Labor Mobility Over the Business Cycle

Eugenia Gonzalez-Aguado*

June 2022

Abstract

This paper studies the macroeconomic effects of internal migration in an economy with labor market frictions and quantifies its role in mitigating asymmetric shocks. Labor mobility is viewed as a key mechanism to stabilize the economy from regional shocks in currency unions. However, this view does not take into account the equilibrium effects of worker mobility in the presence of search frictions. First, I gather new evidence connecting individual migration decisions to aggregate economic outcomes over the business cycle. I show that during the Great Recession in the United States labor flows across states strongly responded to changes in economic conditions. Moreover, I show that job-to-job transitions account for most of the interstate movements, but during downturns, there is a significant increase in the relocation of unemployed workers across states. Then, I develop a general equilibrium model with local and aggregate business cycles in which search frictions are crucial to generating the observed patterns in the data. I calibrate the model to the U.S. economy during the Great Recession and study the implications of labor mobility on local and aggregate labor markets.

*Toulouse School of Economics. E-mail: eugenia.gonzalez@tse-fr.eu

1 Introduction

In a seminal paper, Mundell (1961) argues that the degree of regional migration within a country or monetary union interacts in a critical way with the design of fiscal transfers. If during a regional downturn agents can migrate from an area with high unemployment to an area with low unemployment, there is less need for fiscal transfers across regions to provide social insurance. However, there is evidence that in the United States internal migration decreases during recessions. Is then labor mobility a useful mechanism to ameliorate differences in regional economic performances during recessions?

In this paper, I gather new evidence connecting individual migration decisions to aggregate economic outcomes, and then I build a quantitative model that jointly accounts for this evidence. I use this model to assess the role of geographical labor mobility over the business cycle. The model is able to reproduce two key aspects of the data that have been overseen in the migration literature. First, migration is procyclical. During recessions, all states suffer from lower output levels and lower employment rates but some states are more affected than others. Despite these regional differences, migration rates overall decrease. Second, the majority of people moving across states in the United States were employed at the time when they moved and a large fraction of movers experience a job-to-job transition—that is, they do not experience a non-employment spell during their transition from one location to another.

As shown by Kennan and Walker (2011), workers' decisions on where to live are significantly influenced by their income prospects in each location. This suggests that migration largely depends on the economic conditions that workers face in their current location and in the potential locations to which they could move. Data from the Survey of Income and Program Participation (SIPP) provides detailed information on individuals in the United States, about their labor status and their decisions to migrate. Given the panel structure of the survey, with this data I observe individuals' characteristics and their economic outcomes both before and after they move to a different state. Then, I provide new evidence on how the determinants of migration change significantly depending on the employment status of the worker. I find that most interstate movers are employed at the time they move, around 56% of movers. Moreover, almost half of the transitions across states are job-to-job transitions. Importantly, during recessions this picture changes dramatically, as the number of workers that move from nonemployment increases and the number of job-to-job transitions for movers decreases. That is, document that although nonemployed workers are more likely to migrate during recessions, the number of workers that move from a job in one state to a job a different state is procyclical, and therefore decreases during recessions. Given that job-to-job transition account for most of the interstate employment transitions, its procyclicality generates migration rates that are also procyclical, even though for nonemployed workers migration rates is countercyclical.

Aggregate flows of workers across states experience significant changes due to fluctuations in regional economic conditions. During recessions, economic performance across regions varies largely.

For instance, although the Great Recession affected all U.S. states, some states were more greatly impacted by the recession than others were. Consider the example of New York and Arizona. In these states, unemployment rates right before 2007 were very low. However, during the recession, in Arizona unemployment rates increased from 4 per cent to almost 12 per cent, whereas in New York it increased only from 4 to around 8 per cent. These large differences in the outcome of the recession generated changes in the migration patterns between these states: the number of workers moving from Arizona to New York increased by 25 per cent between 2007 and 2010, whereas, flows from New York to Arizona declined by more than 30 per cent during this period.

I then use data on bilateral flows of people across U.S. states from the Internal Revenue Service (IRS) to see the relationship between the increase in dispersion during recessions and the migration patterns across states. I find that aggregate labor flows are significantly determined by the relative performance across states. Specifically, I show that during the Great Recession changes in the relative unemployment rates between two states are crucial to explain the observed patterns of migration between these states.

To quantify the importance of these features of migration over the business cycle I build a general equilibrium model of the labor market with multiple locations and search frictions. There is an aggregate productivity process that affects all locations, but each location has a different sensitivity to the aggregate shock. Workers in this economy can be employed or unemployed. There are two features of the search environment in the model that are crucial to generate the patterns observed in the data. First, workers can be living in one location but looking for a job in a different location. Second, I the model allows for on-the-job search, that is, workers can be employed but searching for an alternative job. These two features together allow the model to capture the observed patterns in the data regarding transitions between employment states for both, workers moving to another state and for workers staying in the same state. Specifically, we observe that job-to-job transitions across states are very common, so it is important that in the model workers can search on the job in order to make employment to employment transition, and, in addition to that, they can search in a different location to the one where he is currently working. I model on-the-job search along the lines of the models of Cahuc et al. (2006) and Lise and Robin (2017) which assume sequential auction bargaining for determining the wages in equilibrium. I calibrate the model to match a given set of moments for the 9 U.S. Census Divisions. I show that the model is able to reproduce the main features of the data regarding employment transitions for both employed and nonemployed workers, migration rates, and population shares. Moreover, the model can account for the different patterns of migration for employed and nonemployed workers, namely, that the number of job-to-job transitions for movers is procyclical and the number of noemployment to nonemployment transitions for movers is countercyclical. Intuitively, during recessions spatial differences increase in that job finding rates across locations become more disperse. This incentivizes nonemployed workers located in very adversely affected locations to move to relative better off regions. On the other side, given that the recession affects all locations, job finding rates are overall lower than during booms. This implies that employed workers that are searching for an alternative job abroad will receive fewer offers, which thus lowers the probability that these workers will move to a new location. The total effect of migration is also procyclical. This is due to the higher fraction of movers that are employed.

Related Literature. This paper relates to the literature that studies the cyclical properties of migration. Several papers have focused on the finding that migration is procyclical. Moreover, these patterns are robust across countries. For example, Pissarides and Wadsworth (1989) documents the procyclicality of migration in Great Britain and Milne (1993) for Canada.[1] More recently, focusing on the United States, Saks and Wozniak (2011) analyze the migration across states and counties and find that migration is strongly procyclical even after controlling for relative local economic conditions. They interpret these results as evidence that the net benefit to moving rises during booms. However, these papers focus only on the empirical evidence. I contribute to this literature by providing an explanation to this well-known fact both empirically and theoretically. In particular, I show that the procyclicality of migration is mainly accounted by the procyclical behavior of job-to-job migration and provide a new theoretical framework that is able to capture this patterns.

Another paper that looks at the responses of migration to economic conditions is Monras (2018). He provides evidence that inflow rates—that is, number of people entering a location relative to the population in that location— are more responsive to changes in economic conditions than outflow rates—number of people leaving a location relative to the population in that location. He also develops a model that is able to reproduce this fact.

In this paper I also document the differences in the patterns of migration between employed and nonemployed workers. Schlottmann and Herzog (1981) and Herzog Jr et al. (1993) look at the differences in the propensity to migrate for employed and unemployed workers and find that unemployed workers are more likely to migrate. Using panel data from the SIPP, I document, besides this finding, the differences in the cyclicality of employed and nonemployed workers. Moreover, I use these data to compute employment transition rates—job finding and separation rates—for people that migrate across states.

This paper also contributes to the search and matching literature by providing a new theoretical framework that features both off and on-the-job search and worker mobility across multiple locations. This model mainly builds in the model of Lise and Robin (2017) but adds multiple locations and geographical labor mobility.

The paper is organized as follows. Section 2 presents the main empirical evidence. Section 3 describes the model and its quantitative analysis is presented in Section 4. Then, in Section 5 the main results of the quantitative model regarding the cyclicality of migration are analyzed. Section 6 discusses the role of labor mobility during recessions, and how it affects both the national and local economies. Finally, Section 7 concludes.

[1] See Greenwood (1997) for a review of papers on this topic.

2 Empirical Evidence

This section presents the main empirical evidence that motivates the paper and that is used to discipline the quantitative model. There are three main empirical facts. First, during recessions migration across states decreases even though dispersion of employment rates across states increases. Second, during recessions states that perform relatively worse experience a larger drop in inflows. And, third, mobility patterns are different for employed and non-employed workers: most inter-state transitions are job-to-job transitions, and this kind of mobility is procyclical, which explains the overall procyclicality of migration.

2.1 Data description

I use two sources of U.S. internal migration data. The first one is the Internal Revenue Service (IRS) which collects data on the total number of tax returns and exemptions in each county and state in the United States, and reports how many of these returns and exemptions are from tax fillers that were in a different county/state in the previous fiscal year. For the main analysis, this papers uses data on returns instead of exemptions, but results using exemptions can be found in the Appendix. From 1980 to 1990 the data available only contains the total amount of inflows and outflows to and from a given county, but it does not contain all bilateral flows across any two counties or states. Starting in 1990, the data contains all bilateral flows across counties and states, which allows thus to construct matrices of bilateral flows.[2] This data is aggregate data in the sense that it only contains total amount of flows across location, but it does not allow us to identify particular characteristics of workers moving across states.

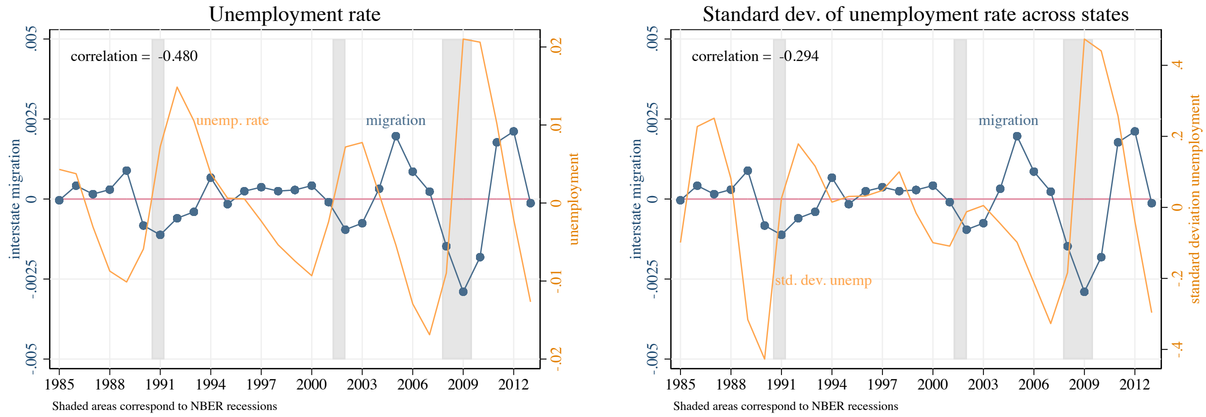
The second source of data that I use is the Survey of Income and Program Participation (SIPP) which is a longitudinal household survey conducted by the U.S. Census. This survey is structured in different panels and within each panel there are different waves corresponding to each time a household is interviewed.[3] In each panel, interviews cover a period between 2 and 4 years. Interviews are conducted every 4 months but responses correspond to monthly or weekly frequencies, depending on the questions. This data is useful to analyze interstate migration because it follows individuals that move across states, allowing thus to have information on income or labor market variables, among others, both before the individual moved and after he moved. Using this data, it is possible to construct transition rates across employment status at the time of the migration at a monthly frequency.

In the baseline analysis, I restrict the analysis of the SIPP data to all individuals between 21 and 60 years old in order to avoid location decisions related to college or retirement. Given that the interest of the paper is in the labor market, I only consider individuals that are somewhat attached

[2] Prior to 1990, the data is available at the National Archives, under the series *County to County, State to State and County Income Migration Flow Data Files.* Post 1990 data is available at the IRS SOI Tax Stats.

[3] I use panels 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1996, 2001, 2002, 2004, and 2008.

Figure 1: Interstate migration and unemployment rate



to the labor market in that they experience at least one employment spell during their time at the survey. In the main analysis I consider workers to be either employed or non-employed. Additional analysis using a definition of unemployment instead of non-employment is provided in the Appendix. The reasons to focus on non-employment are twofold. First, it makes it more comparable to the aggregate data form the IRS, in which there is no distinction of the population regarding their employment status. Second, there is a significant fraction of the population that transition between out of the labor force and employment (or vice versa), and with a focus on unemployment we would miss these type of workers.

Other data sources used in this paper are the Bureau of Labor Statistics that provides data on employment and unemployment by states since 1976, and the Bureau of Economic Analysis that provides data on annual GDP by states since 1963.

2.2 Labor mobility and the business cycle

It has been documented in the literature that migration flows within the United States are procyclical, that is, during recessions there is a decrease in the number of people that move across states.[4] Here, I provide further evidence that shows that, not only migration decreases during recessions, but also recessions are precisely the periods where dispersion of employment measures across states is the largest. This introduces a puzzle in the labor mobility literature, as we would expect that workers would take advantage of a higher dispersion across states to move towards relatively better locations. Instead, the data shows the opposite.

