

[33] A good is said to be "normal" when the associated demand has a positive income elasticity. This assumption is supported empirically in the case of land/housing (Fujita 1989, pp.20-21).

[34] These two results may seem trite. Yet, one should bear in mind that they are contingent on the normality assumption, and that most of the subsequent analysis of the monocentric model stems from these simple results.

[35] This point gave birth to a rich debate between theoretical economists about whether the continuous monocentric city model is well founded or not. Several attempts were made to link the continuous model to the discrete one. There are two main approaches: on the one hand, some economists such as Papageorgiou and Pines (1990) propose a transformation that sets a correspondence between continuous and discrete models on a geometric basis. On the other hand, Asami, Fujita, and Smith (1990) study asymptotic distributions of discrete models and the question of convergence between these and continuous models. Berliant (1991) argues that despite these works, several issues are not addressed. In particular, land consumption is a surface in the discrete model, while it is a density in the continuous model (households consume infinitesimal parcels of land), leading to inconsistencies. To the best of my knowledge, this debate, stimulating but highly technical, remains unresolved at the present day.

(*T3*) Transport costs include the sole monetary costs,

(*T4*) are isotropic,

(*T5*) only determined by location,

(*T6*) and increase with distance.

As far as (*T4*) and (*T6*) are concerned, the introduction of anisotropic or non-increasing transport costs should not be problematic as it merely induces a transformation of space. [36] The same holds true concerning (*T1*), which is mainly made for the sake of simplicity. (*T2*) should be understood as the fact that only one mode is available at each location. The existence of various modes throughout the city (e.g., public transit in the city center, car in the periphery) has no importance whatsoever for the model. The only thing that actually matters is the structure of transport costs. Given this point, (*T2*), (*T3*), and (*T5*) are all significant assumptions, and several extensions study how modifying them alters equilibrium patterns (→ *2.3.2*).

Housing market

(*H1*) Each household manages the construction of its house by itself. In other words, the housing industry is not represented.

(*H2*) Only the private rental sector is represented.

(*H3*) Land is owned either publicly or by absentee landlords.

(*H4*) Dwellings are perfectly homogeneous.

This time, all assumptions are clearly important (→ *2.3.2*).

Households

(*HH1*) There is only one household type, meaning that households all share the same characteristics.

(*HH2*) Households have homogeneous preferences, in the sense that their utility does not include a random component such as in random utility theory.

Once again, (*HH1*) and (*HH2*) are both important and are discussed in *2.3.2*.

[36] Since transport costs are in , locations can be indexed by instead of using polar coordinates , where *t* is the transport cost to the CBD. In this setting, usual integrations are carried out over the set of feasible *t*. must verify a few conditions, however, to ensure that exists and is finite for all .

Employment

(*E1*) All jobs are located in the CBD,

(*E2*) and there is only one type of job, yielding a fixed wage Y.

Idem.

Space

(*S1*) There exists a CBD prior to the settlement of households.

(*S2*) Space exerts influence on household residential decisions only *via* transport costs.

The preexistence of the CBD is paramount and secondary at the same time. Paramount inasmuch as it explains **why people gather in a city**. Without this spatial heterogeneity, agglomeration cannot occur based on Starrett's spatial impossibility theorem (1978).[37] Yet, it is **merely a way of explaining the existence and structure of transport costs**. When the transportation technology is not explicitly represented, it does not matter where employment is located and whether it is localized or not. The one important thing is that settling at distance *r* from a point named CBD entails the transport expense $T(r)$. Only if one wants to study specific transportation technologies (e.g., by considering congestion or various transport modes), does employment location become crucial. All in all, the CBD is generally an appropriate way to introduce transport costs in the model, no more, no less.

Regarding (*S2*), considering the role of location directly in the utility function greatly enhances the complexity of the problem, which is why utility is generally a function of *z* and *s* exclusively. The famous work of Brueckner, Thisse, and Zenou (1999) illustrates this point tellingly: the introduction of amenities in the utility function leads to multiple equilibriums, and findings remain relatively vague due to the analytical complexity.

d) Discussion

As exposed above, housing demand, which encompasses location and land consumption, chiefly depends on the following factors in the standard monocentric city model:

- job accessibility through transport monetary costs;
- the relative land rental price (trade-off between land and the composite good).

[37] This issue has brought about a vast amount of literature inquiring into the origin of cities. In an attempt to overcome the assumption of a preexistent CBD, several works endogenize the formation of city centers using agglomeration mechanisms. See the reference book of Fujita and Thisse (2002 in English / 2003 in French), or more recently Mori (2006).

The paradigm of urban economics thus lies in the **trade-off between accessibility and space**. The search for accessibility leads to higher population densities, whereas the yearning for residential space exerts the opposite effect.[38] In this simplified framework, **transport is central in influencing residential decisions**.

As a result, the monocentric city model is a powerful tool to understand how evolutions in the transportation system have shaped cities (e.g. Gin and Sonstelie 1992). Comparative statics, first performed by Wheaton (1974), also give interesting insights into the role of population and economic growth in urban sprawl. As a matter of fact, two predictions of the monocentric city model have led to intensive empirical testing. The first one is the capitalization of accessibility by real estate prices. The second one is the impact of various variables on the density curve (primarily the fact that it decreases with distance to CBD, but also the effect of population, income, and so on).[39]

2.3.2 Extensions of the monocentric city model

Because this was still not enough, many works proved the usefulness of the monocentric framework by extending the model to take other key economic mechanisms into account. Several major extensions are now outlined, structured according to the above guideline.

a) Transportation system

A first set of extensions has improved the representation of the transportation system and tested how it changes results. Two main issues are often addressed: the co-existence of various transport technologies, hence addressing (*T1*) and (*T2*), and congestion (*T5*).

A good representative of the first strand is provided by Anas and Moses (1979), who study the combination of a dense secondary transportation network with a primary network that is both sparse and radial (representing mass transit or expressways). They show that various urban forms can emerge at the equilibrium land-use depending on the characteristics of each network, and determine the areas of prevalence of each mode. The fundamentals of the model remain unchanged, however.

On the other hand, congestion adds a new consideration in residential strategies by introducing interaction between household location choices. This point is especially cogent in the case of new radial infrastructures. While these make remote locations attractive at first, due to affordable housing and good access to the CBD, households may ultimately regret their

[38] This is in the case of transport technologies where cost increases with distance.

