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Housing Liquidity, Mobility, and the Labour Market

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We study the interactions among geographical mobility, unemployment, and home-ownership in an economy with heterogeneous locations, endogenous construction, and search frictions in the markets for both labour and housing. The decision of home-owners to accept job offers from other cities depends on how quickly they can sell their houses (*i.e.* the houses' *liquidity*), which in turn depends on local labour market conditions. Consequently, home-owners accept job offers from other cities at a lower rate than do renters, generating a link between home-ownership and unemployment both at the city level and in the aggregate. When calibrated to match aggregate U.S. statistics on mobility, housing, and labour flows, the model predicts that the effect of home-ownership on aggregate unemployment is small. When unemployment is high, however, changes in the rate of home-ownership can have economically significant effects.

Key words: Liquidity, Mobility, Home-ownership, Unemployment

JEL Codes: J61, J64, R23

1. INTRODUCTION

In this paper, we study the relationships among geographical mobility, unemployment, and the value of owner-occupied housing in an environment characterized by frictions in the markets for both labour and houses. The price of a house reflects its *liquidity*—that is, the speed with which it can be transferred from one home-owner to another—and this in turn affects both mobility and labour market outcomes. Our model is consistent both with recent micro-evidence on the relationship between ownership and unemployment across cities and with large observed differences in mobility between renters and owners. Nevertheless, we find that the impact of home-ownership on aggregate unemployment is likely to be economically significant only if both unemployment and average mobility are high. This combination is inconsistent with calibration targets based on the economies of either the U.S. or of several continental European nations.

In our economy, a growing population of *ex ante* identical households may choose to live in any of a large (finite) number of cities. Cities are of two types that differ in regard to the productivity of jobs. Households are at any point in time resident in one particular city and are either employed or unemployed. Irrespective of their current employment status, households receive randomly job offers in both their city of current residence and in other cities. In order to take a job in a different city, a household must move to that location.

Households require housing in their city of residence and may either rent in a competitive market or purchase in a market characterized by a search friction. Migrating home-owners put their houses up for sale and initially rent in their new city while searching for a house. New housing of each type is constructed in response to anticipated demand. In this environment,

we compute a stationary equilibrium (which is unique within a class) characterized by constant relocation, housing market activity, and construction of new housing units.

The willingness of a worker to accept a job in another city depends on the offered wage, their current employment status, rents, the price of houses in the city where the offered job is located, and the market value of their current house if they own one. As vacant houses have an opportunity cost, the latter depends on how quickly a buyer can be found. Thus, the liquidity of housing affects the distribution of households across cities and unemployment both at the city level and in the aggregate. At the same time, the frequency with which households choose to relocate affects the liquidity of housing in all cities.

There is considerable evidence that home-owners move less frequently than renters, even after controlling for both household and locational characteristics (see, e.g. Böheim and Taylor, 2002). Recently, it has been argued that because of its relationship to mobility, home-ownership creates frictions in the labour market that may lead to inefficient outcomes.¹ Indeed, it has been conjectured that differences in home-ownership rates across countries may be a leading factor driving differences in unemployment. For example, using cross-country regressions, Oswald (1997, 2009) estimates the effect of reducing home-ownership by 10% to be a reduction of unemployment by between 1.7 and 2 percentage points. Similarly, Nickell (1998) estimated the effect of a 10% *increase* in home-ownership to be a rise in unemployment of 1.3 percentage points.

It is difficult to reject this conjecture using micro-data.² Although unconditionally the unemployment rate among renters is significantly *higher* than that among owners, this largely reflects the differing characteristics of households in the two groups. Home-owners, for example tend to be older and more educated than renters, and are more likely to be married. People with these characteristics are also less likely to be unemployed, independent of any direct effect of ownership on mobility. Moreover, there may be factors that operate in the opposite direction. For example, home-owners may search harder locally for jobs or be willing to accept lower wages than renters, so that their unemployment duration is shorter.³

Our framework allows us to isolate the effects of home-ownership *per se* on unemployment through its effect on mobility. We model all households as *ex ante* identical and so in our theory, home-ownership affects mobility, rather than the reverse. Ownership, *ceteris paribus*, increases the likelihood of unemployment for an individual because, while job separation and offer rates are the same for all, only unemployed home-owners turn down job offers in equilibrium. There is, however, a second effect which offsets the impact of home-ownership on unemployment in particular cities. While high-wage cities have a lower vacancy rate and thus a higher rate of home-ownership, they also have higher rents, and so are unattractive to the unemployed. These households may remain in or move to a low-wage city without a job offer, just to take advantage of lower rent. In contrast, employed renters in low-wage cities move to high-wage (and high rent) cities as long as the wage premium is sufficient. Unemployed home-owners never re-locate to a high-wage city without an offer. These factors combine to generate higher unemployment in low-wage cities, where home-ownership is also lower. This is consistent with the findings of Coulson and Fisher (2009), who find that across U.S. metropolitan areas, home-ownership rates are correlated positively with average wages and negatively with unemployment.

1. See, for example Blanchflower (2007) and Harford (2007).

2. Rouwendal and Nijkamp (2007) critically review some of the literature on this issue.

3. Munch, Rosholm and Svarer (2006) find evidence of the former effect using Danish data. On the other hand, in a French data set, Brunet and Lesueur (2009) find that, once controls for search intensity are included, home-owners have lower exit rates from unemployment. Coulson and Fisher (2009) find no evidence that owners accept lower wages in the U.S.

In a version of our model calibrated to match aggregate U.S. labour market flows and mobility rates for both owners and renters, the equilibrium fraction of unemployed home-owners that turn down offers of jobs in different cities is substantial: over 45% in low-wage cities and 23% overall. Consequently, in accordance with the empirical evidence, home-owners are significantly less mobile than renters. Nevertheless, we find that the impact of home-ownership on aggregate unemployment is small: A 10% reduction in the home-ownership rate is associated with a reduction of unemployment of only one-third of a percentage point. Effects in the range of those estimated by Oswald (2009) and Nickell (1998) can be obtained in equilibrium, but only if average unemployment is raised significantly *and* relatively high mobility is maintained. These assumptions are consistent neither with our baseline calibration (based on U.S. targets) nor with calibrations to European economies, which typically exhibit much lower mobility rates.

Others have developed theories of the impact of home-ownership on labour market outcomes. For example, Dohmen (2005) and Munch, Rosholm and Svarer (2006) present models of labour market search in which home-owners and renters are assumed to behave differently. Coulson and Fisher (2009) present a theory based on endogenous job creation that is consistent with the cross-city evidence on unemployment but implies counter-factually that home-owners receive lower wages than renters as a result of their immobility. All these theories, however, abstract from both housing choice and transactions in the housing market. Owners are either simply assumed to be immobile or to face higher moving costs than renters. Here, because the price of housing is endogenously determined, the relative degree of mobility depends on labour and housing market conditions.

Rupert and Wasmer (2011) develop a theory of the relationship between unemployment and housing market frictions that focusses on the trade-off between commuting time and locational decisions within a single labour market. In contrast, our work focusses on the role of housing markets in generating frictions *between* labour markets. Also, they do not distinguish between ownership and renting, a trade-off that plays a significant role in our results. As such, we view our paper as complementary to theirs.

Albrecht *et al.* (2007) consider a search model in which the flow values of search to buyers and sellers change over time and Caplin and Leahy (2008) study the role of trading frictions (due to mis-match) on house price dynamics. These papers are related to ours but study neither the mobility nor the interactions between the labour and housing markets.

Recently, several authors have also studied spatial aspects of housing prices. Van Nieuwerburgh and Weil (2010) study the long-run connection between wages and house prices in a multi-city model with free mobility, stochastic productivity, and endogenous construction. Consistent with our analysis, they also find a long-run relationship between wages and prices across cities. Their model does not, however, distinguish between owning and renting, labour is assumed to be perfectly mobile and there are no search frictions in housing markets. Consequently, there is no notion of housing liquidity, no differences between the mobility of owners and renters and no unemployment. Ortalo-Magne and Prat (2010) distinguish between the spatial (where to live) and quantity decision (how much to invest) dimensions of housing choice and study their implications for portfolio allocation theory. We distinguish only between owned and rented housing and abstract from the quantity decision in order to focus on market frictions.

Since we focus on households' location decisions and abstract from most forms of risk by studying a stationary equilibrium, we conjecture that financing constraints are of secondary importance for our analysis.⁴ For this reason, we abstract from them entirely and also do not

4. We investigate this conjecture in a crude way by considering a case in which unemployed households are unable to buy houses, a restriction that can be viewed as a very stark form of borrowing constraint. In our environment, this makes little difference for the phenomena we study.

consider direct moving costs in order to focus on mobility *per se*. There is, however, a substantial literature that considers these issues. Using life cycle a model, Ortalo-Magne and Rady (2006) find important effects of financial constraints. Kiyotaki, Michaelides and Nikolov (2011) find much smaller effects but consider mortgages financed by equity rather than debt. Halket and Vasudev (2009) study the use of housing as a form of savings in a model of uninsured idiosyncratic risk based on Aiyagari (1994). Their work, along with that of Favilukis, Ludvigson and Van Nieuwerburgh (2010) studies the role of housing in determining consumption, wealth, and aggregate economic activity in settings with borrowing constraints. Much of this literature devotes considerable attention to movements in house prices and their implications for aggregate wealth and consumption. In contrast, we focus on the effects of the illiquidity of housing on labour market outcomes for individual households.

A substantial literature also focuses on the relationship between the length of residence spells (which tend to be higher for home-owners than for renters) and investments in social capital (see, e.g. DiPasquale and Glaeser, 1999). Empirically, Coulson, Hwang, and Imai (2002) find that the fraction of home-owners in a neighbourhood is associated with higher property values. While our model is consistent with this observation (as home-ownership and house prices are both higher in high-wage cities) as well as the fact that home-owners remain in a particular city longer than do renters, in this paper, we abstract from investment in social capital.

This remainder of the paper is organized as follows: Section 2 describes the environment. Section 3 defines a symmetric stationary equilibrium and establishes its existence and uniqueness within a class. Section 4 characterizes the equilibrium and considers the implications of the theory for the relationships among ownership, mobility, and unemployment at the individual, city, and aggregate levels. Section 5 calibrates the economy to match several aspects of the U.S. economy. Section 6 assesses the theory's quantitative implications and considers their robustness to changes to various parameters. Section 7 concludes and describes future work. The data used in the calibration are described in Appendix A. Proofs, longer derivations, details of some of the extensions, and statistics associated with robustness exercises are provided in the Technical Appendix in the Supplementary Material.

2. THE ENVIRONMENT

Time is continuous. At each point in time, t , the economy is populated by a measure, $\bar{N}(t)$, of infinitely lived, *ex ante* identical, risk-neutral households who discount the future at rate ρ . The population grows at rate v .

There are multiple locations, called *cities*, which are of two types indexed by $i \in \{1, 2\}$. There are a finite number, s_i , of cities of type i and all cities of a given type are identical. Households must, at any point in time, reside in exactly one city. They are free, however, to move between cities instantaneously at no direct cost. Each city contains two types of residential dwellings. Let $R_i(t)$ and $H_i(t)$ denote the stocks of *rental* and *owner-occupied* housing in cities of type i , respectively. Let π^R and $\pi^H > \pi^R$ denote the flow utilities received by households, which are renters and home-owners, respectively, any city.⁵

Firms in cities of type i produce output, y_i , of a single consumption good using labour, l_i , according to the following technology:

$$y_i = A_i l_i, \quad (1)$$

where A_i is a constant city type-specific productivity parameter, and $A_2 > A_1$.