Figure 1 shows the evolution of interstate migration rate together with the evolution of the national unemployment rate (left panel) and the standard deviation of unemployment rates across states (right panel). Recessions are associated with an increase in unemployment rate, an increase in the geographical dispersion of unemployment rates—measured as the standard deviation

[4] See Saks and Wozniak (2011).

Table 1: Cyclicality of interstate migration

Correlations	Annual	Quarterly
Migration and unemployment rate	-0.482	-0.192
Migration and employment rate	0.334	0.135
Migration and st. dev. unemp. across states	-0.325	-0.026
Migration and st. dev. emp. across states	-0.202	-0.104
Unemployment rate and st. dev. unemp. across states	0.802	0.810
Employment rate and st. dev. emp. across states	-0.742	-0.568

of unemployment across states— and a sharp decrease in the migration rate. Table 1 reports the corresponding correlations between migration, unemployment or employment rates, and a measure of dispersion across states. Migration at an annual frequency is measured using the IRS data, whereas migration at a quarterly frequency is computed using microdata from the SIPP.[5] We observe procyclical migration and countercyclical dispersion of employment and unemployment rates across states.

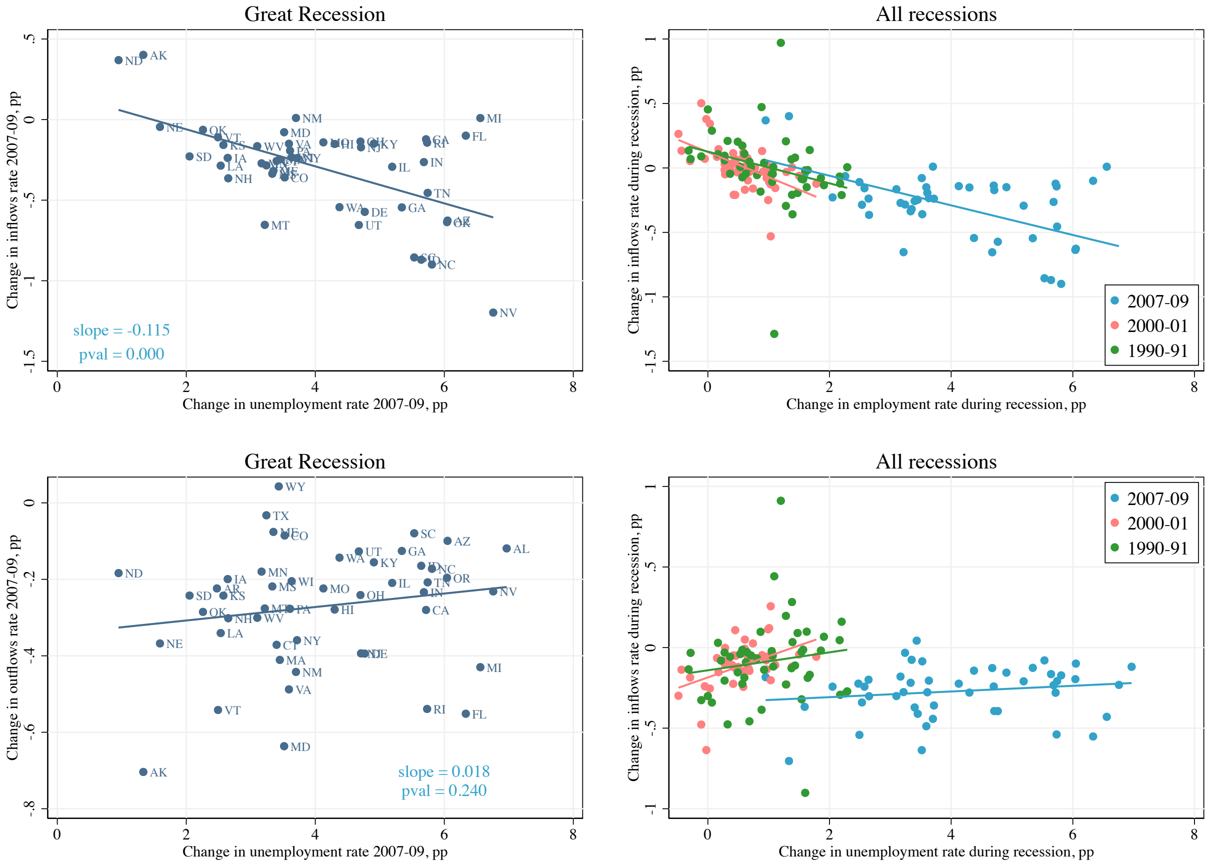
2.3 Inflows and outflows across states

Even though migration decreases during recessions, inflows and outflows of individuals moving into and out of a state do respond to economic differences across states. Here, I show how inflows to a particular state changed during recessions depending on how large the increase in unemployment rate was in that state. I define the inflow rate as the number of people that move to a state in a particular year over the total population in that state.

The top-left panel of Figure 2 shows the relation between the growth in the inflow rate during the Great Recession in a given state and its change in unemployment rate in that state during those years. There is a clear negative relation: states who suffered the most (larger increase in unemployment rate) such as Nevada, North Carolina, or Arizona, are the states whose inflows decrease the most. That is fewer people moved into this states compared to before the recession. On the other hand, states in which unemployment rates did not increase significantly, such as Nebraska, and especially, Alaska and North Dakota, experienced relatively higher inflow rates. In line with the results above about procyclical migration rates, in this figure it is also apparent that most states experienced a decrease in the inflows of people that they received during the recession. The right panel of Figure 2 augments the data points by including two previous recessions. We can see that, although unemployment rates were not as affected by the recessions of 2001 and 1990-91 as they where in 2007-09, the negative relation between change in inflows and change in unemployment rates still holds.[6]

[5] Both series show similar patterns. See Appendix X for a comparison.
[6] See Appendix for the same analysis done with employment rates. Same conclusions hold.

Figure 2: Change in Inflows and Outflows and Unemployment by States



When we consider outflows instead of inflows, we should expect the opposite relation: states where unemployment rates increased the most should see an increase in the outflows from their state. The bottom panels of Figure 2 plot the change in the outflow rate, that is, number of people leaving a state over number of people in that state, against the change in unemployment rates during recessions. The relationship is positive although less significant that the relationship between inflows and unemployment. This result is in line with what previous literature has found. Monras (2018) shows that most of the variation in-migration rates respond more strongly to economic shocks than out-migration rates.

Bilateral flows. If instead of focusing on total inflows or outflows in one state we analyze flows between any two states, we can show that relative economic conditions between these two states matter for the decision to move. To see this, I run the following regression:

$$f_{odt} = \alpha_{od} + \beta U_{odt} + \gamma X_t + t + u_{odt}, \tag{1}$$

where f_{odt} is the amount of people in logarithms that moved from state o to state d in year t, and U_{odt} is the difference between the unemployment rate in origin o and destination d states. That is,

Table 2: Bilateral flows and unemployment

Flows from o to d:			
$\text{Unemp}_o - \text{Unemp}_d$	0.030	0.030	0.030
	(0.000)	(0.000)	(0.000)
Unemp rate in US		-0.767	
		(0.047)	
Recession year			-0.038
			(0.002)

the higher U_{odt} is the better the destination state is in unemployment terms relative to the origin state, and so, we should expect a positive relationship between U_{odt} and f_{odt}. Finally, X_t contains other national variables such as national unemployment rate or an indicator for recession years. Fixed effects α_{od} are added in order to control for any idiosyncrasy between states o and d that makes flows higher or lower in these states. This could capture, for example, distance across states, or similarity of weather conditions.

Table 2 contains the results of regression (1) and confirms that the direction of flows across any two states respond to changes in economic conditions between these two states. In the first column, only fixed effects and the time trend are added in the regression, besides the main variable of interests, the difference in unemployment rates. A one percentage point increase in the difference in unemployment rates between origin and destination states, is associated with a 3 percent increase in flows from origin to destination states. The same result holds if we add variables that control for the national economic conditions in a given year, as shown in columns 2 and 3. In particular, an increase in the national unemployment rate, or a recession year, decrease significantly the flows between any two states. This is then another way to see the procyclicality of migration, now with respect to bilateral flows instead of total flows.

2.4 Labor mobility and workers employment status

The current employment status of a worker is an important factor in the decision of moving into a new location. Using SIPP data, I classify all workers that moved across states between month t and month $t+1$ by their employment status before and after moving—that is, their employment status in month t and in month $t+1$. Here, I focus on employment transitions between employment and non-employment, which includes unemployed and out of the labor force.[7] The same analysis with unemployment instead of non-employment is done in Appendix A, and the main conclusions of the

[7] To avoid having in the sample individuals not attached to the labor market, the baseline sample considered here only contains individuals that experience at least one employment spell during the time that they are in the database (2-4 years depending on the panel.)

Table 3: Employment transitions

	Non-movers			Movers		
Unconditional transitions:	E_{t+1}	N_{t+1}	Total	E_{t+1}	N_{t+1}	Total
E_t	0.85	0.01	0.86	0.55	0.09	0.64
N_t	0.02	0.12	0.14	0.06	0.30	0.36
Conditional transitions:						
E_t	0.98	0.02	1	0.86	0.14	1
N_t	0.11	0.89	1	0.17	0.83	1

Notes: This table shows the monthly employment transitions of workers using data from the SIPP. The top-panel of the table reports the unconditional transition rates, that is, the fraction of non-movers (left columns) or movers (right columns) that experienced each type of employment transition. The bottom panel reports the conditional transitions, that is, conditional on being employed or non-employed and non-moving (left columns) or moving (right columns) what fraction of workers were employed or non-employed in the following period.

analysis remain.

Most of the workers that move across state were employed at the time of moving. In particular, 58% of movers were employed the month before moving and most of them (90% of previously employed movers) were also employed in the first month in the new location. The upper panel of Table 3 show this decomposition of non-movers and movers by employment transition, that represent the fraction of the population in each group (non-movers and movers) that underwent each type of transition. It is remarkable that half of the movers experienced a E-E transition, that is, they had a job both before and after moving to a new state. On the other hand, the fraction of movers that were non-employed before moving is also large relative to their weight in the total population: 38% of movers did not have a job before moving, whereas for non-movers they only represent 29% of them. This indicates that non-employed workers have a higher tendency to move.

The lower panel of Table 3 contains the transition matrices for non-movers and movers, that is, conditional on being employed in a given month, how many workers continued employed (E-E transition) and how many were non-employed (E-N transition) in the following month. And, similarly for workers that were non-employed in a given period, to obtain the N-E and N-N transition rates. For non-movers, these conditional transition rates are very similar to the job finding and separation rates obtain in the literature, as they represent the bulk of the whole population. Interestingly, we observe significant differences when we consider only the group of individuals that moved across states. Workers that were employed before moving have very high E-E transition rates compare to non-movers, and workers that were non-employed before moving have very high N-E transition rates compare to non-movers.

The cyclicality of migration varies depending on the type of employment transitions that the

Table 4: Cyclicality of Migration by Employment Transition

Correlation of migration	E-E	E-N	N-E	N-N
Unemployment rate	-0.366	-0.117	-0.293	0.284
Employment rate	0.413	0.187	0.281	-0.294

worker goes through when moving. Table 4 shows the correlation of migration by employment transitions with measures of national economic conditions—employment and unemployment rate. The amount of intestate moves that involve a job-to-job transition is clearly procyclical, whereas those that involve a non-employment to non-employment transitions is clearly countercyclical. It is therefore the procyclicality of job-to-job movers (which accounts for around 50% of all transitions) the one that drives the procyclicality of migration.

3 Model

A multi-location model with labor search frictions is considered here. Crucial to capture the cyclical patterns of migration as in the data is to introduce in the model the decisions for both types of workers, employed and unemployed, on whether to move to a new location, and the possibility of searching abroad in a different location than their current. The probability of finding a job in each location is given in equilibrium by the incentives of firms to post vacancies. These incentives endogenously change with the aggregate productivity in the economy. To analyze the different local effects of a recession, I allow each location to differ not only on their average productivity, but also on their sensitivity to the national cycle, that is, their sensitivity to the aggregate shock.

3.1 Environment

There is a continuum of infinitely-lived workers of measure one who search for work and move across N different locations. There is a continuum of firms that post vacancies in each of these locations in order to find potential workers. Time is discrete. When workers and firms meet they draw a match productivity y that is constant throughout the duration of the match. A given match produces using linear technology $z_{it}y$, where z_{it} is the location specific aggregate productivity that evolves stochastically. The match is also characterized by the wage paid to worker. I assume that wages are set as piece-rates functions over the the total productivity of the match, such that the worker gets a fraction r of what it produces. Therefore, in each location i there is a distribution $e_i(r, y)$ across piece-rates, r and productivity, y of employed workers. The aggregate state of the economy consists of $\{e_{it}(r, y)\}_{i=1}^N$, total unemployment in each location, $\{u_{it}\}_{i=1}^N$, and aggregate productivity in each location $\{z_{it}\}_{i=1}^N$.

