Opportunity to Move: Macroeconomic Effects of Relocation Subsidies

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24 November 2016

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November 24, 2016

Abstract

The unemployment insurance system in the U.S. does not provide incentives to look for jobs outside local labor markets. In this paper I introduce relocation subsidies as a supplement to unemployment benefits, and study their effects on unemployment, productivity and welfare. I build a job search model with heterogeneous workers and multiple locations, in which migration is impeded by moving expenses, cross-location search frictions, borrowing constraints, and utility costs. I calibrate the model to the U.S. economy, and then introduce a subsidy that reimburses a part of the moving expenses to the unemployed and is financed by labor income taxes. During the Great Recession, a relocation subsidy that pays half of the moving expenses would lower unemployment rate by 0.36 percentage points (or 4.8%) and increase productivity by 1%. Importantly, the subsidies cost nothing to the taxpayer: the additional spending on the subsidies is offset by the reduction in spending on unemployment benefits. Unemployment insurance which combines unemployment benefits with relocation subsidies appears to be more effective than the insurance based on the benefits only.

Keywords: unemployment insurance, relocation subsidies and vouchers, local labor markets, moving costs, geographic mobility, internal migration

JEL Classification: E24, J61, J64, J65, R23

*I thank Nezih Guner for invaluable comments and suggestions. This paper benefited from conversations with Jérôme Adda, Lorenzo Caliendo, Matt Delventhal, Jan Eeckhout, Paul Klein, Joan Llull, Kurt Mitman, Francesc Obiols, Anya Parkhomenko, Ronni Pavan, Tyler Ransom, Chris Rauh, Alessandro Ruggieri, Arnau Valladares-Esteban, as well as feedback from seminar and conference participants at Universitat Autònoma de Barcelona, University of Stockholm, Universitat Pompeu Fabra, Barcelona GSE PhD Jamboree, Doctoral Workshop on Quantitative Dynamic Economics at University of Konstanz, SAEe Girona, and MOVE-Barcelona GSE Macroeconomics Workshop in honor of T. Kehoe. I gratefully acknowledge financial support provided by the grant ERC-2010-StG-GA263600 and the FPI Severo Ochoa Scholarship from the Ministry of Economy and Competitiveness of Spain.

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"I want to get out of here, but I can't... I got no money. I'm stuck."
Charlie LeDuff, "Detroit" (2014)

1 Introduction

In 2010 the unemployment rate in the U.S. hit 9.6%, a level not seen since early 1980s. As most commentators have focused on the national rate of unemployment, the tremendous regional differences received little attention (Figure 1). The aggregate numbers hid the fact that some areas managed to live through the Great Recession largely unaffected, while others took the hit of the crisis. In 2010 metropolitan areas with booming economies such as Omaha, Washington DC, and Oklahoma City posted unemployment rates of 5-6%, whereas some of the hardest-hit cities, such as Detroit and Las Vegas, saw their unemployment climb above 13%.[1] Besides high degree of variation across space, local unemployment exhibits strong persistence over time: cities with high unemployment rates in a given year also have high unemployment in the following years (Figure 2).[2]

These large and persistent differences imply that many unemployed individuals keep searching for jobs in locations with scarce job opportunities instead of moving to places with more abundant jobs. This may happen for several reasons. First, individuals may face high moving costs, both monetary and non-monetary. The non-monetary costs include the disutility of moving away from family, friends and familiar environment, and are likely to be sizable. They also include psychological stress associated with moving, time spent on organizing the move and finding a new home, etc. All these costs may be high enough that moving is not optimal even though the current location does not offer the best economic environment. Second, even if relocation is optimal given costs, individuals may simply not have enough savings or not be able to borrow to finance the move. The financial constraint may be especially relevant for the low-skilled unemployed. Finally, there may be significant information barriers, whereby unemployed workers have imprecise information about labor markets in other locations.

These moving constraints diminish the ability of workers to respond to local shocks and, as a result, may have adverse macroeconomic effects. In particular, the reduced ability to move may lead to higher national unemployment and lower productivity – the effects

[1] In this paper I use the notions of *metropolitan statistical area* (MSA) and *city* interchangeably, as is common in the literature. For the purposes of this paper, MSAs are more relevant than cities since the former constitute a contiguous labor market and often comprise several cities.

[2] The high persistence of local joblessness can be explained by slow response of both population and in- and out-migration rates to regional productivity and labor market shocks, as shown by Davis, Fisher and Veracierto (2014) and Nenov (2015).

I explore in this paper. The effect of moving constraints on unemployment arises via two channels. First, the constraints may lead to higher geographic mismatch of job openings and job seekers: a situation in which a person cannot find a job in location A, and there is a job he is looking for in location B, but he cannot relocate from A to B. Second, if, due to moving constraints, an individual only searches locally, the duration of his search is likely to be longer than if he also searched in other locations. Longer unemployment spells will mechanically result in a higher national unemployment.[3] The effect of moving constraints on productivity may arise if they prevent labor from allocating efficiently across space.

In this paper, I study the effects of *relocation subsidies*, a policy first proposed by Moretti (2012), on unemployment, productivity and welfare. Currently, the U.S. unemployment insurance system does not provide incentives for the unemployed workers to look for jobs outside their local labor markets. Relocation subsidies, on the other hand, encourage workers to move to more vibrant labor markets. The question I ask in this paper is whether relocation subsidies combined with unemployment benefits is a better unemployment insurance policy than the benefits alone.

To study the effects of the subsidies, I build a job search model with multiple locations in which moving constraints explicitly enter the decision-making of a job-seeker, and thus affect geographic mobility of labor, as well as local and national unemployment. The economy consists of multiple locations, each with its own labor and housing market. The variation in unemployment stems from different job creation rates across locations. The model economy is populated by finitely lived individuals with heterogeneous skills. An individual may be employed or unemployed, and in the latter case he receives unemployment benefits. The benefits are financed by taxes on labor income. Workers can move between locations at any time. The decision to migrate depends on employment status, wages, housing rents, the state of the labor market (i.e. the job creation rate), and preferences for locations. The ability to migrate is inhibited by the following moving constraints: (1) moving cost, (2) borrowing limit, and (3) cross-location job search friction. The moving cost is a lump-sum amount paid by a worker who relocates. For some workers the cost is so high that moving would be suboptimal even if another location offers better wages or rent. The borrowing limit places a constraint on an individual's ability to finance the move from external sources. Some workers may find it optimal to move but they might not possess enough funds to finance the relocation. Finally, the cross-location search friction lowers the probability of receiving an outside offer as compared to a local offer.

[3]Andersson, Haltiwanger, Kutzbach, Pollakowski and Weinberg (2014) find that better job accessibility within an MSA reduces unemployment duration. The same result should hold for the cross-city job accessibility.

I calibrate the model to the U.S. economy by targeting central facts about local and national labor and housing markets, and internal migration. In order to bring the model to the data, I split all metropolitan areas in the U.S. into four groups by wage earnings and unemployment rate: low wage-low unemployment, low wage-high unemployment, high wage-low unemployment, and high wage-high unemployment. Then I calibrate the parameters that describe labor and housing markets in the model so as to match the average statistics of the four groups of cities in the data.

Then I introduce a relocation subsidy that pays a fraction of the monetary moving costs to every unemployed worker willing to move. Together with unemployment benefits, the subsidies are financed by a proportional tax on labor income. Essentially, the government expands the unemployment insurance system by adding the moving subsidies.

I find that during 2009-2011, a period of high unemployment in the aftermath of the Great Recession, a moving subsidy that pays 50% of moving expenses would reduce the national unemployment rate by 0.36 percentage points (or 4.8%) and increase productivity by 1%.[4] The effect on productivity comes from the fact that moving subsidies put more individuals to work (extensive margin) and also make them move to more productive locations (intensive margin): for example, population of the low-unemployment high-wage group of cities expands by 6%. Importantly, these subsidies cost nothing to the taxpayer, since the additional expenses on moving subsidies are offset by a reduction of outlays for unemployment benefits. In other words, I find that unemployment benefits combined with relocation subsidies constitute a more efficient unemployment insurance system than unemployment benefits only. The policy, however, does not produce a positive welfare effect. The subsidies attract workers toward more productive places, which leads to higher housing prices there. Even though the consumption of goods increases after the introduction of the subsidies, the consumption of housing falls.[5]

This paper is related to several strands of literature. One of the first studies to document the variation of local unemployment rates in the U.S. is Blanchard and Katz (1992). In a more recent study, Rappaport (2012) reports large and persistent differences in unemployment across metropolitan areas and argues that they can be explained by skill mismatch, differences in amenities, and high moving costs.

The role of moving costs for geographic mobility is studied in Kennan and Walker, 2011,

[4]The calibrated moving cost is $8,425, hence a subsidy that covers half of moving costs is equal to $4,213.

[5]This result is similar to the one found by Eeckhout and Guner (2015). They build a spatial model and study optimal federal income taxes that take into account differences in local prices and maximize welfare. Even though alternative taxation raises output by 1.6%, it has virtually no effect on welfare because reallocation of workers to more productive cities leads to a rise in housing prices and negates the positive effects of higher wages.

Bayer and Juessen (2012) and others. Coen-Pirani (2010), Lkhagvasuren (2012), Beaudry, Green and Sand (2014) and Schmutz and Sidibé (2016) study the importance of moving costs and/or cross-location job search frictions in a general equilibrium framework. These papers follow a positive approach and take the moving cost as given. In this paper, I consider a policy that can change the moving cost for unemployed migrants.

This paper is connected to the literature on optimal unemployment insurance over the business cycle, see Jung and Kuester (2015), Mitman and Rabinovich (2015), Kroft and Notowidigdo (2016) and Landais, Michaillat and Saez (2016). A more related line of research has studied the interaction between geographic mobility and unemployment policies. Hassler, Rodríguez Mora, Storesletten and Zilibotti (2005) propose a theory in which societies with lower geographic mobility vote for higher unemployment insurance. On the empirical side, Goss and Paul (1990) argue that during recessions unemployment benefits are likely to retard out-migration of the involuntarily unemployed. At the same time, Rupert and Wasmer (2012) find that the size of unemployment benefits has a tiny effect on mobility within cities. In this paper, unemployment policy is specifically designed to stimulate mobility.

This paper is also related to the literature on spatial mismatch: the unemployment that emerges when workers and firms which would find it mutually optimal to form a match do not do so because they are spatially separated. Using state-level data, Herz and van Rens (2015) find that the mismatch is virtually nonexistent. However, differences in wages and unemployment between MSAs in many large U.S. states are comparable to the cross-state differences. Şahin, Song, Topa and Violante (2014) use county-level data and estimate that geographic mismatch contributed 0.45 percentage points (about 5%) to the national unemployment rate in 2010, however their modeling framework is silent about the sources of the mismatch. Analysis in the current paper suggests that moving constraints might be an important source of the mismatch.

In this paper, I do not distinguish between owner-occupied and rental housing. The evidence on the importance of homeownership for internal migration and local unemployment is mixed. Head and Lloyd-Ellis (2012) find that the effect of homeownership on unemployment is small in booms but can become significant in recessions. Karahan and Rhee (2013) focus on the downpayment constraint as the key friction. They reckon that the housing bust during the Great Recession reduced migration and increased the dispersion of local unemployment rates, as well as contributed 0.5 percentage points to aggregate unemployment. Several other studies, e.g. Schulhofer-Wohl (2012), Demyanyk, Hryshko, Luengo-Prado and Sørensen (2016) and Valetta (2013), evaluated the effect of underwater mortgages on internal migration and unemployment in the U.S., and found that negative home equity does not reduce labor mobility or increase unemployment. Oswald (2016) studies the importance of mortgage interest deduction for labor mobility and finds a very small effect. At the same time, Ferreira, Gyourko and Tracy (2010) and Sterk (2015) find that negative home equity does reduce geographic mobility.

This paper is also connected to the recent literature about the importance of internal migration in mitigating negative local shocks during the Great Recession. Monras (2015) finds that during the Great Recession internal migration mitigated up to one-third of the effect of the recession on wages in the hardest-hit locations. At the same time, Yagan (2014) argues that at the individual level migration provided very little insurance against negative local shocks in the Great Recession.

Research on policies that promote geographic mobility has been scarce. Ransom (2015) estimates a structural model of individual migration decisions, and studies the response of migration to local labor market shocks in the U.S. In a counterfactual exercise he introduces a moving subsidy, and finds that it induces migration of the unemployed. Yet his paper abstracts from macroeconomic effects of the subsidies. Bryan, Chowdhury and Mobarak (2014) ran a field experiment in Bangladesh in which they randomly assigned a monetary incentive to rural households to temporarily migrate to urban areas. They find that consumption of treated households rises and their propensity to migrate again, without the subsidy, goes up.

The paper proceeds as follows. Section 2 outlines the model without moving subsidies. Section 3 describes the calibration of the model to the U.S. data. Section 4 introduces moving subsidies into the calibrated economy and analyzes their effects. Section 5 concludes.

2 Environment

The model economy consists of I locations, each with its own labor and housing markets.[6] Workers can move across locations at any time after paying a one-time moving cost κ. Time is discrete. Each location i is characterized by TFP level A_i, job offer arrival rate θ_i, and a construction cost parameter χ_i. The size of total labor force in all cities is normalized to 1.

2.1 Workers

The economy is populated by high and low skilled workers, $s \in \{L, H\}$. Their measures in the entire economy are λ_H and λ_L, with $\lambda_H + \lambda_L = 1$.

