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Credible redistributive policies and migration across U.S. states ☆

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ABSTRACT

We ask whether worker mobility has undermined the ability of U.S. states to redistribute income. We build a tractable model where both migration decisions and redistribution policies are jointly determined. Our model features a large number of heterogeneous regions and skilled and unskilled workers with idiosyncratic migration costs. The calibrated model is able to account for the main features of interstate migration, as well as some qualitative features of the cross-sectional distribution of redistributive policies. We conduct a counterfactual experiment in order to isolate the effect of worker mobility on state-level redistributive policies. We find that migration has induced substantial convergence in tax rates across U.S. states, but no race to the bottom. Interestingly, the degree of convergence has been much lower for transfers due to an offsetting tax-base effect.

1. Introduction

Migration flows across U.S. states have been very large in recent decades. In 2000, over 40% of the population lived in a state other than their state of birth. These population flows have fueled growth in the South and the West of the U.S. At the same time, there remain considerable differences in taxation and redistributive transfers across U.S. states in spite of the high degree of geographical worker mobility. Since Tiebout (1956), there is a widespread belief that the mere threat of migration to other states will affect within-state redistribution levels.

The goal of this paper is to quantify the effects of labor mobility on the ability of regional governments to redistribute income. We build a multi-region model of labor flows and redistribution policies. In our model, skilled and unskilled workers base their migration decisions on after-redistribution income. Their location decisions change regional skill composition, which in turn determines the degree of income redistribution. We calibrate our model using recent data for U.S. states. We then compare the cross-section of redistributive policies in two scenarios that differ on the degree of worker mobility.

There are two defining features of our model. First, we require redistribution policies to be *credible*. That is, a region's policy must reflect the social preferences of the population living in each region once migration has taken place. This rules out promises of unrealistically low taxes, which no government would choose to validate once workers have already

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incurred in the sunk cost of moving.[1] Second, we model bilateral labor flows, introducing mobility costs and heterogeneous technologies across regions. The quantitative aim of our analysis is in the spirit of the macroeconomics literature on the determinants of internal migration flows, pioneered by Greenwood (1969) and reinvigorated by Blanchard and Katz (1992).

We calibrate the model to match output per worker and the skill premium in each state, and calibrate mobility costs as a function of geographic variables. Following Dahl (2002) and Aghion et al. (2005), we define migrants as individuals whose state of residence in year 2000 differs from their state of birth. We are considering a time period of roughly three decades, thus allowing sufficient time for tax policies to react to changes in the size and skill composition of the population.

Remarkably, the calibrated model reproduces the main features of bilateral worker flows and the cross-section of redistribution policies. The model's prediction for the skill composition of each state's workforce fits the data very well. Crucially, the model correctly predicts that the pattern of net flows is strongly correlated across skill levels. We also evaluate the role of each of the income determinants of migration, as they lay at the core of our theory. We find that labor productivity (TFP) has been the main driver of labor flows for most states. We also provide some measures of tax progressivity and redistributive transfers, and find that the cross-sectional distribution of policies generated by the model is quite similar to the one in the data. We find our results to be robust across several definitions of migrant and policy measures.

We proceed to use the calibrated model to evaluate the effects of interstate migration on the cross-sectional distribution of redistributive policies. Specifically, we compare the policies predicted by the model in two alternative scenarios. In the first, migration costs have been calibrated to match the size of labor flows observed in the data. In the second scenario, migration costs are prohibitively high and, as a result, all workers remain in their state of birth.

Our main finding is that interstate migration has induced substantial convergence, but no downward pressure, in tax rates. The mechanism is simple and relies heavily on regional heterogeneity. The states with the highest tax rates in the no-mobility scenario (e.g. Virginia and Georgia) have experienced substantial skilled in-migration due mainly to relatively high TFP. The resulting increase in the relative supply of skilled labor has reduced the skill premium and thus the need for tax-based redistribution. Likewise, the states with low initial taxes (e.g. North Dakota and West Virginia) have suffered net out-migration of skilled labor, leading to a higher skill premium and a larger redistributive tax. Extending the model to include regional amenities improves the fit and delivers larger convergence in policies.

Interestingly, the cross-section of transfers per recipient in the two mobility scenarios are quite similar, showing only a small degree of convergence. The reason is that the changes in tax rates following a change in skill composition are largely offset by a change in the tax base. An increase in the fraction of skilled in a state leads to a tax cut but simultaneously raises the ratio of payers to recipients. As a result, these states could afford essentially unchanged transfers at lower tax rates.

As we study the joint determination of labor flows, income, and tax policies across regions, we bring together several strands of research. We briefly summarize the work on each area that is closer to our model. There is a long-standing literature on the consequences of labor mobility for redistribution policies. Tiebout (1956) suggested that competition in this form may lead to an efficient allocation of workers, an argument later criticized by Bewley (1981). In a well-known paper, Epple and Romer (1991) developed a model of redistribution where voters are fully aware of the general-equilibrium effects of migration on policies. Our approach is closer to models where migration flows determine the factors of production available at each location—Wilson and Wildasin (2004) provide a comprehensive review. In a follow-up paper, we find that labor mobility can induce symmetry-breaking equilibria in a set up where only skilled workers are mobile (Armenter and Ortega, 2009). Work in this literature typically does not pursue a quantitative characterization of labor flows.[2] We instead attempt to integrate the policy decision in a framework suited for quantitative analysis, featuring realistic mobility costs and regional heterogeneity.

This paper is also related to the literature pioneered by Rosen (1979) and Roback (1982). These papers study the joint determination of income and prices of immobile factors under perfect labor mobility. Recent contributions to this literature include Moretti (2004) and Greenstone et al. (2008), who extend the Roback model by including local externalities. Our study is more closely related to Albouy (2009), who studies the impact of federal taxation on local prices and location decisions.

Our emphasis on the model's quantitative implications for bilateral labor flows is related to the recent research in macroeconomics on the determinants of internal migration in the U.S. Building on Blanchard and Katz (1992), Coen-Pirani (2006) shows how a general equilibrium model with search frictions can reproduce the main facts on gross migration flows across U.S. states during the postwar period. Models with search have also been used to studies differences in state-level unemployment rates, as in Lkhagvasuren (2005) and Hassler et al. (2005). Finally, our work is also related to recent research in labor economics that studies internal migration, such as Dahl (2002) and Kennan and Walker (2006).

Section 2 lays out the model. The calibration is described in Section 3. We then evaluate the model's performance with respect to labor flows and redistribution policies in Sections 4 and 5, respectively. Section 6 presents our counter-factual exercise. We discuss some extensions and robustness exercises in Section 7 and draw our conclusions in Section 8.

[1] The work on tax competition has a long tradition, starting with Tiebout (1956). Non-credible promises are often at the core of "race to the bottom" arguments. See Oates (1972) and Zodrow and Mieszkowski (1986).

[2] Most of the literature models only one factor of production as mobile. Some notable exceptions are Cremer and Pestieau (1998), Schmidheiny (2005), and Morelli et al. (2008).

2. The model

We present the model in three steps. First, we describe the set-up for the "national" economy, made up of several regions (or states). We then focus on the endogenous determination of redistribution policy given the workforce in the region. The last subsection details how labor flows are determined in equilibrium and formally defines an equilibrium.

2.1. Setup

We consider a national economy consisting of $r \in \{1, 2, \dots, R\}$ regions. In each region $r \leqslant R$, there are two types of workers: unskilled and skilled, denoted by subscripts $i = 1$ and $i = 2$, respectively. Each region r starts with a measure $e_i^r > 0$ of workers of each type. After all migration decisions have been made, the measure of workers of type i in region r is n_i^r.

Definition 1. A national distribution of workers $n = \{n_1^r, n_2^r\}_{r \leqslant R}$ is feasible if

$$\sum_{r \leqslant R} n_i^r = \sum_{r \leqslant R} e_i^r$$

for $i = 1, 2$ and $n_i^r \geqslant 0$ for all $r \leqslant R$, $i = 1, 2$.

Let $x^r = (c_1^r, c_2^r, l_1^r, l_2^r)$ be an allocation for region r where c_i^r and l_i^r denote consumption and hours worked by an agent of type i in region r. We let $x = \{x^r\}_{r \leqslant R}$ be a national allocation. We assume that preferences over consumption and labor are represented by a separable utility function $U(c_i, l_i) = u(c_i) - v(l_i)$, with $u' > 0$, $u'' < 0$, $v' > 0$ and $v'' > 0$. To save on notation we shall often write $U(x_i^r)$ with the understanding that $x_i^r = (c_i^r, l_i^r)$.

Unskilled and skilled labor are differentiated inputs in the production process. We assume that unskilled workers can only supply unskilled labor as they are not qualified to perform certain tasks. Skilled workers, though, can supply either skilled or unskilled labor.

Production of the homogenous consumption good in region r is given by $F^r(n_1^r l_1^r, n_2^r l_2^r)$. We assume production function F^r is differentiable, constant returns to scale, strictly quasi-concave, and satisfies $F_{12}^r > 0$ as well as the appropriate Inada conditions.[3] In order to be precise about what we mean by "scarce," let $\eta^r = n_2^r / n_1^r$ be the ratio of skilled to unskilled workers in region r. Let $\bar{\eta}^r$ be given by

$$F_1^r\big(1, \bar{\eta}^r\big) = F_2^r\big(1, \bar{\eta}^r\big).$$

Skilled labor is scarce in region r as long as $\eta^r < \bar{\eta}^r$, which we assume for all regions from now on. We are now set to define feasible allocations.

Definition 2. A national allocation x is feasible given $n = \{n_1^r, n_2^r\}_{r \leqslant R}$ if

$$n_1^r c_1^r + n_2^r c_2^r \leqslant F^r\big(n_1^r l_1^r, n_2^r l_2^r\big) \tag{1}$$

and hours worked and consumption are non-negative for all $r \leqslant R$ and $i = 1, 2$.

