Housing Markets in a Simple Pure Consumption Economy*

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Abstract

This paper studies different housing market arrangements in an intertemporal pure consumption economy, consisting of a desirable and an undesirable housing location. Economic agents are heterogenous with respect to the utility premium they derive from living in the desirable location. This utility premium, or match, is drawn independently in every period, and also the popularity ranking of the locations may be reversed between periods. Under owner-occupation, the opportunity cost of living in a desirable location takes the form of random capital losses, and forgone capital gains. The rental arrangement corresponds to owner-occupation, with capital gains and losses taking place with probability one. We show that under the rental arrangement the agents have strong incentives to choose their location according to the current match, while under owner-occupation these incentives are weaker, and borrowing constraints play a larger role in clearing the housing market. We demonstrate that there is more residential mobility under rental markets than under owner-occupied housing. According to a utilitarian social welfare criterion, the rental arrangement outperforms owner-occupation.

Keywords: Household mobility, Liquidity constraints, Owner-occupation, Rental housing.

1 Introduction

This paper is a theoretical investigation into the relative merits of different housing arrangements in allocating people in space and in time. Our starting point is the double nature of houses as both consumption goods and assets. Under the rental arrangement these two functions are separated, and for a tenant a house is definitely a consumption good which is bought in every period for the services it offers. At each moment of time there is also an intimate connection between benefits received and costs incurred: people residing in a desirable area pay for the privilege in the form of higher rents. The rental market thus offers people strong incentives to choose their location based on current benefits, or the current match.

By contrast, when bought, a house not only entitles its owner to a stream of services, but it is also an asset which may either appreciate or depreciate in value. Then at least a part of the costs for living in a currently desirable area consists of capital losses which are incurred by those who happen to own a house there when prices fall. Likewise the compensation for those settling for a currently unpopular area partially takes the form of random capital gains.

This paper suggests, that the randomness introduced by the asset aspect of owner-occupied housing loosens the link between services received and payments made, and the incentives to choose one's location in every period based on the goodness of match are weaker than under the rental arrangement. In particular we find that the uncertain punishment embodied in capital losses does not provide a strong enough deterrent for wealthy agents to move out of the desirable location when their match is poor. Then, a part of the mechanism equating housing supply and demand assumes a different form: some of those agents who are hit by a negative shock become liquidity constrained, and thus cannot buy a house in a desirable area even when their match is good.

We try to convey these ideas in the simplest possible framework. We consider an infinite horizon pure consumption economy, consisting of two locations. Both locations have a fixed stock of houses. In each period one of the locations is desirable while the other one is (relatively) undesirable. When living in the desirable area, an agent receives a higher instantaneous utility stream, reflecting e.g. a better quality of environmental amenities and other public goods, a greater variety of services or well-paid jobs, safety and various socio-economic aspects of the neighborhood. The agents are heterogenous with respect to the utility premium they derive from residing in the desirable location, or in the quality of their 'match'. The match may also change over time. This may reflect changes in the socio-economic status of the agent (or the household), such as having children, finishing studies and entering the labor market, or retiring. The match may also improve or deteriorate as a result of alterations taking place in the neighborhood. For example, new bars and restaurants typically render an area more appealing for some people, while less appealing for others.

It is also possible that the overall ranking of the locations is reversed. A polluting factory or a prison tends to render a location less popular, while, say, a new school or improving public transport is likely to enhance its appeal. The changing attractiveness of different areas may also follow from labor market conditions, or from fads and fashions. When a location becomes (relatively) more or less appealing for the population as a whole, also relative housing prices in different regions change. This gives rise to capital gains and losses.

In the economy, financial and insurance markets are incomplete in two ways. First, we stipulate that idiosyncratic shocks (i.e. draws of the match) are uninsurable. This assumption is rather natural, since a putative insurer cannot (perfectly) observe an agent's match, and if asked, the agent typically faces incentives to misreport his type.[1] Second, we also assume that housing price movements are uninsurable. Although there have been a few real-life experiments with housing price index based financial instruments[2] in the U.S. and in the U.K., this assumption still seems to be broadly consistent with empirical evidence.

We then analyze the economy under owner-occupation and rental housing. Under

[1] Rather obviously, idealized insurance markets which cover the greater housing costs of agents with the best current match are not feasible. However, most probably, there are incentive compatible mechanisms, which are more elaborate and more efficient than the simple incomplete market outcome analyzed in this paper.

[2] These instruments are often called Case Shiller securities. For a discussion, see e.g. Shiller (1993).

owner-occupation the opportunity cost of living in a currently desirable location consists of stochastic capital losses and forgone capital gains. Our analysis shows, that the rental arrangement corresponds to a special case of owner-occupation, with both costs and benefits accruing with probability one. An agent incurring a capital loss, or making a gain, moves up or down the wealth ladder. At the lowest allowed step he is liquidity constrained and cannot afford a house in the desirable location.

We show that the higher the probability of changes in relative housing prices, the more inclined an agent with a given wealth is to choose the unpopular neighborhood when his match is poor. Also, the shape of the wealth distribution depends on the frequency of regional shocks. In particular, the liquidity constrained group is smaller, when transitions up and down the wealth ladder happen with a larger probability. Combining individual agents' decision rules at different wealth levels and the wealth distribution, we can then assess the aggregate functioning of the economy. We find that, according to a standard utilitarian welfare criterion, the owner-occupied arrangement functions better in turbulent times, with frequent capital gains and losses, than in tranquil times. Also residential mobility increases together with the frequency of shocks. Moreover, the rental arrangement outperforms owner-occupation in encouraging residential mobility, and results in higher social welfare.

The double role of housing as a consumption good and an asset has been recognized at least since Henderson and Ioannides (1983) who studied its implications for tenure choice. The basic problem arises from the fact that a household's consumption demand for housing may constrain its investment choice for housing, or vice versa. A subsequent paper by Henderson and Ioannides (1987) considered a model with more general institutional characteristics and then analyzed it empirically. Bruenecker (1997) further studied the interaction between the consumption demand and the investment demand for housing in a mean-variance portfolio context, while Flavin and Yamashita (2002) undertook a corresponding econometric analysis. Recent literature has also recognized that owner-occupied housing may serve as a hedge against the risk that house prices rise in the future (see Cocco (2000), Davidoff (2003), Ortalo-Magné and Rady (2002b), and Sinai and Souleles

(2003))[3]. However, none of these papers has considered the implications of housing market capital losses and gains for regional allocation of economic agents. The only paper towards this direction we found is by Ortalo-Magné and Rady (2002a) who studied household mobility, volatility of house prices and income distribution.[4] While they demonstrated in a stochastic two-location, two-period model that home-ownership enables more households to remain in the more desirable location at the expense of newcomers, their analysis does not consider the possibility of capital losses in the housing market. Also, their analysis (like the other aforementioned ones) is merely partial equilibrium in nature, while the present paper is concerned with a general equilibrium outcome. More importantly, we take up the question of aggregate welfare instead of an individual's optimization problem that is the common perspective in the bulk of the previous contributions.

The liquidity constraint theme of this paper is closely related to that of Stein (1994) who studied the effects of a down-payment on the formation of house price movements. Whereas Stein considered a static economy with an exogenous debt distribution, we analyze a dynamic model and derive an endogenously arising wealth distribution across the agents. It is also worth mentioning that in the economy of this paper agents can become mismatched due to similar reasons as in the recent searching models for housing markets by Wheaton (1990) and Williams (1995).