Preferences. Workers live and work T periods. They consume a homogeneous good and rent housing. They have the following Stone-Geary preferences on the two types of

[6] This model builds upon the model of “islands” Lucas and Prescott (1974), and is closely related to the more recent model of Alvarez and Shimer (2011).

consumption:

$$\tilde{v}(c,h) = \ln\left[c^{1-\gamma}(h-h_{\min})^{\gamma}\right], \tag{2.1}$$

where $h_{\min}$ represents the minimum amount of housing everyone must rent.[7] Individuals discount future utility with a factor β.

In addition, individual utility depends on location in two ways. First, every individual has a "preferred" location i^* which is fixed for life (*permanent component*). If a worker lives outside his preferred location, he suffers a disutility μ. This component is described by the function $\mu(i^*, i)$:

$$\mu(i^*, i) = \begin{cases} 0, \text{ if } i = i^* \\ \mu < 0, \text{ if } i \neq i^* \end{cases}$$

Second, every period a worker receives an *i.i.d.* shock to utility $\varepsilon(j)$ which is associated with choosing to live in location j next period (*transitory component*). As common in the discrete-choice literature, I assume that the shock follows the extreme value type 1 distribution with parameters μ_ε and σ_ε, and that it has zero mean.[8] This shock should be interpreted as the utility cost or benefit of moving to a given location, not related to the location's job and housing market characteristics. Hence the instantaneous utility of a worker who resides in location i, while preferring to live in location i^*, and will move to location j next period is given by

$$\tilde{v}(c,h) + \mu(i^*, i) + \varepsilon(j). \tag{2.2}$$

Labor market. A worker can be employed or unemployed. The measures of employed and unemployed workers of skill s, age a, living in city i are denoted by $n(s,a,i)$ and $u(s,a,i)$, respectively. The total employment and unemployment in location i are denoted by n_i and u_i. Employed workers earn wage $w(s,a,i)$ and unemployed workers receive benefits $b(s,a,i)$, both of which depend on skill, age and location. I assume that the benefits for each type are a fraction of wage for the same type: $b(s,a,i) = \bar{v}w(s,a,i)$. The benefits do not expire.[9]

Newborn (age-1) workers enter the economy unemployed. Every period a worker receives an offer from the local labor market with probability θ_i, and an offer from location j with probability $\Delta\theta_j$. There is on-the-job search and the offer arrival rates do not depend on

[7] Stone-Geary preferences are widely used to model non-homothetic demand. In the current context, they imply a negative relationship between income and the share of income spent on housing. See Ganong and Shoag (2014) for empirical evidence.

[8] The density function of the extreme value type 1 distribution with parameters μ_ε and σ_ε is $f(x) = \exp(-\exp(-(x-\mu_\varepsilon)/\sigma_\varepsilon))$. The mean of a random variable with such distribution is $\mu_\varepsilon + \sigma_\varepsilon\bar{\gamma}$, where $\bar{\gamma} \approx 0.5772$ is the Euler-Mascheroni constant. The variance is $\sigma_\varepsilon^2\pi^2/6$. The shock has zero mean if $\mu_\varepsilon = -\sigma_\varepsilon\bar{\gamma}$.

[9] In the U.S., unemployment benefits expire after 26 weeks though their duration may be prolonged in a recession. In Section 3.2 I argue that assuming the 26-week expiration would have a negligible quantitative effect on the calibrated model, whereas it would increase the computational cost significantly.

employment status. An individual cannot receive more than one offer per period. The parameter $\Delta \leq 1$ is the cross-city search friction. The search friction is necessary for two reasons. First, according to the evidence surveyed in Ioannides and Loury (2004), around half of jobs are found through social networks. Social networks have local nature, i.e. for most people the majority of their acquaintances live in the same geographical area. Second, relatively few individuals actually search for jobs in other locations. Marinescu and Rathelot (2014) analyzed job applications on CareerBuilder.com, a leading job board in the U.S., and found that only 16% were sent to employers in other states.

Migration. While most labor market models with multiple locations do not allow job search across locations or moving without a job offer, in this model any worker is free to move to any city at any time. If a worker living in i receives an offer from j and moves there, he does not experience a spell of unemployment and starts the new job in the next period. However, if a worker moves to j without an offer, he must start there unemployed.

Relocation to another city implies a monetary moving cost κ which is independent of age or skill level.[10] On the other hand, $\mu(i^*, j) - \mu(i^*, i)$ captures the utility loss or gain from moving for a worker whose preferred location is i^*. This non-monetary cost/benefit may capture many components, such as an idiosyncratic preference for location-specific amenities, cost of separating from friends and family or benefit of reuniting with them, etc.

Budget Constraint. A worker can save or borrow up to a limit B at an exogenous interest rate r. Income is taxed at rate τ. Let $y(s, a, i)$, which is equal to $w(s, a, i)$ for an employed individual and $b(s, a, i)$ for an unemployed one, denote the labor income. Then the budget constraint of a worker with skill level s, aged $a < T$, in location i are

$$c + p_i h + k' + \mathbb{I}_{\text{move}}\kappa \leq (1 - \tau)y(s, a, i) + (1 + r)k. \tag{2.3}$$

The value of the indicator function $\mathbb{I}_{\text{move}}$ is 1 if the worker moves to another location $j \neq i$, and 0 otherwise. In the last period of life ($a = T$) a worker does not migrate and consumes all assets, hence the last period's budget constraint is $c + p_i h \leq (1 - \tau)y(s, a, i) + (1 + r)k$.[11]

Demand for Consumption Good and Housing. Let $\tilde{y} \equiv (1 - \tau)y$ denote the after-tax income. The maximization of the utility function (2.1) subject to the budget constraint (2.3) yields the demand function for the consumption good

$$c(\tilde{w} - \mathbb{I}_{\text{move}}\kappa, p, k, k') = (1 - \gamma)\left(\tilde{y} - \mathbb{I}_{\text{move}}\kappa + (1 + r)k - k'\right) - (1 - \gamma)p h_{\min}, \tag{2.4}$$

[10] Amior (2015) finds that the high-skilled are more mobile because they expect larger surpluses accruing to job matches. Notowidigdo (2013) attributes lower mobility of the low-skilled to a lower incidence of shocks to demand for low-skilled labor. However, neither study finds that moving costs depend on skill level.

[11] Note that unemployment benefits in the U.S. are taxable just as any other type of labor income.

and housing

$$h(\tilde{w} - \mathbb{I}_{\text{move}}\kappa, p, k, k') = \frac{\gamma}{p}\left(\tilde{y} - \mathbb{I}_{\text{move}}\kappa + (1+r)k - k'\right) + (1-\gamma)h_{\min}. \tag{2.5}$$

Then the indirect utility function is given by

$$v(\tilde{w} - \mathbb{I}_{\text{move}}\kappa, p, k, k') = \ln\left[\gamma^{\gamma}(1-\gamma)^{1-\gamma}\left[\tilde{w} - \mathbb{I}_{\text{move}}\kappa + (1+r)k - k' - ph_{\min}\right]p^{-\gamma}\right]. \tag{2.6}$$

2.2 Production of the Consumption Good

In every location there is a representative firm that hires labor of both skills to produce a homogeneous consumption good. The good is the numeraire, traded across cities at zero cost. The production technology is given by

$$Y_i = A_i\left((\psi_L n_{Li})^{\eta} + (\psi_H n_{Hi})^{\eta}\right)^{\frac{1}{\eta}},$$

where n_{si} is amount of labor of skill s in city i in efficiency units: $n_{si} \equiv \sum_{a=1}^{T}\phi(a)n(s,a,i)$. Parameter ψ_s represents the productivity of a worker with skill level s, while function $\phi(a)$ accounts for the age-specific productivity of a worker.[12]

Firms maximize profit by selecting the amount of labor of each type. The equilibrium wage for an s-skilled worker who is a periods old and lives in city i is given by

$$w(s,a,i) = A_i\psi_s\phi(a)\cdot\frac{\left((\psi_L n_{Li})^{\eta} + (\psi_H n_{Hi})^{\eta}\right)^{\frac{1-\eta}{\eta}}}{(\psi_s n_{si})^{1-\eta}}. \tag{2.7}$$

The wage of an s-skilled individual is lower if the skill is abundant locally, however, when skills are complementary ($\eta < 1$), the wage is increasing in the supply of the other skill.

2.3 Housing Market

The housing market is modeled along the lines of the Rosen-Roback spatial equilibrium model.[13] In every city housing is built by a representative developer. The developers own houses and rent them out to the inhabitants.[14] I assume that developers are also landlords, i.e. they own the land the houses are built on. I assume that they have zero measure in

[12]For computational reasons I do not differentiate between age and experience.

[13]See Rosen (1979), Roback (1982) and Glaeser, 2008 for details.

[14]I do not distinguish between rented and owned housing. In their studies of responses of migration to local labor market shocks, Davis, Fisher and Veracierto (2014) and Nenov (2015) find that housing plays a small role. Thus abstracting from homeownership should not affect the analysis of the effects of moving subsidies on labor reallocation.

the economy. However, in the quantitative section, in order to capture welfare effects, I redistribute the revenues of the developers among all workers in the economy.

Housing is built using the consumption good and land. Each city has a fixed land endowment Λ_i. The amount of housing built in the current period is equal to $q_{it}\Lambda_i$: the size of land plot Λ_i times the average number of stories per unit of land q_i. Housing depreciates at rate ρ, and the residential stock that remains from the previous period is $(1-\rho)Q_{i,t-1}\Lambda_i$. Thus the supply of housing at time t is

$$Q_{it}\Lambda_i = q_{it}\Lambda_i + (1-\rho)Q_{i,t-1}\Lambda_i.$$

The cost of building q_{it} new stories over the $(1-\rho)Q_{i,t-1}$ stories that remain from the previous period is $\chi_i\left(q_{it} + (1-\rho)Q_{i,t-1}\right)^{\zeta_i}$, where ζ_i and $\chi_i > 0$ are cost parameters. This cost function exhibits urban congestion: it is increasingly costly to build new houses if a city already has plenty of them. Existing housing cannot be demolished.

The number of stories is a continuous variable. In this case, since the marginal cost of construction increases in the existing amount of housing, the developer will optimally choose to use for construction all available land, Λ_i. Therefore, the problem of the developer is reduced to the choice of the number of stories and is given by

$$\max_{q_{it}\geq 0}\left\{p_{it}\left(q_{it}\Lambda_i + (1-\rho)Q_{i,t-1}\right) - \chi_i\left(q_{it} + (1-\rho)\bar{q}_{i,t-1}\right)^{\zeta_i}\Lambda_i\right\}.$$

For an interior solution, the profit-maximizing housing supply function is[15]

$$Q(p_i) = \left(\frac{p_i}{\chi_i\zeta_i}\right)^{\frac{1}{\zeta_i-1}}\Lambda_i, \tag{2.8}$$

where $\frac{1}{\zeta_i-1}$ is the price elasticity of housing supply in city i.

Using the demand function for housing (2.5), we can define the purchasing power of inhabitants of city i, Π_i, as the sum of individual demands for housing. Therefore the aggregate demand for housing in city i is

$$Q^d(p_i) = \frac{\gamma}{p_i}\Pi_i + (1-\gamma)h_{\min}(n_i + u_i). \tag{2.9}$$

In equilibrium, $Q(p_i) = Q^d(p_i)$. Thus, combining equations (2.8) and (2.9), we can define

[15]The case of $q_{it} = 0$ is trivial and is not analyzed here since in a stationary economy $q_{it} > 0$.

the equilibrium rent p_i implicitly as[16]

$$\left(\frac{1}{\zeta_i \chi_i}\right)^{\frac{1}{\zeta_i - 1}} \Lambda_i p_i^{\frac{\zeta_i}{\zeta_i - 1}} - (1-\gamma) h_{\min} p_i (n_i + u_i) = \gamma \Pi_i. \tag{2.10}$$

2.4 Government

There is a government whose function is to provide unemployment benefits. To do this, it levies a proportional income tax τ on wages and unemployment benefits earned by workers.[17] The government budget must balance, i.e. tax revenues must equal the expenditures on unemployment benefits:

$$\sum_{s=L,H} \sum_{a=1}^{T} \sum_{i=1}^{I} (\tau w(s,a,i) n(s,a,i) + \tau b(s,a,i) u(s,a,i)) = \sum_{s=L,H} \sum_{a=1}^{T} \sum_{i=1}^{I} b(s,a,i) u(s,a,i). \tag{2.11}$$

2.5 Workers' Decisions

Every period a worker decides (1) how much to save or borrow, (2) whether to move to another location, and (3) how to split his disposable income between consumption and housing, in order to maximize the discounted sum of per-period utilities (2.1) subject to the budget constraint (2.3) and the borrowing limit B.

Timing. Each period consists of the following sequence of events. First, production of the consumption good takes place, and workers receive wage payments. After this, workers observe a realization of the vector of utility shocks. At the same time, new job offers are generated and randomly distributed among all workers according to the probabilities specified in Section 2.1. Then migration decisions are made. Those who received an offer from another location may move by accepting the offer. Workers may also move to another location without a job offer from there. Accepted offers only turn into jobs starting from the next period. Then the developers build housing to accommodate the demand. Next workers spend their disposable income on consumption, housing and moving expenses. If the expenses are below labor and capital income, they save the difference. Otherwise they borrow to cover the expenses, but up to the limit B. After that, migration occurs. Finally, a fraction δ of existing jobs is randomly destroyed.[18]

[16] It is straightforward to show that the solution p_i exists and is unique.

[17] See footnote 11.

[18] Since an accepted offer turns into a job from the next period, the new job cannot be destroyed before a worker spent there at least one period, and therefore workers who migrate are immune to job destruction. This assumption should not affect the results in model period is short.