While we do not model trade explicitly, our definition of a national allocation would also apply in an economy with balanced trade in final or intermediate goods.

2.2. Redistribution policy

Redistribution policy in each region is decided by a fiscal authority that looks after the welfare of its residents. We start by studying the problem of optimal redistribution policy for a given workforce (n_1, n_2). For notational convenience we have dropped the superscripts indexing each region.

We do not exogenously restrict the tax instruments available to the fiscal authority. In particular, we allow for non-linear tax schedules and hence progressive income taxation. We assume, though, that workers' types are unobservable so the tax schedule can only be a function of the workers' actions. Private information constrains income redistribution: a very aggressive redistribution policy would induce skilled workers to take on unskilled jobs.[4]

[3] We can view this production function as the reduced form of a more general function that combines capital and an aggregate of labor in a constant-returns-to-scale fashion provided that each of the regional economies faces a perfectly elastic supply of capital. In this context, labor inflows into a region trigger a proportional capital inflow.

[4] Our approach has two advantages with respect to the common assumption that the government is restricted to choose a linear income-tax schedule. First, the equilibrium pins down allocations. As a result, our results are robust to alternative assumptions on the tax instruments available to the government. Second, characterizing allocations turns out to be highly tractable and allows us to provide some analytical results.

We proceed as follows. First, we state the optimal redistribution policy problem as a principal-agent problem in the spirit of Mirrlees (1971). This approach reduces the problem to choosing feasible allocations subject to a set of incentive compatibility constraints. These constraints ensure that all workers truthfully reveal their type. Second, we show that we can decentralize the resulting allocation as a competitive equilibrium with a lump sum tax on skilled workers. Finally we describe the key properties of the redistribution allocation.

In our economy only skilled workers can mislead the government by supplying unskilled labor. Thus the only incentive-compatibility constraint states that a skilled worker is no worse off than an unskilled worker.

Definition 3. Feasible allocation $x = (c_1, l_1, c_2, l_2)$ is incentive-compatible if

$$U(c_1, l_1) \leqslant U(c_2, l_2). \tag{IC}$$

The optimal redistribution policy problem is then to pick the incentive-compatible allocation which provides the highest social welfare given the current workforce (n_1, n_2) or, more compactly, given the ratio of skilled to unskilled workers, $\eta = n_2/n_1$. We label the resulting allocation as *second-best*.

Definition 4. An allocation x is second-best given η if it solves

$$\max U(c_1, l_1) + \eta U(c_2, l_2) \tag{2}$$

subject to (IC) and feasibility,

$$c_1 + \eta c_2 \leqslant F(l_1, \eta l_2) \tag{RC}$$

as well as non-negativity constraints.

Our next result states that second-best allocations can be decentralized in terms of a lump-sum tax on skilled workers and a transfer to unskilled ones.

Proposition 1. *Let x be a second-best allocation given η. Then there exists a lump-sum tax τ and wage rates (w_1, w_2) such that allocation x can be decentralized as a competitive equilibrium*:

1. *Pair (c_1, l_1) solves the problem of unskilled households*:
$$\max U(c_1, l_1) \quad s.t. \quad c_1 \leqslant w_1 l_1 + \eta\tau,$$
with $c_1 \geqslant 0, l_1 \geqslant 0$.
2. *Pair (c_2, l_2) solves the problem of skilled households*:
$$\max U(c_2, l_2) \quad s.t. \quad c_2 \leqslant w_2 l_2 - \tau,$$
with $c_2 \geqslant 0, l_2 \geqslant 0$.
3. *Wages equal marginal products*: $w_i = F_i(l_1, \eta l_2)$ *for* $i = 1, 2$.

Proof. In Appendix A. □

Hence second-best allocations can be implemented with a very simple, non-distortionary tax system.[5] The precise value of lump-sum tax τ is a function of the skill ratio as well as the production technology. Clearly, the decentralization we present is not unique as it depends on the specific tax instruments available to the government. This is why we shall focus on redistribution measures, like total taxes or total transfers over income, that are uniquely determined as they are built directly from the allocation.

We collect below the key properties of second-best allocations.

Proposition 2. *Let x be a second-best allocation given η, then*:

1. *The incentive-compatibility constraint* (IC) *is binding*: $U(c_1, l_1) = U(c_2, l_2)$.
2. *There is a strictly positive skill premium,* $w_1 < w_2$.
3. *Skilled workers consume more* $(c_2 > c_1)$ *and work more* $(l_2 > l_1)$ *than unskilled workers.*
4. *The tax is strictly positive*: $\tau > 0$.

[5] In contrast with Mirrlees (1971) there is no need to distort the labor supply of the unskilled worker. The reason is that the marginal rate of substitution between consumption and labor is proportional across workers.

Proof. In Appendix A. □

In the second-best allocation, consumption and wages are higher for skilled workers. It is clear that the fiscal authority would like to redistribute income from skilled to unskilled workers more aggressively. However, the need to provide the right incentives to skilled workers limits the amount of redistribution. Second-best allocations are thus fully characterized by four equations: the binding incentive and resource constraints, together with the equality of marginal rates of substitution to marginal products of labor for each skill type.[6]

We finish this section with an important result. In a laissez-faire economy, a larger ratio of skilled workers makes unskilled workers better off and skilled workers worse off. However, this is not true for second-best allocations: *both* types of workers are strictly better off with a higher skill ratio. The higher skill ratio leads to a lower skill premium and a lower lump sum tax.

Proposition 3. *Let $\eta < \eta' < \bar{\eta}$ and let x and x' be second-best allocations under η and η', respectively. Then $U(c_2, l_2) < U(c_2', l_2')$ and $U(c_1, l_1) < U(c_1', l_1')$. Moreover, second-best allocations are decentralized with lump sum taxes $\tau > \tau'$ and feature skill premium $w_2/w_1 > w_2'/w_1'$.*

Proof. In Appendix A. □

The mechanics behind the result are simple. The incentive compatibility constraint is binding for all $\eta < \bar{\eta}$. It is not possible to raise the welfare of unskilled workers without a parallel increase in the welfare of skilled workers. Otherwise the incentive compatibility would be violated. Thus skilled workers need to be compensated with a tax cut to prevent them from taking unskilled jobs.

2.3. Labor mobility and credible policy equilibrium

We model migration decisions as follows. Each worker in each region r receives one *opportunity to migrate*, (r', m), specifying a destination region $r' \neq r$ and a migration cost m in terms of utility. We assume each region generates migration opportunities equally, that is, a fraction $1/(R-1)$ of workers born in region r receive opportunities to migrate to each region $r' \neq r$. The arrival of opportunities is also independent of the skill level of the worker, so the number of i-type workers from r with an opportunity to move to $r' \neq r$ is thus given by $e_i^r/(R-1)$ for $i = 1, 2$. The restricted opportunities to move play an important role in the model's ability to match the data on net bilateral inflows. If workers were unrestricted in their choice of destination, then all migrant workers would move to the state with highest welfare, which is clearly at odds with the data (as we document below).[7]

Individual migration cost m_i is given by

$$m_i = g(r, r') + \varepsilon_i$$

where the term $g(r, r')$ captures the impact of geographical proximity on mobility costs, and ε_i is an idiosyncratic mobility cost distributed with c.d.f. $D_i(\varepsilon_i)$ for $i = 1, 2$. We allow the distribution to differ by skill type, which will be helpful in matching the skill composition of overall net flows. As we show later, this specification of mobility costs will be able to replicate the geographical pattern of labor flows in the data: not surprisingly, workers are more likely to move to nearby states.

The whole matrix of (gross) bilateral migration flows for each worker type can be summarized by the fraction of workers of type $i = 1, 2$ moving from r to r', denoted $\delta_i(r, r')$. We will let $\delta_i(r, r) = 0$. There cannot be more migrants than opportunities: therefore we have that $\delta_i(r, r') \leqslant (R-1)^{-1}$.

Given migration flows δ_i for worker types $i = 1, 2$, the final workforce in region r is

$$n_i^r = e_i^r \left(1 - \sum_{r' \in R} \delta_i(r, r')\right) + \sum_{r' \in R} \delta_i(r', r) e_i^{r'} \tag{3}$$

for $i = 1, 2$. The first term are the individuals initially in region r that choose to stay in the region. The second term is the aggregation of all inflows from other regions $r \neq r'$.

The migration cost is the only idiosyncratic determinant of the migration decision. Hence if a worker of type i born in region r with migration opportunity $(r', \bar{m})$ finds it beneficial to migrate, then all workers of the same type in region r with

[6] The binding incentive-compatibility constraint implies that skilled and unskilled workers have identical welfare. We can relax this result easily. For example, if tasks are unobservable as in Mirrlees (1971), skilled workers are always better off. Alternatively we could introduce different preferences or different labor endowments (in efficiency units) across worker types. This is important as we will take the position later that skills are acquired.

[7] Our specification of mobility frictions is also very tractable because it avoids *ex-post* heterogeneity, that is, once a worker has moved into region, she is identical to all the workers of the same type in the region. Microeconomic models assume a large amount of heterogeneity as each worker has a distribution of idiosyncratic work offers across states—see Dahl (2002) and Kennan and Walker (2006) for example. Clearly, this rich heterogeneity allows for a very good fit of the data. However, it would render the redistribution policy problem intractable.

opportunities to r' and lower migration costs, $m \leqslant \bar{m}$, will migrate as well. It is thus useful to define the following threshold. For each pair of regions (r, r'), we can define the mobility cost incurred by the *marginal migrant*:

$$\mu_i(r, r') = g(r, r') + D_i^{-1}(\delta_i(r, r')).$$

Before proceeding further, we define a national equilibrium for any given set of feasible policies $\{\tau_r\}_{r \leqslant R}$. Recall from the previous section that second-best allocations can be decentralized with lump-sum taxes.

