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Housing and the labor market: Time to move and aggregate unemployment ☆

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ABSTRACT

Conventional macro-search models (Mortensen and Pissarides) with unemployment benefits and taxes have been able to account for the variation in unemployment rates across countries but do not account for the role geographic mobility or commuting time might play. We build a model in which both unemployment and mobility rates are endogenous. Our findings indicate that an increase in unemployment benefits and in taxes does not generate a strong decline in mobility but does increase unemployment as in the standard model. We find that with higher commuting costs the effect of housing frictions plays a large role and can generate a substantial decline in mobility.

1. Introduction

The Mortensen–Pissarides model has been shown to successfully explain cross-country differences in unemployment and unemployment spells with two labor market policies: unemployment benefits and taxes. Mortensen and Pissarides (1999) highlights the fact that roughly half of the mileage between a US unemployment rate (6%) to a European one (11%) can be explained by each feature.

However, we posit that there are other policies that can affect the functioning of labor markets. In particular, policies that affect geographic mobility can affect the decision to accept a job, having a direct effect on employment and unemployment rates as well as the duration of unemployment. The policies we have in mind that can affect mobility or commuting decisions are such things as housing regulations and taxes that affect commuting costs, such as gasoline taxes. Moreover, there are substantial differences in mobility rates across countries.

Table 1 provides data on mobility for the United States and Europe. Lines 1–4 in the table show the fraction of individuals in each category having moved to a new residence from year to another. The last line in the table shows the fraction of moves that are between U.S. counties or "travel-to-work" areas in Europe. The residential mobility rate is roughly three times higher in the US than the corresponding rates in Europe for all categories of the labor force. The largest share of the moves is within areas or counties, although there is more inter-area mobility in the US. Some of the mobility can certainly be attributed to students moving. Although we could not find mobility for the student category, we can find

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Table 1
Mobility.

	US (%)	Europe (%)
Total	15.5	4.95
Employed workers	17.1	5.38
Unemployed workers	25.2	10.94
Out of labor force	11.3	2.63
Between counties/areas	42	20.5
Age 16–19	17.5	5
Age 20–24	35	4.4

Source: US: Bureau of the Census, 2000; Europe: European Community Household Panel, 1999–2001. For the age categories for Europe the data comes from Eurostat for 1994–1999.

mobility by age. For 16–19 year olds, the mobility patterns look similar to the total. However, for the 20–24 age group, mobility rates are much higher in the US, 35% as compared to 4.4% for Europe.

In this paper we explore qualitatively and quantitatively through an example, how low mobility can lead to a lower rate of employment. The mechanisms identified in this paper are as follows. Low mobility reflects the inability of housing markets to efficiently allocate workers across locations, for example due to housing market regulations. Therefore, job offers may be less attractive to workers, *ceteris paribus*, due to the difficulty to relocate. Given this, workers could choose to commute longer distances in order to avoid turning down offers. But transport costs may be an obstacle. Coupled with high benefits, then, more job offers are rejected, and commute distances are, on average, lower, and unemployment is higher. That is, there is a *complementarity* between various factors; in particular, difficulty to relocate has stronger effects on job acceptance if commute costs are larger. Our first task is to explore the potential causes of low mobility within a model. The second task is to provide a quantitative account of the consequences of low mobility. We build a modified version of Mortensen–Pissarides in order to capture geographical mobility. Workers receive offers characterized by a commute distance, and have the possibility to move conditional on receiving new location offers.[1] Within a very parsimonious setup, our model captures job acceptance decisions, decisions to move to another dwelling and job creation decisions, with search and matching frictions in the housing and labor market.

In our model, a job location has an associated commuting time that may affect the job acceptance decision. Obstacles to mobility (that arise from rent controls, for example) will affect the reservation strategy of workers. Thus, aggregate unemployment affects the functioning of the housing market. The model can be thought of as the "dual" of typical search models of the labor market. In particular, in the standard search setup there is a non-degenerate distribution of wages but distance is degenerate. In our model, the distribution of wages is degenerate but there exists a non-degenerate distribution of distance from one's job.

The model is also used to provide a quantitative exercise to capture the effect these mechanisms have on unemployment, unemployment duration, and residential mobility. We explore the effects from changes in four factors: benefits, labor taxes, commute costs and housing frictions. Our findings indicate that an increase in unemployment benefits and in taxes do not generate a strong decline in mobility. With higher commuting costs the effect of housing frictions play a large role and can generate a large decline in mobility. We also show that there is a complementarity between commuting and moving decisions, as well as unemployment benefits generosity and mobility costs.

In a related model, Head and Lloyd-Ellis (2008) use a spatial model of housing and show that home owners are less mobile than renters, but that the effect of home ownership on unemployment is quantitatively small. In our paper there is no distinction between owning a home or renting and therefore we abstract from such differences. We view our paper as complementary to theirs as they focus mainly on renting vs. owning. Gaumont et al. (2006) provide an example of how a non-degenerate wage distribution can arise from ex-ante homogeneous agents. In their model, when a worker chooses a job they also randomly choose a "cost to taking the job" that can be interpreted in the context of our model as a commuting cost.

Section 2 presents the model with labor market and housing frictions. Section 3 describes the optimal strategies and equilibrium as well as how frictions in the housing market affect mobility and unemployment rates. Section 4 extends the model to allow for "family shocks." Section 5 lays out the numerical example and parameters. Section 6 concludes.

2. Model

We begin by considering a simple model where a geographical mobility decision interacts with a job acceptance decision to expose the main logic of our framework. We initially assume away any "family shocks" in this section. In

[1] For ease of exposition we refer to locations as housing units, however, we do not explicitly model a housing sector.

Section 4 we enrich the model to prepare the calibration exercise and include family and demographic shocks into the analysis. In Appendix A.4 we explore the role of relocation costs.

