August 2007

Credible Redistribution Policy and Skilled Migration*

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Abstract

We analyze the joint determination of skilled worker flows and redistributive policies across fiscally independent regions. In our model, regional governments lack commitment so their policy choices must be credible, that is, they must be sustained once all migration has taken place. In equilibrium there is no race to the bottom in redistributive policies. We show, though, that skilled migration generates regional inequality. The endogenous determination of fiscal policy effectively introduces aggregate increasing returns to scale in skilled labor. As a result, low mobility costs induce symmetry-breaking, so regional income inequalities are a necessary part of stable equilibria. Worker mobility also amplifies pre-existing welfare differences across regions.

Keywords: Credible Policies, Worker Mobility, Redistribution

JEL Codes: E61, J61

*The views expressed in the paper are those of the authors and do not necessarily reflect the views at the Federal Reserve Bank of New York or the Federal Reserve System. Any errors or omissions are the responsibility of the authors.

1 Introduction

One of the most often-voiced concerns about globalization is the impact of worker mobility on the ability of sovereign states to redistribute wealth. Does migration pose a threat to progressive income taxation? Can welfare states of different size coexist in a world with integrated labor markets?

These concerns have played a prominent role in the recent enlargement of the European Union (EU). Indeed, worker mobility has significantly lagged behind in the European integration process, often due to intense political opposition. Specifically, the 2003 and 2005 Treaties of Accession allowed incumbent countries to restrict temporarily work permits issued to citizens of the new members. France and Germany, among others, have imposed severe restrictions at least until 2009.[1] Other existing members, like the UK and Ireland, did open their labor markets and have received large worker inflows.

This paper proposes a new theory for the joint determination of skilled worker flows and redistributive policies across regions with independent fiscal authorities. We crucially depart from previous literature by focusing on credible policies. That is, we dismiss the ability of governments to commit to policies which do not answer the redistributive demands of the after-migration workforce. Policy competition is still present in our environment as skilled workers decide whether and where to move by comparing after-tax incomes. As far we know, we are the first to study *credible* redistributive policies with mobile workers.

The first insight of the paper is that the popular race-to-the-bottom argument relies on non-credible policy threats. As the argument goes, skill-scarce regions will sharply reduce income taxation in order to attract qualified workers. The remaining regions are then forced to respond by reducing taxation themselves to avoid a damaging brain drain. In the resulting equilibrium, redistribution is reduced to its minimum everywhere, and no country succeeds in attracting skilled

[1] Quotas are tighter and more widespread for citizens from Bulgaria and Romania, the latest countries to join the EU in 2007.

workers.[2] However, these aggressive cuts in redistribution policies are not credible: once workers have settled, governments would have a strong incentive to renege on their promised tax cuts.

In contrast, our equilibrium with credible policies features the optimal level of redistribution within a region given the final resident workforce, that is, once all migration decisions have been taken. Nevertheless, we find that worker mobility has strong implications for the cross-regional welfare distribution. First, low mobility costs induce symmetry-breaking, that is, they introduce welfare differences even if regions are ex-ante identical.[3] Inequality across regions is thus a necessary part of (stable) equilibria when mobility costs are low. Second, skilled worker mobility amplifies any pre-existing welfare differences. Regions with a technological or human capital disadvantage will suffer a brain drain, as their skilled workers migrate to more developed regions.

Both equilibrium implications follow from the same key observation: endogenous taxation introduces "increasing returns" in skilled labor. Following an inflow of skilled workers, the welfare of skilled workers in the region increases. Since skilled workers are the scarce factor, the wage skill premium falls. However, the fall in the skilled wage is more than offset by lower taxes as the government responds to the reduced wage inequality and a larger tax base. Simply put, redistribution policy implies that after-tax income for skilled workers in a region becomes proportional to average output. As a result, skilled workers move into relatively skill-abundant regions.

We model the policy decision as the decision of a benevolent government subject to some informational constraints. We do not wish to arbitrarily restrict the fiscal instruments available and, in particular, we want to allow for progressive income taxation. The government's actions, though, are constrained by the lack of common knowledge: workers' types are unobservable, so that the tax schedule can only be a function of workers' consumption and labor decisions. Asymmetric information introduces then a trade-off between efficiency and redistribution. We

[2] See Wilson and Wildasin (1998) and Cremer and Pestieau (2003) for excellent reviews of the literature on taxation under factor mobility.

[3] Symmetry-breaking arises in several economic environments. See Matsuyama (2002) and Mookherjee and Ray (2003), and references therein.

solve for the government's decision as a Mirrlees' allocation problem. It turns out that there is a simple characterization for the key properties of (second-best) allocations. We also show that second best allocations can be decentralized as competitive equilibria using lump sum taxes.

Let us now turn to the determination of migration flows across regions. Skilled workers decide whether and where to move, subject to a set of frictions. For tractability, we assume each worker entertains just one opportunity to move, specifying an idiosyncratic mobility cost and a destination region. Each worker then compares the welfare gain of migration with her mobility cost, correctly forecasting the redistribution policy she would encounter. Under these assumptions we prove uniqueness of equilibria, given any cross-section of policies, for any number of regions. We compare high and low mobility environments by shifting the distribution of idiosyncratic mobility costs.

Finally, we restrict to credible policies by imposing sub-game perfection on the policy decision: the government's choice must be optimal given the final workforce. Alternatively, one can think of a sequential game where workers first decide their location and the government, taking as given the after-migration workforce, then sets policy optimally. We emphasize that this timing is simply a convenient modelling device to capture the lack of commitment by the government, rather than the precise order of actions.

Our finding of regional welfare divergence is reminiscent of Cai and Treisman (2005), in the context of capital mobility. However, in their economy there is divergence only when initial asymmetries are large enough. In contrast, endogenous policy induces symmetry-breaking in our environment. That is, even when regions are identical ex-ante, (stable) equilibria always feature welfare differences.

Since Tiebout (1956), economists and political scientists have been interested in the consequences of policy competition on efficiency in environments with mobile factors. Tiebout (1956) suggested that voter mobility will induce local governments to efficiently supply public goods. However, Bewley (1981) has shown that Tiebout's result requires highly restrictive assumptions in order to produce efficient sorting. Buchanan and Goetz (1972) and Stiglitz (1977) have also criticized Tiebout's result.

In a different vein, the highly influential work of Oates (1972) forcefully argued that policy competition leading to a race to the bottom in taxation. Zodrow and Mieszkowski (1986) formalize the argument in a framework with local, distortionary taxation of capital. Their work has contributed to the widely spread belief that factor mobility will induce underprovision of public goods.

In a very influential contribution, Oates (1972) argued that tax competition in a context of high factor mobility would lead to underprovision of public goods. In other words, it would trigger a race to the bottom in tax levels on the mobile factor. Zodrow and Mieszkowski (1986) formalize the original argument in a two-region framework where capital can move costlessly and capital taxes are governments' only source of revenue. More recently, Brown and Oates (1987) have worked out a similar two-region model where poor individuals are the mobile factor. Needless to say, these models assume commitment on the part of the governments.