[39] Regarding the first point, I suggest the reader to refer to the recent work of Deschamps (2008). Otherwise, see Anas, Arnott, and Small (1998) for a brilliant discussion of the second point.

move when excess migration to the periphery results in high levels of congestion. One related issue is that of optimality based on this new externality (see Fujita 1989 or the recent contribution of De Palma *et al.* 2008).

Another important issue is that of daily travel-times and the **Value of Time (VoT)**. In the standard framework, time spent in transportation is beyond scope, while it is known to exert a significant influence on household residential decisions. The easiest way to overcome this difficulty is to replace the usual monetary cost by the **generalized cost of travel**, which incorporates a valuation of time spent in commuting. In this setup, transport costs depend on household income inasmuch as it determines the VoT (and the transport mode). The second method, more satisfactory and realistic, involves adding a **time budget constraint** to the household maximization problem. [40]

b) Employment

During the last two centuries, the development of new transport systems (mainly roads and railways) combined to lower transportation costs and increased speeds has fostered **job decentralization**.[41] Therefore, the assumption that all jobs are located in the CBD is somehow unrealistic nowadays. The monocentric urban model allows for job dispersion as long as employment conserves a circular symmetry and is less dispersed than residences, i.e. that any circle contains more jobs than houses (Solow 1973, White 1988). In this case, wages vary over location and offset differences in commuting costs.

In a different direction, a seminal work by Kain (1968) has given birth to a prolific literature on the issue of **spatial mismatch**. While this literature sheds significant light on this phenomenon from both a positive and normative point of view, it basically relies on the monocentric framework (sometimes replaced by a simplified two-zone model), introducing few new elements as far as residential strategies are concerned. This includes the role of distance to employment on available information (Wasmer and Zenou 2002) and the issue of redlining (Zenou and Boccard 2000). [42]

c) Towards a better representation of the household

A key extension concerning the representation of households lies in the introduction of **several income classes**. This extension, studied at length in Fujita (1989), is made easier by the notion of **bid rent curves**, which are now widely used in urban economics. Bid rent

[40] The first method implicitly assumes that income and monetized time are fungible, that is to say that leisure time can be considered as being equivalent to buying additional composite good *z*, which seems unrealistic. Moreover, severe difficulties arise when trying to determine the time endowment that must be added to income. The second method is exposed in Fujita 1989, pp.31-38.

[41] See Anas, Arnott, and Small (1998) about job decentralization in the U.S. and the decline of traditional CBDs.

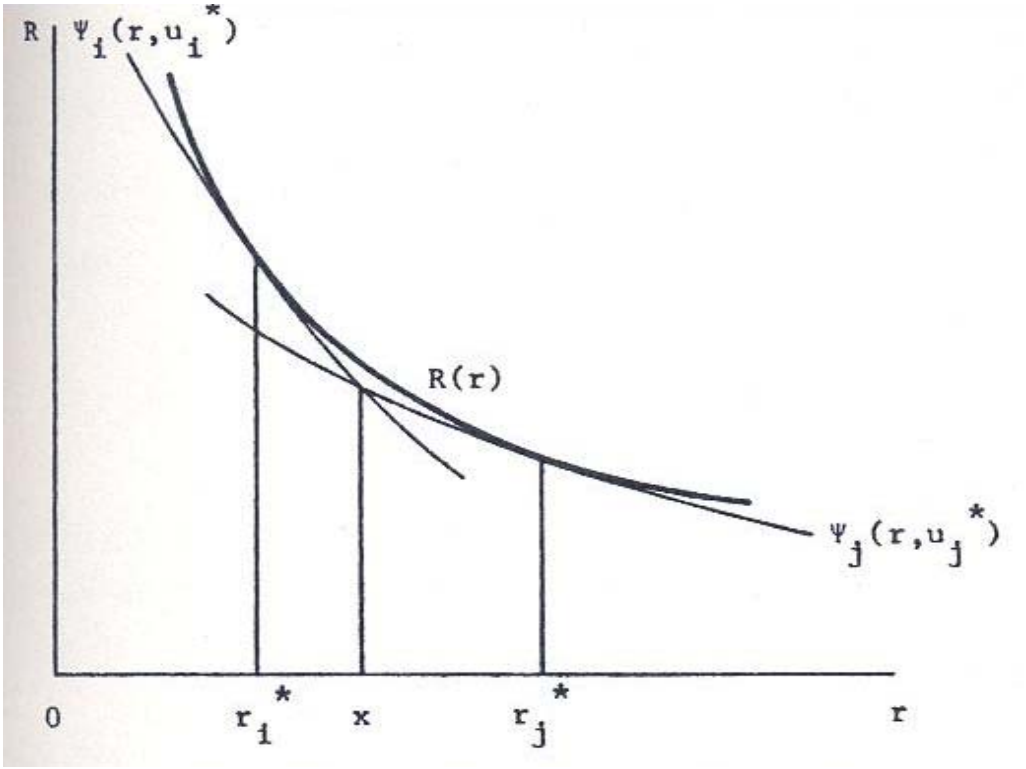
[42] See Gobillon, Selod, and Zenou (2007) for an insightful review of literature on spatial mismatch.

$\Psi_Y(r,u)$ is defined as the maximum land rent per surface unit that a household with income *Y* is willing to pay at location *r*, given a target utility *u*:

$$\boldsymbol{\Psi_Y(r,u) = \max_{z,s}\left\{\frac{Y - T(r) - z}{s}\middle| U(z,s) = u\right\}} \qquad (M4)$$

Under standard assumptions, one can show that $\Psi_Y(r,u)$ decreases with both *r* and *u*. Furthermore, the **steepness** of the bid rent curve mirrors the willingness to live close to the CBD. In theory, low income households have steeper bid rent curves than rich ones inasmuch as they are more affected by transport costs, and thus locate closer to the CBD (*Figure 3*).[43] This result is frequently mentioned to account for the phenomenon of **income sorting** and the localization of low-income households in the city centers of U.S. metropolitan areas.

Figure 3 Bid rent curve and equilibrium location, rich vs. poor households



The poor household is denoted by index i, the rich one by index j. For each household, the bid-rent curve must be tangent to the land rent curve at the optimal location. Because the bid-rent curve of the poor household is steeper than that of the rich one, the above figure illustrates why the former locates closer to the CBD than the latter.