2.1. Preferences and search for locations

Time is continuous and individuals discount the future at rate r. Individuals live in dwellings, defined as a bundle of services generating utility to an individual. The defining characteristic of a dwelling, however, is that the services it provides are attached to a fixed location. The services can, of course, depend on the quality of the dwelling and its particular location. Amenities such as space, comfort, proximity to theaters, recreation, shops and job increase the utility of a given dwelling. The dwelling may also be a factor of production of home-produced goods. In addition, the dwelling could be a capital asset. For these services, individuals pay a rent or a mortgage. To keep things tractable we do not model the market for houses or locations. Therefore, we do not keep track of individual house prices. Moving to a new location is costless and instantaneous once a location has been found.

In this paper we focus on one particular amenity, distance to work. Because a dwelling is fixed to a location, the commuting distance to one's job, ρ, becomes an important determinant of both job and location choice. We assume that space is symmetric, in the sense that the unemployed have the same chance of finding a job wherever their current residence. Therefore, ρ is a sufficient statistic determining both housing and job choice. We call this property isotropy of space: Wherever an individual is located, space looks the same. The implication is that there is no reason to move to a different location if unemployed. Section 5.5.1 discusses the isotropy assumption.

Agents randomly receive opportunities to move to a new location that (possibly) allows them to obtain a shorter commute. These opportunities are assumed to be Poisson arrivals with parameter λ_H. The distribution of *new* vacancies is given as $G_N(\rho)$.

We make the simplifying assumption that the ease in which an agent can change locations can be captured in this single variable, λ_H. An interpretation is that it captures various frictions that makes it more difficult to relocate.[2] An increase in λ_H means there are more arrivals of opportunities to find a new location. As λ_H approaches infinity, housing frictions go to zero. The main idea behind λ_H is that agents may not move instantaneously to their preferred location. Such restrictions might arise from length of lease requirements or eviction policies. In the Appendix we discuss the relationship between housing market regulations and housing offers, λ_H, but for now we assume it represents housing market frictions. To simplify the analysis we assume that the rent or mortgage (we make no distinction between renting and owning) is such that utility across dwellings will be equalized to reflect any differences in amenities, a fact that results from the assumption that space (distance) is isotropic.

2.2. Labor market

Individuals can be in one of two states: employed or unemployed. While employed, income consists of an exogenous wage, w.[3] There is no on-the-job search, yet a match may become unprofitable, leading to a separation, which occurs exogenously with Poisson arrival rate s.

Unemployed agents receive income b, where b can be thought of as unemployment insurance or the utility from not working. While unemployed, job offers arrive at Poisson rate p, indexed by a distance to work, ρ, drawn from the cumulative distribution function F_J. Recall that we have imposed equal wages across all locations.

Let $E(\rho)$ be the value of employment for an individual residing at distance ρ from the job. Let U be the value of unemployment, which does not depend on distance, given the symmetry assumption made above. We can now express the problem in terms of the following Bellman equations:

$$(r+s)E(\rho) = w-\tau\rho+sU+\lambda_H \int \max[0,(E(\rho')-E(\rho))]\, dG_N(\rho') \tag{1}$$

$$(r+p)U = b+p\int \max\,[U,E(\rho')]\, dF(\rho'), \tag{2}$$

where τ is the per unit cost of commuting and ρ is the distance of the commute.[4] Eq. (1) states that workers receive a utility flow $w-\tau\rho$; may lose their job and become unemployed—in which case they stay where they are; they receive a housing offer from the distribution of new vacancies G_N, which happens with intensity λ_H, in which case they have the option of moving closer to their job. Eq. (2) states that the unemployed enjoy b; receive a job offer with Poisson intensity p, at a distance ρ', from the distribution $F(\rho)$. They have the option of rejecting the offer if the distance is too far.

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[2] For example, regulations in a housing market, such as rent controls or the inability to evict tenants.

[3] An exogenous wage greatly simplifies the analysis because the wage does not depend on commute distance. However, in the example we allow the wage to depend on taxes and benefits and examine alternative choices for the parameters as a robustness check on the importance of this assumption. In the Appendix we show how the model could be recast in terms of a wage-posting framework.

[4] It is possible to reinterpret commuting as any non-pecuniary aspect of the job.

3. Optimal behavior, equilibrium and steady-states

We now derive the job acceptance and moving strategies of individuals and characterize the equilibrium and steady states.

3.1. Reservation strategies

Observe that E is downward sloping in ρ, with slope

$$\frac{\partial E}{\partial \rho} = \frac{-\tau}{r+s+\lambda_H P_W}, \tag{3}$$

where P_W is the probability of moving conditional on receiving a housing offer. Note that $0 < P_W < 1$ and possibly depends on ρ. The function $E(\rho)$ is monotonic so that there exists a well-defined reservation strategy for the employed, with a reservation distance denoted by $\rho^E(\rho)$, below which a *housing offer* is accepted. Note that there is state-dependence in the reservation strategy of the employed, $\rho^E(\rho)$, with presumably $d\rho^E(\rho)/d\rho > 0$. Evidently, the further away the tenants live from their job, the less likely they will be to reject a housing offer.

After some intermediate steps (described in the Appendix), we can show that the slope of $E(\rho)$ is given by

$$\frac{\partial E}{\partial \rho} = \frac{-\tau}{r+s+\lambda_H G_N(\rho)}. \tag{4}$$

Next, in the absence of relocation costs (this case is studied in the Appendix), tenants move as soon as they get a dwelling offer closer to their current one, implying

$$\rho^E(\rho) = \rho.$$

Denote by ρ^U the reservation distance for the unemployed, below which any *job offer* is accepted, it is defined by

$$E(\rho^U) = U.$$

Using the fact that $E(\rho^U) = U$, we obtain

$$b + p\int_0^{\rho^u} [E(\rho') - U]\, dF(\rho') = w - \tau\rho^U + \lambda_H \int_0^{\rho^U} [E(\rho') - U]\, dG_N(\rho'). \tag{5}$$

Integrating Eq. (5) by parts gives the following implicit equation defining ρ^U:

$$\rho^U = \frac{w-b}{\tau} + \int_0^{\rho^U} \frac{\lambda_H G_N(\rho) - pF(\rho)}{r+s+\lambda_H G_N(\rho)}\, d\rho. \tag{6}$$

The determination of ρ^U is shown in Fig. 1.