There are considerations other than policy credibility that qualify the race to the bottom argument. In an influential paper, Epple and Romer (1991) argue that significant local redistribution is feasible once voters internalize the impact of migration flows on the price of a fixed factor. Other work has pointed out the importance of asymmetries, and political treatment of immigrants. We find our critique of the race to the bottom argument more general. In particular, our results do not rely on an arbitrary restriction of the fiscal instruments available.

There is, of course, a large literature that compares different fiscal systems in presence of mobile agents. These papers take the policy systems as exogenous, which allows a complete quantitative analysis — see, for example, Fernandez and Rogerson (2003) on education finance systems. By letting policies be endogenously determined we capture better an environment with independent fiscal authorities. Armenter and Ortega (2007) apply a version of the model presented to worker flows and redistribution policies among U.S. states. The model can replicate some of the key qualitative relationships present in the data. Analyzing Census data, Armenter and Ortega

(2007) also confirm previous evidence that migration flows are skill-biased, that is, skilled workers are more likely to migrate than their unskilled counterparts. We assume that unskilled workers are immobile but, as we argue in the paper, our results stand as long as worker flows are skill biased.

The paper is organized as follows. In the next Section we introduce our economy and then move to analyze optimal redistribution policy in a closed economy. Section 4 takes on labor mobility and our definition of a world equilibrium. Our analysis of a world equilibrium with credible policies and its most important properties is in Section 5. Section 6 contains a two-region economy illustrating the results. Section 7 concludes.

2 The Economy

We consider a world economy consisting of $R = \{1, 2, ..., N\}$ regions. In each region $r \in R$, 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 denoted n_i^r.

Definition 1 *A workers' distribution $n = \{n_1^r, n_2^r\}_{r \in R}$ is feasible if*

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

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

Let non-negative vector $x^r = (c_1^r, c_2^r, l_1^r, l_2^r)$ denote 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. Each worker owns one unit of time to be used for work or leisure. We let $x = \{x^r\}_{r \in R}$ be a world allocation. We assume that the preferences of workers of both types are represented by a common utility function $U(c_i, l_i)$. To save on notation we shall often write $U(x_i^r)$ with the understanding that $x_i^r = (c_i^r, l_i^r)$. Utility function $U(c_i, l_i)$ is assumed to be differentiable, strictly concave, with $U_c > 0$, $U_l < 0$, $U_{cc} < 0$, and $U_{ll} < 0$. We also assume that consumption and leisure are complements: $U_{cl} \leq 0$.[4] Under

[4] This assumption is satisfied by the whole family of CES utility functions. The quantitative literature in macroeconomics usually employs transformations of the Cobb-Douglas utility function that satisfy this condition.

these assumptions, indifference curves in the (l, c) space are increasing and strictly convex.

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. Throughout the paper, we restrict our attention to economies where skilled labor is the scarce factor and it is inefficient to have a skilled worker supplying unskilled labor.

Production of the non-tradeable consumption good in region r is given by $F^r\left(n_1^r l_1^r, n_2^r l_2^r\right)$. We assume production function F^r is differentiable, constant returns to scale, strictly concave, and satisfies $F_{12}^r > 0$ as well as the appropriate Inada conditions.[5]

We are now set to define feasible allocations.

Definition 2 *An allocation x^r is feasible given $\left(n_1^r, n_2^r\right)$ if*

$$n_1^r c_1^r + n_2^r c_2^r \leq F^r\left(n_1^r l_1^r, n_2^r l_2^r\right)$$

and non-negativity constraints on hours and consumption.

We want to think of skilled labor as the input with higher marginal product. To guarantee this, we assume that skilled workers are relatively scarce. More precisely, we define the skilled-to-unskilled ratio $\eta^r = \frac{n_2^r}{n_1^r}$ and consider only skill ratios below $\bar{\eta}^r$, where $\bar{\eta}^r$ is given by

$$F_1^r\left(1, \bar{\eta}^r\right) = F_2^r\left(1, \bar{\eta}^r\right) - \varepsilon$$

for some small $\varepsilon > 0$.[6] We will show that, given any skill ratio $\eta^r \leq \bar{\eta}^r$, the marginal product of skilled labor will be above the marginal product of unskilled labor in equilibrium, confirming our conjecture that it is inefficient to use a skilled worker for unskilled tasks.

3 Optimal Redistribution in a Closed Economy

Redistribution policy in our model is endogenously determined as the decision of a regional fiscal authority which looks after the welfare of its residents. We start by studying the problem of

[5] We can allow for additional inputs, like capital, as long as they are perfectly mobile across regions: as its marginal product equates, the resulting production in labor inputs is constant returns to scale.

[6] This definition of $\bar{\eta}^r$ avoids stating the conditions for our results with an open set.

optimal redistribution policy for a given workforce (n_1, n_2). For notational convenience, we drop 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 worker's types are unobservable so the tax schedule can only be a function of the workers' actions. This constraints redistribution policy. Since skilled workers can perform unskilled tasks, a very aggressive redistribution policy would lead skilled workers to pass off as unskilled.

We state the optimal redistribution policy problem as a classic Mirrlees direct taxation problem.[7] Rather than dealing with a highly dimensional function space, the Mirrlees 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. In our case, only skilled workers can mislead the government. Hence, the only incentive compatibility constraint states that a skilled worker is not worse off than an unskilled worker.

Definition 3 *A feasible allocation $x = (c_1, l_1, c_2, l_2)$ is incentive compatible if*

$$U(c_1, l_1) \leq U(c_2, l_2).$$

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). We label the resulting allocation as *second best.*

Definition 4 *An allocation x is second best given (n_1, n_2) if it solves*

$$\max n_1 U(c_1, l_1) + n_2 U(c_2, l_2)$$

subject to

$$U(c_1, l_1) \leq U(c_2, l_2),$$
$$n_1 c_1 + n_2 c_2 \leq F(n_1 l_1, n_2 l_2).$$

and non-negativity constraints for x.

[7] Mirrlees (1971).

We can re-write the second best problem in terms of the ratio of skilled to unskilled workers η. Constant returns to scale imply that $F(n_1 l_1, n_2 l_2) = n_1 F(l_1, \eta l_2)$ and therefore second best allocations also solve

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

subject to

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

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

and non-negativity constraints.

Before documenting the properties of the second best allocations, it is useful to have a benchmark. The first best allocation is the allocation solving the optimal redistribution policy problem in the case of complete information, that is, without the incentive constraint (IC).

Definition 5 *We say that an allocation x is first best given η if it solves*

$$\max_x U(c_1, l_1) + \eta U(c_2, l_2) \tag{FBP}$$

subject to (RC) and non-negativity constraints for x.

Problem FBP is a standard concave program over a convex set. It follows that the first order conditions are necessary and sufficient,

$$U_c(c_1, l_1) = U_c(c_2, l_2)$$

$$MRS_i(c_i, l_i) = F_i(l_1, \eta l_2)$$

for $i = 1, 2$, where $MRS_i = -U_l(c_i, l_i)/U_c(c_i, l_i)$. Not surprisingly, in the first best allocation the marginal utility of consumption is equalized across worker types. In addition, the marginal rate of substitution between labor and consumption for each type of worker is equalized to the corresponding marginal product of labor.