Source: Fujita (1989)

The hypothesis of a complete income sorting, as suggested by the previous result, is challenged by the observation that income actually varies to a substantial extent within

[43] A demonstration of this result is provided in Fujita (1989), pp.28-29.

neighborhoods (Ioannides 2004), a phenomenon named **income mixing**. Various theories have been developed to account for this point, which are thoroughly reviewed in Ortalo-Magné and Rady (2008).

Another extension of the monocentric model (Fujita 1989, based on Beckmann 1973) simultaneously considers the **household structure** (size plus the number of workers) and a time–budget constraint. Using the bid rent approach, one can show households with larger proportions of workers to locate closer to the CBD than the others, inasmuch as they are more affected by commuting costs.[44]

Lastly, Anas (1990) addresses the issue of **taste heterogeneity** using discrete choice theory. He shows taste heterogeneity to reduce the pressure in the housing market, which flattens bid rent curves and leads to larger cities. When the variance of the error term tends toward zero, the model converges towards the standard monocentric model.

d) Towards a better representation of the housing stock

While various works aim to improve the representation of the household to gain further understanding about the formation of housing demand, other authors pointed out the need for advances concerning the **representation of the housing stock**. In this regard, the introduction of the housing industry by Muth (1967) is a major improvement as it allows one model supply-based retroactions in the operation of the housing market. This modification does not modify the household location behavior, however.

An insightful extension of the monocentric urban model is proposed by Brueckner and Rosenthal (2006), who argue the **age of the housing stock** to be a decisive variable to understand the patterns of income sorting. In fact, this argument is not recent and is better known as the hypothesis of **filtering**, which has been extensively documented.[45] The basic idea is that as the quality of a building decreases with time, from an absolute as well as relative point of view inasmuch as new buildings are usually better equipped. As a result, the income of the residents progressively goes decreasing as households succeed to one another, until the building is only inhabited by low-income households. When it occurs, urban renewal leads to gentrification and the eviction of the former inhabitants, allowing the cycle to start anew.

[44] Fujita (1989) shows this result in the case of a log–linear utility function and in the absence of nonwage revenues.

[45] See Olsen (1969) for an introduction to this notion.

e) Taxation

The introduction of taxation in the monocentric city model is likely one of the simplest extensions. Fujita (1989, pp.83-88) discusses distortions brought about by basic tax systems, which are flat rate or proportional taxations. Mainly, addition of taxes results in lower utility at equilibrium, lower housing demand and thus a smaller city.

2.3.3 Tell me who you are, I will tell you who you live with: models of segregation and social interaction

Alongside the development of the monocentric literature, research developed in a different direction to explore another important aspect of the residential decision, which is the **choice of neighborhood**. The issue of segregation in the U.S. has clearly been central in accounting for the development of this literature. Unlike the monocentric city model, the transport system is seldom represented and the choice of housing quantity is often overlooked. In other words, among the four main constituents of housing demand, the emphasis is wholly put on the location choice, and all other issues are disregarded. A presentation of three seminal works pertaining to this strand of literature as well as some of their extensions ensues.

a) Schelling's model of segregation

With his famous games taking place on either a line or a 2-dimensional chess board, Schelling (1969, 1971) provides a meaningful insight into the dynamics of settlement. He shows how very **specific patterns such as complete segregation can stem from decentralized decisions**, thereby indicating a form of auto-organization.

The model studies the impact of neighborhood composition on location choices. Two types of households are considered, differing only by their color (black or white). Individual housing demand is unitary,[46] and location is chosen on the sole basis of neighborhood composition. At each period, households assess whether they are satisfied with their current situation. If not, they move to the closest available and satisfactory location, until an equilibrium solution is reached. Schelling shows **complete segregation** to be the **typical outcome** of this game, individuals of the same group localizing in either one large district or a collection of clusters, which are the formal equivalent of "ghettos". The crux of the model is that even minor forms of aversion to the other group can ultimately lead to perfect segregation. [47]

[46] One household equals one housing unit, with the underlying assumption of indivisibility of the housing good.

[47] In Schelling's original model, the rule stipulates that black (white) households do not want to live in white (black) ghettos. More specifically, if the share of neighbors of the other color exceeds a specified amount, households locate elsewhere. This means that households do exhibit some propensity to segregation, but still tolerate the other color to a more or less important extent. Emergence of perfect segregation under this context is likely Schelling's model most striking result. Further works have even showed that preference for

This simple model proves powerful to explain the emergence of segregation in a relatively realistic dynamic setting. Furthermore, additional developments by Schelling shed light onto the emergence or not of ghettos upon the arrival of waves of immigrants. Past a certain threshold, segregation forces are set into motion, eventually giving birth to ghettos. [48] Although primarily applied to the analysis of racial segregation, Schelling's framework allows one to examine to a certain extent any kind of preferences in terms of neighborhood composition (social groups, income-based, and so on).

b) "Good neighbors": the Becker and Murphy model

Becker and Murphy (2000) study the impact of neighborhood composition and exogenous amenities on household location choices in a standard economic framework, based on the early work of Becker (1957). Unlike Schelling's model, system dynamics are not specified. On the other hand, the model features a basic representation of the housing market, and the analysis focuses on the market equilibrium resulting from the interaction of households' residential choices.

The model takes place in a two zone setting. Two types of households, named *H* and *L*, are to settle in one of the two zones, named *A* and *B*. The willingness to pay of type *j* household to be in zone *i* takes the following form:

$$\boldsymbol{V_{j|i} = V_{j|i}(h_i, a_i)} \quad \begin{matrix} \boldsymbol{i \in (A, B)} \\ \boldsymbol{j \in (H, L)} \end{matrix} \qquad \text{(BM1)}$$

where h_i is the share of type *H* households in zone *i* and a_i the level of exogenous amenities in zone *i*. $V_{j|i}$ increases with both h_i and a_i. Contrary to the previous situation, **both household types seek the vicinity of one specific group** generating positive externalities, the *H* population. [49]

Let us disregard the issue of exogenous amenities for now, discussed further in *2.3.4*. In order to fix upon where to live, households maximize their surplus $P_i - V_{j|i}(h_i, a_i)$, where P_i is the price of a housing unit in zone *i*. As in Schelling's model, the residential choice boils down to the location choice, which depends exclusively on neighborhood composition. Housing demand is once again taken as unitary.