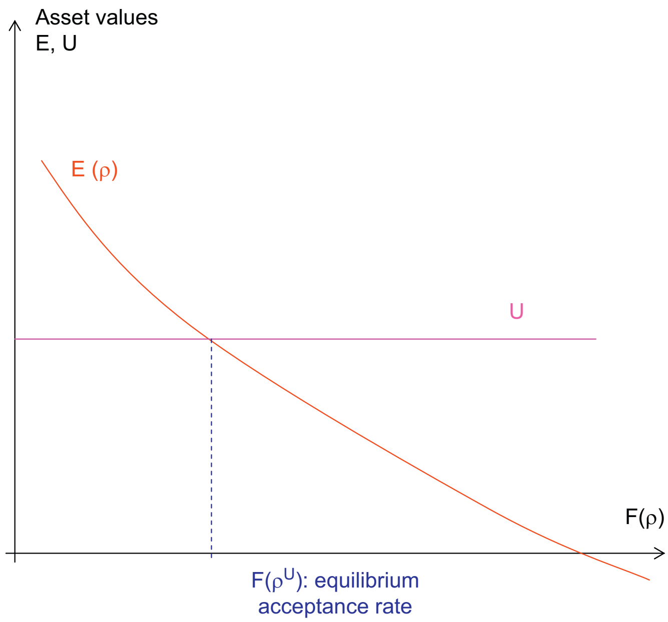

Fig. 1. Determination of ρ_u.

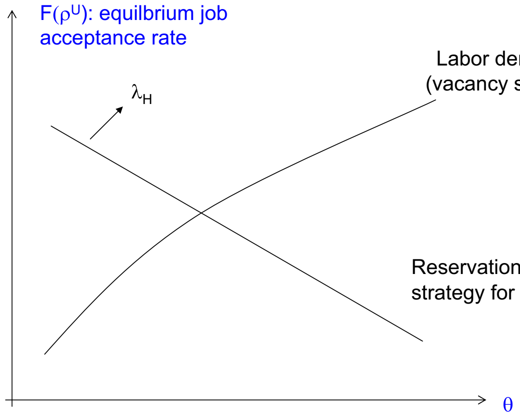

Fig. 2. Vacancies and reservation strategy.

With this specification the model is quite parsimonious, since a single variable, ρ, determines:

1. *Job acceptance*: $F(\rho^U)$.
2. *Residential mobility rate*: $\int \lambda_H G_N(\rho)$ over the distribution of commute distance of employed workers $d\Phi$.

3.2. Free entry

Assuming free entry of firms, and defining $\theta = V/U$ as labor market tightness, we have

$$\frac{y-w}{r+s} = \frac{c}{q(\theta)P_F},$$

where P_F is the rate of acceptance of job offers by the unemployed, as expected from the viewpoint of the firm. We assume, still by symmetry, that the distribution of contacts between the firm and unemployed workers is given as $F(\rho)$, so that $P_F = F(\rho^U)$. This generates a positive link between θ and ρ^U since $q'(\theta) < 0$, characterized by

$$q(\theta)F(\rho^U) = \frac{c(r+s)}{y-w}. \tag{7}$$

The intuition is quite simple. The firm's iso-profit curve at the entry stage depends negatively on both θ (as a higher θ implies more competition between the firm and the worker) and on ρ^U (as more of their offers will be rejected because of distance). The zero-profit condition thus implies a positive link between θ and ρ^U. Note that this relation is independent of λ_H. On the other hand, ρ^U is determined through (Eq. (6)). It is decreasing in $p(\theta)$ and thus in θ, as can be seen in Eq. (A.4). When there are more job offers (higher θ) workers can wait for offers closer to their current residential location; they are pickier. The two curves are represented in (ρ^U,θ) space in Fig. 2.

3.3. Unemployment and the Beveridge curve

Recapitulating, an increase in λ_H, the efficiency of the housing sector, raises the acceptance rate of job offers, increasing θ and thus increasing job offers by firms.

Letting $p(\theta) = \theta q(\theta)$, the steady state unemployment rate is given as

$$u = \frac{s}{s+p(\theta)F(\rho^U)}. \tag{8}$$

In terms of a Beveridge Curve representation (vacancy and unemployment space), increasing λ_H shifts the Beveridge curve inward (less structural mismatch) and also leads to a counter-clockwise rotation of θ. A graphical representation of this result is shown in Fig. 3.

3.4. Housing frictions and mobility

It is now possible to determine how housing frictions affect the decisions of workers and firms. We first show the effect of regulations (λ in our model) on the labor market. Then we show how they affect the commute distances.

3.4.1. The effect of regulations in the housing market

Proposition 1. *An increase in λ_H makes the unemployed less choosy about jobs*: $\partial\rho^U/\partial\lambda_H > 0$.

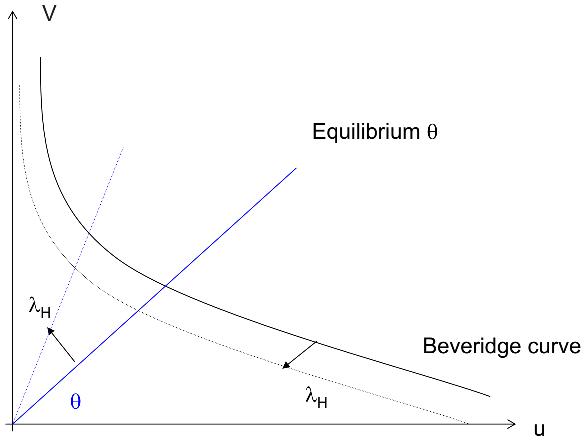

Fig. 3. Beveridge curve.