Definition 5. A national equilibrium given policies $\{\tau_r\}_{r \leqslant R}$ is a national allocation, matrices of migration flows δ_i for $i = 1, 2$, a set of marginal migration costs $\{\mu_i(r, r')\}_{r, r' \in R}$ for $i = 1, 2$, and a national worker distribution $\{n_1^r, n_2^r\}_{r \leqslant R}$ such that:

1. For every $r \leqslant R$, x_r is a competitive equilibrium given τ_r and $\{n_1^r, n_2^r\}$.
2. The worker distribution is feasible and satisfies (3).
3. For each $r \leqslant R$, all individually profitable moves from r to r' have taken place. If $\delta_i(r, r') < (R-1)^{-1}$, we have that

$$U(x_i^{r'}) - U(x_i^r) \leqslant \mu_i(r, r'),$$

with equality if $\delta_i(r, r') > 0$, for all $r' \neq r$ and $i = 1, 2$. If $\delta_i(r, r') = (R-1)^{-1}$ then

$$U(x_i^{r'}) - U(x_i^r) \geqslant \mu_i(r, r').$$

We have already discussed Condition 2. Condition 3 states the optimality of migration decisions. Migration takes place from region r to r' until the marginal migrant is indifferent. Migration (from r to r') does not take place at all if it is not profitable for the potential migrant with zero mobility costs, that is, if $U(x_i^{r'}) < U(x_i^r)$. Note that each individual migrant takes policies (allocations) as given. It is also possible that all workers with an opportunity to migrate to a particular region indeed migrated to that region, $\delta_i(r, r') = (R-1)^{-1}$. In this case, the utility gap between the two regions may remain large.

Next we define our concept of policy equilibrium. Crucially, we require policies to be credible, that is, the redistribution allocation implemented in each region must be second-best given the final workforce in the region. We rule out promises of low taxes or high benefits that will not be honored once workers have already incurred in the cost of moving.

Definition 6. A credible-policy equilibrium is a national equilibrium given policies $\{\tau_r\}_{r \leqslant R}$ such that, for every $r \leqslant R$, allocation x_r is a second-best allocation.

2.3.1. Equilibrium refinement

In our economy there may be multiple credible policy equilibria, specially if regions are similar and mobility costs for skilled workers are low. Consider a symmetric economy with two regions as an illustration. There is one credible policy equilibrium with no labor flows. Symmetry is preserved: both regions implement the same policy, welfare is identical and so no worker is willing to move. If mobility costs are sufficiently high, this is indeed the unique credible policy equilibrium. However, there may be more equilibria if mobility costs are low for skilled workers. Say skilled workers start flowing from region 1 to 2 raising the skill ratio in the latter region and decreasing it in region 1.[8] By Proposition 3, welfare in region 2 increases, and thus can validate the initial decision to move. Since both regions are identical *ex-ante*, there is another equilibrium where regions 1 and 2 exchange their roles.

The credible policy equilibrium is generically unique under a simple tâtonnement refinement.[9] We simply require that the equilibrium worker distribution be attained through a sequence of arbitrarily small labor flows such that at each step migrant workers move to regions with higher welfare.[10] For illustration consider again a two region economy, but this time region 1 has a small advantage in technology and thus, in autarky, welfare in region 1 is higher than in region 2. For low mobility costs there are two credible policy equilibria. In one equilibrium a small fraction of workers move from region 2 to region 1, and workers in region 1 are better off in equilibrium. In the other equilibrium a large contingent of workers move from region 1 to region 2, overturning the welfare ranking in autarky: workers in region 2 end up better off than workers in region 1. The latter equilibrium does not satisfy the tâtonnement refinement as the equilibrium requires a large group of workers to coordinate into moving to the region with lower *ex-ante* welfare.

For the remainder of the paper we focus on the unique credible policy equilibrium selected by the tâtonnement refinement.

2.3.2. Equilibrium properties

Here we describe some features of migration flows in equilibrium. These play a key role later in our calibration as well as in the evaluation of the model. First, bilateral migration flows are one-way. If in equilibrium any worker migrates from

8 Note that skilled workers must be more mobile than unskilled workers in order for worker inflows to raise the skill ratio in the destination region.

9 The non-generic case is the symmetric economy. In this case there are always two equilibria as regions can always be re-labeled.

10 For a formal definition and proof see Armenter and Ortega (2009).

region r to region r', it cannot be the case that workers from region r' are moving to region r as mobility costs are positive. This observation makes clear that ours is a theory of net bilateral flows.[11] Second, in equilibrium both types of workers move in the same direction. Specifically, if unskilled workers are migrating from region r to region r', then skilled workers are doing likewise. This result follows from the binding incentive-compatibility constrain. The previous remarks imply that each region will suffer outflows of workers toward all other regions with higher equilibrium utility. Given migration rates $\delta_i(r, r')$, we define *total net out-migration rates* by

$$\Delta_i(r) = \frac{e_i^r - n_i^r}{e_i^r},$$

where n_i^r is given by Eq. (3). If regions are similar in size and mobility costs, we expect $\Delta_i(r)$ to be non-increasing in the region's welfare, $U(x_1^r)$. We collect these results into a proposition that needs no proof.

Proposition 4. *Let δ and x be part of a credible policy equilibrium. Relabel regions in increasing equilibrium utility,*

$$U(x_1^1) \leqslant U(x_1^2) \leqslant \cdots \leqslant U(x_1^R).$$

Then for any r and r':

1. *Migration is one-way, $\delta_i(r, r')\delta_i(r', r) = 0$, for $i = 1, 2$.*
2. *Both skilled and unskilled move in the same direction: $\delta_1(r, r') > 0$ if and only if $\delta_2(r, r') > 0$.*
3. *Bilateral net outflows are positive $\delta_i(r, r') \geqslant 0$ if and only if $r < r'$.*

Moreover, if mobility costs and worker endowments are symmetric across regions, total net out-migration rates are weakly decreasing: $\Delta_i(r) \geqslant \Delta_i(r')$ for $r < r'$.

3. Calibration

This section calibrates the model using data on wages, labor productivity and net bilateral migration flows for U.S. states in year 2000. Before we discuss our calibration strategy, we describe the functional forms as well as the data used for the calibration.

3.1. Functional forms

We assume that each state's aggregate production function belongs to the CES family:

$$F^r(L_1, L_2) = \theta_r\big((1-\alpha_r)L_1^\rho + \alpha_r L_2^\rho\big)^{1/\rho}$$

where $\theta_r > 0$ pins down total factor productivity (TFP), $0 < \alpha_r < 1$ captures the "skill bias," that is, the relative productivity of skilled to unskilled workers, and $\rho < 1$ governs the elasticity of substitution between skilled and unskilled workers, $\sigma = 1/(1-\rho)$. Agent's preferences over consumption and labor bundles, (c_i, l_i), are separable and logarithmic:

$$U(c, l) = ln(c) + ln(1-l).$$

We model the geographic pattern of flows with a simple specification

$$g(r, r') = \beta d(r, r') + \gamma b(r, r')$$

where $d(r, r')$ is the distance between the center points of regions r and r' and $b(r, r')$ is a dummy that takes value 1 whenever the two regions share a border.

Finally, it is convenient to assume that idiosyncratic mobility costs are drawn from an exponential distribution:

$$\varepsilon \sim D_i(\varepsilon) = 1 - \exp(-k_i\varepsilon),$$

where $k_i > 0$ for each of the worker types $i = 1, 2$. Higher values of k_i imply higher mobility (that is, lower mobility costs).

Table 1 lists all the parameters in the model. More specifically, we need to assign values to the 105 parameters. Out of these, 101 are needed to characterize the production technologies: a pair (θ_r, α_r) for productivity and skill bias for each state; and a common value for the elasticity of substitution between skilled and unskilled labor, σ. We have four additional parameters: coefficients β and γ relate mobility costs to geographical variables, and distributional parameters $\{k_1, k_2\}$ pin down the distributions for the idiosyncratic component of migration costs.

[11] We note that, in our model, a region may receive net inflows from some regions and, simultaneously, experience net outflows to others. Coen-Pirani (2006) and Lkhagvasuren (2005) study models with matching frictions that give rise to two-way bilateral migration.

Table 1
Summary of model parameters.[a]

Technology parameters	
σ	Elasticity of substitution between skilled and unskilled labor
α_r	Skill bias, $r = 1, 2, \ldots, R$
θ_r	Total factor productivity, $r = 1, 2, \ldots, R$
Worker endowments	
$e_i(r)$	Initial worker distribution, $i = 1, 2$; $r = 1, \ldots, R$
Labor flows parameters	
k_i	Worker mobility, $i = 1, 2$
β, γ	Mobility costs parameters

[a] See text for details.

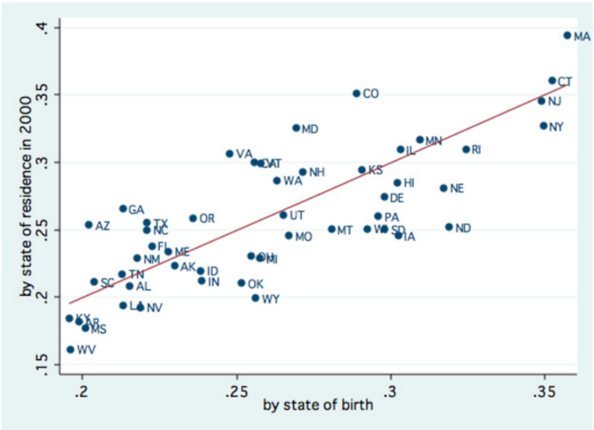

Fig. 1. Fraction of college graduates before migration (sorted by state of birth) and after migration (sorted by state of residence in 2000, vertical axis). *Source*: 2000 U.S. Census. Figure includes a 45-degree line, not a linear fit.