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racial mixing could still lead to high degrees of segregation when coupled to aversion to living in ghettos (Pancs and Vriend 2007).

[48] See the movie Gran Torino for a brilliant depiction of such a phenomenon in the U.S.

[49] This means that the presence of *H* individuals yields positive externalities for all households. One might think of rich households who attract high quality services and finance high levels of local public goods, or of well – educated and behaving communities with low levels of criminality.

When a zone has a higher concentration of *H* than the other one, the fact that *H* individuals yield positive externalities results in an **agglomeration force** which attracts all households and ultimately leads to higher housing prices. Two alternatives arise then. If the *L* group has a greater willingness to be near the *H* one than *H* individuals themselves do, the equilibrium outcome is **perfect mixing**. [50] In the opposite situation, [51] *L* individuals are excluded from the *H* ghetto, leading to **perfect segregation**. The silver lining is that the *L* group is compensated with lower housing prices in this last scenario, because of the **capitalization of the positive externality** by housing prices.

c) The Tiebout hypothesis

In his famous article "A Pure Theory of Local Expenditures" (Tiebout 1956), which originally aims to provide a non-political solution to the issue of free-riding in public economics, Tiebout proposes another economic mechanism explaining the phenomenon of segregation, and in particular income sorting. As previously, the analysis places the focus on the equilibrium rather than on dynamics, and the model intends to show the **role of the provision and financing of public services in residential choices**.

In the original version of the model, the metropolitan area is divided into various jurisdictions offering different levels of publics services at a variety of prices (tax rates). Individuals may settle in any community, with the additional assumptions of perfect mobility (i.e. no moving cost) and perfect information. The crux of the model is that **individuals have heterogeneous tastes for public services**. As a consequence, they look for communities that are in accordance with their tastes. Furthermore, the ability to pay for public services also varies across individuals as a result of income heterogeneity. The main finding of the model is that because residents can "**vote with their feet**", jurisdictions and residents will determine an equilibrium provision of local public goods in accord with residents' tastes, hence sorting population into optimum communities.

In direct line with the Tiebout hypothesis, the issue of **local taxation** is paramount in understanding household location choices, as suggest Nechyba and Walsh (2004). They argue that "*homogeneous suburban communities allow high-income households to escape redistributive central city taxation while improving the quality of public goods*" (Brueckner and Rosenthal 2006).

[50] Under this assumption, *L* individuals outbid *H* individuals in a zone with a high level of *H* population. Consequently, part of *H* individuals is forced to move to the other zone, evening the amount of *H* in each zone. This back-pulling force also ensures the stability of the equilibrium.

[51] E.g. when *H* individuals are endowed with a higher income and can thus pay more than *L* individuals to stay together.

To conclude, let us note that the Tiebout model is most accurate in suburban areas with several independent communities. The cost of moving between communities tends to be lowest in these areas, and the set of possible choices is very diverse.

2.3.4 The role of amenities

In a fashion similar to Schelling or Becker and Murphy, other economists, including Diamond (1980), Fujita (1989), and Brueckner, Thisse, and Zenou (1999), incorporate amenities into the utility function in an extended version of the monocentric city model. For the sake of brevity, the review focuses on this last work.

The standard monocentric city model is amended by integrating exogenous and endogenous amenities in the utility function, which thus becomes:

$$\boldsymbol{U = U(z, s, a, \bar{Y})} \qquad \text{(AMEN1)}$$

where a and $\bar{Y}$ measure the level of exogenous amenities and average income in the neighborhood, respectively. $\bar{Y}$ is taken as a proxy for the level of endogenous amenities. Households take a and $\bar{Y}$ as given (i.e. they exert no "market power") when choosing their location. In sum, the basic derivation of the household maximization problem remains unchanged in each location, but **the steepness of bid-rent curves is affected by the gradient of amenities**.

The introduction of amenities has a twofold impact, in a way fairly similar to what occurs in Becker and Murphy's model (2000):

- Amenities raise the level of housing prices inasmuch as households value them.
- **Spatial variations in the level of amenities may alter the equilibrium land-use**. In the present framework, if the bid-rent curve of rich households is affected to the point that it becomes steeper than that of poor households (because of high levels of amenities near the CBD), the standard pattern low-income households near the CBD, high-income ones in the suburbs, is reversed.

As stated by Brueckner, Thisse, and Zenou (1999, p.91), "the virtue of the theory is that it ties location by income to a city's idiosyncratic characteristics. It thus **predicts a multiplicity of location patterns across cities**, consistent with real-world observation". According to the authors, and based on the argument cited above, this theory explains why low-income households are localized in city centers in the U.S. when they are often evicted from these same areas in Europe, hence the title of the paper.

While this approach, very close to the one proposed by Becker and Murphy (2000), looks promising because of its seeming simplicity, it induces three major difficulties. The first one

is that it greatly increases the complexity of the analytical derivation, which forces Brueckner, Thisse, and Zenou (1999) to remain relatively vague about the domain of validity of their findings. The second one is that the presence of endogenous amenities entails **multiple equilibriums**. Lastly, the issue of **how to measure amenities** in practice remains largely unanswered.

DEFINITION AND TYPOLOGY OF AMENITIES

Amenities are any tangible or intangible benefits of a property, especially those which raise the attractiveness or value of the property or contribute to its comfort or convenience. Customarily, two types of amenities are distinguished in the economic literature:

Exogenous amenities: amenities that are not influenced by current households' residential choices, such as historical monuments, landscape, and so on.[52]

Endogenous amenities: amenities depending on neighborhood composition (through the average income level, preferences for public goods, etc.). Typical examples of endogenous amenities are public facilities, services, or the level of criminality.

Note that **neighborhood composition** is already in itself an endogenous amenity. The fact that it is originally a specific field of research accounts for the choice of presenting models of segregation and social interaction separately. Withal, inasmuch as endogenous amenities are often measured by a proxy based on the composition or average income of the neighborhood, one could argue that there is a thin line between the two.

To conclude, let us also note that while various intrinsic housing attributes are considered as amenities in everyday language (e.g. a swimming pool), the economic literature restricts the use of the term "amenity" to **extrinsic housing attributes**.

2.4 Collective decision-making within the household

In all the literature discussed thus far, the household is treated as an individual would be. Typically, the household has a single objective function that it wishes to maximize, having several variables of adjustment at its disposal to do so (e.g., location, home size), and subject to various constraints. This corresponds to a unitary vision of the household. As Donni underlines, "*there is increasing agreement, however, that economists cannot ignore the fact that most households are composed of several individuals who take part in the decision process*" (Donni, 2008).