Proof. See Appendix.

The proposition shows that an increase in the arrival rate of housing opportunities increases the probability the unemployed will accept jobs as they are willing to live farther away from their job initially because moving closer is relatively easier.

Next, differentiating (Eq. (7)) and using Proposition 1, we can determine the effect of housing frictions on job creation:

Proposition 2. *An increase in λ_H increases job creation*: $\partial\theta/\partial\lambda_H > 0$.

Proof. Same as Proposition 1. □

This is an indirect effect caused by more job creation through the higher job acceptance rate of workers. Another interpretation of this effect is that *firms do not like to create jobs where workers have no place to live*.

Using these results it is now possible to determine the effect of housing market frictions on unemployment.

Proposition 3. *An increase in λ_H has two effects on unemployment*:

- *it raises the job acceptance rate of workers* (*through a higher threshold ρ^U*);
- *it raises θ* (*Proposition 2*) *and thus job creation.*

Proof. See Appendix.

Therefore, increases in the opportunity to move will decrease unemployment due to workers being more willing to accept jobs and because there are more vacancies created by firms, which increases market tightness.

3.4.2. Distribution of commute distance

Let $\Phi(\rho)$ be the steady-state distribution of employed workers living at a location closer than ρ. Φ is governed by the following law of motion, for all $\rho < \rho^U$:

$$(1-u)\frac{\partial\Phi(\rho)}{\partial t} = upF(\rho)+(1-u)(1-\Phi(\rho))\lambda_H G_N(\rho)-(1-u)\Phi(\rho)s. \tag{9}$$

Eq. (9) states that the number of people residing in a location at a distance less than ρ from their job changes (either positively or negatively) due to:

- $(+)$ the unemployed, u, receiving a job offer at rate p with a distance closer to ρ with probability $F(\rho)$;
- $(+)$ the employed, $1-u$, who are further away from the current distance ρ (a fraction $1-\Phi(\rho)$), who receive an offer in the housing market with intensity λ_H closer to ρ with probability $G_N(\rho)$;
- $(-)$ the employed, $1-u$, who receive an s-shock, that is, exogenous job destruction.

In steady state and for all $\rho < \rho^u$:

$$\Phi(\rho) = \frac{\lambda_H G_N(\rho)+pF(\rho)\frac{u}{1-u}}{\lambda_H G_N(\rho)+s} \tag{10}$$

$$\Phi(\rho)=\frac{\lambda_H G_N(\rho)+\frac{F(\rho)}{F(\rho^u)}s}{\lambda_H G_N(\rho)+s}\leq 1. \tag{11}$$

The second line above is obtained by replacing u with its steady-state expression in (Eq. (8)). Note that for $\rho=\rho^U$, $\Phi(\rho^U)=1$ as no unemployed individual ever accepts a job offer farther away from a job than ρ^U.

3.4.3. Log linearization

First, consider the special case: $\lambda_H\to\infty$. In the case where housing frictions go to zero, the model collapses to $\Phi(\rho)=1$, meaning that all workers will be located epsilon-close to their job. The job acceptance decision is indeterminate since we now have

$$\rho^U=\frac{w-b}{\tau}+\int_0^{\rho^U} d\rho.$$

The intuition is straightforward: if $w>b$, all job offers are accepted, meaning that ρ^U goes to infinity. Therefore, we obtain the standard Pissarides value for tightness: $q(\theta^P)=(c(r+\sigma))/y-w$ with $\theta^P>\theta^*$ where θ^* is equilibrium tightness in our mode. In addition,

$$\frac{q(\theta^P)}{q(\theta^*)}=F(\rho^U)<1$$

and therefore, with $q(\theta+d\theta)=q(\theta)+q'(\theta)d\theta=q(\theta)(1+\eta_q\; d\theta/\theta)$, we have

$$\frac{q(\theta^P)}{q(\theta^*)}=1+\eta_q\; d\theta/\theta^*=F(\rho^U),$$

hence

$$\frac{d\theta}{\theta^*}=\theta^P-\theta^*=\frac{1-F(\rho^U)}{-\eta_q}>0.$$

The percentage change in tightness is of the order of magnitude of the rejection rate of job offers divided by the elasticity of matching. Since the percentage change in unemployment is the percentage change in tightness multiplied by $(1-u)\eta_p$, the overall change in unemployment due to imperfect housing markets is of the order of magnitude of the fraction of rejected offers $1-F(\rho^U)$ if $\eta_p\simeq-\eta_q\simeq 0.5$.

4. Extension with family shocks

In reality, many residential moves occur due to changes in marital status, family size, schooling choices, neighborhood quality, and so on. To better capture these effects and to better fit the mobility data in the calibration section we now extend the model to include “family shocks.”

In addition to the λ_H shock, individuals may receive a family shock that arrives according to a Poisson process with parameter δ. The shock changes the valuation of the current location, necessitating a move. Upon the arrival of the shock they make one draw from the existing stock of housing vacancies, distributed as $G_S(\rho)$.[5] Note that agents may sample from the existing stock of houses at any time.