The first best allocation will not equate the welfare of both types of workers. As long as skilled labor is more productive, skilled workers will be called to supply more work hours. Equating the marginal utility of consumption will not generically "compensate" the skilled workers for having less leisure. Indeed, under the assumption of complementarity between leisure and consumption, we can prove that in first best allocations skilled workers will be strictly worse than unskilled workers.

Proposition 6 *Let $\eta \leq \bar{\eta}$ and x be a first best allocation given η. Then unskilled workers enjoy higher welfare than skilled workers,*

$$U(c_1, l_1) > U(c_2, l_2).$$

Proof. In the Appendix ■

It follows trivially that the first best allocation is not incentive compatible: the informational friction is meaningful.

3.1 Properties of the Second Best

The characterization of second best allocations is not difficult. Policy models with linear tax rates are often hindered by implementability constraints shaping non-convex choice sets. In contrast, we can assert the necessity and sufficiency of the first order conditions associated with problem (SBP).

Proposition 7 *The first order conditions associated with problem (SBP) are necessary and sufficient to characterize the second best allocations.*

Proof. In the Appendix ■

Proposition 6 already made clear that first best allocations will not be incentive compatible. Combined with the sufficiency of the first order conditions for both the first and second best problem, we can show that the incentive constraint (IC) is binding.

Proposition 8 *Let $\eta \leq \bar{\eta}$. Then for any second best allocation x given η, the incentive compatibility constraint (IC) is binding:*

$$U(c_1, l_1) = U(c_2, l_2).$$

Proof. Assume otherwise. Then the necessary first order conditions for the first and second best allocations coincide. By the sufficiency of both sets of conditions (see Proposition 7), it implies second best allocations are first best as well. But then Proposition 6 implies $U(c_1, l_1) > U(c_2, l_2)$, violating the incentive compatibility constraint ■

Equipped with Propositions 7 and 8, we can characterize the second best allocation with just four equations. The first order conditions associated with problem (SBP) yield that the labor supply is not being distorted, that is,

$$MRS_i(c_i, l_i) = F_i(l_1, \eta l_2)$$

for $i = 1, 2$. Hence, the second best allocations are fully characterized by the marginal rate of substitution equating the marginal product of each worker, the incentive compatibility constraint (IC) and the binding resource constraint (RC).[8]

Let us now point out a couple of properties of second best allocations. First, we confirm that there is a positive skill premium, that is, the marginal product of a skilled worker is higher than that of an unskilled worker. Second, skilled workers work more than unskilled ones, and are "compensated" with higher consumption. Their consumption, though, is strictly less than their pre-tax labor income.

Proposition 9 *Let $\eta \leq \bar{\eta}$. Then in any second best allocation x given η,*

1. *There is a strictly positive skill premium*

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

2. *Skilled workers consume more, $c_2 > c_1$, and supply more labor, $l_2 > l_1$, than unskilled workers,*
3. *Skilled worker consumption c_2 is strictly less than skilled labor income*

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

We finish this subsection with an important result. Consider two economies with skill ratios $\eta < \eta' \leq \bar{\eta}$. In a laissez-faire economy, a larger ratio of skilled workers makes the abundant factor, that is, unskilled workers better off and skilled workers—the scarce factor—worse off. However, this is not true for second best allocations: *both* types of workers are strictly better off with a higher skill ratio.

[8] Recall this only holds for $\eta \leq \bar{\eta}$.

Proposition 10 *Let $\eta < \eta' \leq \bar{\eta}$ and let x and x' be second best allocations given η and η', respectively. Then*

$$U(c_2, l_2) < U(c_2', l_2')$$

and

$$U(c_1, l_1) < U(c_1', l_1').$$

Proof. In the Appendix ■

The mechanics behind the result are simple. The incentive compatibility constraint is binding for all $\eta < \bar{\eta}$. It is not possible then for the unskilled worker's welfare to increase with η without a proportional increase in the skilled worker's—otherwise the incentive compatibility would be violated. Intuitively, the skill wage premium falls as the skill ratio increases. Because skilled workers were taxed to the point of equating skilled and unskilled worker welfare, skilled workers must be compensated by the fall in their wages or they will switch to be unskilled workers.

3.2 Decentralization

Here we show that second best allocations can be decentralized into a competitive equilibrium with lump sum taxes. Hence, there is no distortionary taxation in our economy, although redistribution is bounded by the presence of informational frictions.

Proposition 11 *Let x be a second best allocation given $\eta \leq \bar{\eta}$. Then there exists a lump sum tax τ and wages rates (w_1, w_2) such that allocation x can be decentralized as a competitive equilibrium defined by*

1. *Pair (c_1, l_1) solves the unskilled household problem*

$$\max U(c_1, l_1) \;\; s.t. \;\; c_1 \leq w_1 l_1 + \eta\tau,$$

with $c_1 \geq 0$, $l_1 \geq 0$.

2. *Pair (c_2, l_2) solves the skilled household problem*

$$\max U(c_2, l_2) \;\; s.t. \;\; c_2 \leq w_2 l_2 - \tau$$

with $c_1 \geq 0$, $l_1 \geq 0$.

3. *Wages equal marginal products:*

$$w_1 = F_1(l_1, \eta l_2),$$
$$w_2 = F_2(l_1, \eta l_2).$$

Proof. The sufficient conditions for a competitive equilibrium allocation are

$$MRS(c_1, l_1) = F_1(l_1, \eta l_2),$$

$$MRS(c_2, l_2) = F_2(l_1, \eta l_2),$$

$$c_1 + \eta c_2 = F(l_1, \eta l_2),$$

$$c_2 = F_2(l_2, \eta l_2)\, l_2 - \tau.$$

It is trivial to show that there exists τ such that competitive equilibrium allocations satisfy $U(c_1, l_1) = U(c_2, l_2)$. By the sufficiency of first order conditions of the second best problem, the Proposition follows ■

We will use later the definition of competitive equilibrium contained in Proposition 11.

Our results on second best properties have their counterparts for the decentralized economy. We highlight the implications of Proposition 11: as the skill ratio increases $\eta < \eta'$, skilled workers are better off despite the skill wage premium falling, i.e., $w_2/w_1 > w_2'/w_1'$. It follows that taxation must be falling, $\tau > \tau'$. The fall in taxation is not necessarily a fall in redistribution, as the change in transfers $\eta\tau$ generally has an ambiguous sign.