Bellman Equations. The *individual state* of a worker is $(s, a, i^*, i, k, o, \varepsilon)$, where s is skill, a is age, i^* is preferred location, i is current location, k is savings, and o is the job offer status: no offer ($o = o_N$) or offer from location j ($o = o_j$). Finally, ε is the vector of the realizations of utility shocks for each choice of location. The *aggregate state* is described by the distribution of labor across individual states $\Phi : \mathcal{X} \to \mathbb{R}_+$, where $\mathcal{X} \equiv \{L, H\} \times \{1, ..., T\} \times \{1, ..., I\} \times \{1, ..., I\} \times [B, \infty) \times \{o_N, o_1, ..., o_I\} \times \mathbb{R}^I$ is the space of individual states. The aggregate state determines the distribution of labor and housing prices across locations, $w(m, s, a; \Phi)$ and $p_i(\Phi)$, but workers take the prices as given.

A worker can be in four possible situations with respect to current employment status and availability of a job offer: (1) employed worker without a job offer, (2) employed worker with a job offer, (3) unemployed worker without a job offer, and (4) unemployed worker with a job offer. Each of these possibilities dictates a specific form of the value function, but all of them describe a simultaneous choice of location and assets.

Situation (1): employed worker without a job offer. In this case a worker can stay in the current location and retain his job in the next period with probability $1 - \delta$. Alternatively, the individual can move to another location l but, since he did not receive a job offer from l, he will have to start next period unemployed. The value function of this worker describes the decision between staying in the current location i and moving to location l, and the decision on asset holdings for each location choice, such that the budget and the borrowing constraints are satisfied:

$$
\begin{aligned}
\mathcal{W}(s, a, i^*, i, k, o_N, \varepsilon; \Phi) \;=& \\
\max\Bigg\{ &\max_{k'} \Big\{ v(\tilde{w}(s, a, i; \Phi), p_i(\Phi), k, k') + \varepsilon(i) - \mu(i^*, i) + \beta(1-\delta)\mathrm{E}\left[\mathcal{W}(s, a+1, i^*, i, k', o', \varepsilon'; \Phi')\right] \\
&\qquad + \beta\delta\mathrm{E}\left[\mathcal{U}(s, a+1, i^*, i, k', o', \varepsilon'; \Phi')\right] \Big\}, \\
&\max_{l \neq i} \Big\{ \max_{k'} \Big\{ v(\tilde{w}(s, a, i; \Phi) - \kappa, p_i(\Phi), k, k') + \varepsilon(l) - \mu(i^*, i) + \beta\mathrm{E}\left[\mathcal{U}(s, a+1, i^*, l, k', o', \varepsilon'; \Phi')\right] \Big\} \Big\} \Bigg\}
\end{aligned}
$$

$$
\text{such that} \;\; \begin{cases} c + p_i(\Phi)h + k' \leq \tilde{w}(s, a, i; \Phi) + (1+r)k \text{ , if worker stays in location } i \\ c + p_i(\Phi)h + k' + \kappa \leq \tilde{w}(s, a, i; \Phi) + (1+r)k \text{ , if worker moves to location } l \neq i \end{cases}
$$
$$
\text{and} \quad k' \geq B, \tag{2.12}
$$

where $v(\tilde{w}(s, a, i; \Phi) - \mathbb{I}_{\text{move}}\kappa, p_i(\Phi), k, k')$ is the indirect utility of disposable income (see equation 2.6). The expectation of the future value function is taken with respect to the type of job offer and the vector of future utility shocks ε', and can be written as

$$\mathrm{E}\left[\mathcal{W}(s,a+1,i^*,i,k',o',\varepsilon';\Phi')\right] = \int \Bigg[\theta_i \mathcal{W}(s,a{+}1,i^*,i,k',o_i,\varepsilon';\Phi') + \sum_{j\neq i} \Delta\theta_j \mathcal{W}(s,a{+}1,i^*,i,k',o_j,\varepsilon';\Phi') + \left(1-\theta_i-\sum_{j\neq i}\Delta\theta_j\right)\mathcal{W}(s,a+1,i^*,i,k',o_N,\varepsilon';\Phi')\Bigg] d\varphi(\varepsilon'), \quad (2.13)$$

where θ_j is the probability of receiving a job offer from location j (see section 2.1), and $\varphi(\varepsilon')$ is the joint distribution of the vector of the utility shocks (*i.i.d.* extreme value type 1). The expectation of the value of being unemployed is defined analogously. When deciding on future location j, a worker takes into account both the expected value of this choice in the next period and the current random utility associated with choosing location j. All else equal, the worker is more likely to choose to move to his preferred location i^* in order to avoid the utility penalty brought by $\mu(i^*,i)$.

Situation (2): employed worker with job offer from city $j \neq i$.[19] In this case a worker can also stay in the current location and keep his job in the next period with probability $1-\delta$. However, he can also take up the offer from location j and move there without having to go through a spell of unemployment. As usual, he can also move to another location $l \neq j$, but then he will have to start the next period without a job. The value function describes the decision on whether to stay in i, move to j or to $l \neq i,j$, and the decision on asset holdings for each location choice, such that the budget and the borrowing constraints hold:

$$\begin{aligned}
\mathcal{W}(s,a,i^*,i,k,o_j,\varepsilon;\Phi) \; = \;& \\
\max\Bigg\{ & \max_{k'}\Big\{ v(\tilde{w}(s,a,i;\Phi),p_i(\Phi),k,k') + \varepsilon(i) - \mu(i^*,i) + \beta(1-\delta)\mathrm{E}\left[\mathcal{W}(s,a+1,i^*,i,k',o',\varepsilon';\Phi')\right] \\
& \qquad + \beta\delta\mathrm{E}\left[\mathcal{U}(s,a+1,i^*,i,k',o',\varepsilon';\Phi')\right]\Big\}, \\
& \max_{k'}\Big\{ v(\tilde{w}(s,a,i;\Phi)-\kappa,p_i(\Phi),k,k') + \varepsilon(j) - \mu(i^*,i) + \beta\mathrm{E}\left[\mathcal{W}(s,a+1,i^*,j,k',o',\varepsilon';\Phi')\right]\Big\}, \\
& \max_{l\neq i,j}\Big\{ \max_{k'}\Big\{ v(\tilde{w}(s,a,i;\Phi)-\kappa,p_i(\Phi),k,k') + \varepsilon(l) - \mu(i^*,i) + \beta\mathrm{E}\left[\mathcal{U}(s,a+1,i^*,l,k',o',\varepsilon';\Phi')\right]\Big\}\Big\}\Bigg\}
\end{aligned}$$

$$\text{such that} \quad \begin{cases} c + p_i(\Phi)h + k' \leq \tilde{w}(s,a,i;\Phi) + (1+r)k \text{ , if worker stays in location } i \\ c + p_i(\Phi)h + k' + \kappa \leq \tilde{w}(s,a,i;\Phi) + (1+r)k \text{ , if worker moves to location } j\neq i \text{ or } l\neq i,j \end{cases}$$

$$\text{and} \quad k' \geq B. \quad (2.14)$$

[19] An employed worker never accepts an offer for a job in his current city since it is exactly the same as his current job. Hence if $j = i$, this situation is the same as the situation (1) in which no offer arrives.

Situation (3): unemployed worker without a job offer. Such worker can either keep searching in his current location i or move to search in location l. The value function of the worker describes the decision between remaining in i and moving to l, and the decision on assets for each location, such that the budget and the borrowing constraints are satisfied:

$$
\begin{aligned}
&\mathcal{U}(s,a,i^*,i,k,o_N,\varepsilon;\Phi) \;= \\
&\quad \max\Bigg\{ \max_{k'}\Big\{ v(\tilde{b}(s,a,i;\Phi),p_i(\Phi),k,k') + \varepsilon(i) - \mu(i^*,i) + \beta \mathrm{E}\left[\mathcal{U}(s,a+1,i^*,i,k',o',\varepsilon';\Phi')\right] \Big\}, \\
&\qquad\quad \max_{l\neq i}\Big\{ \max_{k'}\Big\{ v(\tilde{b}(s,a,i;\Phi)-\kappa,p_i(\Phi),k,k') + \varepsilon(l) - \mu(i^*,i) + \beta \mathrm{E}\left[\mathcal{U}(s,a+1,i^*,l,k',o',\varepsilon';\Phi')\right] \Big\}\Big\}\Bigg\}
\end{aligned}
$$

$$
\text{such that } \begin{cases} c + p_i(\Phi)h + k' \leq \tilde{b}(s,a,i;\Phi) + (1+r)k \text{ , if worker stays in location } i \\ c + p_i(\Phi)h + k' + \kappa \leq \tilde{b}(s,a,i;\Phi) + (1+r)k \text{ , if worker moves to location } l \neq i \end{cases}
$$
$$
\text{and} \quad k' \geq B. \tag{2.15}
$$

Situation (4): unemployed worker with job offer from city j. In this case the worker can always reject the offer and remain unemployed in his current location. On the other hand, if the offer comes from his current location ($j = i$), then he may simply accept the offer without incurring any cost. If the offer arrives from location $j \neq i$, then, in order to accept the offer, the worker must pay the moving cost κ. Alternatively, he can relocate to another location $l \neq i, j$ and search there. The value function of this worker describes the decision between keeping searching in location i, accepting a job offer from location j (where j possibly equals i) or moving to search to another location $l \neq i, j$, and the decision on asset holdings for each location choice, such that the budget and the borrowing constraints are satisfied:

$$
\begin{aligned}
&\mathcal{U}(s,a,i^*,i,k,o_j,\varepsilon;\Phi) \;= \\
&\quad \max\Bigg\{ \max_{k'}\Big\{ v(\tilde{b}(s,a,i;\Phi),p_i(\Phi),k,k') + \varepsilon(i) - \mu(i^*,i) + \beta \mathrm{E}\left[\mathcal{U}(s,a+1,i^*,i,k',o',\varepsilon';\Phi')\right] \Big\}, \\
&\qquad\quad \max_{k'}\Big\{ v(\tilde{b}(s,a,i;\Phi)-\mathbb{I}_{i\neq j}\kappa,p_i(\Phi),k,k') + \varepsilon(j) - \mu(i^*,i) + \beta \mathrm{E}\left[\mathcal{W}(s,a+1,i^*,j,k',o',\varepsilon';\Phi')\right] \Big\}, \\
&\qquad\quad \max_{l\neq i,j}\Big\{ \max_{k'}\Big\{ v(\tilde{b}(s,a,i;\Phi)-\kappa,p_i(\Phi),k,k') + \varepsilon(l) - \mu(i^*,i) + \beta \mathrm{E}\left[\mathcal{U}(s,a+1,i^*,l,k',o',\varepsilon';\Phi')\right] \Big\}\Big\}\Bigg\}
\end{aligned}
$$

$$
\text{such that } \begin{cases} c + p_i(\Phi)h + k' \leq \tilde{b}(s,a,i;\Phi) + (1+r)k \text{ , if worker stays in location } i \\ c + p_i(\Phi)h + k' + \kappa \leq \tilde{b}(s,a,i;\Phi) + (1+r)k \text{ , if worker moves to location } j \neq i \text{ or } l \neq i,j \end{cases}
$$
$$
\text{and} \quad k' \geq B. \tag{2.16}
$$

2.6 Distribution of Labor across Locations

Every period workers who reach age T leave the labor force. There is no population growth, and generations are replaced as follows. Every worker of age 2 to T_f ("fertile" ages) gives birth to an age-1 worker with probability $\frac{1}{T_f-1}$, which is the exactly the population replacement rate for the entire economy. Hence the measure of the newborns in location i is equal to the average size of a cohort between ages 2 and T_f in the location.

I assume that in every city i fraction ν of newborns have location preference for the city they were born in (i.e. $i^* = i$), whereas location preferences of fraction $1-\nu$ of newborns are randomly distributed according to exogenous probabilities $\{\xi_{i^*}\}_{i^*=1}^{I}$. The distribution of the newborns by skill level is the same in all cities. Thus the size of the s-skilled newborn population in city i whose preferred location is i^* is given by

$$n(s,1,i;i^*) = (1-\nu)\lambda_s\xi_{i^*}\frac{1}{T_f-1}\sum_{a=2}^{T_f}\sum_{s=L,H}\left[n(s,a,i)+u(s,a,i)\right] + \mathbb{I}_{i=i^*}\cdot\nu\lambda_s\frac{1}{T_f-1}\sum_{a=2}^{T_f}\sum_{s=L,H}\left[n(s,a,i)+u(s,a,i)\right]. \quad (2.17)$$

The fraction of workers born in location i who have preference for i is equal to $(1-\nu)\xi_i+\nu$. The measure of all s-skilled newborns in location i is given by $n(s,1,i) = \sum_{i^*=1}^{I} n(s,1,i;i^*)$.

After workers are born, they can move across locations in order to maximize their lifetime expected utility. Since the utility shocks ε are extreme value type 1, we can obtain closed-form expression for labor flows across locations.[20] Denote by $\bar{\mathcal{W}}(j|s,a,i^*,i,k,o)$ and $\bar{\mathcal{U}}(j|s,a,i^*,i,k,o)$ the employed and unemployed worker's value of choosing to live in j next period, just before the realization of the utility shock.[21] Then, the *conditional choice probability* that an employed worker in state (s,a,i^*,i,k,o) will choose location j for the next period is

$$\frac{\exp\left(\bar{\mathcal{W}}(j|s,a,i^*,i,k,o)\right)^{\frac{1}{\sigma_\varepsilon}}}{\sum_{l=1}^{I}\exp\left(\bar{\mathcal{W}}(l|s,a,i^*,i,k,o)\right)^{\frac{1}{\sigma_\varepsilon}}}. \quad (2.18)$$

The conditional choice probability that an unemployed worker in state (s,a,i^*,i,k,o) will choose location j for the next period is

$$\frac{\exp\left(\bar{\mathcal{U}}(j|s,a,i^*,i,k,o)\right)^{\frac{1}{\sigma_\varepsilon}}}{\sum_{l=1}^{I}\exp\left(\bar{\mathcal{U}}(l|s,a,i^*,i,k,o)\right)^{\frac{1}{\sigma_\varepsilon}}}. \quad (2.19)$$

[20]The possibility of obtaining closed-form solutions for conditional choice probabilities in models with extreme value type 1 shocks was first discovered by McFadden (1973).