On the empirical front, a series of studies have examined whether owner-occupiers are more unemployed and less mobile than those who rent their homes. The most cited paper is by Oswald (1997) who observed from OECD data that the rate of owner-occupied housing is positively correlated with the average rate of unemployment (for additional evidence see e.g. Green and Hendershott (2001) and Nickell and Layard (1999)). Also various microeconomic studies have indicated that home-owners are more sluggish to move in response to changing labor market conditions than people who rent their homes (see e.g. Barceló (2003), Cameron and Muellbauer (2001), Hughes and McCormick (1985,

[3]These papers also analyze the role of the home as a hedging device against adverse shocks in good prices or labor income. In fact, Henderson and Ioannides (1983) already considered homeownership as a means to ensure desired housing consumption when future house prices are uncertain.

[4]Also Rady and Ortalo-Magné (1999, 2001) are somewhat related and provide explanations for why house prices tend to be very volatile - an important factor in the present theory.

1987), Henley (1998), and Gardner et al. (2000)). While none of the theoretical arguments presented in these studies give well founded role for capital losses and gains in the housing market, the empirical content is broadly consistent with the theoretical findings of the present paper. Thus, our paper takes a step towards better understanding of this large body of empirical evidence and perhaps also offers a route to discovering new hypotheses for empirical examination.

The plan of the paper is as follows. Section 2 lays down the model basics. Section 3 shows how an agent's wealth evolves under different housing arrangements. It turns out that the wealth accumulation of an agent in the rental market can be represented as special case of the one of the owner-occupied housing arrangement. In Section 4, we solve the agents' optimal moving policy that depends on their wealth. Section 5 proceeds from the individual to the aggregate level and derives the aggregate wealth distribution of the economy. Sections 6 provides mobility and welfare comparisons between the two housing market arrangements. In section 7 we summarize our findings, discuss their generality and how we have examined their robustness in some of our related studies.

2 The basics of the economy

The economy has two locations, or neighborhoods. Both locations have an equal, fixed, stock of identical houses. Each house is occupied by a single economic agent and no one agent is ever homeless. For convenience, assume that in each location the stock of houses and the mass of agents each comprises a continuum of size unity.

There are infinite discrete time periods indexed by $t = 0, 1, ...$ In each period, one of the locations is deemed more desirable than the other. When a period changes, the ranking of the locations is reversed with probability $\pi \in [0, 1]$.

The agents are heterogenous in the quality of their match, or type. In every period the match θ of each agent is randomly drawn from a cumulative distribution function $G(\theta)$, on some support $[\theta_L, \theta_H]$, where $0 < \theta_L < \theta_H < \infty$. The aggregate heterogeneity of agents is unchanged over time so that G is stationary. The actual utility of an agent is conditional on the neighborhood where he resides. We assume that an agent receives utility θ, the value of his type, when living in the desirable location. For simplicity, the utility of anyone agent living in the less desirable location is normalized to zero. Finally, the agents live forever and discount future utilities by a common factor $\beta \in (0,1)$.

The sequence of events in any time period is the following. First, a random process determines which location is desirable and which is not. Second, each agent observes his current type θ, which is drawn from the distribution $G(\theta)$. Finally the agents decide where they want to live. Depending on their choice, they either stay where they are or they migrate to the other location. However, if the agent is liquidity constrained, he cannot move from an undesirable location to a desirable location. Liquidity constraints will be discussed in the next section.

Denote the median type by θ_m. In every period, the aggregate welfare is maximized, if all agents with $\theta > \theta_m$ are allocated to the desirable location, those with $\theta < \theta_m$ live in less desirable location, and the group (always of measure zero, if G is continuous) with $\theta = \theta_m$ is divided between the locations so that capacity constraints in housing are not violated. If this allocation rule is followed, the expected utility of a representative agent in any period is

$$W^* = \frac{1}{2}E[\theta \mid \theta \geq \theta_m] = \int_{\theta_m}^{\theta_H} \theta dG(\theta) \tag{1}$$

To implement the first best outcome, half of the agents who are in the desirable location at the beginning of a period must move to the undesirable location, while the same amount of agents must make the journey in the opposite direction. Thus the measure of aggregate mobility needed in any period is

$$M^* = 1$$

3 Housing arrangement and the evolution of wealth

While in the social optimum the place where an agent lives should only depend on his type, in the market outcome the choice is also influenced by wealth. In particular an agent's moving decisions may be radically restricted by the liquidity constraint. This section studies how an agent's wealth evolves under different housing arrangements.

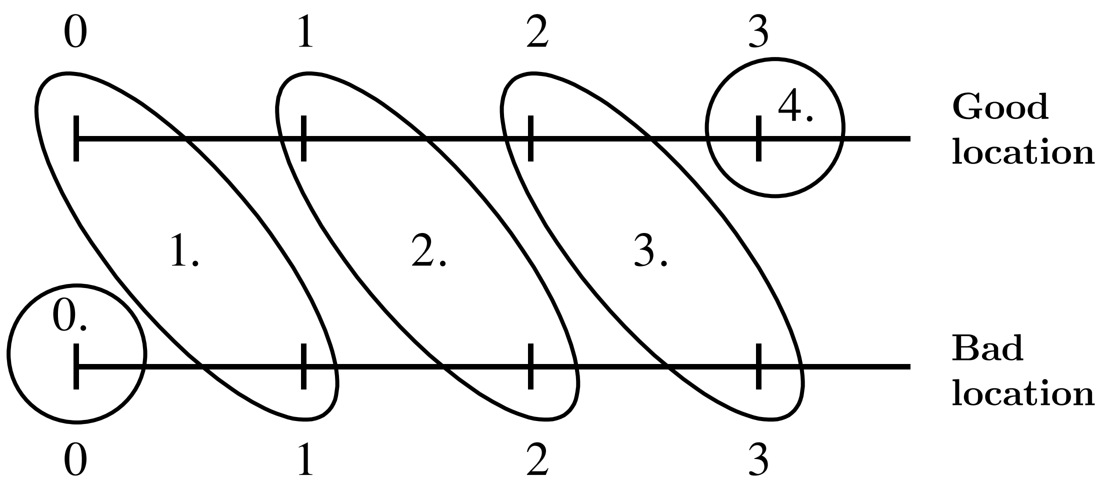
We begin by owner-occupied housing. Let p_g and p_b, respectively, denote the market prices of the houses in the desirable and undesirable (or good and bad) neighborhoods. These steady state prices satisfy the inequality $p_g > p_b$. A move from the good neighborhood to the bad neighborhood by an agent entails that he sells his current house in the good location and buys another home in the less desirable location. The difference in house prices $p = p_g - p_b$ is then deposited to the agent's bank account. In the opposite case, an agent moving from the less desirable neighborhood to more desirable location withdraws p units from his account to make up for the difference between house prices. For a move from the bad to the good location to be possible, the agent's bank balance has to be large enough to cover the costs. To be more specific we assume that there is a maximum level of debt which cannot be exceeded. If this requirement is not met, the agent is liquidity constrained and cannot move. To keep the model as simple as possible we assume that the bank is just a clearinghouse which keeps track of agents' balances. In particular, the bank does not pay any interest to the deposits. An alternative interpretation of the financial institutions is that money is the only store of value in the economy.[5] Note that the savings or money holdings of an agent then always comprise a multiple of p.