[52] There is obviously a limit to the notion of exogeneity, the extent to which humans can alter their surroundings being unfathomable. This notion always refers to a set of assumptions, usually a scenario with no drastic change, no extraordinary event, and a timeframe limited to a few decades at the very most.

2.4.1 Collective models of the household

a) Changing the paradigm

To examine the situation where the various household members may have diverging objectives, the literature on collective models makes two assumptions:[53]

- each member has specific, generally different preferences;
- the decision-making process entails Pareto-efficient outcomes.

Formally, and assuming for the sake of exposition that the household is composed of only two household members noted *A* and *B*, efficiency of the decision-making process translates as the following maximization problem:

$$\max_{x_A, x_B, P} \mu(p, Y, s) u_A(x_A, x_B, Z) + \big(1 - \mu(\pi, Y, s)\big) u_B(x_A, x_B, Z)$$
$$s.t. \;\; p_x(x_A + x_B) + p_z Z = Y$$

where *x* is a private good consumed by both members with price p_x and *Z* a public good with price p_z. Function μ, which depends on the vector of prices *p*, household income *Y*, and a sharing rule *s*, determines the location of the household equilibrium along the Pareto frontier. It may be interpreted as the relative importance of individual *A* in the maximizing behavior of the household.

b) Differences with other approaches

Compared to standard "unitary models", collective models explicitly introduce weights in the household maximization problem. This allows any equilibrium solution along the Pareto frontier, as opposed to a unitary model which typically assumes $\mu = 1/2$.

Compared to a non-cooperative approach, where each household member behaves strategically (typically Nash), the collective model internalizes the externality stemming from the public good. This ensures efficient outcomes in all cases, contrary to the non-cooperative equilibrium.

2.4.2 The case of residential choices

There are various reasons why household members, in particular a husband and its wife, might have diverging views regarding residential choices. We can at least mention three main kinds of situation:

[53] This literature owes much to the contributions of Leuthold (1968), Manser and Brown(1980), McElroy and Horney (1981), and Chiappori (1988, 1992). See Donni (2008) for a short review of this literature.

- The decision to move might be beneficial to one spouse more than the other, in particular if it is based on professional considerations.
- The decision to either own or rent has usually a major impact on the household consumption and savings behavior for the following years. Rules of the marriage contract regarding wealth distribution in case of divorce are thus likely to influence the views of each member regarding this decision, and potentially generate conflicts.
- The location choice is a typical example of diverging objectives within the household, as each member wishes to minimize its commuting time (subject to other constraints in terms of quality of the neighborhood, home size, and so on).

There is actually scarce existing literature studying residential choices using collective models, and it generally focuses on the location choice.[54] Empirical works are even rarer. In sum, the analysis of residential choices through the prism of collective decision-making remains to be done in its largest part.

[54] See Jayet (1997) for a perfect illustration of such works, and a short review of other works on this topic.

3 Residential choice and household behavior : applied modeling

Urban and housing economics have proved more than helpful in identifying most of the economic forces at work in the housing market. Yet, many urban and transportation modelers soon argued that their representation of the housing market and their findings were hardly transferrable to applied modeling, for they were too stylized.[55] These practitioners, while aware and influenced by the economic literature, still chose to distance themselves from this field and began to develop models of their own.

The first noteworthy generation of applied models is traditionally attributed to Lowry (1964). His seminal model gave rise to countless extensions, presented for the most part in Batty (1976). Based on the nomenclature proposed in DSC *et al.* (1999) and represented in **Error! Reference source not found.**, those were mostly static models: there is no notion of system dynamics, models only providing the long-term equilibrium. At some point static models were disparaged, and the most cited argument to account for this downfall states that **urban systems involving several processes with differing temporalities**, static models could not possibly be realistic. Be that as it may, it is rarely argued why this would preclude any form of long-term equilibrium or even make this notion irrelevant.[56] After Lowry, the second most influential contribution in this field was probably brought by Wilson (1974). His work led to a second wave of models, named entropic models because of their affiliation to statistical physics. Few years later, spatial-economics models made use of Lowry's and Wilson's findings and completed them by a more thorough description of the economic system based on Leontief's Input–Output framework.[57] However, entropic and spatial-economics models were soon found to be guilty of the same charge, implying that cross-sectional models could not possibly well represent the various temporalities of the urban system.[58] This last consideration resulted in the development of activity-based modeling, which focuses on "*the different processes of change which affect activities and the spaces they occupy; they are therefore the complete opposite of general equilibrium modeling*" (DSC *et al.* 1999). In particular, recent activity-based models often include micro-simulation techniques.

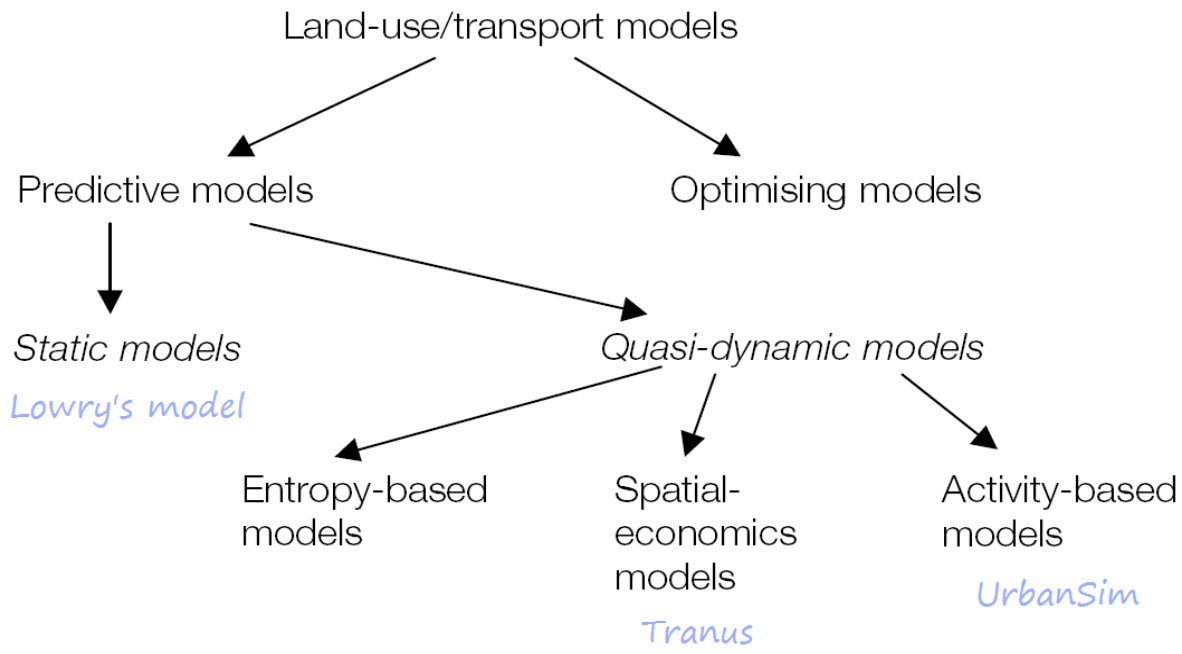
[55] The controversy over the relevance of the monocentric framework marks the epitome of this line of thought.