3.2. Data

We now provide a brief description of the data used in the calibration. Appendix B contains further details on the sources. Let us begin with the demographic data. In the spirit of our model, we need a relatively long time period between before and after migration. The reason is that changes in the size of redistributive programs in reality do not occur instantaneously. To construct our matrix of bilateral migration flows across U.S. states we employ a 5% public sample of the 2000 U.S. Census. Our baseline definition for a skilled worker is an individual with a college degree. All the rest are classified as unskilled. Following Aghion et al. (2005) and Dahl (2002) we define a migrant as a worker that resides in year 2000 in a state different from her state of birth.[12] We want to focus on migration that has been motivated by the economic forces in our model (after-redistribution labor income). Thus we restrict our baseline sample to individuals born between 1955 and 1975 (that is, 25–45 years old in year 2000). A substantial fraction of younger individuals will be attending college in a state different from their state of birth. Likewise, older individuals may take migration decisions motivated by retirement.

Thus we have empirical counterparts for the initial and final worker distribution, denoted $e_i^d(r)$ and $n_i^d(r)$ respectively, for worker types $i = 1, 2$.[13] We construct the bilateral net migration matrices, N_i^d, for both types of workers $i = 1, 2$. The typical element $N_i^d(r, r')$ is the net out-migration from state r to state r' for worker type i.

Fig. 1 plots the skill fraction by state of birth and state of residence in 2000. The dispersion in skill ratios by residence is quite high, ranging from less than 0.20 (West Virginia) to above 0.35 (Massachusetts), with an average of 0.26. Naturally, the fraction of skilled workers before and after migration is highly correlated. However the difference is quite large for several states. For instance, there were big increases in the fraction of skilled workers in Virginia or Colorado and large reductions in Wyoming and North Dakota. Table 2 reports the fraction of skilled workers for all states.

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[12] We are thus leaving foreign-born workers out of the analysis. Accounting for foreign-born workers made little difference to our results. In Section 7 we consider two alternative definitions of migrant.

[13] The superscript d stands for data.

Table 2
Descriptive statistics.

State	Skill fraction by state of birth[a]	Skill fraction by state of residence[b]	Skill premium[c]	Gross state product over employment[d]
Alabama	0.22	0.21	1.78	49,430
Alaska	0.23	0.23	1.45	68,116
Arizona	0.20	0.24	1.69	57,496
Arkansas	0.20	0.18	1.84	45,759
California	0.26	0.27	1.69	66,336
Colorado	0.29	0.34	1.61	59,796
Connecticut	0.35	0.35	1.91	77,903
Delaware	0.30	0.28	1.64	89,223
Florida	0.22	0.24	1.82	54,528
Georgia	0.21	0.27	1.84	61,028
Hawaii	0.30	0.28	1.40	54,382
Idaho	0.24	0.21	1.56	45,964
Illinois	0.30	0.30	1.57	64,692
Indiana	0.24	0.22	1.52	54,210
Iowa	0.30	0.25	1.51	48,475
Kansas	0.29	0.29	1.51	48,929
Kentucky	0.20	0.19	1.71	50,553
Louisiana	0.21	0.20	1.60	57,098
Maine	0.23	0.24	1.76	46,559
Maryland	0.27	0.34	1.72	61,502
Massachusetts	0.36	0.39	1.71	68,701
Michigan	0.26	0.24	1.64	60,614
Minnesota	0.31	0.32	1.64	56,658
Mississippi	0.20	0.18	1.50	44,723
Missouri	0.27	0.25	1.64	52,294
Montana	0.28	0.25	1.45	39,994
Nebraska	0.32	0.28	1.60	48,860
Nevada	0.22	0.18	1.53	60,593
New Hampshire	0.27	0.30	1.68	55,825
New Jersey	0.35	0.34	1.77	75,655
New Mexico	0.22	0.22	1.74	52,063
New York	0.35	0.31	1.85	75,983
North Carolina	0.22	0.25	1.76	58,808
North Dakota	0.32	0.26	1.44	41,880
Ohio	0.26	0.24	1.69	55,446
Oklahoma	0.25	0.21	1.67	45,739
Oregon	0.24	0.26	1.60	52,932
Pennsylvania	0.30	0.27	1.77	58,440
Rhode Island	0.33	0.29	1.74	60,482
South Carolina	0.20	0.22	1.77	51,983
South Dakota	0.30	0.25	1.57	46,597
Tennessee	0.21	0.22	1.82	52,108
Texas	0.22	0.24	1.81	60,812
Utah	0.27	0.26	1.47	50,592
Vermont	0.26	0.31	1.61	45,755
Virginia	0.25	0.32	1.86	62,449
Washington	0.26	0.29	1.61	63,437
West Virginia	0.20	0.17	1.71	49,270
Wisconsin	0.29	0.25	1.41	53,346
Wyoming	0.26	0.20	1.62	57,466
Min	0.20	0.17	1.40	39,994.00
Mean	0.26	0.26	1.66	56,429.68
Max	0.36	0.39	1.91	89,223.00
St. dev.	0.05	0.05	0.13	9782.51

[a] Fraction of skilled in state-born population. Census 2000.
[b] Fraction of skilled in state-resident population in 2000. Census 2000.
[c] College hourly wage over non-college hourly wage. Census 2000.
[d] Gross state product over employment. BEA Regional Accounts in 2000.

We also use data on worker productivity and skill premium for each state, denoted y_r^d and π_r^d respectively. Our measure of worker productivity is gross state product divided by employment in year 2000. According to our calculations, average worker productivity was \$56,430 (Table 2). A prominent data feature is the large cross-state dispersion. Worker productivity was an average of \$77,500 in the top 5 states (Delaware, Connecticut, New York, New Jersey, and Massachusetts). At the other end, the average worker productivity was \$43,600 for the bottom decile (Vermont, Oklahoma, Mississippi, North Dakota, and Montana). Our measure of skill premium (also built using Census data) is the ratio of hourly wages for college

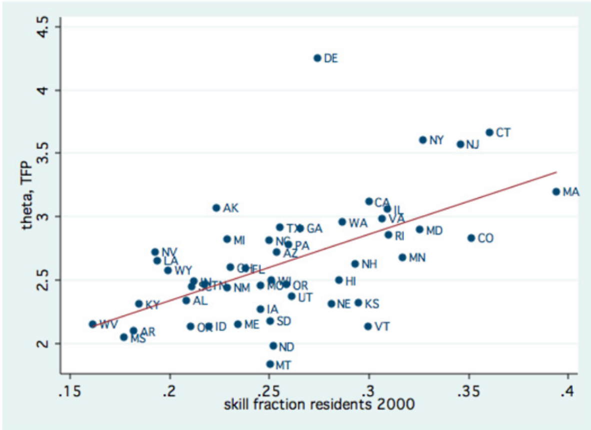

Fig. 2. Total factor productivity. Calibrated parameters. *Source*: Own calibration.

graduates (skilled) and workers without a college degree (unskilled). For the sake of comparability, we estimate state-specific wages using a sub-sample of individuals with comparable demographics, described in detail in Appendix B. The average skill premium in our sample is 1.66 (Table 2). Finally, we use as a measure of the distance between two states, $d(r, r')$, the distance between geographical state centers.

3.3. Calibration strategy

We now proceed to match the model parameters to the data. We start by calibrating the technology parameters using data on worker productivity and skill premium for each state. We then discipline the calibration of the labor flows parameters by fitting the data on bilateral migration rates.

Ciccone and Peri (2005) use data on skill premium differences across U.S. states to estimate the elasticity of substitution between skilled and unskilled labor. Based on their results, we set $\rho = 0.4$, implying an elasticity of substitution of $\sigma = 1.67$. We calibrate state-level production parameters following closely Hendricks (2004). For each state, we have two parameters, θ_r and α_r, to fit two moments of the data, the skill wage premium, π_r^d, and output per worker, y_r^d, taking as given the skilled-to-unskilled ratio in the data η_r^d. Thus we match exactly the data on skill premium and output per worker across states.

We now turn to the labor flows parameters: distance coefficients β and γ, and mobility cost distribution parameters k_1 and k_2. We regress the observed bilateral net flows on distance and border dummies to obtain parameters $\{\beta, \gamma\}$, and pick $\{k_1, k_2\}$ to obtain the best fit for total gross out migration rates for skilled and unskilled workers.

3.4. Parameter values

We now present the calibrated parameters and the fit of the model. The distribution of TFP parameters θ_r (Fig. 2) closely tracks the distribution of output per worker in the data. Across states, TFP ranges from 1.86 (Montana) to 4.31 (Delaware). Note also that states with a higher fraction of skilled workers also tend to have higher labor productivity. Another interesting feature of our calibration is that states with a large relative supply of skilled labor also feature a large relative demand for that type of labor.[14] The correlation of the skill-bias parameter (α) with the skill fraction is 0.86. The reason is that skill fractions and skill premia do not display any systematic relationship in the data.[15]

Let us now turn to the fit of labor flows. Changes in the ratio of skilled to unskilled are the main determinant of changes in redistribution policy. Hence it is key that the model matches the cross-section in the data. Fig. 3 plots the predicted skill fraction against actual values, which shows a remarkably good fit. The correlation coefficient is 0.87, and the model explains 76 percent of the variation in the data.

Calibrated parameters $\{\beta, \gamma, k_1, k_2\}$ all have the expected signs. Mobility costs increase with distance, $\beta = 0.025$, and are smaller whenever two states share a border, $\gamma = -0.6$. Additionally, average migration costs are lower for skilled workers, which follows from parameter values $k_1 = 0.18$ and $k_2 = 0.22$.[16] This is consistent with the higher mobility rates for skilled workers documented in several studies (see Bound and Holzer, 2000 in the context of U.S. internal migration).

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[14] In our calibration, households supply about 40% of their time endowment to the labor market. We also explored richer preference specifications that allowed us to pin the labor supply to one third of their time endowment, with no discernible differences in the results.

[15] This result confirms the findings in Hendricks (2004). Our calibration uses more recent data and we allow for differences both in skill bias and in labor productivity. Our estimates for state-level skill premium are consistent with those reported in Beaudry et al. (2006). See also Glaeser and Saiz (2003).