4 Labor Mobility and World Equilibrium

We now describe our modelling of migration decisions. Each skilled worker in each region r receives one opportunity to move, (r', m), specifying a destination region $r' \neq r$ and a migration cost m in terms of utility. Each region generates migration opportunities equally, that is, a fraction $1/(N-1)$ of skilled workers born in state r receive opportunities to migrate to each other region r'. Hence, the number of potential migrants from r to $r' \neq r$ is given by

$$\frac{e_2^r}{N-1}.$$

Migration cost m is idiosyncratic, drawn from a distribution with cdf $D(m)$ with $D'(m) > 0$ for all $m \geq 0$ and $D(0) = 0$. The equilibrium will require that if a skilled worker born in region

r with migration opportunity $(r', \bar{m})$ chooses to migrate, all his compatriots with opportunities (r', m) and lower migration costs, $m \leq \bar{m}$, migrate as well.[9]

Let $\delta(r, r')$ be the fraction of potential migrants that actually move from r to r'. The whole matrix of (gross) migration flows from one region to the others can then be summarized by function $\delta : R^2 \rightarrow [0, 1]$. We will let $\delta(r, r) = 0$. For each pair of regions (r, r'), we can define the highest mobility cost paid by a migrant as follows,

$$\mu(\delta(r, r')) \equiv D^{-1}(\delta(r, r')).$$

We note that $\mu(x)$ is unbounded as $x \rightarrow 1$ and is differentiable for $x > 0$, with $\mu'(x) > 0$.

Given migration flows δ, the native skilled workforce that remains in region r is given by

$$e_2^r \left(1 - \frac{1}{N-1} \sum_{r' \in R} \delta(r, r')\right).$$

Total inflows into the region are given by

$$\sum_{r' \in R} \frac{\delta(r', r)}{N-1} e_2^{r'}.$$

Hence, the final skilled workforce in region r is

$$n_2^r = e_2^r \left(1 - \frac{1}{N-1} \sum_{r' \in R} \delta(r, r')\right) + \sum_{r' \in R} \frac{\delta(r', r)}{N-1} e_2^{r'}. \quad (1)$$

Before proceeding to our equilibrium with endogenous redistribution, it is useful to define a world equilibrium for any given set of feasible policies $\{\tau_r\}_{r \in R}$.

Definition 12 *A world equilibrium given policies $\{\tau_r\}_{r \in R}$ is a set of allocations $\{x_r\}_{r \in R}$, a pattern of migration flows $\delta : R^2 \rightarrow [0, 1]$ and a worker distribution $\{n_1^r, n_2^r\}_{r \in R}$ with $\eta^r \leq \bar{\eta}^r$ for all $r \in R$, such that*

1. *For every $r \in R$, x_r is a competitive equilibrium given τ_r and $\{n_1^r, n_2^r\}$,*
2. *The worker distribution is feasible and satisfies (1) and $n_1^r = e_1^r$ for all $r \in R$,*
3. *For each $r \in R$, all individually profitable moves from r to r' take place, that is,*

$$U(x_2^{r'}) - U(x_2^r) \leq \mu(\delta(r, r')),$$

with equality if $\delta(r, r') > 0$, for all $r' \neq r$.

[9] It is possible to entertain richer environments but only at a significant cost in terms of tractability. As will soon become clear, these assumptions map into simple and intuitive mobility equilibrium conditions.

Condition 3 states the rationality of the 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 if it is not profitable for the potential migrant with zero costs: $U(x_2^{r'}) - U(x_2^r) < 0$. Note that each individual migrant takes policies (allocations) as given.

In a world equilibrium, the bilateral gross flow between any two given regions must be equal to the net flow.[10] That is, workers only flow in one direction between any pair of regions; in our notation, $\delta(r, r')\,\delta(r', r) = 0$. It is possible, though, that a region may be attracting workers from another region while losing some of its own to some other regions. Hence, overall gross flows in a region are not necessarily equal to net flows.

It is also clear from the mobility equilibrium conditions that workers only move to higher welfare regions (not necessarily to the highest). It is then possible to order the regions according to its welfare and workers will move only in one direction.

For instance, a possible situation is one where some (skilled) workers migrate from region 2 to region 1, $\delta(2,1) > 0$, and from region 3 to region 2, $\delta(3,2) > 0$. However, our framework then implies migration from region 3 to region 1, that is, $\delta(3,1) > 0$. The reason is that welfare in this 3-region example is ordered:

$$U(x_2^1) > U(x_2^2) > U(x_2^3).$$

Observe that workers native to region 3 will migrate to the two locations with higher welfare. Clearly, the argument can be extended to larger numbers of regions. We can construct a ranking of regions (possibly with ties) in terms of (skilled) worker welfare. Recall that, within each region, the utility of all workers is equalized through redistribution. Furthermore, a region with a certain level of welfare will suffer outflows toward all regions with higher welfare.

We close the section with the uniqueness property of a world equilibrium given policies $\{\tau_r\}_{r\in R}$. As it will be clear later, there often is a multiplicity of policy equilibria. Proposition 13 makes clear that such multiplicity arises solely from the endogenous policy decision.

[10] The models in Coen-Pirani (2006) and Lkhagvasuren (2006) generate gross flows larger than net flows.

Proposition 13 *For each set of feasible policies $\{\tau_r\}_{r \in R}$ there is a unique world equilibrium.*

Proof. In the Appendix ■

5 Credible Policies

We start this section by defining our concept of policy equilibrium. We view the final workforce composition as the key determinant of redistribution policy. As a result, our policy equilibrium requires allocations to be second best given the workers' distribution.

It is useful to visualize our equilibrium concept as a sequential game. First, workers decide where to go; then each region decides its policy. The requirement that allocations are second best is akin to subgame perfection. This rules out regions making non-credible redistribution promises to attract skilled workers. Regions still engage in tax competition to attract skilled workers.

Definition 14 *A credible policy equilibrium is a world equilibrium such that for every $r \in R$ allocation x^r is second best given $\{n_1^r, n_2^r\}$.*

The restriction to credible redistribution policies is important to prevent a "race to the bottom" where regions keep cutting their redistribution policies to attract skilled workers. Allocations in a credible policy equilibrium are second best, so it follows from Proposition 9 that there is always positive taxation and, indeed, as much redistribution as possible.[11]

A credible policy equilibrium will often not be unique. This is a direct consequence of Proposition 10: the welfare of skilled workers under second best allocations increases with the skill ratio. To see this, consider a symmetric two region world with relatively low mobility costs. There is a credible policy equilibrium where both regions are identical and implement the same second best allocations. There are no migration flows as skilled workers get exactly the same welfare in both regions.

Yet there are other credible policy equilibrium in the symmetric, two-region world. Say some skilled workers move from one region to the other. The region receiving skilled workers sees

[11] We have ruled out the possibility that worker flows lead to skilled labor not being the scarce factor in any region. Redistribution would be trivially zero in this event, as skilled and unskilled workers will earn the same wage rate.

the skill ratio increase, which delivers higher welfare to the skilled workers and validates their migration choices. Eventually, mobility costs kick in and equilibrium is restored but now workforce composition and tax levels differ in the two regions.

We shall argue that the no flows equilibrium is inherently unstable under low mobility costs. In order to refine our equilibrium concept, we introduce a definition of local stability. Loosely speaking, imagine a small measure of skilled workers accidentally moves to another region. An equilibrium will be stable if these skilled workers end up regretting the move: the utility gain from migration is less than the mobility cost they face.

