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The Impact of Borrowing Constraints on Mobility and Tenure Choice

L. GOBILLON[1]
D. LE BLANC[2]

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[1] CREST-Laboratoire de Microéconométrie, Timbre J390, 15 Boulevard Gabriel Péri, 92245 Malakoff Cedex, France. Email : gobillon@ensae.fr

[2] CREST-INSEE, Département de la Recherche, Timbre J310, 15 Boulevard Gabriel Péri, 92245 Malakoff Cedex, France. Email : leblanc@ensae.fr

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Laurent Gobillon*
CREST

David le Blanc†
INSEE-CREST

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*CREST, Malakoff 2, 15 Boulevard Gabriel Péri, Bureau 2122, Timbre J390, 92240 MALAKOFF Cedex. email : gobillon@ensae.fr.

†INSEE-CREST, Malakoff 2, 15 Boulevard Gabriel Péri, Bureau 2020, Timbre J310, 92240 MALAKOFF Cedex. email : leblanc@ensae.fr.

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Abstract:

We study the impact of borrowing constraints on the residential mobility and housing tenure choices of households. At each period, a household chooses between staying in his current dwelling, moving and owning, and moving and renting. Moving implies paying a fixed cost. The household has access to a credit market but loans are subject to specific constraints. The model is estimated on two complementary household datasets containing common covariates. We then simulate policy reforms intended to encourage homeownership. Implementing such a policy modify the flows of household moving and owning at each period. One robust finding is that a large proportion of the "new" marginal mover-owners would, in the absence of the policy, have been stayers, rather than mover-renters. At the intensive margin, we find that policies implemented by the French government to stimulate ownership may lead to a decrease in the average value of the dwellings purchased by mover-owners, thus potentially leading to the construction of low-quality dwellings.

JEL Classification: R21; R23

Keywords: Residential Mobility; Tenure Choice; Borrowing Constraints

Résumé:

Nous étudions l'impact des contraintes d'emprunt sur la mobilité résidentielle et les choix des ménages entre propriété et location. A chaque période, les agents choisissent entre rester dans leur logement actuel, changer de logement et devenir propriétaire, et changer de logement et devenir locataire. Le modèle est estimé sur deux sources de données complémentaires. Nous simulons ensuite des mesures de politique économique destinées à favoriser l'accession à la propriété. Nous montrons que les propriétaires induits à changer de logement et à devenir propriétaires par ces mesures seraient en grande majorité restés dans leur logement précédent en l'absence de mesure. Certains dispositifs mis en oeuvre pour stimuler l'accès à la propriété se traduisent par une baisse de la valeur moyenne des logements achetés par les propriétaires.

Classification JEL : R21, R23

Mots-clefs: mobilité résidentielle, Choix propriété/location, contraintes d'emprunt.

1 Introduction

In many developed countries, homeownership is encouraged, either indirectly via provisions of the tax code which render ownership attractive (see Rosen, 1985 for a description of the U.S. case), or directly, for example in the form of State loans that complement the private market loan supply for some categories of households. Other forms of State subsidies are directly aimed at loosening the borrowing constraints that supposedly prevent low and medium-income households to finance the purchase of a home on the credit market. One such subsidy has been recently introduced in France, in the form of interest-free loans of limited amount granted to candidate owners. Although the effects of such policies on the flows into homeownership have been examined before (see references below), the question of how such policies affect the demand of housing capital of individual owners has received much less attention. However, this question is important, since in many countries another goal of Government intervention is the improvement of housing quality. A policy causing a decrease in the average demand of housing capital by owners, although stimulating ownership, could have the undesirable side effect of resulting in construction of low-quality dwellings. Roughly speaking, a policy that stimulates homeownership will result in two effects: at the intensive margin, households who would have chosen to own without the policy will still do so, but they will now be able to buy more expensive dwellings. At the extensive margin, some new households will decide to own. These marginal households are less wealthy than supramarginal ones, and buy cheaper dwellings. Empirically, the overall result on the mean value of dwellings bought by owners is uncertain. In this paper, we expose and estimate a model which can deal with these issues, and explore the empirical effects of several policies intended at stimulating homeownership.

Economic analyses of these issues traditionally focus on the impact of the credit market on the tenure choice of households (see Linneman and Wachter, 1989; Linnemann, Wachter, Megbolugbe and Cho, 1997; Duca and Rosenthal, 1994; Lafayette, Haurin and Hendershott, 1997; Haurin, Hendershott and Wachter, 1997). They highlight the fact that borrowing constraints have an important impact on the access to homeownership. However, most of the existing studies neglect the impact of those constraints on residential mobility. Any change on the credit market affects not only the tenure choice of movers, but also the number of movers. This issue is of primary importance when studying the effect of policies on homeownership. Two exceptions are Zorn (1989), and Ioannides and Kan (1996). Zorn (1989) recognizes the three-fold nature of the choice faced by households at each period: stay in the current dwelling, move and rent, move and own. Ioannides and Kan (1996) introduce a dynamic model involving the same three choices at each period. Unfortunately, the model is not analytically solvable, even without introducing borrowing constraints. Neither of them examines the effect of constraints on the demand for housing capital of mover-owners.

The aim of this paper is to estimate a utility-consistent model of mobility and tenure choice on French data. Although the correct framework for analyzing those issues is clearly an intertemporal optimization problem, the only data available to us are cross-sections including retrospective questions on mobility and past tenure. Thus, we restrict our attention to a two-period model, trying to keep the essential arbitrages from the dynamic problem. Our model embeds both the discrete choices faced by the households at each period (staying in one's current dwelling, moving and renting, moving and owning) and the continuous choices of housing stock. We explicitly introduce borrowing constraints in the maximization problem. The borrowing constraints potentially lower the utility associated to moving and owning, thus making more likely the choice of alternatives like moving and renting or staying in the current dwelling.

The model involves two basic tradeoffs. First, at each period, a household faces the following choice: either moving and being able to optimally choose the stock of housing, or staying in his current dwelling, thus saving the moving costs, but being confronted to the inadequateness of his housing stock to his current needs. This tradeoff generates a (s, S) rule, familiar to the investment literature. In words, the household will move only if his current housing stock is too far from the optimal one. Second, the household who wishes to move has to choose between rental and ownership. This is done by comparing the rental unit cost to the expected user cost of ownership (Henderson and Ioannides, 1983). The latter quantity is traditionally modelled as some function of the past movements of housing prices, of the interest rate, and of the deterioration rate (see Hendershott and Shilling, 1981, Rosen, 1979, and most of the specialized literature thereafter). We depart from this assumption, by recognizing explicitly that the user cost involves the housing price expectations of households. Hardly anything is directly known about those expectations, but, if a model with user cost is to be believed, the choices of the households between rental and ownership can be used to recover these expectations.

Coming now to the econometric specification, our model is the first, to our knowledge, to use all the information available from the data. Whereas Zorn (1989) and Ioannides and Kan (1996) explain jointly mobility and tenure choice in their empirical investigations, we explain mobility, tenure choice and the desired stock of housing capital simultaneously. Our specification allows for observed and unobserved heterogeneity in the moving costs, as well as in the expected user cost of ownership. The other sources of heterogeneity are more traditional, and concern respectively the taste for housing, current income, and wealth.

We estimate the model on two complementary French datasets: the 1996 Enquête Logement (EL) of the Institut National de la Statistique et des Etudes Economiques (INSEE) and the 1997 Enquête Patrimoine (EP) of INSEE. Both datasets contain many common conditioning variables, including household income. The EL includes many detailed retrospective questions about residential mobility and tenure choices between 1992 and 1996, but no information on wealth. Conversely, the EP is centered on the study of households' wealth, but contains no information on residential mobility. Our estimation procedure allows to efficiently recover the parameters of the model, by maximizing the joint likelihood of the two samples.

We then proceed to simulations consisting in changing supply-side parameters such as the interest rates of loans, the minimum downpayment and the maximum payment-to-income ratio imposed by the lenders. We also analyze a policy aimed at stimulating homeownership, introduced in 1996 and called Prêt à Taux Zéro, which consists in granting low and medium-income owners-to-be a loan at zero interest rate. This loan complements the other loans those households obtain on the market (see below). As this program was implemented just after the date of the survey we are using, and as figures about the number of recipients on the period 1997-2000 are available from another source, we can assess the accuracy of our model by comparing those figures to the ones predicted by the model.

Changes in credit market parameters which tend to loosen the borrowing constraints result in increased flows into ownership, the "new" mover-owners being stayers or mover-renters in the benchmark case. In all our scenarios, there are more switches from staying to moving-and-owning than switches from moving-and-renting to moving-and-owning. For example, in the case of a raise of the maximum payment-to-income ratio from 30% to 35%, the corresponding proportions are respectively 70% and 30 %.

At the intensive margin, we find that an increase in the maximum payment-to-income ratio increases the average value of the dwellings purchased by mover-owners, whereas decreasing the minimum downpayment ratio or implementing the PTZ leads to a *decrease* in this average value. These findings have important implications in terms of policy targeted at stimulating homeownership.

The paper is organized as follows. Section 2 is devoted to an exposition of the salient features of the French housing market, with a special attention to ownership. Section 3 presents the data at hand. In section 4, we expose the main features of the theoretical model. The econometric specification is derived in section 5. This section also discusses identification and estimation issues. Estimation results are given in section 6. Section 7 provides the main insights from some policy simulations. Section 8 concludes.

2 Borrowing Constraints in the Housing Market: the French Case

The main features of the French situation concerning mobility and tenure choice can be summarized as follows:

1) In France, 54 % of households own their home, but few households (between 7 and 10 %)

own extra housing stock in their portfolios. This suggests that from a pure investment point of view, housing is not a "good" asset, and that consumption motives are predominant when considering the household's attraction toward homeownership.

2) the proportion of households owning their dwelling increases with age (or with income or wealth, those being closely correlated with age); the residential trajectories of individual households often begin in the rental sector, switching to ownership in the middle of the life-cycle. This suggests the existence of borrowing constraints: the young households, having accumulated less wealth, would face more severe restrictions on the loan market for housing.

Whereas point 1) is quite specific to the French case, point 2) seems to fit to many developped countries.

As mentioned above, homeownership has always received a lot of attention from the French successive governements since the second World War. In 1977, a reform of the Housing Subsidies Program created direct subsidies to new owners, as well as a system of State provided loans, called PAP (Prêt d'Accession à la Propriété) and PC (Prêt Conventionné). Between 1977 and 1984, nearly 60 % of the new owners who needed a mortgage benefited from one of these loans. During those years, the ownership rate increased markedly, from 45 % in 1970 to 54 % in 1988. The success of the system can be attributed to the fact that the real interest rates of the PAP during this period were nearly negative, due to the very high inflation rate. From 1984 on, this situation changed. The French economic policy was focused on reducing inflation, which fell from around 11 % to 4 % in 1987 and below afterwards. In the meantime, the interest rates of the PAP and PC loans did not fall under 7 or 8 %. Thus, their real interest rates increased sharply. In the end of the eighties, default by owners who had got endebted at very high interest rates became quite common, and the private lenders became more restrictive on the attribution of loans (Lacroix, 1995). This explains why the PAP system, at the beginning of the nineties, was used by only 15 % of the new owners with a mortgage. Between 1988 and 1996, the ownership rate remained steady at about 54 %. In a context where inflation was durably reduced to 1 or 2 %, the government's new priority was to reduce the borrowing constraints faced by the less wealthy households. In the end of 1995, the PAP was replaced by a new system called Prêt à Taux Zéro (PTZ), which is still in use. The PC and the personal subsidy system remained as before. The PTZ consists in granting low and medium-income households who want to become owners a loan at zero interest rate, which complements the other loans the household obtains on the market. The PTZ is reserved to households who do not own their home yet. Moreover, it has been designed such that only households buying a new dwelling can apply for it.[1] The amount as well as the duration of the PTZ vary according to the family type as well as the income of the household. The poorer the household and the larger its size, the higher the amount of the loan. Nearly 120,000 households a year have benefited from PTZ since 1996 (Thomas and Grillon, 2001). But nothing is known about the changes caused by the PTZ in the aggregate flows into homeownership, due to the lack of adequate models. Our approach allows us to unveil some empirical aspects of the problem.

In parallel to the introduction of the PTZ, France has recently experienced a sharp reduction in mandatory fees associated to houses purchases (Secrétariat d'Etat au Logement, 1999). The reductions were aimed at stimulating mobility and ownership. In France, the costs incurred by the buyers are very heavy[2]. We leave this point aside in the present paper.

To keep the model tractable, we do not explicitly model the tax system. This would certainly be a major problem in the U.S. case. Indeed, in this country, the tax subsidies to owner-occupied housing include full deductibility of the nominal mortgage interest payments from taxable income, non taxation of imputed rental income, and various tax provisions such as exemption of housing capital gains for the elderly which make capital gains from homeownership essentially untaxed (Rosen, 1985). In this context, the impact of inflation on the user cost of homeownership has to be taken into account, and this can only be done properly by modelling the tax system (Poterba, 1984). In France, such an approach would be useful in analyzing

[1] As usual in France, subsidies to ownership are also subsidies to construction. To benefit from the PTZ in an old dwelling, the household has to undertake repairs and upgrading, for a minimal amount of 40% of the dwelling price. In practice, this threshold of 40% is too high, and hardly any households use the PTZ to buy old dwellings.

[2] These costs include mandatory taxes and fees that can reach up to 10 % of the house price, and may also include advertising and agency fees.

the pause in the increase of the ownership rate between the late eighties and the late nineties. We think it is much less useful nowadays, inflation being very low and *expected* to remain so, if only by virtue of the Maëstricht treaty which founded EU in 1992. Moreover, the French tax code is less favourable to ownership than the U.S. one. For example, in general, nominal interest payments on the mortgage are not deductible from taxable income. We therefore argue that when focusing on the impact of borrowing constraints, we need not model the tax system explicitly.

3 The data

At this point, it is necessary to briefly discuss the structure of the data at hand. Since no panel data containing all the relevant information is available, we rely on two complementary cross-sections. Both surveys are undertaken by INSEE (the French National Institute of Statistics) on representative samples of the French population. The first one is the 1996 Enquête Logement (EL). The main purpose of this survey is to accurately describe the housing stock in France, as well as the housing conditions of French households. As a consequence, the housing conditions are described in detail, together with sociodemographic descriptors of the households, including a reliable income measure and the value of the dwellings of recent owners (in fact, it is the precise buying price, including transaction costs as well as taxes, etc). Although a cross-section, the EL contains detailed retrospective questions about mobility and past tenure. For all the households who moved in during the last four years before the survey, we have detailed information regarding their situation (tenure, characteristics of the dwelling, professional status, etc.) in the dwelling they occupied 4 years ago, at the beginning of 1993. Thus, we can define as *movers* households that did not live in the same dwelling four years before the survey. However, no information exist concerning the households' wealth in the EL.

The second dataset is the 1997 Enquête Patrimoine (EP thereafter). It includes exactly the same socio-demographic characteristics as the EL, including income.[3] In addition, it contains

[3] Indeed, the data on income in the two surveys has been collected from exactly the same questionnaire, which

detailed information on the net wealth of households. Our estimation strategy will consist in using both datasets to recover the unknown parameters of the model. The common socio-demographic covariates will be used to link the two samples. Broadly speaking, the EP will serve to identify the relationship between wealth and income, which is missing in the EL (see below), whereas the EL will serve to identifiy the rest of the parameters of the model.

In this paper, we restrain ourselves to the mobility and tenure choices of the private sector renters. The main reason for this is that previous studies on French data (e.g. Gobillon, 2001) as well as preliminary investigations showed that owners tend to move very unfrequently, and are far less subject to borrowing constraints than renters. As such, they are relatively unsensitive to the type of changes in the borrowing constraints that we want to study. Also, we exclude from the sample households who do not pay any rent (for example those living in a lent dwelling, or squatting), farmers, as well as households living in the public social sector (HLM) in Metropolitan France, at the initial date (1993), and at the terminal date (1996). The households living in HLM pay much lower rents than the market rents, and thus their propensity to move is low compared with households renting in the private sector (see Le Blanc and Laferrère (2001) for a study of the French HLM system; on this issue, see also Hughes and McCormick (1981)). We also exlude from the sample "new" households, that is households just formed between 1993 and 1996. This is because we are not studying the formation of households and the leaving home decision. This would call for a specific economic model; in any case, the incentives to move are certainly very different for those households and already constituted households. Thus, we restrict the sample from the EL to the households who rented in the private sector in 1993. We also consider only private sector renters in the EP sample. This leaves us with 4140 observations in the EL sample and 3360 in the EP sample.

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insures the comparability of the two samples.

4 The model

4.1 Dynamic modelling of mobility and tenure choice

As shown in section 2, the empirical evidence suggests that mobility and tenure choices are best modelled in an intertemporal framework. In particular, considering that moving is the only way for households to adjust their stock of housing capital, moving costs prevent households to move at each period. In presence of borrowing constraints, access to homeownership can be delayed relative to the no-borrowing constraint situation, since the household has to gather a sufficient downpayment. Thus, borrowing constraints will cause some households to stay in their current dwelling for some periods, instead of moving and owning. Lastly, uncertainty on future income as well as on housing prices and rents has an impact on the choices of the household. For convenience, in what follows, we consider that the households form point expectations about future housing prices and rents.

A life-cycle model that potentially encompasses all these issues has been introduced by Ioannides and Kan (1996). We adapt their framework to our problem.[4] The objective of the household is to maximize the expected utility $E\sum_{t=0}^{T}\delta^t u(C_t, K_t)$ under some constraints to be detailed below. C_t is the period t consumption of a non-durable (Hicksian) composite good assimilated to the numeraire, K_t denotes the stock of housing capital of the dwelling occupied by the household at period t, u is the (individual-specific) single period utility function, and δ is the intertemporal discount factor.

The stock of housing capital, K_t, directly enters the utility function. This corresponds to the standard hypothesis that housing services per time unit, which are what the household cares about, are produced proportionnally to the housing stock. Moreover, we suppose that the tenure mode does not affect the production of housing services.[5]

[4]Ioannides and Kan do not explicitly introduce borrowing constraints in their theoretical model, but rather in an *ad hoc* fashion in their empirical application.

[5]Alternatively, we could allow for differences between ownership and rental, either by considering externalities of the tenure mode on the level of utility, or by considering that a housing stock k produces a flow of housing services equal to k for the renters and $\xi_1 k$ for the owners, with $\xi_1 > 1$. See also Henderson and Ioannides (1983) for alternative hypotheses on this point.

The timing of the model is the following. At the beginning of period t, the household is endowed with an income Y_t. He then decides to stay in his current dwelling or to move, and, in case of a move, he chooses a housing tenure and a stock of housing capital. We thus define the decision variable as $D_t = (d_t, C_t, K_t)$ where d_t takes three values depending on the moving and tenure choice: to stay in the current dwelling ($d_t = s$), to move and become a renter ($d_t = r$), to move and become an owner ($d_t = o$). In case the household does not move, his housing capital remains unchanged,[6] and he just decides how much to consume today and how much asset wealth to transfer to period $t+1$. In comparison, a household deciding to move has an additional degree of freedom, since he also chooses a quantity of housing capital. This additional degree of freedom is obtained at a cost C_0, the moving cost. If the household moves, he can decide either to own or rent his new house. The unit rent and the unit price of housing capital are denoted ρ_t and p_t respectively. The purchase of a house is submitted to a proportional transaction cost equal to λ times the current sale price of the new house. Thus, a moving tenant incurs the cost C_0, whereas a moving owner incurs the cost $C_0 + \lambda p_t K_t$.

Households can invest in two assets: owner-occupied housing capital, whose unit price p_t varies with time, and a riskless asset with return r_a.[7] We do not allow possession of housing capital for other uses than the household's main home. Thus, the portfolio of homeowners consists in assets and the stock of housing capital of their dwelling, while renters hold only the riskless asset. Define A_t the amount of asset wealth held by the household at the beginning of period t. We suppose that households face liquidity constraints. For renters, the constraint has the form $A_t \geqslant 0$: asset wealth cannot be negative. For owners, the constraint has the form $A_t \geqslant -p_t K_{t-1}$: negative equity on housing is not allowed. Potential owners can borrow at the riskless rate r_a on a specific credit market to finance the purchase of a dwelling. However,

[6] Adding depreciation of the housing capital is straightforward but not essential to our point, in contrast with standard models of investment. In fact, households can maintain their dwellings. From now on, we consider only the no depreciation case.