[21]In discrete-choice literature these functions are called *conditional value functions*.

2.7 Equilibrium

The environment is stationary. There is no aggregate uncertainty at either national or city level. The equilibrium is solved numerically using the procedure outlined in Appendix A.1.

Definition 2.1. A *stationary equilibrium* consists of value functions $\mathcal{W}$ and $\mathcal{U}$ and the associated decision rules that determine optimal assets and whether or not to accept a job offer; conditional choice probabilities (2.18) and (2.19); tax rate τ; wages $w(s,a,i)$ and rents p_i; distribution of workers across individuals states, Φ; and a transition function $F : \mathcal{X} \to \mathcal{X}$, such that: (1) the value functions maximize expected lifetime utility and the decision rules attain the value functions; (2) wages $w(s,a,i)$ and rents p_i maximize profits of production firms and developers, respectively; (3) labor markets clear in every city (i.e. wages equalize demand for workers and supply of those who are not unemployed); (4) housing markets clear in every city; (5) the resource constraint holds (aggregate output is equal to aggregate consumption plus construction costs); (6) the government budget is balanced; (7) the distribution of labor is stationary: $F(\Phi) = \Phi$.

3 Quantitative Analysis

3.1 Data

I use the individual-level data from the American Community Survey (ACS, Ruggles et al, 2015). In the benchmark calibration I will use the data for 2005-2007, a low-unemployment period.[22] Then I will perform an additional calibration for 2009-2011, a high-unemployment period (Figure 3).

Workers. The sample consists of household heads aged 25-64, who participate in the labor force, are not institutionalized, live in an MSA, and are not recent immigrants (i.e. lived in the U.S. last year).[23] The data counterparts of high and low-skilled workers are individuals with college degree or higher and those with a lower educational attainment. In my sample, 36.5% of individuals are high-skilled.

Locations and labor markets. The ACS identifies 283 MSAs for the years of interest.[24] However, for computational reasons, I cannot include 283 separate locations in the quanti-

[22]The individual data on migration at the MSA level is only available starting from 2005.

[23]I only include heads of household, since households often migrate together. If I did, my data on migration rates by income and education would be biased towards characteristics of married individuals.

[24]ACS only identifies metro areas with population of at least 100,000. There are 283 such metro areas in the U.S., and they are home to 82% of the labor force.

tative model.[25] Therefore I split the 283 metro areas into four groups: low unemployment and low wage ("LULW"), high unemployment and low wage ("HULW"), low unemployment and high wage ("LUHW"), and high unemployment and high wage ("HUHW"). A metro area belongs to a low/high group if its unemployment or wages are below/above the national mean in 2005-2007. Wages and unemployment rates for each group of cities are estimated from the ACS.[26] Since heads of households of prime age have higher propensity to be employed, the 2005-2007 average national unemployment rate in my sample (4.4%) is lower than the number reported by the BLS (4.8%). Table 1 summarizes the characteristics of the four groups.

Migration. In the ACS respondents are asked in which metropolitan area they lived a year ago. I define a person as a migrant if last year he lived in a different group of MSAs. The geographic mobility rate is calculated as the ratio of the number of individuals who are migrants in the current year to the population size in the previous year. The mobility rate between the four city groups in 2005-2007 is 1.99%. The mobility rate across *all* cities (i.e. both between and within city groups) is 2.67%.[27] Thus, even though I aggregate all the 283 MSAs into four groups only, I still capture 3/4 of all migration across metro areas. This should not be surprising since the MSAs are split into groups by unemployment and wages, and job-related reasons account for more than a half of interstate migration (Kaplan and Schulhofer-Wohl, 2015).

Housing. As a measure of housing costs, I use self-reported rents from the ACS. In order to control for the characteristics of a dwelling, I employ the hedonic-regression approach by Eeckhout, Pinheiro and Schmidheiny (2014) and estimate MSA-specific rent indices. The controls include the building type, floor area, the number of rooms, and the age of structure. Then I aggregate the MSA-specific rent indices into four indices for each of the city groups.

3.2 Parameter Values

The parameters of the model are calibrated to match central facts about local labor and housing markets, and internal migration in the U.S. in the 2005-2007 period. The model period is 1 month, and workers in the model live for 480 periods or 40 years (ages 25-64). The rest of the section describes the calibration. The calibrated parameters are summarized in Tables 2 and 3. Table 4 compares the targeted moments with the moments produced by

[25]The dynamic problem of a worker includes decisions regarding every possible future location, given current location. Therefore the state space expands exponentially in the number of locations.

[26]While estimates of the MSA-level unemployment are often taken from the Local Area Unemployment Statistics program by the Bureau of Labor Statistics, I need to use microdata to calculate unemployment rates specific to my sample.

[27]Empirical facts about internal mobility in the U.S. are summarized in Molloy et al (2011).

the model. The calibrated parameters match the targeted moments nearly perfectly.

Workers. The annual discount factor β is set to 0.96. The age-dependence of worker's productivity is specified as a quadratic function of age:

$$\phi(a) = \phi_0 + \phi_1 a + \phi_2 a^2. \tag{3.1}$$

Parameters ϕ_0, ϕ_1 and ϕ_2 are estimated from the data on annual wage earnings for each age from 25 to 64 years old using the Current Population Survey (CPS) in 2005-2007 from the IPUMS (Flood et al, 2015). The estimating regression includes a college dummy and MSA fixed effects. The oldest fertile age is $T_f = 40$, following Monte and Ellis (2014) who document that 93% of all births in the U.S. in 2012 were to mothers younger than 40. The productivity of the low-skilled is normalized to $\psi_L = 1$, while the productivity of the high-skilled ψ_H is calibrated to match the observed college premium.

The exogenous interest rate is set to $r = 0.04$.[28] In Appendix A.2, I show that the results of quantitative experiments performed in this paper are not sensitive to the value of the interest rate. The borrowing constraint B is calibrated to match the fraction of households with negative or zero net worth in the data, which corresponds to the fraction of workers with $k \leq 0$ in the model. The proportion of such households was 19% in 2007, according to the analysis of the Survey of Consumer Finances by Michel et al (2012). The calibrated borrowing constraint is equivalent to $2,165 (about 50% of average monthly wage income) in 2005 dollars.

Locations and labor markets. The exogenous productivity in the LULW group of cities is normalized to $A_{\text{LULW}} = 1$, while the productivities in other groups are set to match the mean wage in each group of cities relative to the mean wage in the LULW group. I assume that the job destruction rate δ is common to all cities, and equate it to the estimated average transition probability from employment to unemployment in 2005-2007: 0.0118 a month, following Gomes (2015). The job offer arrival rates, θ_i, are calibrated to match the average unemployment rate in each group of cities i. Unemployment benefits are set to 50% of the wage rate for each combination of skill, age, and city, i.e. $b(x, a, i) = 0.5w(x, a, i)$.[29] The parameter that determines the elasticity of substitution between high and low-skilled labor, η, is set to 0.6, following Card (2009).[30]

[28] Since markets are incomplete and the borrowing constraint plays a crucial role in the model, to entice borrowing the interest rate must satisfy $\beta(1 + r) < 1$.

[29] According to the description of unemployment insurance by the Social Security Administration, "in most of the States, the formula is designed to compensate for a fraction of the usual weekly wage (normally about 50%)". See http://ssa.gov/policy/docs/progdesc/sspus/unemploy.pdf

[30] Using a similar CES production function, Card (2009) estimates that the elasticity of substitution between college-equivalent and high school-equivalent labor in the U.S. is between 1.5 and 2.5, which corre-

Migration. The larger is the variance of the utility shocks, the more willing individuals are to move. Therefore, σ_ε is calibrated to reproduce the 1.99% mobility rate between the city groups. The disutility of living away from the preferred location, μ, is calibrated to match the ratio of migration into unemployment to migration into employment (13% in the data).[31] This moment indicates the willingness of individuals to move into unemployment, and is likely to reflect how much they dislike to live outside their preferred locations.

Since the moving cost is identical for all workers, it is relatively cheaper for the high-skilled to move. Therefore I use the ratio of the mobility rate of the high-skilled to that of the low-skilled (1.43) to identify the moving cost κ. The calibrated moving cost is equivalent to \$8,425 (15.6% of mean annual wage earnings) in 2005 dollars.[32]

The fraction of the newborn population that has preference for living in the home location (ν) is calibrated to match the mobility rate in ages 25-44. The rationale for using this moment to identify ν is that migration is higher in early ages when many workers are trying to relocate to their preferred location. Note, however, that I cannot match the migration in ages 25-44 exactly: the model produces the mobility rate of 3.49%, compared to 3.16% in the data. The reason is that in the model migration halts years before the agents leave the economy, since the benefits of moving for a short period usually do not exceed the costs. In reality individuals keep moving when old. Therefore, in order to match the overall mobility rate, my model must overpredict migration in ages 25-44 and underpredict migration in 45-64.

The distribution of workers by preferred location, ξ_i, is calibrated to match the observed population shares of each group of cities $i \in \{\text{LULW}, \text{HULW}, \text{LUHW}, \text{HUHW}\}$. The cross-location search friction Δ is set as follows. I take the fraction of individuals who apply for jobs in another state: 0.155 from the analysis of the Career-Builder.com data by Marinescu and Rathelot (2014). Since they only consider cross-state applications, whereas in the current paper the geographic unit of analysis is an MSA, I multiply 0.155 by 2.54, the ratio of cross-MSA to cross-state mobility in the data, and obtain $\Delta = 0.3935$. To assess the sensitivity of results to this admittedly ad-hoc way of calibrating a parameter, in Appendix A.2 I fully recalibrate the model using $\Delta = 0.3$ and $\Delta = 0.5$, and show that the results of the policy experiment described in the next session do not vary significantly with Δ.

---

sponds to η between 0.33 and 0.6. To be conservative I take $\eta = 0.6$.

[31] In the model, there are four types of migration by employment status: from employment to employment (EE), from employment to unemployment (EU), from unemployment to employment (UE), and from unemployment to unemployment (UU). The targeted moment is (EU+UU)/(EE+UE). The data counterparts of (EU+UU) and (EE+UE) are the numbers of interstate migrants who reported that the main reason for moving was "to look for work or lost job" and "new job or job transfer", respectively.

[32] This number falls in the ballpark of the existing ones, though there is no consensus on how large the moving costs are, since they are typically model-dependent. Estimates vary from 10% of mean annual labor income in Lkhagvasuren (2012), to \$34,248 in Bayer and Juessen (2012), to \$312,000 in Kennan and Walker, 2011. The average cost of a professional move is \$12,230 in 2010, according to Worldwide ERC (2015).

The values of the parameters Δ and θ_i (Table 3) imply that the probability of not receiving any job offer within 6 months ranges from 0.1% to 0.4%. Hence assuming that unemployment benefits do not expire, instead of imposing the 6-month expiration term currently in effect in the U.S., would not have a tangible effect on the quantitative results.

Housing I assume that the supply elasticity parameter ζ_i is the same in all cities. Blackley (1999) estimates various specification of several models of housing markets and obtains price elasticities of housing supply ranging from 1.6 to 3.7. I take the average, 2.65, which corresponds to $\zeta = 1.38$. Equation (2.10) demonstrates that it is impossible to separately identify land areas Λ_i and construction cost parameters χ_i within the model, since what matters for the rental price is the ratio $\Lambda_i/\chi_i^{\frac{1}{\zeta-1}}$. Hence I set $\Lambda_i = 1$ in all cities. Then I normalize the construction cost parameter for the LULW group of cities to $\chi_{\text{LULW}} = 1$, and calibrate χ_{HULW}, χ_{LUHW} and χ_{HUHW} to match the rent indices in these groups relative to the LULW group. Calibrating Λ_i and setting $\chi_i = 1$ would yield the same results. The annual housing depreciation rate is $\rho = 0.994$, following Malpezzi, Ozanne and Thibodeau (1987).

The housing preference parameters, γ and $h_{\min}$, are calibrated jointly to match the share of housing in the expenditures of an average household and the difference in the expenditure shares between high and low skilled workers. The expenditure share is 0.24, following Davis and Ortalo-Magné (2011). Using the 2005-2007 ACS data, I estimate that the fraction of earnings spent on housing by college workers is 0.74 of the fraction spent by non-college workers.