5. This difference in flow utility could be associated with the size differential between owned and rented houses or with the non-monetary value individuals place on being an owner.

Each city has a labour market that functions much like that considered by Lucas and Prescott (1974). For a household to enter this market in any city, they must first receive an *offer*. Firms enter and hire workers to operate the production technology. Inside each labour market, firms and workers take the wage, w_i , as given, and the market clears in Walrasian fashion. A household may work only in their city of current residence. At any point in time, each household is either employed, by which we mean present in a labour market and receiving wage income w_i , or unemployed in which case they receive flow consumption z .

All households, regardless of their employment status, randomly receive offers of jobs both in their city of residence and in the other cities. Let μ and μ^* denote the Poisson rates at which households receive offers from within and outside their city of residence, respectively. The rates at which households receive offers are symmetric across cities and $\mu > \mu^*$. Let fraction β_i of “outside offers” (*i.e.* those from other cities) received by households in a city of type i come from another city of type i . Thus, fraction $1 - \beta_i$ of outside offers come from a city of type $j \neq i$. A household (employed or unemployed) that receives an employment offer must either accept or reject it immediately. Employed households in all cities lose their jobs at Poisson rate δ . Loss of a job does not affect a household’s residency status. New households enter the economy unemployed and immediately rent.

There are also in the economy a large number of specialized firms called *real estate managers* (REMs). These firms are owned by households and perform three functions: first, they build houses of both types using a development technology described below. Second, they rent housing in cities of type i to households in a competitive market at flow rent κ_i . Third, they intermediate between buyers and sellers in city-specific markets for owner-occupied housing.

Only REMs hold vacant houses. They receive no direct service flow from houses and hold them only for the purposes either of re-sale or conversion into rental units. An REM can convert a formerly owner-occupied unit into a rental unit at a fixed per unit cost $d^R \geq 0$. Similarly, an REM can convert a rental unit to an owner-occupied one at cost $d^H \geq 0$. Home-owners may sell their houses at any time to an REM in a competitive market specific to their city of residence. Let V_i (the value of a vacant house) denote the price at which such transactions take place in cities of type i .

Vacant houses are matched randomly with potential *home buyers*, the stock of whom is comprised simply of all current renters within the city. Let ϕ_i denote the ratio of the measure of buyers to the stock of vacant houses available for sale in a city of type i . We assume that the rate at which buyers find houses is constant and given by λ . It follows that the rate at which houses match with potential buyers is given by

$$\gamma_i = \lambda \phi_i, \quad i = 1, 2. \quad (2)$$

We adopt this specification for expositional simplicity. Our main results, however, are robust to several generalizations of the matching function.

When a potential home buyer matches with a vacant house, we assume that the buyer and the REM which owns the house share the aggregate match surplus (provided it is positive) according to a simple bargaining rule, with σ denoting the buyer’s share of the total surplus. Let P_i^W and P_i^U denote the prices paid for houses in cities of type i by employed and unemployed households, respectively.⁶

6. Since they earn zero profits when purchasing a previously owned house, the role played by REMs in intermediating transactions is virtually equivalent to assuming that households which wish to move continue to own their vacant house until they match with and sell to another household. Assuming that this function is performed by REMs greatly simplifies our analysis, however, because it rules out the possibility of a household moving from one city to another, and

Given the matching process, it takes time for owner-occupied houses to be transferred from one household to another. This results in houses being to some extent *illiquid* in the sense that their value depends on the speed with which a buyer can be found for a vacant house. To see this, note that the value of a vacant house in cities of type i satisfies

$$\rho V_i = \gamma_i E[\max\{P_i^j - V_i, 0\}], \quad i = 1, 2, \quad j = W, U. \quad (3)$$

In every city, there are at any time at most four types of households, as each may be either employed or unemployed and may either rent or own a house. The measures of households in cities of type i that are employed-owners, employed-renters, unemployed-owners, and unemployed-renters are given by N_i^{WH} , N_i^{WR} , N_i^{UH} , and N_i^{UR} , respectively. The values associated with being in each of these states are given, in the same order, by W_i^W , W_i^R , U_i^H , and U_i^R .

Additions to the stocks of each type of housing may be made using construction technologies that we represent by cost functions. The unit cost of producing additional rental housing is given by

$$C_i^R(R_i, \bar{N}) = c_0 + c_i^R \frac{R_i}{\bar{N}}, \quad (4)$$

and that of providing owner-occupied housing is

$$C_i^H(H_i, \bar{N}) = c_0 + c_i^H \frac{H_i}{\bar{N}}, \quad (5)$$

where the c s are positive constants. This linear specification is similar to that assumed by Glaeser *et al.* (2010). Under this specification, at each point in time, the cost of providing an additional unit of either type of dwelling consists of a common constant, c_0 , and a city-specific component, which depends linearly on the existing stock of that particular type of housing relative to the population.

We interpret c_0 as the cost of constructing the house, which we assume to be the same across cities and dwelling types. We interpret the second component as reflecting the cost of land. The elasticities of unit costs with respect to housing stocks are allowed to vary by city and by type of dwelling. Unit construction costs are higher the larger is the existing stock of housing, reflecting mainly the rising cost of land. Note that we divide these stocks by the aggregate population $\bar{N}(t)$ in order to obtain stationarity. This is analogous to assuming that the supply of residential land increases with the population (see Davis and Heathcote, 2005). Recall that once produced, existing houses can, in principle, be converted from rental to owner occupied and *vice versa* at constant unit costs d^H and d^R , respectively.

3. STATIONARY EQUILIBRIUM

We consider equilibria that are symmetric in that all households of a given type behave in the same way and stationary in that the fractions of the total population in each household state remain constant. In such an equilibrium, there is constant construction of both rental and owner-occupied houses, provided that conversion costs are sufficient to guarantee that REMs do not convert previously constructed houses from one use to the other.

then returning to its previous location and moving back into its old house before selling. While in principle, this would make little difference, and in practice, it would happen very infrequently in equilibrium, allowing for it would expand the number of household states and complicate the analysis substantially, while adding nothing significant to our results.

In a stationary equilibrium, the values of households in a city of type i satisfy

$$\begin{aligned} \rho W_i^R &= w_i + \pi^R - \kappa_i + \delta(U_i^R - W_i^R) + (1 - \beta_i)\mu^* \max\{W_j^R - W_i^R, 0\} \\ &\quad + \lambda \max\{W_i^H - P_i^W - W_i^R, 0\}, \end{aligned} \quad (6)$$

$$\begin{aligned} \rho U_i^R &= z + \pi^R - \kappa_i + (\mu + \beta_i\mu^*)(W_i^R - U_i^R) + (1 - \beta_i)\mu^* \max\{W_j^R - U_i^R, 0\} \\ &\quad + \lambda \max\{U_i^H - P_i^U - U_i^R, 0\}, \end{aligned} \quad (7)$$

$$\begin{aligned} \rho W_i^H &= w_i + \pi^H + \delta(U_i^H - W_i^H) + (1 - \beta_i)\mu^* \max\{W_j^R + V_i - W_i^H, 0\} \\ &\quad + \beta_i\mu^* \max\{W_i^R + V_i - W_i^H, 0\}, \end{aligned} \quad (8)$$

$$\begin{aligned} \rho U_i^H &= z + \pi^H + \mu(W_i^H - U_i^H) + (1 - \beta_i)\mu^* \max\{W_j^R + V_i - U_i^H, 0\} \\ &\quad + \beta_i\mu^* \max\{W_i^R + V_i - U_i^H, 0\}, \end{aligned} \quad (9)$$

where the subscript $j \neq i$ indexes cities of the other type.

A *stationary symmetric equilibrium* for this economy is a collection of 10 values (eight for the different types of households, W_i^R , W_i^H , U_i^R , and U_i^H , and two for vacant houses in each city type, V_i); rents, κ_i ; house prices, P_i^W and P_i^U ; wages, w_i , and employment levels, l_i ; ratios of buyers to houses for sale, ϕ_i ; and measures of households in each of the eight states, N_i^{WR} , N_i^{UR} , N_i^{WH} , and N_i^{UH} , for $i = 1, 2$, such that

- i. Given wages, firms choose employment levels l_i to maximize profits. Free entry into production implies zero profits so that

$$w_i = A_i. \quad (10)$$

- ii. House purchase prices (P_i^W , P_i^U) in each city are consistent with the surplus sharing rules.
- iii. The values of vacant housing satisfy equations (2) and (3).
- iv. Given prices and the value of vacant houses in each city, the values of households in each state satisfy equations (6)–(9).
- v. The rents, $\kappa_i \geq 0$, clear the markets for rental housing in each city:

$$N_i^{WR} + N_i^{UR} = R_i, \quad i = 1, 2. \quad (11)$$

- vi. The distribution of households over states and cities is consistent with the population:

$$\sum_{i=1,2} s_i [N_i^{WR} + N_i^{UR} + N_i^{WH} + N_i^{UH}] = \bar{N}. \quad (12)$$

- vii. The paths of the housing stocks in each city are consistent with profit maximizing construction and free entry on the part of REMs,

$$\frac{\kappa_i}{\rho} = c_0 + c_i^R \frac{R_i}{\bar{N}}, \quad \dot{R}_i \geq 0, \quad (13)$$

$$V_i = c_0 + c_i^H \frac{H_i}{\bar{N}}, \quad \dot{H}_i \geq 0, \quad (14)$$

where the option to convert housing from one type to another is not exercised:

$$d^H \geq V_i - \kappa_i/\rho \geq -d^R. \quad (15)$$

- viii. Market tightness, ϕ_i , equals the ratio of buyers to houses for sale where, given house prices (P_i^W, P_i^U) and the values of being in each state, buyers consist of all those renters who wish to buy and houses for sale consist of all those vacant houses that REMs wish to sell if given the opportunity.

Depending on parameters, stationary equilibria exhibit a range of characteristics with regard to the functioning of labour and housing markets. Our approach will be to concentrate on equilibria with particular characteristics (which we refer to as our *benchmark configuration*) because, as we will show below, our calibration will give rise to an equilibrium with these features. Because in each city, the equilibrium wage is proportional to local productivity and is unaffected by conditions in the housing market (see equation (10)), from now on we will refer to city types 1 and 2 as low- and high-wage cities, respectively.