Definition 15 *A credible policy equilibrium* $\{x, n, \delta, \tau\}$ *is locally stable if, for any pair of regions* $r, r' \in R$, *there exists* $\bar{\varepsilon} > 0$ *such that for all* $\varepsilon \in (0, \bar{\varepsilon})$,

$$U\left(\tilde{x}_2^{r'}\right) - U(\tilde{x}_2^r) \leq \mu\left(\delta\left(r, r'\right) + \varepsilon\right)$$

where bundles $\tilde{x}^r$ *and* $\tilde{x}^{r'}$ *are second best given* $\{n_1^r, n_2^r - \varepsilon e_2^r\}$ *and* $\left\{n_1^{r'}, n_2^{r'} + \varepsilon e_2^r\right\}$, *respectively.*

5.1 Symmetry Breaking

Under low mobility costs, the stable credible policy equilibria are symmetry-breaking, that is, regions with identical fundamentals necessarily end up with different allocations. With high mobility costs, the unique equilibrium has no workers moving so it preserves the symmetry.

Proposition 16 *Consider* R *identical regions, that is,* $e_1^r = e_1^{r'}$, $e_2^r = e_2^{r'}$, $F^r = F^{r'}$ *for all* $r, r' \in R$. *For mobility costs small enough, the symmetric distribution of workers,* $n^r = n^{r'}$ *for all* $r, r' \in R$, *is not a locally stable credible policy equilibrium.*

Proof. It is trivial to show that there is a credible policy equilibrium without commitment with a symmetric workers' distribution. We have shown that second best allocations are a differentiable function of the skill ratio, $x^r(\eta^r)$. Proposition 10 makes clear that the skilled worker welfare is increasing in η^r. Therefore,

$$\frac{\partial U\left(x^r\left(\eta^r\right)\right)}{\partial n_2^r} > 0.$$

For an arbitrarily small $\varepsilon > 0$ we can then conclude that

$$U(\tilde{x}_2^{r'}) - U(\tilde{x}_2^r) > 0$$

for allocations $\tilde{x}^r$ and $\tilde{x}^{r'}$ are second best given $\{n_1^r, n_2^r - \varepsilon e_2^r\}$ and $\left\{n_1^{r'}, n_2^{r'} + \varepsilon e_2^r\right\}$ respectively. The mobility costs at $\delta = \varepsilon$ are $\mu(\varepsilon)$ which can be made arbitrarily close to zero has $D'(\varepsilon)$ is arbitrarily close to zero as well. Hence there exists D such that

$$U(\tilde{x}_2^{r'}) - U(\tilde{x}_2^r) > \mu(\varepsilon)$$

and therefore the symmetric workers' distribution cannot constitute a locally stable equilibrium

■

Returning to the previously discussed symmetric two-region world, a small measure of workers would make whatever region they move into a better place. If the gain in welfare is larger than the mobility cost, then the symmetric equilibrium is not stable and one of the two regions will necessarily have a higher skill ratio and be better off.

5.2 Amplification of Differences

In a stable equilibrium allocations will be different across (ex ante identical) regions. However, we do not know which regions will gain and which ones will lose from worker mobility. This is obvious in the case of identical regions but even when the environment is asymmetric our definition of local stability leaves the door open to equilibrium indeterminacy.

We present an equilibrium selection based on a simple tâtonnement argument. Imagine there are just two regions, A and B, with the same initial labor endowments. Region A has a technological advantage such that, in autarky, skilled workers are strictly better off than in region B. There are two locally stable equilibria. In one equilibrium region A gains some skilled workers; in the other, region B gains enough skilled workers to overcome its technological disadvantage. One can think of the tâtonnement refinement as follows: the equilibrium must be achieved by specifying a sequence of arbitrarily small sets of workers; for each set in the sequence, workers always move to the region with higher welfare at that point. The equilibrium with flows from A to B can be reached no matter how small the groups are. In contrast, the second equilibrium requires that a large group moves to the region with lower ex-ante welfare, region B, in order to turn around the welfare ranking of regions.

Let us now formalize this idea. Basically, an equilibrium will be admissible if one can construct a sequence of worker distributions and second best allocations converging to it where no skilled worker ever moves toward a region with lower welfare.

Definition 17 *A credible policy equilibrium* $\{x, n, \delta, \tau\}$ *is admissible if there exists a sequence of feasible worker distributions, allocations and migration flows* $\{n_j, x_j, \delta_{j+1}\}_{j=0}^{\infty}$ *such that*

1. *Allocations* x_j *are second best given* n_j *for all* $j \geq 0$*,*
2. *Migration flows satisfy*
$$U\left(x_j^r\right) \leq U\left(x_j^{r'}\right)$$
if $\delta_{j+1}(r, r') > 0$ *for all pairs* $r, r' \in R$ *and all* $j \geq 0$*,*
3. *The worker distribution satisfies*
$$n_{2j}^r = e_2^r\left(1 - \frac{1}{N-1}\sum_{r' \in R}\delta_j(r, r')\right) + \sum_{r' \in R}\frac{\delta_j(r', r)}{N-1}e_2^{r'}$$
for $j \geq 0$ *with* $n_0^r = e_0^r$ *for all* $r \in R$*.*
4. *Allocations converge to* x*.*

With the admissibility refinement, we are in place to document the second key property of the model: admissible equilibrium outcomes always amplify initial differences. To follow up on the previous example, the only admissible equilibrium has region A increasing its skill ratio at the expense of region B. Region A ends up with higher welfare both because of the technological advantage and the inflow of skilled workers.

The next Proposition formalizes this idea in a two-region world.

Proposition 18 *Consider a two region world* $R = \{A, B\}$ *with*
$$U\left(\tilde{x}_2^A\right) > U\left(\tilde{x}_2^B\right)$$
where $\tilde{x}_2^r$ *is the bundle for skilled workers in the second best allocation given labor endowments* $\{e_1^r, e_2^r\}$*. Any admissible equilibrium* $\{x, n, \delta, \tau\}$ *features*
$$U\left(x_2^A\right) - U\left(x_2^B\right) \geq U\left(\tilde{x}_2^A\right) - U\left(\tilde{x}_2^B\right)$$
with strict inequality if $n \neq \left\{e_1^A, e_2^A, e_1^B, e_2^B\right\}$*.*

Proof. Since $U\left(\tilde{x}_2^A\right) > U\left(\tilde{x}_2^B\right)$, any sequence leading to an admissible equilibrium will need to feature region A gaining skilled workers. Hence welfare in region A will be strictly higher than $U\left(\tilde{x}_2^A\right)$ and in region B will be strictly lower than $U\left(\tilde{x}_2^B\right)$. The result follows ■

In a generic economy with R economies, not every pair of regions will necessarily diverge in welfare terms. It can be shown, though, that the welfare differences between the top and bottom regions will increase.

Observe that when regions only differ in their technologies, worker mobility improves overall production; workers flow to the region with superior technology, amplifying cross-region differences. When regions only differ in their labor endowments, (skilled) workers flow away from the region where they are scarce. In this case, worker mobility widens the gap between the marginal products of skilled labor in the two regions.

5.3 Unskilled Mobility

So far we have assumed that only skilled workers are geographically mobile. Our results on symmetry breaking and welfare divergence stand as long as labor flows are skill-biased, i.e., skilled workers are overrepresented in the migrant population. Armenter and Ortega (2007) and references therein provide supportive evidence for the case of internal migration in the US.