[7] In doing this, we considerably simplify the choice problem of the household. It is well known (Henderson and Ioannides, 1985) that the choice to own or to rent is driven not only by consumption motives, but also by portfolio considerations. Due to the hypotheses made here and below, in our case the portfolio side of the problem reduces to the comparison of the rate of return on the riskless asset and the expected return on housing, which consists in rents and capital gains.

they cannot borrow more than a maximum amount determined by their characteristics (see section 4.2.2 below for the discussion of the precise form of the borrowing constraints). This maximum amount in turn determines an upper bound on the stock of housing capital that can be purchased, $K_{\max}$.

At the beginning of period t, the situation of the household is fully described by the vector of state variables (A_t, K_{t-1}, j_{t-1}), where K_{t-1} is the stock of housing capital of the dwelling, chosen in period $t-1$ or before and carried through to the current period, and j_{t-1} is his housing tenure in the previous period ($j_{t-1}=0$ for a previous renter and $j_{t-1}=1$ for a previous owner).[8] Compared to a standard life-cycle consumption model, this decision problem contains two additional state variables, the previous tenure mode and the stock of housing capital of the dwelling occupied at the beginning of the period. This is due to the existence of positive moving costs, which prevent households from adjusting their housing capital (and tenure mode) perfectly at each period.

As usual with discrete-continuous dynamic choice problems, the optimization problem of the household can be expressed sequentially. Define F_s^t, F_r^t and F_o^t the period t value functions in each discrete alternative, and $F^t = \max\limits_{d \epsilon \{s,r,o\}} F_d^t$, the three Bellman equations write:

- Staying ($d_t = s$)

$$F_s^t\left(A_t, K_{t-1}, j_{t-1}\right) = \max_{C_t, K_t} \left\{u\left(C_t, K_t\right) + \delta E_t F^{t+1}\left(A_{t+1}, K_t, j_t\right)\right\}$$

$$\text{s.t.} \begin{cases} K_t = K_{t-1} \\ j_t = j_{t-1} \\ A_{t+1} = (1+r_a)\left(A_t + Y_t - C_t - \rho_t K_{t-1}\right) & \text{if } j_{t-1} = 0 \\ A_{t+1} = (1+r_a)\left(A_t + Y_t - C_t\right) & \text{if } j_{t-1} = 1 \\ A_{t+1} + j_t p_{t+1} K_t \geqslant 0 \end{cases}$$

[8] Strictly speaking, the vector of state variables should also include all the variables relevant to the determination of the maximum amount that the household can borrow at time t. As this remark is pointless in our two-period empirical framework, we do not elaborate on this point.

- Moving and renting ($d_t = r$)

$$F_r^t(A_t, K_{t-1}, j_{t-1}) = \max_{C_t, K_t} \left\{ u(C_t, K_t) + \delta E_t F^{t+1}(A_{t+1}, K_t, j_t) \right\}$$

$$\text{s.t.} \begin{cases} j_t = 0 \\ A_{t+1} = (1 + r_a)(A_t + Y_t - C_0 - C_t - \rho_t K_t) & \text{if } j_{t-1} = 0 \\ A_{t+1} = (1 + r_a)(A_t + p_t K_{t-1} + Y_t - C_0 - C_t - \rho_t K_t) & \text{if } j_{t-1} = 1 \\ A_{t+1} \geqslant 0 \end{cases}$$

- Moving and owning

$$F_o^t(A_t, K_{t-1}, j_{t-1}) = \max_{C_t, K_t} \left\{ u(C_t, K_t) + \delta E_t F^{t+1}(A_{t+1}, K_t, j_t) \right\}$$

$$\text{s.t.} \begin{cases} j_t = 1 \\ K_t \leqslant K_{\max} \\ A_{t+1} = (1 + r_a)(A_t + Y_t - C_0 - C_t - (1 + \lambda) p_t K_t) & \text{if } j_{t-1} = 0 \\ A_{t+1} = (1 + r_a)(A_t + Y_t + p_t K_{t-1} - C_0 - C_t - (1 + \lambda) p_t K_t) & \text{if } j_{t-1} = 1 \\ A_{t+1} \geqslant -p_{t+1} K_t \end{cases}$$

Note that full choice is not always available to the household, if liquidity constraints are present. For example, if the moving costs exceed current period total wealth, moving is forbidden to the agent.

4.2 A two-period version of the model

4.2.1 Objective function

Due to the quasi-static nature of our data, we have to adapt the model presented above to a two-period framework, trying to keep its essential features. We do the following simplifications. We suppose that there is no uncertainty in the model. Households receive a strictly exogeneous[9]

[9] We deliberately rule out the problem of the potential endogeneity of wages, considering the wage trajectory as certain and known by the households. Our primary concern is to explain moves which occur within job markets,

income each period and make point expectations of future housing prices. We suppose that the single period utility function takes the form $u(C_t, K_t) = \alpha \ln C_t + (1-\alpha) \ln K_t$ with $0 < \alpha < 1$. We consider that households are myopic about the future and approximate the value function at period $t+1$ as a function of their total wealth at the beginning of period $t+1$, $\ln(W_{t+1})$, where $W_{t+1} \equiv A_{t+1} + p_{t+1}K_t$ for owners, $W_{t+1} \equiv A_{t+1}$ for renters. This hypothesis can be justified by the household's ignorance about how he will use his wealth in the future. Thus, the objective function of the household takes the form:

$$\alpha \ln C_t + (1-\alpha) \ln K_t + \delta \ln W_{t+1}$$

Note that due to this definition, W_{t+1} is bound to be positive.

4.2.2 Borrowing constraints

We suppose that no borrowing constraint is imposed on potential renters. Potential owners have access to the credit market, and can borrow at the lending rate r. However, we suppose that the households only have limited access to credit. They must face two constraints imposed by the lenders. The first one, which we call the *income constraint*, relates annual repayments P and current income Y_t through the inequality $P/Y_t \leqslant e$, with e the maximum payment-to-income ratio. Suppose the loan is a constant annuity mortgage with rate r and duration N. Then, denoting M the value of the loan, we have $P = \tilde{r}M$ where $\tilde{r} = r\frac{(1+r)^N}{(1+r)^N-1}$. The income constraint then writes $M < eY_t/\tilde{r}$. The second constraint, which we call the *downpayment constraint*, relates the downpayment D to the purchase price of the house V through the inequality $D \geq aV$, with a the minimum downpayment-to-value ratio. We have $V = D + M$, so the maximum value

when no change of job occurs. Indeed, this represents a by no account negligible part of gross mobility: in France between 1993 and 1996, roughly half of the moves took place within the same local job market. Also, we are primarily concerned with the homeownership strategy of households. Empirical evidence shows that transitions from renting to owning mostly take place in the same urban area or the same job market. Thus, it seems quite reasonable to suppose that this strategy can be well described in an exogenous income setting.

a household can finance is equal to:[10]

$$V_{\max} = W_t + \min\left(\frac{e}{\tilde{r}}Y_t, \frac{1-a}{a}W_t\right) \tag{1}$$

which corresponds to a housing stock of $K_{\max} = \frac{1}{(1+\lambda)p_t}V_{\max}$.

We suppose that the first repayment occurs in the first period, so that the wealth evolution equation of mortgage holders reads:

$$A_{t+1} = (1+r_a)(W_t + Y_t - C_0 - C_t - D - P) - (M - P)(1+r)$$

We make the assumption:

$$H_1 : r = r_a$$

In this case, the household is indifferent to the mode of financing. Considering that $V = D + M = (1+\lambda)p_t K_t$, the wealth evolution equation simplifies to:

$$W_{t+1} = (1+r_a)(W_t + Y_t - C_0 - C_t - \pi_t K_t) \tag{2}$$

where $\pi_t \equiv (1+\lambda)p_t - \frac{p_{t+1}}{1+r}$ can be interpreted as the user cost of housing for mover-owners.

4.2.3 Analytical results

From now on, we focus on previous renters who will constitute our estimation population. Thus, we restrict the analysis to the households for which $j_{t-1} = 0$. We make the following assumption throughout:

$$H_2 :\ A_t + Y_t > \max(C_0, \rho_t K_{t-1})$$

It means that the sum of total wealth and current income at the beginning of period t exceeds both the rent if staying in the current dwelling and the moving costs. This assumption

[10] This form of constraint appears in Linnemann and Wachter (1989), and in many studies quoted in the introduction.

is made to insure that the household is bound neither to remain in its previous dwelling because of prohibiting moving costs, nor forced to move because he cannot pay the rent.

As before, the moving and tenure choice decisions are summarized by a discrete variable d_t taking three values corresponding to three states: staying in the current dwelling ($d_t = s$), moving and renting the new house ($d_t = r$), moving and owning the new house ($d_t = o$). The resolution of the model can be decomposed in two stages. The first is the computation of optimal values of the continuous variables in each discrete situation, which gives the corresponding optimal values of utility, F_s^t,F_r^t and F_o^t. The discrete choice problem then writes:

$$\begin{aligned}
\{d_t = s\} &\iff \left\{F_s^t - F_r^t \geq 0, F_s^t - F_o^t \geq 0\right\} \\
\{d_t = r\} &\iff \left\{F_r^t - F_s^t \geq 0, F_r^t - F_o^t \geq 0\right\} \\
\{d_t = o\} &\iff \left\{F_o^t - F_s^t \geq 0, F_o^t - F_r^t \geq 0\right\}
\end{aligned}$$

The first stage of the resolution of the model is presented in detail in Appendix A. The stayer's and the mover-renter's problems cause no difficulty. Denote K_r the optimal value of housing capital in the mover-renter problem. In the mover-owner's case, the optimal values of current consumption and housing capital differ depending on the borrowing constraint being binding or not. Denote K_o^{uc} the optimal value of housing capital that would be chosen by the household in the absence of borrowing constraints.[11] Due to Cobb-Douglas form of the objective function, K_o^{uc} and K_r are linked by the structural relation

$$\pi_t K_o^{uc} = \rho_t K_r \tag{3}$$

The second stage involves comparing the optimal utilities in the three discrete alternatives.

[11]Note that K_o^{uc} is unambiguously defined in our two-period model. If more time periods were to be considered, a serious difficulty would arise from the fact the household has to consider the possibility of binding borrowing constraints in all future periods (Zeldes, 1989).

We first address the staying/moving and renting issue, by comparing F_s^t and F_r^t. We obtain:

$$\begin{aligned} F_s^t - F_r^t = \quad & (\alpha+\delta)\ln\left(\tfrac{1-\alpha}{\alpha+\delta}\right) + (\alpha+\delta)\ln\left[\left(\tfrac{1+\delta}{1-\alpha}\right)\tfrac{K_r}{K_{t-1}} + \tfrac{C_0}{\rho_t K_{t-1}} - 1\right] \\ & -(1+\delta)\ln\left(\tfrac{K_r}{K_{t-1}}\right) \end{aligned}$$

We consider the case where the moving costs C_0 are inferior to the rent if staying $\rho_t K_{t-1}$ The model then gives a kind of (s, S) rule, familiar to the investment literature: there exist two values such that, if the desired stock of housing capital K_r lies between them, the household is better off staying than moving and renting, whereas if the desired stock of housing capital lies outside the interval delimited by these values, the household prefers to move.[12]

Figure 1 illustrates the (s, S) rule.

[*Insert Figure* 1 *here*]

For estimation purposes, the formula above is not very convenient. We introduce the optimal housing capital when moving and renting if moving costs are zero. Denote it K_r^{nc}. Then, for small moving costs and K_{t-1} not far from K_r^{nc}, we get (see Appendix A):

$$F_s^t - F_r^t \# \frac{C_0}{\rho_t K_r^{nc}} - \theta_1 \left[\ln\left(K_r^{nc}\right) - \ln\left(K_{t-1}\right)\right]^2 \tag{4}$$

with $\theta_1 \equiv \frac{(1+\delta)}{2(\alpha+\delta)}$.

Next, we look at the tenure choice when moving. We obtain:

$$\begin{aligned} F_r^t - F_o^t \quad = \quad & (1-\alpha)\ln\left(\frac{\pi_t}{\rho_t}\right) \\ & +1_{K_o^{uc} > K_{\max}}\left[(1-\alpha)\ln\left(\frac{K_o^{uc}}{K_{\max}}\right) - (\alpha+\delta)\ln\left[\frac{1+\delta}{\alpha+\delta} - \frac{1-\alpha}{\alpha+\delta}\left(\frac{K_o^{uc}}{K_{\max}}\right)\right]\right] \end{aligned}$$

[12]If $C_0 > \rho_t K_{t-1}$, there exists a unique value superior to K_{t-1} such that, if the optimal housing capital K_r lies under this value, the household prefers staying to moving and renting, whereas if the optimal capital lies above this value, the reverse is true. Thus, high moving costs prevent the household from reducing its housing consumption. This case could be considered as an artefact; it mainly arises from our considering only two periods. In this setting, the households do not have several periods to make a move profitable. However, this case could adequately describe the situation of old people, because they do not have much time left to amortize a move.

The first term applies to all households. Its sign depends on the relative magnitude of the unit rent and the expected user cost. For unconstrained households, tenure choice is driven by the relative position of ρ_t and π_t, via the wealth evolution equation. It is optimal to rent if the unit rent is lower than the user cost; if the converse inequality holds, it is optimal to own.[13] The second term applies only to constrained households, and is always positive. When the household is constrained, the impossibility to reach the optimal housing stock can offset a lower user cost. In this case, the difference of utility increases with the strength of the constraint, measured by the ratio $\frac{K_o^{uc}}{K_{\max}}$.

When K_o^{uc} is not far from $K_{\max}$, we have:

$$F_r^t - F_o^t \# \ln\left(\frac{\pi_t}{\rho_t}\right) + 1_{K_o^{uc} > K_{\max}} \theta_2 \left[\ln\left(K_o^{uc}\right) - \ln\left(K_{\max}\right)\right]^2 \tag{5}$$

with $\theta_2 \equiv \frac{(1+\delta)}{2(\alpha+\delta)} = \theta_1$.

The comparison of F_s^t and F_o^t involves no supplementary calculation, since we have $F_s^t - F_o^t = \left[F_s^t - F_r^t\right] + \left[F_r^t - F_o^t\right]$. Equations (3), (4) and (5) will be the basis of the estimation procedure presented below.

5 Econometric setting

5.1 Sources of heterogeneity

To specify the econometric model, it is convenient to classify the endogenous variables according to their observability.

First, some of the variables introduced above are never observable. It is the case of C_0, K_r^{nc}, π_t, and K_o^{uc}.

Moving costs will be modelled as the first source of heterogeneity among the households. In

[13] Note that, alternatively, if we suppose that ownership gives utility *per se* to the household, the difference $F_r^t - F_o^t$ will contain parameters and variables that reflect this difference. For example, if the instantaneous utility of ownership contains a pure externality, $u(C, K) = \ln(K^{1-\alpha} C^{\alpha} \xi)$, where $\xi \geq 1$, the consumption-housing arbitrage is not modified, but the utility difference now contains a term $-\ln \xi$.

fact, the only costs considered in the theoretical model are monetary. These costs are likely to vary very much among households. One obvious shifter of these costs is the family composition: for example, the costs are likely to be lower for singles than, say, families with small children, for whom moving means finding new schools, new childcare arrangements, and so on. One could adopt a broader view of moving costs as well, and include in these costs all the psychological costs of moving (or at least the monetarizable part of them). We specify:

$$\frac{C_0}{\rho_t K_r^{nc}} = X_1\gamma_1 + \varepsilon_1 \tag{6}$$

X_1 includes a constant term, age dummies, a dummy for being divorced and a dummy for living in couple, the number of children in 1992, the number of children born after 1992.

In order to complete the specification of equation (4), we approximate the quadratic term by $\theta_1 (\ln K_r - \ln K_{t-1})^2$, where θ_1 is a constant to be estimated. Making the approximation $K_r \simeq K_r^{nc}$ amounts to neglecting the impact of moving costs in the determination of the optimal housing stock. We obtain:

$$F_s^t - F_r^t = X_1\gamma_1 + \varepsilon_1 - \theta_1 (\ln K_r - \ln K_{t-1})^2 \tag{7}$$

Looking at equation (5), we see that if ownership generates no utility *per se*, the choice between owning and renting is driven by the expected user cost of ownership. Many authors (for example Hendershott and Shilling (1982) and subsequent studies reviewed above), when coming to empirical estimation, consider the user costs as certain and calculate it from past changes in housing prices. We believe there are many reasons to think that the households differ in their expectations about future housing prices. These differences can arise from differences in information (related to the education level, for example), from idiosyncratic optimism or pessimism, and so on. Also, insofar as the tax code contains some provisions on the deductibility of part of loan repayments, households in different tax brackets will also have different user costs, other things equal. Moreover, the expected user costs, which are unknown, can be recovered by looking at the choices of households. So, in line with Henderson and Ioannides (1986), we directly specify

$$\ln\left(\frac{\pi_t}{(1+\lambda)\,p_t}\right) = X_2\gamma_2 + \varepsilon_2 \tag{8}$$

The set of explanatory variables X_2 includes a constant, age dummies, dummies for being a foreigner, being unemployed in 1992, living in a house, living in the Greater Paris area, as well as two local variables built form the 1990 Population Census: the vacancy rate and the proportion of renters in the town of residence in 1990.

We obtain:

$$F_r^t - F_o^t = X_2\gamma_2 + \varepsilon_2 - \ln(\frac{\rho_t}{(1+\lambda)\,p_t}) + 1_{K_o^{uc}>K_{\max}}\theta_2\left[\ln\left(K_o^{uc}\right) - \ln\left(K_{\max}\right)\right]^2 \tag{9}$$

As we are particularly concerned with the correct specification of the effect of borrowing constraints, alternative specifications of equation (9) will be estimated. The main alternative specification consists in replacing the quadratic term $\theta_2\left[\ln\left(K_o^{uc}\right) - \ln\left(K_{\max}\right)\right]^2$ by a linear term $\kappa\left[\ln K_o^{uc} - \ln K_{\max}\right]$. These two specifications can be nested in a model containing both a linear and a quadratic term that will also be estimated. This allows us to choose between the three models. Another test of the model validity consists in testing the equality of the parameters θ_1 and θ_2 predicted by the theoretical model.

Other variables are observed only for some endogenously selected subsample in the EL dataset. Indeed, we observe the desired rent $L_r \equiv \rho_t K_r$ for mover-renters. Similarly, for stayers, we observe the rent corresponding to the dwelling occupied at period $t-1$, $L_{t-1} \equiv \rho_t K_{t-1}$. For mover-owners we observe the purchase value of the dwelling V. Depending on the borrowing constraint being binding or not, V is equal either to $V_{\max}$, the maximum value, or to $V_o^{uc} \equiv (1+\lambda)\,p_t K_o^{uc}$. However, the data contains no information about the prevailing regime (borrowing constraint binding or not). Thus, all we know is that $V = \min\left(V_o^{uc}, V_{\max}\right)$.

To gain some flexibility, we suppose that the desired rent can be written:

$$\ln(L_r) = X_3\gamma_3 + \phi_1 \ln Y_t + \varepsilon_3 \tag{10}$$

In this equation, current income is used as a proxy of the permanent income and the explanatory variables in X_3 accounts for taste heterogeneity. X_3 includes a constant, a dummy for the possession of a secondary home, the number of children in 1992, the number of children born after 1992, dummies for the size of the urban unit in 1992, a dummy for being a civil servant, a dummy for being divorced, and a socio-economic index of the town of residence in 1992. This index is based on a factor analysis of the socioeconomic composition of the "communes" (towns) at the 1990 Population Census (see Tabard, 1993).

Using the structural equation (3), we obtain $\ln(L_r) = \ln(\rho_t K_r) = \ln(\pi_t K_o^{uc}) = \ln\left(\frac{\pi_t}{(1+\lambda)p_t}\right) + \ln(V_o^{uc})$, so that

$$\ln(V_o^{uc}) = X_3\gamma_3 - X_2\gamma_2 + \varepsilon_3 - \varepsilon_2 \tag{11}$$

Instead of specifying an equation for net wealth, we directly specify an equation for the maximum value $V_{\max}$:

$$\ln(V_{\max}) = X_5\gamma_5 + \phi_2 \ln Y_t + \varepsilon_5 \tag{12}$$

$V_{\max}$ is calculated from income and wealth by formula (1). We worked on the basis of a composite loan reflecting the state of the market when the households decided on their new tenure. To select the term of the loan, we take the mean duration of the loans issued out between 1993 and 1996, according to the EL. We thus obtain a term $N = 14$. The interest rate chosen is the value observed for State loans PAP in the year of the move, except for stayers for whom we consider the mean value of this interest rate during the 1993-1996 period. The maximum payment-to-income ratio is taken to be $e = 30\%$, which is the official norm for the State loans and the quasi official one for private loans. The minimum downpayment is fixed at $a = 20\%$ of the dwelling value. Again, this value corresponds to the current practice in France at the beginning of the nineties.