Take two agents i and j. At the beginning of a period agent i has $n \times p$ units of wealth in his bank account and a house in the undesirable location, while agent j has $(n-1) \times p$ units in the bank and a house in the desirable location. Now it should be fairly easy to see that there is no real difference between the two agents' financial position. As housing markets are assumed to be frictionless i can sell his house in the bad neighborhood and buy another in the good neighborhood. After this transaction he has exactly the same assets as j. The same argument also applies the other way round. We can then define a wealth class consisting of two financial states:

$$\text{Wealth class } n : \begin{cases} (n-1) \times p \text{ units in bank and a house in the good location} \\ n \times p \text{ units in bank and a house in the bad location.} \end{cases} \tag{2}$$

[5]Section 7 provides some discussion on structure of asset markets.

Figure 1: Wealth class, bank savings, and house location



This classification system simply captures that fact that to assess an agent's aggregate wealth, we must add together the value of his house and his bank savings. Agents belonging to the same wealth class have the same amount of aggregate assets.

A case with five wealth classes, ranging from 0 to 4, is illustrated in Figure 1. Bank savings of people living in the desirable and the undesirable location are measured on the two horizontal axes. As a convenient normalization, we denote the lowest permitted bank balance by 0. Wealth classes 1, 2, and 3, delimited by ellipsoids, each consist of two financial states, in accordance with the definition (2) given above. In the lowest wealth class 0, the agents are liquidity constrained and cannot move to the good neighborhood. Thus this wealth class is a singleton. Also the highest wealth class, in our example class 4, contains only one financial state. Agents belonging to this class are so wealthy that they never want to move to the less desirable neighborhood.

If an agent is in wealth class n in period t, what is his class in the next period? Suppose agent the decides to live in the good neighborhood. Then with probability $1-\pi$ the relative ranking of locations remains intact and the agent begins the next period with the same possessions. With probability π the ranking is reversed, and the agent suffers a capital loss. In the next period the agent has $(n-1)\times p$ units of money in the bank

Table 1: Wealth class in period $t+1$ depending on house location and housing arrangement, when the initial wealth class is n

	Good location	Bad location
Owner-occupied housing	n with probability $1-\pi$ $n-1$ with probability π	n with probability $1-\pi$ $n+1$ with probability π
Rental housing	$n-1$ with probability 1	$n+1$ with probability 1

and a house in an undesirable neighborhood. Thus he has fallen one step down to wealth class $n-1$.

Next suppose the agent chooses the less desirable neighborhood, instead. With probability $1-\pi$ the neighborhood is unpopular also in the subsequent period, and the agent stays in wealth class n. With probability π there is a change in fortunes, and the agent makes a capital gain. With $n \times p$ units of money and a house in a desirable neighborhood, the agent has succeeded in climbing to wealth class $n+1$.

Next we turn to rental housing. Assume the housing stock in both locations is managed by a real estate company, owned by the agents. Let r_g and r_b denote per period level of rents in the good and in the bad location, respectively. These steady state rents satisfy the inequality $r_g > r_b$. In every period the total revenue collected by the real estate company is $r_g + r_b$. This revenue is then distributed to the agents, with each of them receiving $(r_g + r_g)/2$ units. Now the net change in an agent's balances depends on where he lives. Those residing in the desirable neighborhood pay $r = (r_g - r_d)/2$ units more than they earn, while those choosing the less desirable location gain r units. The savings of an agent then always constitute a multiple of r. Since the housing stock is in common ownership, knowing an agent's bank balance also tells his level of wealth. The transition from one wealth class to another is simple. Those agents who choose the good location always pay a net price r and fall one class down, while others who settle for the unpopular neighborhood climb one ladder. In accordance to owner-occupation, we also assume that there is a maximum amount of debt which cannot be exceeded. An agent reaching the lowest allowed bank balance can only live in the less desirable neighborhood, no matter what his type is.

The differences between owner-occupied and rental housing are summarized in Table

1. Three points are worth emphasizing. First, in the rental arrangement, those who want to live in the popular neighborhood always pay for the privilege, and likewise those who stay in the less coveted location are duly compensated. In contrast, when houses are owner-occupied, both payment and compensation take place only with probability π. This distinction between random and non-random payments and revenues is the key insight of the paper. In what follows we demonstrate that the closer link between costs and benefits implies that rental housing does a better job in allocating agents in space and time. Second, while the workings of the rental market are independent of the transition probability π, the market with owner-occupation is affected by the length of the popularity cycle. Finally, rental markets are equivalent to owner-occupation with deterministic cycles: capital gains and losses which occur with certainty are indistinguishable from rental costs and revenues. This fact considerably simplifies the subsequent analysis: instead of analyzing two separate model variants, each corresponding to one housing arrangement, we can simply construct a model of owner-occupation, and then study renting by setting π equal to one.

4 The agent's problem

Consider the optimization problem of any one agent. In every period he chooses his location so as to maximize the expected discounted utility stream

$$E_\theta \sum_{t=0}^{\infty} \beta^t \theta \lambda_t,$$

where λ_t denotes an indicator function which is equal to one, if the agent lives in the desirable location in period t, and zero otherwise. This is a stochastic dynamic control problem in which the state variable is the level of wealth, that evolves according to the law of motion

$$n_{t+1} = (1 - s_{t+1})\, n_t + s_{t+1} \left[(1 - \lambda_t)(n_t + 1) + \lambda_t (n_t - 1) \right]$$

where s_t is an indicator function which is equal to one if there is a regional shock and zero otherwise. The liquidity constraint the agent faces is

$$\lambda_t = 0 \text{ if } n_t = 0$$

The problem can be conveniently presented in a recursive form. Let $V(n)$ denote the optimal value of the problem for an agent who has n units of wealth. $V(n)$ satisfies the Bellman equations

$$\begin{aligned} V(n) &= E_\theta \left[\max \left\{ \theta + \beta \left[(1-\pi)V(n) + \pi V(n-1) \right], \right. \right. \\ & \left. \left. \beta \left[(1-\pi)V(n) + \pi V(n+1) \right] \right\} \right] \text{ for } n \geq 1 \end{aligned} \tag{3}$$

and

$$V(0) = \beta \left[(1-\pi)V(0) + \pi V(1) \right] \tag{4}$$

Note that the value function $V(n)$ is evaluated after the regional shock has been realized but before the type θ has been revealed to the agent. The maximization problem then defines the optimal choice of location that takes place when the value of θ becomes known. Inside the maximum operator, the first expression is the value of living in the desirable neighborhood, while the second expression is the value of choosing the less desirable location. If the agent's optimal decision is to live in the good neighborhood, he can immediately 'eat' whatever value θ realized. His prospects for the next period are discounted by β and are given in the square brackets in the first argument of the maximization problem. There is a probability $1-\pi$ that the location will be popular also tomorrow so that he will be facing the same value function as today, while with probability π the location loses its appeal and the agent suffers a capital loss. If the agent chooses the undesirable neighborhood, his utility in the current period is zero. With probability $(1-\pi)$ his neighborhood is out of vogue also in the next period, while with probability π the ranking of the locations is reversed, and the agent makes a capital gain. It is worth noting that in the special case with $\pi = 1$ the recursion (3), (4) captures the agent's maximization