A worker decides optimally every period whether to migrate to another location or not. If he decides to move, he will then search for a job in the new location. If he decides to stay in the current location, he decides whether to search for a job in the current location (search *locally*) or in a different location (search *abroad*). It is assumed that every period a worker can only search in one location. The efficiencies of searching abroad or locally can potentially be different.

The location and searching decision for workers will depend on the economic conditions in each location and also on idiosyncratic preference shocks that workers receive every period. In particular, they draw two types of preference shocks. The first type of shock is the moving shock: if the worker moves he receives utility ζ^m, and if he stays ζ^s. The second shock is the location shock, $\{\zeta_i^l\}_{i=1}^N$, which indicates the utility that a worker gets by moving (or searching abroad) to a particular location i. I assume that each of theses shocks follow an Extreme Value Type I distribution with scale parameters ψ for the moving shocks, and ν for the location shocks.

Timing. There are three main sub-periods to consider in every period, t: first, the *location decision stage*, second, the *matching stage*, and finally the *production stage*.

At the beginning of a period agents observe the realization of the aggregate productivity shock, which defines all location-specific productivity $\{z_{it}\}$. The period then starts with aggregate state $S_t = (\{z_{it}, e_{it}(r, y), u_{it}\}_{i=1}^N)$. Then, exogenous destruction of matches happen. With a given probability σ, which is equal across locations, existing matches are destroyed and workers become unemployed. At this stage, *location decision stage*, workers have to decide whether they want to move, where to move, and where to search for a new job. These moving decisions take place as follows. First, moving shocks, (ζ^m, ζ^s), are realized and, both employed and unemployed workers decide whether to move to a new location or stay. Then, location shocks, $\{\zeta_i^l\}_{i=1}^N$, are realized. If the worker decided to move out of his current location, in this stage he decides where to move. If the worker decided to stay in its initial location, he decides where to search given his location shocks. Workers can only search in one location in every period.

At the start to the second sub-period, the *matching stage*, there have been changes in the distribution of workers across locations and employment states given by their location decisions. The distribution of workers in location i is $e_{it}^+(r, y)$, which may differ from the one at the beginning of the period due to exogenous match separations, but also endogenous separations due to workers deciding to quit to move to a new location. Unemployment in location i at this stage is given by u_{it}^+, which may differ from the initial unemployment in that location because of 1) exogenous separations, 2) unemployed workers moving across locations, that is, inflows of unemployed workers from other locations to location i and outflows of unemployed workers in i towards other locations, and 3) employed workers from other locations quitting their jobs and moving into unemployment in location i. The number of searchers in each location is given by the intra-period distributions $\{e_{it}^+(r, y), u_{it}^+\}$, together with their endogenous searching decisions.

Given the number of searchers, firms decide how many vacancies to post in each location, and matches happen. Upon matching, a firm and a worker first draw what would be their match productivity y from a distribution with cumulative distributed function $F(y)$, and then negotiate the wage. Here, more workers will move across locations: those workers who were searching in a different location that their own, receive an offer, and accept the offer will then move to their new location to start working at the new firm.[8] After all matches are realized, the new distribution of employment at the end of the period—which will be the initial distribution next period—is given by $\{e_{it+1}(r, y), u_{it+1}\}$. Finally, in the *production stage* production and consumption takes place.

Matching technology. All workers search for new jobs every period. There is a matching technology $m(v_i, s_i)$ that determines how many matches happen for a given number of vacancies v_i and searchers s_i in location i. This function is assumed to be constant returns to scale. The rate at which local workers find a vacancy is $\lambda_i \equiv m(v_i, s_i)/s_i$. If workers are searching abroad, from any location $j \neq i$, their probability of finding a vacancy is given $\alpha\lambda_i$, where α reflects potential differences in searching efficiencies when workers search locally compared with when they search from abroad. Workers that are currently employed and searching locally on-the-job meet a new vacancy with probability $\rho\lambda_i$, where ρ represents the efficiency of on-the-job search, and if they search from abroad, this probability is given by $\rho\alpha\lambda_i$. The probability that a vacancy posted by a firm finds a worker is $q_i \equiv m(v_i, s_i)/v_i$.

3.2 Workers

Here, I describe the value functions of workers at each of the three stages of a period: when they make location decisions, the search values in the matching stage, and the values at the end of the period, that is, at the production stage. Given these values, we can then compute the moving and searching probabilities of each type of workers.

Location decisions. At the beginning of the period workers can be unemployed in location i, with value U_i, or employed in location i with a contractual piece-rate r and with match productivity y, in which case the value is $W_i(r, y)$. Starting with the unemployed workers, the first decision an unemployed worker has to make is whether to move or not. Let U_i^{move} be their value of moving out of location i, and U_i^{stay} the value of staying. Then, unemployment value at the beginning of the period is given by

$$U_i = \mathbb{E}\max\{U_i^{\text{move}} + \zeta_m, U_i^{\text{stay}} + \zeta_s\}, \tag{2}$$

where the expectation is taken with respect to the moving shocks, ζ_m and ζ_s. Time subscripts are omitted here for simplicity. Workers that decide to move out of their current location, have to decide next where they want to move. They can choose any location $j \neq i$, and once they move

[8] During a period, there are two stages where we can see workers moving: at the beginning of the period, *location decision stage*, if workers move to unemployment in a new locations, and in the *matching stage* if workers move to employment in a new location. The same worker cannot move twice in a period, as it is assumed that once they move in the *location decision stage* they will search locally in that period.

they will search for a job locally in the new location j.[9] Let $S_{ij}^{u\ell}$ be the value of searching locally in location j for unemployed workers that started the period in location i and are now in location j, which will be described below. Then, the value of moving is

$$U_i^{\text{move}} = \mathbb{E} \max_{j \neq i} \{S_{ij}^{u\ell} + \zeta^j\}, \tag{3}$$

where the expectation is taken with respect to location shocks, $\{\zeta^j\}$.

On the other hand, workers that do not move have to decide next whether they want to search locally in their current location i, or search abroad in location $j \neq i$. Let S_{ij}^{ua} be the value of searching abroad in location j for unemployed workers that are currently in location i. Then, the value of staying for workers that started the period unemployed is

$$U_i^{\text{stay}} = \mathbb{E} \max \big\{S_{ii}^{u\ell} + \zeta^i, \max_{j \neq i}\{S_{ij}^{ua} + \zeta^j\}\big\}. \tag{4}$$

Next, the values for employed workers are described. Workers that start the period employed and survive the exogenous separation shock follow the same sequence of decisions. First, they decide whether to move out or not. If they want to directly move to a new location—before the matching stage—, they quit their current job and move to unemployment in a new location, so their value would then be U_i^{move}. If instead workers decide to stay, their value is $W_i(r, y)^{stay}$. Then, at the beginning of the period, the value for an employed worker in location i earning wage r and with match productivity y, is

$$W_i(r, y) = \mathbb{E} \max\{U_i^{\text{move}} + \zeta_m, W_i(r, y)^{\text{stay}} + \zeta_s\}. \tag{5}$$

Similarly as workers that are unemployed, employed workers that decide not to move out have then to decide whether to search locally or abroad, so their value is given by

$$W_i(r, y)^{\text{stay}} = \mathbb{E}\big\{S_i^{e\ell}(r, y) + \zeta^i, \max_{j \neq i}\{S_{ij}^{ea}(r, y) + \zeta^j\}, \big\} \tag{6}$$

where, $S_i^{e\ell}(r, y)$, and $S_{ij}^{ea}(r, y)$ are the values of searching locally in i, and searching abroad in location j when current location is i, for employed workers. These searching values are described in what follows.

Wages. Before turning to the description of the values at the matching stage, it is useful to describe first how wages are determined in equilibrium. Wages are defined as piece-rate contracts. A worker that produces $z_{it}y$, receives a wage $w_t = r z_{it} y$, where $r \in [0, 1]$ is the endogenous contractual piece

[9] In order to avoid the unlikely case of workers moving to a new location and searching abroad in another location, the model assumes that if one moves out at the beginning of the period, one cannot search abroad yet in another location.

rate. A piece rate $r = 1$ allocates the entire match value to the worker and leaves the employer with zero expected profit from that particular match. The piece rate is determined using a sequential auction bargaining protocol as in Cahuc et al. (2006). I assume that firms cannot observe where the worker comes from, and, therefore, wages only depend on the firm location and not on the worker current or previous locations. An alternative interpretation of this assumption is that firms cannot discriminate on wages depending on the origin location of the worker.

Let $V_i^e(r, y)$ be the value after the matching stage for a worker in location i with piece-rate r and productivity y, and let V_i^u be the value of being unemployed. Consider an unemployed worker who meets a firm in location i and draw a match productivity y from distribution with density $f(y)$ and cumulative distribution function $F(\cdot)$. This firm offers a wage $\underline{r}_i(y)$ such that,

$$V_i^e(\underline{r}_i(y)) = \gamma V_i^e(1, y) + (1 - \gamma)V_i^u \equiv \underline{V}_i^e(y)$$

where, $\gamma \in [0, 1]$. That is, the wage offered to an unemployed worker is such that the value of being employed is a weighted average between the total surplus of the match, $V_i^e(1, y)$, and his outside option, remaining unemployed, V_i^u.

When an employed worker meets a potential alternative employer, he draws his productivity with the alternative employer y' from distribution $f(y)$, and the incumbent and alternative employers bargain to attract the worker. Suppose that the *dominant* firm, that is the firm that keeps the worker, is the poacher in location j. Then, the poacher wins the bargain by offering a piece rate $\overline{r}_j(y', y)$ defined as the solution to the following equation

$$V_j^e(\overline{r}_j(y', y), y') = \gamma V_j^e(1, y') + (1 - \gamma)V_j^e(1, y) \equiv \overline{V}_i^e(y', y).$$

That is, the value for the worker of being employed in the new firm in location j with productivity y' is a weighted average of the total surplus at the poacher firm and the incumbent firm (which becomes his outside option in the negotiation with the new firm). However, because the firm does not know where the worker comes from, that is, it does not know the location of his outside option, it assumes that it is a local offer.

Note that if the worker receives an offer from the same location where he is currently working he will only accept the offer if the productivity at the alternative firm is higher than his current productivity. If the productivity at the alternative firm is lower than current but is high enough, the worker does not move but he can still renegotiate his contract at the current firm using as outside option this offer from alternative firm. In particular, if $y' \in [\overline{y}_i(r, y), y]$ the worker stays and renegotiates, where the threshold is defined as the productivity $\overline{y}_i(r, y)$ that solves

$$V_i^e\left(\overline{r}_i(y, \overline{y}_i(r, y)), y\right) = V_i^e(r, y).$$

Search values. When deciding where to move and where to search, workers take into account the value of searching in each location, which are described here. The values of searching locally and abroad depend mainly on the probabilities of matching with a vacancy in a given location and the values of being employed or unemployed, as it is standard in labor search models. Consider first the case of workers that start the period unemployed in location i and are searching locally in location j. If $j \neq i$ it means that the worker moved at the beginning of the period. When workers move, they have to pay a cost τ_{ij}. If $j = i$, then the worker did not move and decided to search locally (assume $\tau_{ii} = 0$). When searching locally, there is a probability λ_i that the worker meets a vacancy. Upon meeting the vacancy, worker and firm draw match productivity y from a distribution whose cumulative distribution function is $F(y)$. Given the draw for potential match productivity, workers decide whether to accept the offer and become employed, or reject and continue unemployed. Let the value of starting a new job from unemployment be $\underline{V}_j^e(y)$, and the value of remaining unemployed be period V_j^u. Then, the value of searching locally is given by

$$S_{ij}^{u\ell} = \lambda_j \int_{\overline{y}_j^{u\ell}}^{\infty} \underline{V}_j^e(y) \mathrm{d}F(y) + \left(1 - \lambda_j + \lambda_j F(\overline{y}_j^{u\ell})\right) V_j^u - \tau_{ij}, \tag{7}$$

where $\overline{y}_j^{u\ell} \equiv \min\{y \in \mathcal{Y} : \underline{V}_j^e(y) \geq V_j^u\}$.

When searching abroad, there are two main differences. First, efficiency of searching abroad is different from searching locally. In particular, assume that the probability of matching when searching abroad is given by $\alpha_u \lambda_j$, where α_u is a constant. The second difference relative to searching locally is about the cost of moving. Workers that search abroad only pay the moving cost if they actually move, that is, if they find an offer and accept it. On the contrary, searching abroad has its own cost c_a that workers have to pay. Moreover, if they move after finding and accepting an offer, the moving cost that they have to pay is τ_{ij}/τ_a, where τ_a is a constant reflecting lower moving costs for workers that move to a new job.[10] The value of searching abroad in location j for unemployed workers currently living in location i is then,

$$S_{ij}^{ua} = \alpha_u \lambda_j \int_{\overline{y}_{ij}^{ua}}^{\infty} \left(\underline{V}_j(y) - \tau_{ij}/\tau_a\right) \mathrm{d}F(y) + \left(1 - \alpha_u \lambda_j + \alpha_u \lambda_j F(\overline{y}_{ij}^{ua})\right) V_i^u - c_a, \tag{8}$$

where $\overline{y}_{ij}^{ua} \equiv \min\{y \in \mathcal{Y} : \underline{V}_j^e(y) - \tau_{ij}/\tau_a \geq V_i^u\}$.