Nevertheless, we briefly discuss the alternative scenario where only unskilled workers can move. As we shall see, the previous results are dramatically changed. For simplicity, let us consider the two-region world. When regions are symmetric, the symmetric equilibrium is locally stable: any small group of unskilled workers moving would reduce the destination region skill ratio, and regret the move—even if there were no mobility costs. In a world with asymmetric regions, workers still flow to the region with higher utility at autarky. But now unskilled migration flows reduce interregional differences in outcomes, inducing regional convergence. As a result of migration, the region with initial advantage (due to better technology or more skilled labor endowments) suffers a reduction in its skilled ratio, while the other region experiences an increase.

6 A Two-Region Economy

We present here a two-region economy $R = \{1, 2\}$ in order to illustrate the main results of the paper. First, we consider how allocations and taxes vary with the skill ratio. Then we solve numerically for a credible policy equilibrium and discuss the equilibrium properties.

6.1 Specification

We use a simple preference specification, given by a log separable utility

$$U(c, l) = \log(c) + \psi \log(1 - l)$$

for $\psi > 0$. Preferences are assumed to be identical across regions.

The production function is assumed to be of the CES form

$$F^r(l_1, l_2) = \theta^r \left[(1 - \alpha^r) l_1^\rho + \alpha^r l_2^\rho\right]^{1/\rho}$$

with $\rho \in (0, 1)$, $\alpha \in (0, 1)$ and $\theta > 0$. Among the interesting sources of variation across regions are differences in overall labor productivity, θ^r, or the degree of skill bias, α^r.

Throughout the exercise, we equate the endowment of unskilled workers in each region to 1, i.e., $e_1^1 = e_1^2 = 1$. Finally, the distribution of mobility costs is assumed to be a Pareto distribution. It can be shown that the mobility cost function is then given by

$$\mu(\delta) = (1 - \delta)^{-k} - 1$$

with $k > 0$.

6.2 Allocations in a Closed Economy

We first compute second best allocations as a function of the skill ratio $\eta = n_2/n_1$. We also take a look at the corresponding decentralization as a competitive equilibrium. These comparative statics are at the core of the mechanics of policy equilibria.

Figure 1 plots the second best allocation as a function of the skill ratio in the first two (clockwise) graphs. The solid line corresponds to unskilled worker consumption and labor, the dashed line is the skilled worker's. All variables are shown per worker. As Proposition 9 stated, skilled workers consume and work more than unskilled workers. As the skill ratio increases and skilled labor is less scarce, the gap between the two worker types narrows. The third graph plots the wage rates, confirming there is a skill wage premium and that the gap closes as expected.

Note that the fall in the skilled labor supply and wage rate would combine for a quite steep decrease in labor income. However, Proposition 10 makes clear that skilled worker's welfare is *increasing* with the skill ratio—otherwise the allocation would not be incentive compatible. The first graph in Figure 1 shows that skilled worker consumption increases with the skill ratio despite the falling labor income.[12]

The second row of graphs in Figure 1 displays output per worker, taxes over labor income and transfer per recipient. Output per worker increases with the supply of the scarce factor. Both taxes and transfers decrease with the skill ratio: as the wage gap disappears, so does the demand for redistribution. Note that transfer per recipient is flatter than the tax rate, reflecting the growth on the tax base (skilled workers).

6.3 Two-Region Equilibrium

We first compute the symmetric case, $F^1 = F^2$ and $e_2^1 = e_2^2 = .5$. This will illustrate the symmetry-breaking property of world equilibria with low mobility costs. Figure 2 introduces an useful diagram to visualize credible policy equilibria for two-region worlds. In the horizontal axis we have the skill ratio of region 1, $\eta^1 = n_2^1/n_1^1$. If there is no worker moving, the skill ratio in both regions is equal to .5 and it is indicated with a vertical dotted line. If the skill ratio in region 1 increases, the skill ratio of region 2 is given by $\eta^2 = 1 - \eta^1$, which follows from the equilibrium mobility condition.[13] The solid line computes the difference in welfare between regions for a

[12] Whether skilled worker consumption increases or it is just a smoother function of the skill ratio depends on the preferences. The skilled worker gains some leisure as the skill ratio increases. If leisure is heavily weighted in the preferences, it is possible to increase the skilled worker's welfare with a decreasing consumption schedule.

[13] Recall the unskilled worker population is equal to 1 in both regions.

given skill ratio

$$DU\left(\eta^1\right) = U^1\left(c\left(\eta^1\right), l\left(\eta^1\right)\right) - U^2\left(c\left(1-\eta^1\right), l\left(1-\eta^1\right)\right).$$

This is an increasing function of η^1, as welfare increases with the skill ratio. It is equal to 0 at $\eta^1 = .5$ because the symmetry of regions.

The dashed line is the mobility cost of the last worker moving for a given skill ratio η^1. We express the mobility cost in terms of welfare of region 2 and use negative numbers when the workers in region 1 are incurring in the mobility costs. This way the mobility equilibrium condition is satisfied anytime the solid and dashed line cross, $DU\left(\eta_1\right) = \mu\left(\eta_1 - .5\right)$.

Figure 2 depicts the case of high mobility costs. The only equilibrium involves zero flows as the welfare differences does not compensate the mobility costs for any skill ratio.

Figure 3 displays the same economy with low mobility costs. Now the solid and dashed line intersect at three points. First, there is an equilibrium, indicated by letter A, with zero flows: because of symmetry, the two country are ex-ante equal so there are no gains to migrate even if mobility costs are zero. Then there are two more equilibria, B and B',[14] where skilled workers moved up to the point that the welfare difference equates the mobility costs. These equilibria feature sharp welfare differences between regions despite having identical fundamentals.

It is easy to see in Figure 3 why the symmetric equilibrium is not locally stable. Any small deviation in the skill ratio η^1 would make it profitable to move into one region or the other, eventually attaining one of the asymmetric equilibria, B or B'.

We move now to the amplification of differences. We endow region 1 with a superior technology by letting $\theta^1 > \theta^2$, that is, by uniformly raising the labor productivity of both types. The corresponding diagram is in Figure 4. Now zero flows is not an equilibrium, as region 1 delivers strictly more welfare, $DU(.5) > 0$, and some skilled workers wish to move. The only policy equilibrium features a positive flow of skilled workers from region 2 to region 1 and hence an

[14] Equilibrium B and B' are the flip side of each other, i.e., $\eta^1_B = \eta^2_{B'}$.

increase in the welfare difference between the two regions.

There is no guarantee, though, that the asymmetry leads to a unique equilibrium. Figure 5 shows an economy with technology differences, $F^1 \neq F^2$, featuring three equilibria.[15] Equilibrium B is locally instable, but both equilibria A and C are locally stable. However, equilibrium A is more natural: region 1, which had a technological advantage at equal skill ratios. attracts workers. Equilibrium B requires that a large mass of workers decide to move into region 2 despite its lower ex-ante welfare. Our equilibrium stability refinement selects equilibrium A.