[56] PIRANDELLO, a LUTI model developed by Cofiroute and Vinci for the Greater Paris Region, constitutes a stimulating attempt at reinstating static modeling. Note that I concur with DSC *et al.* (1999) on their discussion about the relevance of static models.

[57] See Leontief (1986) for an introduction to input-output economics.

[58] Cross-sectional models are calibrated on one time period, and predict the spatial distribution of all activity in each time period, rather than predicting changes from one time period to the next.

Figure 4 Classification of LUTI models



Quasi-dynamic models have a treatment of time, simplified into discrete periods, and at least some of the relationships within the model include lagged variables. This is different from the traditional economic meaning of "dynamic", which implies that economic agents may react in real time to changing conditions, hence the term "quasi-dynamic".

Source: adapted from David Simmonds Consultancy & Marcial Echenique and Partners Ltd (1999)

This section describes and analyzes the representation of the household behavior in applied modeling as far as the residential choice is concerned. Considering the choice of UrbanSim as the urban model of the Sustain City project, this section starts by focusing on UrbanSim as a representative of activity-based models. Nevertheless, the second subsection draws a more general picture of the state of the art in applied modeling.

3.1 Representing the household behavior in activity-based models

Aiming to improve the representation of the housing market, which is clearly limited in static and entropic models, spatial economics models have opted for a more standard economic framework, but which led them to focus on the notion of market equilibrium. As a result, several researchers questioned the ability of these models to correctly take into account the **various temporalities of urban processes**. Their "original doubt" gave birth to quasi–dynamic **activity-based models**. These models have the following characteristics (DSC *et al.* 1999):

- Their primary goal is to analyze processes of change linked to economic activities and the space they occupy.

- Economy, activities, and demography are often modeled at a very detailed level. The same is equally true concerning relocation decisions.
- The partition of the study area is typically very refined, with zones often the size of a block.

Activity-based models can be divided further between those based on micro-simulation and the others. Famous examples of the latter category include DELTA, developed by David Simmonds and Consultancy, and the first versions of UrbanSim, developed by Paul Waddell. Micro-simulation models, which explicitly represent each individual, are more recent and have consequently less history of actual application. Among others, let us cite the stimulating ILUTE project for the Greater Toronto Area (Salvini and Miller 2005) and the model RAMBLAS (Veldhuisen *et al.*, 2000) for the Netherlands. While I do draw the distinction, one should bear in mind that only a thin line separates the two categories, which mainly involves the level of precision. Otherwise, these models are quite alike as regards their general spirit and their structure.

Considering the fact that most activity-based models share a similar structure, only differentiating themselves by more or less substantial refinements, and the choice of UrbanSim in the Sustain City project,[59] UrbanSim is chosen to illustrate its category.

3.1.1 UrbanSim: aiming for a more realistic representation of the residential process

I first describe the formation of housing demand, followed by a critical analysis of the model concerning this specific matter. A general overview of UrbanSim is to be found in Work Package 2.5.

a) The two-step formation of housing demand

UrbanSim models the residential process in two steps: the evaluation of housing needs and the residential choice *per se*. The mathematical formulation is not reported as it is less relevant in this specific case.

Step 1: Determining housing needs

The first step determines "**aspatial housing demand**", also referred to as housing needs. More specifically, this step aims to list households looking for a home, implying that demand is not located at this stage, hence the term "aspatial". In UrbanSim, aspatial housing demand at period *t* consists of:

[59] Current endeavors to develop activity-based models in France include the projects SIMAURIF and SIMBAD, both based on UrbanSim, and MOBISIM, a "new" model showing striking resemblance with this same model. See PREDIT (2008) for an outline of these projects.

- newly formed households;
- preexisting households who have decided to move.

Establishing the first household set is the very purpose of the demographic transition sub–model. It determines the variations in each stock of households, who are stratified by type (size, head of household's age, income, etc.). The user must provide the sub-model with external demographic projections though, which must at least include trends relative to the total population of the study area. The sub–model can take into account more refined projections (e.g., by household type). Otherwise, a constant demographic structure is assumed by default.

The mobility sub–model generates the second household set. It assumes constant residential mobility rates for each household type, which are estimated on an historical basis. Within each subset (based on the stratification by household type), the required number of moving households is randomly, uniformly drawn from the whole population. The combination of newly created and moving households forms the list of households looking for a home.

Step 2: The residential choice

Once aspatial demand determined, households on the list of movers make their choice one after the other among the set of vacant dwellings. The dwelling choice is modeled by a **multinomial logit model** (MNL) applied to a **sample of options**, randomly and uniformly drawn within the whole set of vacant dwellings.[60] Usual choice variables may be regrouped into three main categories (Waddell *et al.* 2003):

- Housing characteristics: price, development type (density, land-use mix), housing age.
- Urban design-scale (local accessibility): neighborhood land-use mix and density, employment level of the neighborhood.
- Regional accessibility: accessibility to populations and to services, travel time to the CBD and to the nearest airport.

Although this list is the standard set of variables used to estimate the location model, the user can easily replace it with his own list, meaning that UrbanSim offers a relatively flexible structure in this regard.

b) A marginalist approach to housing demand

The primary characteristic of activity-based models is that at each period, they only treat **"marginal housing demand"**. Unlike all other LUTI models, activity-based models focus on

[60] Estimation of the MNL can be carried out in a stratified way (one estimation per household type) or on the whole household set by introducing interaction terms when necessary, this last option being most often used.

the fraction of households who decide to be active on the housing market at a given period. In UrbanSim, those are newly created households and "movers".