Employed workers can also search locally or abroad. When matching with a new vacancy, the incoming and new firm compete to keep the worker through a sequential auction bargaining protocol. If workers productivity at the incoming firm is y and the draw for the new vacancy is y', the value of accepting the new offer is given by $\overline{V}^e(y, y')$, which is derived below. Then, for an employed worker, the value of searching locally when he is currently in location i, with piece-rate r and productivity

[10] For instance, this may reflect the fact that companies are willing to help workers move.

y is

$$S_i^{e\ell}(r,y) = \rho\lambda_i \int_y^\infty \overline{V}_i(y',y)dF(y') + \rho\lambda_i \int_{\overline{y}_i^{e\ell}(r,y)}^y \overline{V}_i(y,y')dF(y') + [1-\rho\lambda_i F(y)]\, V_i^e(r,y), \quad (9)$$

where ρ is the efficiency of searching on-the-job. If the worker decides to search abroad in location j then his value is

$$\begin{aligned} S_{ij}^{ea}(r,y) =& \rho\alpha\lambda_j \int_{\overline{y}_{ij}^e(y)}^\infty \left(\overline{V}_j(y',y) - \tau_{ij}\right) dF(y') + \rho\alpha\lambda_j \int_{\underline{y}_{ij}^{ea}(y)}^{\overline{y}_{ij}^e(y)} \left(\overline{V}_j(y,y')\right) dF(y') \\ &+ \left[1 - \rho\alpha\lambda_j + \rho\alpha\lambda_j F(\underline{y}_{ij}^{ea}(y))\right] V_i^e(r,y). \end{aligned} \quad (10)$$

Production stage. After the matching stage, workers can be employed or unemployed. Employed workers produce at the matched firm $z_i y$ units of goods, whereas unemployed workers home-produce b units of good. There is no saving technology and workers are assumed to be risk-neutral. Then, the values at the end of the period are

$$V_{it}^u = b + \beta \mathbb{E}_t U_{it+1} \quad (11)$$

for unemployed workers, where β is the discount factor, and, for employed workers,

$$V_{it}^e(r,y) = r z_{it} y + \beta(1-\delta)\mathbb{E}_t W_{it+1} + \beta\delta \mathbb{E}_t U_{it+1}. \quad (12)$$

Moving probabilities. Given the values for the workers and the assumption of Extreme Value Type I distributed preference shocks, we can compute the probabilities of workers to move to a particular location, to stay and search locally in their location, or to stay and search abroad in another given location.

There are two stages in a given period where workers can move: before or after the matching stage. If they move at the beginning of the period, in the *location decision stage*, they move to unemployment in the new location and search there. Alternatively, they can move after matches happen. This happens if they search abroad, find an offer, and accept it. In this case they would be moving to employment in the new location. Let μ_i^u be the probability of moving out of location i to any other location. Given the assumed form of the moving and location shocks, we can express the moving probabilities in closed form. In particular, the decision of moving out of a location is determined by the values U_i^{move} and U_i^{stay}, as can be seen from equation (2). Then,

$$\mu_i^u = \frac{\exp\left(U_i^{\text{move}}\right)^{1/\psi}}{\exp\left(U_i^{\text{move}}\right)^{1/\psi} + \exp\left(U_i^{\text{stay}}\right)^{1/\psi}}, \quad (13)$$

where ψ is the scale parameter corresponding to the moving shocks. The probability of moving from i to a particular location j at the beginning of the period is given by the probability of moving out of i, μ_i^u, and the probability of choosing location j which will depend on the value of searching in each of the potential locations and on the location shocks, $\{\zeta^j\}$, which have scale parameter ν. This probability is given by

$$\mu_{ij}^u = \mu_i^u \frac{\exp\left(S_{ij}^{u\ell}\right)^{1/\nu}}{\sum_{j\neq i} \exp\left(S_{ij}^{u\ell}\right)^{1/\nu}}. \tag{14}$$

If the worker is currently employed, the probability of quitting and moving at the beginning of the period from i to any other location is

$$\mu_i^e(r,y) = \frac{\exp\left(U_i^{\text{move}}\right)^{1/\psi}}{\exp\left(U_i^{\text{move}}\right)^{1/\psi} + \exp\left(W_i^{\text{stay}}(r,y)\right)^{1/\psi}} \tag{15}$$

and, the probability of moving from i to j at the beginning of the period is

$$\mu_{ij}^e(r,y) = \mu_i^e(r,y) \frac{\exp\left(S_{ij}^{u\ell}\right)^{1/\nu}}{\sum_{j\neq i} \exp\left(S_{ij}^{u\ell}\right)^{1/\nu}}. \tag{16}$$

After the matching stage, workers can also move to a new location if they search abroad, find a vacancy, and accept the offer. The probability that an unemployed worker currently in location i searches abroad in j is

$$\chi_{ij}^u = (1-\mu_i^u) \frac{\exp\left(S_{ij}^{ua}\right)^{1/\nu}}{\exp\left(S_{ii}^{u\ell}\right)^{1/\nu} + \sum_{j\neq i} \exp\left(S_{ij}^{ua}\right)^{1/\nu}}. \tag{17}$$

The first term, $(1-\mu_i^u)$ is the probability that the worker does not move at the beginning of the period, and the second term represents the decision on where to search, which depends on the values of searching abroad in each of the locations different than current, S_{ij}^{ua}, and the value of searching locally in current location, $S_{ii}^{u\ell}$. Similarly, the probability that an employed worker searches abroad in location j is

$$\chi_{ij}^e(r,y) = (1-\mu_i^e(r,y) \frac{\exp\left(S_{ij}^{ea}(r,y)\right)^{1/\nu}}{\exp\left(S_i^{e\ell}(r,y)\right)^{1/\nu} + \sum_{j\neq i} \exp\left(S_{ij}^{ea}(r,y)\right)^{1/\nu}}. \tag{18}$$

Notice that χ^u and χ^e represent the probability of searching abroad, but not the probability of actually moving to a new location. An unemployed worker searching abroad moves with probability $\chi_{ij}^u \alpha_u \lambda_j (1-F(\overline{y}_{ij}^{ua}))$, and an employed worker moves with probability $\chi_{ij}^e(r,y)\alpha_e \rho \lambda_j (1-F(\overline{y}_{ij}^{ea})(y))$.

3.3 Firms

Let $V_i^J(r,y)$ be the value for the firm of a match with productivity y and piece rate contract r. This value is given by the fraction $1-r$ of production that the firm keeps and the continuation value of keeping the match during next period. The match will continue next period if it does not end exogenously, with probability $1-\delta$, the worker does not quit to move to another location, with probability $\mu_{ii}^e(r,y)$, and the worker does not accept another job offer. Moreover, if the match continues, there is a possibility of having to renegotiate the contract due to an alternative offer for the worker. Let $N_i(r,y)$ be the probability of not having to renegotiate the contract, that is,

$$
\begin{aligned}
N_{it}(r,y) =& p_{ii,t}^e(r,y)\left[1-\rho\lambda_{it}+\rho\lambda_{it}F\left(\underline{y}_{ii,t}^e(r,y)\right)\right] \\
&+\sum_{j\neq i} p_{ij,t}^e(r,y)\left[1-\rho\alpha\lambda_{jt}+\rho\alpha\lambda_{jt}F\left(\underline{y}_{ij,t}^e(r,y)\right)\right].
\end{aligned}
$$

Then, the value of the match for the firm is

$$
\begin{aligned}
V_{it}^J(r,y) &= (1-r)z_{it}y \\
&+\beta(1-\sigma)\mathbb{E}_t\Bigg\{N_{i,t+1}(r,y)V_{it+1}^J(r,y)+p_{ii,t}^e(r,y)\rho\lambda_{it}\int_{\underline{y}_{ii,t}^e(r,y)}^{y} V_{i,t+1}^J(\overline{r}_{i,t}(y,y'),y)dF(y') \\
&+\sum_{j\neq i} p_{ij,t}^e(r,y)\rho\alpha\lambda_{jt}\int_{\underline{y}_{ij,t}^e(r,y)}^{\overline{y}_{ij,t}^e(y)} V_{i,t+1}^J(\overline{r}_{i,t}(y,y'),y)dF(y')\Bigg\}. \qquad (19)
\end{aligned}
$$

Vacancies. Firms that are vacant, that is, not matched with an employed worker, decide to post vacancies in a given location i. The incentives to post vacancies depend on the aggregate productivity and on the composition of searchers in each location. First, I describe here what are the types of searchers in the matching stage of the period. Then, the composition of searchers is used to evaluate the value of filling a vacancy for a vacant firm. Finally, firms use the expected value of filling a vacancy to decide how many vacancies to post in each location, such that in equilibrium the free-entry condition is satisfied.

I start describing the types of searchers that there are in an economy when workers arrive to the *matching stage*. In particular, workers searching in location i can be broadly of 4 types: unemployed searching locally, unemployed searching from abroad, employed searching locally, and employed searching from abroad. The number of unemployed workers in location i at the beginning of the period, before exogenous separations, is given by u_{it}, and the total number of employed workers is given by $\overline{e}_{it}=\int e_{it}(r,y)d(r,y)$, where $e_{it}(r,y)$ is the measure of employed workers with current wage r and match productivity y. Then, the total number of unemployed workers searching locally in i who started the period in location j is

$$u^l_{ji,t} = \begin{cases} \chi^u_{ii,t} \left(u_{it} + \delta \overline{e}_{it}\right) & \text{for } j = i \\ \mu^u_{ji,t} \left(u_j + \delta \overline{e}_{jt}\right) + (1-\delta) \int e_{jt}(r,y)\mu^e_{ji,t}(r,y)d(r,y) & \text{for } j \neq i \end{cases} \tag{20}$$

where the first line refer to the fraction of unemployed workers, including displaced employed workers, that started the period in location i and decide to stay and search locally, χ^u_{ii}. The second line refers to workers that moved at the beginning of the period to search locally in location i. These workers could be unemployed and decide to move, μ^u_{ji}, or employed who decided to quit to move, $\mu^e_{ji}(r,y)$. Similarly, the total number of unemployed workers searching abroad in i who started the period in location j is given by the fraction of workers who are unemployed in i, including those employed that were displaced at the beginning of the period, and decide to search abroad in location i, that is,

$$u^a_{ji,t} = \mu^u_{ji,t} \left(u_{j,t} + \delta \overline{e}_{j,t}\right), \tag{21}$$

We turn now to the number of employed searchers in a given location, which can also be searching locally or from abroad. The total number of employed workers with current piece-rate r and productivity y searching locally in location i is given by

$$e^l_{it}(r,y) = \chi^e_{ii,t}(r,y)(1-\delta)e_{i,t}(r,y), \tag{22}$$

and, the total number of employed searching in location i from a different location $j \neq i$ is

$$e^a_{ji,t}(r,y) = \chi^e_{ji,t}(r,y)(1-\delta)e_j(r,y). \tag{23}$$

Given the definitions of these 4 types of searchers, we can now define the total number of searchers in location i. Each type of searcher have a different search efficiency given by parameters α, which represents efficiency of searching abroad, and ρ, which represents efficiency of searching on-the-job. Therefore, the total number of searchers in efficiency units is

$$s_{it} = \sum_{j=1}^{N} u^l_{ji,t} + \alpha \sum_{j \neq i} u^a_{ji,t} + \rho \int e^l_{it}(r,y)d(r,y) + \rho\alpha \sum_{j \neq i} \int e^a_{ji,t}(r,y)d(r,y). \tag{24}$$

Next we need to compute what is the expected value of filling a vacancy, which depends on the composition of searchers in each location. This is because the value of filling a vacancy with a worker that is currently unemployed is different from the value of filling a vacancy with a worker that is currently employed, due to the differences in the wages that the firm will offer to these workers, and in the decisions of workers to accept the offer. Therefore, the firm needs to take into account what is the probability of matching each type of worker. The probability that the worker that a vacancy meets is an unemployed worker that is searching locally is $\frac{1}{s_i}\sum_j u^l_{ji}$, and an unemployed that is searching abroad is $\frac{\alpha}{s_i}\sum_j u^a_{ji}$. Similarly, the probability that the worker that a vacancy meets is an employed worker that is searching locally of type (r, y) is $\frac{\rho}{s_i} e^l_i(r, y)$, and searching abroad $\frac{\alpha\rho}{s_i}\sum_j e^a_{ji}(r, y)$. Then, the expected value of meeting a vacancy is defined as

$$
\begin{aligned}
J_i =& \frac{1}{s_i}\left(\sum_{j=1}^{N} u^l_{ji} + \alpha \sum_{j\neq i} u^a_{ji}\right) \int_{\overline{y}^u_{ji}}^{\infty} V^J_i\left(\underline{r}_i(y), y\right) dF(y) \\
&+ \frac{1}{s_i}\int \left[\left(\rho e^l_i(r, y') + \rho\alpha \sum_{j\neq i} e^a_{ji}(r, y')\right) \int_{\overline{y}^u_{ji}(y')}^{\infty} V^J_i\left(\overline{r}_i(y, y'), y\right) dF(y)\right] d\left(r, y'\right),
\end{aligned}
$$

where the values $V^J_i(r, y)$ are as defined in (19).