X_5 includes some variables common to the EP and EL samples: a constant, age dummies, a dummy for living in couple and a dummy for the woman's participation in the job market, two dummies for the possession of a secondary home and for the possession of other dwellings, the socio-economic index of the town of residence in 1992, dummies for the size of the urban unit in 1992, the number of children born between 1992 and 1996. Ideally, information concerning the occurrence of events such as bequests, donations, etc., having affected the households during the period 1993-1996 should be included in equation (12). Unfortunately, this type of information is known only for mover-owners in the EL, and thus cannot be used.

Finally, L_{t-1} is known only for stayers. However, detailed characteristics of the dwelling occupied in $t-1$ are available for all households. So we specify an imputation equation of the form:

$$\ln L_{t-1} = X_6\gamma_6 + \varepsilon_6$$

X_6 includes variables relative to the dwelling occupied in 1992: dummies for the number of rooms, for the date of building, and for the size of the urban unit, the socio-economic index of the town, and a constant.

Due to the nature of our data which consist in two separate datasets containing different endogenous variables, we cannot hope to recover unrestricted correlations between all the residuals. Therefore, we impose some structure on the correlations. However, as income is observed in the two samples, we can identify the correlations between the residual of an income equation and all the other residuals. We thus introduce the following income equation:

$$\ln(Y_t) = X_4\gamma_4 + \varepsilon_4 \tag{13}$$

X_4 includes a constant, age dummies, dummies for the size of the urban unit in 1992, the highest diploma obtained by the head of the household, a dummy for living in couple, and a dummy for the woman's participation in the job market. Since the EL and the EP may not have exactly the same sample structure, we allow the parameters γ_4 and the variance of the residual ε_4 to differ between the two surveys.

The vector of residuals $(\varepsilon_1, \varepsilon_2, \varepsilon_3, \varepsilon_4, \varepsilon_5, \varepsilon_6)'$ is supposed normal, with mean zero and covariance matrix to be defined in the next section. Denote $\varepsilon_i = \lambda_i \varepsilon_4 + \eta_i$, with $E(\eta_i \varepsilon_4) = 0$, and $V(\eta_i) = \sigma_i^2$ for $i \in \{1, 2, 3, 5, 6\}$. We make the following identifying restrictions:

$$\begin{aligned} E(\eta_i \eta_5) &= 0 \quad \text{for } i \in \{1, 2, 3, 6\} \\ E(\eta_i \eta_6) &= 0 \quad \text{for } i \in \{1, 2, 3\} \end{aligned}$$

The first set of restrictions states that the only correlations we allow between the residuals of quantities estimated from the EL and quantities estimated from the EP are due to the correlations of these residual with the income variable, which is common to both datasets. Indeed, if we denote σ_4 the standard error of ε_4, we have $E(\varepsilon_i \varepsilon_5) = \lambda_i \lambda_5 \sigma_4^2$, $i \in \{1, 2, 3, 6\}$. The second set of restrictions is made for convenience. Its justification is the following: whereas X_1, X_2 and X_3 contain socio-demographic descriptors of the household, X_6 contains attributes of the dwelling (it is merely an imputation equation). ε_6 can then be interpreted as reflecting unobserved differences in quality that explain differences in rents. We suppose that all the correlations between this variable and the taste parameters are captured by the income residual.

5.2 Identification issues

To summarize, the econometric model includes the six following equations:

$$\begin{array}{lcll}
F_s^t - F_r^t & = & X_1\gamma_1 - \theta_1\left[\ln L_r - \ln L_{t-1}\right]^2 + \lambda_1\varepsilon_4 + \eta_1 & \text{(moving equation)} \\
F_r^t - F_o^t & = & X_2\gamma_2 - \ln(\frac{\rho_t}{(1+\lambda)p_t}) & \\
 & & +\theta_2.1_{V_o^{uc}>V_{\max}}\left[\ln V_o^{uc} - \ln V_{\max}\right]^2 + \lambda_2\varepsilon_4 + \eta_2 & \text{(tenure choice equation)} \\
\ln L_r & = & X_3\gamma_3 + \phi_1 \ln Y_t + \lambda_3\varepsilon_4 + \eta_3 & \text{(rent equation)} \\
\ln Y_t & = & X_4\gamma_4 + \varepsilon_4 & \text{(income equation)} \\
\ln V_{\max} & = & X_5\gamma_5 + \phi_2 \ln Y_t + \lambda_5\varepsilon_4 + \eta_5 & \text{(maximum value equation)} \\
\ln L_{t-1} & = & X_6\gamma_6 + \lambda_6\varepsilon_4 + \eta_6 & \text{(previous rent equation)}
\end{array}$$

along with a redundant equation determining V_o^{uc}:

$$\ln V_o^{uc} \quad = \quad X_3\gamma_3 - X_2\gamma_2 + (\lambda_3 - \lambda_2)\,\varepsilon_4 + \eta_3 - \eta_2 \quad \text{(unconstrained house value equation)}$$

Due to the complex relationship between the latent variables and the observed variables of the model, we find necessary to spend a little space discussing the other identification matters. This informal discussion of identification has four main points.

1) First, as income appears as an explanatory variable in the desired rent equation and in the maximum value equation, we have to impose some exclusion restrictions between the regressors X_4 of the income equation and the regressors X_3 and X_5 (similarly to instrumental variable exclusion restrictions), in order to identify λ_3, λ_5, γ_3, and γ_5.

2) Second, we observe the housing purchase value for the households of the EL sample moving and owning. The three equations $V = \min(V_o^{uc}, V_{\max})$, (12) and (11) can then be thought as a canonical disequilibrium model in which we observe for each observation the minimum between supply and demand (i.e. V in our framework), without information about the prevailing regime (i.e. $V_o^{uc} > V_{\max}$ or $V_o^{uc} < V_{\max}$). It is well known (see Laroque and Salanié (1989), Hartley and Mallela (1977)) that the normality assumption suffices to identify all the parameters in the

canonical disequilibrium model including the correlation matrix of the residuals of the demand and supply equation, under mild hypotheses, one being that at least one variable of the supply equation is excluded from the demand equation and *vice versa*. We impose these restrictions to gain some identification power even if there are not necessary, as the EP sample brings enough information to ensure the identification of the parameters. One thing to note is that *a priori* knowledge of the regime is not necessary.

3) The last problem concerns the identification of the variance parameters σ_1^2 and σ_2^2 (indeed, the parameters γ_1/σ_1 and γ_2/σ_2 are identified as in a standard discrete choice model). σ_2 is identified because of the fixed coefficient (-1) of the variable $\ln(\frac{\rho_t}{(1+\lambda)p_t})$, which comes from the structural model. In a pure utility-based discrete choice model, σ_1 is identified, see Walker (2001). In our case, the same line of argument should apply. However, to secure identification, we impose another exclusion restriction, namely that X_1 must contain a variable that does not appear in X_2.

5.3 Estimation method

The model is estimated by maximum likelihood. The contributions of observations to the likelihood depend on the sample considered. For this section, in order to distinguish the variables from their realizations, we denote with a star the variables.

First consider the observations from the EP sample. We observe draws of $(V^*_{\max}, Y^*_t)$. Thus, the contribution of these observations to the likelihood writes

$$P\left(\ln Y_t^* = \ln Y_t, \ln V^*_{\max} = \ln V_{\max}\right)$$

For the observations of the EL sample, we have to distinguish three cases:

- stayers ($d_t = s$): we observe $(d_t = s, L^*_{t-1}, Y^*_t)$. The contribution of these observations to the likelihood writes

$$P\left(F_s^t > F_o^t, F_s^t > F_r^t, \ln Y_t^* = \ln Y_t, \ln L^*_{t-1} = \ln L_{t-1}\right)$$

- mover-renters ($d_t = r$): we observe $(d_t = r, Y_t^*, L_r^*)$. The contribution of these observations to the likelihood writes

$$P\left(F_r^t > F_o^t, F_r^t > F_s^t, \ln Y_t^* = \ln Y_t, \ln L_r^* = \ln L_r\right)$$

- mover-owners ($d_t = o$): we observe $(d_t = o, Y_t^*, \min(V_o^{uc}, V_{\max}))$. The contribution of these observations to the likelihood writes

$$P\left(F_o^t > F_r^t, F_o^t > F_s^t, \ln Y_t^* = \ln Y_t, \min\left(\ln V_o^{uc}, \ln V_{\max}^*\right) = \ln V\right)$$

Due to the presence of nonlinear terms in equations (7) and (9), which include two residuals that are not always observed (in fact, they are never observed simultaneously), evaluating the likelihood function requires either numerical integration or simulation. After trying both methods, we kept simulation, since it was less time-consuming. To simulate the likelihood, we use a straightforward extension of the GHK method. The details of the calculation of the likelihood are given in Appendix B.

Due to the intricateness of the model, we proceeded in several steps. During the two preliminary steps, we jointly estimated equations (13) and (12) on the EP sample and then treated the corresponding parameters as known when dealing with the EL observations. To obtain a first set of coefficients on the EL sample, we replaced the quadratic terms in equation (7) and (9) respectively by a proxy which was integrated to the other regressors in X_1 and a linear term. This left us with a model where only linear combinations of the residuals appeared, leading to straightforward estimation. Then, we estimated the model with the quadratic terms, still treating the EP parameters as known. Finally, we estimated the full model jointly on the two samples. The two sets of parameters where very close, the only significant changes bearing (as could be expected) on some of the parameters in equation (12). The comparison of the two sets of standard errors shows that proceeding in two steps leads to invisible (or at worst negligible) underestimation of the standard errors. So, the two procedures are practically equivalent, and proceeding in two steps, which is computationally quicker, does not lead in our case to erroneous conclusions about the significance of the parameters. This estimation from two complementary samples is close in spirit to the study of Arellano and Meghir (1992), who used data from the U. K. Family Expenditure Survey and the U. K. Labour Force Survey to estimate a model of labour supply and on-the-job search. However, they stick to two-steps estimation procedures, resulting in a loss of efficiency. On the contrary, our estimation procedure allows us to efficiently recover all the parameters of the model.

6 Empirical results

6.1 Descriptive statistics

Table 1 gives some descriptive statistics on the EL sample. The households in this sample represent about 3.34 millions of households. Nearly half of them (1.6 millions) moved during the four years considered. This corresponds to an annual mobility rate of 12 %, higher than the mobility rate of the whole population, which is about 8 %. This is largely due to an age effect. Mobility declines sharply with age, and renters are on average younger than owners. Looking at the tenure choices of movers, we see that rental (1.0 millions) dominates ownership (0.6 million).

It is interesting to compare the characteristics of households who chose not to move during the period, to move and rent, and to move and own. These statistics are given in table 1. On average, stayers are much older than movers. Whereas the mean age for stayers is 48 in 1992, it falls to 35 both for mover-renters and mover-owners. Experiencing a birth during the 1993-1996 period was a strong incentive to move: 56 % of mover-owners and 34 % of mover-renters are in this case, only 15 % of stayers. The other socio-economic characteristics tend to oppose mover-owners, on one hand, to stayers and mover-renters on the other hand. Whereas the rate of households whose head lives alone is high among stayers and mover-renters (between 40 and 50%), it is much lower for mover-owners (16%). Divorce is more frequent among stayers and mover-renters. These households also have fewer children on average, and are more often foreigners. Turning to features related to the labor market, we notice that mover-owners are better off than the other households. They have higher diplomas and participate in the labor market more frequently. The participation rate in 1992 is 93 % for mover-owners, but only 66% for stayers and 85% for mover-renters. Among couples, the participation rate of women is also higher among mover-owners than among the other households. Considering the financial situation of households, mover-owners are the wealthiest. Their mean income and mean wealth are 34 and 46 thousands euro, respectively, against 24 and 37 thousands euro for mover-renters, and 22 and 28 thousands euro for stayers.[14] Finally, mover-renters pay higher rents than stayers. As they are better off, this may reflect access to higher quality or larger dwellings.

[*Insert Table* 1 *here*]

As age is a key variable when one looks at mobility, we represent figures on mobility and tenure choice as a function of age. Figure 2 shows that staying becomes the most frequent choice only after age 30. For age less than 30, whereas 25% of households stay in their house on the 1993-1996 period, 47% and 29% are mover-renters and mover-owners, respectively. By contrast, the staying rate is far higher in the 40-49 age bracket, reaching 61%. In this group, only 23% and 16% choose moving-and-renting and moving-and-owning, respectively. When moving, households mainly rent their new house until age around 45 (see Figure 3). Between 45 and 60, owning and renting are equally frequent. After 60, renting dominates again.

[*Insert Figures* 2 *and* 3 *here*]

Figure 4 gives some information about the distribution of three key variables in our model: net wealth, the maximum affordable value ($V\max$), and the observed purchase value for mover-owners[15]. The value of all these variables increases until 30. After that age, the maximum value

[14] The wealth used in the descriptive statistics of this section was imputed on the basis of the estimated coefficients of a wealth model on EP data.

[15] See footnote 13. The maximum housing value ($V\max$) was then constructed using the formula (1).

and net wealth are nearly constant until 50 and then decrease. In fact, the wealth distribution is rather flat. This is not surprising as we focus on previous renters only. Whereas the purchase value increases regularly until age 50, it then becomes messy due to lack of data. The more striking fact of these distributions is that for all ages, the purchase value is higher than the maximum housing value. This is due to a selection effect, the wealthier households being over-represented among mover-owners. It also suggests that a great proportion of households are constrained.

Figure 5 shows the proportion of households for whom the income constraint is binding in formula (1), for different values of the parameters e and a. In the baseline case ($a = .2$, $e = .3$), at all ages, more than 90 % of the households are constrained by income. When the maximum payment-to income ratio is raised to .35, the income constraint becomes less binding on average, but the effects are more visible for young households. When the minimum downpayment constraint is raised to .25, the wealth constraint becomes binding for more than 30 % of households under age 40. However, it is hard to assess on *a priori* grounds for which category of households the mobility and tenure choices will be affected most by changes in e and a.

[*Insert Figures* 4 *and* 5 *here*]

6.2 Estimation results

Recall that we estimate the model for three alternative specifications of the borrowing constraints in equation (9): with a linear term (model 1), a quadratic term (model 2) or both (model 3) (see table 2). In the most general model, the coefficient of the quadratic term is very small and not statistically different from zero at conventional levels. The linear term, on the contrary, is highly significant and positive. A likelihood ratio test indicates that the general model should be preferred to the quadratic specification at the 1% level, and that model (1) is not statistically different from model (3) even at the 10% level. So, model 2 is rejected on statistical grounds. However, the quadratic specification is nevertheless interesting to test the equality $\theta_1 = \theta_2$. The estimated difference $\widehat{\theta}_1 - \widehat{\theta}_2$ is .06, with an estimated standard deviation of .29. The equality of the two coefficients is accepted at any conventional level of significance. This strengthens our trust in the model.

[*Insert Table 2 here*]

For the rest of the study, we could work with either model 1 or model 3. We compared those two models on the basis of their predicted flows and mean values of the continuous variables and found no significant difference between the two models. For the sake of parcimony, we keep the linear specification. All the results below refer to model 1. The full model contains 105 parameters. To save space, we relegate all tables to Appendix C and insist on some features of the results.

First, we examine the two coefficients θ_1 and κ. As predicted by the theoretical model, θ_1 is positive: the further the current stock of housing capital from the optimal one, the more households are willing to move. The constraint coefficient κ is very significant and positive, as expected. Thus, borrowing constraints have a strong impact on mobility and tenure choice.

The estimated coefficients of the income equation for the EL and EP samples can be found in Table C1. Overall, the two samples give estimates of the same magnitude, but some parameters are found to be statistically different in the two equations, indicating that allowing for two different sets of parameters is necessary to improve the fit of the model. The coefficients of both equations have the usual sign. Income rises with age and then declines (after 50 years with our particular age brackets), as usual in cross-section datasets, rises with diploma, and is higher in the Paris area than elsewhere. Couples have a higher income, especially if the spouse works.

Table C2 provides the estimation results for the maximum value equation. Income has a positive effect on $V_{\max}$. Having a secondary home or possessing some other dwellings increases $V_{\max}$. The age effects, as well as the family structure effects are, at first glance, more surprising. The age profile is U-shaped. Couples have a lower $V_{\max}$ than single households, whether the wife is working or not. These results stem from the fact that we control for total family income. If we rewrite the $V_{\max}$ equation in reduced form, replacing log-income by its expression as a function of the exogenous variables, living in couple and the fact that the wife works both have a positive effect on $V_{\max}$.

The coefficients of the moving costs equation are shown in table C3. In accordance with intuition, moving costs increase with the age of the head of the household and with the number of children born before 1993. A birth after 1992 reduces the moving cost.[16] Another variable, the dummy for living in couple, has a less intuitive coefficient: being in couple appears to lower moving costs, though the coefficient is not significant at 5 %. The sign of this coefficient was robust to alternative specifications.

Table C4 shows the estimated value of the parameters of the user cost equation. Unsurprisingly, it is difficult to find explanatory variables with a significant effect. No significant age profile emerges, and the interpretation of other coefficients is not straightforward.

6.3 Global fit of the model

To assess the global fit of the model, we first look at the predictions in term of aggregate flows. The results are presented in table 3. The model accurately reproduces the overall aggregate flows, though it slightly overpredicts moving and owning. Splitting the sample by age brackets, we see that the accuracy the predicted flows remains good, with a deterioration for the two higher age brackets, for which the model predicts too many mover-owners.

Another important issue concerns the adequation of the predicted dwelling value for mover-owners with the actual one. The model slightly underestimates the dwelling value for all age brackets, the worst fits being again for the the two highest age brackets. For the whole sample, the dwelling value for mover-owners is underpredicted by 4 %. The same thing happens for the predicted rent of mover-renters. The overall rate of underestimation is -3.6 %, the fit being nearly perfect for the younger households, and less good for higher age brackets. This may be due to the number of mover renters in each cell, which decreases with age. However, considering

[16] Note that births have two effects on the utility difference between staying and moving and renting : one via the moving cost, and another via the quadratic term in equation (7), since young children appear in the determination of the optimal housing capital (equation (10)). Thus, a birth shifts upwards the optimal stock of housing capital, and this in turn lowers the utility of staying.

the structural restrictions imposed on the model (we have only two equations for fitting L^*, V_o^{uc}, and the rental-ownership choice), the fit of the model seems quite good.

Eventually, we look at the predicted proportion of constrained households in the whole population. This figure is 53 %. Zorn (1989), working on a sample representative of the U.S. population, found 61 % of constrained households. Note however that Zorn considered all households, not only previous renters as we do. Preliminary versions of this paper considered also previous mortgage holders and previous outright owners ; the proportion of constrained households in these two categories was found to be much lower (around 20 %). From a life-cycle point of view, looking at the whole population at a given moment in time, we would expect to see that younger households are the more constrained. However, working on the population of renters, we find no age pattern in the proportion of constrained households. This is easily understood, since if our model is true, the population of renters at any point in time is the result of a filtering process in which, in all previous periods, the wealthiest households moved towards ownership[17]. This finding is also in line with the direct examination of the net wealth of French households in each tenure as a function of age, which shows no clear age pattern among renters, and an average net wealth at all ages much lower than that of owners (Lagarenne and le Blanc, 2000).

[*Insert table* 3 *here*]

7 Simulations

Our model is built so as to allow for simulating changes on parameters that affect the maximum value $V_{\max}$. These parameters are the interest rate, the duration of the loans, as well as the minimum downpayment and the maximum payment-to-income ratios. The three latter variables have no impact on other endogenous quantities of the model. Thus for example, to simulate the effect of an increase in the maximum payment-to-income ratio, if suffices to recompute $V_{\max}$

[17] Preliminary work on this model showed that when previous owners are included, the proportion of constrained households declines with age from 50 % of the households under 30 years to 22 % in the 40-49 age bracket, and rises again for households aged 50 or more.

for all households and to calculate the value of the endogenous variables of the model (see Appendices B3 and B4 for the precise description of the simulation method). By contrast, the interest rate also affects the expected user cost and thus the ownership-rental trade-off. Thus, we have to make hypotheses concerning the revision of the households' expectations of user cost in reaction to a change in the interest rate. These in turn are governed by the beliefs of the households about the impact of this change on future housing prices. We have no hint about what would be the sensible thing to do about this ; however, it seems possible to bound the effects of a change in the interest rate between two polar cases. The first one corresponds to the households believing that future housing prices will fully reflect the change ; in this case, the anticipated user cost remains the same. The second one corresponds to the households believing that future housing prices will not react ; in this case, the anticipated user cost must be adjusted. We present the results corresponding to those two possibilities.