Bellman equations are now augmented by a new term (second line) starting with δ: when agents receive a family shock δ, they need to relocate and sample the existing stock G_S

$$(r+s)E(\rho)=w-\tau\rho+sU+\lambda_H\int \max[0,(E(\rho')-E(\rho))]\; dG_N(\rho')+\delta\int \max[U-E(\rho),E(\rho'')-E(\rho)]\; dG_S(\rho'') \tag{12}$$

$$(r+p)U=b+p\iint \max[U,E(\rho'),E(\rho'')]\; dF_J(\rho')\; dG_S(\rho''), \tag{13}$$

Given that we assume that households now have an option to sample into the existing stock of dwelling G_S, we must adapt the determination of the job acceptance decisions. The unemployed receive an offer at distance ρ' but also have the option to move instantaneously if they find a residence in the stock of existing vacant units at distance ρ''. To the extent that ρ' and ρ'' are independent draws, this means that there is a distribution, F, combining F_J and G_S such that the integral terms can be rewritten as $\int\max[U,E(\rho)]\; dF(\rho)$, where ρ is the minimum of the two draws: $\rho=Min(\rho',\rho'')$.[6]

[5] The one draw assumption is not very strong. It is equivalent to making up to N independent draws, in which case it is like one single draw from a distribution $(G_S)^N$. See Lemma 1 in David et al. (2010).

[6] We prove in the Appendix that $1-F(\rho)=(1-F_J(\rho))(1-G_S(\rho))$.

The slope of E with respect to ρ is now

$$\frac{\partial E}{\partial \rho} = \frac{-\tau}{r+s+\lambda_H G_N(\rho)+\delta}, \tag{14}$$

leading to

$$\rho^U = \frac{w-b}{\tau} + \int_0^{\rho^U} \frac{\lambda_H G_N(\rho)+\delta G_S(\rho)-pF(\rho)}{r+s+\lambda_H G_N(\rho)+\delta} d\rho. \tag{15}$$

The determination of ρ^U is shown in Fig. 1. Next, a job separation can now occur in two ways. First, due to the exogenous shock s. Second, workers may receive a family shock, δ, requiring them to redraw from the vacant housing stock distribution, G_S, but are unable to find a sufficiently close dwelling to the current job and (optimally) quit. That is, job separations are given by

$$\sigma = s+\delta(1-G_S(\rho^u)). \tag{16}$$

Therefore, we have an additional effect of ρ^U on unemployment, through quits.

The free entry condition becomes

$$q(\theta)F(\rho^U) = \frac{c(r+\sigma)}{y-w}, \tag{17}$$

where s has been replaced by σ, and similarly for the rate of unemployment

$$u = \frac{\sigma}{\sigma+p(\theta)F(\rho^U)}. \tag{18}$$

Finally, the distribution of commute distance is also affected: in the law of motion of $\Phi(\rho)$, we have, for all $\rho < \rho^U$, two additional terms

$$(1-u)\frac{\partial \Phi(\rho)}{\partial t} = upF(\rho)+(1-u)(1-\Phi(\rho))\{\lambda_H G_N(\rho)+\delta G_S(\rho)\}-\delta(1-u)\Phi(\rho)(1-G_S(\rho))-(1-u)\Phi(\rho)s, \tag{19}$$

- $(+)$ the employed, $1-u$, who are further away from the current distance ρ (a fraction $1-\Phi(\rho)$), who face a δ-shock that brings them closer to ρ after sampling in the stock G_S;
- $(-)$ the employed, $1-u$, who were at a distance less than ρ (a fraction $\Phi(\rho)$), receive a δ-shock that brings them further away from ρ after sampling in the stock G_S; note that a fraction of them would even quit if their new ρ is above ρ^U.

This leads to

$$\Phi(\rho) = \frac{\lambda_H G_N(\rho)+\delta G_S(\rho)+\frac{F(\rho)}{F(\rho^u)}\sigma}{\lambda_H G_N(\rho)+\delta+\sigma} \leq 1 \tag{20}$$

5. Numerical example

Below we parameterize the model to show numerically the effect of various experiments.

5.1. Strategy

In this section, we will match the extended model of Section 4 to the U.S. data, in particular the mobility rate. We therefore need to calculate the mobility rate from the model. Denote by M_K^S the number of movers of status $S=(U,E)$ (unemployed, employed) and for reason $K=(J,D)$ (job-related or family-related), we have:

1. Job-related mobility of the employed (those with a job but relocate once they sample a better housing location)

$$M_J^E = (1-u)\lambda_H \int_0^{\rho^U} G_N(\rho)\, d\Phi(\rho) \tag{21}$$

$$M_J^E = (1-u)\lambda_H \left[G_N(\rho^U) - \int_0^{\rho^U} g_N(\rho)\Phi(\rho)\, d\rho \right], \tag{22}$$

where the second line is found by integrating by parts and noticing that $\Phi(\rho^U) = 1$.

2. Job-related mobility of the unemployed (those who have a job offer, accept it with probability $G(\rho^U)$ and may relocate if they drew a location from G_S closer from their current ρ)

$$M_J^U = up \int_0^{\rho^U} G_S(\rho)\, dF_J(\rho).$$

3. Family-related mobility:

$$M_D^U = u\delta,$$

$$M_D^E = (1-u)\delta,$$

$$M_D^{E+U} = \delta.$$

Note that in M_D^E, some workers quit their job (a fraction $1-G_S(\rho^U)$) since they did not find acceptable housing in the current stock.

5.2. Taxes, benefits and wages

So far, the model has abstracted from taxes. As shown in Mortensen and Pissarides (1999) and Prescott (2004), taxes and benefits can explain much of the variation in unemployment rates across countries. We therefore introduce a tax on labor denoted by t which will be set to 0.22 for the US and 0.4 for Europe. However, it is quite well known that taxes on labor lower wages and therefore that there is a "crowding out" effect: a one percentage point increase in taxes does not necessarily imply a one percentage point increase in labor costs. The net effect depends, in principle, on the elasticity of demand, supply and the bargaining power of workers. In the model developed so far, it is possible to make wages endogenous and introduce a bargaining game. However, the cost is to lose most of the simplicity of the model as the wage will then depend on commute distance. We take an alternative route here: keep an exogenous wage, but argue that part of the effect of taxes is diluted due to a crowding out parameter denoted by ε.[7] In short, if taxes are t, the total labor cost is denoted by $w(1+\varepsilon t)$ and the net wage of workers is $w[1-(1-\varepsilon)t]$. It follows that the main equations of the model become:

$$q(\theta)F(\rho^U) = \frac{c(r+\sigma)}{y-w(1+\varepsilon t)}, \tag{23}$$

$$\rho^U = \frac{w[1-(1-\varepsilon)t]-b}{\tau} + \int_0^{\rho^U} \frac{\lambda_H G_N(\rho)+\delta G_S(\rho)-pF(\rho)}{r+s+\lambda_H G_N(\rho)+\delta}\, d\rho, \tag{24}$$

while the stock-flow equations and the rate of unemployment are unchanged. We set ε to be 0.35, implying that a 10% increase in labor taxes generates a 3.5% increase in labor costs and a 6.5% decrease in the net wage of workers.[8]