Let us consider more carefully these two sets of households. As regards newly created households, one can note that the demographic model is external to UrbanSim. This precludes any retroaction from the housing market onto the general demographic structure or onto household composition, which is a first shortcoming.[61] As far as the second household set is concerned, it is based on the strong assumption of a constant share of movers within each household type, who are randomly picked to boot. This implies that **no economic consideration underlies the decision to move**.[62]

c) A two-step decision tree

A second key characteristic of activity-based models is the **independence between the decision to move and the residential choice**, which constitute the two and only steps of the decision tree. In comparison to **Error! Reference source not found.**, the tree has been rather pruned… The separation of these two decisions is blatant in the architecture of UrbanSim (see Work Package 2.5). The demographic transition and mobility modules deal with the decision to move and the location choice module with the residential choice. This postulate might seem crude, as it drastically reduces interactions between housing demand and supply. Indeed, separating the two issues is tantamount to considering that households decide whether to move or not without considering the current available supply.

Lee and Waddell (2010) endeavor to address this limitation by linking the decision to move and the residential choice within a two-tier nested MNL model structure. This approach, presented in greater detail in Work Package 2.4, represents a promising step toward a better representation of the decision tree and of the interactions between each elemental decision.

d) The residential choice: multinomial logit models, again and again

The residential choice is deeply rooted in discrete choice theory, once again relying on the use of multinomial logit models, which ensures micro-economic consistency. Unlike TRANUS, the utility function includes several variables however, the choice of which was strongly influenced by the economic literature described in *section II*. This encompasses market conditions (price), dwelling characteristics (size, age), and lastly neighborhood characteristics

[61] Among other things, housing prices could exert an influence on household size (e.g., as children wait longer to leave the family home or share apartments as coping strategies.) or on the number of children.

[62] Waddell (200x) did test endogenizing the decision to move based on utilitarian considerations, but found the test to be unsuccessful in the sense that it did not improve the explanatory power of the model. Notwithstanding, I think that this matter should be investigated more thoroughly in order to understand and take into account **spatial variations in household residential mobility**. Among other things, this could include the influence of a decrease in accessibility or in neighborhood quality on the household decision to move.

(including various measures of accessibility). The presence of price and transport variables allows UrbanSim to represent the **space–accessibility trade–off**, while the accessibility to population term enables taking into account some forms of amenities, and thereby modeling segregation to some extent.[63]

Unlike previous models, the **quality of the neighborhood** is considered through "urban design-scale" variables, namely land-use mix, density, and employment level. Concerning the first one, Waddell *et al.* (2003) find households to prefer residential or mixed neighborhoods to industrial ones, in accordance with intuition. On the other hand, the choice of the last two variables seems controversial. First, employment levels might be strongly correlated with regional measures of accessibility, as well as with density. This last variable might also lead to endogeneity issues. To conclude on this point, let us note that the mean housing age of the cell is another way of measuring the quality of the neighborhood, and allows representing the well-known phenomenon of filtering.

Lastly, **heterogeneity of preferences** may be modeled through the interaction of dwelling characteristic variables with household type variables, allowing one to take into account economic mechanisms such as the normality of the housing good, or more simply the influence of household composition on the residential choice.

e) Current shortcomings

Despite clear improvements with respect to the representation of the residential choice, several shortcomings remain. The first one has to do with the utility function, which includes the housing price in addition to dwelling and neighborhood characteristics. As a consequence, **it is unclear whether this is a direct or indirect utility function**. Besides, the housing price should capitalize most of the amenities, meaning that such a formulation necessarily involves endogeneity issues (unless assuming that prices substantially diverge from their equilibrium value).

Secondly, the choice of a multinomial model implies that there is no correlation between alternatives. In plain words, there is **no structuring or prioritizing of choices** (such as can be found for instance in nested logit models). Numerous empirical works challenge this assumption in the case of the housing market.[64] As a matter of fact, it seems quite obvious that one can establish a hierarchy among all the decisions variables included in the location choice model. The number of rooms, the type of tenure, and the housing type are usually a more important factor than the travel time to the airport.

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[63] Refer to Coulombel (2006) for a longer discussion about the choice of variables and potential issues.

[64] To cite only one, Gobillon (2001) reports that 76% of households making a short-distance move state that the primary purpose behind this move is linked to one or a combination of the three factors indicated further, that is, home size, housing tenure, or housing type; results are based on the ECHP survey.

Lastly, the choice of sampling alternatives reflects the premise that households are imperfectly informed of the available supply in the housing market. Though cogent this postulate might seem, the issue lies in the sampling method itself. The subset of alternatives is randomly and uniformly drawn from the whole set of vacant dwellings, **disregarding any strategic consideration in the search process** of the household. Furthermore, this might occasion a residential utility loss for the household compared to its previous location. While this point is not necessarily problematic when considering constrained moves (change of workplace, end of lease, etc.), it is so when the motive underlying the move is the very increase of one's quality of life.

3.2 A critical analysis of the state of the art in luti modeling

3.2.1 The hegemony of discrete choice theory

A first striking trend in urban modeling is that **it constantly aims toward a better representation of the housing market**, be it regarding the demand side or the supply one (although a substantial amount of work remains to be done concerning supply). Micro-economic founding has become a key concern when developing a LUTI model, leading to explicit representations of the household as an economic agent and of the residential process.