[16] Recall that a high value of k_i is associated to high mobility, that is, low migration costs on average.

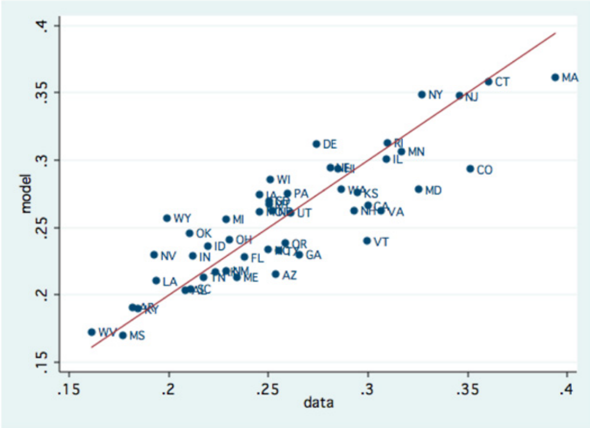


Fig. 3. Fraction of skilled workers in data (sorted by state of residence) and in the model. *Note*: Data from 2000 U.S. Census. 45-degree line included.

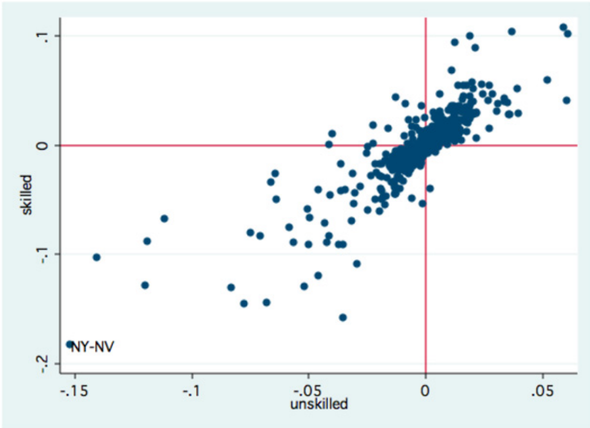


Fig. 4. Net bilateral migration flows, by skill level. *Source*: U.S. Census 2000, 5% sample. In total 1225 bilateral pairs, excluding two extreme observations (California–Nevada and Massachusetts–New Hampshire).

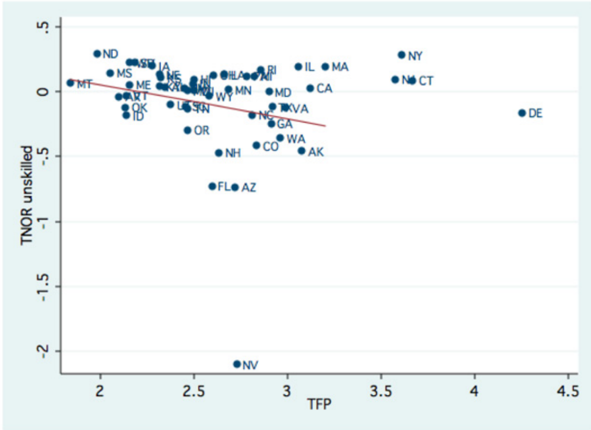
4. Model evaluation: Migration flows

We evaluate the performance of the model in accounting for data on bilateral migration flows across US states. Specifically, we focus on two equilibrium predictions: skilled workers migrate from one state to another if and only if unskilled workers do so as well, and total net out-migration rates (for both types of workers) for a given state should be decreasing in the equilibrium level of utility of that state relative to the others (Proposition 4).

The first of the two predictions can be tested using the net bilateral migration matrices built with our data. Fig. 4 plots the bilateral net out-migration rates of skilled and unskilled workers.[17] Strikingly, the net out-migration rates for both types of workers have the same sign in 83% of the cases: most pairs fall either in the top-right or bottom-left quadrants. Deviations from the pattern are not only few but also quantitatively very small. This finding is quite revealing. It shows that the internal migration decisions of skilled and unskilled workers are strongly aligned. This is highly informative regarding the role of regional heterogeneity in the model. In particular, it shows that the large regional differences in TFP are what drives bilateral migration flows, with differences in the scarcity of skilled labor playing a much smaller role.

We now turn to the second prediction on migration flows. Namely, the negative relationship between total net out-migration rates (TNOR), for both skill types, and the state's equilibrium utility. There is a very close relationship between a state's TFP level and its equilibrium level of utility thus we choose to examine total out-migration rates as a function of

[17] To obtain a more informative scale in Fig. 4 we exclude two extreme observations: the bilateral flows between California and Nevada, and Massachusetts and New Hampshire. In both instances there are large flows of workers of both types in the same direction (toward Nevada and toward New Hampshire, respectively).



(a)

(b)

Fig. 5. Total net out-migration rates, by skill level and TFP: (a) unskilled workers; (b) skilled workers. *Note*: Total outflows minus total inflows over initial population in the state. Linear fit included, not a 45-degree line. The regression has been estimated excluding four states: Connecticut, Delaware, New Jersey and New York.

the calibrated TFP parameter. Fig. 5 relates TFP levels and total net out-migration rates for unskilled and skilled workers, respectively. Two features stand out. First of all, we note the clear negative relation between TFP levels and total net out-migration rates for both skill types, as predicted by the model.[18] Second, we also note that in both figures the top TFP states display anomalous behavior (New Jersey, New York, Connecticut, Delaware).[19] According to the model, these states should have attracted large inflows of workers. That is, they should have had very low TNOR. Instead these states lie well above the predicted line (based on all other states only). This anomaly is likely to reflect high housing prices and other congestion costs. In Section 7 we present an extension of the model that includes amenities, which improves the fit of the model.

Secondly, we note that the slope of the fitted line for TNOR as a function of TFP is substantially larger (in absolute value) for skilled workers than for unskilled. That is, as we move along the cross-section toward states with higher TFP, the model predicts lower outmigration rates for both workers. However, the drop is substantially larger for skilled workers. This is also a feature of our calibrated model, since migration costs for skilled workers are on average lower than for unskilled ones. An obvious but important implication is that high-utility (TFP) states not only experience population inflows but, in addition, enjoy an increase in the share of skilled workers thanks to interstate migration. Conversely, low-TFP states lose population and suffer a skill loss.

[18] We can only prove this property for economies with regions with symmetric worker endowments and mobility costs. Fortunately, the differences in size and mobility in our calibrated model are not large enough to overturn Proposition 4.

[19] Arizona, Florida and, particularly, Nevada also appear as outliers.

Table 3
Summary statistics of income redistribution at the state level in year 2000.

	Mean	St. dev.	Min	Max
Total personal current tax/state income	0.13	0.02	0.1	0.19
State and local taxes plus property tax/state income	0.03	0.01	0	0.05
Average income tax rate skilled family (Taxsim)	0.27	0.02	0.23	0.3
Redistributive transfer (TANF + FS)	\$6099	\$1608	\$3879	\$11,877

Source: For transfers, sources are U.S. Department of Health and Human Services, and the Department of Agriculture. For income tax rates, we use the NBER tax simulator (Taxsim). For aggregate tax measures, we use the BEA regional accounts 2000–2001.

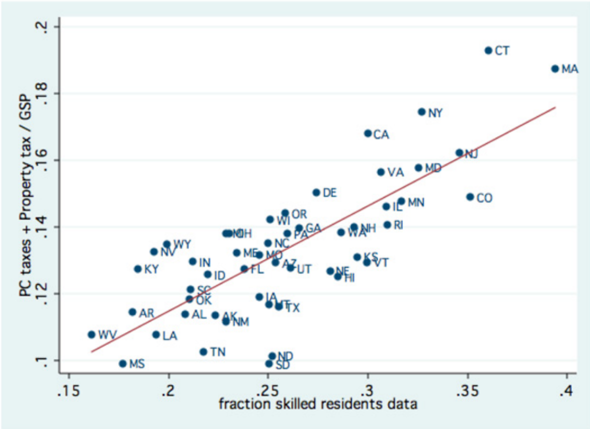


Fig. 6. Total taxes over state income, data. *Note*: Personal current taxes at all levels plus property taxes divided by gross state product (BEA).

5. Model evaluation: Redistributive policies

The model has two key predictions regarding the cross-section of policies. First, states with a higher skill premium should redistribute income more aggressively. Secondly, states with higher consumption levels (say, because of relatively high TFP) should provide larger transfers (in dollars). The reason is that the goal of transfers is to reduce the gap between the consumption levels of skilled (rich) and unskilled (poor) workers. The goal of this section is to examine whether these relationships are present in the data.

Building a comprehensive yet simple measure of redistribution at the state-level is not an easy task. In reality, income redistribution takes place both through taxes and through public spending. We focus here in measures of tax-based redistribution, and discuss redistribution through spending and transfers in Section 7. We also note that we did not target any variable related to taxes or transfers in the calibration. We shall thus evaluate the performance of the model in a qualitative fashion. It would be unreasonable to expect a tight quantitative fit between model and data along this dimension.

We choose to compare our model's predictions to total personal taxes in the data, that is, including both federal, state and local taxes. The main reason to include federal taxes is that in our model only equilibrium allocations are determined. In these allocations, the difference between, say, income and consumption is total net taxes (state and federal).[20] Implicitly, we are assuming that the federal government sets taxes and transfers first. Then each state's fiscal authority decides whether to increase or decrease the amount of redistribution taking place within its borders.[21]

Let us start by comparing model and data regarding the size of total taxes relative to state income. The Bureau of Economic Analysis reports tax revenue by state annually. As summarized in Table 3, on average, total personal taxes (mainly, state plus federal income tax) in 2000 were 13.26% of state income. Differences across states are quite large, ranging from 9.84% to 19.23%.[22] In addition, Fig. 6 shows that there is a strong positive relationship between a state's skill fraction and total personal taxes as a fraction of state income. We can now compute the analog measure in our calibrated economy. The distribution of tax revenue over state income predicted by the model turns out to be quite similar to the one in the data, with a mean of 11.03% and ranging from 7.22% to 16.14%. The model also generates the positive relationship found in the data.