Finally, it is unrealistic to assume that a change in unemployment benefits has no direct effect on wages, and only an indirect effect on the average wage in the economy through an increase in reservation wages. This is why in the calibration we allow for the direct effect by arguing that $w(b) = w_{US} + (1-\beta)(b-b_{US})$ where any additional dollar of unemployment compensation raises the wage by $1-\beta$ where β can be thought of as the bargaining power of workers: This is the same specification as that emerging from Nash-bargaining. We set $\beta = 0.5$ so that the bargaining power is symmetric. We set $w_{US} = 0.6$ and the output generated in the match is normalized to $y=1$. Labor taxes in the US are given by $t=0.22$ and unemployment benefits are $b=0.25$. Labor taxes in Europe are $t=0.4$ and unemployment benefits are equal to $b=0.4$ (for a wage of 0.627). So, roughly speaking a replacement rate of 42% in the US and 64% in Europe.

5.3. Parameters

The time period is 1 month and the interest rate, r, is set to 0.0033, corresponding to an annual rate of 0.04. We calibrate to the mobility rate of the employed, 17.1% annually between March 1999 and March 2000, so the target is (17.1/12)%. The number for the employed that move comes from the Bureau of the Census.[9] Of the roughly 31 million persons who moved during that year, 22.3 million of them were employed, 1.5 million unemployed and 7.8 million out of the labor force.

We have three distributions to account for: G_N, new housing offers, G_S, the stock of houses and F, job offers. We assume that these distributions are represented by exponential functions with parameter $\alpha : F = G_N = 1-e^{-\alpha\rho}$ and $G_S = 1-e^{-(\alpha/3)\rho}$.

[7] In the Appendix we derive results for endogenous wages in a wage posting model

[8] Assuming that ε is being approximated by $\varepsilon^{LS}/(\varepsilon^{LS}+\varepsilon^{LD})$ where ε^{LS} and ε^{LD} are the absolute elasticities of labor supply and labor demand, this would imply that $\varepsilon^{LD}/\varepsilon^{LS} = 2$.

[9] Why People Move: Exploring the March 2000 Current Population Survey, P23-204, Bureau of the Census, May, 2001.

Table 2
Commute time as a fraction of total hours worked.

	US	Fr
Mean	0.102	0.079
10th percentile	0.020	0.021
25th percentile	0.041	0.031
Median	0.083	0.063
75th percentile	0.125	0.094
90th percentile	0.188	0.167

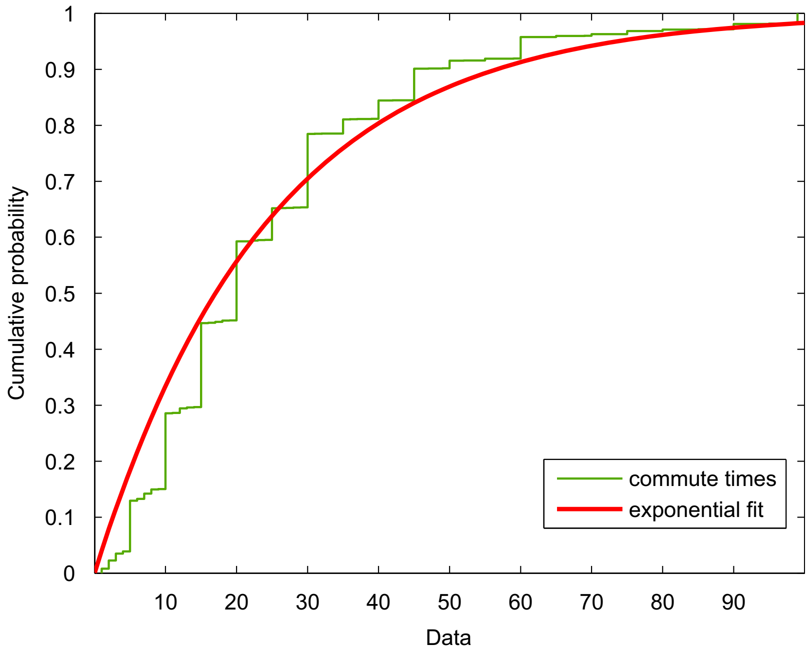

Fig. 4. Distribution of commute times in the US.

To calculate α and τ, we proceed as follows. First, Table 2 shows the distribution of commute times from the Census 2000 as a fraction of total hours worked.[10] The median commuter spends 0.083 of its working time to commute.

We assume that each hour of commute time has a utility cost estimated to be half of the hourly wage of workers (see VanOmmeren et al., 2000). Hence, the total median cost for the median commuter should be 0.083/2 expressed as a fraction of the wage, or $0.083/2*(w/y)$ as a fraction of output (normalized to 1).

The total median cost is also calculated from the distribution of wage offers. Letting ρ^m be the median commute distance, $\rho^m = \ln 2/\alpha$, the total cost incurred for the median commuter is therefore given by

$$0.083/2*(w/y) = \tau\rho^m$$

or

$$\tau = \frac{0.083/2*(w/y)}{\ln 2/\alpha}.$$

We then estimate α from the slope of the distribution F in the data. Inspection of Fig. 4 shows that there is an optimal value of α that best approximates the c.d.f. We find empirically that it is equal to 9.77 after estimating $\ln(1-F(\alpha\rho)) = \alpha\rho$ from the data. Hence, $\tau = 0.585(w/y)$.

