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**HOUSING TENURE, GEOGRAPHICAL  
MOBILITY AND THE LABOUR  
MARKET: THE ROLE OF THE  
EMPLOYMENT EXIT RATE**

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# Housing Tenure, Geographical Mobility and the Labour Market: the Role of the Employment Exit Rate

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## Abstract

This paper studies the effect of home-owners' migration costs on unemployment in an economy where workers move both for work- and non-work-related reasons. To this end, a search model with heterogeneous locations is developed and calibrated to the US economy. Both the employment and unemployment exit rates are endogenous. Migration costs imply that home-owners quit their jobs less often than renters and find jobs at a higher rate. Consistent with the empirical evidence, the model predicts that home-owners have a lower unemployment rate than renters.

Keywords: Home-Ownership, Unemployment, Labour Mobility

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# 1 Introduction

Migration is more costly for those who are owners of their house. It is well known that selling and buying a house entails some costs that renters do not need to pay. Therefore, it is not surprising that home-owners migrate at a much lower rate than renters. The empirical evidence shows that being a home-owner has a negative effect on geographic mobility, even after controlling for the different characteristics of home-owners and renters.<sup>1</sup>

Oswald (1996) underscored the possibility that home-owners' lower levels of migration have an effect on the labour market. In particular, what is known as the Oswald hypothesis states that a higher home-ownership rate implies a higher unemployment rate. The main reason behind this idea is that home-owners' mobility costs prevent them from migrating when labour prospects in their location are poor. This implies that it takes longer for them to get jobs and, as a consequence, their unemployment rate is higher. However, the empirical studies on this issue find the opposite result.<sup>2</sup>

The mechanism behind the Oswald hypothesis is that higher migration costs hinder mobility for work-related reasons. However, one should also take into account the effect of these costs on the migration for non-work-related reasons. Non-work-related migration also affects the labour outcomes of workers even if the reason that motivates it is not related to the job market. A clear example is the case of an employed worker: Except for close moves, migration requires that an employed worker quits his job. Therefore, if home-owners' migration costs reduce the rate at which they migrate for non-work-related reasons, their transition rate to unemployment should be lower.

The aim of this paper is to study the effect of home-owners' migration costs on unemployment. Its main contribution consists in including non-work-related migration and its impact on the labour outcomes of workers. In addition, in this paper I focus on the transition rates both into and out of unemployment in order to explain the unemployment rate. I develop a job search model with two locations that differ in the wages they offer and the rate at which job offers arrive. The population consists of home-owners and renters, who only differ in their costs of migration.

The economy is subject to shocks, referred to as local shocks, that affect simultaneously the wage and the arrival rate of job offers in each location. I consider the

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<sup>1</sup>Recent estimates can be found in Caldera and Andrews (2011) and Coulson and Grieco (2013).

<sup>2</sup>The empirical literature includes Van Leuvensteijn and Koning (2004); Munch et al. (2006, 2008); Battu et al. (2008); Coulson and Fisher (2009); Zabel (2012); Laamanen (2017); Blanchflower and Oswald (2013); Taskin and Yaman (2016).

migration generated by local shocks as work-related-migration. This kind of migration can also be triggered by accepting a non-local job offer or by losing a job. Migration for non-work-related reasons is introduced through the assumption that workers have idiosyncratic preferences with respect to the locations, which are also subject to shocks. Although the reason that triggers migration can be classified as work and non-work related, migration decisions in the model depend on the interaction of the incentives provided both by the labour market and by the elements external to it.

Workers not only can accept or reject the job offers they receive but they can also quit their job. I assume that an employed worker who migrates necessarily quits his job. Thus, migration costs also affect the unemployment rate through the employment exit rate.

I solve the model numerically with the parameters calibrated to match some features of the US labour market. The model generates that home-owners have a lower unemployment rate than renters, despite being restricted by their migration costs. This result is consistent with the empirical evidence in Coulson and Fisher (2009) for the US, who find that home-owners have a lower probability of being unemployed.

I find that unemployed home-owners have a higher job finding rate than renters. On the other hand, renters have a higher employment exit rate than home-owners. So both transitions contribute to the lower unemployment rate of home-owners. With respect to the job finding rate, Taskin and Yaman (2016) have already estimated that in the US it is higher for home-owners. With respect to the employment exit rate I use data from the Current Population Survey and find that it is higher for renters. Since the mechanism in the model for this relationship is the quitting behaviour of workers, their quits rate is also calculated. Taking into account only those quits that imply a transition from employment to unemployment, I find that in the Current Population Survey the quits rate for home-owners is 61% lower than it is for renters.

The model implies that it is also possible that renters have a lower unemployment rate than home-owners. In particular, when the incentives provided by the idiosyncratic preferences to live in a location are lower and when the difference in wages across locations is higher.

Various theoretical models that relate home-owners' migration costs and unemployment have been proposed in the literature. Dohmen (2005) studies how this interaction is affected by workers skills. In Coulson and Fisher (2009) the introduction of firm behaviour implies that although home-owners have a higher unemployment rate, an increase in the proportion of home-owners does not necessarily lead to higher unem-

ployment at the aggregate level. In Rouwendal and Nijkamp (2010) home-owners and renters not only differ in their mobility costs, but also in their housing costs (for example mortgage payments). Finally, Head and Lloyd-Ellis (2012) develop a model with search frictions in both the labour and the housing markets, in which locations are heterogeneous at the level of wages. They find that the locations with higher wages have a higher home-ownership rate and a lower unemployment rate. This result, which is consistent with the empirical evidence, is also true here.

In this literature, migration costs imply that home-owners have a lower job finding rate and a higher unemployment rate than renters.<sup>3</sup> The different result found here can be explained by non-work-related migration and the assumption that choice of location affects the arrival rate of job offers for the worker. This is not the case in the previous models.<sup>4</sup> In contrast, the assumption that a worker's job prospects depend on where he is located is common in the literature on regional reallocation, for example Shimer (2007) and Lkhagvasuren (2012).

Models that study the interaction between the housing market, migration and the labour market but that do not take into account housing tenure include Rupert and Wasmer (2012), Nenov (2015) and Sterk (2015). Among these, the present paper is more closely related to Rupert and Wasmer (2012) who study the role of housing frictions on unemployment in a model that includes non-work-related migration.

The rest of the paper is organized as follows. Section 2 describes the model economy. Section 3 analyses the effect of the cost of migration on workers' employment decisions. Section 4 implements the numerical calibration and Section 5 concludes.

## 2 The Model

### 2.1 Setting

Time is continuous. The economy is populated by a measure 1 of infinitely lived workers who are risk neutral. They discount the future at a rate  $r$ . There are two locations, 1 and 2, indexed by  $c \in \{1, 2\}$ . The utility of workers depends on their income,  $x$  and

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<sup>3</sup>In Dohmen (2005) this is so conditional on the level of skills of home-owners and renters.

<sup>4</sup>This kind of migration has a different nature from relocation for non-employment reasons in Head and Lloyd-Ellis (2012). The latter receives this name because it generates random migration (in opposition to directed migration) but the moves are associated with receiving a job offer. Therefore, they do not affect the transition into unemployment. In addition, in their model this kind of moves does not involve any decision by the worker.

their preference  $b \in \{0, 1\}$  for the location they reside in. A worker with income  $x$  and preference  $b$  has utility  $u(x, b) = x + \bar{b}b$  with  $\bar{b} > 0$ . Workers are subject to preference shocks that arrive at a Poisson rate  $\lambda_B$ . When this kind of shock hits a worker with preference  $b$ , his preference turns to  $-b$ .

Workers can be either employed or unemployed. They receive job offers from each location at a rate that does not depend on their labour market status. An offer from the current location of the worker will be referred to as a *local job offer* while an offer that does not come from his location will be referred to as a *non-local job offer*. A worker receives local job offers according to a Poisson process with arrival rate  $\alpha_y > 0$  with  $y \in \{h, l\}$ . Non-local job offers arrive at Poisson rate  $\varepsilon\alpha_y$ . The parameter  $\varepsilon$  implies that workers that are not resident in a location may receive job offers from that location at a different rate than residents. Employed workers live and work in the same location and receive income  $w_y$  with  $w_l \leq w_h$ . At any time,  $y = h$  in one of the locations whereas in the other  $y = l$ . In the location with  $y = h$ , workers receive local job offers at rate  $\alpha_h$  but non-local job offers at rate  $\varepsilon\alpha_l$ . Similarly, in the location with  $y = l$ , workers receive local job offers at rate  $\alpha_l$  but non-local job offers at rate  $\varepsilon\alpha_h$ . The economy is subject to local shocks that arrive at a Poisson rate  $\lambda_Y$ . When this type of shock hits the economy, location  $h$  turns to  $l$  and vice versa. Employed workers are subject to separation shocks with Poisson rate  $s$ . A worker hit by a separation shock becomes unemployed. Unemployed workers' income is  $z$  with  $0 \leq z < w_l$ .