In principle, the model could also be used to assess the impact of changes in transaction costs. These costs affect the expected user cost, the buying price of housing, and the desired value of the dwelling for owners. However, we do not undertake such simulations. Apart from the discussion above on the reactions of households on their expected user cost, it has been known for a while that models with user cost like ours tend to predict excessively large fluctuations in demand for durables in reaction to price changes (see Deaton and Muellbauer (1980), p. 108 and ch. 11). Also, the less realistic part of our theoretical model lies in the limited time horizon. In reality, shocks on current housing prices can be absorbed over long time periods (for example, a buyer will keep his dwelling longer). For this reason, our model will tend to overestimate the impact on demand of such shocks.

To assess the empirical relevance of our model, we first simulated the reform consisting in the introduction of the "Prêt à Taux Zéro" (PTZ, zero rate loan) already mentioned in section 2. The PTZ is roughly equivalent to a downpayment subvention, since it decreases the amount the household has to borrow from the banks. The amount of this subvention can be calculated by comparing the initial amount of the PTZ to the discounted value of the repayment. So, to simulate the reform, we simply add the amount of the subvention to $V_{\max}$ for each household.[18] We obtain that the introduction of the reform in our 1996 sample would have benefited to 533,000 households in four years. Since we did not take into account the restriction of the PTZ to new dwellings (see section 2), and since a large proportion of mover-owners choose to buy old dwellings, this number must be a loose upper bound for the real one. From the Ministery of Housing, the real figure for the four years 1996-1999 on a comparable field (former HLM renters excluded) is 423,000. This result conforts our trust in the good calibration of our model.

A selection of results from the simulation of the PTZ are shown in table 4. Our model predicts that in four years, the PTZ would have induced nearly 75,000 "new " households to turn to ownership. From an efficiency point of view, the PTZ thus suffers from a "windfall effect" of about 85 %, that is, 85 % of the recipients would have chosen to move and own without it. This figure is in line with other evaluations that have been made by the French Ministry of Housing using totally different approaches.

[*Insert table* 4 *here*]

To compare the predictions of our model with those of Zorn (1989), we then focus on a uniform rise of $V_{\max}$ by 10 % in the sample. As table 5a shows, this loosening of the borrowing constraint results in switches from rental to ownership, but also and more importantly in switches from staying to owning. In fact, in all the simulations undertaken below, the simulated changes in flows from staying to owning always dominate in absolute value the flows from renting to owning. In this particular case, the 10 % rise of $V_{\max}$ results in a 6 % rise of the flow of new owners each period, amongst whom 1/4 would have rented otherwise, and 3/4 would not have moved during the period. The overall proportion of constrained household falls by 3.5 points. In Zorn's study, a 10% increase in $V_{\max}$ induced a 5% increase in the flow of mover-owners, 1/6

[18] Since the precise provisions of the PTZ are very intricate, and since the precise assessment of its effects on demand would require introducing another alternative in the discrete choice part of the model (one would have to consider owning a new dwelling and owning an old dwelling as two distinct options), we did not integrate all the PTZ provisions in our simulations. The most important of them is that the amount of the loan must not exceed 20 % of the total purchase value or 50% of the total amount of the loans.

of them being renters in the benchmark case, and 5/6 being stayers.

[*Insert table* 5*a here*]

Tables 5b, 5c, and 5d give the results of simulations of changes in e, a and r respectively.

Increasing the maximum payment-to-income ratio e from 30% to 35% induces 7,000 shifts from staying and 3,000 from moving and renting, thus increasing the flow of owners by 1.7 %. The proportion of constrained households as a whole falls by 1.3 %. Increasing the minimum downpayment ratio to 25 % has a huge negative impact on ownership, the flow of owners being cut by 9.8 % (60,000 households every 4 years). The proportion of constrained households as a whole rises by 8 %. 71% of the marginal households choose not to move during the period, and 29% choose to move and rent. Finally, a rise of 1 point in the interest rate of the loans, without changes in the households' expected user cost, reduces the flow of households moving and owning in the period by only .7% (4,600 out of 616,000 in the benchmark case). By contrast, when the rise in the interest rate is fully passed on the user cost, the flow of owners each period is reduced by 9.1 % (-56,000). In each case, 3/4 of the evicted owners stay in their dwellings, and 1/4 move and rent. Those results show that the model is not well suited for simulations on the interest rate.

[*Insert tables* 5*b*, *c*, *d here*]

Other simulations are possible, particularly as regards the duration of the loans. The fact is that between 1984 and 1996, the average duration of the loans of recent homeowners decreased by about 2 years, from 16.5 years to 14.5 years. Due to lack of space, we do not present the results of the simulation. Looking at formula (1) however, it can be seen that a rise in the duration of the loans, N approximately yields the same effects than an appropriate rise in the maximum payment-to-income ratio e.

One of the main advantages of our model compared with previous ones it that it allows for an examination of the effects of the changes also at the intensive margin. That is, we can look at the changes in the stock of housing capital chosen by owners. The response of the mean dwelling value of mover owners to a loosening of the borrowing constraints is always the sum of two effects: on one hand, households who would have moved and owned in the benchmark case continue to turn towards ownership, and buy more expensive dwellings. On the other hand, households who would not have chosen ownership now decide to move and own. These marginal households are less wealthy than supramarginal ones, and buy cheaper dwellings. Empirically, either effect can dominate. This selection effects are well known in other fields, see for example Bjorklund and Moffit (1987) for an example on the effect of welfare programs on wages. Interestingly, we obtain contrasted results from our simulations. We find that an increase in the maximum payment-to-income ratio *increases* the average value of the dwellings purchased by owners (see table 5b), whereas decreasing the minimum downpayment ratio (table 5c) or implementing the PTZ (table 4) leads to a *decrease* in this average value. Thus, in the particular case of the PTZ, the selection effect dominates. The implementation of this type of policy in the French population is likely to lead to the building of cheaper dwellings than would have been without the policy. This is an important finding, since the fact that subventions to potential owners might increase the overall quality of new dwellings has always been one of the main justifications of the French Ministry of Housing for those subventions.

The selection effects in the cases of changes in e and a are visible in the series of figures 6 to 15. The figures representing changes in mean income and gross flows in each category are similar for the two simulations; however, figures showing the proportion of constrained households, the mean maximum value in each category and the mean value of dwelling for mover-owners show opposite results for the two simulations.

[*Insert figures* 6 *to* 15 *here*]

8 Discussion

In this paper, we estimate a model of residential mobility and tenure choice in presence of borrowing constraints on potential owners. In our model, households choose at each period between staying in their dwelling, moving and owning, moving and renting. Mobility is the direct result of the inadequacy of the housing capital to the households' needs. When the current housing capital is too far from the optimal one, households decide to move and incur the related costs in order to adjust their stock. We show how borrowing constraints on potential homeowners distort the classical tenure choice tradeoff between renter and owner user costs. The more binding the borrowing constraints, the less households tend to move, and, when moving, the less they tend to own their new dwelling. The model is estimated using household data from two complementary samples. Our econometric framework allows us to use all the information on the discrete and continuous choices of households. In this field, this, to our knowledge, had never been done before. The relative complexity of the econometric model has at least two rewards. Firstly, we are able to give a structural interpretation to the parameters appearing in the discrete choice problem. Secondly, we show that the effect of borrowing constraints can be estimated without *a priori* assessing which households are constrained and which are not. With better datasets, the estimation procedure could be simplified. For example, having information on past rents for all previous renters, which would typically be the case in a panel dataset, would allow to eliminate one of the six equations of the model.

The model, estimated on a sample of French households who rented a dwelling in 1992, is used to estimate the impact of the 1996 policy reform consisting in offering loans at zero rate (PTZ) to low income households. The estimated number of households who use these loans in a four year period is in line with the real figure. We then focus on the effects on the mobility and tenure choice patterns of changes in the minimum downpayment ratio and in the maximum payment-to-income ratios set by the lenders. We find that the impact of these economic parameters on the flows into homeownership are quite large. We get as a general outcome that the changes in flows from staying to owning always dominate in absolute value the flows from renting to owning. We also find a large influence of the minimum downpayment ratio on the size of the flow of mover-owners, which is in line with empirical studies made in France in the early 90's, when the lenders hardened their borrowing requirements in order to limit the default risks (Lacroix, 1995). Our result also are in line with those obtained by Zorn (1989) on U.S data.

One of the main advantages of our model compared with previous ones it that it allows for an examination of the effects of the changes also at the intensive margin. That is, we can look at the changes in the stock of housing capital chosen by mover-owners, in response to changes in economic parameters. In France at least, this issue is important because the fact that subventions to potential owners might induce them to purchase better quality dwellings is almost always invoked as the main justification for those subventions by the French governement. On this point, we obtain interesting results. The response of the mean dwelling value of mover owners to a loosening of the borrowing constraints is always the sum of two effects: on one hand, households who would have moved and owned in the benchmark case continue to turn towards ownership, and buy more expensive dwellings. On the other hand, households who would not have chosen ownership now decide to move and own. These marginal households are less wealthy than supramarginal ones, and buy cheaper dwellings. Overall, one effect or the other dominates. We find that an increase in the maximum payment-to-income ratio increases the average value of the dwellings purchased by owners, whereas decreasing the minimum downpayment ratio or implementing the PTZ leads to a *decrease* in this average value. Thus, in the particular case of the PTZ, the selection effect dominates.

In spite of these positive results, we are aware that our approach is not exempt from several shortcomings. On the theoretical side, one may not be fully satisfied with our story, namely, that mobility is the direct result of the inadequacy of the housing capital to the household's needs. Another explanation to mobility is the opportunities to get better jobs, and better wages, in some other place. One may argue that income profiles are not exogenous like in our model, but influenced by mobility itself. Thus, the explicit incorporation of location and endogeneity of wages in our model seems to be an interesting topic for further research. Another limitation of our approach, common to all the related models quoted in the introduction, comes from the fact that only the demand side of the market is modelled. The obvious consequence is that the simulation results do not take into account the adjustment of prices which would occur on the housing market in response to changes in demand. In practice, housing prices will react, if only in the short run, because housing takes time to build (the short-term supply elasticity of housing is low). This prevents any assertion on welfare issues.

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A Solution of the model

A.1 The three maximization programs

We first solve the maximization program for a previous renter in each case: moving-and-renting, moving-and-owning, staying. In all this section, we define the "cash in hand" at the beginning of period t, $x_t \equiv A_t + Y_t$. We make the following assumption throughout:

$$\text{H2} : x_t > \max\left(C_0, \rho_t K_{t-1}\right)$$

A.1.1 The moving-and-renting case

The maximization program can be written:

$$\begin{aligned} & \max_{C_t, K_t, W_{t+1}} \left[\alpha \ln C_t + (1-\alpha)\ln K_t + \delta \ln\left(W_{t+1}\right)\right] \\ \text{s.t.} \quad : \quad & W_{t+1} = (1+r_a)(x_t - C_0 - C_t - \rho_t K_t) \end{aligned}$$

with $W_{t+1} = A_{t+1}$.

The consumption, housing stock, wealth at period $t+1$ at the optimum are then:

$$C_r = \frac{\alpha}{1+\delta}\left(x_t - C_0\right), K_r = \frac{1-\alpha}{\left(1+\delta\right)\rho_t}\left(x_t - C_0\right), W_{t+1,r} = \left(1+r_a\right)\frac{\delta}{\alpha+\delta}\left(x_t - C_0\right)$$

A.1.2 The moving-and-owning case

The maximization program consists in:

$$\begin{aligned} & \max_{C_t, K_t, W_{t+1}} \left[\alpha \ln C_t + (1-\alpha)\ln K_t + \delta \ln\left(W_{t+1}\right)\right] \\ \text{s.t.} \quad : \quad & W_{t+1} = (1+r_a)(x_t - Y_0 - C_t - \pi_t K_t) \\ \text{and} \quad : \quad & K_t \leq K_{\max} \end{aligned}$$

where $\pi_t = (1+\lambda)\, p_t - \frac{1}{(1+r_a)} p_{t+1}$ and $W_{t+1} = A_{t+1} + p_{t+1} K_t$.

We have two cases for variables at the optimum:

- **borrowing constraint not binding:**

The solution is that of the renter case, with ρ_t substituted for π_t:

$$\begin{aligned} C_o^{uc} &= \frac{\alpha}{1+\delta}(x_t - C_0), K_o^{uc} = \frac{1-\alpha}{(1+\delta)\,\pi_t}(x_t - C_0) \\ W_{t+1,o}^{uc} &= (1+r_a)\,\frac{\delta}{\alpha+\delta}(x_t - C_0) \end{aligned}$$

- **binding borrowing constraint:**

$$\begin{aligned} K_o^c &= K_{\max}, C_o^c = \frac{\alpha}{\alpha+\delta}\left[x_t - C_0 - \pi_t K_{\max}\right] \\ W_{t+1,o}^c &= (1+r_a)\,\frac{\delta}{\alpha+\delta}\left[x_t - C_0 - \pi_t K_{\max}\right] \end{aligned}$$

The condition for the borrowing constraint to be binding is:

$$\frac{1-\alpha}{1+\delta}\frac{(x_t - C_0)}{\pi_t} > K_{\max}$$

A.1.3 The staying case

A stayer is characterized by $K_t = K_{t-1}$. He maximizes his intertemporal utility, choosing the optimal consumption and wealth of period $t+1$ under his budget constraint:

$$\begin{aligned} &\max_{C_t, W_{t+1}} \left[\alpha \ln C_t + (1-\alpha)\ln K_{t-1} + \delta \ln\left(W_{t+1}\right)\right] \\ \text{s.t.} \quad &: \quad W_{t+1} = (1+r_a)(x_t - C_t - \rho_t K_{t-1}) \end{aligned}$$

where $W_{t+1} = A_{t+1}$. Calculation gives:

$$\begin{aligned} K_t &= K_{t-1}, C_s = \frac{\alpha}{\alpha+\delta}\left(x_t - \rho_t K_{t-1}\right) \\ W_{t+1,s} &= (1+r_a)\frac{\delta}{\alpha+\delta}\left(x_t - \rho_t K_{t-1}\right) \end{aligned}$$

A.2 The maximization problem

The discrete choice d_t has three possible values, s, r, and o, corresponding to staying in the current dwelling ($d_t = s$), moving and renting the new dwelling ($d_t = r$), moving and owning the new dwelling ($d_t = o$). The value of d_t is obtained through:

$$d_t = \arg\max_{s,r,o} \left[F_s^t, F_r^t, F_o^t\right]$$

with F_s^t, F_r^t and F_o^t, the household's optimal utilities when, respectively, staying, moving-and-renting, and moving-and-owning.

A.2.1 Tenure conditionnally to moving

We obtain

$$\begin{aligned} F_r^t - F_o^t &= (1-\alpha)\ln\left(\frac{\pi_t}{\rho_t}\right) \\ &\quad +1_{K_o^{uc}>K_{\max}}\left[(1-\alpha)\ln\left(\frac{K_o^{uc}}{K_{\max}}\right)-(\alpha+\delta)\ln\left[\frac{1+\delta}{\alpha+\delta}-\frac{1-\alpha}{\alpha+\delta}\left(\frac{K_o^{uc}}{K_{\max}}\right)\right]\right] \end{aligned}$$

Define $f(x) = (1-\alpha)\ln x + (\alpha+\delta)\ln\left(\frac{1+\delta}{1-\alpha} - x\right) + (\alpha+\delta)\ln\left(\frac{1-\alpha}{\alpha+\delta}\right)$. We have $f'(x) = \frac{(1+\delta)(1-x)}{x\left(\frac{1+\delta}{1-\alpha}-x\right)} > 0$ for $0 < x < 1$. Noting that $f(1) = f'(1) = 0$, a Taylor expansion of f around 1 gives $f(x) = -\frac{1}{2}\frac{(1-\alpha)(1+\delta)}{\alpha+\delta}(x-1)^2 + o((x-1)^2)$ which leads to

$$F_r^t - F_o^t \simeq (1-\alpha)\left[\ln\left(\frac{\pi_t}{\rho_t}\right) + 1_{K_o^{uc}>K_{\max}}\frac{1}{2}\frac{(1+\delta)}{\alpha+\delta}\left[\ln\left(K_o^{uc}\right)-\ln\left(K_{\max}\right)\right]^2\right]$$

A.2.2 Staying vs. moving and renting

We obtain:

$$\begin{aligned} F_s^t - F_r^t &= (\alpha+\delta)\ln\left[\frac{1-\alpha}{\alpha+\delta}\right] + (\alpha+\delta)\ln\left[\frac{1+\delta}{1-\alpha}\frac{K_r}{K_{t-1}} + \frac{C_0}{\rho_t K_{t-1}} - 1\right] \\ &\quad -(1+\delta)\ln\left(\frac{K_r}{K_{t-1}}\right) \equiv g(K_r) \end{aligned}$$

We have $g(K_{t-1}) > 0$, reflecting the fact that it is suboptimal to incur the moving cost if it is to consume the same amount of housing. If $C_0 < \rho_t K_{t-1}$, hypothesis H2 gives:

$$K_r > \frac{1-\alpha}{1+\delta}\left(K_{t-1} - \frac{C_0}{\rho_t}\right) > 0$$

so the expression is well defined. We have $g\left[\frac{1-\alpha}{1+\delta}\left(K_{t-1} - \frac{C_0}{\rho_t}\right)\right] = -\infty$. We get:

$$g'(x) = \frac{(1-\alpha)\left(K_{t-1} - \frac{C_0}{\rho_t} - x\right)}{x\left[x + \frac{1-\alpha}{1+\delta}\left(K_{t-1} - \frac{C_0}{\rho_t}\right)\right]}$$

g is maximum (and strictly positive) when $K_r = K_{t-1} - \frac{C_0}{\rho_t} < K_{t-1}$. So, g is increasing on the interval $\left]\frac{1-\alpha}{1+\delta}\left(K_{t-1} - \frac{C_0}{\rho_t}\right), K_{t-1} - \frac{C_0}{\rho_t}\right[$, and decreasing on the interval $\left]K_{t-1} - \frac{C_0}{\rho_t}, +\infty\right[$. Therefore, there exists two values α and β, $\frac{1-\alpha}{1+\delta}(K_{t-1} - \frac{C_0}{\rho_t}) < \alpha < K_{t-1} - \frac{C_0}{\rho_t}$, $\beta > K_{t-1}$, such that, if K_r lies between α and β, the household chooses to stay, and if K_r is outside the interval $[\alpha, \beta]$, the household chooses to move. This is the (s, S) rule.

If $C_0 > \rho_t K_{t-1}$, we have $g(0) = +\infty$, $g(+\infty) = -\infty$. g' is always negative so g is decreasing on R^{+*}. In this case, there exists a unique value $\gamma > K_{t-1}$ such that, if $K_r < \gamma$, the household does not move, whereas if $K_r > \gamma$, the household moves. Thus, high moving costs prevent from reducing housing consumption.

Writing the utility difference as a function of the two arguments C_0 and K_r^{nc}, a Taylor expansion around $(C_0 = 0, K_r^{nc} = K_{t-1})$ gives:

$$F_s^t - F_r^t = (1-\alpha)\left[-\frac{C_0}{\rho_t K_r^{nc}} + \frac{1}{2}\frac{(1+\delta)}{(\alpha+\delta)}\left(\ln K_r^{nc} - \ln K_{t-1}\right)^2\right]$$

B Likelihood

B.1 Simulating the likelihood function

The model is estimated by Simulated Maximum Likelihood. To simulate the likelihood, we use a straightforward extension of the GHK method. The GHK method (see for example Gouriéroux and Monfort, 1996, p98 et 105) is designed to provide an unbiased simulator of $E\left[h(v)1_{v\in D}\right]$, where h is a given integrable function, D is a rectangular domain and v is a (multivariate) normal residual with law $N(0,\Sigma)$. A particular case of moments of the form above is the probability $P(v \in D)$, which corresponds to $h = 1$. Our own problem is to compute quantities of the form$P(v \in D)$ and $E\left[h(v)1_{v\in D}\right]$, where v still follows $N(0,\Sigma)$, but the domain D is defined generically by a recursive system of constraints of the type:

$$\begin{cases} A_1 \leq v_1 \leq B_1 \\ A_2(v_1) \leq v_2 \leq B_2(v_1) \\ A_3(v_1,v_2) \leq v_3 \leq B_3(v_1,v_2) \\ etc. \end{cases}$$

where A_1 and B_1 are constants, A_2 is a function of v_1, A_3 is a function of v_1 and v_2, etc. For obvious reasons, we call this system of constraints "lower triangular". For the remaining of this section, we work in dimension 2, the argument being clearly valid for higher dimensions.