Unsurprisingly, given that commute costs per kilometer are higher in France and the benefits are higher, the mean commute time as well as the median are two percentage points lower in France: the unemployed are more choosy.

The program finds the parameters of the model given a target unemployment rate of 4.2% in the US (the average between March 1999 and March 2000), and a target job hiring rate of $p=1/2.4$ monthly. The latter implies an average

[10] The second column of Table 2 is based on the French Time Use Survey 1998-1999. We thank Elena Stancanelli for providing us with the relevant data.

Table 3
Findings.

	Benchmark	Higher b	Higher b, tax	$\tau*1.5$	$\lambda_h/2$
θ_h	1.000	0.686	0.270	0.196	0.166
ρ^U	0.081	0.075	0.064	0.054	0.049
Unemp	0.042	0.054	0.096	0.128	0.147
Unemp Dur (months)	2.400	3.116	5.752	7.905	9.281
Reject	0.767	0.784	0.813	0.840	0.852
Mobility*100	0.244	0.227	0.198	0.170	0.081

duration of unemployment of 2.4 months and therefore imposes a value for σ given that $u=\sigma/(\sigma+p)$ then $\sigma=p(u/(1-u))=0.0183$.

We match the mobility rate to a target value of 17.1% annually with (Eq. (22)). The program finds the values of α and λ_H that are consistent with the target for mobility, given ρ^U, obtained from (Eq. (6)).

We set $p(\theta)=A\theta^{0.5}*F(\rho^U)$. Setting $\theta=1$ gives $A=0.586$. Together with the free-entry condition, (Eq. (7)), this fixes a value for recruiting costs c after normalizing $y=1$.

5.4. Findings

The findings for the benchmark economy are given in Table 3. The benchmark calibration is given in the first column. The other columns show the cumulative effect of institutional changes: higher benefits, b, (from 0.25 to 0.4); then, higher taxes (from 0.22 to 0.4); then a 1.5 increase in commute costs, and finally a decrease in the arrival rate of housing offers by a factor of 2 to roughly match the residential mobility rate (for job related reasons) in Europe (0.00082 per month). The fact that the arrival of housing offers needs to be divided by 2 suggests that the housing market in Europe is considerably more sclerotic than that of the US.

The combination of benefits and taxes more than doubles the unemployment rate, similar to that in Mortensen and Pissarides (1999). The inclusion of the housing market frictions and commute costs increases the unemployment rate by about 50%, from 9.6% to 14.7%.

Our findings indicate that labor market institutions can account for a large part of cross-country differences in unemployment but perform poorly in terms of explaining low mobility. Adding in housing frictions and commute costs delivers both low mobility and a quite sizeable increase in unemployment. Taxes and benefits alone generate a 4 percentage point increase in unemployment. Interestingly, housing frictions, per se, account for only a small portion of unemployment when commute costs are low. In other words, there is strong complementarity between the two parameters.

5.5. Robustness

We provide several robustness checks to get a better understanding of the behavior of the model. In the first, we change the assumption of isotropy. Then we look at various changes to parameters.

5.5.1. Isotropy

The assumption of isotropy of space in our model is convenient: the current location of employed and unemployed workers does not affect their choices of job acceptance. Relaxing this assumption leads to a more complex set of equations in which all distributions of wage offers and housing offers are indexed by the current location.

In particular, the unemployed may now have a motive for moving, given that some locations may be better than other to get better subsequent job offers. The previous two main equations now become a function of the current location denoted with index of location j in the relevant space:

$$(r+s)E(\rho,j)=w-\tau\rho+sU(j)+\lambda_H\int \max[0,E(\rho',j')-E(\rho,j)]\,dG_{N,j}(\rho'), \tag{25}$$

$$(r+p)U(j)=b+p\int \max[U(j),E(\rho',j')]\,dF_j(\rho')+\lambda_H^U\int \max[U(j'),U(j)]\,dG_{N,j}(\rho'), \tag{26}$$

where the distributions and the asset values are now themselves indexed by the current location j of workers. In the second equation, the last term reflects the fact that moving to another location when unemployed may be preferred to staying.

A first insight to the extension with anisotropy is therefore to raise the mobility rate in the calibrated model, through the additional mobility of the unemployed. Note however that the parameter δ played a similar role in our previous benchmark model extended with demographic shocks so that, strictly speaking, one can generate a non-zero mobility rate of the unemployed workers even with isotropic space.

A second insight is that the arrival rate of offers when unemployed may be lower for the unemployed: in the second equation describing the asset value of unemployment, we introduced a notation λ_H^U specific to the unemployment status with $\lambda_H^U \leq \lambda_H$ of the employed. This may arise due to a possible reluctance of landlords to sign a lease with an unemployed worker/household.

Third, given the relative degree of complexity of eviction procedures in some European countries, the mobility rate of the unemployed workers in this second equation may be even lower in Europe, arguably close to zero, while it may remain positive in a more fluid housing market. This extension may therefore exacerbate differences between Europe and the US from the calibration.

To go further, some spatial structure is requested. A convenient and frequent assumption in the literature (e.g. see Fujita, 1989) is to assume a monocentric city, in which one particular point in space is the Central Business District (CBD hereafter) and all jobs are located in this point, which will be the origin by convention. Therefore, on a line representing space, the relevant statistic will still be ρ, the distance to the CBD. The key question will be whether Eq. (25) still requires indexing asset values with the current location.

For this to be the case, one of the two following conditions needs to hold:

1. The distribution of housing offers characterized by G_N depends on the current location j.
2. The value of being unemployed in j depends on the location j.