There are four types of shocks in the economy: local shocks, preference shocks, separation shocks and job offers. When workers receive any of these shocks they decide whether or not to quit their job (if they are employed), whether or not to accept a job offer (if they have received one), and whether or not to migrate to the other location.<sup>5</sup> If a worker with preference  $b$  migrates, his preference turns to  $-b$  and he must pay a cost  $\bar{C}$ . In Section 4, I will simulate this economy assuming that there are two type of workers: workers with migration costs, the “home-owners”, and workers with no migration costs, the “renters.” The type will be exogenously given. Since being a home-owner or a renter will only affect the problem of the worker through  $\bar{C}$ , in this section I omit housing tenure from the description of the model, which applies for any worker with migration cost  $\bar{C} \geq 0$ .

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<sup>5</sup>For simplicity, it is assumed that the worker can decide to migrate after any kind of shock except after receiving a local job offer. This assumption does not affect the results of the model.

## 2.2 Worker's Problem

The state of a location can be summarized by the variable  $y$ . I denote the value of a worker with preference  $b$  who lives in the location in state  $y$ , as  $V_e(b, y)$ , with  $e = w$  if he is employed and  $e = u$  if he is unemployed. Since employed workers receive job offers at the same rate as the unemployed, we have that  $V_w(b, y) > V_u(b, y)$ . This relationship is used to simplify the definitions of the values of the workers below.

The value of an employed worker satisfies

$$\begin{aligned}
 rV_w(b, y) = & u(w_y, b) \\
 & + \varepsilon \alpha_{-y} (\max \{V_w(-b, -y) - \bar{C}, V_w(b, y)\} - V_w(b, y)) \\
 & + s (\max \{V_u(-b, -y) - \bar{C}, V_u(b, y)\} - V_w(b, y)) \\
 & + \lambda_B (\max \{V_u(b, -y) - \bar{C}, V_w(-b, y)\} - V_w(b, y)) \\
 & + \lambda_Y (\max \{V_u(-b, y) - \bar{C}, V_w(b, -y)\} - V_w(b, y)).
 \end{aligned} \tag{1}$$

This worker has a utility flow  $u(w_y, b)$  and can receive four different type of shocks.<sup>6</sup> First, he receives a non-local offer with rate  $\varepsilon \alpha_{-y}$ . If he receives the offer, he can accept and migrate, reject and migrate, keep the current job in  $c$  or quit the job and remain in  $c$ . Since  $V_w(b, y) > V_u(b, y)$ , neither the second nor the forth case maximize the worker's value, so they are omitted. The worker will obtain the maximum between the value of accepting the non-local offer and migrating,  $V_w(-b, -y) - \bar{C}$ , and the value of keeping the current job in  $c$ ,  $V_w(b, y)$ .

The second type of shock in equation (1) is the separation shock, which comes at a rate  $s$ . In this case, the worker will choose between remaining in his location, which has value  $V_u(b, y)$ , and migrating, which has the value  $V_u(-b, -y) - \bar{C}$ .

Finally, the worker also receives a preference shock with rate  $\lambda_B$  and a local shock with rate  $\lambda_Y$ . In both cases, the option of quitting the job and remaining in his current location does not maximize his value and is omitted. However, he still has to choose between remaining employed in his current location and migrating. In the case of a preference shock his preference will become  $-b$ . Therefore, his value will be  $V_w(-b, y)$  if he remains in his location. On the other hand, if he moves, he must quit his job. Thus, he will obtain  $V_u(b, -y) - \bar{C}$ . In the case of a local shock, the state of the current location of the worker turns to  $-y$  and the value that the worker will obtain if he

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<sup>6</sup>According to the setting, he can also receive a local job offer. Since this type of shock does not affect the value of the worker, it is omitted from equation (1).

remains is  $V_w(b, -y)$ . On the contrary, if he migrates, his location will be in state  $y$ , which implies that he will obtain the value  $V_u(-b, y) - \bar{C}$  if he migrates there.

The value for a worker who is unemployed, has preference  $b$  and lives in the location in state  $y$  is  $V_u(b, y)$  and satisfies

$$\begin{aligned}
rV_u(b, y) &= u(z, b) \\
&+ \alpha_y (V_w(b, y) - V_u(b, y)) \\
&+ \varepsilon \alpha_{-y} (\max \{V_w(-b, -y) - \bar{C}, V_u(b, y)\} - V_u(b, y)) \\
&+ \lambda_B (\max \{V_u(b, -y) - \bar{C}, V_u(-b, y)\} - V_u(b, y)) \\
&+ \lambda_Y (\max \{V_u(-b, y) - \bar{C}, V_u(b, -y)\} - V_u(b, y)).
\end{aligned} \tag{2}$$

This worker has a utility flow  $u(z, b)$  and can receive four different shocks: he can receive a local job offer, a non-local job offer, a preference shock and a local shock. The values he can obtain in each case are derived analogously to the case of the employed worker.

The solution of the system given by (1) and (2) makes it possible to obtain the policy rules of the workers. The optimal migration decision of a worker is defined as

$$m_e(b, y, e') = I(V_{e'}(-b, -y) - \bar{C} > V_e(b, y)), \tag{3}$$

where  $e$  is his labour market status,  $b$  is his preference,  $y$  is the state of the location where he lives and  $e'$  will be his labour market status if he decides to migrate. The function  $I(\cdot)$  is the indicator function, which is equal to one if condition  $V_{e'}(-b, -y) - \bar{C} > V_e(b, y)$  is satisfied.

### 2.3 Workers' Transition Rates and Flows

Using the policy rules in (3) and the Bellman equations (1) and (2), it is possible to compute workers' transition rates between employment and unemployment. According to the Bellman equation for an employed worker, a worker becomes unemployed if he receives a separation shock or if, after a preference or a local shock, he migrates. Therefore, the employment exit rate (or transition rate from employment to unemployment) of a worker with preference  $b$  and in the location in state  $y$  is

$$eu(b, y) = s + \lambda_B m_w(-b, y, u) + \lambda_Y m_w(b, -y, u).$$



Similarly, from the Bellman equation for an unemployed worker, one can calculate the unemployment exit rate of a worker (or transition rate from unemployment to employment) with preference  $b$  and in the location in state  $y$  as

$$ue(b, y) = \alpha_y + \varepsilon \alpha_{-y} m_u(b, y, w).$$

### 3 Relationship Between the Migration Costs and the Employment Decisions

In this section I study the effect of the migration cost on the labour decisions of the workers. In order to make the analysis as simple as possible, I consider the case in which the two locations have the same wage and the same arrival of job offers,  $w_h = w_l$  and  $\alpha_h = \alpha_l = \alpha$ , and there are no local shocks,  $\lambda_Y = 0$ . The wage is normalized to 1. These simplifying assumptions are reasonable for an economy whose regions have a low degree of heterogeneity and allows analysis of the role of the preference for the current location,  $b$ .

Workers' labour decisions are given by the policy rules included in  $ue(b, y)$  and  $eu(b, y)$ . The unemployment exit rate,  $ue(b, y)$ , depends on  $m_u(b, y, w)$ . On the other hand, the employment exit rate,  $eu(b, y)$ , depends on  $m_w(b, y, u)$ . As the problem is the same in the location in state  $h$  and in the location in state  $l$ , I omit variable  $y$  in this section. Proposition 1 focuses on  $m_w(b, u)$ . It states that, if the worker lives in his preferred location, that is if  $b = 1$ , the value of remaining employed in his location is higher than the value of migrating and becoming unemployed, that is,  $m_w(b, u) = 0$ . However, if the worker does not live in his preferred location, this will be true only if the migration cost is greater or equal to threshold  $R_1$ .