Secondly, as far as I know, **all the latest models rely on discrete choice theory**; multinomial logit models are especially rife in this field. Although this theoretical setting seems fitting for the housing market, it is founded on the central assumption of a utility-maximizing household. However, the housing market has many specificities, including the affective dimension a home has for households, or the difficulty of getting accurate information about the various dwelling attributes (intrinsic and extrinsic) prior to the actual moving in. Furthermore, the residential choice may sometimes be made with a sense of urgency (end of a lease, etc.). All these elements **challenge the postulate of utility maximization** to some extent. An interesting ongoing research in this field investigates the relevancy of applying prospect theory to the residential choice so as to improve the representation of the household behavior.[65]

3.2.2 The residential process: still simple decision trees

In most models so far, the decision tree of the residential process is relatively basic. It typically involves only two successive decisions: in the case of "micro-oriented" models (i.e. activity-based models), the decision to move precedes the residential choice, whereas "macro-

[65] See Bilal *et al.* (2009).

oriented" models represent first the location choice, then the dwelling choice.[66] Moreover, the two decisions are usually modeled independently. For activity-based models, the ensuing shortcomings were discussed in *3.1.1c*) . For "macro-oriented" models, this two-step structure boils down to considering that the location choice is paramount, while the residential choice only comes next. In other words: "location, location, location". At first, this could seem oversimplistic. However, zones are typically large in macro-oriented models, meaning that one will generally find a relatively diverse housing stock in his zone, and thus an appropriate match. As a result, this assumption might not be so off the point after all, but should still be appropriately tested.

What drawbacks do such simple decision trees involve for activity-based models? First, maintenance or home improvements are not considered as an option. As a result, residential mobility is likely overestimated in times of recession or high housing prices. Secondly, the home search process is seldom modeled.[67] Although this probably affects the system dynamics rather than the long term equilibrium,[68] the specific impact of not representing this process has yet to be assessed. **The most problematic point is likely the independence between the decision to move and the residential choice *per se***, as it is clear that households behave strategically in the housing market, unless being forced to move with no forewarning. The recent contribution of Lee and Waddell (2010) is a promising way in this regard.

3.2.3 The decision to move: a neglected issue in applied modeling

The **decision to move** is undoubtedly **the most neglected aspect** in the residential process, most models putting much more emphasis on the location choice. This point is not trivial, for it is not quite clear why the transportation system would have a stronger influence on residential choices than on residential mobility, which is the very implicit assumption behind this choice of priorities. Quasi-dynamic macro-oriented models have quite an awkward standing in this regard, as they waver between a long-term equilibrium approach and the need to represent some dynamics. Fulfilling this latter task is usually entrusted to attractor weights, which would miraculously set the path between the successive equilibriums. Activity-based models do not fare much better in this regard, and there is still but little interest in applied

[66] Note that some "macro-oriented" models do not represent the dwelling choice at all, e.g., the Garin-Lowry model and several entropic models.

[67] Search behaviors have been investigated by the ILUTE model (Bilal *et al.* 2009).

[68] If one assumes that the home search process becomes more efficient with time as households learn more about their environment, in the end these would find the relevant alternatives.

modeling as to why people move,[69] or in the influence of changing conditions (in accessibility, neighborhood quality...) in this regard.[70]

3.2.4 The location choice: monocentric after all?

The above analysis has emphasized the influence of urban and housing economics on applied modeling. Indeed, and this holds especially true for activity-based models, the use of discrete choice theory allows for flexible specifications of the utility function; as a result, **one can easily incorporate the latest findings from the economic literature**, which is constantly evolving. Scientific reviews such as *Urban Studies* include numerous works addressing the residential choice based on discrete choice theory, and modelers can draw on this whole body of literature to specify their model.

Among economic works, the **monocentric model holds a certain place** as it is a systematic reference for LUTI models. Most models actually put strong emphasis on the space-accessibility trade-off, sometimes being the one and only location principle for households. Except for the last extreme case, this seems befitting as LUTI models aim to represent interactions between transport and land-use, which is the very purpose of the monocentric framework. Notwithstanding, this raises an important issue, that is **which of actual commuting time or accessibility is the most relevant decision variable** as far as household residential strategies are concerned. In all LUTI models of my knowledge, the modeling framework determines the choice. When a workplace is explicitly assigned to households, the commuting time is used, otherwise an accessibility measure is chosen instead. It is rarely argued which measure should be preferred and resulting caveats.

In addition to the above elements, several issues continue to undermine the current representation of the household residential choice. First, financial considerations are left out of the picture. Among other things, the **role of expectations** with respect to future housing prices and the prospect of a capital gain are not represented. Following this line of thought, the tenure choice includes no strategic consideration such as discussed in the economic literature (e.g., as a way to insure oneself against inflation, → *2.2.1a)*). Secondly, and this will end the list, **the introduction of the housing price as a way to compensate for the missing budget constraint seems highly controversial** in regard to the twofold issue of incoherency and endogeneity (→ *3.1.1e*) and Work Package 2.4).

[69] Once again, ILUTE constitutes one noteworthy exception.

[70] If your neighborhood becomes congested as a result of a public policy drastically reducing road capacity to promote an already congested public transit system, to the point that all you can hear at peak hour is horning cars in an urge to move forward, you might want to leave, right?

4 Conclusions

The state of the art in the representation of households' behaviors with respect to the residential choice has brought several points to light.

First, there still lacks a comprehensive vision of the whole residential process. While the economic literature has shed light onto most important matters in this field (to a more or less important degree though), it usually focuses on the question at hand and makes substantial simplifying assumptions to do so. In particular, at the present day there remain two significant gaps in the theory:

- one is the link between the dynamics of residential mobility and the spatial aspects of the residential choice;
- the other one is the failure to take both dimensions of housing into account in the consumer program (i.e. as a consumption good and an investment one).

Secondly, the unitary vision of the household keeps on prevailing in the economic literature on housing as well as in applied modeling. The question of how to cope with potentially diverging objectives regarding for instance the residential location choice is largely unaddressed as for now, and the household is typically assumed to maximize a comprehensive utility function.

Last but not least, applied modeling was and is still deeply influenced by economic works, starting with urban economics, and closely followed by discrete choice theory. The former has greatly shaped the representation of the household location choice, in particular through the price – accessibility trade-off, while the latter has proved central in bringing micro-economic founding to applied models. Discrete choice theory also offers a flexible framework which allows one to introduce the elements he finds to be relevant in relation to the residential choice, in particular in the light of recent works. Recently, several works have drawn on prospect theory to try and improve the representation of the household behavior, by including features that stray from the standard, rational, utility-maximizing rationale.

The relatively open architecture of UrbanSim has the advantage of allowing the continuous development of increasingly more refined models. Ideally, all the economic mechanisms described in the review of the economic literature could be represented. However, even prior to the issues of coherence and of complexity that such an endeavor would raise, one must bear in mind the limitations of data sources regarding the housing market. Therefore, the choice of focusing in the Sustain City project on representing the collective decision of the household and the investment dimension of the housing good seems wise as well as cogent in the light of this state of the art.

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