One can see from Eq. (26) that this second condition amounts to the fact that the job offers distribution F also depends on current location.

In other words, if the spatial unit we consider is such that information about job offers and housing offers does not depend on space (e.g. a small town or a city with centralized information on jobs and housing such as the internet), then all the equations become independent on the current location and our previous analysis carry through exactly identically: the spatial structure is irrelevant, except for determining reservation commute distances.

Alternatively, if any of the distributions G_N and F depends on the current location, then we need to consider a different model. In Wasmer and Zenou (2002, 2006) and, the authors have precisely studied a search and matching model within a monocentric city. In their model, the efficiency of job matching did depend on distance (redlining, see Zax and Kain, 1996, or imperfect information spreading, Rogers, 1997, Zenou, 2009) leading to two urban equilibrium: one in which the unemployed lived at the periphery of the city (segregated city) and one in which they lived closer to the center (Wasmer and Zenou, 2002). In Wasmer and Zenou (2006) they study the case in which mobility costs affect the equilibrium and lead to a third equilibrium where the unemployed and the employed coexist within the same areas. The idea of integrating this spatial structure with search frictions in a monocentric city with our model of frictional housing market and reservation commute distance, has, to our knowledge, not been done and would generate many additional insights.

5.5.2. *Alternative values of τ and λ_H*

Next, we explore the importance of the assumption that commuting costs, τ, are assumed to be 1.5 larger in column 4 in Table 3. We believe that τ is between 1.25 and 1.75 higher in Europe than in the US, because of higher gasoline taxation and the possibly larger cost of insuring. However, we cannot attribute a precise value to the higher commute costs in Europe because public transportation may be a partial (and imperfect) substitute. To be agnostic, we present a simulations in which we describe the effect of multiplying τ by 1.25 and 1.75 (Table 4).

Next, we look at the unemployment effect of dividing λ_H by less than 2 (1.67), and more than 2 (2.33). The experiments shows no big difference in terms of the resulting unemployment rate.

5.5.3. *Endogeneity*

Due to the fact that the wage is not endogenous we now provide several robustness exercises to show how the findings change with a change in the parameters. Table 5 shows how unemployment is affected by changes in β, ϵ and α. As with Table 3 the columns after the benchmark in column 1 show the cumulative effect of institutional changes. Changing β or α has only small effects on unemployment. However, changes in ϵ can have large effects on unemployment. When $\epsilon = 0.15$ unemployment rises to over 20%. Note that this value of ϵ means that the wage of the worker falls by 85%.

Table 4
Robustness.

	Unemployment rate
$\tau * 1.5$	0.128
$\tau * 1.25$	0.112
$\tau * 1.75$	0.143
$\lambda_H/2$	0.147
$\lambda_H/1.67$	0.146
$\lambda_H/2.33$	0.148

Table 5
Robustness: effects on unemployment.

	Benchmark	Higher b	Higher b, tax	$\tau*1.5$	$\lambda_h/2.0$
Changes in β					
$\beta=0.5$	0.042	0.054	0.0956	0.1272	0.1322
$\beta=0.4$	0.042	0.054	0.0911	0.1212	0.1263
$\beta=0.3$	0.042	0.054	0.0877	0.1166	0.1219
$\beta=0.6$	0.042	0.054	0.1013	0.1349	0.1399
$\beta=0.7$	0.042	0.054	0.1088	0.1449	0.1499
Changes in ϵ					
$\epsilon=0.15$	0.042	0.0597	0.1475	0.197	0.2026
$\epsilon=0.25$	0.042	0.0564	0.1124	0.1498	0.1551
$\epsilon=0.35$	0.042	0.054	0.0956	0.1272	0.1322
$\epsilon=0.45$	0.042	0.0522	0.0861	0.1143	0.1193
$\epsilon=0.55$	0.042	0.051	0.0805	0.1068	0.1118
Changes in α					
$\alpha=9.77$	0.042	0.054	0.0956	0.1272	0.1322
$\alpha=11$	0.042	0.0539	0.0953	0.1267	0.1317
$\alpha=13$	0.042	0.0538	0.095	0.1259	0.1309
$\alpha=9$	0.042	0.054	0.0957	0.1275	0.1325
$\alpha=7$	0.042	0.0541	0.0961	0.1282	0.1334

6. Concluding comments

In this paper we have taken seriously the idea that labor market frictions, and in particular the reservation strategies of unemployed workers when they decide whether to accept a job offer, depend strongly on the functioning of the housing market. This interconnection between two frictional markets (housing and labor) can be used to understand differences in the functioning of labor markets. This paper has offered such a model, based on decisions to accept or reject a job offer, given the commuting distance to jobs. The model is relatively parsimonious, thanks to simplifying assumptions such as the isotropy of space, an unrealistic assumption but which conveniently provides closed form solutions and makes it possible to explain quit, job acceptance and geographic mobility decisions with a decision rule based on a single dimension.

In our numerical example, we find that labor market institutions can lead to large changes in unemployment but have little effect on mobility. In contrast, our ‘‘spatial block’’, that is housing frictions combined with higher commute costs, explain well low mobility and a quite sizeable increase in unemployment.

Interestingly enough, housing frictions, per se, account for only a small portion of unemployment when commute costs are low: there is a strong complementarity between the two parameters: when commuting is costly and when it is difficult to relocate in the future, then job rejection is much more frequent.

Future work should attempt to enrich the model to introduce more specific urban features such as anisotropy of space and the existence of centers in cities and suburbs, as well as different groups of the labor force. Our work is a first step in integrating housing and labor markets in a coherent macroeconomic model. In particular, since the model is simple, it can be extended to deal with new issues such as discrimination in the housing market, mobility allowances or ‘‘moving toward opportunity’’ schemes, spatial mismatch issues and so on, as in the urban economics literature.

Appendix A. Supplementary data

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jmoneco.2011.10.008.

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