**Proposition 1.** *There is a migration cost value*

$$R_1 = \frac{1}{r + 2\lambda_B} \left( \bar{b} - \frac{r + 2\lambda_B + \alpha\varepsilon + s}{\alpha + r + \lambda_B + s} (1 - z) \right)$$

*such that: if  $\bar{C} < R_1$  and  $b = 0$ ,  $m_w(b, u) = 1$ ; otherwise,  $m_w(b, u) = 0$ .  $R_1$  is positive when  $\bar{b} > \frac{r + 2\lambda_B + \alpha\varepsilon + s}{\alpha + r + \lambda_B + s} (1 - z)$ .*

*Proof.* See Appendix. □

This result determines the transition rate to unemployment,  $eu(b)$ . As  $\lambda_Y = 0$ , there are only two reasons for a worker to become unemployed, either he receives a separation shock or he is hit by a preference shock and quits. Proposition 1 implies a worker only quits his job if  $\bar{b}$  is sufficiently large, he receives a preference shock that turns his preferences into  $b = 0$  and his migration cost is low enough. In this case,  $eu(b = 1) = s + \lambda_B$ .

The policy rule included in  $ue(b)$ ,  $m_u(b, w)$ , determines the acceptance decision of an unemployed worker who receives a non-local offer. Proposition 2 and 3 establish that, for a worker to accept a non-local offer and migrate, it is necessary that the migration cost is below some threshold, denoted as  $R_2$  when the worker has preference  $b = 0$  and  $R_3$  when the worker has preference  $b = 1$ . Threshold  $R_2$  is positive for any combination of parameters, so when  $b = 0$  there is always a range of migration costs for which the optimal policy rule is to migrate. The results in proposition 2 and 3 are consistent with the idea that workers with high migration costs are restricted to their local labour market. However, for some range of the parameters, the migration cost must also be above another threshold in order for a worker to accept a non-local offer. In particular, when  $b = 1$  and  $\lambda_B > R_\lambda$ , the migration cost must be above the threshold denoted as  $R_4$  in order for the worker to accept a non-local offer. It must be said that this threshold is not always binding; if  $\bar{b}$  is sufficiently low, then  $R_4 < 0$ . On the other hand, if  $\bar{b}$  is sufficiently high, then  $R_4 = R_3$  (as can be seen in the Appendix). So, if the value of  $\bar{b}$  is sufficiently high, workers do not migrate for any value of the migration costs.

**Proposition 2.** *There is a migration cost value*

$$R_2 = \frac{\bar{b}}{r + 2\lambda_B} + \frac{1 - z}{\alpha + r + s}$$

*such that: if  $\bar{C} < R_2$ , then  $m_u(b = 0, w) = 1$ ; otherwise,  $m_u(b = 0, w) = 0$ .*

*Proof.* See Appendix. □

**Proposition 3.** *There are migration cost values,  $R_3$  and  $R_4$ , and a value for  $\lambda_B$ ,  $R_\lambda$  ( $R_3$ ,  $R_4$  and  $\lambda_B$  are defined in the Appendix) such that:*

- If  $\lambda_B \leq R_\lambda$  and  $\bar{C} < R_3$ , then  $m_u(b = 1, w) = 1$ ;*
- If  $\lambda_B > R_\lambda$  and  $R_4 < \bar{C} < R_3$ , then  $m_u(b = 1, w) = 1$ ;*
- Otherwise,  $m_u(b = 1, w) = 0$ .*

*Proof.* See Appendix. □

The result that a worker accepts a non-local offer for some migration cost and rejects it when this cost is lower is not intuitive. This depends on how  $V_u(1)$  and  $V_w(0)$  vary when the migration cost changes. When  $\lambda_B > R_\lambda$ ,  $\bar{b}$  is such that  $0 < R_4 < R_3$  and  $\bar{C}$  is in a neighbourhood of  $R_4$ , both  $V_u(1)$  and  $V_w(0)$  are decreasing with  $\bar{C}$ , but the effect on  $V_u(1)$  is larger, which makes  $V_w(0) - V_u(1)$  increasing with  $\bar{C}$ . Although this situation is possible in the model, it cannot arise with the values of the parameters found in the calibration section. Using them and taking the value of  $\alpha_l$  for  $\alpha$  delivers  $R_\lambda = 0.36$ . If  $\lambda_B$  had this value, it would imply an average duration between shocks of 3 months. The calibrated value for this parameter is  $\lambda_B = 0.0029$ .

We can now compare the transition rates of two workers, a renter and a home-owner, who only differ in their migration costs. Let the cost be zero for the renter and  $\bar{C}_o > 0$  for the home-owner. The results in this section imply that the renter's transition rate from employment to unemployment is greater than or equal to the home-owner's rate. Furthermore, it is strictly greater if the workers live in their preferred location ( $b = 1$ ),  $\bar{b} > \frac{r+2\lambda_B+\alpha\varepsilon+s}{\alpha+r+\lambda_B+s}(1-z)$  and  $\bar{C}_o \geq R_1$ . In this case, the home-owner's transition rate to unemployment is  $s$ , whereas an employed renter becomes unemployed at rate  $s + \lambda_B$ . On the other hand, the model implies that, for  $\lambda_B \leq R_\lambda$ , the home-owner's transition rate from unemployment to employment is lower or equal to that of the renter, with strict inequality depending on the value of  $\bar{C}_o$ .

The next question is how the transition rates of home-owners and renters compare between each other without conditioning for preferences. Notice that an employed renter can have a lower transition rate to unemployment than a home-owner if the renter lives in his preferred location and the home-owner does not. This will be the case if  $\bar{C}_o < R_1$ , which implies that the renter's transition is  $s$  and that of the home-owner is  $s + \lambda_B$ . Similarly, if an unemployed renter lives in his preferred location and an unemployed home-owner does not, the home-owner's rate to employment can be greater than that of the renter. In particular, if  $R_3 < 0$  and  $\bar{C}_o < R_2$ . The unconditional transition rates depend on the distribution of workers with different preferences. In the following section I calibrate the model and compute numerically the distribution of workers in order to obtain those transition rates.

## 4 Numerical Results

### 4.1 Calibration

In this section I study numerically the role of migration costs on unemployment and migration for the version of the model presented in Section 2. I simulate the model with the parameters calibrated to the US economy for the period 2005-2014. A time period is one month. There are two type of workers: home-owners, with migration costs  $\bar{C} = \bar{C}_o$ , and renters, with migration costs  $\bar{C} = 0$ . In this section, I make explicit the dependence of the transition rates on housing tenure, that I denote by  $ht$ . To compute the model, I simulate the Poisson local shocks for a period of 600 months. At time 0, the population distribution is set such that the proportion of home-owners is 68%. This is the average home-ownership rate of the population in the labour force living in Metropolitan Statistical Areas (MSAs) during the period 2005-2014 according to the Current Population Survey (CPS). I also assume that 50% of home-owners and renters prefer location 1 and the other half location 2. For a description of how the population distribution is calculated, see Appendix A.

I normalize  $w_h$  to 1. Following Shimer (2005), I set  $r = 0.004$ . The parameters  $w_l$ ,  $z$ ,  $\bar{C}_o$  and  $\lambda_Y$  are set to directly match an associated target in the data. The remaining ones,  $\bar{b}$ ,  $\varepsilon$ ,  $\alpha_h$ ,  $\alpha_l$ ,  $s$  and  $\lambda_B$  are jointly calibrated so that the model matches several targets related to the labour market and the migration behaviour of workers. Below I discuss the data sets and targets used.

For the migration costs, I consider that  $\bar{C}_o$  is the home-owners' transaction costs in selling and buying a house. Gruber and Martin (2003), with data of the Consumption Expenditure Survey, report that these amount to 9.5% of the value of home-owners' houses. In order to obtain the median value of a home-owner's house I use the American Housing Survey, that provides this value as a proportion of annual income, with income defined as the income a household receives when the members are employed. I use the surveys from 2005 to 2013, and obtain that the median value of an owner-occupied house is 35 times the monthly income. This implies that transaction costs are 3.3 times the monthly income. I set  $\bar{C}_o = 3.3w_h = 3.3$ .

As is standard in search models, I target the unemployment rate and the job finding rate of unemployed workers. I also include the rate at which workers quit their jobs to become unemployed. I calculate these targets with the micro data of the CPS obtained from IPUMS (Flood et al., 2015). In the model, the job finding rate is obtained as

the mean of  $ue(b, y, ht)$  weighted by the population distribution conditional on being unemployed at the beginning of month  $t$ . On the other hand, the quits rate is obtained as the mean of  $eu(b, y, ht) - s$  weighted by the population distribution conditional on being employed at the beginning of month  $t$ . The quits rate that I calculate, both in the model and in the data, only includes quits associated to an employment exit transition into unemployment. Appendix B contains details on the computation of these targets in the data.