Finally, given the expected value of meeting a vacancy the firm decides how many vacancies to post. The cost of posting a vacancy in location i is κ_i. In equilibrium, it must be that vacant firms break-even, that is, they make zero profits in expectation. Formally, the free-entry condition is

$$\kappa_i = \beta q\left(\theta_{it}\right) \mathbb{E} J_{i,t+1} \tag{25}$$

where $q\left(\theta_i\right) \equiv m(v_i, s_i)/v_i$ is the probability for a firm of matching with a worker.

3.4 Employment and population dynamics

Here the evolution of employment and unemployment is described. Moving and searching decisions, together with employment transitions, shape the distribution of employment and unemployment in each location. Then, given the number of unemployed local and abroad searchers defined in (20) and (21), the total number of unemployed workers in location i at the beginning of period $t+1$ is

$$u_{i,t+1} = \sum_{j\neq i}\left(1 - \lambda_{it} + \lambda_{it} F(\overline{y}^u_{ii,t})\right) u^l_{ji,t} + \sum_{j\neq i}\left(1 - \alpha\lambda_{jt} + \alpha\lambda_{jt} F(\overline{y}^u_{ij,t})\right) u^a_{ij,t} \tag{26}$$

and, the number of employed with wage r and match productivity y is

$$\begin{aligned}
e_{i,t+1}(r,y) = & \left[1-\rho\lambda_{it}+\rho\lambda_{it}F\left(\underline{y}_{ii,t}(r,y)\right)\right]e^{l}_{it}(r,y) \\
& +\sum_{j\neq i}\left[1-\alpha\rho\lambda_{jt}+\alpha\rho\lambda_{jt}F\left(\underline{y}_{ij,t}(r,y)\right)\right]e^{a}_{ij,t}(r,y) \\
& +\rho\lambda_{it}\int_{r'}\int_{\underline{y}_{ii,t}(r',y)}^{y} e^{l}_{i,t}(r',y)\mathbb{I}\{\overline{r}_i(y,y')=r\}dy'dr' \\
& +\alpha\rho\sum_{j\neq i}\lambda_j\int_{r'}\int_{\underline{y}_{ij}(y')}^{\overline{y}_{ij}(y')} e^{a}_{ij,t}(r',y)\mathbb{I}\{\overline{r}_i(y,y')=r\}dF(y')dr' \\
& +\rho\lambda_i f(y)\int_{r'}\int_{-\infty}^{y} e^{l}_{i,t}(r',y')\mathbb{I}\{\overline{r}_i(y,y')=r\}dy'dr' \\
& +\alpha\rho\lambda_i f(y)\sum_{j\neq i}\int_{r'}\int_{-\infty}^{\overline{y}_{ji}(y')} e^{a}_{ji,t}(r',y')\mathbb{I}\{\overline{r}_i(y,y')=r\}dy'dr' \\
& +\lambda_i f(y)\mathbb{I}\{\underline{r}_{ii}(y)=r\}u^{l}_{ii}+\alpha\lambda_i f(y)\sum_{j\neq i}\mathbb{I}\{\underline{r}_i(y)=r\}u^{a}_{ji} \qquad (27)
\end{aligned}$$

where, the first line are the employed with current wage r and productivity y that did not get an offer, or matched with a firm but the match productivity was not high enough to trigger renegotiation of current contract r. The second line and third lines are the employed with current productivity y that matched with a firm $y'$and stayed in current match y but renegotiated their contract to r. The fourth and fifth lines are employed workers that found a new match with productivity y and their new piece rate contract is r. The last line includes all unemployed workers that match with a firm and draw productivity y, and their initial wage is r. Then, total employed are $\overline{e}_{i,t} = \int e_{i,t}(r,y)d(r,y)$, and population in location i is $n_{i,t} = u_{i,t} + \overline{e}_{i,t}$.

3.5 Equilibrium

Consider the economy in period t. The equilibrium is defined as a set of market tightness $\{\theta_{i,t}\}$, search and moving probabilities for unemployed, $\mu^{u}_{ij,t}$ and $\chi^{u}_{ij,t}$, and employed $\mu^{e}_{ij,t}(r,y)$ and $\chi^{e}_{ij,t}(r,y)$, vacancies posted in each location $\{v_{it}\}$, such that, for a given initial distribution $\{u_{i,t-1}, e_{i,t-1}(r,y)\}$,

i. given market tightness in each location and location specific productivity $\{z_{it}\}$, moving and searching probabilities solve the problem of the worker. That is, they solve (14)-(18).

ii. free-entry condition (25) in each location is satisfied,

iii. the evolution of the employment distribution, and number of unemployed workers follow (26) and (27).

3.6 Solution method

The solution to this problem depends on the distribution of employment, $e_i(r, y)$, and unemployment $u(i)$ in each location $i = \{1, ..., N\}$. This implies that the aggregate state of the economy contains infinite-dimensional objects which makes the problem difficult to solve using standard methods. Here, I follow the methodology proposed by Winberry (2016) in which the distributions are approximated using a flexible parametric family. This reduces the dimensionality of the problem by only having to record as state variables a given number M moments of the distribution. Here I summarize the main steps of the algorithm. The algorithm consist of three steps as follows:

The first step consists of discretizing the distributions of employment over wages, r, and productivities, y using M moments of the distribution. In particular, I approximate the function $e_i(r, y)$ as follows:

$$e(r, y) \approx \phi_0 \exp \phi_1^1 \left(r - m_1^1\right) + \phi_1^2 \left(y - m_1^2\right) + \sum_{h=2}^{M} \sum_{k=0}^{h} \phi_h^k \left[\left(r - m_1^1\right)^{h-k} \left(y - m_1^2\right)^k - m_h^k\right] \tag{28}$$

where, m_1^1 and m_1^2 are the first moments with respect to r and y respectively, and

$$m_h^k = \int \left(r - m_1^1\right)^{h-k} \left(y - m_1^2\right)^k e(r, y) \mathrm{d}r \mathrm{d}y \tag{29}$$

Then, in the second step, I solve steady state of the economy. Start by guessing market tightness in each location θ_i. Given the market tightness we can solve unemployed and employed value functions by value function iteration. Once we have these values, we can find the wages and solve the value of the firm. Then, we need to find the stationary distribution for employed and unemployed workers in each location. To do this, we start with a guess on the number of unemployed in each location, and guesses for each of the moments in the distribution, $\{m_h^k\}$. Then, given the moving decisions of the workers, and their decisions on whether to accept or reject the offers they receive, we can compute the law of motion for these functions, and iterate until convergence to a stationary distribution. Given these distributions, we can solve the free entry condition and update θ_i, until convergence. Finally, in the last step I solve for the dynamics of the model using perturbation methods.

4 Quantitative analysis

In this section, the data is used to set the parameters of the model. Then, the model is solved quantitatively and the model results are analyzed. The model is used to run counterfactuals that shed light into the role of labor mobility to mitigate or amplify recessions.

4.1 Parameterization

I calibrate the model to the United States and assume that a location is a Census Division.[11] A period in the model is a month. The discount factor, β, is set to $(1/1.05)^{1/12}$ which corresponds to an annual interest rate of 5%. I set labor market parameters γ and η, that is, workers bargaining power and matching function elasticity equal to 0.5. The remaining of the of the parameters are set to match moments in the data using the simulated method of moments. I explain these moments and parameters below.

Productivity. The stochastic process for productivity in a given location i is

$$\log z_{i,t+1} = (1-\rho)\overline{z}_i + \rho \log z_{i,t} + \sigma_i \varepsilon_{t+1}. \tag{30}$$

The parameter $\overline{z}_i$ is set as the average output per employed person observed in the data (normalized to one in a given location). I choose ρ to match autocorrelation and volatility of the U.S. real GDP at a quarterly frequency. This stochastic process assumes that there is only one aggregate productivity shock, ε, that affects all locations. The sensitivity of each location to an aggregate shock is determined by the parameter, σ_i. To generate an increase in dispersion during recessions as in the data, it must be the case that the correlation between average productivities $\{\overline{z}_i\}$ and the sensitivities to the aggregate shock $\{\sigma_i\}$ is negative. That is, low productivity locations are the ones that suffer more after a negative productivity shock, which further increases the dispersion of productivities across locations. Then, to get countercyclical dispersion of productivities, I exogenously set $\sigma_i = \sigma/\overline{z}_i^3$, where σ is set to match the volatility of aggregate productivity in the United States. I show that this parameterization is then able to capture the patterns of dispersion across locations as in the data.

As for the match productivity, y, I assume that they are drawn from a Beta distribution with parameters β^1 and β^2, which are chosen to match the wage distribution as in the data. In particular, these moments are the difference between the log wage in the 90th percentile of the distribution and the 10th percentile (P90-P10), and the difference between the log wage in the 50th percentile of the distribution and the 10th percentile (P50-P10), which capture the dispersion in the wage distribution.

Migration parameters. Moving costs τ_{ij}, that is the cost that a worker pays to move from i to j, are a linear function of distance between i and j, D_{ij}. In particular,

$$\tau_{ij} = \gamma_0 + \gamma_1 D_{ji}. \tag{31}$$

Parameter γ_0 is related to the degree of mobility in the economy, and it is set so as to match the fraction of workers that move across divisions in the United States. Parameter γ_1 is pinned down

[11] There are 9 Census Divisions which are: New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, and Pacific.

Table 5: Parameters From Moment Matching

Parameter		Value
Efficiency on-the-job search	ρ	0.990
Efficiency search abroad employed	α_e	0.812
Efficiency search abroad unemployed	α_u	0.130
Exogenous separation rate	σ	0.022
Scale parameter location shocks	ν	0.952
Scale parameter moving shocks	ψ	1.398
Home production	b	0.601
Vacancy cost	κ	1.389
Moving cost, constant	γ_0	9.411
Moving cost, distance parameter	γ_1	0.455
Moving cost, search abroad	τ_a	4.804
Cost searching abroad	c_a	2.675

by targeting the correlation between flows across each pair of U.S. divisions and their corresponding distance. Amenity values for each of the location $\{a_i\}$ are set to match the share of population in each division.

The migration parameters that are left to specify are the ones related to the Type I Extreme Value distribution of location and moving shocks, that is, ν and ψ, respectively. I choose these parameters so as to match the relative wage of workers that changed location during a given month and experienced a E to N transition, and the percentage of movers that were unemployed in their origin location when they moved. Intuitively, the parameter ψ is the scale parameters of the distribution of the moving/staying shocks so the larger it is, the more likely it is that a worker would move to any other location. To see this, recall that the probability that a currently employed worker quits its current job to move to any other location is

$$m^e_{it}(r, y) = \frac{\exp\left(U^{\text{move}}_{it}\right)^{1/\psi}}{\exp\left(U^{\text{move}}_{it}\right)^{1/\psi} + \exp\left(W^{\text{stay}}_{it}(r, y)\right)^{1/\psi}}, \tag{32}$$

where, U^{move}_i is the value of moving and W^{stay}_i is the value of staying employed in i. Therefore, as ψ increases, differences between the value of being employed or unemployed matter less, which makes the employed worker more likely to move. That is why the parameter ψ is associated with the percentage of workers that moved across locations when they were currently employed. Appendix A shows how wages of movers evolved around the time of moving for different employment transitions, and how they compare with those of non-movers. Similarly, the parameter ν is the scale parameter of the distribution of location shocks, that is, how much a worker likes a given location regardless of

Table 6: TARGETED MOMENTS

	Data	Model		Data	Model
Labor market moments:			Wage moments:		
Employment rate	0.861	0.837	P90 − P10	1.380	1.053
EN transition non-movers	0.018	0.018	P50 − P10	0.720	0.658
Job to job rate	0.012	0.014	EN movers	-0.207	-0.391
EN transition movers	0.145	0.170	NE movers	0.100	0.163
NE transition for movers	0.173	0.338			
Vacancies/non-employed	0.260	1.374			
Replacement rate	0.400	0.447			
Migration moments:					
Migration rate	0.018	0.024			
Correlation flows and distance	-0.230	-0.227			
Share non-employed movers	0.359	0.269			

the local economic conditions. This parameter, together with ψ, is then associated with the overall migration rate.

Labor market and search parameters. The labor market parameters that have to be chosen are the vacancy cost parameters, κ and χ, efficiency of on-the-job and abroad search, ρ, α_e, and α_u, the exogenous separation rate δ, and home production productivity b. I set $\kappa_i = \kappa \bar{z}_i$, so that it is proportional to the productivity in each location, and choose the parameter κ to match the average employment rate in the United States and the dispersion of employment rates across locations.