3.1. Benchmark equilibrium configuration

We begin by supposing that a stationary equilibrium with the following features exists, derive certain conditions that the economy must satisfy for this to be so, and then show that in these circumstances, the equilibrium must be unique. We then compute an equilibrium and verify that it does indeed have the following characteristics:

1. There are positive measures of unemployed renters in all cities. Because these households are mobile, this restriction requires that in equilibrium, they are indifferent with regard to their city of residence. That is,

$$U_1^R = U_2^R = U^R. \quad (16)$$

2. Employed renters in low-wage cities (Type 1) always accept employment offers from high-wage cities (Type 2) but not vice versa

$$W_2^R > W_1^R. \quad (17)$$

3. Employed home-owners do not move if offered a job in any other city:

$$W_i^H - V_i > \max[W_i^R, W_j^R]. \quad (18)$$

4. A fraction $\theta_i \in (0, 1)$ of the unemployed home-owners in cities of type i that receive an offer of employment in cities of type $j \neq i$ accept that offer and move. We may think of θ_i as the probability with which an individual unemployed home-owner re-locates to the other city in response to an offer. In order for these probabilities to be interior, it must be that the relevant home-owners are indifferent

$$U_1^H - V_1 = W_2^R, \quad (19)$$

$$U_2^H - V_2 = W_1^R. \quad (20)$$

Under the assumption that at least one equilibrium with these characteristics exists, we now derive several other features that it must necessarily have. First, we have the following lemmas.⁷

7. Proofs of all lemmas and propositions are contained in the Technical Appendix in the Supplementary Material.

Lemma 1. *All renters, whether employed or not, buy houses when they get the chance. That is, the surplus from a meeting between a renter and an REM is always positive.*

$$W_i^H - W_i^R > V_i \quad \text{and} \quad U_i^H - U_i^R > V_i, \quad i = 1, 2. \quad (21)$$

We also have the following lemma.

Lemma 2. *The value of a vacant house in cities of type i is given by*

$$V_i = \frac{(1-\sigma)\gamma_i}{\rho + (1-\sigma)\gamma_i} [\alpha_i(W_i^H - W_i^R) + (1-\alpha_i)(U_i^H - U_i^R)], \quad (22)$$

where $\alpha_i = N_i^{\text{WR}}/R_i$ represents the fraction of renters in type i cities that are employed.

Given this and the four requirements that define our benchmark configuration, the Bellman equations for home-owners, equations (8) and (9), simplify to

$$\rho W_1^H = w_1 + \pi^H + \delta(U_1^H - W_1^H), \quad (23)$$

$$\rho W_2^H = w_2 + \pi^H + \delta(U_2^H - W_2^H), \quad (24)$$

$$\rho U_1^H = z + \pi^H + \mu(W_1^H - U_1^H), \quad (25)$$

$$\rho U_2^H = z + \pi^H + \mu(W_2^H - U_2^H) + \beta_2\mu^*(W_2^R + V_2 - U_2^H). \quad (26)$$

The first two expressions reflect the fact that employed owners do not accept outside offers from any other city. Unemployed owners in cities of both types accept offers of employment in their own city and are indifferent regarding offers from cities of the other type. Unemployed owners in low-wage cities, however, always turn down offers from other low-wage cities, whereas those in high-wage cities always accept offers from other high-wage cities.

Since unemployed renters are indifferent with respect to their location (equation (16)) and employed renters do not move from the high-wage city to the low-wage one (equation (17)), we may express the Bellman equations for renters as follows:

$$\begin{aligned} \rho W_1^R &= w_1 + \pi^R - \kappa_1 + \delta(U_1^R - W_1^R) \\ &\quad + (1-\beta_1)\mu^*(W_2^R - W_1^R) + \lambda(W_1^H - P_1^W - W_1^R), \end{aligned} \quad (27)$$

$$\begin{aligned} \rho U^R &= z + \pi^R - \kappa_1 + (\mu + \beta_1\mu^*)(W_1^R - U^R) \\ &\quad + (1-\beta_1)\mu^*(W_2^R - U^R) + \lambda(U_1^H - P_1^U - U^R), \end{aligned} \quad (28)$$

$$\rho W_2^R = w_2 + \pi^R - \kappa_2 + \delta(U_2^R - W_2^R) + \lambda(W_2^H - P_2^W - W_1^R), \quad (29)$$

$$\begin{aligned} \rho U^R &= z + \pi^R - \kappa_2 + (\mu + \beta_2\mu^*)(W_2^R - U^R) \\ &\quad + (1-\beta_2)\mu^*(W_1^R - U^R) + \lambda(U_2^H - P_2^W - U^R). \end{aligned} \quad (30)$$

We then have the following lemma.

Lemma 3. *The value of a job to a renter in each city is given by*

$$W_1^R - U^R = \Gamma_1 = \left(\frac{\rho + \delta + \mu + \sigma\lambda}{\rho + \delta + \mu + \mu^* + \sigma\lambda} \right) \left(\frac{w_1 - z}{\rho + \delta + \mu} \right), \quad (31)$$

$$W_2^R - U^R = \Gamma_2 = \left(\frac{w_2 - z}{\rho + \delta + \mu + \beta_2\mu^*} \right) - \frac{[(\rho + \delta + \mu)(1-\beta_2) - \sigma\lambda\beta_2]\mu^*\Gamma_1}{(\rho + \delta + \mu + \beta_2\mu^*)(\rho + \delta + \mu + \sigma\lambda)}. \quad (32)$$

Using these expressions, we can now state the first main implication of the restrictions imposed by our benchmark configuration.

Proposition 1. *The net benefit to an employed renter of living and working in a high-wage city as opposed to in a low-wage one is proportional to the wage differential:*

$$W_2^R - W_1^R = \Gamma_2 - \Gamma_1 = \frac{w_2 - w_1}{\rho + \delta + \mu + \beta_2 \mu^*}. \quad (33)$$

Note that equating equations (28) and (30), and using equations (27) and (29), it is also apparent that the rent differential between high- and low-wage cities is proportional to the wage differential:

$$\kappa_2 - \kappa_1 = \left(\frac{\mu - (1 - \beta_1 - \beta_2)\mu^* - \sigma \lambda}{\rho + \delta + \mu + \beta_2 \mu^*} \right) (w_2 - w_1). \quad (34)$$

The house value differential across city types is also proportional to the wage differential and is given by

$$\rho(V_2 - V_1) = \left(\frac{\rho + \mu + \beta_2 \mu^*}{\rho + \delta + \mu + \beta_2 \mu^*} \right) (w_2 - w_1). \quad (35)$$

Thus, while the *levels* of rents and house values in all cities depend on the housing stocks, neither the rent nor the price *differential* does.

Proposition 2. *The dispersion in house values across cities exceeds that in the present discounted value of rents. That is*

$$V_2 - V_1 > \frac{\kappa_2 - \kappa_1}{\rho}.$$

This result stems from the frictions in both the labour and the housing markets. The rent differential is determined by unemployed renters who can move costlessly between cities even if they do not receive an offer. In contrast, the differential in the value of houses is determined by the marginal (unemployed) home-owners who must first receive an outside offer and then incur the (endogenous) liquidity cost of selling their house. That the dispersion in the present discounted value of rents across U.S. cities is indeed less than that for prices is documented by Van Nieuwerburgh and Weil (2010). Our model offers one possible explanation for this observation based on the interaction of labour and housing market frictions. As we will see below, however, in our baseline calibration, the difference turns out to be quantitatively small.

In a stationary equilibrium, the growth rates of housing stocks and the measures of households in each state are all equal to ν so that the fractions of the population in each state remain constant. We therefore use lower cases to represent values in *per capita* terms (e.g. $n_i^{\text{WR}} = N_1^{\text{WR}}/N$, etc.). Consequently, rental market clearing (equation (11)) can be expressed as follows:

$$n_i^{\text{UR}} + n_i^{\text{WR}} = r_i, \quad i = 1, 2. \quad (36)$$

Since in each city renters constitute the potential buyers in the housing market, we may write the ratios of buyers to sellers as follows:

$$\phi_i = \frac{n_i^{\text{WR}} + n_i^{\text{UR}}}{h_i - n_i^{\text{WH}} - n_i^{\text{UH}}}, \quad i = 1, 2. \quad (37)$$

The flow of households between states in a stationary equilibrium under the benchmark configuration is described by equations (36) and (37) and the following equations:

$$(\delta + (1 - \beta_1)\mu^* + \lambda + \nu)n_1^{\text{WR}} = (\mu + \beta_1\mu^*)n_1^{\text{UR}} + (1 - \beta_2)\frac{s_2}{s_1}\mu^*(n_2^{\text{UR}} + \theta_2 n_2^{\text{UH}}), \quad (38)$$

$$(\mu + (1 - \beta_1)\mu^*\theta_1 + \nu)n_1^{\text{UH}} = \delta n_1^{\text{WH}} + \lambda n_1^{\text{UR}}, \quad (39)$$

$$(\delta + \nu)n_1^{\text{WH}} = \lambda n_1^{\text{WR}} + \mu n_1^{\text{UH}}, \quad (40)$$

$$(\delta + \lambda + \nu)n_2^{\text{WR}} = (\mu + \beta_2\mu^*)n_2^{\text{UR}} + (1 - \beta_1)\frac{s_1}{s_2}\mu^*(n_1^{\text{UR}} + n_1^{\text{WR}} + \theta_1 n_1^{\text{UH}}), \quad (41)$$

$$(\mu + (1 - \beta_2)\mu^*\theta_2 + \beta_2\mu^* + \nu)n_2^{\text{UH}} = \delta n_2^{\text{WH}} + \lambda n_2^{\text{UR}}, \quad (42)$$

$$(\delta + \nu)n_2^{\text{WH}} = \lambda n_2^{\text{WR}} + \mu n_2^{\text{UH}}. \quad (43)$$

From equation (38), we have that the increase in the number of employed renters in a given low-wage city, νn_1^{WR} , must equal the measure that *become* employed renters in that city minus the measure of agents that *cease* being employed renters in the city. Those that become employed renters in a given low-wage city consist of (1) unemployed renters in that city who receive an offer, μn_1^{UR} , (2) unemployed renters in other low-wage cities who receive an offer from this city (in each of the $s_1 - 1$ other low-wage cities, $\beta_1 \mu^* n_1^{\text{UR}} / (s_1 - 1)$ unemployed renters receive offers from this city), (3) unemployed renters in high-wage cities that receive an offer from this city (in each of the s_1 high-wage cities, $(1 - \beta_2) \mu^* n_2^{\text{UR}} / s_1$ unemployed renters receive offers from this city), and (4) unemployed owners in high-wage cities that receive and accept job offers in low-wage cities, $s_2(1 - \beta_2) \mu^* \theta_2 n_2^{\text{UH}} / s_1$. Agents cease being employed renters in a low-wage city by losing their job, δn_1^{WR} , by accepting an offer in a high-wage city, $(1 - \beta_1) \mu^* n_1^{\text{WR}}$, or by buying a house, λn_1^{WR} .

Similarly, from equation (39), we have that the change in the measure of unemployed home-owners in a given low-wage city equals the difference between the flows into and out of that state, and from equation (40), we have the same for *employed* home-owners in that city. Equations (41)–(43) represent the analogous conditions for high-wage cities.

Combining equations (12), (36), and (37), we can then derive the following expression implied by rental market clearing aggregation:

$$\frac{s_1 r_1}{\phi_1} + \frac{s_2 r_2}{\phi_2} = s_1 r_1 + s_2 r_2 + s_1 h_1 + s_2 h_2 - 1. \quad (44)$$

For given housing stocks, this condition yields a locus of combinations of matching rates, ϕ_1 and ϕ_2 , consistent with market clearing and aggregation. This locus is depicted in Figure 1 as the downward sloping curve labelled AM.⁸

Equations (19)–(32) and (38)–(43) can be used to derive a relationship between the ratios of buyers to sellers in the low- and high-wage cities, ϕ_1 and ϕ_2 , making use of the requirements that both unemployed renters with no job offer and unemployed home-owners with an offer from a city of the other type be indifferent between locations (*i.e.* the first and third conditions for the benchmark configuration, equations (16) and (18)). Fixing the stocks of housing in all

8. As we demonstrate below, for the equilibria, we study here, $\phi_2 > \phi_1$. Thus, all relevant (ϕ_1, ϕ_2) combinations lie above the 45° line.