The degree of heterogeneity across locations in the arrival rate of job offers and wages (given by  $\alpha_l/\alpha_h$  and  $w_l/w_h$ ) can be accounted for by targeting the level of heterogeneity across MSAs in job finding rates and real wages. However, the CPS sample is not designed to be used at this level of disaggregation. In addition, the model only requires computation of two rates: one for the location in state  $h$  and one for the location in state  $l$ . Thus, I classify the MSAs as being  $h$  or  $l$  using data on employment and unemployment from the Local Area Unemployment Statistics (LAUS) of the Bureau of Labour Statistics. The LAUS series are based on the CPS but also on other sources, like unemployment insurance claims counts, the Current Employment Statistics survey of establishments and the Quarterly Census of Employment and Wages. For each year, I use the LAUS data to classify the MSAs with an unemployment rate above the average as  $l$  and those with an unemployment rate below the average as  $h$ . Then, I use the CPS to calculate the job finding rate of the unemployed and the median nominal wage for the workers who live in each of these two types of locations. I also use the classification of the MSAs as  $h$  and  $l$  from the LAUS data to calculate  $\lambda_Y$ . I define this as the rate at which the MSAs change type and consider that a MSA changes type if the change lasts for more than a year. The parameter is calculated as the average across MSAs weighted by their labour force size.

One difficulty that arises when using data at the MSA level is that the definition of the MSAs changes through time and, thus, each data set may use a different definition of MSA. In Appendix B I describe the geographic dimension of the data sets used in the calibration and how I homogenize them to a single definition of MSA.

From the LAUS data, I obtain that  $\lambda_Y = 0.0078$ . From the CPS sample I obtain that the average job finding rate of the unemployed during the period was  $ue = 32\%$ , the ratio between the job finding rate in the  $l$  and the  $h$  MSAs was 0.83, the unemployment rate was  $urate = 7.1\%$  and the quits rate was  $q = 0.22\%$ .

Real wages are calculated as nominal weekly earnings from the CPS deflated by the Regional Price Parities from the Bureau of Economic Analysis. These price indexes are

available from 2008. I obtain that  $w_l = 0.94$ . With respect to unemployment income, it is equal to 70% of  $w_h$ , which is between the values proposed by Shimer (2005) and Hagedorn and Manovskii (2008). Therefore,  $z = 0.7$ .

I include two targets related with the migration behaviour of workers: the migration rate and the reallocation rate. Following Nenov (2015), I define the migration rate in period  $t$  as

$$mig_t = \sum_i outrate_{i,t} \frac{pop_{i,t}}{pop_t},$$

and the reallocation rate as

$$real_t = \frac{1}{2} \sum_i |inrate_{i,t} - outrate_{i,t}| \frac{pop_{i,t}}{pop_t},$$

where  $inrate_{i,t}$  is the in-migration rate in the MSA  $i$  in period  $t$  with origin in another location of the US,  $outrate_{i,t}$  is the out-migration rate in the MSA  $i$  in period  $t$  with destination to another location in the US,  $pop_{i,t}$  is the population in MSA  $i$  in period  $t$ , and  $pop_t$  is total population for the MSAs in the sample in period  $t$ . Although the CPS provides information on inter-county migration, it is not possible to calculate flows among MSAs because the data do not identify the county of origin. It would be possible to compute inter-state flows but that would miss some flows across MSA that are intra-state. Therefore, in order to obtain the level of migration and reallocation, I use data on annual inter-county flows from the Internal Revenue Service to obtain migration flows across MSAs. I find that the annual migration rate during the period was  $mig = 3.3\%$  and the reallocation rate was  $real = 0.29\%$ . Appendix A contains how these rates are computed in the model.

Table 1 reproduces the targets used for the calibration of  $\bar{b}$ ,  $\varepsilon$ ,  $\alpha_h$ ,  $\alpha_l$ ,  $s$  and  $\lambda_B$  and their values from the model. The model matches the targets very well. The parameter values are in Table 2.

## 4.2 Benchmark Results

The unemployment and transition rates generated by the model for renters and home-owners are reported in Table 3. I find that the home-owners' unemployment rate is 5.4% (0.4 percentage points) lower than that for renters. The model also provides the workers' transition rates. Home-owners have a higher unemployment exit rate and a lower

Table 1: Calibration targets

	Data	Model
<i>urate</i>	7.1%	7.1%
<i>ue</i>	32%	32%
<i>ue l to h</i>	83%	83%
<i>mig</i>	3.3%	3.4%
<i>real</i>	0.29%	0.29%
<i>q</i>	0.22%	0.20%

*Notes:* Calculations are based on MSA level data in the period 2005-2014. The model is simulated 3000 times for 650 time periods keeping the last 600 time periods. *urate* is the unemployment rate, *ue* is the unemployment exit rate, *ue l to h* is the ratio between the unemployment exit rate in the *l* and the *h* MSAs, *mig* is the annual inter-MSA migration rate, *real* is the reallocation rate and *q* is the quits rate.

Table 2: Parameters

Pre-set Parameters		
Parameter	Description	Value
$r$	discount factor	0.004
$w_h$	wage in the location in state $h$	1
$w_l$	wage in the location in state $l$	0.94
$z$	unemployment income	0.7
$\bar{C}_o$	migration cost home-owners	3.3
$\lambda_Y$	arrival rate of local shocks	0.0078
Jointly-calibrated Parameters		
Parameter	Description	Value
$b$	preference parameter	0.11
$\varepsilon$	non-local offer parameter	0.069
$\alpha_h$	local arrival rate of job offers from $h$	0.35
$\alpha_l$	local arrival rate of job offers from $l$	0.29
$s$	arrival rate of separation shocks	0.023
$\lambda_B$	arrival rate of preference shocks	0.0029

employment exit rate than renters. Therefore, both transitions contribute to home-owners having a lower unemployment rate. The difference in relative terms is higher for the employment exit rate, 5.2%, compared to only 0.5% in the case of the unemployment exit rate. To further understand the contribution of these two transitions, consider what the unemployment rate for each group of workers would be if their transition rates in all periods are the values in Table 3 and the labour market is in steady state. Renters'

Table 3: Unemployment and transition rates (model)

	Renters	Home-owners	Difference
<i>wrate</i>	7.37%	6.97%	-0.40***
<i>ue</i>	31.92%	32.09%	0.17***
<i>eu</i>	2.54%	2.41%	-0.13***
<i>q</i>	0.29%	0.16%	-0.13***

*Notes:* The model is simulated 100 times for 650 time periods keeping the last 600 time periods. *wrate* is the unemployment rate, *ue* is the unemployment exit rate, *eu* is the employment exit rate and *q* is the quits rate. Test of significance performed on coefficient  $\beta$  in the regression  $x_{it} = \beta + e_{it}$  with  $x_{it}$  being the difference between the home-owners' and the renters' rate in simulation  $i$  and period  $t$ . Coefficients with \*\*\* are significant at 1% level.

unemployment rate would be  $\frac{2.54\%}{2.54\%+31.92\%} = 7.37\%$  and home-owners' unemployment rate would be  $\frac{2.41\%}{2.41\%+32.09\%} = 6.98\%$ . These are almost the same values as those generated in the simulations. If home-owners had the same employment exit rate as renters, their unemployment rate would be  $\frac{2.54\%}{2.54\%+32.09\%} = 7.33\%$ , whereas if they had the same unemployment exit rate, it would be  $\frac{2.41\%}{2.41\%+31.92\%} = 7.01\%$ . Therefore, the difference in the employment exit rates implies that the home-owners' unemployment rate is 4.9% lower than the renters', while for the case of the unemployment exit rate this is only 0.5%.