The parameters related to the efficiency of searching on-the-job, ρ, and abroad, α_e and α_u, together with the exogenous separation rate parameter δ, help pin down the transitions across employment status (employment and non-employment) in the model. Hence, I choose these parameters to match these transitions for workers that moved and workers that did not move in the data. The productivity of home production while non-employed, b, is chosen to match an average replacement rate, that is, the ratio of b over the average wage, equal to 40%, as is standard in the literature. Table 5 shows the values for all the parameters chosen to match these moments in the data.

Moreover, searching abroad has two additional parameters: the cost of moving when finding a job relative to moving without a job, τ_a, and the cost of searching, c_a. In general, given the presence of a moving cost, the wage accepted by a worker who has to move will be different than the same worker that does not move. In the data, the wage of non-employed workers moving to a job (NE transition) in a new location is 10% higher than the wage of non-employed workers starting a new job in their current location. I use this moment to pin down the value of τ_a. Intuitively, the higher the moving cost is, the higher the wage has to be to accept an offer elsewhere. Vacancies to

Table 7: Employment Transitions in the Model

	Non-movers			Movers		
Unconditional transitions:	E_{t+1}	N_{t+1}	Total	E_{t+1}	N_{t+1}	Total
E_t	0.82	0.01	0.83	0.60	0.13	0.73
N_t	0.02	0.15	0.17	0.09	0.18	0.27
Conditional transitions:						
E_t	0.98	0.02	1	0.83	0.17	1
N_t	0.10	0.90	1	0.35	0.65	1

Notes: This table shows the model implied employment transitions. The top-panel of the table reports the unconditional transition rates, that is, the fraction of non-movers (left columns) or movers (right columns) that experienced each type of employment transition. The bottom panel reports the conditional transitions, that is, conditional on being employed or non-employed and non-moving (left columns) or moving (right columns) what fraction of workers were employed or non-employed in the following period.

non-employed ratio is also added to the targeted moments.

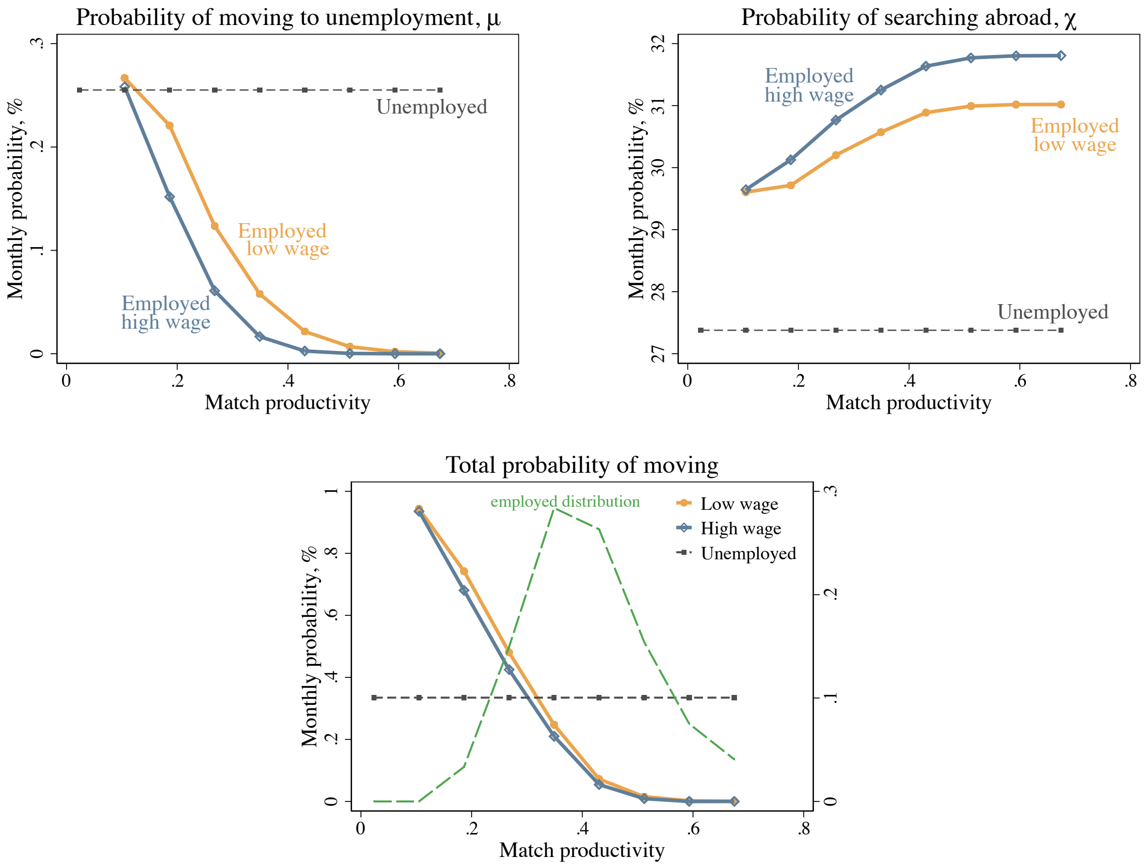
4.2 Model Results

Table 6 shows all the moments used to set the parameter values in the model with their corresponding value in the data and in the model. In general, the model is able to reproduce these key moments of the data. Importantly, the model can fit well some properties of the data that the literature has overseen, namely the fraction of migrants that are unemployed in their origin location when they moved and the transitions between employment status for workers that moved. In standard models of migration, it is generally assumed that only unemployed workers can move to another location. However, in the data, only about half of migrants are unemployed. To capture this, a key feature of the model is allowing workers to search i) on-the-job and ii) abroad, that is, from a different location than where they are applying to get a job. These features of the model also allow it to generate the transition rates across employment status observed in the data . To see this Table 7 shows the model implied employment transitions for movers and non-movers. The model reproduces one of the salient facts about internal migration, namely that most transitions across locations are job-to-job transitions. This occurs even though the share of non-employed workers that move is larger than the share of employed workers that move.

To understand the forces in the model that produce these results, I turn next to evaluate the incentives to move for the different agents in the economy. First, I show the differences across types of workers—unemployed, and employed with different wages and different match productivities—, in a given location. Second, I show the differences in moving probabilities across locations.

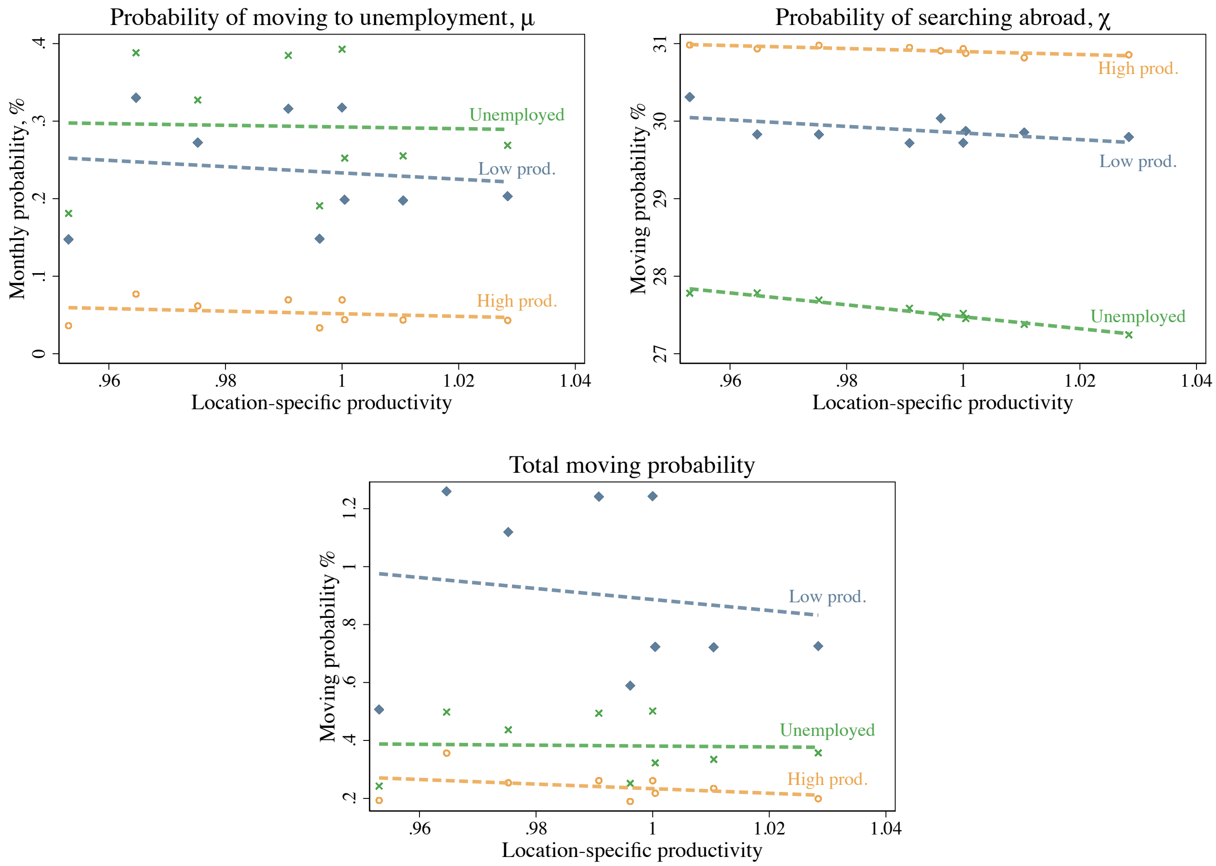
Moving probabilities across types of workers. First, the moving and searching abroad probabilities for different types of workers are analyzed. Figure 3 shows moving and searching abroad

Figure 3: Moving Probabilities by Type of Worker



probabilities for unemployed and employed workers as a function of their match productivity at a given location. Recall that moving probabilities, μ, refer to the probability of moving at the beginning of the period to unemployment in new location—before new matches happen in the same period—, and for employed workers that implies quitting your current job to move to unemployment in a new location. These probabilities are given in the model by equations (13) and (15). The top-left panel of Figure 3 shows how the probability of quitting a job to move depends negatively on their current match productivity, which reflects a lower willingness to move to unemployment in a new location when current job becomes better. A similar intuition explains why the higher your negotiated wage is (blue line) the less willing you are to quit and move to a new location. Interestingly, these are reversed when we look at the probabilities of searching abroad, χ, as shown in the top-right panel of Figure 3. These probabilities are given by equations (17) and (18). In this case, the probability of searching abroad increases with wage and match productivity. However, a higher probability of searching abroad does not necessarily correspond to a higher probability of actually moving. To move after searching abroad, workers need first to find a job offer, and then accept that offer. Accepting an offer on-the-job is always less likely for workers that currently have either a high negotiated wage or a high match productivity. For instance, workers at the top of the job ladder,

Figure 4: Moving Probabilities by Productivity in Origin Location



that is, with the highest match productivity, $\overline{y}$, do not accept any local offer. They could still accept an offer from other locations only if productivity is high enough and compensates the moving cost. In the baseline calibration, it is never the case that a worker with current match productivity $\overline{y}$ accepts either a local or an abroad offer, so searching abroad probabilities are irrelevant for those workers. This is shown in the bottom panel of Figure 3 which shows the total moving probability for low and high wage workers, and for unemployed workers. This adds the probability of moving, μ, to the probability of searching abroad, χ and accepting an offer. The dashed green line displays the distribution of employed workers.

Moving probabilities across locations. Next, I turn to explain the incentives to move for workers based on their current location. Workers moving probabilities not only depend on their employment status but also on their location relative conditions, namely, location-specific productivity and amenities. Figure 4 shows the probability that workers would move out of each location given their location productivity in the baseline calibration. The probability of moving to unemployment, μ, decreases with the worker's current location productivity, as shown in the top-left panel of Figure 4. Similarly, searching abroad probabilities also decrease with current location productivity. This is specially relevant for unemployed workers. Overall, total moving probabilities, that is the combined probability of moving to unemployment at the beginning of the period, and the probability of accepting an offer abroad and move after the matching stage, which are shown in the bottom panel of Figure 4, are also decreasing in the origin location productivity. For employed workers who are searching abroad, the probability of accepting an offer to move depends crucially on the productivity at the new match: only if the new match is productive enough, both in terms of match-specific productivity, and location-specific productivity, they will accept the offer.