To adapt the GHK method to our case, it suffices to note that:

1) Starting from a domain D defined by lower triangular constraints changes nothing to the spirit of the GHK method. Indeed, choleskization of the constraints will still result in a lower triangular system of constraints of the form:

$$\begin{cases} \widetilde{A}_1 \leq u_1 \leq \widetilde{B}_1 \\ \widetilde{A}_2(u_1) \leq u_2 \leq \widetilde{B}_2(u_1) \end{cases}$$

defining a new domain D^*.

2) The fact that the below-diagonal part of the constraints is nonlinear in the residuals does not affect the demonstration of unbiasedness of the GHK simulator. Indeed, let us introduce the following drawings:

u_1^s in $N(0,1)$ truncated to $\left[\widetilde{A}_1, \widetilde{B}_1\right]$

u_2^s in $N(0,1)$ truncated to $\left[\widetilde{A}_2(u_1^s), \widetilde{B}_2(u_1^s)\right]$

Then an unbiased simulator of $P(v \in D) = P(u \in D^*)$ is

$$\widetilde{p}(u_1^s) = \left[\Phi(\widetilde{B}_1) - \Phi(\widetilde{A}_1)\right]\left[\Phi(\widetilde{B}_2(u_1^s)) - \Phi(\widetilde{A}_2(u_1^s))\right]$$

An unbiased simulator of $E\left[h(v)1_{v\in D}\right]$ is

$$h(Cu^s)\widetilde{p}(u_1^s)$$

The proof mirrors the proof of unbiasedness of the GHK estimator given in Gourieroux and Monfort, 1996. The joint distribution of (u_1^s, u_2^s) has density $g(x) = 1_{D^*(x)}\frac{\prod_{i=1}^{2}\phi(x_i)}{\widetilde{p}(x_1)}$. Then

$E\left[h(Cu^s)\widetilde{p}(u_1^s)\right] = \int 1_{D^*(x)}\frac{\widetilde{p}(x_1)}{\widetilde{p}(x_1)}h(Cx)\prod_{i=1}^{2}\phi(x_i)\prod_{i=1}^{2}dx_i$

$= \int h(Cx)1_{D^*(x)}\prod_{i=1}^{2}\phi(x_i)\prod_{i=1}^{2}dx_i$

$= E\left[h(Cu)1_{D^*(u)}\right]$, where $u \xrightarrow{law} N(0, I_2)$

$= E\left[h(v)1_{D(v)}\right]$, where $v \xrightarrow{law} N(0, \Sigma)$

■

If we draw S realizations of the u^s vector, the probability $P(v \in D)$ will be approximated by the simulator

$$\frac{1}{S}\sum_{s=1}^{S}\widetilde{p}(u_1^s, u_2^s)$$

The practical implementation of the method is straightforward (program available from the authors on request). In our calculations, we generally set the number of simulations to $S = 100$.

B.2 Calculation of the likelihood contributions

The parameters of the model are estimated by maximizing the joint likelihood of our two samples, the EP and the EL sample. Recall that $\varepsilon_i = \lambda_i \varepsilon_4 + \eta_i$, $i \in \{1, 2, 3, 5, 6\}$. In all the sequel, we denote $Z_4 \equiv X_4\gamma_4$, and $Z_i \equiv X_i\gamma_i + \lambda_i (\ln Y_t - Z_4)$ for $i \epsilon \{1, 2, 3, 5, 6\}$. We also denote φ_u and F_u respectively the pdf and the cdf of a normal variable u. In addition, denote $\widetilde{p}_t \equiv (1 + \lambda)p_t$.

First consider the observations from the EP sample. We observe draws of $(V^*_{\max}, Y^*_t)$. Thus, the contribution to the likelihood of the EP observations is simply:

$$L_p = P\left(\ln Y^*_t = \ln Y_t, \ln V^*_{\max} = \ln V_{\max}\right)$$

Conditioning on ε_4 and using the independance between ε_4 and η_5, we obtain:

$$L_p = \varphi_{\varepsilon_4}(\ln Y_t - Z_4)\varphi_{\eta_5}(\ln V_{\max} - Z_5)$$

Next, consider the observations from the EL sample. The contribution of households to the likelihood function depends on their discrete decision (staying, moving and renting, moving and owning). Without the quadratic terms $\left[\ln L^*_r - \ln L^*_{t-1}\right]^2$ and $[\ln V^{uc}_o - \ln V^*_{\max}]^2$ in the moving and tenure choice equations, the likelihood would be quite easy to write down and to compute. In fact, we would split each likelihood contribution into two terms corresponding to $V^{uc}_o \leqslant V^*_{\max}$ and $V^{uc}_o > V^*_{\max}$ to get rid of the constraint dummy $1_{V^{uc}_o > V^*_{\max}}$, the two resulting probabilities being linear in the ε's. The presence of the quadratic terms forces us to use either numerical integration, or simulation. As integration in two dimensions is required, we use the simulation method.

- stayers: we observe $(d_t = s, Y^*_t, L^*_{t-1})$. The likelihood contribution is:

$$L_s = P\left(F^t_s > F^t_r, F^t_s > F^t_o, \ln Y^*_t = \ln Y_t, \ln L^*_{t-1} = \ln L_{t-1}\right)$$

In this case, as in all the subsequent ones, we split this probability into two parts L_1 and L_2, corresponding to the cases $V_o^{uc} \leqslant V_{\max}^*$ and $V_o^{uc} > V_{\max}^*$, in order to deal with the indicator function in the tenure choice equation. The first part of the contribution to the likelihood can then be written:

$$L_1 = P\left(F_s^t > F_r^t, F_s^t > F_o^t, V_o^{uc} \leqslant V_{\max}^*, \ln Y_t^* = \ln Y_t, \ln L_{t-1}^* = \ln L_{t-1}\right)$$

Conditioning on ε_4 and η_6 and using the independance of η_6 with the other residuals η_j, $j \in \{1,2,3,5\}$, gives:

$$L_1 = \varphi_{\varepsilon_4}(\ln Y_t - Z_4)\varphi_{\eta_6}(\ln L_{t-1} - Z_6)P(A_1)$$

where A_1 denotes the event

$$\left\{\begin{array}{c} -\infty < \eta_3 < +\infty \\ -\infty < -\eta_1 \leq Z_1 - \theta_1 \left[Z_3 + \eta_3 - \ln L_{t-1}\right]^2, \\ -\infty < -\eta_1 - \eta_2 \leqslant Z_1 + Z_2 - \ln(\frac{\rho_t}{\widetilde{p}_t}) - \theta_1 \left[Z_3 + \eta_3 - \ln L_{t-1}\right]^2, \\ -\infty < -\eta_2 - \eta_5 \leqslant -Z_s - \eta_3 \end{array}\right\}$$

and $Z_s = Z_3 - Z_2 - Z_5$.

The probability $P(A_1)$ is estimated with the extended GHK method presented above.

For the second part of the likelihood, we have:

$$L_2 = P\left(F_s^t > F_r^t, F_s^t > F_o^t, V_o^{uc} > V_{\max}^*, Y_t^* = Y_t, L_{t-1}^* = L_{t-1}\right)$$

Using the independance of η_6 with the other residuals η_j, $j \in \{1,2,3,5\}$, this term can be rewritten:

$$L_2 = \varphi_{\varepsilon_4}(\ln Y_t - Z_4)\varphi_{\eta_6}(\ln L_{t-1} - Z_6)P\left(A_2\right)$$

where A_2 denotes the event

$$\left\{ \begin{array}{c} -\infty < \eta_3 < +\infty \\ -\infty < \eta_2 + \eta_5 \leqslant Z_s + \eta_3 \\ -\infty < -\eta_1 \leq Z_1 - \theta_1 \left[Z_3 + \eta_3 - \ln L_{t-1} \right]^2 , \\ -\infty < -\eta_1 - \eta_2 \leqslant Z_1 + Z_2 - \ln(\frac{\rho_t}{\widetilde{p}_t}) - \theta_1 \left[Z_3 + \eta_3 - \ln L_{t-1} \right]^2 + \theta_2 \left[Z_s + \eta_3 - (\eta_2 + \eta_5) \right]^2 \end{array} \right\}$$

The probability $P(A_2)$ is estimated with the extended GHK method.

- mover-renters: we observe $(d_t = s, Y_t^*, L_r^*)$. The likelihood contribution is then:

$$L_r = P\left(F_r^t > F_o^t, F_r^t > F_s^t, \ln Y_t^* = \ln Y_t, \ln L_r^* = \ln L_r\right)$$

We split this probability into two parts L_3 and L_4, corresponding to the cases $V_o^{uc} \leqslant V_{\max}^*$ and $V_o^{uc} > V_{\max}^*$. The first part can be written:

$$L_3 = P\left(F_r^t > F_o^t, F_r^t > F_s^t, V_o^{uc} \leqslant V_{\max}^*, \ln Y_t^* = \ln Y_t, \ln L_r^* = \ln L_r\right)$$

Conditioning on ε_4 and η_3 gives:

$$L_3 = \varphi_{\varepsilon_4}(\ln Y_t - Z_4)\varphi_{\eta_3}(\ln L - Z_3)P(A_3|\eta_3 = \ln L_r - Z_3)$$

where A_3 denotes the event:

$$\left\{ \begin{array}{c} -\infty < \eta_6 < +\infty \\ -\infty < -\eta_2 - \eta_5 \leqslant Z_r \\ -\infty < -\eta_2 \leq Z_2 - \ln(\frac{\rho_t}{\widetilde{p}_t}), \\ -\infty < \eta_1 \leqslant -Z_1 + \theta_1 \left[\ln L_r - Z_6 - \eta_6 \right]^2 , \end{array} \right\}$$

and $Z_r = Z_2 + Z_5 - \ln L_r$.

The only difference with the previous case is that we have to condition the vector $(\eta_6, -\eta_2 - \eta_5, -\eta_2, \eta_1)$ on the known value $\eta_3 = \ln L_r - Z_3$ before computing the probability $P(A_3)$.

For the second part of the likelihood, we have:

$$L_4 = P\left(F_r^t > F_o^t, F_r^t > F_s^t, V_o^{uc} > V_{\max}^*, \ln Y_t^* = \ln Y_t, \ln L_r^* = \ln L_r\right)$$

This term can be rewritten:

$$L_4 = \varphi_{\varepsilon_4}(\ln Y_t - Z_4)\varphi_{\eta_3}(\ln L_r - Z_3)P\left(A_4 \left| \eta_3 = \ln L_r - Z_3 \right.\right)$$

where A_4 denotes the event:

$$\left\{ \begin{array}{c} -\infty < \eta_6 < +\infty, \\ -\infty < \eta_2 + \eta_5 \leqslant -Z_r, \\ -\infty < -\eta_2 \leq Z_2 - \ln(\frac{\rho_t}{\widetilde{p}_t}) + \theta_2 \left[Z_r + \eta_2 + \eta_5\right]^2, \\ -\infty < \eta_1 \leqslant -Z_1 + \theta_1 \left[\ln L_r - Z_6 - \eta_6\right]^2 \end{array} \right\}$$

- mover-owners: we observe $(d_t = s, Y_t^*, \min(V_o^{uc}, V_{\max}^*))$.The likelihood contribution is then:

  $$L_o = P\left(F_o^t > F_r^t, F_o^t > F_s^t, \ln Y_t^* = \ln Y_t, \min\left(\ln V_o^{uc}, \ln V_{\max}^*\right) = \ln V\right)$$

  We split this probability into two parts, L_5 and L_6, corresponding to the cases $V_o^{uc} \leqslant V_{\max}^*$ and $V_o^{uc} > V_{\max}^*$. The first part can be written:

  $$L_5 = P\left(F_o^t > F_r^t, F_o^t > F_s^t, V_o^{uc} \leqslant V_{\max}^*, \ln Y_t^* = \ln Y_t, \ln V_o^{uc} = \ln V\right)$$

Conditioning on ε_4 and $\eta_2 - \eta_3$ gives:

$$L_5 = \varphi_{\varepsilon_4}(\ln Y_t - Z_4)\varphi_{\eta_3 - \eta_2}(\ln V - Z_3 + Z_2)P\left(A_5 | \eta_2 - \eta_3 = Z_o\right)$$

where A_5 denotes the event

$$\left\{\begin{array}{c} -\infty < \eta_3 - \eta_6 < +\infty, \\ -\infty < -\eta_5 \leqslant Z_5 - \ln V, \\ -\infty < \eta_2 \leq -Z_2 + \ln(\frac{\rho_t}{\widetilde{p}_t}), \\ -\infty < \eta_1 + \eta_2 \leqslant -Z_1 - Z_2 + \ln(\frac{\rho_t}{\widetilde{p}_t}) + \theta_1 \left[Z_3 - Z_6 + \eta_3 - \eta_6\right]^2, \end{array}\right\}$$

with $Z_o = Z_3 - Z_2 - \ln V$.

The probability $P(A_5)$ is estimated with the extended GHK method, after conditioning the vector $(\eta_3 - \eta_6, -\eta_5, \eta_2, \eta_1 + \eta_2)$ on $\eta_2 - \eta_3 = Z_o$.

For the second part of the likelihood, we have:

$$L_6 = P\left(F_o^t > F_r^t, F_o^t > F_s^t, V_o^{uc} \geqslant V^*_{\max}, \ln Y_t^* = \ln Y_t, \ln V^*_{\max} = \ln V\right)$$

This term can be rewritten, using the assumption that η_5 is independent of the other residuals η_j, $j \in \{1, 2, 3, 6\}$:

$$L_6 = \varphi_{\varepsilon_4}(\ln Y_t - Z_4)\varphi_{\eta 5}(\ln V - Z_5)P(A_6)$$

where A_6 denotes the event:

$$\left\{\begin{array}{c} -\infty < \eta_3 - \eta_6 < +\infty, \\ -\infty < \eta_2 - \eta_3 \leqslant Z_o, \\ -\infty < \eta_2 \leqslant -Z_2 + \ln(\frac{\rho_t}{\widetilde{p}_t}) - \theta_2 \left[-Z_o + (\eta_2 - \eta_3)\right]^2, \\ -\infty < \eta_1 + \eta_2 \leqslant -Z_1 - Z_2 + \ln(\frac{\rho_t}{\widetilde{p}_t}) + \theta_1 \left[Z_3 - Z_6 + \eta_3 - \eta_6\right]^2 - \theta_2 \left[Z_o - (\eta_2 - \eta_3)\right]^2 \end{array}\right\}$$

$P(A_6)$ is estimated using the extended GHK method.

B.3 Simulation Method

This section briefly describes our simulation method. When simulating some changes in the exogenous parameters of the model, we want to obtain smooth estimators of both the discrete choice probabilities and some continuous variables.

1) Predicting the flows in each category

We want to estimate the predicted flows in each category, given by $NP\left(d_t=j\right)$, with $j\epsilon\left\{r,s,o\right\}$. We have

$$\begin{aligned}P\left(d_t=j\right) &= E_X\left[P\left(d_t=j\right|X)\right]\\ &= E_X\left[P\left(d_t=j,V_o^{uc}\leqslant V_{\max}\right|X)\right]+E_X\left[P\left(d_t=j,V_o^{uc}>V_{\max}\right|X)\right]\end{aligned}$$

A consistent estimator of this quantity when N tends to infinity is:

$$\frac{1}{N}\sum_{i=1}^{N}P\left(d_t=j,V_o^{uc}\leqslant V_{\max}\right|X_i)+\frac{1}{N}\sum_{i=1}^{N}P\left(d_t=j,V_o^{uc}>V_{\max}\right|X_i)$$

However, the probabilities involved in the two sums cannot be computed directly because of nonlinearities in the combination of residuals. We use the GHK method. The resulting estimator of $P\left(d_t=j\right)$, noted $\widehat{P}\left(d_t=j\right)$, is consistent when N and S tend to infinity.

2) Prediction of continuous endogenous variables

We are interested in the expected maximum housing value and the *desired* value in each category, $E\left(V_{\max}\right|d_t=j)$ and $E\left(V_o^{uc}\right|d_t=j)$, the expected purchase value for moving-owners: $E\left(V\right|d_t=o)$, and the expected rent for moving renters: $E\left(L_r\right|d_t=r)$.

We have $E\left(V_{\max}\right|d_t=j)=\frac{E\left(V_{\max}1_{\{d_t=j\}}\right)}{P(d_t=j)}$

An estimator of $P\left(d_t=j\right)$ is given above. The numerator writes

$E\left(V_{\max}1_{\{d_t=j\}}\right)=E_X\left[E\left(V_{\max}1_{\{d_t=j\}}\right|X)\right]$

$=E_X\left[E\left(V_{\max}1_{\{d_t=j,V_o^{uc}\leqslant V_{\max}\}}\right|X)\right]+E_X\left[E\left(V_{\max}1_{\{d_t=j,V_o^{uc}>V_{\max}\}}\right|X)\right]$

A consistent estimator of this quantity when N tends to infinity is:

$$\frac{1}{N}\sum_{i=1}^{N} E\left(V_{\max} 1_{\{d_t=j, V_o^{uc}>V_{\max}\}} \middle| X_i\right) + \frac{1}{N}\sum_{i=1}^{N} E\left(V_{\max} 1_{\{d_t=j, V_o^{uc}>V_{\max}\}} \middle| X_i\right)$$

Once again, we apply the extended GHK method, this time to evaluate $E\left(V_{\max} 1_{\{d_t=j, V_o^{uc}>V_{\max}\}} \middle| X_i\right)$ and $E\left(V_{\max} 1_{\{d_t=j, V_o^{uc}>V_{\max}\}} \middle| X_i\right)$. The resulting estimator of $E\left(V_{\max} 1_{\{d_t=j\}}\right)$ is noted $\widehat{E}\left(V_{\max} 1_{\{d_t=j\}}\right)$. Finally, a consistent estimator of $E\left(V_{\max} \middle| d_t = j\right)$ is:

$$\widehat{E}\left(V_{\max} \middle| d_t = j\right) = \frac{\widehat{E}\left(V_{\max} 1_{\{d_t=j\}}\right)}{\widehat{P}\left(d_t = j\right)}$$

The same kind of method can be used to compute a smooth estimator of $E\left(V_o^{uc} \middle| d_t = j\right)$ and $E\left(L_r \middle| d_t = r\right)$.

To estimate $E\left(V \middle| d_t = o\right)$, first write $E\left(V \middle| d_t = o\right) = \frac{E\left(V 1_{\{d_t=o\}}\right)}{P(d_t=o)}$. Then

$E\left(V 1_{\{d_t=o\}}\right) = E_X\left[E\left(V 1_{\{d_t=o, V_o^{uc}\leqslant V_{\max}\}} \middle| X\right)\right] + E_X\left[E\left(V 1_{\{d_t=o, V_o^{uc}>V_{\max}\}} \middle| X\right)\right]$

As $V = \min\left(V_o^{uc}, V_{\max}\right)$, this can be rewritten:

$E\left(V 1_{\{d_t=o\}}\right) = E_X\left[E\left(V_o^{uc} 1_{\{d_t=o, V_o^{uc}\leqslant V_{\max}\}} \middle| X\right)\right] + E_X\left[E\left(V_{\max} 1_{\{d_t=o, V_o^{uc}>V_{\max}\}} \middle| X\right)\right]$

Estimators of these two terms have already been computed to contruct $\widehat{E}\left(V_{\max} 1_{\{d_t=o\}}\right)$ and $\widehat{E}\left(V_o^{uc} 1_{\{d_t=o\}}\right)$.

B.4 Simulating some changes in the housing market parameters

In our model, changes in the minimum downpayment-to value ratio a, the maximum repayment-to-income ratio e and the loan duration N, affect only the maximum housing value $V_{\max}$. To simulate policy changes, we just have to compute the new maximum housing value $V'_{\max}$ as a function of the parameters a, e, r, N. We have:

$$V'_{\max} = W_t + \min\left(\frac{e'}{\tilde{r}'} Y_t, \frac{1-a'}{a'} W_t\right)$$

where $\tilde{r}' = \frac{(1+r)^{N'}}{(1+r)^{N'}-1}$, a' and e' are the new housing market parameters.