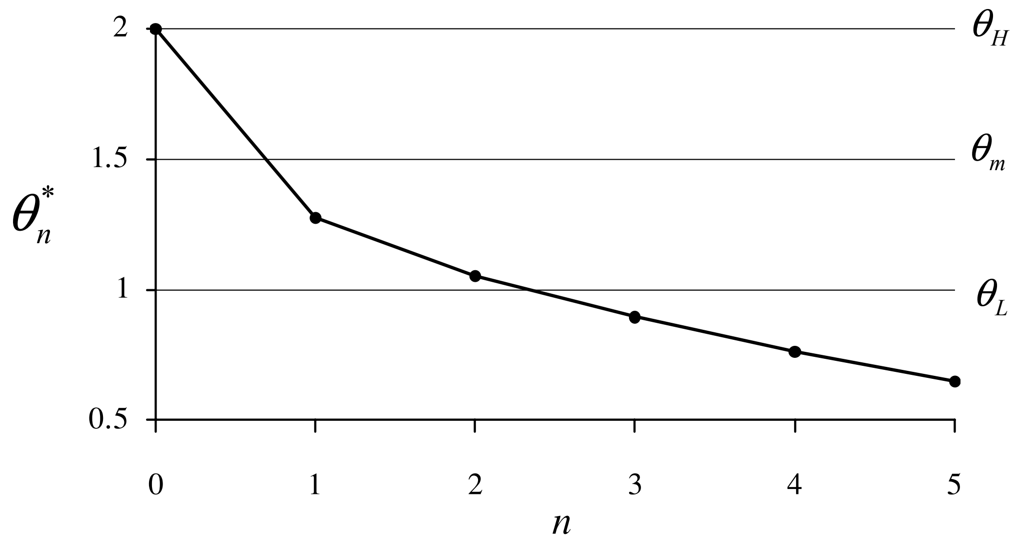


Figure 2: The θ_n^*-curve when θ is uniformly distributed on $[1,2]$, $\beta = .95$ and $\pi = .3$

problem under rental markets. That is

$$V(n) = E_\theta \left[\max\left\{\theta + \beta V(n-1), \beta V(n+1)\right\}\right] \text{ for } n \geq 1$$

and

$$V(0) = \beta V(1)$$

Essentially, the maximization problem involves a trade-off between present benefits and future options. The agent wants to avoid the situation where his choices are limited by the liquidity constraint. Choosing the desirable location when the match is poor entails the possibility that this option may not be available in the future when the match is better.

In each wealth class $n \geq 1$ there is then a critical quality of match

$$\theta_n^* = \pi\beta[V(n+1) - V(n-1)] \tag{5}$$

that equates the two arguments in the maximization operator in (3). Agents with $\theta > \theta_n^*$ choose the desirable neighborhood, while those with $\theta < \theta_n^*$ go to the less desirable neighborhood in the hope of gaining an additional option. Finally, agents with $\theta = \theta_n^*$ are indifferent between the two alternatives; if the distribution $G(\theta)$ is continuous, this group is always of measure zero. Figure 2 shows θ_n^* with different values of n when the earnings are uniformly distributed on $[1, 2]$, $\beta = .95$, and $\pi = .3$. Clearly, θ_n^* decreases with n. This is a general property of θ_n^*, and it stems from the fact that the value function is concave. Also this finding has a natural interpretation. If an agent has accumulated a large number of options (or assets), an additional option is of less value. To put it differently, the more assets the agent has, the more distant is the prospect of being liquidity constrained at some point in the future. Thus, wealthy agents are willing to live in the popular location even when their match is not so good. In particular, there is a level of wealth $\overline{n} < \infty$ such that if $n \geq \overline{n}$, $\theta_n^* < \theta_L$ and the agent always chooses the desirable neighborhood[6]; in Figure 2, $\overline{n} = 3$.

The market outcome is clearly not socially optimal. In the optimal arrangement the choice of location should depend on the current match only, so that the cut-off level would be equal to θ_m for all agents; this is captured by the straight horizontal line that crosses the vertical axis at 1.5 in Figure 2. In particular, agents at the two extreme ends of the wealth ladder deviate radically from the optimal decision rule, as their location is unaffected by the match.

Next we study what happens when the environment becomes more turbulent, or the housing market arrangement is altered. For a numerical illustration, see also Figure 3.

Lemma 1 *The θ_n^*-schedule shifts up as π increases.*

Proof See the appendix. ■

In other words, when costs and gains occur with a higher probability, a better match, or a bigger wealth buffer, is needed before the agent chooses the popular location. This is because transitions from one wealth class to another are likely to happen more often, and the prospect of becoming liquidity constrained is an increasingly powerful deterrent.

[6] Assume by contrast that $\lim_{n\to\infty} \theta_n^* = \widehat{\theta} \geq \theta_L > 0$ and $\theta_n^* \geq \widehat{\theta}\ \forall n$. Now as θ_n^* is a non-increasing sequence, which is bounded from below, we can conclude that for all $k < \infty$, $\lim_{n\to\infty}(\theta_n^* - \theta_{n-k}^*) = 0$ and $\lim_{n\to\infty}\left(\int_{\theta_n^*}^{\theta_H} \theta dG(\theta) - \int_{\theta_{n-k}^*}^{\theta_H} \theta dG(\theta)\right) = 0$. As a consequence $\lim_{n\to\infty}[V(n+1) - V(n-1)] = 0$. But then (5) implies that $\lim_{n\to\infty} \theta_n^* = 0$. A contradiction.

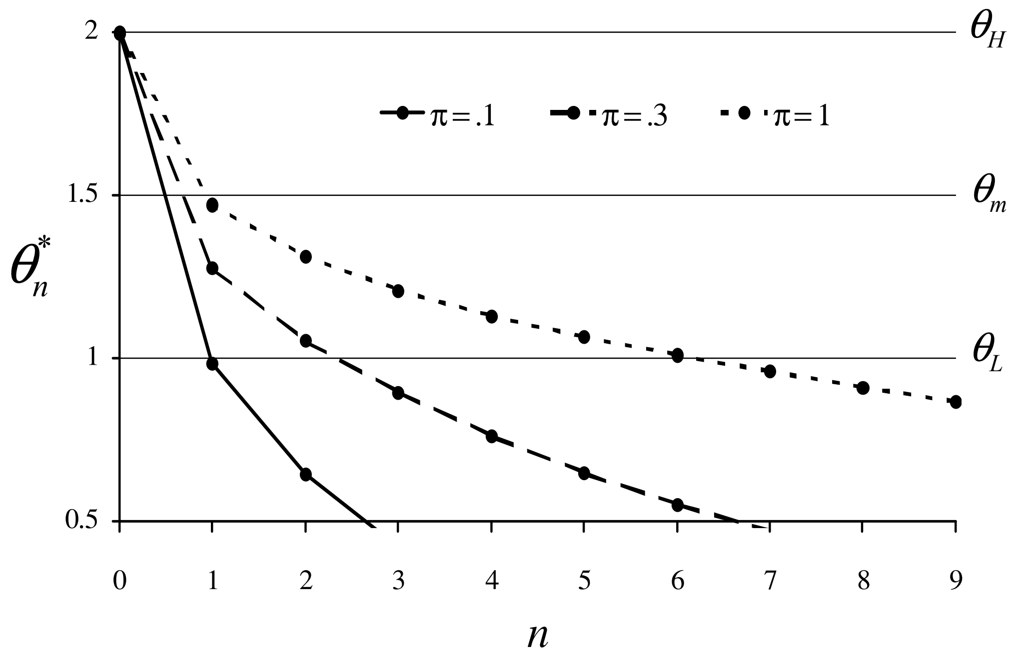


Figure 3: The θ_n^*-curve with different values of π when θ is uniformly distributed on $[1, 2]$ and $\beta = .95$

This property already suggests why the rental arrangement fares better in our model than owner-occupation. Under rental markets the agents are more likely to move voluntarily to the less desirable neighborhood, when their match is poor. Then the mechanism allocation people in space and time can rely predominantly on self-selection, rather than liquidity constraints. However, to say something more precise about the efficiency of different housing arrangements, we need to know how the wealth distribution is determined. This is the question we are going to address next.