I find that employed renters who live in their preferred location (i.e. with  $b = 1$ ) quit their job and migrate whenever they receive a preference shock but not when they receive a local shock. Therefore, the transition rate from employment to unemployment for this group of workers is simply  $s + \lambda_B$ .<sup>7</sup> Furthermore, this behaviour implies that all employed renters live in their preferred location. Thus,  $s + \lambda_B$  is the renters' employment exit rate. Employed home-owners who live in their preferred location follow the same policy as renters only when the location is in state  $l$ . However, if the location is in state  $h$ , neither a local shock nor a preference shock make them migrate. This implies that the home-owners who live in the location in state  $h$  do not quit as long as this is their preferred location. In addition, their policy implies that in the location in state  $h$ , there are some employed home-owners who do not live in their preferred location. Those workers quit their job and migrate when there is a local shock but they only account for 5% of employed home-owners in  $h$ .<sup>8</sup> Therefore, most home-owners who live in  $h$  do

<sup>7</sup>The transition rates conditional on preferences, the state of the location and housing tenure are in the Appendix.

<sup>8</sup>Table 7 in Appendix C contains the distribution of workers.



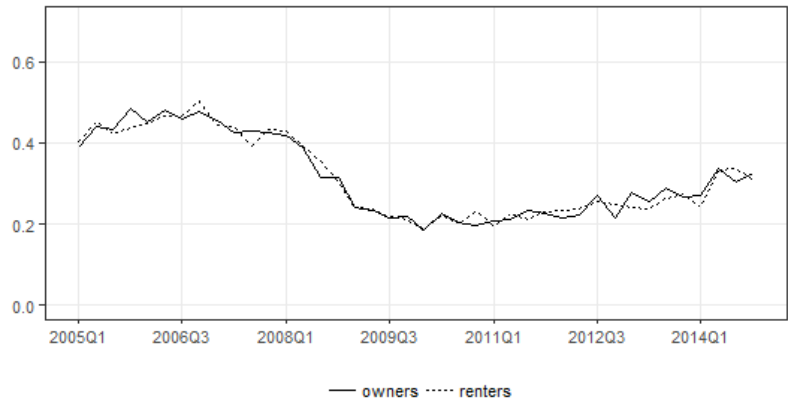
not quit their job after a shock, which implies that the home-owners' employment exit rate is lower than that for renters.

With respect to the unemployment exit rate, the model implies that both groups of workers follow the same policy: they accept a non-local offer only when living in the non-preferred location. However, all unemployed workers live in their preferred location, which implies that unemployed workers do not accept non-local offers. Despite having the same policy, home-owners have a higher unemployment exit rate than renters. This is because the proportion of unemployed home-owners in the location in state  $h$  is higher than the proportion of renters (from Table 7 in Appendix C we can obtain that 49% of the home-owners who are unemployed live in the location in state  $h$ , while this is 46% for the case of renters). In turn, the proportion of unemployed across locations matters because the arrival rate of job offers is higher in the location in state  $h$ .

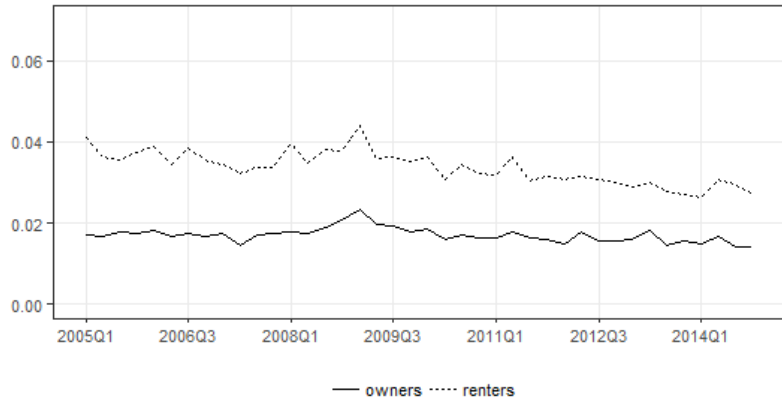
The difference in unemployment rates between home-owners and renters in the CPS is much larger than in the model, the home-owners' unemployment rate is 4.64 percentage points lower than the renters', that is, 45.5% lower. A likely reason for this is the endogeneity of housing tenure in the data: workers with bad labour market outcomes do not buy a house. Indeed, controlling for demographic variables in a probit regression I find that, on average, being home-owner decreases the probability of unemployment by 1.7 percentage points in 2014, the last year of the sample. I also calculate the effect in the first year of the sample, 2005, and the result is very similar, 1.9. These values are much lower than 4.64 but they are still sizeable and significant. The regression includes as controls the age, educational level, race and occupation of workers. Appendix C contains the results with the CPS data.

Further evidence is provided by Coulson and Fisher (2009), who estimate the effect of being home-owner on the probability of unemployment using an instrumental variable method. The data they use is the 1990 Census Supplement of the CPS with the sample restricted to married males. They find that being a home-owner decreases the probability of being unemployed by 3.6 percentage points.

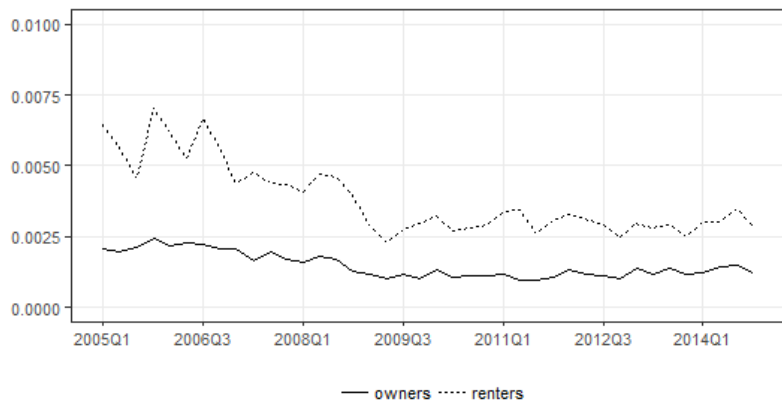
Regarding the unemployment exit rate in the CPS, the difference between home-owners and renters is not significant. Graphically, this can be seen in Figure 1, where the time series for these two groups of workers have been depicted for the period from 2005 to 2014. The unemployment exit rate of renters and home-owners cross many times during the period. In this respect, it is interesting to mention the empirical evidence provided by Taskin and Yaman (2016). In their analysis they use data from several panels (1996 to 2008) of the Survey of Income and Program Participation. They



(a) Unemployment exit rate



(b) Employment exit rate



(c) Quits rate

Figure 1: Transition rates

estimate the effect of being a home-owner on the job finding rate of unemployed males, controlling and without controlling for ownership selection. When that is not controlled for, the effect is not significant but when they do control for ownership selection the effect is significant and amounts<sup>9</sup> to 13%.

I am not aware of any empirical study that estimates the effect of home-ownership on the employment exit rate with US data. However, Munch et al. (2008) estimate for Denmark that being a home-owner decreases the likelihood of leaving employment for unemployment by 29%. Similarly, De Graaff and Van Leuvensteijn (2013) estimate it for 14 European countries and find that it decreases by 21%. In the model, the channel that makes the employment exit rate of home-owners lower is their quits policy. Consistent with this idea, their quitting rate according to the CPS is 61% lower.

Summarizing, the model predicts that home-owners have a lower unemployment rate than renters and that both the employment exit rate and the unemployment exit rate contribute to this pattern. The empirical evidence is consistent with these facts. This is an improvement with respect to the previous literature (Coulson and Fisher, 2009; Head and Lloyd-Ellis, 2012), where migration costs do not generate a lower unemployment rate. In addition, the model implies that the difference, in relative terms, in the employment exit rates is larger than the difference in the unemployment exit rates. The empirical evidence also seems to be in line with that. Finally, future work will be needed to quantitatively match the difference in unemployment between home-owners and renters.

### 4.3 The Role of Migration for Non-Work-Related Reasons

The model includes migration for non-work-related reasons through the parameters  $\bar{b}$  and  $\lambda_B$ . In order to further understand the role of this type of migration for the labour market, Table 4 contains the transition, unemployment and migration rates for different values of these parameters.

With respect to  $\lambda_B$ , both an increase of 30% and a decrease of 30% generate the same qualitative result as in the benchmark case; renters have a higher unemployment rate, a higher transition rate from employment to unemployment and a lower transition rate from unemployment to employment than home-owners. The employment exit rate increases with  $\lambda_B$ , as both home-owners and renters quit their job more often. In contrast, the unemployment exit rate only increases for home-owners, as the proportion

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<sup>9</sup>In Table 9 they report a coefficient of 0.12. Thus, the effect is given by  $\exp(0.12) - 1 \simeq 0.13$

Table 4: Labour market outcomes for different values of  $\lambda_B$  and  $\bar{b}$

	Benchmark	$\lambda_B$		$\bar{b}$	
		30% higher	30% lower	30% higher	30% lower
renters					
- <i>urate</i>	7.37%	7.60%	7.13%	7.37%	6.74%
- <i>ue</i>	31.92%	31.92%	31.92%	31.92%	33.40%
- <i>eu</i>	2.54%	2.63%	2.45%	2.54%	2.41%
home-owners					
- <i>urate</i>	6.97%	7.08%	6.86%	7.37%	6.91%
- <i>ue</i>	32.09%	32.14%	32.05%	31.92%	33.11%
- <i>eu</i>	2.41	2.45%	2.36%	2.54%	2.46%

of those workers in location  $h$  increases. The unemployment rate of both home-owners and renters increase with  $\lambda_B$ .