4 Relocation Subsidies

Currently, the unemployment insurance system in the U.S. does not provide incentives for workers to look for employment in other locations with potentially better job opportunities. If anything, it discourages geographic mobility, since cities with more vibrant labor markets tend to have more expensive real estate, while the unemployment benefits pay a fraction of the last paycheck and thus reflect local cost of living in the current location of an unemployed worker. As a consequence, some jobless individuals (especially those with little savings or ability to borrow) may be stuck in cities with many other unemployed workers and little hope of finding a job.[33]

Moretti (2012) proposes to augment the current unemployment insurance system in the U.S. by relocation subsidies to low-skilled unemployed workers. He argues that such a policy may reduce unemployment and the college earnings gap by allowing low-skilled workers

[33] Carloni (2016) finds that larger unemployment benefits increase unemployed workers' geographic mobility and that the effect is stronger for more liquidity-constrained unemployed workers.

to move to cities with better job opportunities. This proposal attracted interest of policy-makers. In 2015, Congressmen Tony Cárdenas (D-CA) and Mick Mulvaney (R-SC) filed to the Congress the American Worker Mobility Act which "will create a program within the Department of Labor to provide vouchers to the long-term unemployed to relocate for the purpose of attaining or accepting employment."[34]

While Moretti's proposal sounds attractive, it has not yet been evaluated quantitatively. If relocation subsidies could indeed reduce unemployment, then by how much? How large should they be and how expensive would they be to the government? What would be their implications for the distribution of labor across cities, local wages and housing prices, and aggregate productivity? Finally, would the policy be welfare-improving? In a nutshell, the main question is: *are relocation subsidies combined with unemployment benefits a better unemployment insurance policy than the benefits alone?*

The subsidies are designed as follows. The government pays the fraction ω of the moving cost to every unemployed person who moves. In other words, the moving cost faced by an unemployed worker is $(1-\omega)\kappa$. Note that *all* unemployed workers are eligible. In Section 4.2, I consider alternative policies which restrict the eligibility for the subsidies to certain groups of the unemployed. Now both unemployment benefits and moving subsidies are financed by a flat-rate proportional tax τ on labor income. The tax rate must balance the budget:

$$\sum_{s=L,H}\sum_{a=1}^{T}\sum_{i=1}^{I}\left(\tau w(s,a,i)n(s,a,i)+\tau b(s,a,i)u(s,a,i)\right)= \\ \sum_{i=1}^{I}\sum_{j\neq i}\omega\kappa\cdot u_{\text{move}}(i,j)+\sum_{s=L,H}\sum_{a=1}^{T}\sum_{i=1}^{I}b(s,a,i)u(s,a,i), \quad (4.1)$$

where $u_{\text{move}}(i,j)$ is the measure of unemployed workers who move from city i to city j.

To study the welfare properties of moving subsidies, I evaluate how the consumption of goods and the consumption of housing respond to the introduction of the subsidy. One issue with performing welfare analysis is that in the model all workers are renters. Hence, welfare analysis would only consider the utility losses of renters and ignore the gains of homeowners. Given that the homeownership rate in the U.S. is 68.6%, this would be an important omission.[35] In order to account for ownership, I redistribute 68.6% of the value of the national housing stock among all workers by adding $0.686\sum_{i=1}^{I}p_iQ_i(p_i)$ to their disposable income.

In what follows, I introduce relocation subsidies in the economy calibrated to 2005-2007, the period in which unemployment was 4.8% on average. Then, in order to check whether

[34]https://www.congress.gov/bill/114th-congress/house-bill/2755

[35]Data on homeownership in the U.S. can be found at http://www.census.gov/housing/hvs/index.html

the effects of the subsidies differ in a recession, I recalibrate the model to 2009-2011, when unemployment was 9.3%, and introduce the subsidies.

4.1 Effects of Subsidies on Unemployment, Productivity, Welfare

The effects of moving subsidies in the economy calibrated to 2005-2007 are summarized in Table 6.[36] Subsidizing the moving cost stimulates migration: the mobility rate climbs from 1.99% to 2.18% when 20% of the moving cost is subsidized, and to 2.9% when 50% is subsidized. The share of migration to unemployment, i.e. relocation to search employment as opposed to relocation to accept an offer, almost doubles with the 50% subsidy, since now unemployed workers are more willing to go and look for a job in another location instead of staying put and waiting for an offer. Somewhat counterintuitively, the mobility rate of the high-skilled increases faster than that of the low-skilled. The reason is that the low-skilled wage differences across cities are small compared to the high-skilled wage differences. Hence often the wage differences are not sufficient to justify paying the high moving cost and experiencing the disutility of living outside preferred location.[37]

The subsidies reduce unemployment in 2005-2007 but the effect is small. For instance, a subsidy that pays 50% of moving expenses lowers national unemployment rate from 4.42% to 4.28%. In the booming economy of 2005-2007, the job creation rates were quite high even in the high-unemployment groups of cities. In such an environment a worker who wants to relocate can accept any offer, save for a few periods, and then move to a better job. Thus government assistance does not have a large effect on national unemployment. The introduction of the subsidy also leads to a 0.4% increase in productivity.

The relocation subsidies appear to have a positive but tiny economic effect in the 2005-2007 period. However, in those years the economy was booming and unemployment was just 4.8%, hence one should not expect much from any policy that is aimed to cut unemployment. Hence the relocation subsidies should be also tested in a high-unemployment environment.

To address this concern, I recalibrate the job creation and destruction parameters (θ_i and δ) targeting unemployment rates in the four groups of cities in 2009-2011 when the average unemployment rate was 9.3% (7.55% for my sample), and then introduce relocation subsidies in this recessionary economy.[38] Other parameters are kept as in the benchmark 2005-2007

[36]Under full subsidy ($\omega = 1$) the rate of geographic mobility is an abnormal 71%. This result is not surprising given that in the model job tenure does not have any value. When moving is fully paid for, workers simply jump from city to city whenever a good job offer or a positive utility shock arrives. For this reason, in most figures and tables I only show the effects of subsidies up to the 70% subsidy.

[37]This result is consistent with the finding of Amior (2015) that high-skilled workers are more geographically mobile because they experience larger surpluses from matching with firms in other locations.

[38]One reason why I only recalibrate θ_i and δ is that most other parameters are structural and should not have changed from 2005-2007 to 2009-2011.

calibration. Figure 3 depicts the unemployment rate in the 2005-2007 and 2009-2011 periods.

Even though I only recalibrate θ_i and δ, the model matches well all moments of the economy in 2009-2011 (Table 5). In addition, due to high persistence of local unemployment rates and wages, 193 out of 283 metro areas retain their type in terms of above/below mean unemployment and wages as in 2005-2007. Hence I can keep the composition of the city groups as in 2005-2007, and I do not need to recalibrate the parameters that would change due to compositional changes.

The effects of moving subsidies in the recessionary years of 2009-2011 are summarized in Table 7. Most of the effects are larger than in 2005-2007 (Table 6). For instance, a subsidy that reimburses 50% of the moving cost increases the mobility rate from 2.28% to 4.15%.[39] More importantly, moving subsidies are significantly more effective in fighting unemployment in recession than in boom (Figure 4). In the 2009-2011 economy the 50% subsidy reduces unemployment from 7.55% to 7.19% (a 4.8% reduction), while in the 2005-2007 economy the subsidy would only reduce unemployment by 3.2%. Notably, the 0.36 percentage point reduction in 2009-2011 comes very close to the 0.45 percentage point contribution of geographic mismatch to aggregate unemployment found by Şahin, Song, Topa and Violante (2014) for the year of 2010. That is, during the Great Recession the 50% relocation subsidy would be capable of eliminating 4/5 of the geographic mismatch unemployment. Introduction of the subsidy in the recessionary period also leads to a more pronounced effect on productivity: a 1% increase in recession versus 0.4% increase in boom, for the 50% subsidy (Figure 5). The effect comes not only from putting more people to work, but also from the reallocation of labor to more productive cities (Figure 7).

Importantly, the relocation subsidy program does not increase government expenditures. The additional spending on moving subsidies is offset by the reduction in expenses on unemployment benefits, and for moderate subsidy levels the government expenditures even decrease slightly (see Figure 6). In particular, introduction of the 50% subsidy would reduce the expenses from 1.483% of GDP to 1.458%.[40] In other words, the subsidies put enough unemployed individuals to work so as to save the government more money on the benefits than it spends on the subsidies. However, as the subsidies go above 50% of the moving cost, workers start moving excessively which leads to a rapid increase in public spending.

Therefore, I find that unemployment benefits combined with relocation subsidies are a

[39] In the data, the mobility rate fell from 1.99% in 2005-2007 to 1.74% in 2009-2011. However I do not recalibrate the parameters that determine mobility, and obtain the counterfactual mobility rate of 2.28%. This discrepancy should not affect the results of the policy experiment. If anything, it downplays the role of the subsidies, since they would have a larger effect on an economy with a lower mobility rate.

[40] The actual spending on unemployment subsidies in 2009-2011 was slightly higher at 0.0166. Data source: http://www.usgovernmentspending.com

more effective policy tool than unemployment benefits only. The proposed policy has positive effects on unemployment and productivity, yet it does not raise government expenditures. However, it turns out that the subsidy program has very little impact on welfare (Figure 8, Panel b). On the one hand, the policy puts more individuals to work (extensive margin) and locates them in more productive places (intensive margin), thereby boosting productivity and consumption. On the other hand, reallocation of labor to more productive places (LUHW and HUHW groups of cities) drives up local housing prices and leads to lower aggregate consumption of housing. For instance the 50% subsidy increases the consumption of goods by 0.4%, but reduces the consumption of housing by 0.6%. Given that the share of housing in expenses of a median household in the US is 24% (Davis and Ortalo-Magné (2011)), this means that the policy yields nearly no effect on welfare.

One caveat with interpreting the quantitative effects of the subsidies is that the model does not allow for the externalities that a standard search-and-matching model has (Mortensen and Pissarides, 1994). The externalities arise from the fact that if a worker leaves/enters a labor market he increases/reduces the probability that other workers in the market will receive a job offer. In this situation the magnitude of the effects of relocation subsidies depends on how the negative externality in the locations that attract workers compares with the positive externality in the places that lose workers. The relative sizes of the externalities depend on the form of the matching function. In a survey of empirical studies of the matching function, Petrongolo and Pissarides (2001) find strong support for the Cobb-Douglas shape of the function, which implies that the elasticity of the matching function with respect to unemployment is constant. In this case, the positive externalities in cities that lose workers would be offset by the negative externalities in cities that gain workers, and the quantitative conclusions of the policy experiment described in this section would remain the same.

4.2 Restricted Eligibility for Subsidies

In this section I restrict the eligibility for subsidies to some groups of the unemployed and revisit the policy's effects on the economy. In the first experiment only the inhabitants of high-unemployment areas (HULW and HUHW city groups) are allowed to use the subsidy. In the second experiment the subsidy is only paid to the low-skilled workers. These alternative policy experiments are performed using the 2009-2011 calibrated economy. The government faces the same budget as in the equation (4.1), but now $u_{\text{move}}(i, j)$ only includes the movers eligible for the subsidy.

Only workers from high-unemployment cities are eligible. The effect of this policy is shown in Table 8. For most variables of interest, the subsidies have the same qualitative effects as in the benchmark policy but quantitatively they are smaller. In particular, a subsidy that covers 50% of moving expenses only reduces unemployment by 2.6% (compared to 4.8% when all unemployed workers are eligible) and raises productivity by 0.5% (compared to 1%). Notice that at all levels of the subsidy the effects on consumption of goods and housing are positive. Hence, when subsidies are restricted to the residents of high-unemployment areas, welfare does improve, though the magnitude is small. Unlike in the benchmark scenario, under this policy the reallocation of workers to the high-wage cities is smaller since the inhabitants of the low-unemployment low-wage cities (the largest group, see Table 1) are not eligible.

Only low-skilled workers are eligible. One rationale for sponsoring low-skilled mobility is that high-skilled workers usually have sufficient earnings or savings to pay for their move. The effects of this policy are qualitatively identical to the effect of the benchmark policy but quantitatively are much smaller (Table 9). The 50% subsidy achieves worse results in terms of unemployment and productivity than the subsidy that covers all jobless workers: unemployment is only down by 1.6% and productivity is up by 0.3%. The welfare effects of this policy are much smaller than in the case when all jobless workers are eligible. As discussed above, if a low-skilled worker lives in his preferred location, he is unlikely to move somewhere else even with a subsidy. The reason is that the differences in low-skilled wages across cities are typically small, and thus are insufficient to compensate for the disutility of living outside preferred location.

5 Conclusions

Relocation subsidies have been proposed as a policy tool that helps the unemployed move to places where they are more productive or where jobs are abundant. In this paper I quantitatively evaluate the effects of moving subsidies on the economy. In order to do this, I construct a model with heterogeneous workers and multiple locations, each of which has its own labor and housing markets. Workers can move across locations but their mobility is constrained by moving expenses, cross-city search friction, as well as preferences for locations and utility shocks. I calibrate the model to the U.S. economy, and then introduce relocation subsidies that pay a fraction of the moving cost to all unemployed workers who are willing to move. The subsidies are financed by a proportional tax on labor income.

I find that a subsidy that pays 50% of the moving cost is capable of reducing unemployment by 0.36 p.p. (4.8%) and increasing productivity by 1% in the recessionary period of 2009-2011. The policy is less effective in a boom (2005-2007). Most importantly, the introduction of the subsidies keeps government expenses intact: the additional expenses on the subsidies are offset by the savings on unemployment benefits. At the same time, the policy is not welfare-improving. The subsidies attract workers to more productive places, and housing prices there increase, leading to lower average consumption of housing in these places.

The findings of this paper suggest that an unemployment insurance system that combines unemployment benefits with relocation subsidies would be more potent than the system based on unemployment benefits only. The larger effects of the policy in recession than in boom suggest that the subsidies can be used as an automatic stabilizer.