Next, we introduce a more direct measure of tax-based redistribution for which the model has a clear testable implication. A central prediction of the model is that states with a higher skill premium should redistribute income more

[20] Local taxes can be safely ignored because they tend to be low with little progressivity. Thus their redistribution effects are negligible.

[21] The working paper version reports alternative measures excluding federal taxes; the results presented were not sensitive to the change in measures.

[22] Alaska, Florida, Nevada, South Dakota, Texas, Washington, and Wyoming have no state income tax. In addition, New Hampshire and Tennessee only tax capital income.

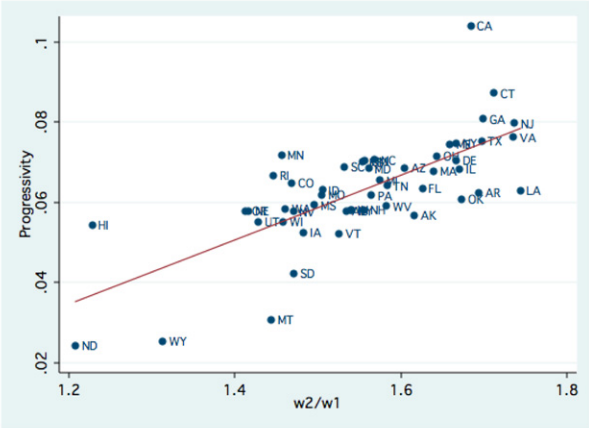


Fig. 7. Comprehensive measure of tax-based redistribution (progressivity) and skill premium. *Note*: Progressivity measure uses income and property taxes combined. Data from BEA and U.S. Census. We include the best linear fit.

aggressively. In terms of taxation, this means that their tax schedules should be more progressive. In the model, redistribution can be easily measured by the gap between skilled workers' pre-tax income and their consumption. However, in the data, individual after-tax income and consumption do not coincide (because of savings). As a result, it is more appropriate to measure tax-based redistribution by comparing incomes before and after taxes. Moreover, in reality, even relatively poor households pay taxes. Therefore the redistributive content of taxes depends on their progressivity. Keeping these points in mind, we introduce the following measures of income redistribution through taxation. The bulk of tax revenue at the state level comes from income taxes, property taxes, and sales taxes. The latter is close to a linear tax and, hence, displays little or no progressivity. Thus, our measure of tax-based redistribution is the sum of the progressivity of the income and property taxes.

To build our measure of progressivity of the tax system, we proceed in four steps. First, we use a 1% sample of the U.S. Census (with homogeneous age, gender, and race) to estimate state-level individual income, home values, and property taxes, by education level. Secondly, we use the NBER's income tax simulator (Taxsim) to compute the income tax (state plus federal) that the average skilled/unskilled worker in each state would have had to pay in year 2000.[23] Third, we measure income tax progressivity as the difference between the average income tax rate paid by the (average) skilled worker minus the average income tax rate paid by the (average) unskilled worker. The average income tax rate of an individual is defined as the ratio of the income tax computed using the tax simulator to that individual's total income. Fourth, we measure property tax progressivity by computing the ratio of property tax (in dollars) over the total income for that worker and then take the difference across skill types.

Fig. 7 reports the sum of the two measures of progressivity against the college wage premium in each state. We find a strong, positive relationship between the two variables. The OLS estimated slope is 0.079 (with standard error 0.011). In words, states with a higher skill premium choose more progressive tax schedules. A closer look at the data reveals that the positive association is driven by the progressivity of the income tax. This is because in most states total income taxes are much higher than property taxes.[24]

6. The effect of worker mobility on redistribution policies

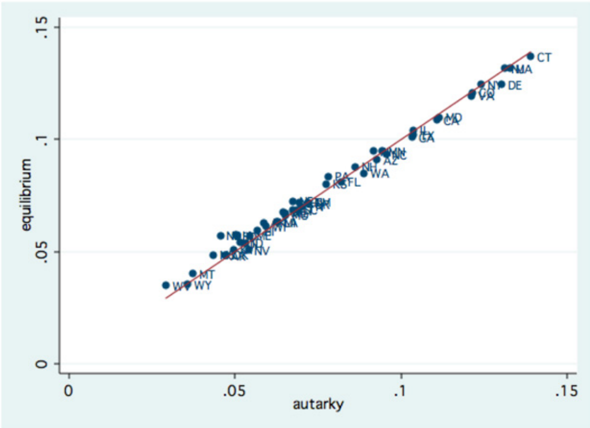
Finally we turn to the main goal of this paper. We ask how worker mobility across U.S. states has affected state-level redistribution policies. In particular, we would like to know whether labor mobility has impaired income redistribution or, more generally, whether it is a force of convergence or divergence in policies. We focus on two dimensions of redistribution: the average tax rate borne by skilled workers and the size of the transfer received by each unskilled worker.

The exercise we perform is the following. We compare the cross-sections of policies in equilibrium and in a counterfactual scenario where migration costs are prohibitively high and no worker finds it profitable to migrate. Equilibrium allocations can be computed in a straightforward manner for both scenarios. In the autarky (no-mobility) scenario, we compute the allocation taking the distribution of workers by state of birth from the data. We keep the technology parameters constant across the two scenarios.

[23] We consider actual differences in the taxation of labor (wage) income and capital income. We also deduct the property tax. Thus, differences across states in the income tax of the average skilled worker reflect both differences in tax rates and in factor prices across states.

[24] On average, across all states, skilled (unskilled) workers pay $9600 ($3700) in income tax and only $1425 ($846) in property tax.

(a)



(b)

Fig. 8. Policy convergence due to labor mobility. Model without amenities. (a) Tax rates: autarky versus equilibrium. (b) Transfers: autarky versus equilibrium. *Notes*: (a) Autarky means that we use data on individuals sorted by state of birth. A linear regression has intercept 0.06 (0.01) and slope 0.75 (0.05) with standard errors in parentheses. R-squared is 0.82 and correlation coefficient 0.90. 45-degree line included. (b) A linear regression has intercept 0.006 (0.001) and slope 0.93 (0.01) with standard errors in parentheses. R-squared is 0.99 and correlation coefficient 0.99. 45-degree line included.

6.1. Tax rates

Our first important result is that worker mobility has induced convergence in tax rates. Fig. 8(a) reports income tax rates under autarky (horizontal axis) and in equilibrium (vertical axis). If all points lined up in a horizontal line, we would have full convergence. If they lied on the 45 degree line then there would be a complete absence of convergence. A simple way to measure the degree of policy convergence is by estimating the slope of a linear regression (with an intercept), where the dependent variable is the tax rate in equilibrium and the explanatory variable is the tax rate in autarky. If the slope coefficient is one then we shall say that there is no policy convergence at all. If the slope coefficient is zero we shall say that there is complete convergence.

The points on the scatter plot reveal some convergence in tax rates (slope 0.75) as a result of interstate worker migration. The states with the highest autarky tax rates have experienced a reduction in tax rates as a result of migration, for instance, Virginia (VA) and Georgia (GA). The converse is true for most states with the lowest autarky tax rates, such as North Dakota (ND) and West Virginia (WV). It is also worth noting that we do not find downward pressure on tax rates: the average tax rate is roughly constant around 23 percent in the two scenarios (Table 4). This finding suggests that the often-voiced concerns that worker mobility triggers a “race to the bottom” in income redistribution policies seem misplaced.

These changes in policies are the result of changes in skill composition driven by migration. Some states (e.g. VA and GA), experienced a large inflow of workers from other states, which led to a reduction in skill premia and in redistributive taxes. Recall that high-TFP states attracted both types of workers, skilled and unskilled. For VA and GA, the inflow of both worker types induced an increase in the skilled–unskilled ratio: skilled workers make up a larger fraction of in-migrants than in the original population of the state. Both GA and VA have initial skill ratios below the national average, so migration flows bring some reversion to the mean. Moreover, skilled workers are more mobile, so they are over-represented among

Table 4
Equilibrium versus autarky. Cross-sections of redistributive policies.

	Mean	St. dev.	Min	Max
Equilibrium				
Tax rate on skilled workers	0.23	0.04	0.12	0.30
Transfer per recipient	\$6964	\$2422	\$3105	\$12,208
Autarky				
Tax rate on skilled workers	0.23	0.05	0.13	0.32
Transfer per recipient	\$6868	\$2577	\$2594	\$12,398

Table 5
Equilibrium versus autarky.

	Winner states[a]	Loser states[b]
Change in tax rate	−0.02	0.05
Perc. change in transfers	−0.03	0.155
Skill gain	0.015	−0.033
TFP	3.16	2.12

[a] Winner states are the 5 states with the largest skill gain (AZ, DE, VA, WA, GA) according to the model.
[b] Loser states are the 5 with the largest skill drain (ND, MS, LA, SD, WV).

migrants. In contrast, states like ND and WV suffered skill-biased outflows that raised the relative price of skilled labor and the need for redistributive taxation.

Let us now quantify these changes. It is helpful to sort states from lower to higher *skill gain*, defined as the fraction of skilled workers in the mobility equilibrium minus the fraction in autarky. Let us now focus on the top and bottom 5 states by skill gain.[25] Skill-winners have an average TFP that is 20 percent above the mean, while skill-losers' TFP is 19 percent below the mean.

As displayed in Table 5, the average skill-winning state experienced an increase in the fraction of skilled workers of 1.5 percentage points. This led to a reduction of 2 percentage points in the average tax rate. Conversely, on average, skill-losing states suffered a reduction in the share of skilled workers equal to 3.3 percentage points, causing the tax rate to increase by 5 percentage points on average.