Parameter  $\bar{b}$  affects the migration and unemployment rates only through changes in the policy rules of workers. If  $\bar{b}$  is 30% higher, renters have the same policy rules as in the benchmark case, so their transition and unemployment rates do not change. However, the policy rules of home-owners change and become the same policy rules that renters have. Therefore, in this case both groups of workers have the same transition and unemployment rates. If parameter  $\bar{b}$  is 30% lower, the two groups of workers have different policy rules. With respect to renters, these policy rules imply that they do not quit their job after receiving a preference shock in  $h$  and that they accept non-local offers when they live in  $l$ . As a consequence, they have a lower transition rate from employment to unemployment and a higher transition rate from unemployment to employment compared with the benchmark case. And, thus, a lower unemployment rate. On the other hand, the change in home-owners' behaviour consists in them not migrating any more when they end up being unemployed in  $h$ ,  $h$  being their less preferred location. This implies that the proportion of home-owners living in  $h$  is higher, which increases their unemployment exit rate and their employment exit rate. The positive effect on the employment exit rate is due to two facts: first, the home-owners in  $h$  with  $b = 0$  are the ones who quit when they receive a local shock whereas the workers in  $l$  are the ones who quit when they receive a preference shock; second, the arrival rate of local shocks is larger than the arrival rate of preference shocks. The positive effect on the unemployment exit rate is due to  $h$  having a higher job offer rate. In addition, the unemployment exit rate also rises because the unemployed home-owners in  $h$  with  $b = 0$  accept non-local job offers from  $l$ . The home-owners' unemployment

Table 5: Labour market outcomes for different degrees of inequality across locations

	Benchmark	$\frac{\alpha_h - \alpha_l}{\alpha_l}$		$\frac{w_h - w_l}{w_l}$	
		30% higher	30% lower	30% higher	30% lower
renters					
- <i>urate</i>	7.37%	7.40%	7.34%	6.74%	7.37%
- <i>ue</i>	31.92%	31.77%	32.04%	33.40%	31.92%
- <i>eu</i>	2.54%	2.54%	2.54%	2.41%	2.54%
home-owners					
- <i>urate</i>	6.97%	6.99%	6.96%	6.97%	6.97%
- <i>ue</i>	32.09%	31.99%	32.17%	32.09%	32.09%
- <i>eu</i>	2.41%	2.41%	2.41%	2.41%	2.41%

rate decreases. However, not as much as the renters' rate. Therefore, if  $\bar{b}$  is 30% lower, renters have a lower unemployment rate than home-owners. It is interesting to note that the decrease in  $\bar{b}$  reduces the incentives to migrate from  $h$  to  $l$  (renters do not quit their job any more in order to migrate to  $l$ , home-owners who are unemployed in  $h$  do not migrate any more) and increases the incentives to migrate from  $l$  to  $h$  (renters accept non-local offers from  $h$ ).<sup>10</sup> Thus, the reduction in  $\bar{b}$  increases the incentives to live in  $h$ . In the next subsection I modify the incentives for living in  $h$  through the differences in the wage and the job offer rate across locations.

#### 4.4 The Role of Heterogeneity across Local Labour Markets

Table 5 contains the results for different values of  $\alpha_h$ ,  $\alpha_l$ ,  $w_h$ ,  $w_l$ .

I consider an increase and a decrease of  $\frac{\alpha_h - \alpha_l}{\alpha_l}$  by 30% with  $\alpha_h$  and  $\alpha_l$  such that their average does not change. I find that both for a higher and a lower level of inequality in job offer rates, renters have a higher transition rate from employment to unemployment, a lower transition rate from unemployment to employment and a higher unemployment rate than home-owners, as in the benchmark case. In fact, these changes in the job offer rates do not affect the policy rules of workers. A lower  $\frac{\alpha_h - \alpha_l}{\alpha_l}$  has a positive effect on the unemployment exit rate in both groups of workers. This is because there are more unemployed workers in the  $l$  location than in the  $h$  location, which implies that the increase in  $\alpha_l$  has a higher impact than the decrease in  $\alpha_h$ .

With respect to wages, I look at changes in  $\frac{w_h - w_l}{w_l}$ , but also keeping the average of

<sup>10</sup>The fact that now unemployed home-owners accept non-local offers from  $l$  when  $b = 0$  is not because they have higher incentives to migrate to  $l$ . In the benchmark case, they followed the same rule but then there were no unemployed home-owners in  $h$  with  $b = 0$ .

the two wages constant. As was the case for parameter  $\bar{b}$ , wages affect the migration and unemployment rates only through changes in the policy rules. A 30% decrease in  $\frac{w_h - w_l}{w_l}$  has no effect in these rules. On the other hand, an increase of 30% changes the policy rules of renters but not of home-owners. The effect on renters is that now they do not quit their job after receiving a preference shock in  $h$  and that they accept non-local offers when they live in  $l$ . The result is that renters have a lower unemployment rate than home-owners.

The numerical exercises realized in this and the previous subsection imply that the result that renters have a higher unemployment rate than home-owners depends on the level of inequality between the local wages and the utility obtained from idiosyncratic preferences. Idiosyncratic preferences provide incentives to live in the location with less job opportunities for part of the population. Therefore, if the utility obtained from this source is lower, the incentives to live in  $h$  are higher. Consistent with that, I find that a decrease in  $\bar{b}$  of 30% produces the same effect on renters as an increase in  $\frac{w_h - w_l}{w_l}$  of 30%. In these cases, renters' unemployment rate is lower than home-owners'.

## 5 Conclusions

This paper develops a model of job search and migration that makes it possible to study the role of mobility costs in unemployment. Migration has direct effects on the labour situation of workers by triggering quits, allowing the acceptance of new jobs or implying a change in labour income. But it also affects the labour market by relocating the population across space.

The calibrated version of the model generates the result that home-owners, while incurring higher migration costs than renters, experience less unemployment. This result can be explained by their higher transition rate from unemployment to employment and their lower transition rate from employment to unemployment. The empirical literature has focused mainly on the first of these two channels. However, the evidence presented in this paper suggests that the transition rate from employment to unemployment should be further investigated. The analysis of the model also highlights the importance of workers' distribution across space. The kind of moves that migration costs prevent tend to be moves from the location with good job prospects to the location with poor job prospects.

The results indicate that a model with non-work-related migration and heterogen-

eous locations delivers a pattern in the unemployment rates of home-owners relative to renters that is qualitatively consistent with the data. Therefore, the model is suitable to be extended to the study of the home-ownership rate at the aggregate level. This would imply the inclusion of the firm side into the labour market and, possibly, externalities in the housing market, as indicated in Blanchflower and Oswald (2013).