The case of endowment differences is particularly interesting. We let region 1 to have more skilled workers than region 2, $e_2^2 = .55 > e_2^1 = .45$, but technologies are equated $F^1 = F^2$. This economy is depicted in Figure 6. We have shifted the axis to cross at $(.55, 0)$, the zero flows state, which is no longer an equilibrium. Because of the ex-ante advantage of a higher skill ratio, the only equilibrium improves welfare at region 1 at the expense of region 2.

Note skilled workers flow to region 1 despite skill labor being more abundant. The observation may be reminiscent of an economy with economies of scale on skill. Our technology, though, is constant returns to scale and it is the endogenous policy decision which breaks the factor scarcity logic.

Finally, if there are only differences in endowments, skilled workers flow to lower tax regions. However, taxes are increasing in region 2 rather than falling—despite it would gain the most from a skill inflow. This is at odds with the "race to the bottom" argument.

7 Conclusions

This paper presents the first analysis of credible redistributive policies under worker mobility. Our starting point was the observation that the race-to-the-bottom argument, highly voiced in policy discussions, is based on non-credible policy threats. Once only credible policies are considered, high degrees of worker mobility are indeed compatible with the existence of income redistribution

[15] To be more precise, we let $\theta^1 > \theta^2$ and $\alpha^1 < \alpha^2$.

policies.

In our model, skilled worker mobility increases the cross-sectional dispersion of skills, income, and the size of redistributive policies. The key observation is that endogenous taxation makes after-tax income for all workers increasing in the fraction of skilled workers in the population. This induces further regional skill concentration. As a result, skilled worker mobility is likely to exacerbate initial regional welfare differences, and even has the ability to create them when differences did not initially exist.

Is it possible to achieve labor market integration without amplifying regional differences? Our analysis suggests that the detrimental effects of further integration can be tamed by enhancing the mobility of unskilled workers. This would reduce the impact of labor flows on the skill distribution of both the origin and destination countries. Since governments respond to changes in the skill composition, the feedback effect of policy on income per capita would be subdued. An obvious alternative is to coordinate redistribution policies across countries. However, the latter may face greater political opposition. As a matter of fact, EU members have been reluctant to curtail their sovereignty on welfare policies but have agreed on common guidelines on worker mobility several times in the past.

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A Proofs

Proof of Proposition 6. Assume x is a first best allocation with $U(c_1, l_1) \leq U(c_2, l_2)$. Consider first the case $l_2 > l_1$. Then $U(c_1, l_1) \leq U(c_2, l_2)$ implies $c_2 > c_1$. Using the properties of U,

$$U_c(c_1, l_1) > U_c(c_2, l_1) \geq U_c(c_2, l_2)$$

so x does not satisfy the necessary first order conditions for first best allocations.

Consider now the case $l_1 = l_2$. Necessary first order conditions $U_c(c_1, l_1) = \lambda$ and $U_c(c_2, l_2) = \lambda$ imply $c_1 = c_2$. But since $F_1(1, \eta) < F_2(1, \eta)$, necessary first order conditions also require $-\frac{U_l(c_1,l_1)}{U_c(c_1,l_1)} < -\frac{U_l(c_2,l_2)}{U_c(c_2,l_2)}$. Hence x is not first best.

Finally, consider the case $l_1 > l_2$. Concavity implies that

$$\frac{1}{1+\eta} U(x_1) + \frac{\eta}{1+\eta} U(x_2) \leq U\left(\frac{1}{1+\eta} x_1 + \frac{\eta}{1+\eta} x_2\right).$$

Next we show that allocation $\tilde{x}$, given by

$$\tilde{x}_1 = \tilde{x}_2 = \frac{1}{1+\eta} x_1 + \frac{\eta}{1+\eta} x_2$$

satisfies (RC) with a strict inequality sign. By construction, $c_1 + \eta c_2 = \tilde{c}_1 + \eta \tilde{c}_2$. On the production side, we have that $l_1 < l_2$ implies

$$\frac{F\left(1, \eta \frac{l_2}{l_1}\right)}{1 + \eta \frac{l_2}{l_1}} < \frac{F(1,\eta)}{1+\eta}$$

for $\eta < \bar{\eta}$ (to see this, differentiate $F(1, \eta)$ with respect to η). We can then rearrange

$$F\left(1, \eta \frac{l_2}{l_1}\right) < F(1,\eta) \frac{1 + \eta \frac{l_2}{l_1}}{1+\eta}$$

and multiplying both sides by l_1,

$$F(l_1, \eta l_2) < F(1,\eta) \frac{l_1 + \eta l_2}{1+\eta} = F\left(\tilde{l}_1, \eta \tilde{l}_2\right).$$

Therefore,

$$\tilde{c}_1 + \eta \tilde{c}_2 = c_1 + \eta c_2 = F(l_1, \eta l_2) < F\left(\tilde{l}_1, \eta \tilde{l}_2\right).$$

Summarizing, allocation $\tilde{x}$ is at least as good as x and satisfies the (RC) with a strict inequality sign. Hence x cannot be first best allocation ■

Proof of Proposition 7. The first order conditions of problem (SBP) are

$$(1-\mu)U_c(c_1, l_1) = \lambda$$

$$(1-\mu)U_l(c_1, l_1) = -\lambda F_1(l_1, \eta l_2)$$

$$(\eta+\mu)U_c(c_2, l_2) = \lambda\eta$$

$$(\eta+\mu)U_l(c_2, l_2) = -\lambda\eta F_2(l_1, \eta l_2)$$

$$\lambda\left[c_1 + \eta c_2 - F\left(l_1, \eta l_2\right)\right] = 0$$

$$\mu\left[U(c_2, l_2) - U(c_1, l_1)\right] = 0$$

for $\lambda \geq 0$ and $\mu \geq 0$.

Consider the alternative program

$$\max_{u_1, u_2, x} u_1 + \eta u_2 \tag{2}$$

subject to

$$u_1 \leq u_2,$$

$$u_1 \leq U\left(x_1\right),$$

$$u_2 \leq U\left(x_2\right),$$

$$c_1 + \eta c_2 \leq F\left(l_1, \eta l_2\right).$$

We show that an allocation x is second best if and only if there exists u_1 and u_2 such that $\{u_1, u_2, x\}$ solve (2). If any solution $\{u_1, u_2, x\}$ to (2) satisfies $u_1 = U\left(x_1\right)$ and $u_2 = U\left(x_2\right)$, our claim follows trivially. Assume that x solves (2) but $u_1 < U(c_1, l_1)$ and $u_2 = U(c_2, l_2)$ (obviously $u_2 < U(c_2, l_2)$ will never be a solution). Construct now an alternative allocation with the same work hours but $u_1 = U(c_1', l_1)$, with $c_1' = c_1 - \varepsilon$, $c_2' = c_2 + \varepsilon/\eta$, and $u_2' = U\left(c_2', l_2\right)$. Allocation

$x' = (c_1', c_2', l_1, l_2)$ satisfies (RC) but $u_2 \leq U(c_2, l_2) < u_2'$ and $u_1 \leq u_2 < u_2'$. Clearly, $\{u_1, u_2', x'\}$ contradicts $\{u_1, u_2, x\}$ being a solution to (2).