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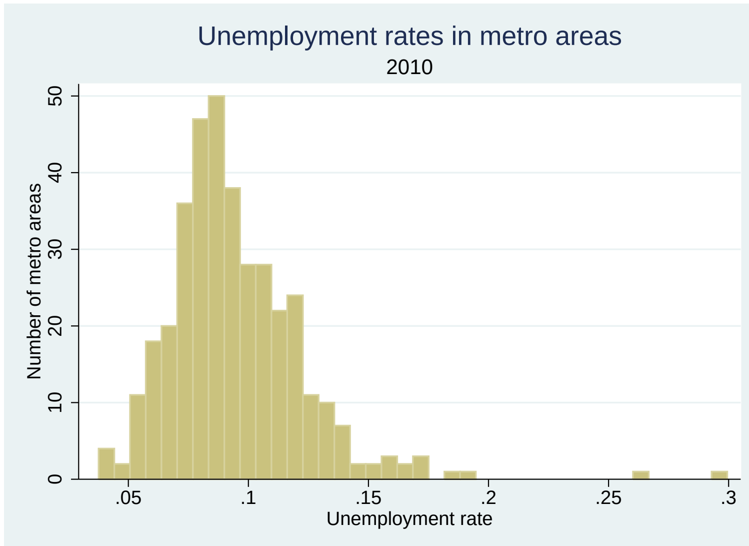
Figures and Tables

Figure 1: Distribution of Local Unemployment Rates

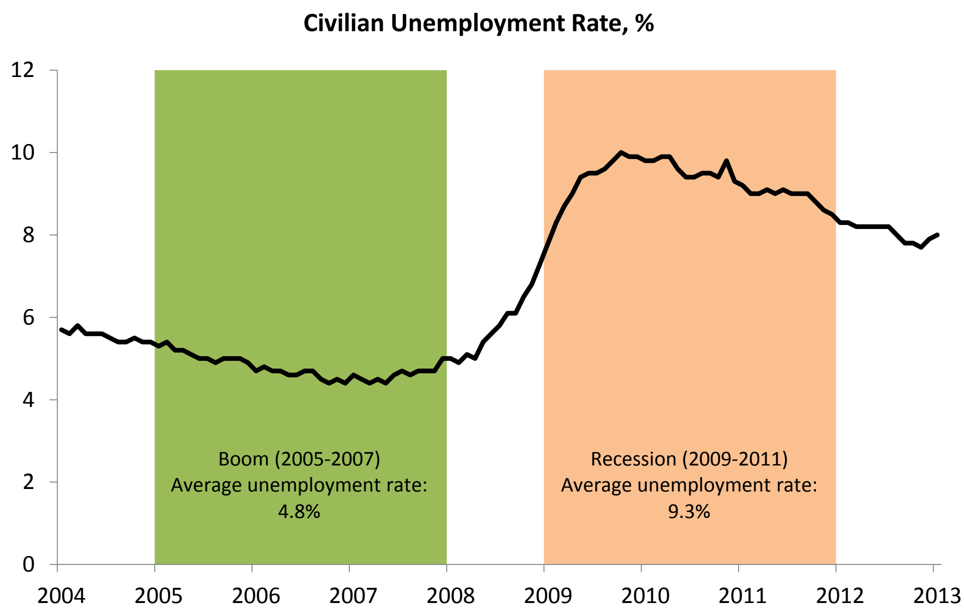


Note: this figure displays the number of metropolitan areas in the U.S. by average unemployment rate in 2010. Data source: U.S. Bureau of Labor Statistics, Local Area Unemployment Statistics, retrieved from http://www.bls.gov/lau/metrossa.htm.

Figure 2: Persistence of Local Unemployment Rates

Note: this figure displays the relationship between the average unemployment rate in a metropolitan area in 2003 and the unemployment rate one, two, four and ten years after (2004, 2005, 2007 and 2013). This relationship also holds for base years other than 2003. Data source: U.S. Bureau of Labor Statistics, Local Area Unemployment Statistics, retrieved from http://www.bls.gov/lau/metrossa.htm.

Figure 3: Unemployment Rate in the U.S., 2004-2013



Note: this figure displays unemployment rate in the U.S. for the two periods used in the calibration of the model: 2005-2007 and 2009-2011. See Sections 3 and 4 for details. Data source: U.S. Bureau of Labor Statistics, Civilian Unemployment Rate [UNRATE], retrieved from FRED, Federal Reserve Bank of St. Louis.

Table 1: Groups of metropolitan areas by unemployment and productivity

Group	# MSAs	Workforce	Unempl.	Mean wage	Examples
LULW	128	17.4 mln	3.5%	$45,733	Dallas, Phoenix, Pittsburgh
HULW	98	11.3 mln	5.2%	$44,396	St Louis, Cleveland, Cincinnati
LUHW	34	11.0 mln	3.9%	$58,547	San Francisco, Washington DC
HUHW	23	14.5 mln	5.2%	$54,311	New York, Chicago, Detroit

Note: all statistics in the table are calculated for the sample of labor force used in this paper. See Section **??** for details. Data source: American Community Survey 2005-2007, retrieved from IPUMS-USA.

Table 2: Parameters calibrated outside the model

			Source
Discount factor (annualized)	β	0.96	
Age-specific productivity	ϕ_0	18131	Age-income profiles
	ϕ_1	155.17	
	ϕ_2	-0.2488	
Oldest fertile age	T_f	40	Monte and Ellis (2014)
Job destruction rate	δ	0.0118	Gomes (2015)
Skill complementarity	η	0.60	Card (2009)
Cross-location search friction	Δ_{ij}	0.394	Marinescu and Rathelot (2014)
Housing supply parameter	ζ	1.38	Blackley (1999)
Housing depreciation	ρ	0.994	Malpezzi, Ozanne and Thibodeau (1987)
Interest rate (annualized)	r	0.04	
Unemployment benefits	$\bar{\upsilon}$	0.5	Empirical evidence

Note: See Section 3 for details.

Table 3: Parameters calibrated within the model

Productivity of the high-skilled	ψ_H	1.740
Exogenous TFP, LULW city	A_{LULW}	1.000
Exogenous TFP, HULW city	A_{HULW}	0.973
Exogenous TFP, LUHW city	A_{LUHW}	1.299
Exogenous TFP, HUHW city	A_{HUHW}	1.206
Job offer arrival rate, LULW city	θ_{LULW}	0.3593
Job offer arrival rate, HULW city	θ_{HULW}	0.2371
Job offer arrival rate, LUHW city	θ_{LUHW}	0.3361
Job offer arrival rate, HUHW city	θ_{HUHW}	0.2484
Standard deviation of utility shock	σ_ε	0.3491
Disutility of living outside preferred location	μ	0.2130
Moving cost	κ	16.4073
Moving cost, % of mean annual wage		15.6
Moving cost, USD		8425
Population with pref. for LULW city	ξ_{LULW}	0.33
Population with pref. for HULW city	ξ_{HULW}	0.22
Population with pref. for LUHW city	ξ_{LUHW}	0.19
Population with pref. for HUHW city	ξ_{HUHW}	0.26
Fraction born with pref. for own city	ν	0.0779
Housing supply elasticity parameter	ζ	1.38
Construction cost parameter	$\chi_{\text{LU-LW}}$	1.00
Construction cost parameter	$\chi_{\text{HU-LW}}$	0.97
Construction cost parameter	$\chi_{\text{LU-HW}}$	1.86
Construction cost parameter	$\chi_{\text{HU-HW}}$	1.33
Preference for housing	γ	0.109
Minimum area requirement	$h_{\min}$	1.02
Borrowing limit	B	4.40
Borrowing limit, % mean monthly wage		50.2

Note: See Section 3 for details.

Table 4: Model performance, benchmark calibration (2005-2007)

	Model	Data
Skill premium	1.72	1.72
Mean wage %, LULW city	1.00	1.00
Mean wage %, HULW city	0.97	0.97
Mean wage %, LUHW city	1.27	1.28
Mean wage %, HUHW city	1.19	1.19
Unemp rate %, LULW city	3.56	3.54
Unemp rate %, HULW city	5.21	5.22
Unemp rate %, LUHW city	3.87	3.86
Unemp rate %, HUHW city	5.24	5.24
Mobility rate, % of labor force per year	1.99	1.99
Mobility rate, high/low skilled	1.44	1.43
Mobility rate, ages 25-44	3.49	3.16
Migration, (EU+UU)/(EE+UE)	0.13	0.13
Population, LULW city	0.32	0.32
Population, HULW city	0.21	0.21
Population, LUHW city	0.20	0.20
Population, HUHW city	0.27	0.27
Rent, LULW city	1.00	1.00
Rent, HULW city	0.85	0.85
Rent, LUHW city	1.53	1.52
Rent, HUHW city	1.24	1.23
Housing expenditure share	0.24	0.24
Expenditure share, high/low skilled	0.74	0.74
Population with negative net worth	0.18	0.19

Note: See Section 3 for details.

Table 5: Model performance, 2009-2011 calibration

	Model	Data
Skill premium	1.72	1.74
Mean wage %, LULW city	1.00	1.00
Mean wage %, HULW city	0.97	0.96
Mean wage %, LUHW city	1.28	1.29
Mean wage %, HUHW city	1.19	1.18
Unemp rate %, LULW city	6.58	6.57
Unemp rate %, HULW city	8.14	8.13
Unemp rate %, LUHW city	6.85	6.86
Unemp rate %, HUHW city	8.79	8.78
Mobility rate, % of labor force per year	2.28	1.74
Mobility rate, high/low skilled	1.85	1.66
Mobility rate, ages 25-44	3.62	2.91
Migration, (EU+UU)/(EE+UE)	0.12	0.24
Population, LULW city	0.31	0.30
Population, HULW city	0.21	0.20
Population, LUHW city	0.21	0.23
Population, HUHW city	0.27	0.27
Rent, LULW city	1.00	1.00
Rent, HULW city	0.85	0.86
Rent, LUHW city	1.54	1.53
Rent, HUHW city	1.24	1.24
Housing expenditure share	0.24	0.24
Expenditure share, high/low skilled	0.74	0.72
Population with negative net worth	0.10	0.26

Note: I recalibrate δ and θ_i to match unemployment rates in 2009-2011, and keep all other parameters as in the 2005-2007 calibration. See Section 4 for details.

Table 6: Effects of relocation subsidies in boom (2005-2007)

Moving subsidy, frac moving cost	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70
Unemployment rate, %	4.42	4.40	4.38	4.36	4.33	4.28	4.23	4.18
GDP	1.000	1.001	1.001	1.002	1.003	1.004	1.006	1.008
Gov't expenses	0.179	0.179	0.178	0.178	0.179	0.180	0.183	0.191
Gov't expenses, % GDP	0.826	0.823	0.821	0.820	0.821	0.825	0.838	0.872
Consumption of goods	1.000	1.000	1.000	1.000	1.001	1.001	1.001	1.001
Consumption of housing	1.000	1.000	0.999	0.998	0.998	0.997	0.995	0.993
Unemp rate LULW city, %	3.56	3.56	3.55	3.53	3.52	3.50	3.47	3.43
Unemp rate HULW city, %	5.21	5.17	5.12	5.06	4.99	4.87	4.73	4.58
Unemp rate LUHW city, %	3.87	3.85	3.84	3.82	3.80	3.76	3.74	3.75
Unemp rate HUHW city, %	5.24	5.22	5.20	5.19	5.17	5.15	5.12	5.09
Population LULW city	0.316	0.316	0.316	0.315	0.314	0.313	0.311	0.309
Population HULW city	0.211	0.211	0.210	0.209	0.209	0.207	0.204	0.201
Population LUHW city	0.205	0.206	0.206	0.208	0.209	0.211	0.214	0.218
Population HUHW city	0.266	0.266	0.266	0.267	0.267	0.268	0.270	0.271
Mean wage LULW city	7.98	7.97	7.97	7.97	7.96	7.96	7.95	7.95
Mean wage HULW city	7.71	7.71	7.70	7.70	7.69	7.68	7.67	7.70
Mean wage LUHW city	10.14	10.15	10.16	10.18	10.20	10.23	10.26	10.26
Mean wage HUHW city	9.46	9.46	9.46	9.47	9.47	9.47	9.46	9.45
Rent LULW city	1.09	1.08	1.08	1.08	1.08	1.08	1.08	1.08
Rent HULW city	0.92	0.92	0.92	0.92	0.92	0.92	0.91	0.91
Rent LUHW city	1.66	1.66	1.66	1.67	1.67	1.68	1.68	1.69
Rent HUHW city	1.34	1.34	1.34	1.34	1.34	1.34	1.35	1.35
Mobility rate, %	1.99	2.08	2.18	2.34	2.57	2.90	3.40	4.16
Mobility rate, high-skilled	2.46	2.68	2.94	3.29	3.75	4.36	5.24	6.63
Mobility rate, low-skilled	1.71	1.72	1.73	1.77	1.87	2.04	2.31	2.69
Migration, (EU+UU)/(EE+UE)	0.13	0.13	0.14	0.16	0.19	0.22	0.30	0.45

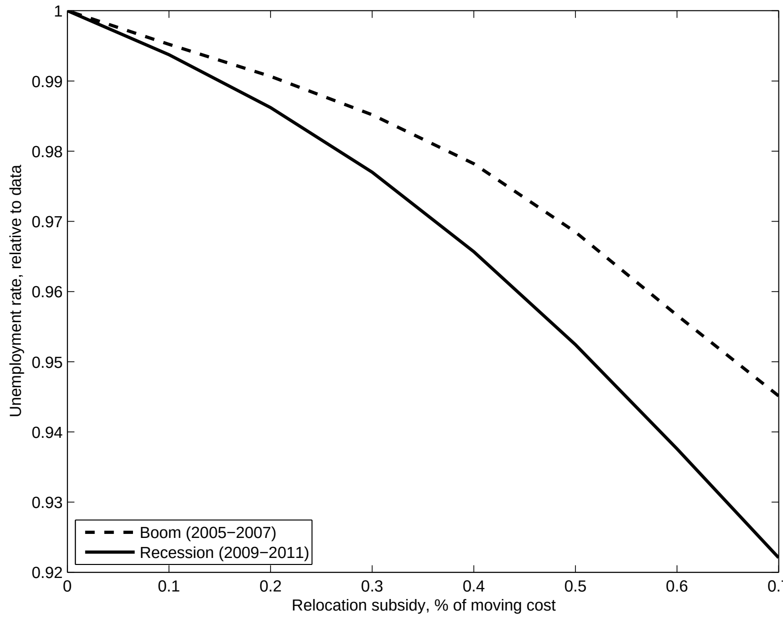
Note: The table shows the effects of various levels of relocation subsidies on the economy calibrated to 2005-2007. See Section 4.1 for details.