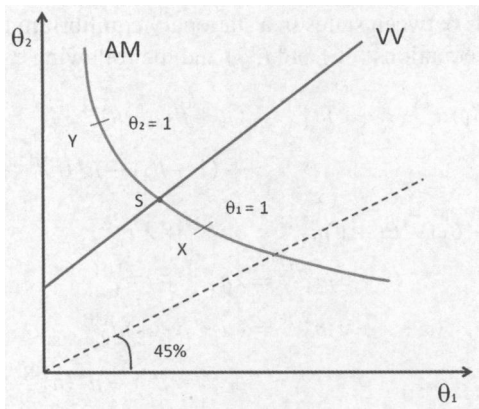


FIGURE 1
Equilibrium for given housing stocks

cities, this relationship determines a locus of combinations of matching rates consistent with these restrictions. We depict this relationship with locus VV in Figure 1 and have the following result:

Proposition 3. *Under the restrictions imposed by the benchmark configuration, for fixed housing stocks, there is a positive relationship between the ratios of buyers to sellers in low- and high-wage cities, ϕ_1 and ϕ_2 . That is, the VV locus is upward sloping.*

To understand this result, consider an increase in the matching rate in low-wage cities, ϕ_1 . *Ceteris paribus*, this is associated with a higher house sale price in these cities and thus lowers the cost of moving for an unemployed home-owner who receives a job offer in a high-wage city. Since this home-owner must be indifferent to moving, this lower cost of relocation must be offset by higher rent in high-wage cities, κ_2 . As unemployed renters with no job offers must also be indifferent between cities, this in turn must be offset by high rent in low-wage cities, κ_1 . Higher rent in low-wage cities discourages migration from high-wage cities, and the resulting reduction in the number of vacant houses raises the matching rate in those cities, ϕ_2 .

Solving the system of equations given by equations (36)–(43) yields the stationary measure of agents in each state plus the fractions of unemployed owners who move in response to offers from a city of a different type. To ensure that this solution is indeed consistent with a stationary equilibrium under the benchmark configuration, two conditions (which we have to this point assumed to hold but not imposed) must be checked.⁹ First, the measure of employed renters must be strictly less than the stock of rental housing in each city: $n_i^{WR} < r_i$, $i = 1, 2$. If this were not the case, then unemployed renters would strictly prefer one city to the other, violating equation (16). Second, the fractions of unemployed owners who move from each city must be interior, that is $\theta_i \in (0, 1)$, $i = 1, 2$, as these are conditions (19) and (20).

In Figure 1, the points $X = (\phi_1^X, \phi_2^X)$ and $Y = (\phi_1^Y, \phi_2^Y)$ represent the combinations of ϕ_1 and ϕ_2 at which $\theta_1 = 1$ and $\theta_2 = 1$, respectively, and rental markets clear.

Lemma 4. *The pairs (ϕ_1^X, ϕ_2^X) and (ϕ_1^Y, ϕ_2^Y) are unique.*

9. This is in addition to the conditions that the option to convert between dwelling types is not exercised.

Provided equations (16), (19), and (20) hold for given housing stocks a combination of matching rates in the two cities consistent with a stationary equilibrium under the benchmark equilibrium is represented by the intersection of the VV and AM loci in ϕ_1 - ϕ_2 space (Figure 1). Only (ϕ_1, ϕ_2) pairs along the AM curve between X and Y yield interior solutions. Since the VV locus is monotone increasing and the AM locus is decreasing, if they intersect, then they do so only once. The following result establishes conditions sufficient to identify a unique intersection point of the AM and VV curves, which satisfies the requirements of the benchmark configuration.

Lemma 5. *For given housing stocks per capita in all cities, the steady state identified by (ϕ_1^*, ϕ_2^*) is the unique equilibrium under the benchmark configuration if*

$$\frac{(1 - \beta_2)\mu^* + \lambda}{\delta + (1 - \beta_1)\mu^* + \lambda + \nu} < \frac{s_1 r_1}{s_2 r_2} < \frac{\delta + \lambda + \nu}{(1 - \beta_2)\mu^* + \lambda} \quad (45)$$

and

$$\phi_1^X > \phi_1^* > \phi_1^Y, \quad \phi_2^X < \phi_2^* < \phi_2^Y. \quad (46)$$

Subject to these conditions, for a given vector of housing stocks and the associated matching rates, (ϕ_1^*, ϕ_2^*) , there exist unique pairs of equilibrium flow rents (κ_1^*, κ_2^*) and vacant house values (V_1^*, V_2^*) , where $\kappa_i^* = \kappa_i(r_1, r_2, h_1, h_2)$ and $V_i^* = V_i(r_1, r_2, h_1, h_2)$.

We now consider the determination of the housing stocks in equilibrium. To find an equilibrium, we must find optimal paths for the stocks of rental and owner-occupied housing in cities of both types that give rise to steady-state matching rates that satisfy the conditions given in Lemma 5. In any stationary equilibrium, all housing stocks must grow at rate ν . Thus, it follows that in any such equilibrium:

$$\frac{\kappa_i}{\rho} = c_0 + c_i^R r_i, \quad (47)$$

$$V_i = c_0 + c_i^H h_i. \quad (48)$$

We may think of equations (47) and (48) as stationary “housing supply curves” for each city type. Recall that independent of the housing stocks, rents, and prices are all positively and linearly related to each other under the benchmark configuration, equations (34) and (35). Thus, given equations (47) and (48), in any stationary equilibrium of such an economy, the stocks of different types of housing must all be linearly and positively related to each other.

The equilibrium system of equations may then be reduced to a single equation relating any one of the four housing prices (rental and house sale prices in each city type) to the four housing stocks. It is straightforward to show that this price is decreasing in the value of an unemployed renter, U^R . Since this is the only component of the equation that depends on the housing stocks, we have the following:

Proposition 4. *Let $U^R(r_1, r_2, h_1, h_2)$ be increasing in all its arguments. Then, if there exists a stationary equilibrium under the benchmark configuration, it is unique.*

To this point, we have derived conditions under which a stationary equilibrium, if one exists, (1) satisfies the conditions of the benchmark configuration and (2) is unique. Below, we compute directly a stationary equilibrium for our calibrated economy and confirm that it satisfies these conditions.

4. MOBILITY, HOME OWNERSHIP, AND UNEMPLOYMENT IN THE STATIONARY EQUILIBRIUM

In this section, we present several results that describe qualitatively the stationary equilibrium of our economy under the benchmark configuration. These results help provide intuition for the quantitative characteristics of our calibrated economy in Section 6.

First, we prove that houses sell more quickly in high-wage cities.

Proposition 5. *If the wage differential across city types, $w_2 - w_1$, is sufficiently large, then market tightness is highest in high-wage cities: $\phi_2 > \phi_1$.*

In general, we find that the minimum wage differential that is sufficient for this result to hold is tiny.

In equilibrium, the home-ownership rate in cities of type i can be expressed as a function of the matching rate:

$$\Omega_i(\phi_i) = \frac{n_i^{UH} + n_i^{WH}}{r_i + n_i^{UH} + n_i^{WH}} = \frac{\frac{h_i}{r_i} - \frac{1}{\phi_i}}{1 + \frac{h_i}{r_i} - \frac{1}{\phi_i}}. \quad (49)$$

The rate of home-ownership is increasing in the ratio of the stock of owned to rental housing. Moreover, since h_i is increasing in γ_i , it follows the following corollary.

Corollary 1. *If the ratio of the stocks of owned and rental houses is the same in both types of city, then home-ownership is greatest in high-wage cities: $\Omega_2 > \Omega_1$.*

Since home-owners and renters receive offers and are separated from jobs at the same rates, they differ only with regard to the likelihood with which they accept offers. As only home-owners turn down jobs in equilibrium, the following result is not surprising.

Proposition 6. *The unemployment rate among home-owners exceeds that among renters who are not new entrants to the labour force.*

Note that the emphasis on renters who are not new entrants to the labour force. Because households in our model are *ex ante* identical, Proposition 6 is not in conflict with the empirical observation that unemployment is higher among *all* renters than among home-owners. Since households enter the population as unemployed renters, this biases upwards the unemployment rate among renters in a way that does not affect that of owners. The unemployment rate among all renters can be expressed as follows:

$$\tilde{u}^R = \underbrace{\frac{\delta}{\delta + \mu + \mu^* + \lambda + \nu}}_{\text{non-entrants}} + \underbrace{\frac{\nu}{(\delta + \mu + \mu^* + \lambda + \nu)(s_1 r_1 + s_2 r_2)}}_{\text{new labour force entrants}}. \quad (50)$$

To isolate the effect of ownership, we can remove this bias by considering only the unemployment rate of those renters who are not new entrants, which is the first term on the right-hand side of equation (50).

The following proposition characterizes the tendency of unemployed renters to remain in or move to the low-wage city:¹⁰

10. Recall that β_i denotes the fraction of outside offers received by households cities of type i that come from other cities of type i .

Proposition 7. *If*(a) $\beta_2 \geq \beta_1$,(b) *relative stocks of ownable to rented housing are similar across cities, $h_1/r_1 \simeq h_2/r_2$, and*(c) *the relative number of renters in small cities is sufficient large, $\frac{s_1 l_1}{s_2 r_2} > \xi$ for $\xi \in (0, 1)$,**then the fraction of renters who are employed is greatest in high-wage cities: i.e. $\alpha_2 > \alpha_1$.*

In any stationary equilibrium, the majority of households (all renters and some home-owners) resident in low-wage cities that receive high-wage job offers move to accept them. In contrast, only unemployed renters and some fraction of unemployed home-owners resident in high-wage cities migrate to a low-wage city to accept a job offer. This asymmetry tends to drive up the rent differential between high- and low-wage cities. This in turn may induce unemployed households with no job offer to remain in or move to a low-wage (and low rent) city. Consequently, the proportion of renters who are unemployed tends to be higher in low-wage cities. Proposition 7 establishes that this is true unless rental housing in low-wage cities is sufficiently scarce.

The unemployment rate in a city of type i can conveniently be expressed as follows:

$$u_i = \underbrace{\left(\frac{\delta + \nu}{\delta + \mu + \nu} \right) \Omega_i}_{\text{home-ownership effect}} + \underbrace{\left[1 - \left(\frac{\delta + \mu + \nu + \lambda}{\delta + \mu + \nu} \right) \alpha_i \right]}_{\text{rent differential effect}} (1 - \Omega_i), \quad (51)$$

where Ω_i is given by equation (49). The first term reflects the positive impact of home-ownership to the city's unemployment rate due to the fact that some unemployed home-owners turn down job offers rather than relocate. The second reflects the fact that there is typically a higher concentration of unemployed renters (represented in equation (51) by $1 - \alpha_i$) in cities with lower rent (i.e. low-wage ones). The home-ownership effect is typically larger in high-wage cities, while the rent differential effect is typically higher in low-wage cities, as some unemployed households move to these cities to take advantage of relatively low rent. Overall, the relationship between unemployment and home-ownership in cities of either type depends on which of the two effects dominate.