6.2. The size of transfers

Let us now turn to the effect of worker mobility on the cross-section of redistributive transfers. The results are displayed in Fig. 8(b), which reports equilibrium transfers in the two scenarios. The main finding is that there is some convergence but to a much more limited extent that in tax rates. In terms of the analogous convergence regression, the slope now is 0.93, rather close to one (no convergence). The relative insensitivity of transfers per recipient is due to an offsetting *tax-base effect*. The budget constraint of the regional government implies that for a given income tax τ, the transfer handed out to the unskilled in the region has to be $\tau\eta$, that is, the product of the tax on skilled workers times the skilled-to-unskilled ratio in the population. As a result, states experiencing an increase in η will have both a larger tax base and a lower skill premium. The resulting lower wage inequality leads to a lower redistributive tax. The size of the transfer, $\tau\eta$, will fall by less than the tax and might even increase. The net effect depends on parameter values. In our calibration, the two effects almost balance out. In response to an increase in skill fraction, the fiscal authority chooses to keep the size of the transfer relatively unchanged, while vigorously reducing the tax on skilled workers.[26] Table 5 reports the percentage change in the size of transfers (per recipient) in skill-winning and in skill-losing states. While the former reduced their transfers by 3 percent on average, the latter increased them by 15.5 percent.

7. Robustness

7.1. Model with amenities

As we noted earlier, the calibrated model fails to account for the high out-migration rates from the states with the highest levels of TFP. This section extends the model by introducing exogenous region-specific factors that influence the location decisions of both types of workers but are not related to income. We refer to these factors as *amenities*. Weather conditions are a good example of a possible determinant of migration decisions which is not directly related to wages.

[25] The top 5 skill-winning states in the data were Arizona, Georgia, Maryland, Virginia and Colorado and the 5 suffering the largest skill drain were North Dakota, Wyoming, Iowa, South Dakota, and Wisconsin. According to our model the top states are Arizona, Delaware, Virginia, Washington and Georgia and the bottom ones are North Dakota, Mississippi, Iowa, South Dakota and West Virginia.
[26] Recall that TFP differences also affect the size of transfers.

We introduce amenities as follows. Total welfare for a worker of type i in region r is given now by

$$U(x_i^r) + A^r$$

where A^r is the utility flow of the amenities in region r. Separability implies that, given a skill ratio, the second best allocation with amenities coincides with the allocation in the baseline model. Thus amenities are simply additional parameters that improve the fit of the model, but do not affect the mechanics of income redistribution.

We have to update the equilibrium condition for the mobility decisions. Now a national equilibrium requires that for each $r \leqslant R$, all individually profitable moves from r to r' have taken place. If $\delta_i(r, r') < (R-1)^{-1}$, we have that

$$U(x_i^{r'}) + A^{r'} - U(x_i^r) - A^r \leqslant \mu_i(r, r'),$$

with equality if $\delta_i(r, r') > 0$, for all $r' \neq r$ and $i = 1, 2$. If $\delta_i(r, r') = (R-1)^{-1}$ then

$$U(x_i^{r'}) + A^{r'} - U(x_i^r) - A^r \geqslant \mu_i(r, r').$$

With the additional degrees of freedom granted by the vector of amenities parameters, $\{A_r\}$, we can improve the fit of migration flows. The correlation between observed and predicted skill ratios is 0.96 and the model explains close to 90 percent of the variation in the data, compared to 0.87 and 0.76 in the model without amenities. The amenities do not overthrow completely the welfare ranking given by TFP levels.[27] However, the calibration assigns low amenities to the states with highest TFP in order to explain their relatively high out-migration rates.

We now re-evaluate the impact of labor mobility in policies using the model with amenities. Figs. 9(a) and 9(b) compare tax rates and transfers, respectively, in autarky and in equilibrium. We largely confirm our findings from the previous section: significant convergence in tax rates and, to a lesser degree, in the size of transfers. In fact, the extended model displays a larger degree of policy convergence, both in tax rates and in transfers. In terms of the policy convergence regressions introduced early, the corresponding slopes are 0.26 and 0.90 (for tax rates and transfers, respectively), compared to 0.75 and 0.93 in the model without amenities.[28] We also note that the changes in the share of skilled workers in skill-winning and skill-losing states is much larger than in the model without amenities, respectively, 5.7 and −4.7 on average. This accounts for the larger changes in redistributive policies before and after migration.

An alternative, more sophisticated approach would be to introduce immobile factors (e.g. land) as in Roback (1982). Differences in TFP across locations would then be offset by higher land prices. This mechanism could explain the observed out-migration in the states with the highest TFP. However, introducing immobile factors greatly complicates the analysis in the presence of mobility frictions and endogenous policies.

7.2. Alternative definitions of migration

We now experiment with two alternative empirical definitions of a migrant, in addition to our baseline (Definition I). Specifically, Definition II restricts the sample to individuals born between 1970 and 1975. Definition III maintains the birth cohorts of the baseline sample (1955–1975) but focuses on migration events that took place between 1995 and 2000 (see Appendix B.1 for details). We examine whether the cross-sections of the share of skilled workers are sensitive to the specific empirical definition of migrant that we use. Recall that changes in the share of skilled workers in a state are the main driver of changes in redistribution policy.

We find very small changes in the cross-sectional distribution of skilled workers across states after migration according to each migrant definition. Under Definition II the skill ratio tends to be slightly below the skill ratio under the baseline definition, due to the lower overall average age. There are no significant changes when using Definition III either. Labor flows for both types of workers are highly correlated across definitions. We thus conclude that the skill composition of migrants and residents is robust to alternative definitions.

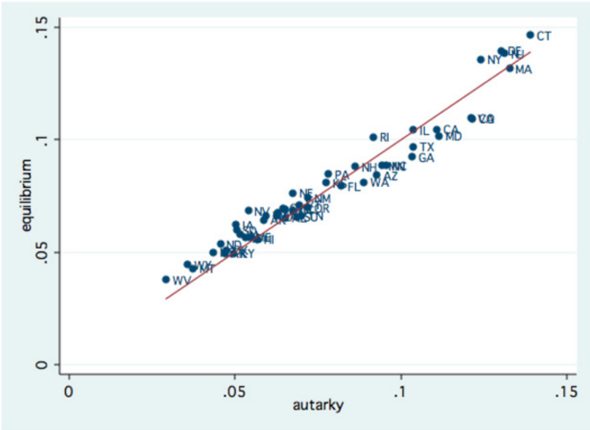
7.3. Redistribution via transfers

We now discuss measures of redistribution through transfers. Following Meyer (2000), we focus on data for the two main income-maintenance programs: Temporary Aid to Needy Families (TANF) and Food Stamps (FS). States enjoy a high degree of discretion in deciding the size of these transfers. The U.S. Department of Health and Human Services, and the Department of Agriculture, respectively, supply data on spending per recipient by state on these programs. With this measure we are taking a quite narrow view on transfers. The reason is that we want to be sure that we are obtaining a measure of redistribution. These programs are means-tested and, therefore, we are confident that higher spending in these programs unambiguously corresponds to greater redistribution. The trade-off is that we are leaving out several types of expenditure that are also partially redistributing income, and that recipients of the TANF and FS are not a representative sample of unskilled workers in our model. Below we build a broader measure of redistributive spending that includes public healthcare and education.

[27] The working paper version contains details in the calibration and resulting parameter values for the model with amenities.

[28] These results are virtually unchanged if we use the actual skill ratios in the data rather than the predicted skill ratios.

(a)



(b)

Fig. 9. Policy convergence due to labor mobility. Model with amenities. (a) Tax rates: autarky versus equilibrium. (b) Transfers. *Notes*: (a) Autarky means that we use data on individuals sorted by state of birth. A linear regression has intercept 0.17 (0.02) and slope 0.26 (0.08) with standard errors in parentheses. R-squared is 0.19 and correlation coefficient 0.43. 45-degree line included. (b) A linear regression has intercept 0.009 (0.002) and slope 0.90 (0.03) with standard errors in parentheses. R-squared is 0.95 and correlation coefficient 0.97.

Sticking to our baseline measure based on TANF and FS, we compute the dollar amount paid in each state in year 2000 through each of the two programs to the average recipient household. Then we add up the two amounts. As can be seen in Table 3, the average transfer is $6099, and ranges from $3879 (Alabama, South Carolina) to $11,877 (Alaska and California). In comparison, the model predicts an average transfer of $8686, somewhat larger than the average in the data.

Let us now compare the cross-section of transfers predicted by the model to those in the data. Our calibrated model features strong positive correlations between TFP levels and transfers, and between transfers and the fraction of skilled workers. Respectively, these correlations are 0.88 and 0.73. The data provides some support for these predictions. The correlation of our empirical measure of transfers with TFP is 0.23, and with the fraction of skilled workers it is 0.40. Our interpretation for the relatively low correlations is that they are due to attenuation bias arising from mismeasurement in our summary variable of transfers.

Our baseline measure may be too narrow as it includes only transfers under the TANF and FS programs, and only a small subset of households qualify for such programs. We build a more comprehensive measure of public spending by including large programs that, to some extent, disproportionately benefit low-income households: state-level spending in healthcare (mostly Medicare), public education (primary and secondary), other income-maintenance programs, and unemployment insurance. For each state, we add all these amounts and divide by the state's population.[29] The downside of the more comprehensive measure is that we do not have a definition of a common recipient for all programs. As a result, we can

[29] The sources for these data are the Bureau of Economic Analysis (Medicare, income-maintenance programs and unemployment insurance compensation), and the National Center for Education Spending. We use data for year 2000 from both sources.

only report data per capita and not per recipient. Moreover, skilled households are likely to benefit significantly from some of these programs as well. Thus only a fraction of this spending is truly redistributive.

Transfers under TANF and FS were \$6099 per recipient. In per-capita terms (that is, dividing total spending in TANF and Food Stamps over state population), the average value of TANF and FS is very low, \$243. Obviously, our more comprehensive measure leads to a much higher average amount, equal to \$3622 per capita. Education accounts for almost two thirds of this value, with healthcare being responsible for most of the remaining amount.