Thus, $V'_{\max}$ depends on W_t that is not observed. But, inversing formula (1), we obtain:

$$W_t = 1_{\left\{\frac{e}{\tilde{r}}Y_t \geqslant (1-a)V_{\max}\right\}} (aV_{\max}) + 1_{\left\{\frac{e}{\tilde{r}}Y_t < (1-a)V_{\max}\right\}} \left(V_{\max} - \frac{e}{\tilde{r}}Y_t\right)$$

When a shift in r occurs, $V_{\max}$ must be modified, but the user cost may also be affected, depending on the price anticipations of households. If these anticipations remain unchanged, the new user cost-to-price ratio is:

$$\frac{\pi'_t}{(1+\lambda)p_t} = 1 - \frac{1+r}{1+r'}\left(1 - \frac{\pi_t}{(1+\lambda)p_t}\right)$$

If the shift in r is fully reflected in price expectations, we have $p_{t+1} = \frac{1+r}{1+r'}p_{t+1}$ and the user cost keeps the same. The two cases provide bounds for the effects of changes in the interest rate.

Figure 1: The (s,S) rule : utility difference between staying and moving-and renting as a function of desired housing capital (case $R_0<\rho_t K_{t-1}$)

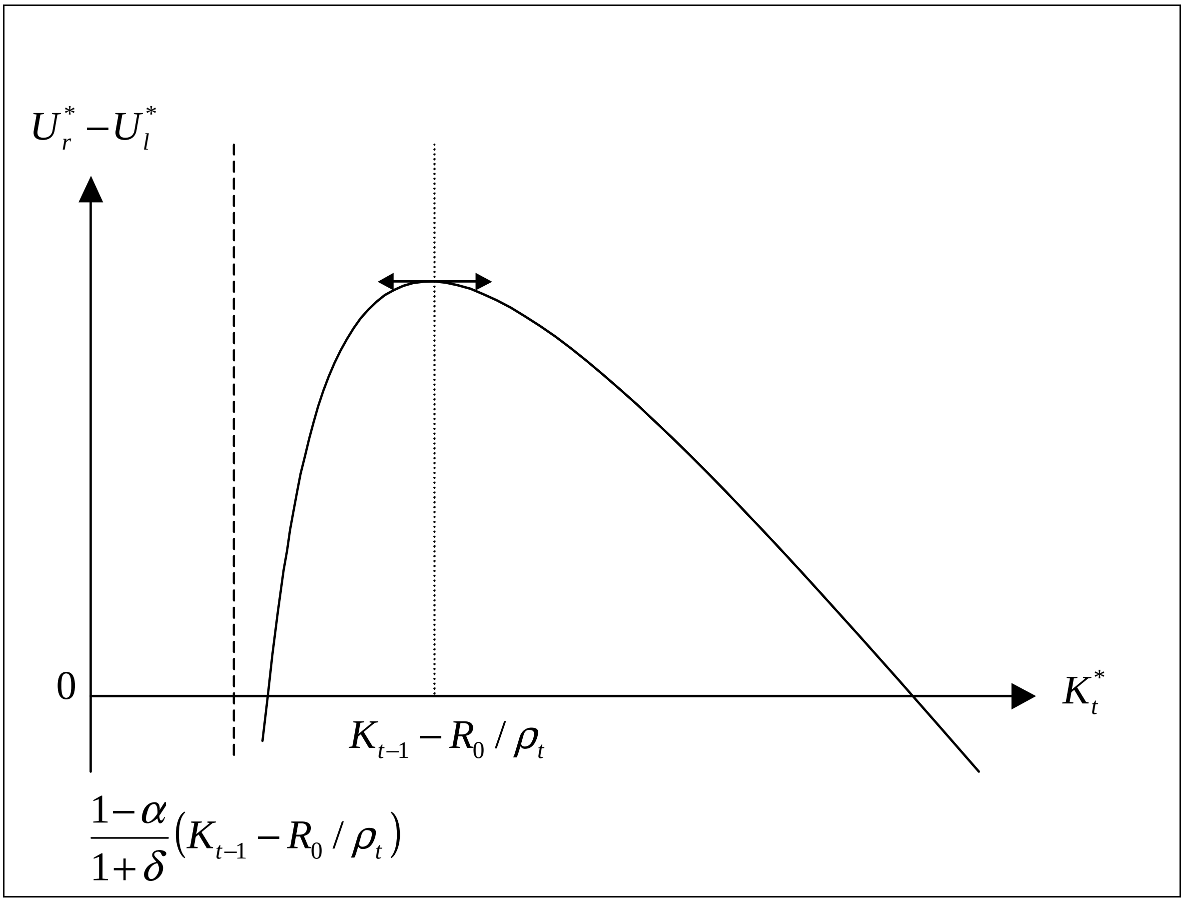

Figure 2

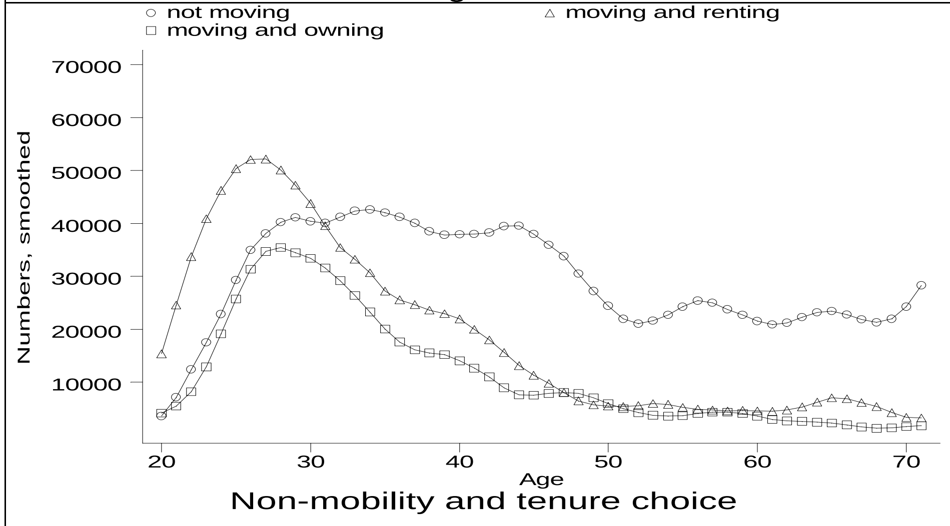

Figure 3

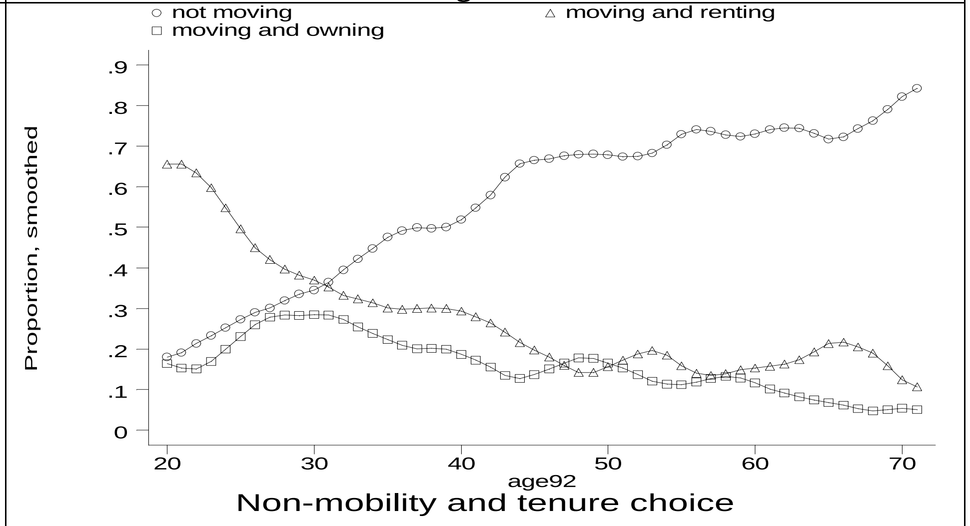

Figure 4

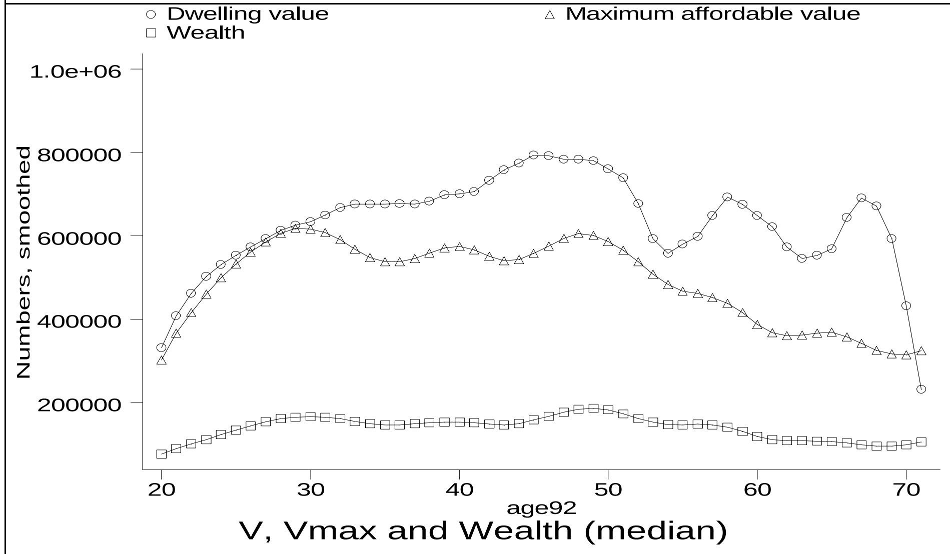

Figure 5

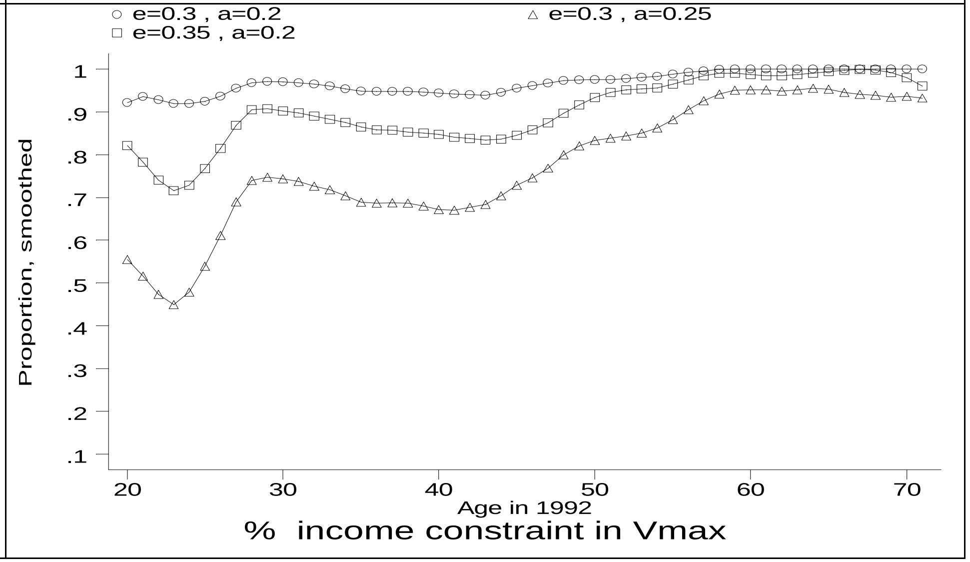

Figure 6: Difference (simulated flow, e=x) – (simulated flow, e=0.3) by category

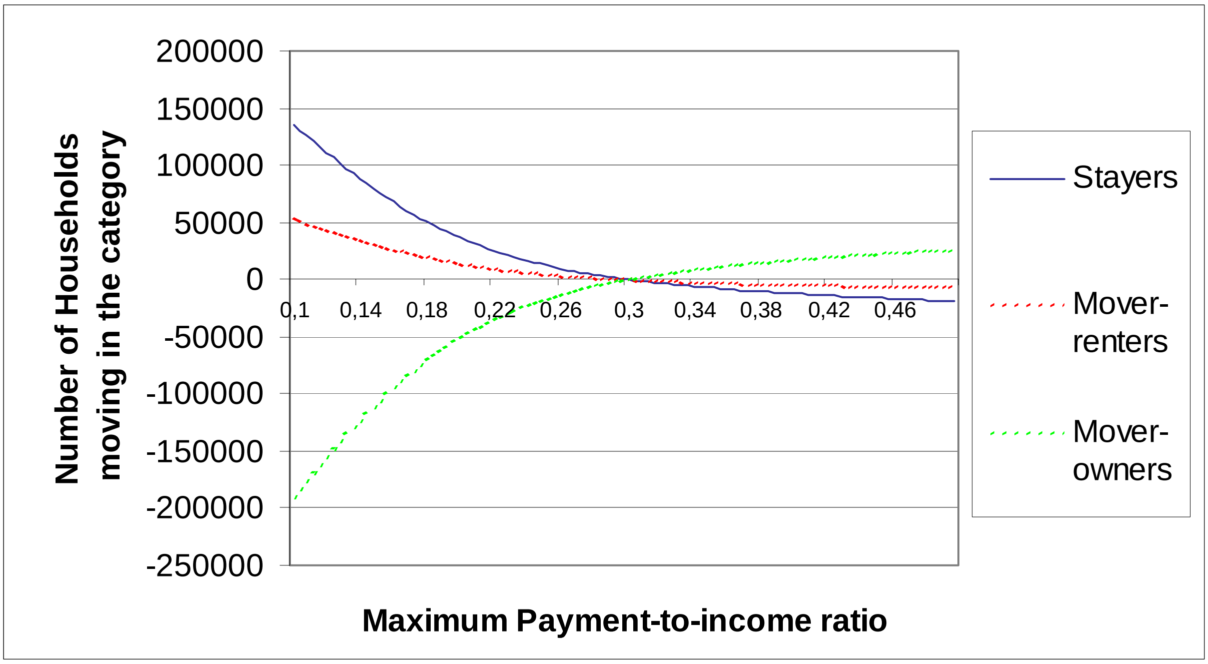

Figure 7: Difference (average income, e=x) – (average income, e=0.3) by category

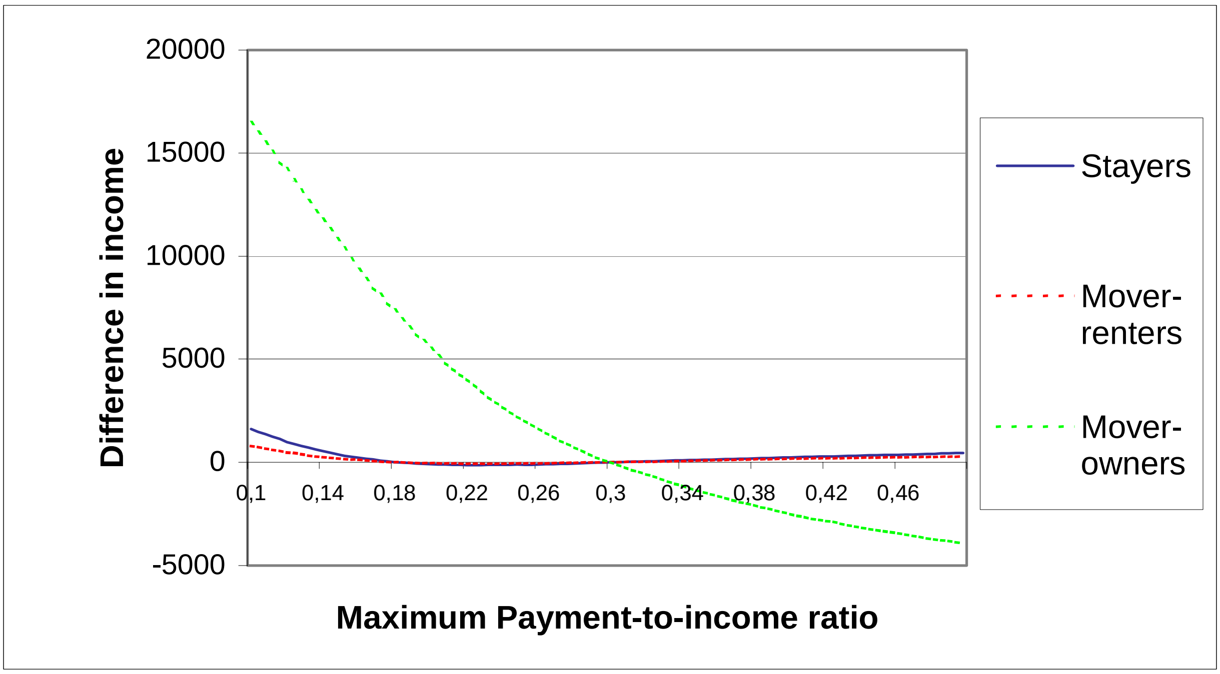

Figure 8: Percentage constrained households (e=x) by category

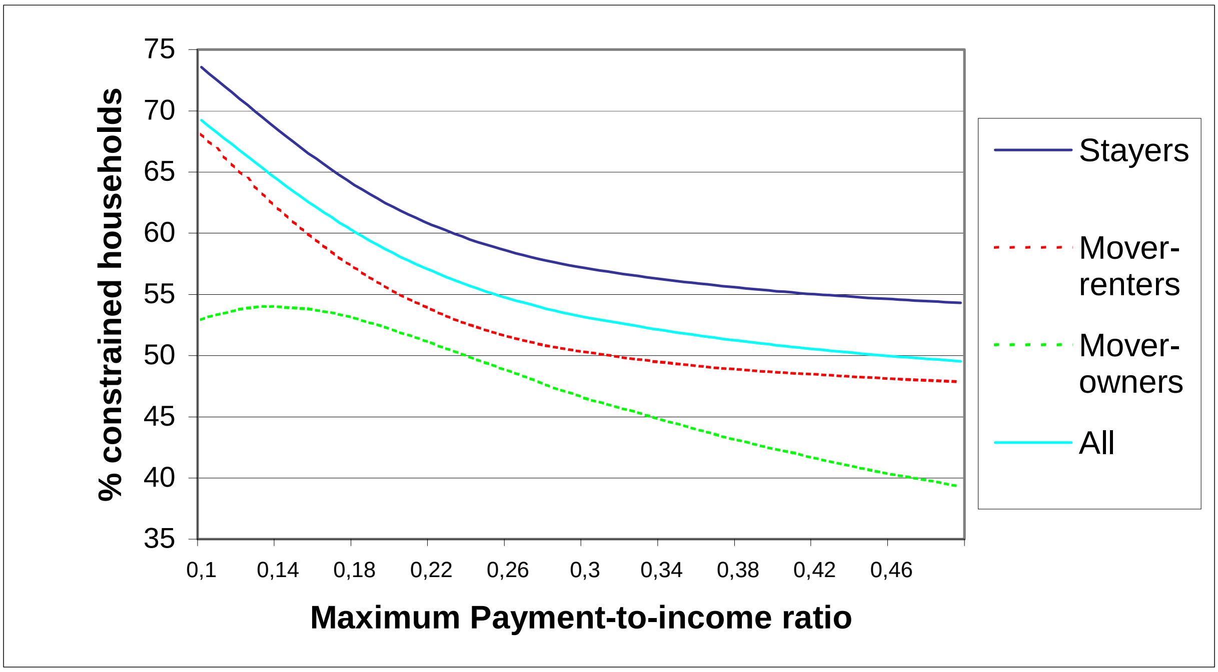

Figure 9: Difference (maximum housing value, e=x) – (maximum housing value, e=0.3) by category