Proposition 8. *If households never receive outside offers from cities of the same type as that in which they currently live (i.e. if $\beta_1 = \beta_2 = 0$), then the aggregate unemployment rate can be expressed as follows:*

$$\bar{u} = A + B\bar{\Omega}, \quad (52)$$

where $\bar{\Omega}$ is the aggregate home-ownership rate and $A > 0$ and $B > 0$ are constants depending only on parameters.

When β_1 and β_2 are positive, the relationship becomes more complicated and \bar{u} no longer depends only on $\bar{\Omega}$. As we will see below, however, in our calibrated economies, the positive relationship remains.

5. CALIBRATION

Before calibrating, it is useful to introduce three generalizations of the basic model that greatly improve our ability to map the economy's parameters into characteristics of the data. These generalizations do introduce new parameters but affect neither the existence of a unique stationary equilibrium under the benchmark configuration nor any of the qualitative results presented in Section 4. Full details of how these changes affect the equilibrium conditions are provided in the Technical Appendix in the Supplementary Material.

5.1. Intra-city relocation

To this point, we have abstracted from housing transactions among households who do not migrate but remain within a city. If all owner-occupied houses within a city are identical, there is no reason for a home-owner to sell one house in order to move to another within the same city. Empirically, however, most actual movement of home-owners is within rather than between cities and most intra-city moves are not job related (Rupert and Wasmer, 2011). Moreover, intra-city relocation affects inter-city migration in the model quantitatively through its effect on the liquidity of housing. In order to account simultaneously for inter-city mobility and the levels of house prices, we now modify our model to allow for intra-city movement of home-owners.

Following Wheaton (1990), we assume home-owners experience *housing taste shocks* at rate ψ . On experiencing a shock, the service flow a home-owner receives from their *current* house falls permanently to $\pi^H - \varepsilon$, while that potentially available to them from other houses remains π^H . All such *mismatched* owners immediately become potential buyers, search for a new house and match with vacant houses via the same technology as renters. Once they find a new house, they immediately sell their old house to an REM at the market price. The REM sells them the new house at a price that reflects the usual bargaining outcome:

$$P_i^{WH} = (1 - \sigma)(W_i^H - \tilde{W}_i^H) + V_i \quad P_i^{UH} = (1 - \sigma)(U_i^H - \tilde{U}_i^H) + V_i, \quad i = 1, 2, \quad (53)$$

where \tilde{W}_i^H and \tilde{U}_i^H denote the values of being a mismatched owner who is employed and unemployed, respectively. Note that while the surplus split is assumed to be the same regardless of whether an REM is bargaining with a renter or a mismatched home-owner, the exchange prices will differ in these situations as the home buyers' outside options differ across the two cases.

We continue to restrict attention to equilibria that are stationary and symmetric. We impose the following additional restrictions on our benchmark configuration and confirm that they hold in the equilibrium of our calibrated economy in addition to restrictions 1–4:

5. Mismatched owners do not become renters

$$\tilde{W}_i^H - V_i > W_i^R \quad \text{and} \quad \tilde{U}_i^H - V_i > U_i^R, \quad i = 1, 2. \quad (54)$$

6. All mismatched owners buy houses when they get the chance.

7. Mismatched unemployed owners in cities of type i accept offers from other cities of the same type i :

$$\tilde{U}_i^H - V_i < W_i^R, \quad i = 1, 2. \quad (55)$$

These conditions together imply that employed home-owners (matched and mismatched) are also unwilling to move from high-wage cities to low-wage ones:

$$W_2^H - V_2 > \tilde{W}_2^H - V_2 > W_2^R > W_1^R. \quad (56)$$

Let \tilde{n}_i^{WH} and \tilde{n}_i^{UH} denote the stocks *per capita* of mismatched employed and unemployed owners in cities of type i , respectively. Since the stock of potential buyers now includes mismatched owners as well as renters, it follows that the ratio of buyers to sellers in type i cities' housing markets is given by

$$\tilde{\phi}_i = \frac{r_i + \tilde{n}_i^{WH} + \tilde{n}_i^{UH}}{h_i - n_i^{WH} - n_i^{UH} - \tilde{n}_i^{WH} - \tilde{n}_i^{UH}}, \quad i = 1, 2. \quad (57)$$

The value of a vacant house in a type i city now satisfies

$$\rho V_i = \lambda \tilde{\phi}_i (\bar{P} - V_i), \quad (58)$$

where the average house price is

$$\bar{P}_i = \eta_i [\alpha_i P_i^{\text{WR}} + (1 - \alpha_i) P_i^{\text{UR}}] + (1 - \eta_i) [\zeta_i P_i^{\text{WH}} + (1 - \zeta_i) P_i^{\text{UH}}].$$

Here, $\eta_i = r_i / (r_i + \tilde{n}_i^{\text{WH}} + \tilde{n}_i^{\text{UH}})$ denotes the fraction of buyers that are renters and $\zeta_i = \tilde{n}_i^{\text{WH}} / (\tilde{n}_i^{\text{WH}} + \tilde{n}_i^{\text{UH}})$ the fraction of mismatched owners that are employed.

This generalization introduces two new parameters: ε and ψ . We restrict attention to cases in which the stationary equilibrium that we compute remains the unique one under the benchmark configuration. For ε sufficiently small, in our calibration, the marginal home-owner in each city is indeed unemployed and satisfied with their current house. Consequently, unemployed households in either city that become dissatisfied with their home strictly prefer to move if offered a job in any other city.

5.2. Inter-city relocation for non-employment related reasons

Although moves between cities are more likely to be job related than moves within cities, it is still the case that many inter-city moves occur for reasons other than to obtain employment or a higher wage. To allow for such moves, we assume that all households are subject to exogenous relocation shocks which cause them to move even if the net benefits of doing so would otherwise be negative. Specifically, we assume that a fraction χ of all those households that receive job offers from other cities simultaneously also receive a relocation shock. This shock changes utility by just enough to induce the household to move.

Random relocation increases the rate at which all types of household move. In addition, its effects are not symmetric across households in different states. For example, a fraction χ of employed owners will now move, whereas none do in the basic model. There is, however, no increase in the fraction of employed renters in low-wage cities that move to high-wage cities (they would have moved anyway). *Ceteris paribus*, an increase in χ tends to increase the mobility of owners relative to renters.

5.3. Mortgage interest deductibility

There are potentially many distortions in housing markets that could drive a wedge between the price that a buyer pays and the price that a seller receives. Although such wedges will not typically affect the our qualitative results, they could have quantitative implications. For the U.S., a particularly significant distortion is the deductibility of mortgage interest payments from taxable income. Following Gervais (2002), we assume that when households buy a house they make a down-payment, dP , (which could be zero) and then take out an infinite mortgage on the remainder, paying $\rho P(1 - d)$ per period, where P is the price received by the seller. We assume that taxable income is computed *net* of these payments for home-owners, so that the effective price paid by the buyer is $(1 - \tau(1 - d))P$, where τ is the income tax rate. Since labour supply is exogenous in our economy and we assume that revenues are transferred back to households as lump-sum transfers, variation in the tax rate affects *only* the cost of purchasing a house relative to renting, and in our computational experiments, we will interpret variations in τ as capturing changes to the deductibility of mortgage interest.

To see how mortgage interest deductibility works in the model let $T = \tau(1 - d)$. In a transaction between an employed renter and a seller, for example the seller receives $(1 - T)P_i^{\text{WR}} - V_i$ and the buyer gets $W_i^{\text{H}} - W_i^{\text{R}} - (1 - T)P_i^{\text{WR}}$. The total surplus in this transaction is therefore

$W_i^H - W_i^R - V_i$ and the price paid satisfies $(1 - T)P_i^{WR} = \sigma(W_i^H - W_i^R) + (1 - \sigma)V_i$. Similar implications hold for unemployed renters and mismatched owners, respectively.

5.4. *Parameter choices: baseline calibration*

We choose parameters so that the stationary equilibrium is consistent with several observed aspects of the U.S. economy (see Appendix A for details). The parameter values and the relevant targets are given in Table 1. The first 9 parameters are set directly to match the associated targets. The remaining 11 parameters jointly determine the extent to which the equilibrium matches the remaining targets as a group. For illustrative purposes, however, in the table, we associate each parameter with a specific target for which it is particularly relevant. We base our calibration on monthly data where possible.

Target values for the discount rate, the unemployment rate, the hiring rate, and the separation rate are taken from Shimer (2005). The relative flow value of non-work, z , which includes unemployment benefits and the estimated relative utility of leisure, is taken from Hall and Milgrom (2008). The average income tax rate and down-payment are taken from Gervais (2002) and the fraction of households that move between counties for non-job-related reasons, χ , is based on a survey conducted as part of the current populations survey (CPS).

We take housing market statistics mainly from the 2000 U.S. Census, which provides information regarding housing markets by metropolitan statistical area (MSA). Using the pre-2006 definitions, there are 279 MSAs listed in the Census. We remove the three Puerto Rican MSAs,

TABLE 1
Parameter choices (baseline calibration)

Parameter symbol	Parameter value	Target and source	Target value
ρ	0.0033	Annual discount factor (Shimer, 2005)	0.96
ν	0.001	Annual population growth, 1990–2000 (USCB)	1.2%
z/w_1	0.71	Flow value of non-work (Hall & Milgrom, 2008)	0.71
w_2/w_1	1.097	Large small city real wage ratio (USCB and ACCRA)	1.097
τ	0.29	Average income tax rate (Gervais, 2002)	29%
d	0.2	% mortgage required as down-payment (Gervais, 2002)	20%
c_0	2.2	Construction as % of house price (Davis & Palumbo, 2008)	71%
β_1	0.285	% population in small cities (USCB)	28.5%
β_2	0.715	% population in large cities (USCB)	71.5%
δ	0.02583	Unemployment rate (Shimer, 2005)	5.7%
μ	0.431	Monthly hiring rate (Shimer, 2005)	0.44
μ^*	0.02248	Annual mobility of renters between counties (CPS/ACS)	12.6%
λ	0.00802	Annual mobility of owners between counties (CPS/ACS)	3.3%
ψ	0.011	% of owner-moves within county (USCB)	57%
χ	0.10	Fraction who move counties for non-job reasons (CPS)	64%
σ	0.452	Average price–average income ratio (USCB/ACCRA)	3.08
$\pi^H - \pi^R$	0.010	Average rent–average income ratio (USCB/NIPA/ACCRA)	0.14
ε	0.005	Half the utility difference between owning and renting	0.0045
$c_1^R r_1$	23.7	Rental units in small cities per household (USCB)	0.09
$c_1^H h_1$	30.4	Owned units in small cities per household (USCB)	0.23
$c_2^R r_2$	50.8	Rental units in large cities per household (USCB)	0.20
$c_2^H h_2$	66.2	Owned units in large cities per household (USCB)	0.49

Notes: USCB, United States Census Bureau; NIPA, National Income and Product Accounts; ACCRA, American Chamber of Commerce Research Association.

Anchorage, and Honolulu and divide the remaining 274 cities into two groups based on population size: those with more and those with less than one million inhabitants in 2000. This results in a group of 49 large and typically “high-wage” Type 2 MSAs and a group of 225 smaller and typically “low-wage” Type 1 MSAs.

For all cities, we have data on nominal incomes, house prices, and rents. We deflate these using the non-shelter cost of living index (COLI) for each MSA. In nominal terms, median household income for the large cities is roughly 23% higher on average than that of the smaller cities. Once adjusted for the cost of living (other than housing), however, we find that real incomes for large cities are on average 9.7% higher than those for small cities.¹¹ Similarly, real house prices and real rents are, respectively, 40% and 20% higher.