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# Appendix

## A Model details

Let  $n_t(b, c, e, ht)$  be the measure at time  $t$  of a worker with preference  $b$  who lives in location  $c$ , with labour market status  $e$  and housing tenure  $ht$ . Equations (4) and (5) state the flows from and into  $n_t(b, c, w, ht)$  and  $n_t(b, c, u, ht)$  when there is no local shock with the state in location  $c$  at time  $t$  denoted by  $y$ .

$$\begin{aligned} \dot{n}_t(b, c, w, ht) = & \alpha_y n_t(b, c, u, ht) \\ & + \varepsilon \alpha_y m_u(-b, -y, w, ht) n_t(-b, -c, u, ht) \\ & + \varepsilon \alpha_y m_w(-b, -y, w, ht) n_t(-b, -c, w, ht) + \lambda_B (1 - m_w(b, y, u, ht)) n_t(-b, c, w, ht) \\ & - (s + \lambda_B + \varepsilon \alpha_{-y} m_w(b, y, w, ht)) n_t(b, c, w, ht) \end{aligned} \quad (4)$$

$$\begin{aligned} \dot{n}_t(b, c, u) = & \lambda_B m_w(-b, -y, u) n_t(b, -c, w) \\ & + s(1 - m_u(b, y, u)) n_t(b, c, w) + s m_u(-b, -y, u) n_t(-b, -c, w) \\ & + \lambda_B m_u(-b, -y, u) n_t(b, -c, u) + \lambda_B (1 - m_u(b, y, u)) n_t(-b, c, u) \\ & - (\alpha_y + \varepsilon \alpha_{-y} m_u(b, y, w) + \lambda_B) n_t(b, c, u) \end{aligned} \quad (5)$$

The first four terms in equation (4) contain the inflow of workers to  $n_t(b, c, w, ht)$ . This flow comes both from workers that are employed and unemployed. The unemployed workers that become employed at  $c$  with preference  $b$  are those who already live in  $c$  and have preference  $b$  and find a local job,  $\alpha_y n_t(b, c, u, ht)$ , and those that live in  $-c$  have preference  $-b$  for their location and find a non-local job (the second term). For the case of the employed, the flow is composed of those workers who work in  $-c$ , have preference  $-b$  for their location and migrate to work in  $c$  (third term) and those that already work in  $c$ , have preference  $-b$  and their preference changes into  $b$ .

The last term in (4) contains the outflow from  $n_t(b, c, w, ht)$ . The outflow rate is composed of the workers who receive a non-local offer and accept, and of the workers that receive a separation shock or a preference shock.

The evolution of  $n_t(b, c, u, ht)$ , given in equation (5), is calculated in a similar way as for the employed.

Suppose that at time  $t_0$  the economy is hit by a local shock and that the measure of workers according to (4) and (5) at  $t_0$  is  $\tilde{n}_{t_0}(b, c, e, ht)$ . Let the state in location  $c$  after the local shock be  $y$ . Then,

$$\begin{aligned}
n_{t_0}(b, c, w, ht) &= (1 - m_w(b, y, u, ht)) \tilde{n}_{t_0}(b, c, w, ht) \\
n_{t_0}(b, c, u, ht) &= (1 - m_u(b, y, u, ht)) \tilde{n}_{t_0}(b, c, u, ht) \\
&\quad + m_w(-b, -y, u, h) \tilde{n}_{t_0}(-b, -c, w, h) + m_u(-b, -y, u, h) \tilde{n}_{t_0}(-b, -c, w, h).
\end{aligned} \tag{6}$$

From  $t_0$  and until the arrival of the following local shock the measure of workers is given again by (4) and (5). For each simulation, I save the population distribution generated at the beginning of each month. That is, I obtain  $n_t(b, c, e, ht)$  for  $t = 1, 2, 3, \dots, 600$ .

Next I describe how the migration rates are calculated. Let the state in location  $c$  in month  $t$  be  $y$ . If there is no local shock, the migration flow out of location  $c$  in month  $t$  is given by

$$\begin{aligned}
&\sum_b \sum_{ht} (sm_u(b, y, u, ht) + \lambda_B m_w(-b, y, u, ht) + \varepsilon \alpha_{-y} m_w(b, y, w, ht)) n_t(b, c, w, ht) \\
&+ \sum_b \sum_{ht} (\varepsilon \alpha_{-y} m_u(b, y, w, ht) + \lambda_B m_u(-b, y, u, ht)) n_t(b, c, u, ht).
\end{aligned}$$

Therefore, in order to compute the migration flows I assume that the population distribution is constant during the month. In the months where a local shock takes place, the flow additionally includes

$$\sum_b \sum_{ht} \sum_e m_e(b, -y, u, ht) n_t(b, c, e, ht).$$

The annual migration rate is calculated as the sum of the monthly migration flows from both cities. In the computation of the migration rate in the model, all flows are taken into account. However, in the data, the migration flow of a person who has already migrated that year is not taken into account. Given that the migration rate is so low, this difference is unlikely to be important. Reallocation in year  $\tau$  is given by

$$\sum_b \sum_{ht} \sum_e |n_{12\tau}(b, c, e, ht) - n_{12(\tau-1)+1}(b, c, e, ht)|.$$

### Proof to Proposition 1:

The system given by (1) and (2) does not satisfy  $V_u(0, y) - \bar{C} > V_w(1, y)$ . Therefore,

$m_w(1, u) = 0$ . On the other hand,  $m_w(0, u) = 1$  if and only if  $V_u(1, y) - \bar{C} > V_w(0, y)$ . The condition for this inequality to be satisfied is  $\bar{C} < R_1$  with:

$$R_1 = \frac{1}{r + 2\lambda_B} \left( \bar{b} - \frac{r + 2\lambda_B + \alpha\varepsilon + s}{\alpha + r + \lambda_B + s} (1 - z) \right)$$

**Proof to Proposition 2:**

The policy rule satisfies  $m_w(0, u) = 1$  if and only if  $V_w(1, -y) - \bar{C} > V_u(0, y)$ . The condition for this inequality to be satisfied is  $\bar{C} < R_2$  with:

$$R_2 = \frac{\bar{b}}{r + 2\lambda_B} + \frac{1 - z}{\alpha + r + s}$$

**Proof to Proposition 3:**

The policy rule satisfies  $m_w(1, u) = 1$  if and only if  $V_w(0, -y) - \bar{C} > V_u(1, y)$ . When  $\lambda_B < R_\lambda$ , the inequality is satisfied when  $\bar{C} < R_3$  with:

$$R_\lambda = \frac{1}{4} \left( 2\alpha + r + 2s + \sqrt{4\alpha^2(1 + 4\varepsilon) + 9r^2 + 28rs + 20s^2 + 4\alpha(3r + 4\varepsilon r + 6s + 4\varepsilon s)} \right)$$

$$R_3 = \begin{cases} \frac{-\bar{b}(\alpha + \lambda_B + r + s) + (2\lambda_B + \varepsilon\alpha + r + s)(1 - z)}{-2\lambda_B^2 + 2\alpha^2\varepsilon + r^2 + 3rs + 2s^2 + \lambda_B(r + 2s) + \alpha(2\lambda_B + r + 2\varepsilon r + 2(1 + \varepsilon)s)} & \text{if } B_2 < \bar{b} \\ \frac{1}{(r + 2\lambda_B + 2\alpha\varepsilon)} \left( -\bar{b} + \frac{\alpha^2\varepsilon(1 + \varepsilon) + (2\lambda_B + r)(2\lambda_B + r + s) + \alpha(\lambda_B(2 + 4\varepsilon) + r + 2\varepsilon r + 2\varepsilon s)}{\alpha^2(1 + \varepsilon) + \alpha(2 + \varepsilon)(\lambda_B + r + s) + (r + s)(2\lambda_B + r + s)} (1 - z) \right) & \text{if } B_1 < \bar{b} \leq B_2 \\ \frac{1}{\alpha + r + s} \left( (1 - z) - \frac{(\alpha + r + 2\lambda_B + s)(r + s + \alpha + \varepsilon\alpha)}{(2\lambda_B + r)(2\lambda_B + r + s) + \alpha(2\lambda_B(1 + \varepsilon) + r + \varepsilon r + 2\varepsilon s)} \bar{b} \right) & \text{if } 0 < \bar{b} \leq B_1 \end{cases}$$

$$B_1 = \frac{(2\lambda_B + r)(2\lambda_B + r + s) + \alpha(2\lambda_B(1 + \varepsilon) + r + \varepsilon r + 2\varepsilon s)}{2(\alpha^2(1 + \varepsilon) + \alpha(2 + \varepsilon)(\lambda_B + r + s) + (r + s)(2\lambda_B + r + s))} (1 - z)$$

and

$$B_2 = \frac{2\alpha^2\varepsilon^2 + (2\lambda_B + r)(2\lambda_B + r + s) + \alpha(\lambda_B(2 + 4\varepsilon) + r + 2\varepsilon r + 2\varepsilon s)}{2(\alpha^2(1 + \varepsilon) + \alpha(2 + \varepsilon)(\lambda_B + r + s) + (r + s)(2\lambda_B + r + s))} (1 - z)$$

When  $\lambda_B > R_\lambda$ , the inequality is satisfied when  $R_4 < \bar{C} < R_3$  with  $R_3$  given above and  $R_4$  given by:

$$R_4 = \frac{-\bar{b}(\alpha + \lambda_B + r + s) + (2\lambda_B + \varepsilon\alpha + r + s)(1 - z)}{-2\lambda_B^2 + 2\alpha^2\varepsilon + r^2 + 3rs + 2s^2 + \lambda_B(r + 2s) + \alpha(2\lambda_B + r + 2\varepsilon r + 2(1 + \varepsilon)s)}$$

## B Data Appendix

This part of the Appendix describes how targets are obtained from the data and the geographic dimension of the data sets.