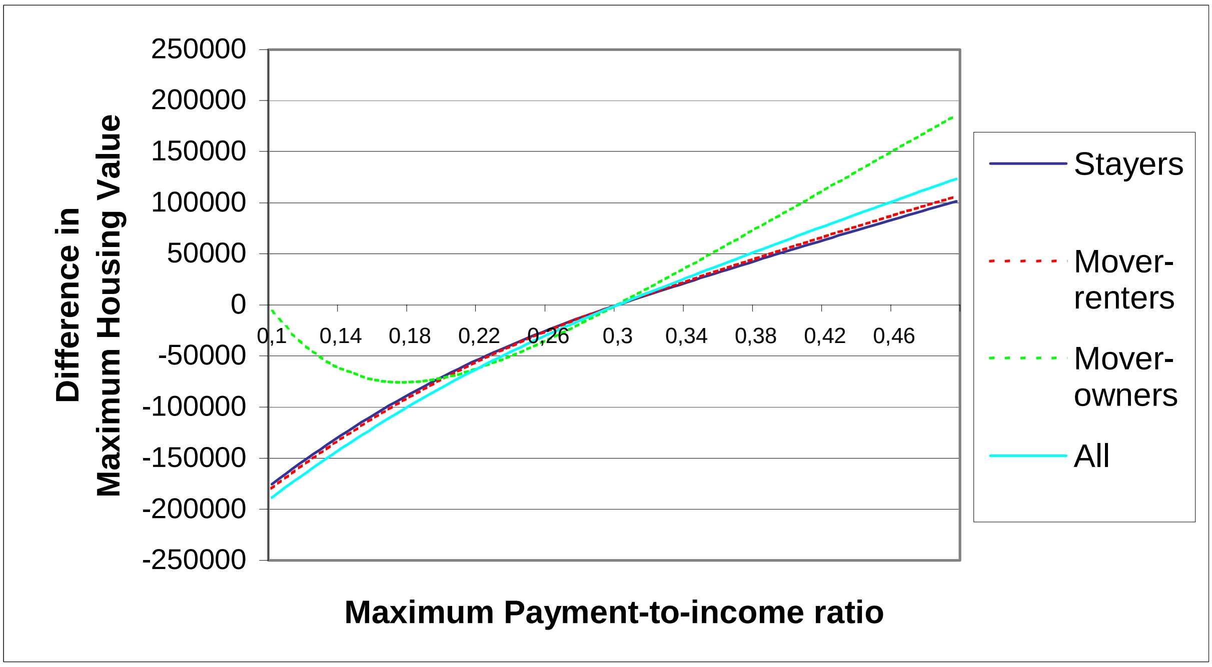

Figure 10: Simulated purchase value (e=x) for constrained owners

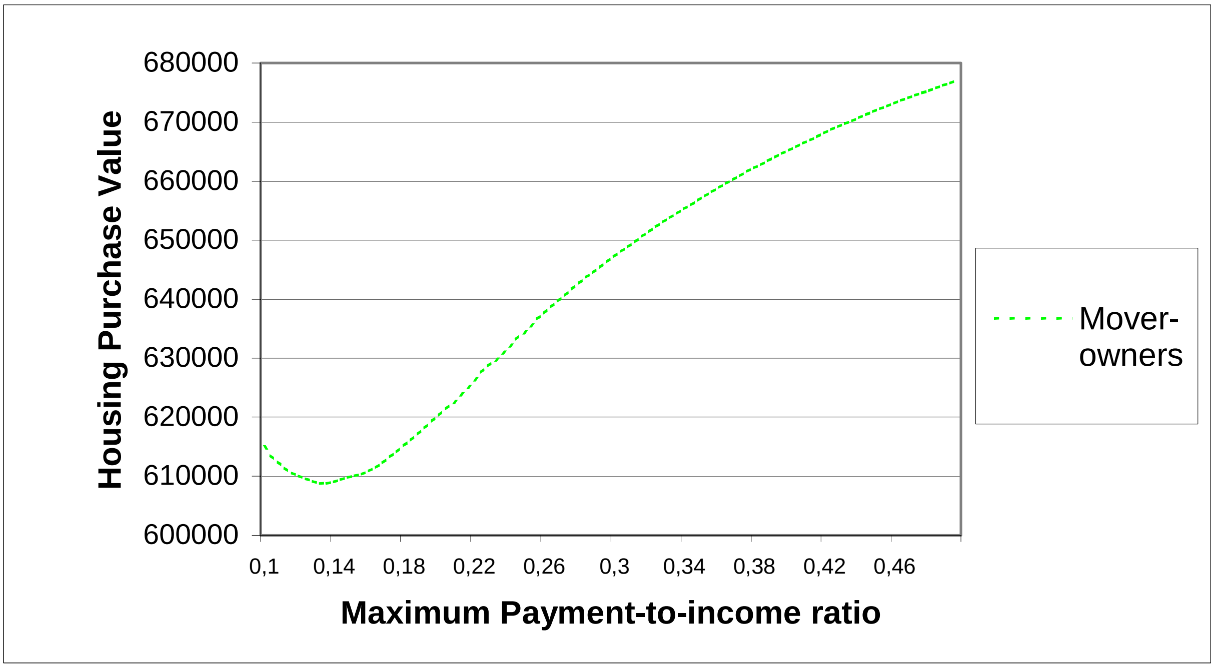

Figure 11: Difference (simulated flow, a=x) – (simulated flow, a=0.2) by category

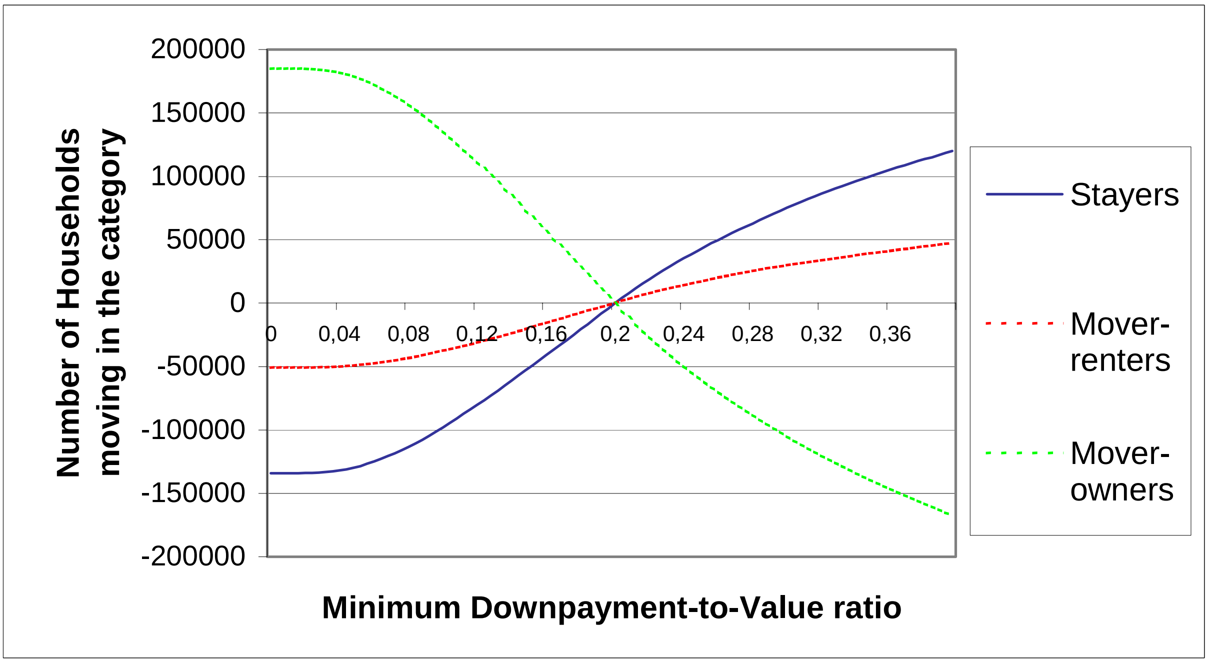

Figure 12: Difference (average income, a=x) – (average income, a=0.2) by category

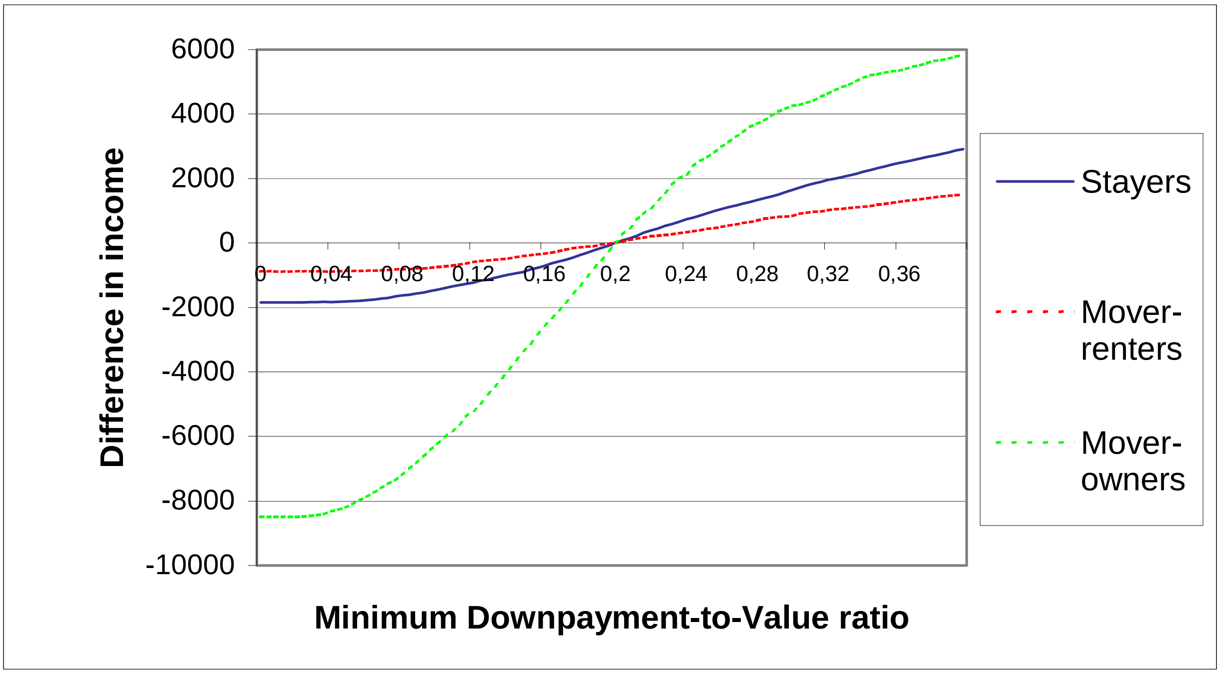

Figure 13: Percentage constrained households (a=x) by category

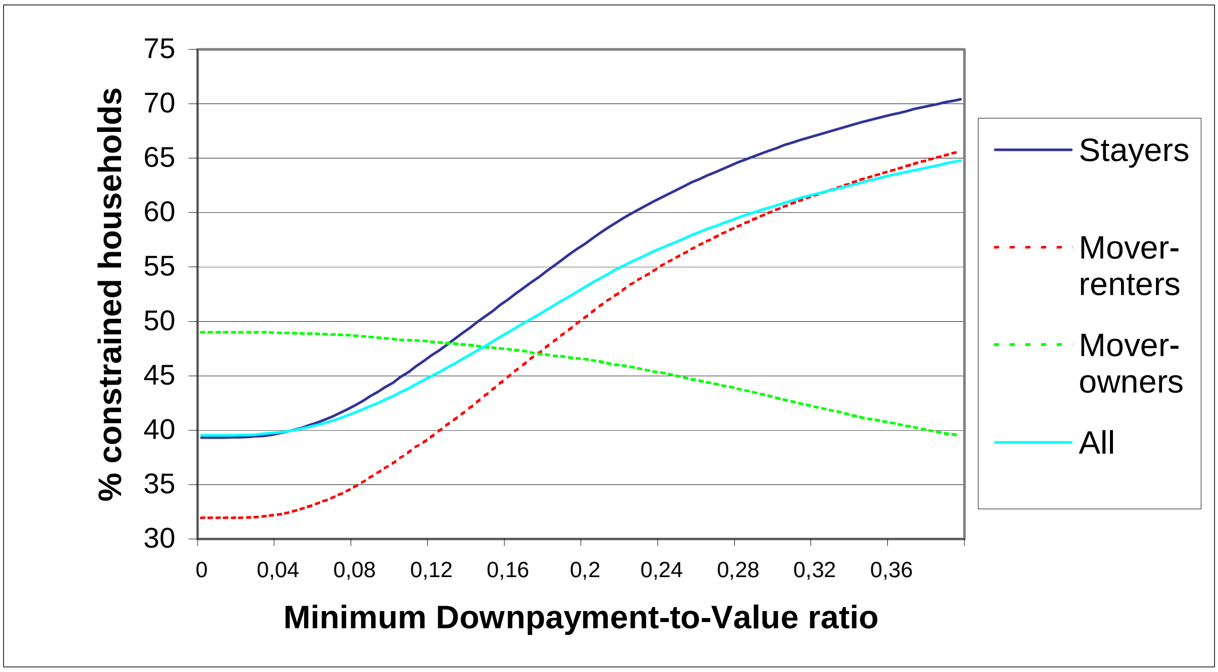

Figure 14: Difference (maximum housing value, a=x) – (maximum housing value, a=0.3) by category

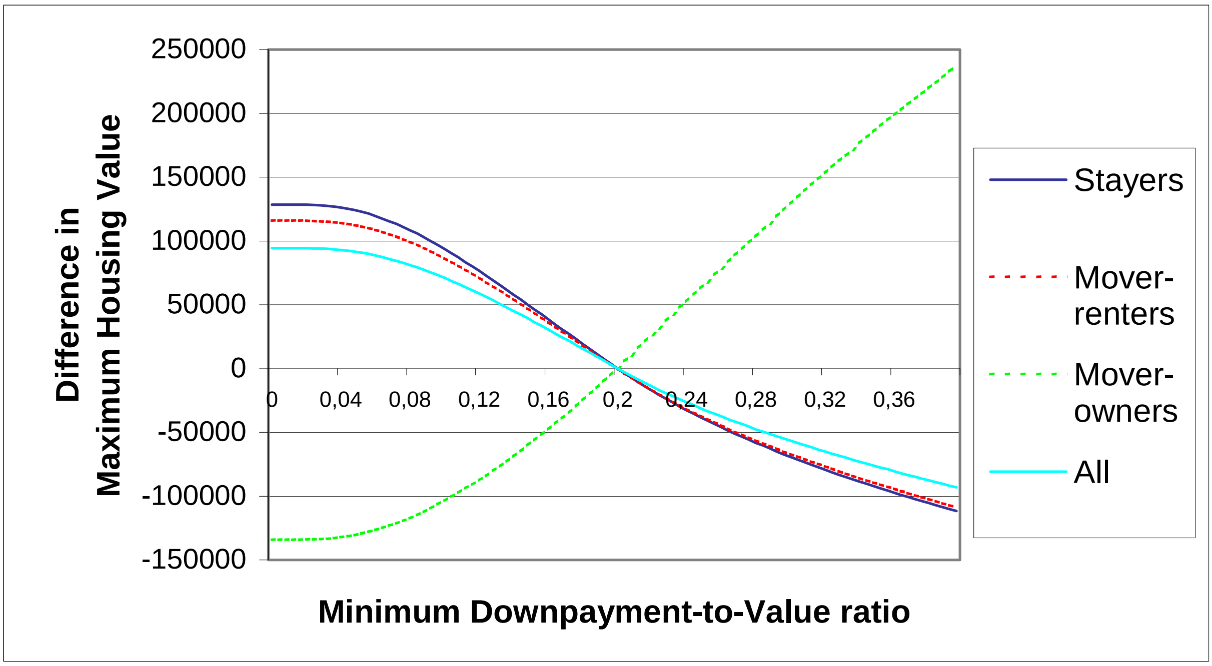

Figure 15: Purchase value (a=x) for constrained owners

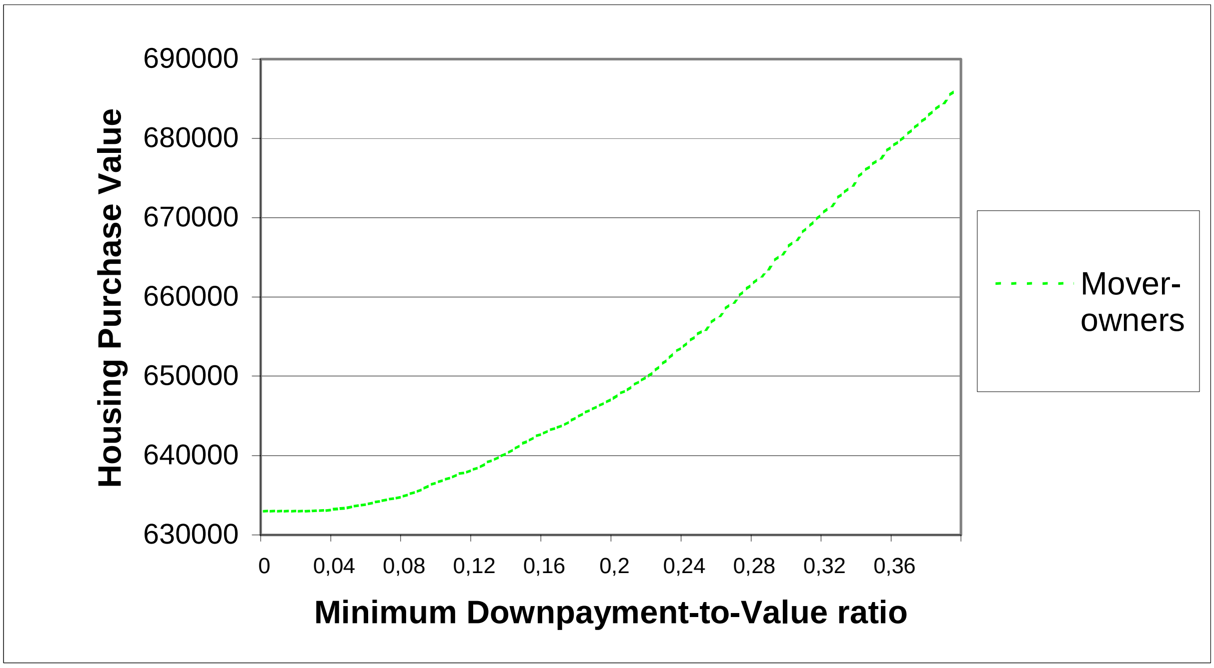

Table 1 : summary statistics, weighted

Variables	All Households	Stayers	Mover-owners	Mover-renters
Number (millions)	3.342	1.730	.605	1.008
Proportion	1.000	.517	.181	.301
Household annual income (thousands of FF)	163 (119)	144 (108)	226 (135)	157 (113)
Computed total net wealth in 1992 (thousands of FF)	222 (476)	183 (298)	303 (385)	241 (710)
Maximum reachable value (thousands of FF)	640 (683)	551 (516)	883 (659)	646 (884)
Dwelling value (thousands of FF)	// //	// //	674 (423)	// //
Annual rent (thousands of FF)	// //	27.0 (19.8)	// //	34.6 (17.3)
Unit rent-to-price ratio	5.437 (.830)	5.414 (.851)	5.562 (.720)	5.403 (.848)
Number of children in 1992	.563 (.926)	.558 (.948)	.713 (.941)	.483 (.865)
Having a spouse	.592 (.492)	.509 (.500)	.839 (.368)	.585 (.493)
Number of children born between 1992 and 1996	.269 (.551)	.144 (.412)	.508 (.690)	.341 (.603)
Divorced	.137 (.344)	.148 (.355)	.078 (.268)	.154 (.361)
Foreigner	.080 (.271)	.083 (.276)	.050 (.217)	.093 (.290)
Occupies a job in 1992	.763 (.425)	.656 (.475)	.932 (.251)	.845 (.362)
Detached house	.318 (.466)	.320 (.466)	.413 (.493)	.259 (.438)
Housing vacancy rate in town in 1990	7.465 (2.814)	7.548 (2.828)	7.114 (2.878)	7.532 (2.736)
Rental rate in 1990	3.303 (7.949)	3.205 (7.897)	29.487 (8.555)	3.962 (7.605)
Owns a secondary house	.067 (.250)	.083 (.276)	.062 (.240)	.043 (.202)
Civil servant	.081 (.273)	.061 (.240)	.118 (.323)	.093 (.290)
1992 socio-economic index	.096 (.416)	.088 (.418)	.061 (.406)	.130 (.414)
Spouse being job occupied	.334 (.472)	.252 (.434)	.574 (.495)	.330 (.471)
Hires a house	.048 (.214)	.039 (.194)	.091 (.288)	.037 (.188)
Male	.741 (.438)	.676 (.468)	.901 (.299)	.757 (.429)
Age in 1992				
Less than 30 years	.272 (.445)	.146 (.353)	.355 (.479)	.438 (.496)
From 30 to 34 years	.157 (.363)	.120 (.325)	.242 (.428)	.168 (.374)
From 35 to 39 years	.122 (.327)	.118 (.322)	.130 (.336)	.124 (.330)
From 40 to 49 years	.176 (.381)	.208 (.406)	.158 (.365)	.132 (.339)
50 years and more	.274 (.446)	.408 (.492)	.116 (.320)	.138 (.345)

Table 1 (continued)