Table 7: Effects of relocation subsidies in recession (2009-2011)

Moving subsidy, frac moving cost	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70
Unemployment rate, %	7.55	7.51	7.45	7.38	7.29	7.19	7.08	6.97
GDP	1.000	1.001	1.003	1.005	1.007	1.010	1.013	1.016
Gov't expenses	0.312	0.310	0.309	0.308	0.308	0.309	0.314	0.326
Gov't expenses, % GDP	1.483	1.475	1.467	1.459	1.455	1.458	1.474	1.525
Consumption of goods	1.000	1.000	1.001	1.002	1.003	1.004	1.005	1.005
Consumption of housing	1.000	0.999	0.998	0.997	0.996	0.994	0.992	0.989
Unemp rate LULW city, %	6.58	6.55	6.51	6.46	6.40	6.32	6.20	6.07
Unemp rate HULW city, %	8.14	8.06	7.96	7.84	7.70	7.52	7.31	7.10
Unemp rate LUHW city, %	6.85	6.80	6.74	6.66	6.56	6.46	6.40	6.34
Unemp rate HUHW city, %	8.79	8.75	8.71	8.66	8.61	8.53	8.45	8.35
Population LULW city	0.314	0.313	0.312	0.311	0.309	0.305	0.301	0.297
Population HULW city	0.210	0.209	0.208	0.207	0.204	0.202	0.198	0.194
Population LUHW city	0.208	0.210	0.211	0.213	0.216	0.220	0.225	0.231
Population HUHW city	0.266	0.267	0.267	0.268	0.269	0.272	0.274	0.277
Mean wage LULW city	7.97	7.97	7.96	7.96	7.94	7.94	7.94	7.94
Mean wage HULW city	7.70	7.69	7.68	7.67	7.66	7.66	7.68	7.69
Mean wage LUHW city	10.19	10.21	10.23	10.27	10.31	10.33	10.33	10.33
Mean wage HUHW city	9.49	9.49	9.50	9.50	9.50	9.49	9.49	9.47
Rent LULW city	1.08	1.08	1.08	1.07	1.07	1.07	1.06	1.06
Rent HULW city	0.92	0.92	0.91	0.91	0.91	0.90	0.90	0.89
Rent LUHW city	1.66	1.67	1.67	1.68	1.68	1.70	1.71	1.72
Rent HUHW city	1.33	1.34	1.34	1.34	1.34	1.34	1.35	1.35
Mobility rate, %	2.28	2.46	2.71	3.07	3.54	4.15	5.01	6.40
Mobility rate, high-skilled	3.20	3.64	4.18	4.84	5.64	6.67	8.13	10.53
Mobility rate, low-skilled	1.73	1.76	1.84	2.01	2.29	2.66	3.16	3.95
Migration, (EU+UU)/(EE+UE)	0.12	0.13	0.14	0.17	0.20	0.24	0.32	0.48

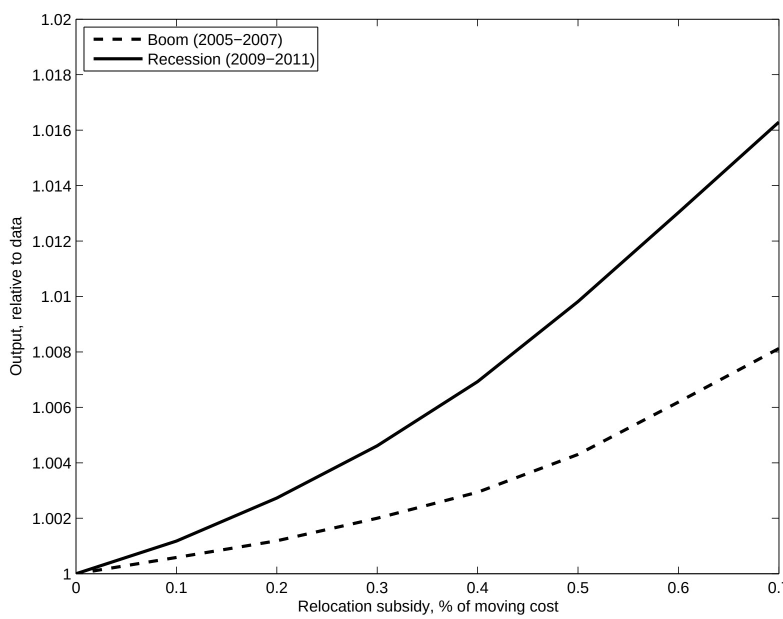
Note: The table shows the effects of various levels of relocation subsidies on the economy calibrated to 2009-2011. See Section **??** for details.

Figure 4: Effect of moving subsidies on national unemployment



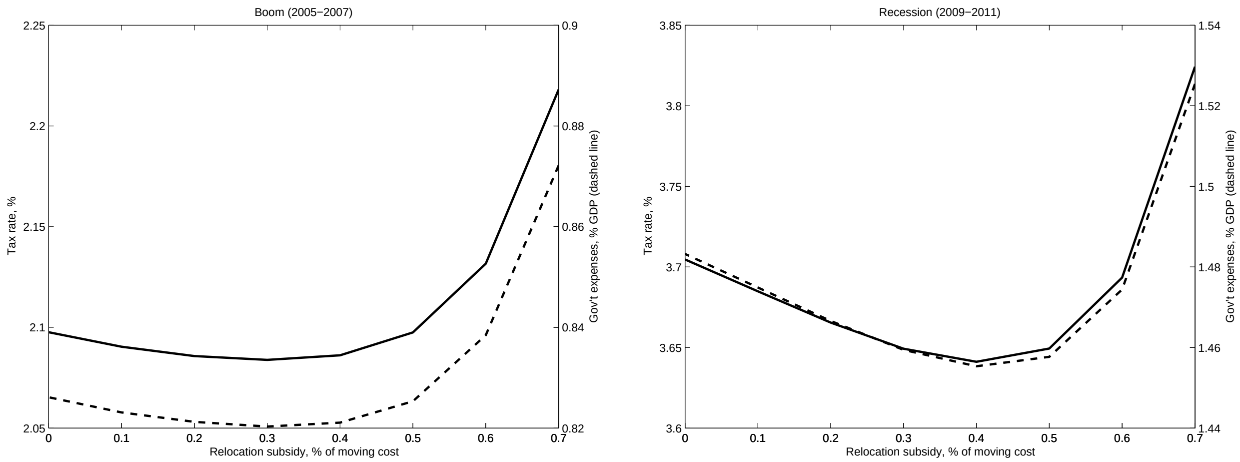
Note: The figure shows the effect of various levels of relocation subsidies on the national level of unemployment in the economies calibrated to 2005-2007 and 2009-2011. See Sections 4.1 and **??** for details.

Figure 5: Effect of moving subsidies on productivity



Note: The figure shows the effect of various levels of relocation subsidies on the national level of output in the economies calibrated to 2005-2007 and 2009-2011. See Sections 4.1 and **??** for details.

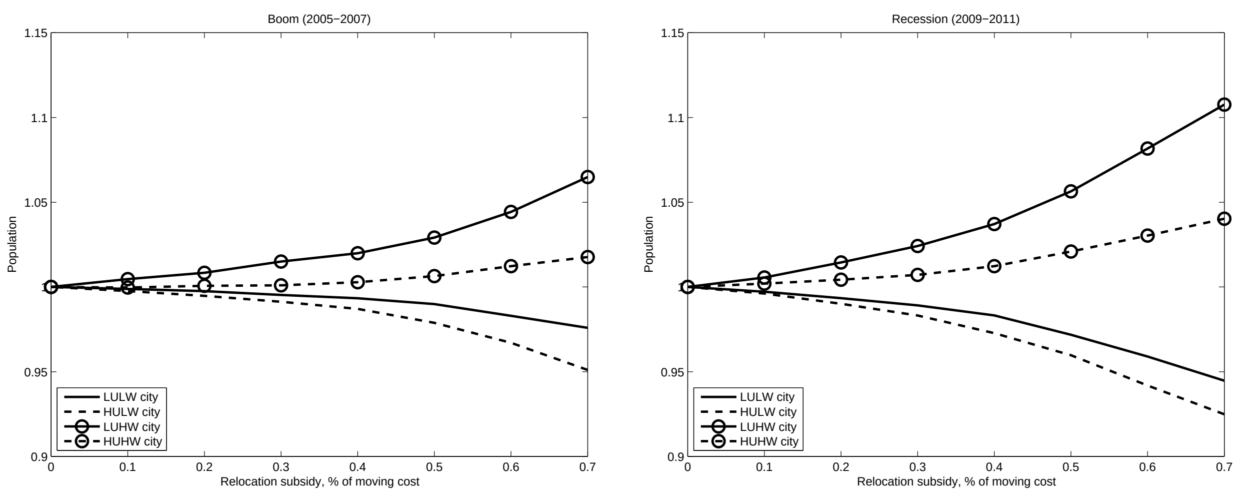
Figure 6: Effect of moving subsidies on tax rate and government expenses



Panel (a) Panel (b)

Note: The figure shows the effect of various levels of relocation subsidies on the budget-balancing tax rate and government expenditures-to-GDP ratio in the economies calibrated to 2005-2007 (Panel a) and 2009-2011 (Panel b). See Sections 4.1 and **??** for details.

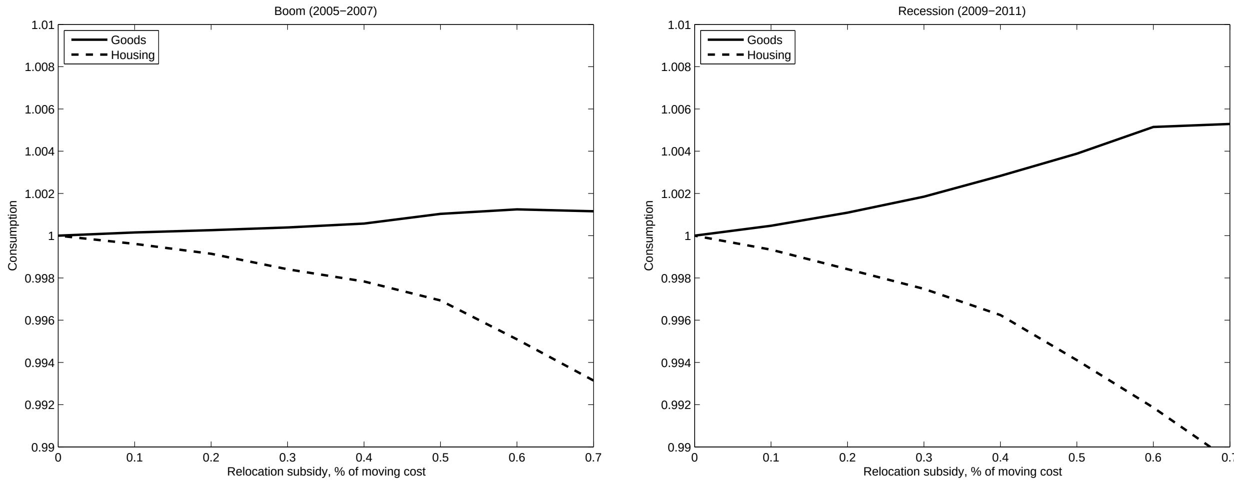
Figure 7: Effect of moving subsidies on distribution of labor across city groups



Panel (a) Panel (b)

Note: The figure shows the effect of various levels of relocation subsidies on the distribution of labor force across city groups in the economies calibrated to 2005-2007 (Panel a) and 2009-2011 (Panel b). See Sections 4.1 and **??** for details.

Figure 8: Effect of moving subsidies on consumption



Panel (a) Panel (b)

Note: The figure shows the effect of various levels of relocation subsidies on the consumption of goods and housing in the economies calibrated to 2005-2007 (Panel a) and 2009-2011 (Panel b). See Sections 4.1 and **??** for details.