One problem for studying housing and rental markets in some areas (*e.g.* Manhattan and central Los Angeles) is the existence of stringent rent control laws in 2000. That this distortion is significant is demonstrated by very low home-ownership rates in these locations relative to other counties within the same MSA and to other cities in their respective population group. Our view (which is consistent with the evidence of Glaeser and Luttmer, 2003) is that rent control in the central areas of these cities generates (both intra- and inter-city) immobility, especially among poorer households. Indeed, it is likely that this immobility is even more acute than for home-owners: when renters move they cannot sell their “claim” to rent-controlled housing. Since our model does not allow for these effects, in computing our calibration targets, we treat some proportion of renters living in these particular areas as being equivalent to home-owners with respect to mobility. We do this by using only the relative stock of ownable to rented housing in the rest (*i.e.* the other counties) of the relevant MSA.

To compute the stocks of owned housing, we divide the number of currently owner-occupied houses by one minus the reported owned-housing vacancy rate for each MSA. For the stocks of rental units, we use only occupied rental units that we take to be the “effective” rental stock.¹² The stocks are aggregated across MSAs and divided by the total number of households. They imply an average vacancy rate for owner-occupied housing of 1.55%, which is similar to the average for MSAs reported by the U.S. Census Bureau between 1986 and 2005. Interestingly, the ratios of owned housing to rental housing for the two groups of cities are virtually identical (*i.e.* $h_1/r_1 \simeq h_2/r_2$) and so differences in ownership rates across city groups arise almost entirely from differences in vacancy rates.

Estimates of housing construction costs by city are hard to come by and, generally, do not distinguish between owned and rental housing (see Glaeser *et al.*, 2010). So, rather than measuring costs directly, we calibrate the parameters of the housing supply functions, so that the *per capita* stocks of each type of housing in each city match the averages in the data (from the 2000 U.S. Census) for each of our two MSA groups. In our Baseline calibration, we assume that construction costs are constant across cities and dwelling types. Following Davis and Heathcote (2007) and Saiz (2010), we choose c_0 so that land accounts for 29% of the price of a house on average across the entire economy. We then select the remaining four parameters, $\{c_i^R, c_i^H\}_{i=1}^2$, so as to match the housing stocks. These imply residential land costs in large cities that are more than twice as high as those of smaller cities.

11. Wage differentials arise in part from difference in the compositions of the workforce across cities. After controlling for educational and occupational differences, Glaeser and Mare (2001) estimate a dense metropolitan wage premium for cities with more than 500,000 inhabitants of 0.24 log points and a non-dense metropolitan premium of 0.14 log points.

12. We abstract entirely from frictions in the rental market. We view vacancies in the rental market as symptomatic of the fact that, once a rental unit is vacated, it may not immediately be available to the rental market. For example, maintenance and decorating may be needed before it is ready to be rented again.

The average annual mobility rate (the percentage of the population that change address in a given year) is provided by the U.S. Census Bureau. Although more than 15% of the U.S. population changes address each year, this includes people who move short distances (*e.g.* within a county). For our purposes, a more appropriate estimate of mobility is that between labour markets. We therefore use as a target the component of the mobility rate associated with people who move between counties, which is 6.4%. According to the U.S. Census Bureau, in 2000, the fraction of moving owners who moved between counties was about 43%.

We jointly choose the values of δ , μ , μ^* , λ , and ψ so that the output of the model matches the target estimates of (1) the average monthly hiring rate from the unemployed workforce (Shimer, 2005), (2) the average unemployment rate, (3) the cross-county annual mobility rate of renters, (4) the cross-county annual mobility rate of owners, and (5) the fraction of owners who move but remain within a county. We assume that the probability with which a household in any city who receives an outside offer from a city of a particular type is proportional to the share of total labour force located in cities of that type; thus, $\beta_2 = 1 - \beta_1$. The population ratio of large to small cities is therefore equal to $\beta_2/\beta_1 = 2.54$.

Given the other parameter values, we set the bargaining parameter, σ , so that the ratio of the average price to the average income in the model matches that for the U.S. economy. Average income in the model includes both income from employment and unemployment in both cities. The average price is computed by weighting \bar{P}_i by the number of housing transactions in each city. To match the target requires that the buyer's share must equal approximately 38% of the surplus.

The net utility from ownership, $\pi^H - \pi^R$, is set so that the ratio of average rent to average income matches that for the U.S. economy. Note that, the income of the average renter in the U.S. is less than half of that of the average owner, reflecting the fact that the characteristics of owners and renters differ systematically. On average, a renter in the U.S. allocates 24% of his after-tax income to rent (see Davis and Ortalo-Magne, 2011). Since in our model all agents are homogeneous, we target the ratio of rent to the average income of owners and renters, which is somewhat lower at about 14% (see Appendix A). Finally, we set ε equal to one-half of the difference between π^H and π^R .¹³

6. THE QUANTITATIVE RELATIONSHIP BETWEEN HOME OWNERSHIP AND UNEMPLOYMENT

6.1. *Baseline calibration*

We compute numerically the unique stationary equilibrium consistent with the benchmark configuration. Table 2 describes the distribution of the total population over locations, jobs, and housing tenure in equilibrium. High-wage cities have larger populations than low-wage ones, and this includes having proportionately more employed renters, employed owners, and unemployed owners. Low-wage cities, in contrast, have proportionally more unemployed renters, reflecting the incentive of these households to live in cities with lower rent.

Table 3.1 contains statistics on mobility and unemployment for the U.S. economy and a series of artificial economies, beginning with the baseline calibration (column 2). Recall that the mobilities of renters and owners in the U.S. economy are calibration targets. With regard to unemployment, the aggregate rate, 5.7%, is also a target, but the breakdown across cities is endogenous. As in the data, low-wage cities have higher rates of unemployment than high-wage ones, although the model overstates the difference due mainly to its prediction of a high

13. Our results are largely insensitive to the exact value of ε , provided it is less than $\pi^H - \pi^R$.

TABLE 2
Allocation of households by location, job, and housing status

	Low-wage cities		High-wage cities		Total
	Renters	Owners	Renters	Owners	
Employed	0.084	0.180	0.220	0.459	0.943
Unemployed	0.008	0.011	0.011	0.027	0.057
Total	0.092	0.191	0.231	0.486	1.000

TABLE 3.1
Mobility and unemployment

	U.S. data	Baseline	Owned –10%	Rental only	No m.i.d.	Increased wage difference
Mobility rate	0.064	0.064	0.080	0.126	0.079	0.044
Of renters	0.126	0.126	0.114	0.126	0.129	0.060
Of owners	0.033	0.033	0.055	—	0.046	0.036
Population ratio	2.54	2.54	2.53	2.47	2.22	10.06
Unemployment rate	0.0570	0.0570	0.0542	0.0525	0.0553	0.0570
In low-wage cities	0.0608	0.0674	0.0633	0.0837	0.0658	0.0591
In high-wage cities	0.0566	0.0530	0.0506	0.0446	0.0505	0.0567
For all renters	0.082	0.0606	0.0585	0.0525	0.0591	0.0607
For non-new entrant renters	—	0.0506	0.0506	0.0506	0.0506	0.0506
For owners	0.044	0.0554	0.0511	—	0.0530	0.0551
Rejection rate	—	0.2355	0.1782	—	0.2127	0.1599
In low-wage cities	—	0.4835	0.4086	—	0.4415	0.4334
In high-wage cities	—	0.1379	0.0877	—	0.1097	0.1369

rate of joblessness among renters in low-wage cities. The overall unemployment rate among owners is somewhat higher than that for renters who are not new entrants to the labour force. This reflects the fact that over 23% of unemployed owners turn down opportunities to relocate for employment reasons. The unemployment rate for *all* renters, however, is actually higher than that for owners. Thus, although renters are much more mobile than owners, they are not unemployed at a significantly lower rate.

The rate at which unemployed home-owners reject outside offers is much higher in low-wage cities than in high-wage ones. This largely reflects the fact that unemployed owners in low-wage cities do not accept offers in other low-wage cities, whereas those in high-wage cities do accept offers from other high-wage cities. Effectively, low house values impose a relatively high cost of moving on home-owners in low-wage cities. Recalling equation (51), however, the home-ownership effect on unemployment is small even in low-wage cities. In contrast, the rent differential effect is very large, as rent is more than twice as high in high-wage cities as in low-wage ones. Overall, this results in significantly higher unemployment in low-wage cities (by one and a half percentage points). Thus, as observed by Coulson and Fisher (2009), the baseline calibration implies a negative relationship between unemployment and home-ownership across cities and a positive one between wages and home-ownership.

Table 3.2 contains selected housing market statistics for the same data and computed examples as Table 3.1. The calibration targets the economy-wide averages of home-ownership rates, the ratio of house prices to annual income, and the ratio of rent to annual income. In the table,

TABLE 3.2
Housing market statistics

		U.S. economy	Baseline	Owned −10%	Rental only	No m.i.d.	Increased wage difference
Low- wage cities	% ownable	68.0	68.0	58.0	—	61.8	63.3
	Rent	0.127	0.088	0.111	0.090	0.113	0.039
	Price	2.54	2.15	2.72	—	2.14	0.797
	$\kappa_1 - \rho V_1$	—	0.0369	0.0369	—	0.0326	0.0991
	Months to sell	—	3.72	3.27	0.0	3.09	13.64
	Ownership rate (%)	67.6	67.4	57.2	0.0	61.1	60.2
	Vacancy rate (%)	1.78	2.77	3.10	—	2.68	11.01
High- wage cities	% ownable	68.0%	68.0	58.0	—	61.8	67.9
	Rent	0.159	0.180	0.203	0.180	0.205	0.228
	Price	3.55	4.49	5.05	—	3.94	5.60
	$\kappa_2 - \rho V_2$	—	0.0160	0.0160	—	0.0160	0.0561
	Months to sell	—	1.42	1.37	—	1.32	1.13
	Ownership rate (%)	67.7	67.8	57.7	0.0	61.5	67.5
	Vacancy rate (%)	1.47	1.06	1.31	0.0	1.14	0.85

rents and prices (both in the data and the model) are normalized by the average income in low-wage cities. The theory accounts reasonably well for the facts that house prices are higher and vacancies lower in high-wage cities than in low-wage ones. In both cases, however, the calibrated economy overstates somewhat the differences across cities. Qualitatively, the model is also consistent with the fact that the rents are higher in high-wage cities. The difference, however, is much bigger in the model than in the data.

The model predicts significantly longer time on the market for houses in low-wage cities. This is the sense in which low-wage city homes are less liquid than high-wage city ones and is a driving force behind the employment and mobility results in Table 3.1. On average, it takes about 2 months to sell a house in the baseline calibration. This is, in fact, close to the estimated time taken to sell a typical house provided by the National Association of Realtors. It should be noted, however, that there is considerable uncertainty surrounding this estimate.¹⁴

We have assumed that the costs of conversion are sufficiently high that no conversion takes place in the stationary equilibrium. It is straightforward to determine the minimum conversion costs necessary to support this using Table 3.2. In low-wage cities, since $\kappa_1 - \rho V_1 > 0$, it is never profitable to convert rental to ownable housing. Provided $d^R > (\kappa_1 - \rho V_1)/\rho = 0.037/0.04 = 0.95$, it is not profitable to convert ownable to rental housing, either. Conversely, in the high-wage city, we can have $d^H = 0$. That is, one-time conversion costs (d^R, d^H) both less than the average monthly wage are sufficient. Another possibility is for REMs to put rented houses up for sale and convert them to owner-occupied houses only once they have matched with a buyer.¹⁵ For these conversion costs, however, it is straightforward to show that this would not be profitable either (see the Technical Appendix in the Supplementary Material).