Diploma				
University diploma more than two years study, engineer school diploma	.151 (.358)	.113 (.316)	.220 (.414)	.175 (.380)
University diploma two year's study	.103 (.304)	.075 (.263)	.142 (.349)	.129 (.335)
High school diploma and equivalent	.046 (.209)	.033 (.179)	.064 (.244)	.056 (.230)
Vocational training certificate	.254 (.435)	.236 (.425)	.296 (.457)	.259 (.438)
School certificate (taken at 16 years)	.126 (.331)	.116 (.320)	.135 (.342)	.137 (.344)
No diploma	.321 (.467)	.428 (.495)	.144 (.352)	.244 (.430)
Town size				
Rural	.160 (.366)	.165 (.371)	.185 (.388)	.136 (.343)
Less than 20,000 inhabitants	.077 (.266)	.068 (.253)	.089 (.284)	.083 (.277)
20,000 – 100,000 inhabitants	.185 (.389)	.187 (.390)	.195 (.397)	.176 (.381)
100,000 – 2,000,000 inhabitants	.349 (.477)	.347 (.476)	.338 (.473)	.358 (.480)
Paris	.229 (.421)	.232 (.422)	.193 (.395)	.247 (.431)
Year the occupied house was built				
Before 1948	.443 (.497)	.457 (.498)	.404 (.491)	.443 (.497)
1949 – 1974	.336 (.472)	.371 (.483)	.324 (.468)	.284 (.451)
1975 – 1981	.126 (.332)	.097 (.296)	.157 (.364)	.157 (.364)
1982 and after	.095 (.293)	.075 (.264)	.115 (.319)	.116 (.321)
Number of rooms				
One room	.110 (.313)	.092 (.289)	.070 (.255)	.164 (.371)
Two rooms	.236 (.424)	.223 (.417)	.180 (.385)	.290 (.454)
Three rooms	.285 (.451)	.280 (.449)	.311 (.463)	.277 (.448)
Four rooms	.212 (.409)	.229 (.420)	.269 (.444)	.149 (.356)
Five rooms	.102 (.302)	.115 (.319)	.102 (.303)	.078 (.269)
Six rooms and more	.056 (.230)	.060 (.238)	.068 (.252)	.041 (.198)

Note: Variables concern the year 1996 except when specified

Table 2: Estimation results for the three specifications of the borrowing constraints effects

	Model 1 (Linear)	Model 2 (Quadratic)	Model 3 (Linear + Quadratic)
θ_1	.110 (.027)	.291 (.066)	.137 (.027)
θ_2		.350 (.031)	.0004 (0.049)
κ	.582 (.040)		.471 (.089)

Table 3: Fit of model 1

		By age bracket				
	Whole sample	Less than 30	30-34	35-39	40-49	50 or more
Stayers						
Simulated number	1,725,610	255,006	209,616	204,234	354,047	702,706
Real number	1,729,846	252,172	208,160	203,607	359,440	706,467
Difference	-4,236	2,834	1,456	627	-5,393	-3,761
Prediction rate	99.8	101.1	100.7	100.3	98.5	99.5
Desired rent (FF)	112,315	108,718	124,143	122,134	125,917	100,413
Desired value (FF)	468,061	502,909	623,995	547,702	555,973	341,818
Maximum value (FF)	676,779	573,609	701,468	736,364	731,717	661,886
Mover-renters						
Simulated number	1,001,443	439,013	165,305	124,515	134,119	138,491
Real number	1,007,557	441,002	169,069	124,973	133,120	139,393
Difference	-6,114	-1,989	-3,764	-458	999	-902
Prediction rate	99.4	99.5	97.8	99.6	100.7	99.3
Desired rent (FF)	133,576	128,635	147,003	141,217	142,886	117,286
Desired value (FF)	411,999	413,819	509,602	435,067	423,544	257,339
Maximum value (FF)	672,265	626,794	790,271	712,882	673,620	638,015
Mover-owners						
Simulated number	615,791	214,330	148,573	78,251	100,027	74,610
Real number	605,441	215,175	146,265	78,421	95,633	69,947
Difference	10,350	-845	2,308	-170	4,394	4,663
Prediction rate	101.7	99.6	101.6	99.8	104.6	106.6
Desired rent (FF)	101,021	95,838	109,186	107,646	107,248	84,099
Desired value (FF)	838,405	754,714	948,952	894,616	918,572	689,213
Maximum value (FF)	1,258,020	1,027,638	1,302,688	1,457,490	1,467,576	1,340,613
Purchase value (FF)	647,236	574,605	712,335	695,355	717,467	579,964
Observed rent value (FF)	138,526	127,531	152,196	152,114	150,115	133,483
Observed purchase value (FF)	674,395	581,661	725,952	717,497	804,009	626,321

Table 4: Deviations from benchmark for the PTZ scenario

	Whole sample	By age bracket				
		Less than 30	30-34	35-39	40-49	50 or more
Stayers						
Simulated number	-52,552	-14,569	-11,030	-7,084	-9,197	-10,672
Desired value (FF)	-4,840	-7,347	-4,316	-4,580	-2,657	-2,030
Maximum value (FF)	58,289	66,164	68,271	61,093	55,435	52,663
% constrained (pts)	-8.0	-7.8	-6.3	-6.5	-6.0	-9.8
Mover-Renters						
Simulated number	-20,798	-11,761	-4,215	-2,119	-1,757	-947
Desired value (FF)	-3,160	-3,862	-2,427	-2,657	-1,899	-902
Maximum value (FF)	54,383	57,285	55,926	53,273	49,541	49,321
% constrained (pts)	-8.4	-8.4	-6.9	-8.1	-7.9	-11.0
Mover-owners						
Simulated number	73,350	26,330	15,245	9,203	10,953	11,619
Desired value (FF)	-24,914	-17,760	-25,447	-25,325	-27,445	-30,244
Maximum value (FF)	-70,683	-44,844	-60,919	-93,108	-88,924	-112,109
Purchase value (FF)	-21,101	-12,886	-19,777	-25,903	-27,029	-28,409
% constrained (pts)	1.2	0.8	0.9	1.6	1.9	1.5
All						
Desired value (FF)	0	0	0	0	0	0
Maximum value (FF)	43,398	45,150	40,626	42,215	40,835	45,418
% constrained (pts)	-6.4	-6.1	-4.5	-5.6	-5.3	-9.0

Table 5a: Deviations from benchmark when Vmax is increased by 10%

	Whole sample	By age bracket				
		Less than 30	30-34	35-39	40-49	50 or more
Stayers						
Simulated number	-27,747	-7,112	-6,174	-3,910	-5,593	-4,958
Desired value (FF)	-5,503	-7,343	-7,801	-6,428	-5,173	-2,098
Maximum value (FF)	72,728	63,819	79,846	80,176	78,475	68,657
% constrained (pts)	-3.6	-3.8	-3.6	-3.5	-3.3	-3.6
Mover-Renters						
Simulated number	-10,506	-5,579	-2,477	-1,150	-895	-405
Desired value (FF)	-3,250	-3,613	-4,126	-2,886	-2,309	-666
Maximum value (FF)	70,390	66,147	84,646	74,484	69,180	64,963
% constrained (pts)	-3.7	-3.9	-3.9	-3.6	-3.2	-3.5
Mover-owners						
Simulated number	38,252	12,691	8,651	5,059	6,488	5,363
Desired value (FF)	-3,350	-1,343	-5,322	-2,893	-3,388	-4,285
Maximum value (FF)	70,277	62,438	77,394	76,329	77,045	59,594
Purchase value (FF)	9,440	11,526	11,810	8,752	8,173	1,431
% constrained (pts)	-2.2	-2.3	-2.5	-1.8	-1.9	-1.7
All						
Desired value (FF)	0	0	0	0	0	0
Maximum value (FF)	78,221	70,605	90,111	86,690	84,312	71,303
% constrained (pts)	-3.5	-3.6	-3.6	-3.4	-3.2	-3.5

Table 5b: deviation from the benchmark case for the scenario a=0.25

	Whole sample	By age bracket Less than 30	30-34	35-39	40-49	50 or more
Stayers						
Simulated number	42,790	11,844	9,941	6,464	8,922	5,618
Desired value (FF)	7,936	10,256	11,468	9,098	7,426	2,291
Maximum value (FF)	-39,597	-45,031	-54,339	-48,718	-47,310	-26,090
% constrained (pts)	5.1	5.6	5.0	5.0	4.8	5.0
Mover-Renters						
Simulated number	17,269	9,253	4,233	1,665	1,575	543
Desired value (FF)	4,865	4,951	7,518	4,004	3,247	812
Maximum value (FF)	-38,361	-39,024	-48,570	-39,315	-38,869	-23,305
% constrained (pts)	5.8	6.2	5.7	5.1	5.2	5.5
Mover-owners						
Simulated number	-60,058	-21,097	-14,174	-8,129	-10,496	-6,161
Desired value (FF)	7,601	6,116	9,659	8,383	9,838	6,623
Maximum value (FF)	65,378	46,395	61,742	90,254	86,794	74,302
Purchase value (FF)	8,351	4,479	8,975	12,580	11,823	10,727
% constrained (pts)	-1.6	-1.3	-1.5	-1.9	-1.7	-2.1
All						
Desired value (FF)	0	0	0	0	0	0
Maximum value (FF)	-32,285	-32,705	-38,036	-36,517	-38,317	-22,827
% constrained (pts)	4.4	4.6	3.8	4.2	4.2	4.6

Table 5c: deviation from the benchmark case for the scenario e=0.35

	Whole sample	By age bracket Less than 30	30-34	35-39	40-49	50 or more
Stayers						
Simulated number	-7,214	-1,614	-1,472	-943	-1,215	-1,970
Desired value (FF)	-1,573	-2,099	-2,410	-1,661	-1,207	-981
Maximum value (FF)	27,397	24,317	29,662	29,157	28,639	26,654
% constrained (pts)	-1.1	-1.1	-1.0	-1.0	-0.9	-1.2
Mover-Renters						
Simulated number	-2,980	-1,594	-746	-284	-218	-138
Desired value (FF)	-1,172	-1,386	-1,408	-945	-801	-313
Maximum value (FF)	28,646	27,616	34,557	28,998	27,377	25,955
% constrained (pts)	-1.0	-1.1	-1.2	-0.9	-0.7	-0.9
Mover-owners						
Simulated number	10,194	3,208	2,219	1,226	1,433	2,109
Desired value (FF)	-109	875	-493	-23	-147	-160
Maximum value (FF)	45,824	42,585	51,044	49,199	53,259	30,195
Purchase value (FF)	9,829	10,323	11,424	10,307	9,860	5,632
% constrained (pts)	-2.2	-2.2	-2.3	-2.0	-2.3	-2.0
All						
Desired value (FF)	0	0	0	0	0	0
Maximum value (FF)	32,989	31,776	39,815	35,186	34,396	28,409
% constrained (pts)	-1.3	-1.4	-1.5	-1.2	-1.1	-1.3

Table 5d: Deviations from benchmark for the scenario r=+1 pts
(effect on the maximum housing value only)

	Whole sample	By age bracket Less than 30	30-34	35-39	40-49	50 or more
Stayers						
Simulated number	3,304	703	646	396	569	991
Desired value (FF)	677	844	1,109	825	650	343
Maximum value (FF)	-9,853	-8,821	-10,770	-10,318	-10,289	-9,578
% constrained (pts)	0.5	0.6	0.5	0.5	0.4	0.6
Mover-Renters						
Simulated number	1,284	649	277	139	161	59
Desired value (FF)	493	501	692	288	672	66
Maximum value (FF)	-10,275	-9,972	-12,257	-10,515	-9,731	-9,235
% constrained (pts)	0.4	0.4	0.5	0.5	0.3	0.4
Mover-owners						
Simulated number	-4,588	-1,351	-922	-535	-730	-1,050
Desired value (FF)	172	-181	-105	-49	-357	1,632
Maximum value (FF)	-14,991	-14,411	-17,435	-16,472	-17,180	-6,103
Purchase value (FF)	-3,819	-4,019	-4,638	-4,195	-4,143	-1,164
% constrained (pts)	0.9	1.0	1.0	0.8	0.8	0.7
All						
Desired value (FF)	0	0	0	0	0	0
Maximum value (FF)	-11,716	-11,322	-14,142	-12,502	-12,249	-10,029
% constrained (pts)	0.6	0.6	0.6	0.6	0.5	0.6

Deviation from benchmark for the scenario r=+1 pts
(two effects: on the maximum housing value and the user cost)

	Whole sample	By age bracket Less than 30	30-34	35-39	40-49	50 or more
Stayers						
Simulated number	41,036	9,502	8,649	5,664	8,407	8,814
Desired value (FF)	-11,861	-14,642	-20,558	-15,740	-16,589	-7,091
Maximum value (FF)	919	3,677	8,406	1,241	1,020	-2,399
% constrained (pts)	-0.5	-0.7	-0.8	-0.7	-0.7	-0.3
Mover-Renters						
Simulated number	14,828	7,501	3,424	1,592	1,412	899
Desired value (FF)	-6,960	-7,646	-9,215	-7,597	-7,128	-3,156
Maximum value (FF)	-3,473	-2,447	-4,904	-2,848	-1,706	-8,054
% constrained (pts)	-0.3	-0.4	-0.3	-0.4	-0.4	0.0
Mover-owners						
Simulated number	-55,864	-17,003	-12,072	-7,255	-9,820	-9,714
Desired value (FF)	-55,454	-47,643	-68,114	-59,330	-64,106	-41,220
Maximum value (FF)	-8,451	-14,461	-10,578	3,994	-388	4,027
Purchase value (FF)	-19,235	-15,977	-21,907	-19,151	-22,859	-19,503
% constrained (pts)	-2.3	-2.0	-2.5	-2.5	-2.5	-2.5
All						
Desired value (FF)	-24,087	-23,780	-37,631	-27,380	-28,034	-12,653
Maximum value (FF)	-11,716	-11,322	-14,142	-12,502	-12,249	-10,029
% constrained (pts)	-0.6	-0.6	-0.8	-0.6	-0.7	-0.3

APPENDIX C: ESTIMATION RESULTS

Table C1: income equation

Variable	Parameter	Standard Err.	P>|T|
EL Income equation			
Constant	11.0804	.0262	.0022
No diploma - reference			
University diploma more than two year's study, engineer school diploma	.8574	.0219	< .0001
University diploma two years study	.6216	.0290	< .0001
High school diploma and equivalent	.4141	.0450	< .0001
Vocational training certificate	.2732	.0213	< .0001
School certificate (taken at 16 years)	.4137	.0231	< .0001
No spouse being job occupied - reference			
Spouse having a job	.2962	.0203	< .0001
Age in 1992: from 35 to 39 years - reference			
Less than 30 years	-.1569	.0244	< .0001
From 30 to 34 years	-.0218	.0269	.4170
From 40 to 49 years	.0581	.0239	.0151
More than 50 years	.0091	.0246	.7102
Town size: 100,000 – 2,000,000 inhabitants - reference			
Rural	-.0694	.0241	.0039
Less than 20,000 inhabitants	.0020	.0290	.9459
20,000 – 100,000 inhabitants	-.0215	.0221	.3289
Paris	.1660	.0181	< .0001
Living alone - reference			
Live in couple	.4689	.0175	< .0001

Variable	Parameter	Standard Err.	P>|T|
EP Income equation			
Constant	11.1179	.0373	< .0001
No diploma - reference			
University diploma more than two year's study, engineer school diploma	.6252	.0301	< .0001
University diploma two years study	.5260	.0363	< .0001
High school diploma and equivalent	.2708	.0288	< .0001
Vocational training certificate	.2754	.0259	< .0001
School certificate (taken at 16 years)	.2899	.0375	< .0001
No spouse having a job - reference			
Spouse having a job	.2759	.0339	< .0001
Age in 1992: from 35 to 39 years - reference			
Less than 30 years	-.4472	.0362	< .0001
From 30 to 34 years	-.1468	.0403	.0003
From 40 to 49 years	.0560	.0381	.1412
More than 50 years	-.0363	.0369	.3244
Town size: 100,000 – 2,000,000 inhabitants - reference			
Rural	.0624	.0313	.0463
Less than 20,000 inhabitants	.0626	.0274	.0225
20,000 – 100,000 inhabitants	.0103	.0227	.6498
Paris	.0849	.0292	.0037
Living alone - reference			
Live in couple	.4166	.0320	< .0001

Table C2: maximum value equation

Variable	Parameter	Standard Err.	P> |T|
Constant	-4.6322	.6957	< .0001
Logarithm of income	1.4764	.0612	< .0001
No secondary house – reference			
Owns a secondary house	.6525	.0742	< .0001
Age in 1992: from 35 to 39 years - reference			
Less than 30 years	.1544	.0510	.0025
From 30 to 34 years	.0795	.0560	.1556
From 40 to 49 years	-.0961	.0504	.0567
More than 50 years	.2207	.0480	< .0001
No house in hiring – reference			
Hires a house	.9167	.0931	< .0001
No spouse having a job – reference			
Spouse having a job	.0210	.0438	.6319
Living alone – reference			
Live in couple	-.2435	.0441	< .0001

Table C3: moving costs equation

Variable	Parameter	Standard Err.	P> |T|
Constant	.1410	.0332	< .0001
Number of children in 1992	.0159	.0070	.0230
Number of children born between 92 and 96	-.0287	.0122	.0189
Living alone – reference			
Live in couple	-.0113	.0119	.3449
Not divorced – reference			
Divorced	-.0617	.0187	.0010
Age in 1992: from 35 to 39 years - reference			
Less than 30 years	-.1187	.0306	.0001
From 30 to 34 years	-.0305	.0195	.1173
From 40 to 49 years	.0654	.0225	.0036
More than 50 years	.1542	.0395	.0001

Table C4: user cost equation

Variable	Parameter	Standard Err.	P> |T|
Constant	-1.3434	.1022	< .0001
Housing vacancy rate in town in 1990	.9990	.5674	.0783
Proportion of renters in town in 1990	.2911	.2141	.1741
Age in 1992: from 35 to 39 years - reference			
Less than 30 years	.0342	.0591	.5630
From 30 to 34 years	-.1091	.0613	.0753
From 40 to 49 years	-.0161	.0622	.7962
More than 50 years	.0651	.0662	.3256
Nationality: French – reference			
Foreigner	.0394	.0748	.5983
Job occupation: not unemployed – reference			
Unemployed	-.2955	.0562	< .0001
House status: not a detached house - reference			
Detached house	-.0772	.0372	.0381
Residential location: do not live in Paris - reference			
Live in Paris	-.1926	.0422	< .0001

Table C5: variance and covariance parameters

Parameter	Estimated value	Standard Err.	P>|T|
σ_1	.1988	.0452	< .0001
σ_2	.5785	.0439	< .0001
σ_3	.3886	.0084	< .0001
σ_4 (EL)	.4761	.0037	< .0001
σ_4 (EP)	.5676	.0040	< .0001
σ_5	.7507	.0069	< .0001
σ_6	.5871	.0102	< .0001
λ_1	.0305	.0124	.0139
λ_2	-.1365	.0342	.0001
λ_3	-.1157	.0266	< .0001
λ_5	-.6460	.0638	< .0001
λ_6	.1111	.0300	.0002
ρ_{12}	-.2228	.1382	.1070
ρ_{13}	-.3843	.0611	< .0001
ρ_{23}	.2541	.0749	.0007

Table C6: rent equation

Variable	Parameter	Standard Err.	P>|T|
Constant	7.1813	.2521	< .0001
Logarithm of income	.3629	.0214	< .0001
Socio-economic index	.2932	.0294	< .0001
Number of children in 1992	.0626	.0101	< .0001
Number of children born between 92 and 96	.0721	.0169	< .0001
Town size: 100,000 – 2,000,000 inhabitants - reference			
Rural	-.1231	.0288	< .0001
Less than 20,000 inhabitants	-.0463	.0307	.1321
20,000 – 100,000 inhabitants	.0194	.0271	.4757
Paris	.0030	.0258	.9075
Not divorced – reference			
Divorced	.0923	.0264	.0005
No secondary house – reference			
Owns a secondary house	-.0188	.0282	.5050
Job status : not a civil servant – reference			
Civil servant	.0184	.0303	.5428

Table C7: previous rent equation

Variable	Parameter	Standard Err.	P>│T│
Constant	11.2598	.0963	< .0001
Socio-economic index	.5481	.0471	< .0001
Town size: 100,000 – 2,000,000 inhabitants - reference			
Rural	-.2157	.0446	< .0001
Less than 20,000 inhabitants	.0155	.0705	.8256
20,000 – 100,000 inhabitants	-.0588	.0425	.1665
Paris	.1815	.0444	< .0001
Year the occupied house was built : 1982 and after – reference			
Before 1948	-.6536	.0860	< .0001
1949 – 1974	-.3277	.0878	.0002
1975 – 1981	-.0804	.1006	.4237
One room – reference			
Two rooms	.2462	.0505	< .0001
Three rooms	.4252	.0499	< .0001
Four rooms	.5613	.0524	< .0001
Five rooms	.6904	.0599	< .0001
Six rooms and more	.9724	.0655	< .0001