Table 8: Effects of moving subsidies in recession. Alternative policy: subsidize only inhabitants of high-unemployment cities

Moving subsidy, frac moving cost	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70
Unemployment rate, %	7.55	7.53	7.50	7.46	7.41	7.36	7.30	7.23
GDP	1.000	1.001	1.001	1.002	1.003	1.005	1.006	1.007
Gov't expenses	0.312	0.311	0.310	0.310	0.309	0.310	0.310	0.313
Gov't expenses, % GDP	1.483	1.479	1.474	1.470	1.466	1.465	1.468	1.479
Consumption of goods	1.000	1.001	1.001	1.003	1.004	1.005	1.007	1.010
Consumption of housing	1.000	1.000	1.000	1.000	1.000	1.001	1.001	1.003
Unemp rate LULW city, %	6.58	6.59	6.61	6.62	6.64	6.66	6.69	6.72
Unemp rate HULW city, %	8.14	8.06	7.95	7.81	7.66	7.46	7.22	6.93
Unemp rate LUHW city, %	6.85	6.84	6.84	6.82	6.81	6.81	6.81	6.84
Unemp rate HUHW city, %	8.79	8.75	8.71	8.67	8.61	8.54	8.44	8.34
Population LULW city	0.314	0.314	0.314	0.314	0.314	0.314	0.314	0.316
Population HULW city	0.210	0.209	0.208	0.207	0.205	0.202	0.199	0.195
Population LUHW city	0.208	0.209	0.210	0.210	0.211	0.212	0.214	0.215
Population HUHW city	0.266	0.266	0.267	0.267	0.268	0.270	0.271	0.273
Mean wage LULW city	7.97	7.97	7.98	7.97	7.97	7.98	7.97	7.96
Mean wage HULW city	7.70	7.69	7.69	7.68	7.67	7.68	7.69	7.72
Mean wage LUHW city	10.19	10.20	10.20	10.22	10.23	10.24	10.25	10.24
Mean wage HUHW city	9.49	9.49	9.49	9.49	9.49	9.48	9.48	9.47
Rent LULW city	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
Rent HULW city	0.92	0.92	0.91	0.91	0.91	0.91	0.90	0.90
Rent LUHW city	1.66	1.66	1.67	1.67	1.67	1.67	1.68	1.68
Rent HUHW city	1.33	1.33	1.34	1.34	1.34	1.34	1.34	1.34
Mobility rate, %	2.28	2.37	2.49	2.65	2.85	3.09	3.42	3.85
Mobility rate, high-skilled	3.20	3.42	3.67	3.96	4.30	4.69	5.19	5.91
Mobility rate, low-skilled	1.73	1.75	1.79	1.87	1.99	2.15	2.36	2.63
Migration, (EU+UU)/(EE+UE)	0.12	0.12	0.13	0.14	0.15	0.17	0.20	0.27

Note: The table shows the effects of various levels of relocation subsidies on the economy calibrated to 2009-2011, when only inhabitants of cities belonging to high-unemployment groups (HULW and HUHW) are eligible for the subsidies. See Section 4.2 for details.

Table 9: Effects of moving subsidies in recession. Alternative policy: subsidize only low-skilled workers

Moving subsidy, frac moving cost	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70
Unemployment rate, %	7.55	7.54	7.53	7.51	7.47	7.43	7.37	7.31
GDP	1.000	1.000	1.000	1.001	1.002	1.003	1.005	1.007
Gov't expenses	0.312	0.311	0.311	0.310	0.309	0.307	0.305	0.303
Gov't expenses, % GDP	1.483	1.481	1.478	1.473	1.466	1.456	1.444	1.431
Consumption of goods	1.000	1.000	1.000	1.001	1.001	1.002	1.003	1.005
Consumption of housing	1.000	1.000	1.000	1.000	0.999	0.998	0.997	0.995
Unemp rate LULW city, %	6.58	6.58	6.59	6.59	6.58	6.55	6.51	6.46
Unemp rate HULW city, %	8.14	8.13	8.11	8.06	8.00	7.92	7.82	7.67
Unemp rate LUHW city, %	6.85	6.83	6.80	6.76	6.70	6.64	6.56	6.50
Unemp rate HUHW city, %	8.79	8.77	8.75	8.74	8.72	8.70	8.67	8.66
Population LULW city	0.314	0.314	0.314	0.314	0.314	0.312	0.309	0.307
Population HULW city	0.210	0.210	0.210	0.209	0.208	0.206	0.204	0.201
Population LUHW city	0.208	0.208	0.209	0.209	0.210	0.212	0.216	0.219
Population HUHW city	0.266	0.266	0.266	0.267	0.267	0.268	0.270	0.272
Mean wage LULW city	7.97	7.97	7.97	7.97	7.96	7.96	7.97	7.97
Mean wage HULW city	7.70	7.70	7.69	7.68	7.68	7.68	7.68	7.71
Mean wage LUHW city	10.19	10.19	10.21	10.23	10.25	10.26	10.27	10.27
Mean wage HUHW city	9.49	9.49	9.49	9.49	9.48	9.47	9.46	9.44
Rent LULW city	1.08	1.08	1.08	1.08	1.08	1.08	1.07	1.07
Rent HULW city	0.92	0.92	0.92	0.92	0.91	0.91	0.91	0.90
Rent LUHW city	1.66	1.66	1.66	1.66	1.67	1.67	1.68	1.69
Rent HUHW city	1.33	1.33	1.33	1.34	1.34	1.34	1.34	1.34
Mobility rate, %	2.28	2.30	2.35	2.45	2.61	2.83	3.14	3.63
Mobility rate, high-skilled	3.20	3.21	3.24	3.28	3.34	3.42	3.52	3.62
Mobility rate, low-skilled	1.73	1.75	1.82	1.95	2.17	2.47	2.91	3.63
Migration, (EU+UU)/(EE+UE)	0.12	0.13	0.15	0.17	0.20	0.21	0.24	0.29

Note: The table shows the effects of various levels of relocation subsidies on the economy calibrated to 2009-2011, when only low-skilled workers are eligible for the subsidies. See Section 4.2 for details.

A Appendix

A.1 Solving the Model

Solving the model involves finding wages, housing rents, and the initial distribution of labor across locations such that the equilibrium, as defined in section 2.7, holds for given parameters of the model. Unfortunately, analytical solutions do not exist due to complexity of the model and non-differentiability of the value functions.

To solve the model, I repeat the following sequence of steps until wages and housing prices in step 1 are equal to those in step 4:

1. In the first iteration, guess wages for age-2 workers, rents in every location and the tax rate τ.[41] In the subsequent iterations, use wages, rents and tax rate from step 4.

2. Solve Bellman equations (2.12), (2.14), (2.15), and (2.16), and obtain decision rules for assets. In the last period a worker's value function is equal to the utility of last period's consumption. Therefore I solve the Bellman equation using backward induction starting from the last period. The fact that utility shocks are extreme value type 1 allows to avoid computation of the I-dimensional integral in the expectation of the value function (equation 2.13).[42]

3. Compute stationary distribution of workers across locations. To do this, first guess unemployment of age-1 workers of every type: $u(s, 1, i)$. Then apply the transition equations (2.18) and (2.19), and use the asset decision rules in order to obtain distribution of employment and unemployment ($n(s, a, i)$ and $u(s, a, i)$) for the fertile ages 2 to T_f. Next, update the guess $u(s, 1, i)$ using equation (2.17). Repeat the procedure until $u_t(s, 1, i) = u_{t+1}(s, 1, i)$ for all (s, i).

4. Solve for new wages and rents using the updated distribution of workers across locations. Wages are computed from equation (2.7), while rents are found by solving equation (2.10). Update τ if the government budget (equation 2.11) is not balanced.

A.2 Robustness

In this section I check whether the size of the effects of relocation subsidies are robust to the choice of values for the interest rate (r) and the cross-location search friction (Δ).

[41] I only need to know wages for age-2 workers. Wages for older workers can be determined as a function of age-2 wages using equation (2.7) as: $w(x, a, i) = \frac{\phi(a)}{\phi(2)} w(x, 2, i)$

[42] For more details, see Arcidiacono and Ellickson (2011).

In order to check whether the value of the interest rate matters for the results I set $r = 0.02$ and recalibrate the borrowing constraint to $B = 3.12$ to match the fraction of households with negative or zero net worth. The moments of the recalibrated model remain nearly unchanged (Table 10) and the effects of the subsidies are very similar to the results under $r = 0.04$ (Table 11), even if slightly smaller.

Since the cross-location search friction (Δ) was set in an indirect way using existing studies about cross-state job search (Section **??**), I check whether effects of the main policy would be different under a smaller and a larger value of the friction: $\Delta = 0.3$ and $\Delta = 0.5$. First, since the moments that define geographic mobility are rather sensitive to Δ, I recalibrate other parameters that determine mobility (σ_ε, μ, κ, and ν) for both $\Delta = 0.3$ and $\Delta = 0.5$. The model fit under alternative values of Δ is presented in Table 12. Under $\Delta = 0.3$, the relative migration to unemployment could not be matched exactly, since the offer arrival rate from other locations is too low and too many unemployed workers choose to relocate without waiting for a job offer. Table 13 shows that the effects of subsidies are not significantly affected by the variation in Δ. The effect of subsidies is somewhat muted when the friction is weak $\Delta = 0.5$, since then workers receive job offers from other locations more often and rely less on the mobility support provided by the government.

Table 10: Model performance, 2005-2007 calibration with interest rate $r = 0.02$

	Model	Data
Skill premium	1.72	1.72
Mean wage %, LULW city	1.00	1.00
Mean wage %, HULW city	0.97	0.97
Mean wage %, LUHW city	1.27	1.28
Mean wage %, HUHW city	1.19	1.19
Unemployment rate %, LULW city	3.57	3.54
Unemployment rate %, HULW city	5.24	5.22
Unemployment rate %, LUHW city	3.88	3.86
Unemployment rate %, HUHW city	5.25	5.24
Mobility rate, % of labor force per year	1.91	1.99
Mobility rate, high/low skilled	1.31	1.43
Mobility rate, ages 25-44	3.44	3.16
Migration, (EU+UU)/(EE+UE)	0.14	0.13
Population, LULW city	0.32	0.32
Population, HULW city	0.21	0.21
Population, LUHW city	0.20	0.20
Population, HUHW city	0.27	0.27
Rent, LULW city	1.00	1.00
Rent, HULW city	0.85	0.85
Rent, LUHW city	1.52	1.52
Rent, HUHW city	1.23	1.23
Housing expenditure share	0.24	0.24
Expenditure share, high/low skilled	0.74	0.74
Population with negative net worth	0.19	0.19

Note: I recalibrate B to match the fraction of individuals with negative net worth, and keep all other parameters as in the 2005-2007 calibration. See Appendix A.2 for details.

Table 11: Effects of moving subsidies, different interest rates

Interest rate	0.04		0.02	
Moving subsidy	0.00	0.50	0.00	0.50
Unemployment rate, %	4.42	4.28	4.44	4.29
GDP	1.000	1.004	1.000	1.001
Gov't expenses, % GDP	0.826	0.825	0.830	0.826
Consumption of goods	1.000	1.001	1.000	0.995
Consumption of housing	1.000	0.997	1.000	0.997
Mobility rate, %	1.99	2.90	1.99	2.73
Migration, (EU+UU)/(EE+UE)	0.13	0.22	0.13	0.19

Note: The table compares the effects of a relocation subsidy that pays 1/2 of the moving cost in the economies with different interest rates both calibrated to 2005-2007. See Section 4.1 and Appendix A.2 for details.

Table 12: Model performance, 2005-2007 calibrations with $\Delta = 0.3$ and $\Delta = 0.5$

	Model $\Delta = 0.3$	Model $\Delta = 0.5$	Data
Skill premium	1.72	1.72	1.72
Mean wage %, LULW city	1.00	1.00	1.00
Mean wage %, HULW city	0.96	0.97	0.97
Mean wage %, LUHW city	1.27	1.29	1.28
Mean wage %, HUHW city	1.19	1.20	1.19
Unemployment rate %, LULW city	3.55	3.59	3.54
Unemployment rate %, HULW city	5.18	5.29	5.22
Unemployment rate %, LUHW city	3.90	3.86	3.86
Unemployment rate %, HUHW city	5.31	5.22	5.24
Mobility rate, % of labor force per year	1.98	1.98	1.99
Mobility rate, high/low skilled	1.42	1.43	1.43
Mobility rate, ages 25-44	3.51	3.46	3.16
Migration, (EU+UU)/(EE+UE)	0.18	0.13	0.13
Population, LULW city	0.32	0.33	0.32
Population, HULW city	0.21	0.22	0.21
Population, LUHW city	0.21	0.19	0.20
Population, HUHW city	0.27	0.26	0.27
Rent, LULW city	1.00	1.00	1.00
Rent, HULW city	0.85	0.85	0.85
Rent, LUHW city	1.53	1.49	1.52
Rent, HUHW city	1.23	1.22	1.23
Housing expenditure share	0.24	0.24	0.24
Expenditure share, high/low skilled	0.74	0.74	0.74
Population with negative net worth	0.19	0.20	0.19

Note: I recalibrate σ_ε, μ, κ, and ν to match the four moments that describe geographic mobility for each value of the cross-location search friction: $\Delta = 0.3$ and $\Delta = 0.5$. All other parameters are kept as in the 2005-2007 calibration. See Appendix A.2 for details.

Table 13: Effects of moving subsidies, different cross-location search frictions

Δ	0.3935 (benchmark)		0.3		0.5	
Moving subsidy	0.00	0.50	0.00	0.50	0.00	0.50
Unemployment rate, %	4.42	4.28	4.43	4.27	4.44	4.33
GDP	1.000	1.004	1.000	1.005	1.000	1.003
Gov't expenses, % GDP	0.826	0.825	0.827	0.816	0.830	0.834
Consumption of goods	1.000	1.001	1.000	1.002	1.000	1.000
Consumption of housing	1.000	0.997	1.000	0.998	1.000	0.998
Mobility rate, %	1.99	2.90	1.98	2.80	1.98	2.98
Migration, (EU+UU)/(EE+UE)	0.13	0.22	0.18	0.20	0.13	0.27

Note: The table compares the effects of a relocation subsidy that pays 1/2 of the moving cost in the economies with different cross-location search frictions all calibrated to 2005-2007. See Section 4.1 and Appendix A.2 for details.