5 Stationary wealth distribution

The agents' optimal strategies depend on their wealth. Thus to proceed from the individual level to the aggregate level we need to know the stationary wealth distribution in the economy. In particular, we want to study how the distribution reacts to changes in π.

Denote by f_n the size of wealth class n, and let

$$f_n^b = G(\theta_n^*) f_n, \qquad f_n^g = (1 - G(\theta_n^*)) f_n$$

be the frequency of agents with wealth n who live in location $i \in \{b, g\}$. Notice also that

$$\frac{f_n^b}{f_n^g} = \frac{G(\theta_n^*)}{1 - G(\theta_n^*)} \equiv \gamma_n \tag{6}$$

The 'odds ratio' γ_n decreases with n as wealthy agents are more likely to choose the good neighborhood. It is also worth mentioning that $\gamma_n > (<)\ 1$ when $\theta_n^* > (<)\ \theta_m$.

Now suppose that the ranking of the neighborhoods is reversed. Then all f_n agents who were previously in wealth class n either climb one step up or fall one step down, depending on their house location. They are replaced by f_{n-1}^b class $n-1$ agents who have made a capital gain, and f_{n+1}^g class $n+1$ agents who have suffered a capital loss. The distribution is stationary if and only if

$$f_n \equiv f_n^b + f_n^g = f_{n-1}^b + f_{n+1}^g \tag{7}$$

In addition to the stationarity condition (7), we also want to make sure that the housing markets clear in both regions:

$$\sum_{n=0}^{\overline{n}} f_n^i = 1, \quad i \in \{b, g\} \tag{8}$$

To find the stationary distribution satisfying equations (7) and (8), consider the wealth ladder in Figure 4. When the ranking of locations changes, the ladder is turned upside down, as all agents who previously owned a house in a desirable neighborhood now find that their possession is in less desirable location, and vice versa. This transition is captured by the vertical arrows. Now, the wealth ladder remains unchanged if it is symmetric in the sense that the two groups at the opposite ends of each step - i.e. the two groups with

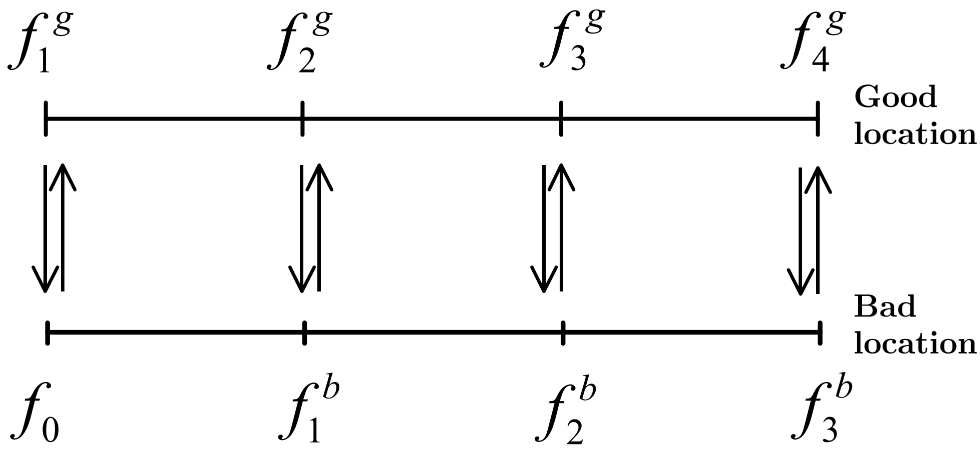


Figure 4: Wealth distribution

the same bank balance or money holdings - are of equal size:

$$f_{n+1}^g = f_n^b \tag{9}$$

The condition (9) also guarantees that there is an equal number of people in both regions, and the demand for housing does not exceed supply in either region.

Now combining (6) and (9) allows us to write simple recursive equations for f_n^i, $i \in \{b, g\}$

$$f_{n+1}^g = \gamma_n f_n^g \text{ and } f_{n+1}^b = \gamma_{n+1} f_n^b \tag{10}$$

and the frequency of any node can be linked to the size of the liquidity constrained group f_0

$$f_n^b = f_{n+1}^g = f_0 \prod_{i=0}^{n} \gamma_i \quad n \geq 0$$

where $\gamma_0 \equiv \frac{G(\theta_H)}{1-G(\theta_H)}$. Finally, recall that in both neighborhoods the housing stock is equal to unity so that we have the constraints (8). Then we get the formulae

$$f_{n+1}^g = f_n^b = \frac{\prod_{i=0}^{n} \gamma_i}{\sum_{k=0}^{\overline{n}-1} \prod_{i=1}^{k} \gamma_i} \quad \text{for } n = 0, ..., \overline{n} - 1$$

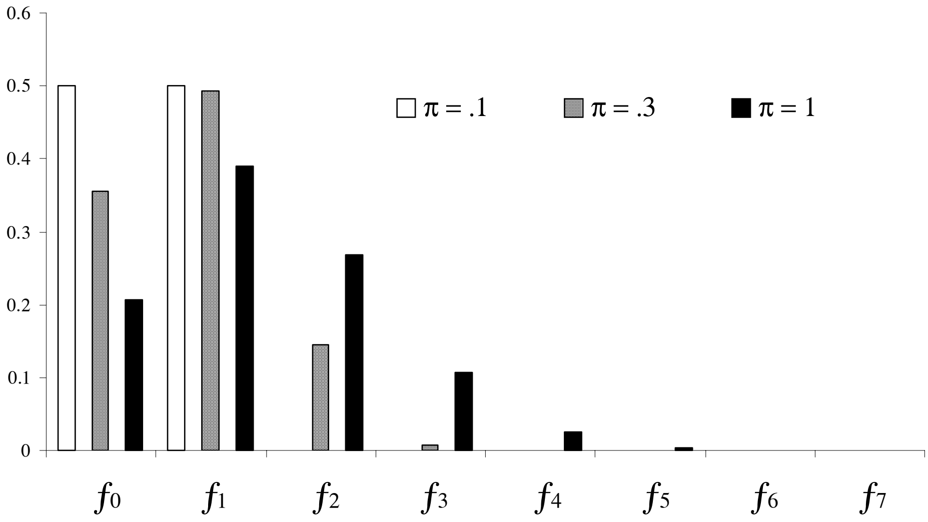


Figure 5: Wealth distributions with different values of π when θ is uniformly distributed on $[1, 2]$ and $\beta = .95$

which, together with the equalities $f_n = f_n^b + f_n^g$, determine the stationary distribution.

Figure 5 shows the stationary wealth distribution for three different values of π, when θ is uniformly distributed on $[1, 2]$ and $\beta = .95$. The distributions are single-peaked, with wealth classes in the middle typically having more mass than those on the tails. The single-peakedness is a general property, and follows from the fact that γ_n is decreasing in n. Intuitively, agents with less assets are likely to choose the less popular location and make capital gains. For wealthy agents, capital losses are more probable. Thus transitions in the wealth distribution tend to happen towards the middle.