We now examine the relationship between our more comprehensive measure of transfers, TFP and the share of skilled workers. Specifically, we estimate two simple linear regression models where the dependent variable is the amount of spending per capita in each state and the explanatory variable is, in one case, our calibrated measure of TFP, and in the other, the share of skilled in the state. In both cases the slope coefficient is positive and highly significant.[30]

In conclusion, the predictions of the model are in line with the main qualitative features of the cross-section data on income redistribution, both when redistribution takes place through taxes and through spending.

8. Conclusions

Our main goal was to study the effect of worker mobility on redistributive policies in U.S. states. Our main finding is that worker mobility has induced substantial convergence, but no downward pressure, in tax rates. We also find some evidence of migration-induced convergence in transfer levels, but to a much lesser degree due to an offsetting tax-base effect.

Our analysis makes clear that differences in TFP are the key determinant of income, labor flows, and transfers per recipient. This is very much in line with recent findings in the international migration literature—see for example Rosenzweig (2007), Grogger and Hanson (2008), and Ortega and Peri (2009).

We hope the model presented here can be the basis for further quantitative work on the study of regional tax competition in a context of realistic labor mobility. Our model has made a number of assumptions, which should be relaxed in future work. In particular, it would be interesting to incorporate immobile factors, such as land, to explore the dynamics of the model, and to endogenize the link between skills and TFP.

Appendix A. Proofs

Proof of Proposition 1. It is straightforward to show that a competitive equilibrium allocation given τ is pinned down by

$$\begin{aligned} &MRS(c_1, l_1) = F_1(l_1, \eta l_2), \\ &MRS(c_2, l_2) = F_2(l_1, \eta l_2), \\ &c_1 + \eta c_2 = F(l_1, \eta l_2), \\ &c_2 = F_2(l_2, \eta l_2) l_2 - \tau. \end{aligned}$$

It is clear that the skilled (unskilled) welfare is decreasing (increasing) with τ. Hence there is a value of τ such that the incentive compatibility constraint (IC) binds. The resulting competitive equilibrium allocations are second-best. □

Proof of Proposition 2. Necessary first order conditions from (2) are then

$$\begin{aligned} &u'(c_1) = u'(c_2), \\ &MRS_i(c_i, l_i) = F_i(l_1, \eta l_2) \quad \text{for } i = 1, 2, \end{aligned}$$

where $MRS_i = v'(l_i)/u'(c_i)$. Hence $c_1 = c_2$. If $l_2 > l_1$, the incentive compatibility constraint (IC) would be violated. If $l_1 \geqslant l_2$, then

$$F_1\left(1, \frac{\eta l_2}{l_1}\right) < F_2\left(1, \frac{\eta l_2}{l_1}\right)$$

as skilled labor is the scarce factor. First order conditions imply then $v'(l_1) < v'(l_2)$ but this contradicts $l_1 \geqslant l_2$. This proves property 1.

For property 2, assume that second-best allocation x has

$$F_1\left(1, \eta\frac{l_2}{l_1}\right) \geqslant F_2\left(1, \eta\frac{l_2}{l_1}\right).$$

The properties of F and $\eta < \bar{\eta}$, imply $l_2 > l_1$. The incentive compatibility constraint implies then that $c_2 > c_1$. Strict concavity of U implies that if $c_2 > c_1$, $l_2 > l_1$, then $-\frac{U_l(c_2,l_2)}{U_c(c_2,l_2)} > -\frac{U_l(c_1,l_1)}{U_c(c_1,l_1)}$. But then x is incompatible with the necessary first order conditions of problem (2) since $MRS_2 > MRS_1$ implies that $F_2 > F_1$, contradicting our initial hypothesis.

[30] The output of these regressions and two supporting figures are available upon request.

Now we prove the third property. By first order conditions for second-best allocation, $MRS(c_2, l_2) > MRS(c_1, l_1)$. Since $U(c_1, l_1) = U(c_2, l_2)$ and indifference curves are strictly convex, we have that $(c_2, l_2) \gg (c_1, l_1)$.

Property 4 also follows. Assume $\tau \leqslant 0$. Because skilled workers are scarce, they will be strictly better off, contradicting property 1. $\square$

Proof of Proposition 3. We first prove that for any $\eta < \bar{\eta}$, second-best allocations x satisfy $c_2 < F_2(l_1, \eta l_2)l_2$. Consider the set $A = \{(c, l)\colon\ c \leqslant F_2(l_1, \eta l_2)(l - l_2) + c_2\}$. Since $MRS(c_2, l_2) = F_2(l_1, \eta l_2)$ and preferences are strictly concave, for any $(c, l) \in A$, $U(c, l) \leqslant U(c_2, l_2)$, with equality sign iff $c = c_2$ and $l = l_2$. Therefore $(c_1, l_1) \notin A$ since the incentive compatibility constraint is binding and $l_1 \neq l_2$ as Proposition 2 indicates. This implies

$$c_1 > c_2 + F_2(l_1, \eta l_2)(l_1 - l_2)$$

and since $F_1(l_1, \eta l_2) < F_2(l_1, \eta l_2)$,

$$c_1 - F_1(l_1, \eta l_2)l_1 > c_2 - F_2(l_1, \eta l_2)l_2.$$

Using constant returns to scale, the resource constraint can be written as

$$\big(c_1 - F_1(l_1, \eta l_2)l_1\big) + \eta\big(c_2 - F_2(l_1, \eta l_2)l_2\big) = 0$$

therefore $c_2 < F_2(l_1, \eta l_2)l_2$.

We next show that second-best allocation x is feasible at η'. Note that

$$F\big(l_1, \eta' l_2\big) - F(l_1, \eta l_2) = F_2(l_1, \hat{\eta} l_2)l_2\big(\eta' - \eta\big),$$

where $\hat{\eta} \in [\eta, \eta']$ by the Taylor theorem. Using the concavity of F,

$$F\big(l_1, \eta' l_2\big) - F(l_1, \eta l_2) > F_2\big(l_1, \eta' l_2\big)l_2\big(\eta' - \eta\big).$$

Since the resource constraint is binding we have

$$F\big(l_1, \eta' l_2\big) - c_1 - \eta' c_2 > \big(F_2\big(l_1, \eta' l_2\big)l_2 - c_2\big)\big(\eta' - \eta\big).$$

Since we proved that $F_2(l_1, \eta' l_2)l_2 - c_2 > 0$, allocation x satisfies the resource constraint with strict inequality sign when $\eta' > \eta$.

By continuity, there exists $\hat{c}_2 > c_2$ such that $F(l_1, \eta' l_2) > c_1 + \eta' \hat{c}_2$. It is clear then that $\hat{x} = \{c_1, \hat{c}_2, l_1, l_2\}$ is feasible and incentive compatible with $U(c_1, l_1) + \eta U(c_2, l_2) < U(c_1, l_1) + \eta U(\hat{c}_2, l_2)$. Since allocations x' cannot do worse than $\hat{x}$, and the incentive constraint is binding for η', the result follows. $\square$

Appendix B. Data

B.1. U.S. Census 2000

Our data is a 5% public-use sample of the 2000 U.S. Census extracted using IPUMS. We define an individual as skilled if he had a college degree and unskilled otherwise. We build three alternative definitions of internal migrant.

Definition I *(Baseline).* Consider the sample of individuals born in the United States between 1955 and 1975 (age 25–45 in year 2000). Define a migrant as an individual whose state of residence in 2000 differed from his state of birth. We build the labor endowments in each state by sorting individuals according to their state of birth. Likewise, we build the after-migration worker distribution by sorting individuals by their residence in year 2000.

Definition II. We consider a more homogeneous sample in terms of year of birth, namely, individuals born between 1965 and 1970 (age 30–35 in year 2000). As in the baseline case, we define a migrant as an individual whose state of birth differs from his state of residence in year 2000. Note that state of birth now coincides with state of residence around 1967.

Definition III. We now employ a definition that exactly determines the year of migration. As in the baseline case, we consider individuals born between 1955 and 1975 (age 25–45 in year 2000). But now we define a migrant as an individual whose state of residence in 1995 differs from his/her state of residence in year 2000.

Skill premia (skilled-to-unskilled ratios of hourly wages) are also obtained from the sample Census sample. To enhance comparability of skill premia across states, we estimate state-level hourly wages restricting to a highly homogeneous sub-sample. In particular, we restrict to white males, age 25–45, that are part of the workforce.

B.2. Bureau of Economic Analysis, Regional Accounts

We compute output per worker by dividing state personal income in year 2001 by total employment in the state in the same year. Our data on tax revenue is also from the BEA. We average over the period 2000–2002. Our main aggregate measure of taxes is personal current taxes (federal, state, and local) over state income. This is mainly the income tax.

B.3. NBER's Taxsim

To compute average income tax rates, for skilled workers, we use NBER's income tax simulator (Taxsim) to compute the tax that a typical skilled family would have to pay in each of the U.S. states, keeping family income constant. We then compute the average tax income tax rate of a skilled worker dividing by pre-tax income. In particular, we assume that a typical family is a two-person household with a joint income of $200,000. The exact figure does not matter much, only the fact that it is kept constant across all states. Leigh (2005) also uses Taxsim in an interesting application.

B.4. U.S. Department of Health and Human Services

Following Meyer (2000), we consider two types of redistributive transfers: Temporary Aid to Needy Families (TANF) and Food Stamps (FS). States have had considerable autonomy in deciding the size of TANF and FS transfers particularly since 1996 when Aid for Families with Dependent Children (AFDC) was replaced by TANF. Using data from the U.S. Department of Health and Human Services, we define each state's transfer as the sum of TANF (and similar state programs) and Food Stamps for a family of 3 with no income in each state in year 2000. The average transfer across all states was 6101 U.S.D per household. The same family would have received 3879 U.S.D in Alabama, the state with the lowest transfers. At the other end of the spectrum, this family would have received 11,877 U.S.D in Alaska or 10,278 U.S.D in California, the states with the highest transfers.

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