14. One reason is that houses may sometimes be strategically de-listed and quickly re-listed in order to reset the “days on market” field in the MLS listing. In their detailed analysis of the housing market in 34 Cook County (Illinois) suburbs, Levitt and Syverson (2006) compute time-to-sale by “summing across all of a house’s listing periods that are separated by fewer than 180 days”. They estimate that the average time on the market for a house that eventually sells is 94 days (3.07 months).

15. We exclude the possibility of the REM selling the house immediately to the current renter.

Overall, in the baseline calibration, our economy is broadly consistent with the cross-city evidence on unemployment, mobility, house prices, rents, and vacancy rates. Houses are significantly less liquid in low-wage cities and this is reflected in both house prices and the frequency with which home-owners turn down offers of employment in other cities. The fact that the model cannot reproduce exactly the quantitative differences in housing market statistics across cities is not surprising. The *only* sources of cross-city heterogeneity are the wage and unit housing costs. In principle, there could be other sources of heterogeneity across city groups (*e.g.* amenities, worker flows). We do not, however, have direct observations on these factors by MSA. Another likely source of divergence between the cross-city difference in the model and the data are the linearity of preferences. Although linearity allows for a tractable analysis of equilibrium with search in two markets, it imposes strong restrictions on the relationship between wages, rent, and price differentials across cities.

We now conduct a series of experiments in order to examine the relationships between housing and both mobility and unemployment. In particular, we are interested in whether and by how much home-ownership affects mobility and unemployment, both in the aggregate and city by city. The results of these experiments are reported in columns three to six of Tables 3.1 and 3.2.

6.1.1. A reduction in the (fixed) supply of owner occupied housing. We first consider an exogenous reduction in the stock of owner-occupied housing in all cities by ten percentage points.¹⁶ We may think of this as being accomplished by changing the costs of construction for owner occupied and rental housing so as to support an equilibrium with the same quantity of housing overall as in the baseline calibration, but with 10% less of it being owner-occupied. Overall, this change in the environment lowers home-ownership rates and increases the matching rates for houses in all cities in the stationary equilibrium. Houses become more liquid everywhere, time on the market falls, and both house prices and rents rise in all cities. The increase in the liquidity of housing results in substantially increased mobility overall (from 6.4% to 8%), which is driven by a significant reduction in the rejection rates of offers by home-owners. Indeed, mobility *falls* for renters.

In spite of the significant increase in mobility, a reduction in the stock of owner-occupied housing (and specifically the associated lower rate of home-ownership) has only a small effect on aggregate unemployment, which falls by only one-third of one percentage point. This effect is roughly one-quarter the size of that estimated by Nickell (1998) and even smaller relative to the estimates of Oswald (2009). Unemployment falls by more (four-tenths of a percentage point) in low-wage cities owing to a relatively large increase in the mobility of home-owners in these cities. Both home-owners and renters experience unemployment at lower rates, but while for the former this results from an reduced rate of rejection of job offers, for the latter it is due only to a composition effect: a smaller fraction of renters are now new entrants to the economy who are by construction unemployed at a high rate.

6.1.2. Complete elimination of owner-occupied housing. We now consider the effect of eliminating owner-occupied housing entirely (calculations associated with this modification to the environment are straightforward but lengthy and so are relegated to the Technical Appendix in the Supplementary Material). In this experiment, all households rent competitively in their city of residence. To make sense of this, suppose that developers build only rental units (facing the same unit costs as in the benchmark). As before, we focus on an interior equilibrium in which the unemployed continue to be indifferent between locations: $U_1^R = U_2^R = U^R$. In this case, the

16. A ten percentage point increase in the stock of owner-occupied housing has essentially symmetric effects in the opposite directions.

unemployed accept offers of employment from all other cities, whereas only the employed in low-wage cities move and only in response to offers from high-wage cities.

Eliminating owner-occupied housing in this way effectively eliminates the trading friction in housing markets¹⁷. Thus, we may think of this experiment as a consideration of the case in which housing is perfectly liquid. The fourth column of Table 3.1 contains statistics on mobility and unemployment for this case and the (very sparse) fourth column of Table 3.2 contains the only relevant housing market statistic for this economy, the rent-income ratio in each city.

The elimination of home-ownership has no significant effect on the distribution of the population across city types, as the rent differential adjusts to equate the values of being unemployed in either city. Although wages are nearly 10% higher in large cities, this is offset by the fact that in our calibrated economy, unit land costs are twice as high. Since moving is costless, households never turn down job offers from a high-wage city and mobility is maximized, rising from 6.4% to 12.6% overall. Aggregate unemployment falls relative to the baseline by roughly four-tenths of a percentage point.

As in the case of a partial reduction in home-ownership, unemployment falls in high-wage cities. However, it rises in low-wage cities, thereby increasing the unemployment gap across city types. This reflects the fact that the increased mobility of low-wage city residents is more than offset by the incentive of unemployed households to live in the low-wage cities in order to take advantage of lower rent. This rent differential is now substantially larger than in the baseline.

6.1.3. Elimination of mortgage interest deductibility. As noted above, home-ownership *per se* contributes to aggregate unemployment, although in our calibration the effect is relatively small. We now consider the elimination of mortgage interest deductibility (m.i.d.). Effectively, such a change to the tax code reduces the return to home-ownership and thus affects the willingness both of households and REM's to purchase and to construct houses, respectively. In this experiment, we allow the housing stocks to adjust in response. Thus, this experiment can be expected to result in an endogenous reduction of the ownership rate, whereas in the previous experiments, home-ownership was reduced exogenously.

The fourth columns of Tables 3.1 and 3.2 contain labour and housing market statistics for this experiment. The elimination of m.i.d. results in a reduction of home-ownership by approximately 6.4 percentage points. Rent rises and house prices fall in all cities. While the housing markets in all cities become smaller, the effect on time on the market differs across cities, with houses becoming slightly more and less liquid in low- and high-wage cities, respectively. Mobility rises overall, both because of a reduction in the rejection rates of offers and because of a drop in the ownership rate. Unemployment falls by roughly two-tenths of one percentage point in the aggregate. Again, the reduction in unemployment is strongest in low-wage cities, and again this is because the effect on mobility through an increase in the liquidity of housing is strongest there.

6.1.4. An increase in the city wage differential. We now consider an increase in the wage differential across cities from 9.7% to 20%, holding fixed construction costs so that, again, the housing stocks adjust. This results in a major movement of households to high-wage cities and affects housing markets significantly as well. Houses become much less liquid in low-wage cities and their prices fall dramatically. Similarly, rents fall significantly as population shifts to high-wage cities. Aggregate mobility is reduced in spite of the fact that job offers are rejected less frequently because of the higher population concentration in high-wage cities. With regard

17. The only two differences are that all households now receive the same utility from housing, π^R and that the unit cost of production is now C_i^R for all housing.

to labour market outcomes, aggregate unemployment remains essentially unchanged relative to the baseline. In contrast, the changes in the housing market are much more significant, with rents and prices moving much further apart across cities and vacancies increasing substantially in low-wage cities.

6.2. *A high unemployment calibration*

Our baseline calibration targets an unemployment rate of 5.7%, which was the average U.S. rate between 1950 and 2005. Long-run unemployment rates in many continental European countries have tended to be significantly higher and in recent years, the U.S. has experienced similarly high rates. Recently, Elsby, Hobijn and Sahin (2011) have documented that continental European labour markets with high rates of unemployment tend to have substantially lower inflows to and outflows from unemployment than Anglo-Saxon ones. In this section, we therefore consider an alternative calibration of the model with aggregate unemployment of 10% and a monthly hiring rate $\mu = 0.1$. We leave all other calibration targets unchanged relative to the baseline. To match the higher unemployment rate, the job separation rate, δ , is reduced to 0.0114 and several other parameters must be adjusted to continue to match other targets.¹⁸ Thus, higher unemployment in this calibration is attributed to a more sclerotic labour market, in line with what might be considered reasonable for a typical continental European economy.

Table 4 contains selected statistics for the “high unemployment” calibration (column one) and for two experiments, reducing the stock of owner-occupied housing by 10% (column two) and eliminating mortgage interest deductibility (column three). Overall, the results of these experiments are qualitatively similar in the high unemployment case to what they are under the baseline calibration. Quantitatively, however, there are both similarities and significant differences. Rents, prices, and vacancy rates across cities are in the same ballpark. The unemployment gap across cities, however, is substantially magnified. Moreover, the difference between the unemployment rates of owners and renters is now much larger.

The effect of home-ownership on aggregate unemployment is now stronger, with an exogenous ten percentage point reduction in the stock of owner-occupied housing resulting in a reduction of aggregate unemployment by almost 1.2 percentage points (as opposed to one-third of a percentage point in the Baseline calibration). This effect is almost as strong as that estimated by Nickell (1998) based on cross country regressions and is arguably economically significant. When a reduction in home-ownership of similar magnitude is induced by removing mortgage interest deductibility (rather than imposed exogenously), aggregate unemployment is reduced by two-thirds of a percentage point. This again contrasts with the baseline calibration in which the analogous experiment reduces unemployment by only two-tenths of a percentage point.

Comparing the high unemployment and baseline calibrations illustrates that the extent to which housing market frictions affect unemployment, both across locations and in the aggregate, depends on both the level of unemployment and the underlying labour flows. Unemployment is high in this calibration because within-city, hiring rates are low and are consequently closer to cross-city hiring rates. This implies that outside offers are a larger fraction of overall job offers, so that rejections by home-owners have a larger effect.¹⁹ In addition, since average unemployment is higher, home-ownership affects the mobility decisions of a larger share of the population.

18. The new parameter values are: $\mu^* = 0.022$, $\lambda = 0.0081$, $\psi = 0.011$, $\pi^H - \pi^R = 0.055$, $\chi = 0.088$, and $\sigma = 0.867$.

19. If, instead, we increase the unemployment rate by increasing δ , the effects of ownership on unemployment are much smaller.

TABLE 4
High unemployment calibration

	Base	Owned –10%	Zero m.i.d.
Mobility rate	0.064	0.080	0.078
Of renters	0.126	0.112	0.125
Of owners	0.033	0.057	0.047
Unemployment	0.1000	0.0878	0.0925
Low wage	0.1392	0.1202	0.1300
High wage	0.0846	0.0750	0.0757
All renters	0.1097	0.1002	0.1031
Non entrants	0.0693	0.0693	0.0693
Owners	0.0953	0.0786	0.0858
Rent			
Low wage	0.098	0.119	0.124
High wage	0.180	0.200	0.205
Price			
Low wage	2.18	2.70	2.17
High wage	4.50	5.01	3.94
Months to sell			
Low wage	3.73	3.29	3.04
High wage	1.43	1.37	1.31
Vacancy rate			
Low wage	2.76	3.11	2.59
High wage	1.07	1.30	1.13

These results suggest that for economies with high unemployment relative to that of the U.S. (*e.g.* many European economies), home-ownership may indeed be a significant factor in generating unemployment. A conclusion along these lines is somewhat suspect, however, because European countries with high levels of unemployment tend to have mobility rates much lower than observed for the U.S.²⁰ For example, Rupert and Wasmer (2011) document average cross-regional mobility rates in Europe of approximately 2%. When we adjust the parameters of our high unemployment case so that mobility is reduced to 2% (holding all other targets the same), the effect of a ten percentage point reduction in the stock of owner-occupied housing on aggregate unemployment is cut in half, to 0.6 percentage points as opposed to 1.2.