We also notice that increasing π from .1 first to .3 and then to 1 shifts the distribution to the right, towards higher wealth classes. When capital gains and losses become more probable, the agents adopt increasingly cautious strategies, and are more likely to choose the less desirable location, in the hope of capital gains. As a result a larger proportion of the agents reach higher wealth levels. Notice also that with bigger values of π, there is less mass on the tails of the distribution. This observation is worth mentioning since agents in the extreme wealth classes are unwilling or unable to move in response to a changing match.

These findings can be restated more precisely, if we define the cumulative distribution function

$$F(n;\pi) = \sum_{i=0}^{n} f_i.$$

Lemma 2 *When π increases, the wealth distribution shifts to the right, in the sense of first-order stochastic dominance. That is $\frac{\partial F(n;\pi)}{\partial \pi} \leq 0$. In particular, the size of the liquidity constrained group decreases.*

Proof By Lemma 1, the θ_n^*-schedule shifts up when π grows. This then increases the 'odds ratio' γ_n, and equations (10) imply that the ratio f_{n+1}^i / f_n^i, $i \in \{b, g\}$ goes up. Thus for each n, $\frac{\partial(1-F(n;\pi))}{\partial \pi} \geq 0$ and $\frac{\partial F(n;\pi)}{\partial \pi} \leq 0$. ■

Finally we can characterize the money market equilibrium.

Remark 1 *Assume that money is the only store of value, and denote the aggregate supply of money by S. Then the money market equilibrium reads*

$$p \sum_{n=1}^{\overline{n}} \left[n f_n^b + (n-1) f_n^g \right] = S$$

It is easy to see that p, which measures both the price of housing in the desirable location and the size of a capital loss (or gain), decreases in monetary terms, when π goes up. As the rental arrangement corresponds to owner-occupation with $\pi = 1$, we can further conclude that $r \leq p$. Notice that if $\overline{n} = 1$, money has no value.

6 Mobility and welfare

Now we are in the position to analyze social welfare and aggregate mobility under different housing arrangements. Take an agent belonging to wealth class n. In any period he chooses the desirable neighborhood if his match $\theta \geq \theta_n^*$ and otherwise goes to the less desirable neighborhood. Given this strategy, the expected utility (before the draw of θ) of the agent, or alternatively the average realized utility of all agents in class n, is

$$\omega_n = \Pr(\theta \geq \theta_n^*) E[\theta \mid \theta \geq \theta_n^*] = \int_{\theta_n^*}^{\theta_H} \theta dG(\theta)$$

In particular, $\omega_{\overline{n}} = \int_{\theta_L}^{\theta_H} \theta dG(\theta)$ if the agent is currently in the highest wealth class $\overline{n}$, and $\omega_0 = 0$ if he is liquidity constrained. Aggregation then involves summing over all wealth classes, and the measure of overall welfare in any given period is

$$W = \sum_{n=0}^{\overline{n}} f_n \omega_n$$

An alternative way to approach social welfare is to imagine that an outsider enters the economy. He is assigned to wealth class n with probability f_n, and his expected intertemporal prospects are then given by the value function $V(n)$. The agent's prospects ex ante, i.e. before he knows his wealth, are

$$\widehat{W} = \sum_{n=0}^{\overline{n}} f_n V(n) \tag{11}$$

The appendix shows that, up to a constant multiplier, the two measures of welfare are equivalent:

$$W = (1-\beta)\,\widehat{W} \tag{12}$$

Next consider mobility in the market outcome. Take any given wealth class n. In the steady state, the portion $1 - G(\theta_n^*)$ of agents with wealth level n live in the desirable location. In any period the share $G(\theta_n^*)$ of the agents, who are in the popular neighborhood at the beginning of the period, get a realization $\theta < \theta_n^*$ and move to the unpopular neighborhood. Therefore, mobility from the desirable to the undesirable location in wealth class n is equal to $G(\theta_n^*)[1-G(\theta_n^*)]$. Similarly, it is easy to see that the crosswise mobility, i.e., from the undesirable to the desirable location, equals the same measure. Thus, overall mobility in wealth class n is

$$\mu_n = 2G(\theta_n^*)[1 - G(\theta_n^*)].$$

Given $G(\theta_n^*) \in [0, 1]$, we know that $\mu_n \in [0, \frac{1}{2}]$. The maximum value $\mu_n = \frac{1}{2}$ is attained when $\theta_n^* = \theta_m$, that is when the agents react to a changing match in the socially optimal way. The more the threshold θ_n^* differs from the socially optimal median rule, the less

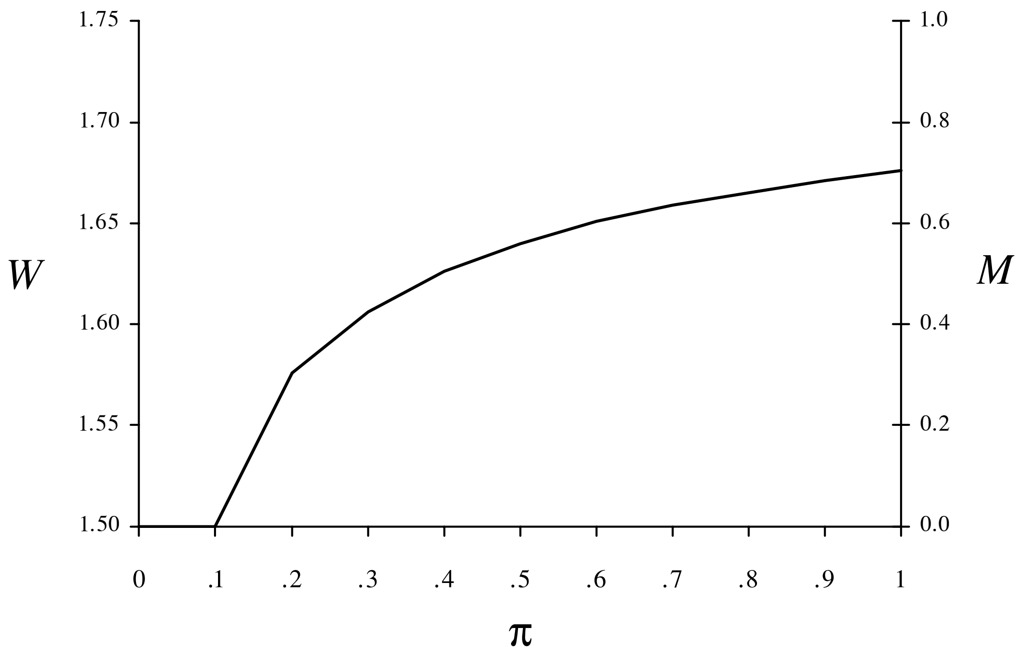


Figure 6: Aggregate mobility and welfare as a function of π when θ is uniformly distributed on $[1,2]$ and $\beta = .95$

migration there is. The intuition behind this finding is easy to grasp: Rich agents, with high θ_n^*, want to live in the popular neighborhood most of the time, and only rarely find it optimal to change location. Likewise poor agents usually stay in the unpopular location; for the liquidity constrained this is obviously the only alternative. Aggregate mobility (M) can then be determined by calculating the weighted average over all wealth classes

$$M = \sum_{n=0}^{\overline{n}} f_n \mu_n$$

Figure 6 uses the uniform type distribution on $[1,2]$ as an example, and shows W and M as a function of π, when $\beta = .95$. Measures of mobility and welfare can be displayed in the same figure, since in the case of the uniform distribution, W is an affine transformation of M.[7] With low values of π there is no mobility and $M = 0$. Half of the

[7] This is an artifact of the uniform distribution.

agents are liquidity constrained, and welfare under pure rationing is $W^R = 1.5$. When π increases, self-selection gradually replaces the debt trap as the main mechanism allocating people in space and time. As the agents face stronger incentives to choose their location according to the current match, both aggregate mobility and social welfare increase. The best possible outcome is achieved when $\pi = 1$, i.e. under the rental arrangement. However, as there are always some liquidity constrained agents, the economy never reaches the fully efficient level of mobility $M^* = 1$ and welfare $W^* = 1.75$.