Another factor that determines moving probabilities across locations is their amenity values. In the calibration, amenity values are chosen so as to match the population shares in each location. For a given level of productivity, the higher the amenity value in one location is, the less likely workers in that location are to move. The calibration of the model results in a negative correlation between amenity and productivity levels across locations.[12]

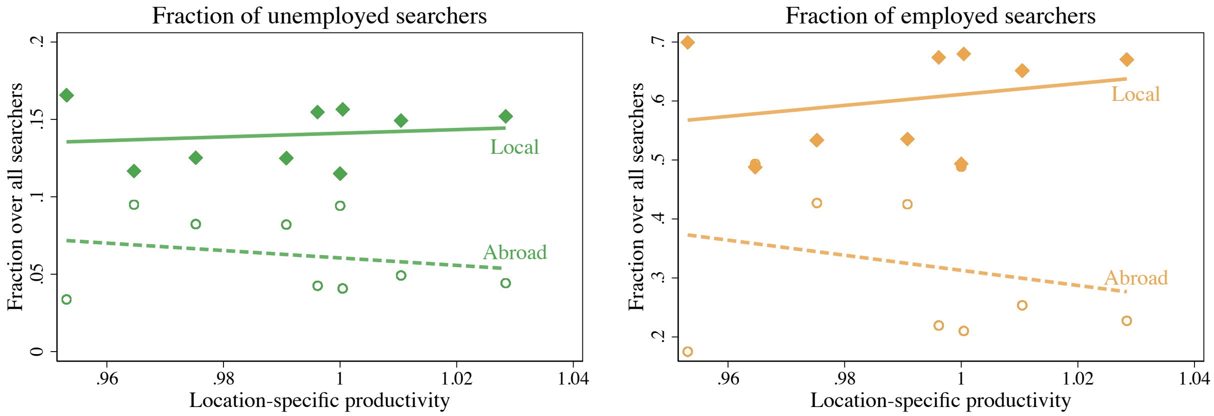
Types of searchers in each location. Firms incentives to post vacancies in each location depend on the value of the producing match, as in standard search models, but here also on the types of searchers that the firm will meet. There are four types of workers a vacancy can meet (aside from the match productivity heterogeneity): unemployed workers searching locally, unemployed workers searching from abroad, employed workers searching locally, and employed workers searching from abroad. Figure 5 plots the fraction in efficiency units of each type of searcher by the location productivity where they are applying. Locations that have a high average productivity tend to have a higher fraction of local searchers than applicants from abroad, both for unemployed searchers (left panel) and for employed searchers (right panel).

In most locations employed workers that search locally account for about half of the total applicants, and about 70 percent of all searchers are employed. The value for a firm to find an employed worker is always lower than that of finding an unemployed worker. This is so, first because the probability that the meeting turns into a productive match is lower, due to the fact that on-the-job searchers only accept offers that are better than their current one. And second, because the wage that a firm has to offer to an employed worker is higher than that of an unemployed worker, due to the sequential auction bargaining process that takes place.

So far, I have described the incentives of workers to move in the deterministic steady state of the model, that is, in the economy without fluctuations in aggregate productivity. The next section shows the results of the model over the business cycle, in the economy with aggregate productivity fluctuations.

[12] Appendix **??** shows the results on how moving probabilities correlates with the amenity levels in the origin location.

Figure 5: Types of Searchers by Productivity in Destination Location



5 Cyclicality of labor mobility

One of the key features of the model is its ability to reproduce the main cyclical stylized fact of internal migration. This will allow us to use the framework proposed here to further study the role of labor mobility over the business cycle. I start by describing the resulting procyclicality of migration in the quantitative model.

Migration is procyclical in the model as in the data and this pattern is due to the procyclicality of the number of workers that move job-to-job. In particular, in the model, the correlation of the quarterly migration rate and employment rate (both detendred using Hodrick-Prescott filter) is about 0.57, which is positive in line with what we see in the data, although much higher (in the data this correlation is 0.14). On the other hand, the model also captures the countercyclicality of those movers that experience a non-employment to non-employment transition. The to panel of Table 8 shows these statistics in the baseline calibration of the model. Migration rate correlates positively with employment rates and negatively with a measure of dispersion across locations—the standard deviation of employment rates. However, when we decompose total migration flows by type of employment transitions, the model generates that the correlation of employment rates and job-to-job migration is 0.691, and that of transitions of non-employed workers moving to non-employment in a new locations is negative (-0.904). A critical feature for these results is the introduction of the possibility of searching abroad, as will be shown below in Section 6.

The intuition of how the main model mechanisms that generates the procycicality of migrations is as follows. During recessions, there is a decrease in job finding rates in all the locations because, due to lower productivity, firms have incentive to post fewer vacancies. This implies that both employed and non-employment workers receive fewer offers. Therefore, workers that are employed searching abroad will have fewer opportunities to move to another job in a new location. This effect is the main force that drives the number of movers experiencing a job-to-job transition to go

Table 8: Cyclicality of Migration in the Model

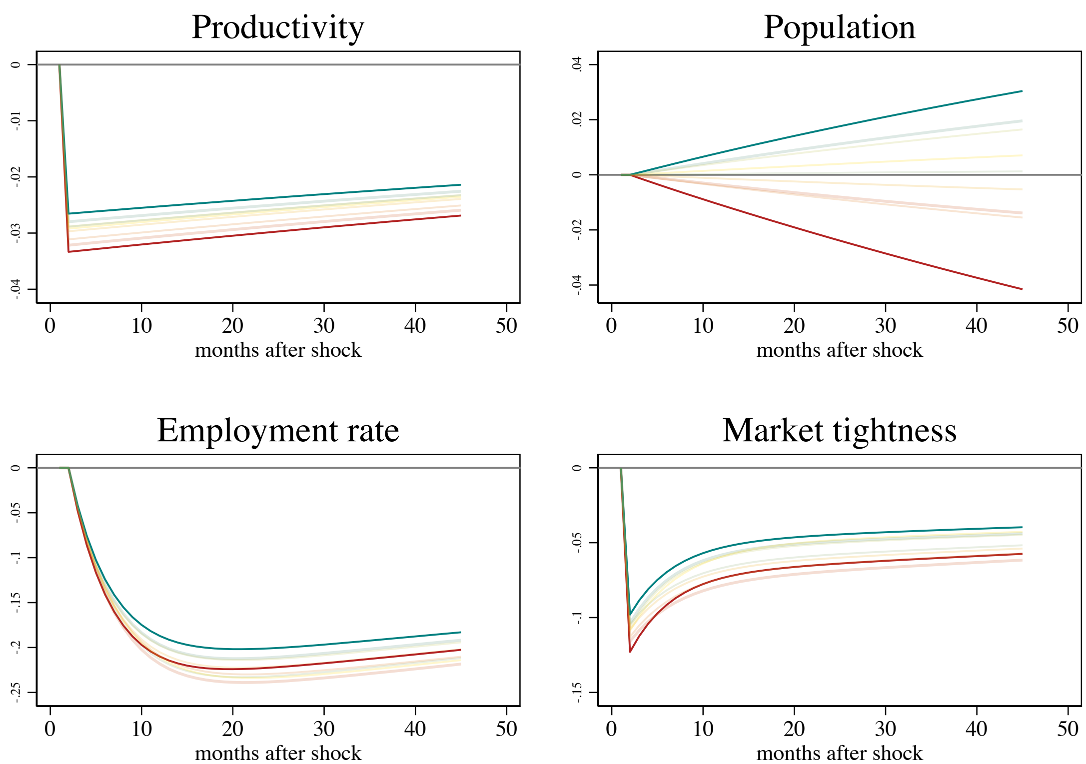
Correlation of migration	Total	E-E	E-N	N-E	N-N
Baseline:					
Employment rate	0.576	0.691	-0.762	0.556	-0.904
SD Employment rate	-0.155	-0.196	0.218	-0.157	0.248
No search abroad:					
Employment rate	-0.821	-0.834	-0.770	-0.124	-0.793
SD Employment rate	0.102	0.099	0.093	0.004	0.088

down during recessions. At the same, during recessions the dispersion of job finding rates increases. Some locations experience higher drops in productivity because they are more sensitive to aggregate shocks (higher σ_i). Workers in this locations have now higher incentives to move to relatively better off in order to get a job faster. This implies that more non-employed workers from most affected locations are going to move and these workers experience a non-employment to non-employment transition. That is why this type of transition is countercyclical. Given that in the model, as in the data, it is mostly employed workers the ones that migrate rather than non-employed workers, the first effect dominates, and total migration is thus procyclical.

To see these model mechanisms at play during recessions, Figure 6 plots the impulse response to a negative shock in the productivity process, that is, a decrease in ϵ_R. The thickest line in red represents the location that is most adversely affected by the shock, whereas the thickest line in red represents the location the least adversely affected by it, as can be seen from the productivity response plot in the upper left panel of the figure. As a response to the shock, population in the most affected location decreases, and population in the least affected location increases which shows the different mobility patterns in locations that are differently hit by the shock. The adverse aggregate productivity shock results in a drop in employment in all locations, but the magnitude of the drop differs by location. This heterogeneity in responses is not only due to the different sensitivities of locations to the aggregate shock, but also to changes in population. For this reason, the relative drop in employment rates do not necessarily correspond one to one to the relative drop in productivity across location. For instance, the most affected location in terms of productivity is not the most affected location in terms of employment rates. This can be due to a composition effect, in the sense that there is an increase in the inflows of non-employed workers towards better off locations, who increase the total pool of non-employment in those locations, and, due to search frictions, it takes time for them to find jobs.

The model allows us to understand the incentives of workers to move during a recession. Figure 7 plots the response to a negative aggregate shock of the moving and searching abroad probabilities, μ and χ, for workers in different locations. Non-employed workers in most negatively affected locations (red line) now have more incentives to move out of their location, as shown in the upper

Figure 6: Impulse Response to a Negative Aggregate Shock



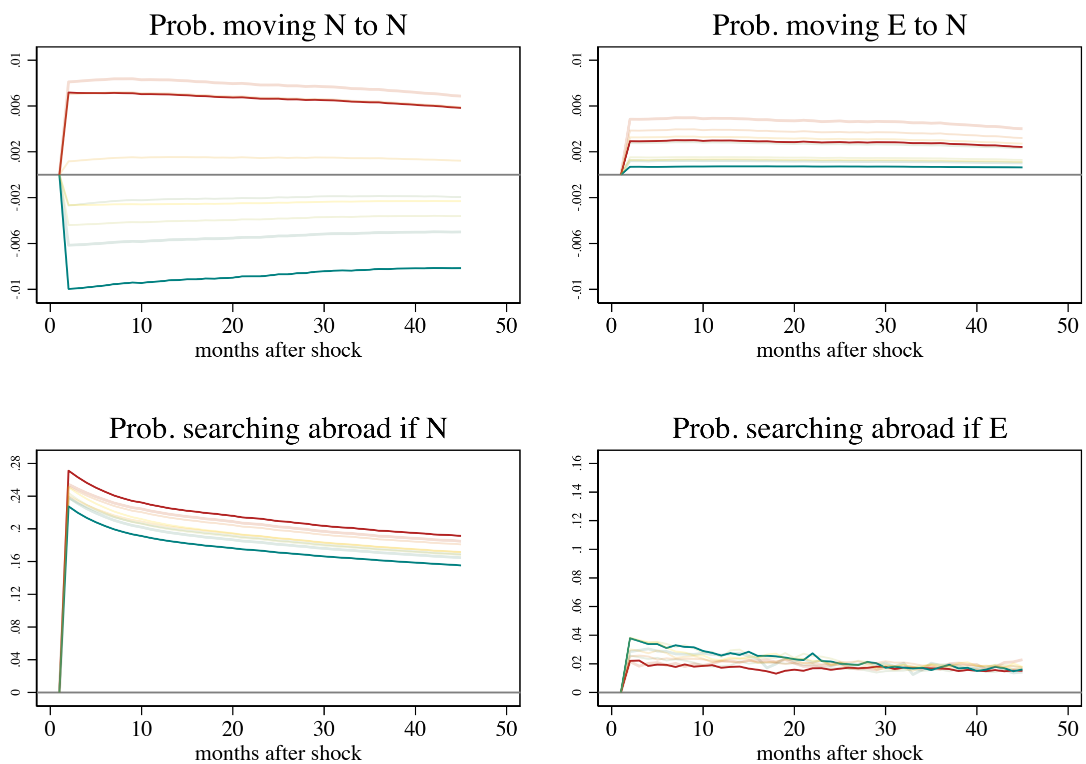
Notes: Green lines represent the response in the least affected location, that is, lowest productivity drop, and red lines the response in the most affected location, that is largest productivity drop.

left panel. On the other hand, non-employed workers in relatively better off locations (green line) have fewer incentives to move out, as probability of finding offers somewhere else have decreased by more than in current location. The upper right panel of Figure 7 shows the average probability that an employed worker moves to non-employment, that is, quits to move to a new location before the search and matching stage.[13] Due to the negative shock, wages of employed workers decrease, and therefore the difference between their wage and home production, b becomes smaller. This implies that, on average, an employed worker is more willing to quit to non-employment to move to a new location after the negative shock. Incentives to move are stronger in relatively worse off locations.

The probability of searching abroad also increases in all locations. However, this is offset by the probability of finding a job, and overall the probability of moving after searching abroad decreases. This is shown in the bottom panels of Figure 7, both for non-employed and for employed workers. The increase in the probability of searching abroad is especially relevant for non-employed in worse off locations, whereas for employed workers this probability barely increases. Thus, for the latter

[13]This is computed as the sum of the probability of moving $\mu_i^e(r, y)$ times the measure of workers employed in location i earning wage r with productivity y.

Figure 7: Impulse Response to a Negative Aggregate Shock: Moving Probabilities



Notes: Green lines represent the response in the least affected location, that is, lowest productivity drop, and red lines the response in the most affected location, that is largest productivity drop.

the decrease in job finding probabilities in all locations largely offsets the increase in the searching abroad probability, which implies a decrease in interstate job-to-job transitions.