6.3. *Robustness*

We now consider briefly the robustness of our quantitative results to two more deviations from the baseline calibration. For each of the alternative calibrations, we consider here, stationary equilibria continue to conform to the benchmark configuration. Moreover, since these variations in parameters have little effect on most of the statistics presented in Tables 3.1 and 3.2 above, here we report results (Table 5) only for the effects of parameter changes on mobility and unemployment (by city type and in the aggregate).²¹

20. Mobility rates have also declined in the U.S. during the last few years.
21. Full results are contained in the Technical Appendix in the Supplementary Material.

TABLE 5
Robustness

	High-wage differential			Low mobility		
	Base	Owned –10%	Zero m.i.d.	Base	Owned –10%	Zero m.i.d.
Mobility rate	0.064	0.081	0.086	0.050	0.0636	0.0622
Unemployment	0.0570	0.0542	0.0550	0.0570	0.0545	0.0555
Low wage	0.0674	0.0634	0.0668	0.0643	0.0603	0.0627
High wage	0.0529	0.0506	0.0492	0.0541	0.0523	0.0522

6.3.1. High-wage differential. In both the baseline and high unemployment calibrations, the cross-city type wage differential is set at 9.7% to capture differences in cost of living between our two categories of MSA’s, even though the unconditional wage difference between these city groups is significantly higher. Above, we considered the implications of increasing the wage differential to 20%, holding all other *parameters* fixed at their levels in the baseline calibration. We now consider an alternative calibration with the wage differential at 15% rather than 9.7%, and other parameters adjusted to maintain the *targets* of the baseline calibration.

The resulting economy is, for the most part, similar to that considered in the previous high-wage differential experiment. Moreover, with regard to the two experiments conducted, the economy responds similar to the baseline calibration. Thus, we conclude that our quantitative results are robust to changes in the wage differential across city types that continue to support a stationary equilibrium under the benchmark configuration.

6.3.2. Low mobility. In the baseline calibration, the target for average mobility is the frequency of moves across county lines. We suspect that this measure overstates to some extent the frequency of moves associated with changes in employment. Because many MSA’s are comprised of multiple counties, a certain number of these cross-county moves are of fairly short distance and thus may not be associated with a change of job. For this reason, we consider the implications of lowering average mobility from 6.4% to 5%, maintaining all other targets of the baseline calibration. Again we compute a baseline version and conduct two experiments. Overall, our quantitative results are robust to variations in mobility of this magnitude. A reduction in mobility has little effect on unemployment in either type of city or in the aggregate.

6.4. *Summary*

Overall, we find that due to its illiquidity owner-occupied housing significantly affects mobility in response to changes in employment status and opportunities. Moreover, the illiquidity of housing results in significant differences in house prices and rents across cities and may generate significant differences in unemployment rates as well. Nevertheless, home-ownership and the illiquidity of housing typically has a fairly small effect on aggregate unemployment. In our baseline calibration, a ten percentage point reduction of home-ownership reduces unemployment by only one-third of a percentage point, less than one quarter of that estimated by Nickell (1998) and Oswald (2009). Moreover, a total elimination of home-ownership increases this effect only slightly. Eliminating mortgage interest deductability would encourage mobility and reduce home-ownership but again the effect on aggregate unemployment would be small (two-tenths of one percentage point in our experiment).

There are two main reasons why the effect of home-ownership on aggregate unemployment is small in our calibrated economies despite the large difference between owners and renters with regard to mobility. First, in order to be consistent with observed inter-city mobility, the rate at which households receive offers from other cities, μ^* , is small relative to the rate at which they receive offers from their own city, μ . Thus, only a small fraction of the overall flow out of unemployment is associated with households moving between cities. Consequently, the friction associated with the time taken to sell does not have much affect on overall unemployment. If we were to increase μ^* and hold mobility constant by reducing the matching parameter λ , the effect of ownership on unemployment would rise. This, however, would imply both a longer average time to sell and a lower average house price than we observe. A second reason for the small effect is that the illiquidity of housing affects unemployment through its influence on the decisions of the unemployed, who make up only 5.7% of households in the baseline. As average unemployment rises, the effect of home-ownership rises in part simply because home-ownership affects the mobility decisions of a larger share of the population.

In a version of the economy with *both* high unemployment (due to lower rates of hiring) and high mobility, the affect of ownership on aggregate unemployment can be large (as illustrated by our high unemployment calibration). Such a configuration of parameters appears, however, to be counter-factual: countries that have high rates of mobility tend to have low average unemployment (*e.g.* the U.S.), and countries with low rates of mobility tend to have relatively high rates of average unemployment (*e.g.* continental Europe).

7. CONCLUSION

We have developed a multi-city model that allows for interactions between search frictions in both housing and labour markets. A house's liquidity—the time it would take to sell it to an appropriate buyer—determines its value in the event that its owner would like to sell it so that he/she can move to a different city. In equilibrium, willingness to move affects cities' populations and rates of both home-ownership and unemployment. These, in turn, determine vacancy rates and, hence, the liquidity of housing in each city.

In equilibrium, home-owners turn down job offers in certain circumstances, even if they are currently unemployed or are offered a higher wage than their current one, because the illiquidity of their house renders migration not worthwhile. The likelihood of unemployment for home-owners exceeds that for otherwise identical renters. Nevertheless, unemployment is negatively related to ownership rates across cities because unemployed renters tend to live disproportionately in low-rent (low-wage) cities, where home-ownership is also lower.

A version of the model calibrated to match U.S. labour market flows and mobility rates for both home-owners and renters generates plausible cross city home-ownership rates and qualitatively reasonable cross-city differences in unemployment, house prices, rents, and time-on-the market. We find, however, that the impact of home-ownership on aggregate unemployment is small. Moreover, this quantitative finding is robust to variations in economy parameters in several dimensions. If parameters are such that the economy exhibits both high unemployment (due to low rates of hiring) and high mobility, the effects of ownership on aggregate unemployment can be economically significant. Such a combination, however, appears to be counter-factual.

Given that the only sources of cross-city heterogeneity in our theory are wages and housing supply conditions, we find that the model performs reasonably well in matching qualitative cross-city differences in price, rents, unemployment rates, vacancy rates, and ownership rates. Its quantitative success in matching these differences is limited, however, for two main reasons. First, the assumption of risk-neutrality on the part of households imposes strong restrictions on the relationships between wage, rent, and price differentials. Second, worker flow rates and other

parameters are assumed to be identical across cities. Weakening these assumptions might allow for a better fit of the model. Moving away from linear preferences in a spatial search equilibrium would, however, significantly complicate the analysis because household decisions would depend on their current wealth. Moreover, we have not yet found the data necessary to compute city-specific worker flows. These remain challenges for future research.

APPENDIX: DATA SOURCES

All population, income and housing data are taken from the U.S. Decennial Census 2000 Summary File 3 (see <http://factfinder.Census.gov/>). The universe of cities are the 279 MSAs minus the three Puerto Rican cities, Anchorage, and Honolulu.

- City populations are taken from Table P1.
- For income in each city, we use median household income (in dollars) from Table P53. Household income for cities of type i is then computed as the population-weighted average of these incomes.
- For house prices, we use the median value (in dollars) for specified owner-occupied houses from Table H76. This category includes only one-family houses on less than ten acres without a business or medical office on the property. The house price for cities of type i is then the average of these prices weighted by the owned-housing stock.
- To compute rents for each city, we start with median contract rents (in dollars) from Table H56. Contract rent is the monthly rent agreed to or contracted for and may or may not include utilities. To correct for the inclusion of utilities, we compute the fraction, α_j , of rents that include utilities in city j computed from Table H68. From NIPA Table 2.4.5, the ratio of total expenditures on household utilities (line 55) in the U.S. to total expenditures on rent (line 50) is 0.43. We therefore compute rent in city j , not including utilities, according to

$$\text{Rent}_j = \frac{(\text{Contract Rent})_j}{1 + 0.43\alpha_j}.$$

The rent for cities of type i is then computed as the average of these rents weighted by the rental stock.

- Effective ownable housing stocks for each city are computed as the sum of owner-occupied units (Table H7) and vacant units that are “for sale only” (Table H8).
- Effective rental housing stocks are assumed to equal the occupied rental units from Table H7.
- Home-owner vacancy rates for each city are computed by dividing the number of vacant units “for sale only” (Table H8) by the effective ownable housing stocks.
- For those MSAs with substantial rent control in 2000, we used only the stocks outside the central PMSA to compute the overall ratio of owned to rental housing. These were the central PMSAs of New York, Los Angeles, Boston, San Francisco, Washington, and Syracuse, NY.

Average mobility rates are from the CPS and are provided on-line by the Census Bureau (<http://www.census.gov/population/www/socdemo/migrate.html>). To be consistent with our housing data, we used the rates from the 1999–2000 CPS. These are close to the average rates over the whole period that data are available. Unfortunately, mobility rates by tenure provided by the CPS are *ex post* mobility rates: the fraction of households of a given *current* tenure type that moved to a different county within the previous year. In our model, mobility rates are by *initial* tenure. The American Community Survey (ACS) for 2008–2010 provides mobility rates by initial tenure (*i.e.* tenure 1 year previously). These are available from American Factfinder (<http://factfinder2.census.gov>). Although average mobility was lower than in 2000, we assume the same ratio of the cross-county mobility rate of renters to that of owners as estimated by the ACS in 2010 (a ratio of 3–8). In fact, the mobility rates provided by the CPS are quite similar (a ratio of 3–3). Studies using longitudinal data (*e.g.* Halket and Vasudev, 2009) also find annual mobility rates of initial renters to be 3–4 times higher than those of initial owners. The fraction of movers who report that their reason for moving is not job-related is taken from the CPS (<http://www.census.gov/hhes/migration/data/cps.html>).

Unemployment rates by MSA are from the 2000 Census. Unemployment rates of owners and renters are from Bernstein (2009) and are based on the CPS between 2005 and 2008. We adjust them using the fractions of households

that are owners and renters, so that the implied weighted-average unemployment rate is 5.7%, but the difference between them is maintained.

To convert income, rents, and prices into real terms, we deflate using the non-shelter Cost of Living Index for 2000 produced by the American Chamber of Commerce Research Association. Unfortunately, it is only possible to obtain this index for 222 of the MSAs. In particular, although we were able to obtain it for the 49 large cities, some of the smaller cities are missing. For the small city group, we compute real values in two ways. First, we compute weighted averages of real values using only the cities for which we have COLIs. Second, we compute a nominal weighted average for all the cities and divide by a weighted average of the COLIs for the cities which had them. Both methods yield similar real values for all three series. Note also that whether we use the full sample of 274 cities or the smaller sample of 222 cities, makes no difference for the average housing stocks and vacancy rates.

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