The following two propositions establish that these properties hold more generally.

Proposition 1 *An increase in π enhances aggregate mobility. As the rental arrangement corresponds to the highest value of π, there is more mobility under rental housing than under owner-occupation.*

Proof See the appendix. ■

Proposition 2 *An increase in π improves aggregate welfare. As the rental arrangement corresponds to the highest possible value of π, rental markets outperform owner-occupation.*

Proof The required derivations are more succinct and clear if some vector notation is introduced. Let V, f and ω be column vectors capturing the value function, the expected utility per period, and the stationary wealth distribution, respectively. Totally differentiating (11) yields

$$\frac{d\widehat{W}}{d\pi} = \frac{df'}{d\pi}V + f'\frac{dV}{d\pi} = \frac{df'}{d\pi}V + f'\frac{\partial V}{\partial \pi}, \tag{13}$$

where the second equality follows from the envelope theorem: as the threshold θ_n^* is chosen optimally in all wealth classes $n \in \{1, ..., \overline{n}\}$, the indirect effect on the value function can be ignored. Next we use the identity (12) to show that also the direct effect $f'\frac{\partial V}{\partial \pi}$ vanishes:

$$f'\frac{\partial V}{\partial \pi} = \frac{\partial(f'V)}{\partial \pi} = (1-\beta)^{-1}\frac{\partial(f'\omega)}{\partial \pi} = 0$$

The first equality exploits the fact that the stationary distribution f depends on π only indirectly, through the choice of policy and the second equality uses (12). The final equality follows from the observation that expected utility in a given period (ω) does not depend directly on π.

Thus only the effect through the stationary wealth distribution remains. By Lemma 2 we know that the distribution shifts to the right, towards higher wealth classes, when π increases. As the value function V is increasing in n, this shift in the stationary distribution translates into higher aggregate welfare $\widehat{W}$:

$$\frac{d\widehat{W}}{d\pi} = \frac{df'}{d\pi} V \geq 0$$

■

7 Discussion

As a summary it may be instructive to reinterpret the model in slightly more abstract terms. We considered an economy with a single indivisible good. In each period half of the population is endowed with one unit of the commodity. The agents value the good differently, and in every period their valuation θ is drawn independently from a stationary distribution $G(\theta)$. There is also money in the economy, and as long as an agent's money holdings are non-negative, he can buy the good in the periods when his endowment is zero. If the agent consumes the good in the current period he receives a positive endowment in the subsequent period with probability $1-\pi$. If the agent does not consume in the current period, the probability of a positive endowment in the subsequent period is π. It is worth noting that this intertemporal allocation rule punishes (rewards) current consumption if $\pi > (<) \frac{1}{2}$. We then showed that the larger the value of π, the more likely it is that the agents consume the good only when their valuation is high. In the housing market context, $\pi = 1$ corresponds to rental markets, and under owner-occupation $\pi < 1$.

While we hope that our highly stylized framework may help in understanding certain aspects of the housing market, we shall next discuss some of the simplifying assumptions, and possible extensions.

(i) The paper compares two regimes, pure owner-occupation and a purely rental arrangement. We take the regime as given and do not derive it endogenously. Now it might seem tempting to think that if the owner-occupied outcome is socially unoptimal, according to a utilitarian welfare criterion, a rental sector would emerge and correct the situation. However, this is not necessarily the case. To see this, notice that each housing arrangement generates a certain wealth distribution, and an agent's willingness to live in a good neighborhood depends on not only his type but also on his wealth. Then an agent with a good match but little wealth might be unwilling (or unable) to rent a house from an agent with a poorer match but more wealth. Obviously, liquidity constrained agents would be altogether ruled out as potential tenants. Notice that utility derived from living in a desirable location is unalienable, and the aspirant tenant cannot transfer a part of his utility premium θ to a (potential) landlord as a payment. To put it in more general term, there are no mutually beneficial trades within a period. (In this sense our pure endowment-consumption model differs from a production economy, where θ measures productivity.)

(ii) Money is the only store of value in our model. If $\pi \in (0,1)$, assets bearing a positive interest rate are not consistent with a stochastic steady state in the pure consumption model. To see this assume that there are such assets, and the agents can save as much as they wish as well as borrow up to a certain limit $-b$, where $-\infty < -b < 0$. For markets to clear some agents should have negative asset holdings. Suppose that an agent owning a house in the bad neighborhood holds negative assets. With a positive probability, the agent never makes a capital gain and, as a result of interest payments, his wealth falls below $-b$. Suppose next that an agent owning a house in the currently popular neighborhood has a negative balance. With a positive probability the agent suffers a capital loss (and makes no subsequent capital gains), and his debt exceeds $-b$.

(iii) While our pure consumption model may be suitable for analyzing certain aspects of housing markets within a city or a region, a labor market based approach is probably more appropriate when analyzing interregional mobility. In a companion paper (Haavio and Kauppi (2003)), we study a production economy, where θ measures an agent's productivity in a booming region, and the regional shocks, taking place with probability π, are interpreted as alterations in regional labor market conditions, or regional business cycles. In this economy the agents choose both where they want to live and work and how much to consume and save (in terms of an interest bearing asset). Although the mechanisms at work are somewhat different, the main findings of this paper by and large carry over to the interregional labor market context. Most notably, we establish in Haavio and Kauppi (2003) that the owner-occupied housing market tends to work better, when regional business cycles are frequent (π is large). This is because capital losses are rather small, and it is relatively easy for the agents to protect themselves through precautionary saving, and thereby to avoid being borrowing constrained. In the labor market model the rental arrangement is actually socially optimal.[8]

Appendix

Proof of Lemma 1

In this appendix we show that the θ_n^*-schedule shifts up when π increases. To derive this result, first notice that an agent's strategy, telling how he chooses his location in each wealth class, essentially involves finding an optimal threshold value θ_n^* for each $n \geq 1$. Given this reinterpretation of the problem, and using matrix notation, the Bellman equations (3) can be reexpressed in the following form

$$V = \max_{\{\theta_n^*\}} \omega + \beta \left[(1-\pi) I + \pi P \right] V \tag{14}$$

for $n \geq 1$ (and $\theta_0 = \theta_H$) where V is the value function, stacked as a column vector, ω is the column vector of expected immediate utility, with elements

$$\omega_n (\theta_n^*) \equiv \int_{\theta_n^*}^{\theta_H} \theta dG(\theta)$$

[8] As labor income (unlike utility) can be used for rental payments, the criticism raised in item (i) is more potent in the production economy: if given a chance, a borrowing constrained agent with a good current match would rent a house in the booming region. To address this criticism, some additional distortions, emanating from e.g. agency costs or taxation must be introduced to the rental sector. These distortions are implicitly present in the analysis of the owner-occupied regime in Haavio and Kauppi (2003), while Haavio (2003) studies them explicitly, together with credit market imperfections, in a model where the housing market arrangement is derived endogenously.

and P is a transition matrix, with elements

$$P_{i,j} = \begin{cases} 1 - G(\theta_i^*) & \text{if } j = i - 1 \\ G(\theta_i^*) & \text{if } j = i + 1 \\ 0 & \text{otherwise} \end{cases} \qquad i, j \in \{0, ..., \overline{n}\}$$

The second step involves analyzing how the value function changes when π is increased. Differentiating the Bellman equation (14) with respect to π, and using the envelope theorem, yields

$$\frac{dV}{d\pi} = \frac{\partial V}{\partial \pi} = \frac{\delta}{\pi}(I - \delta P)^{-1}(P - I)V \tag{15}$$

where

$$\delta \equiv \frac{\pi\beta}{1 - \beta(1 - \pi)}, \quad \delta \in [0, 1)$$

is the uncertainty adjusted discount rate.