The changes in moving and searching probabilities together with the decision on where to move or search shape the total inflows and outflows across locations during a recession. Figure 8 plots the change in inflows and outflows against the change in employment rate in each location and during a recession, peak to trough. Similarly to what we observe in the data (see Figure 2), the model generates that workers move towards relatively less affected locations and out of the the relatively more affected locations. Moreover, also in line with the data as pointed out in Monras (2018), inflows respond more than outflows: after a negative shock in a given location, workers move less towards that location, and move more out of that location, but the first effect is bigger. The model is able to generate these effects even though there are no related moments that are targeted in this regard.

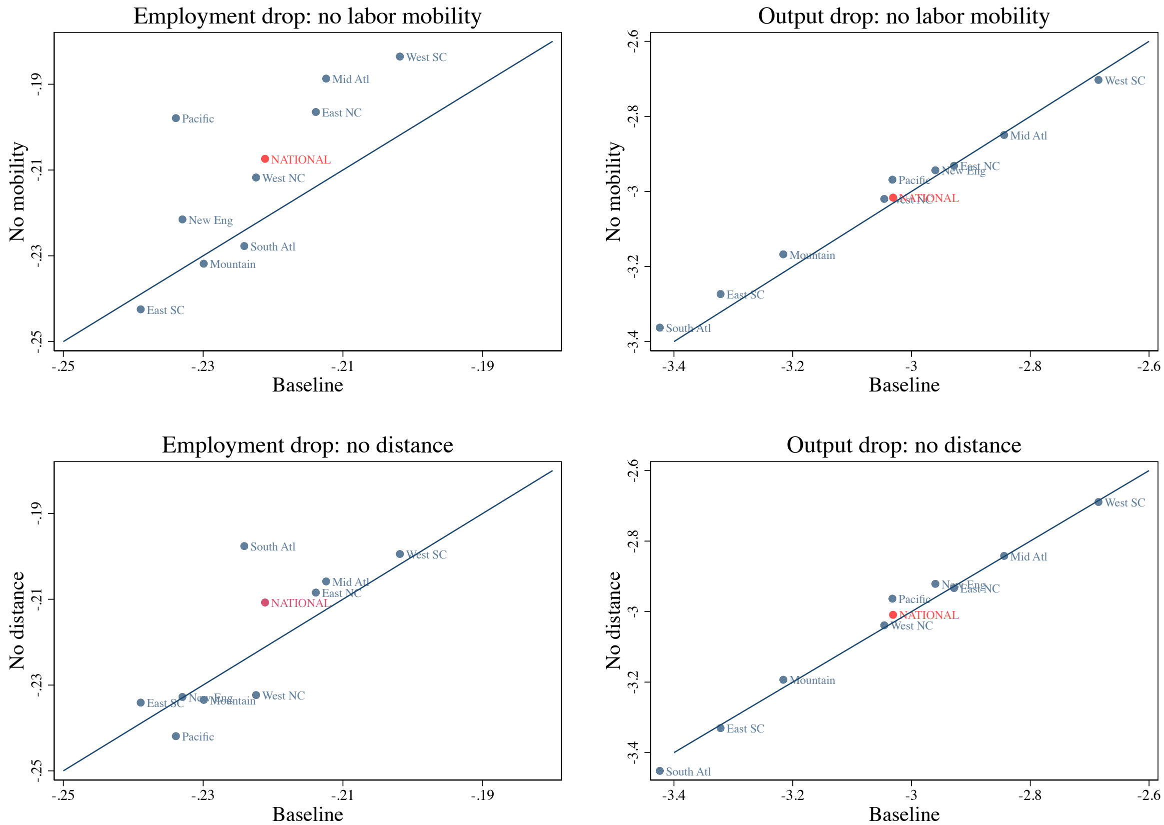
Figure 8: Inflows and Outflows After Negative Shock

6 The role of labor mobility during recessions

In order to assess the mitigating or exacerbating role of labor mobility during recessions, I compare here the baseline model with the counterfactual model in which moving costs τ are set to infinity, that is, a counterfactual in which moving across locations is not possible. In this exercise, only τ is changed and the rest of parameters are kept the same as in the baseline economy. In this counterfactual with no labor mobility, the effects of a negative productivity shock are the standard effects in labor search models, namely, the incentives to post vacancies decrease, and so the employment rate will decreases due to lower job finding probability. The difference across locations in this case only come from differences in the productivity process (average and sensitivity to aggregate shock). The comparison of this counterfactual economy with the baseline economy in which there is labor mobility allows us to capture changes in employment rates arising only from labor mobility itself.

There are three main effects of labor mobility during recessions that arise from the model. First, there is a pure reallocation effect, that is, non-employed workers can move across locations, therefore changing the pool of non-employed workers in each location. This reallocation effect will also capture employed workers moving to other locations as non-employed, which could increase the number non-employed workers overall. Second, labor mobility will also affect the incentives of firms to post vacancies in each location, not just because of the drop in productivity as in the counterfactual economy, but also because of it changes endogenous separations of workers who are now willing to move to another location. Finally, a crucial ingredient of the model with labor mobility is the possibility of moving by searching abroad. By searching abroad, workers have the possibility of moving to a new location if they find a job, but the probability of doing so is lower than when searching locally, that is, there is a loss of efficiency when searching abroad, capture by the parameters α_u and α_e in the model. This difference in the efficiency of searching will also have an effect in employment in the economy with labor mobility that is not present in the counterfactual economy.

Figure 9: Change in Employment and Output in Counterfactuals



Next, I compare the employment and output differences between the baseline economy and the counterfactual economy with no labor mobility, both for the overall, or *national*, economy, and for each of the locations separately. The top panels of Figure 9 shows the drop of employment and output after a negative productivity shock in the baseline economy (x-axis) relative to the counterfactual economy (y-axis), where employment drops are computed as the maximal employment rate or output drop after the shock. Points above the 45 degree line indicates that the drop in employment or output was more severe in the economy with labor mobility. In the overall national economy, employment rates drop by more more with labor mobility, although output remains almost the same between the two economies. However, these effects are heterogeneous across locations. In particular, locations that suffer the most during the recession experience higher employment rates when there is labor mobility. This is at the expense of a reduction in output in that location. The opposite happens in the least affected locations by the recession: employment drops more but output is higher with labor mobility. This is due to a change in the working force composition in each location.

6.1 Geography

Here I explain the role that geography plays for the effects of labor mobility on the economy. Distance across locations is crucial in determining the flow of workers across locations. To capture these patterns, the cost of moving is assumed to be a linear function of distance,

$$\tau_{ij} = \gamma^0 + \gamma^1 \text{Distance}_{ij},$$

with estimated constants γ^0 and γ^1 as shown in Table 5. Now we consider a counterfactual in which distance is not important for the decision of workers to move, that is, γ^1 is set to 0, and γ^0 is re-calibrated to maintain the same migration rate as in the baseline. The bottom panels of Figure 9 shows the results of these counterfactuals and compares employment rates and output with the baseline economy. The results indicate that there are some regions that benefit more from their geographical locations than others. For instance, the West North Central division experiences a much lower employment drop in the baseline than in the counterfactual with no distance across locations. On the other hand, the South Atlantic division would benefit from lower employment drops in the counterfactual economy with no distances.

6.2 Searching abroad

One of the key ingredients in the model is the possibility for workers to search in a different location than their current location, that is, search abroad. This allows the model to generate job-to-job transitions which in the data account for most of the internal migration employment transitions and is the principal cause of procyclical migration. Yet, this type of employment transition has been usually ignored in the migration literature that features labor search frictions. Here I show the importance of including searching abroad in the model, not only in order to capture the employment transitions as in the data, but also to derive conclusions regarding the role of labor mobility during recessions.

To understand the role of searching abroad, I simulate the model setting the efficiency of searching abroad parameters, α_e and α_u to 0. The bottom panel of Table 8 shows the results. First of all, in this counterfactual economy, migration is countercyclical, contradicting the finding in the data. This is so because there are almost no job-to-job transitions, and most movers are non-employed.[14] After a negative productivity shock that generates an increase in dispersion across locations, non-employed workers have incentives to move towards relatively better off regions, generating in this way an increase in total migration.

[14] The only job-to-job transitions involving a change in location in this counterfactual are employed workers that quit their current job, move to a new location, and find a job in the same period. These transitions account as job-to-job as in the data.

7 Conclusion

In this paper I study the role of labor mobility in mitigating or amplifying asymmetric aggregate productivity shocks. I first show evidence on the main patterns of internal migration over the business cycle. A well-known fact is that migration tends to decrease during recessions. I show that this is due to a decrease in job-to-job transitions in downturns. Next, I use the novel empirical evidence to discipline an equilibrium model of labor mobility with multiple locations and search and matching frictions. The key ingredient of the model is the inclusion of on-the-job search and search abroad, so as to capture the large fraction of job-to-job transitions that occur across locations in the data.

The quantification of the model shows that labor mobility has heterogeneous effects across locations, and could amplify recessions in the national economy. This is due to the role of endogenous separations in the model. Even if labor mobility helps reallocating workers where job opportunities are higher, and has therefore a mitigating effect, locations that are affected the most by the recession are disproportionately affected with labor mobility due to the increasing incentives of its workers to leave the location. The model is also used to analyze the role of the efficiency of searching from abroad, as well as the role geography plans in the reallocation of workers during recessions.

References

Cahuc, P., F. Postel-Vinay, and J.-M. Robin (2006): "Wage bargaining with on-the-job search: Theory and evidence," *Econometrica*, 74, 323–364.

Greenwood, M. J. (1997): "Internal migration in developed countries," *Handbook of population and family economics*, 1, 647–720.

Herzog Jr, H. W., A. M. Schlottmann, and T. P. Boehm (1993): "Migration as spatial job–search: a survey of empirical findings," *Regional Studies*, 27, 327–340.

Kennan, J. and J. R. Walker (2011): "The effect of expected income on individual migration decisions," *Econometrica*, 79, 211–251.

Lise, J. and J.-M. Robin (2017): "The macrodynamics of sorting between workers and firms," *American Economic Review*, 107, 1104–35.

Milne, W. J. (1993): "Macroeconomic influences on migration," *Regional Studies*, 27, 365–373.

Monras, J. (2018): "Economic shocks and internal migration," *CEPR Discussion Paper*, No. DP12977.

Mundell, R. A. (1961): "A theory of optimum currency areas," *The American economic review*, 51, 657–665.

Pissarides, C. A. and J. Wadsworth (1989): "Unemployment and the inter-regional mobility of labour," *The Economic Journal*, 99, 739–755.

Saks, R. E. and A. Wozniak (2011): "Labor reallocation over the business cycle: New evidence from internal migration," *Journal of Labor Economics*, 29, 697–739.

Schlottmann, A. M. and H. W. Herzog (1981): "Employment status and the decision to migrate," *The Review of Economics and Statistics*, 590–598.

Winberry, T. (2016): "A toolbox for solving and estimating heterogeneous agent macro models," *Forthcoming Quantitative Economics.*

Appendix A Additional Empirical Evidence

A.1 Alternative Data Sample Selection

Here, I present evidence on the employment transitions, as well as the cyclicality of migration overall and by type of transitions between employment states, considering different worker samples that in the baseline specification in the main text, as reported in Tables 3 and 4. In particular, four different samples are considered. First, I consider the sample of workers actively in the labor market, that is, employed or unemployed, and excludes those not in the labor force. This is in contrast to the baseline specification, where non-employed workers includes both unemployed and workers not in the labor force.

I also consider samples including only men, and another sample including only individuals reporting to be single (this excludes married, widowed, and divorced). This is done to show that the results are not driven by individuals moving to a new location due to a location move of their spouses.

Finally, I consider a different age sample selection, and constrained to individuals aged 21 to 65 years old. In the baseline specification workers are 21 to 54 years old, so as to avoid including location moves related to retirement.

Table 9: Cyclicality of Migration: Alternative Samples

Correlation of migration	Total	E-E	E-N	N-E	N-N
Employed v. Unemployed:					
Unemployment rate	-0.366	-0.366	-0.117	-0.293	0.284
Employment rate	-0.366	0.413	0.187	0.281	-0.294
Only men:					
Unemployment rate	-0.366	-0.366	-0.117	-0.293	0.284
Employment rate	-0.366	0.413	0.187	0.281	-0.294
Only singles:					
Unemployment rate	-0.366	-0.366	-0.117	-0.293	0.284
Employment rate	-0.366	0.413	0.187	0.281	-0.294
Aged 21-65:					
Unemployment rate	-0.366	-0.366	-0.117	-0.293	0.284
Employment rate	-0.366	0.413	0.187	0.281	-0.294

Notes: This table shows the correlation of interstate migration with the national series of unemployment rate and employment rate, constructed using data from the SIPP. Both series are quarterly average of monthly transitions, seasonally adjusted, and detrended using Hodrick-Prescott filter with smoothing parameter 1600. Each column represents different types of migration: Total, and migration involving 4 different types of employment transition.

A.2 Wages at Time of Moving