### Computation of targets

For the computation of the job finding rate of unemployed workers and the quits rate there are two aspects that must be taken into account. First, in the model workers can have only two labour market statuses, which means that the unemployment exit rate is equal to the job finding rate of the unemployed. But in the data there are workers who enter or leave the labour force. Second, the model is in continuous time, the unemployment exit rate derived in subsection 2.3 is an instantaneous rate whereas the data is monthly. Following Shimer (2012) I compute the probability, in the data, that an unemployed worker finds a job in month  $t$  as

$$UE_t = 1 - \frac{u_{t+1} - u_{t+1}^s}{u_t},$$

where  $u_t$  is the number of unemployed in month  $t$  and  $u_t^s$  is the number of short term unemployed (workers who have been unemployed between 0 and 4 weeks) in month  $t$ . Therefore, the probability is calculated as one minus the proportion of the unemployed who do not leave unemployment. The instantaneous rate is  $ue_t = -\log(1 - UE_t)$ .

Shimer (2012) also proposes a measure of the employment exit rate. I adapt his approach to compute the quits rate. As mentioned in Section 4, the quits rate that I calculate only includes quits associated to an employment exit transition into unemployment. First, let the probability of finding a job for a worker who has previously quit his job be

$$UE_{q,t} = 1 - \frac{u_{q,t+1} - u_{q,t+1}^s}{u_{q,t}},$$

where  $u_{q,t}$  is the number of unemployed in month  $t$ , who have quit their job and  $u_{q,t}^s$  is the number of short term unemployed who have quit their job. The instantaneous rate is  $ue_{q,t} = -\log(1 - UE_{q,t})$  and the instantaneous rate of quitting the job,  $q_t$ , is obtained from the following equation:

$$u_{q,t+1} = \frac{(1 - \exp(-ue_{q,t} - q_t)) q_t}{ue_{q,t} + q_t} (e_t + u_{q,t}) + \exp(-ue_{q,t} - q_t) u_{q,t},$$

where  $e_t$  is the number of employed in month  $t$ .

### **The geographic dimension in the data sets**

The CPS uses the definitions of MSAs established by the Office of Management and Budget. Not all MSA are identified in the survey and the definitions are not constant through time. The CPS uses the 1993 definitions for the period 1995-2004, the 2003 definitions for 2005-2014 and the 2013 definition from 2015 on. In order to have homogeneous definitions I restrict the period of the calibration to 2005-2014. Therefore, the data I use is based on the 2003 definitions. The definitions for MSAs from the Office of Management and Budget are county based. However, for the New England states, it additionally provides an alternative set of definitions: the New England City and Town Areas (NECTAs), based on cities and towns instead of counties. In the period 2005-2014, the CPS uses the NECTA definitions to identify the MSAs of New England. With respect to the LAUS data, it is available at the MSA level and at the county level. The MSA level data are based on the 2015 definitions. Therefore, I use the county level series and aggregate them at the MSA level using the 2003 definitions. I obtained the MSA definitions from the US Census Bureau. As the CPS does not use the county based definitions for New England, I cannot apply the MSA classification of  $h$  and  $l$  in the CPS observations of this region.

The 2003 definition identifies 362 MSAs. According to LAUS data, the labour force in the largest MSA, “*New York-Northern New Jersey-Long Island, NY-NJ-PA*,” was 9,646,957 in 2014. The smallest MSA in 2014, “*Carson City, NV*,” had a labour force of 25,116, whereas the average labour force size was 367,107. The CPS sample I use consists of members of the labour force living in an identified MSA excluding New England. Thus, it has 248 MSAs, which contain 90% of the labour force in MSAs.

The data obtained from the Bureau of Economic Analysis are at the MSA level and based on the 2013 MSAs definitions. Since I use these data to deflate the nominal wages obtained from the CPS data, it implies that the boundaries of the MSAs in the nominal wages are not exactly the same as in the deflators. In addition, there are four

MSAs identified in the CPS that do not exist in the 2013 definition because they were merged with other cities. In those cases, I apply the deflator of the merged MSA.<sup>11</sup>

The data from Internal Revenue Service is at the county level and I aggregate it at the MSA level using the 2003 MSAs definitions.

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<sup>11</sup>These MSAs are “*Anderson, IN*” (merged with “*Indianapolis, IN*”), “*Anderson, SC*” (merged with “*Greenville, SC*”), “*Holland-Grand Haven, MI*” (merged with “*Grand Rapids-Wyoming, MI*”) and “*Poughkeepsie-Newburgh-Middletown, NY*” (merged with “*New York-Northern New Jersey-Long Island, NY-NJ-PA*”).

## C Additional Tables

Table 6: Transition rates

(a)  $eu(b, y, ht)$

	$ht = r$		$ht = o$	
	$y = h$	$y = l$	$y = h$	$y = l$
$b = 1$	$s + \lambda_B$	$s + \lambda_B$	$s$	$s + \lambda_B$
$b = 0$	$s + \lambda_Y$	$s + \lambda_Y$	$s + \lambda_Y$	$s$

(b)  $ue(b, y, ht)$

	$ht = r$		$ht = o$	
	$y = h$	$y = l$	$y = h$	$y = l$
$b = 1$	$\alpha_y$	$\alpha_y$	$\alpha_y$	$\alpha_y$
$b = 0$	$\alpha_y + \varepsilon\alpha_{-y}$	$\alpha_y + \varepsilon\alpha_{-y}$	$\alpha_y + \varepsilon\alpha_{-y}$	$\alpha_y + \varepsilon\alpha_{-y}$

Table 7: Distribution of home-owners and renters in the model

	Home-owners		Renters	
	$h$	$l$	$h$	$l$
Employed	49.2	43.9	46.6	46.0
- in preferred location	46.6	43.9	46.6	46.0
- not in preferred location	2.6	0.0	0.0	0.0
Unemployed	3.4	3.6	3.4	4.0
- in preferred location	3.4	3.6	3.4	4.0
- not in preferred location	0.0	0.0	0.0	0.0

Notes: Percentages over total renters and total home-owners, respectively.



Table 8: Unemployment and transition rates (CPS)

	Renters	Home-owners	Difference
<i>urate</i>	10.19%	5.55%	-4.64***
<i>ue</i>	31.51%	31.59%	0.07
<i>eu</i>	3.36%	1.70%	-1.66***
<i>q</i>	0.38%	0.15%	-0.23***

*Notes:* Calculations based on the CPS sample used in the calibration. *urate* is the unemployment rate, *ue* is the unemployment exit rate, *eu* is the employment exit rate and *q* is the quits rate. Test of significance performed on coefficient  $\beta$  in the regression  $x_t = \beta + e_t$  with  $x_t$  being the difference between the home-owners' and the renters' rate. Coefficients with \*\*\* are significant at 1%, with \*\* at 5% and with \* at 10% level using Newey West.

Table 9: Results probit regression

	Unemployment			
	2005	2014	2005	2014
Home-owner	-0.366*** (0.006)	-0.307*** (0.006)	-0.190*** (0.006)	-0.148*** (0.006)
Age			-0.010*** (0.0002)	-0.008*** (0.0002)
College			-0.417*** (0.010)	-0.358*** (0.010)
High School			-0.276*** (0.008)	-0.212*** (0.009)
Asian only			0.003 (0.015)	-0.003 (0.013)
Black			0.356*** (0.008)	0.348*** (0.008)
Other			0.159*** (0.016)	0.199*** (0.015)
Admin and Service			-0.252*** (0.009)	-0.334*** (0.009)
Management			-0.366*** (0.012)	-0.450*** (0.011)
Professional			-0.346*** (0.012)	-0.441*** (0.011)
Sales			-0.177*** (0.008)	-0.255*** (0.008)
Constant	-1.421*** (0.005)	-1.379*** (0.004)	-0.758*** (0.011)	-0.711*** (0.012)
Observations	544,552	534,977	544,552	534,977

*Notes:* Coefficients with \*\*\* are significant at 1%, with \*\* at 5% and with \* at 10% level.