Finally, we turn to studying the first order conditions (5). They can be rephrased using matrix notation

$$\theta^* = \pi\beta D V \tag{16}$$

where $\theta^* = (\theta_1^*, ..., \theta_{\overline{n}}^*)'$ is the vector of threshold values[9] and D is the difference matrix, with elements

$$D_{i,j} = \begin{cases} 1 & \text{if } j = i + 1 \\ -1 & \text{if } j = i - 1 \\ 0 & \text{otherwise} \end{cases} \quad i \in \{1, ..., \overline{n}\}, \ j \in \{0, ..., \overline{n}\}$$

To see how the threshold values θ^* change when π increases, we have to totally differentiate the first order conditions (16). We start by the right hand side:

$$\begin{aligned} \frac{d(\pi\beta D V)}{d\pi} &= \beta D V + \beta\pi D \frac{\partial V}{\partial \pi} = \beta D[I + \delta(I - \delta P)^{-1}(P - I)]V \\ &= \beta(1 - \delta) D (I - \delta P)^{-1} V > 0 \end{aligned} \tag{17}$$

[9] Notice that θ_0^* cannot be freely chosen, as the agents are liquidity constrained.

When deriving the second equality of (17), the result (15) was needed. In signing the expression we have used the following facts: (i) The value function V is increasing n. (ii) Then also $(I-\delta P)^{-1}V = \sum_{i=0}^{\infty}(\delta P)^i V$ is increasing in n. To see this, notice that $(1-\delta P)^{-1}V$ is the value of a Markov process, with transition matrix P and immediate gain in state n given by $V(n)$. As this immediate gain increases with n, the expected present value of the program also increases. (iii) When we premultiply an increasing vector by the difference matrix D, the result is positive.

Now we can get the desired result:

$$\frac{d\theta^*}{d\pi} = \beta(1-\delta)D(I-\delta P)^{-1}V > 0$$

In words, when the probability of capital gains and losses increases, the θ_n^* -schedule shifts upwards. As the case with $\pi = 1$ corresponds to rental markets, we can further conclude that an agent with a given wealth level is more inclined to choose the depressed city when houses are rented than when they are owned.

Proof of Proposition 1

Given the housing market equilibrium (8), the measure of aggregate mobility M can be reexpressed as follows

$$M = f'\kappa - 1$$

where κ is a $(\overline{n}+1)\times 1$ vector with a generic element

$$\kappa_n \equiv \int_{\theta_n^*}^{\theta_H} G(\theta)\, dG(\theta) = 1 - [G(\theta_n^*)]^2$$

Next we define a quasi value function Q, which satisfies the recursive equation

$$Q = \kappa + \eta P Q \quad (18)$$

$$\Leftrightarrow \quad Q = (I-\eta P)^{-1}\kappa = \sum_{i=0}^{\infty}(\eta P)^i \kappa \quad (19)$$

where $\eta \in (0,1)$. Notice that Q is the value of a program with immediate payoff κ, transition matrix P and discount factor η. Now, as $f'P = f'$, M can be further rewritten as

$$M = (1-\eta) f'Q - 1 \tag{20}$$

Then differentiating M with respect to π yields

$$\frac{dM}{d\pi} = (1-\eta)\left[\frac{df'}{d\theta^*}Q + f'\frac{dQ}{d\theta^*}\right]\frac{d\theta^*}{d\pi} \tag{21}$$

The expression (21) consists of three terms $\frac{df'}{d\theta^*}Q$, $f'\frac{dQ}{d\theta^*}$and $\frac{d\theta^*}{d\pi}$. Next we show that all three terms are non-negative.

(i) As the immediate gain κ_n is increasing in n, also the the quasi value function is increasing. By Lemma 2 rising threshold values θ^* shift the wealth distribution f to the right, toward higher values of n. But then $\frac{df'}{d\theta^*}Q \geq 0$.

(ii) Totally differentiating (18) with respect to θ_n^* gives

$$\frac{dQ}{d\theta_n^*} = (1-\eta P)^{-1}\left\{-G\left(\theta_n^*\right) + \eta\left[Q\left(n+1\right) - Q\left(n-1\right)\right]\right\}dG\left(\theta_n^*\right)$$

Next notice that the equation (20) holds for any $\eta \in (0,1)$, and thus the discount factor η can be freely chosen. When η approaches unity, the quasi value function Q explodes, and from equation (19) we get

$$\lim_{\eta\to 1}\eta\left[Q\left(n+1\right) - Q\left(n-1\right)\right] = \infty$$

and thus choosing η close enough to 1 yields $\frac{dQ}{d\theta_n^*} \geq 0$.[10] As the same argument applies for all n, $\frac{dQ}{d\theta^*} \geq 0$, for η close enough to 1. Then it follows immediately that $f'\frac{dQ}{d\theta^*} \geq 0$.

(iii) By Lemma 1, $\frac{d\theta^*}{d\pi} > 0$.

Combining steps (i), (ii) and (iii) gives $\frac{dM}{d\pi} \geq 0$.

[10] Notice that $\frac{dQ}{d\theta_N^*} = 0$ if $dG\left(\theta_n^*\right) = 0$.

Aggregate welfare: The derivation of equation (12)

In this appendix we derive the equation (12).

First, with a given moving policy θ^*, the Bellman equations (14) can be reexpressed using matrix algebra, and the notation introduced in the previous section:

$$V = (1-\delta)\frac{\omega}{1-\beta} + \delta PV \tag{22}$$

Now solving (22) for ω we get

$$\omega = \frac{1-\beta}{1-\delta}(I-\delta P)V \tag{23}$$

On the other hand the stationary distribution f can be solved from the equation

$$f'(I-P) = 0 \Leftrightarrow (I-P')f = 0 \tag{24}$$

which determines f as the eigenvector associated to the unit eigenvalue of P' (See e.g. Ljungquist and Sargent (2000, p. 3)). With these preliminaries, we can now derive the equation (12):

$$\begin{aligned} W &= f'\omega = f'\frac{1-\beta}{1-\delta}(I-\delta P)V = \frac{1-\beta}{1-\delta}f'(I-P+(1-\delta)P)V \\ &= (1-\beta)f'PV = (1-\beta)f'V = (1-\beta)\,\widehat{W} \end{aligned}$$

The second equality follows from (23), elementary manipulations lead to the third equality, the fourth and the fifth equality then use (24).

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