The program (2) is concave over a convex set, hence the necessary first order conditions

$$
\begin{aligned}
1 &= \alpha + \beta_1 \\
\eta &= \beta_2 - \alpha \\
\beta_1 U_c(x_1) &= \phi \\
\beta_2 U_c(x_2) &= \eta\phi \\
-\beta_1 U_l(x_1) &= \phi F_1(l_1, \eta l_2) \\
-\beta_2 U_l(x_2) &= \eta\phi F_2(l_1, \eta l_2) \\
\alpha[u_1 - u_2] &= 0 \\
\beta_1[u_1 - U(x_1)] &= 0 \\
\beta_2[u_2 - U(x_2)] &= 0 \\
\phi[c_1 + \eta c_2 - F(l_1, \eta l_2)] &= 0
\end{aligned}
$$

are also sufficient for the solution to program (2).

Let x be an allocation satisfying the first order conditions associated with problem (SBP). It is straightforward to show that there exist α, β_1, β_2, ϕ, u_1 and u_2 such that allocation x also satisfies the necessary and sufficient conditions for (2). Hence x is a solution to (2) and x is a second best allocation ■

Proof of Proposition 9. We first prove part 1. Assume that second best allocation x has

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

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 (SBP) since $MRS_2 > MRS_1$ implies that $F_2 > F_1$, contradicting our initial hypothesis.

Now we prove the second part. 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 $(c_2, l_2) >> (c_1, l_1)$

To prove that for any $\eta \leq \bar{\eta}$ second best allocations x satisfy $c_2 < F_2(l_1, \eta l_2)$ consider the set $A = \{(c, l) : c \leq F_2(l_1, \eta l_2)(l - l_2) + c_2\}$. Since $MRS(c_2, l_2) = F_2(l_1, \eta l_2)$ and preferences are strictly concave, for any $(c, l) \in A$, $U(c, l) \leq U(c_2, l_2)$, 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 8 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

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

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

Proof of Proposition 10. We show that second best allocation x is feasible at η'. Note that

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

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

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

Since the resource constraint is binding

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

or

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

Since we proved that $F_2(l_1, \eta l_2) l_2 - c_2 > 0$ in Proposition 9 for all η, we can pick an arbitrarily close η' without loss of generality such that $F_2(l_1, \eta' l_2) l_2 - c_2 > 0$. Then allocation x satisfies the resource constraint with strict inequality sign when the skill ratio is η'.

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 ■

Proof of Proposition 13. Assume there exists two world equilibria given the set of feasible policies $\{\tau_r\}_{r\in R}$, denoted $\{x, n, \delta\}$ and $\left\{\tilde{x}, \tilde{n}, \tilde{\delta}\right\}$, with distinct worker distributions. Let $R_1 = \{r : \tilde{n}_2^r > n_2^r\}$ and $R_2 = \{r : \tilde{n}_2^r < n_2^r\}$. Since n and $\tilde{n}$ are distinct feasible worker distributions, both sets are non-empty. From the definition of competitive equilibrium given τ_r is clear that the skilled worker welfare is strictly decreasing in η_r and therefore in n_2^r. Therefore, for all $r \in R_1$, $U(\tilde{x}_2^r) < U(x_2^r)$ and for $r \in R_2$, $U(\tilde{x}_2^r) > U(x_2^r)$.

Take any pair $\{r, r'\}$ with $r \in R_1$ and $r' \in R_2$. Hence

$$U\left(\tilde{x}_2^{r'}\right) - U\left(x_2^{r'}\right) > U(\tilde{x}_2^r) - U(x_2^r)$$

and

$$U\left(\tilde{x}_2^{r'}\right) - U(\tilde{x}_2^r) > U\left(x_2^{r'}\right) - U(x_2^r).$$

If $\delta(r, r') > 0$, the mobility equilibrium conditions imply $\tilde{\delta}(r, r') > \delta(r, r')$, since

$$\mu\left(\tilde{\delta}(r, r')\right) = U\left(\tilde{x}_2^{r'}\right) - U(\tilde{x}_2^r) > U\left(x_2^{r'}\right) - U(x_2^r) = \mu(\delta(r, r'))$$

and μ is strictly increasing. Conversely, if $\delta(r', r) > 0$,

$$\begin{aligned}
U(\tilde{x}_2^r) - U\left(\tilde{x}_2^{r'}\right) &< U(x_2^r) - U\left(x_2^{r'}\right), \\
U(\tilde{x}_2^r) - U\left(\tilde{x}_2^{r'}\right) &< \mu(\delta(r', r)), \\
\mu\left(\tilde{\delta}(r', r)\right) &\leq \mu(\delta(r', r))
\end{aligned}$$

and hence $\tilde{\delta}(r',r) \leq \delta(r',r)$ (the equality comes because $U(\tilde{x}_2^r) - U\left(\tilde{x}_2^{r'}\right)$ can be negative). Finally, if $\delta(r',r) = \delta(r,r') = 0$, then $U\left(\tilde{x}_2^{r'}\right) - U(\tilde{x}_2^r) > 0$ so $\tilde{\delta}(r,r') > 0$.

Add up all skilled workers in set R_1 for equilibrium $\tilde{\delta}$ and $\tilde{n}$,

$$\sum_{r\in R_1} \tilde{n}_2^r = \sum_{r\in R_1} \left\{ e_2^r \left(1 - \frac{1}{N-1} \sum_{r'\in R} \tilde{\delta}(r,r') \right) + \sum_{r'\in R} \frac{\tilde{\delta}(r',r)}{N-1} e_2^{r'} \right\}.$$

Note that flows within set R_1 must sum zero,

$$\sum_{r\in R_1} \left\{ \sum_{r'\in R_1} \frac{\tilde{\delta}(r',r)}{N-1} e_2^{r'} - \frac{1}{N-1} e_2^r \left(\sum_{r'\in R_1} \tilde{\delta}(r,r') \right) \right\} = 0.$$

Hence

$$\sum_{r\in R_1} \tilde{n}_2^r = \sum_{r\in R_1} \left\{ e_2^r \left(1 - \frac{1}{N-1} \sum_{r'\in R_2} \tilde{\delta}(r,r') \right) + \sum_{r'\in R_2} \frac{\tilde{\delta}(r',r)}{N-1} e_2^{r'} \right\}.$$

Now we use the inequalities derived above. We have $\tilde{\delta}(r,r') \geq \delta(r,r')$ for $r \in R_1$ and $r' \in R_2$, so

$$\sum_{r\in R_1} \tilde{n}_2^r \leq \sum_{r\in R_1} \left\{ e_2^r \left(1 - \frac{1}{N-1} \sum_{r'\in R_2} \delta(r,r') \right) + \sum_{r'\in R_2} \frac{\tilde{\delta}(r',r)}{N-1} e_2^{r'} \right\}.$$

We have $\tilde{\delta}(r',r) \leq \delta(r',r)$ for $r \in R_1$ and $r' \in R_2$,

$$\begin{aligned} \sum_{r\in R_1} \tilde{n}_2^r &\leq \sum_{r\in R_1} \left\{ e_2^r \left(1 - \frac{1}{N-1} \sum_{r'\in R_2} \delta(r,r') \right) + \sum_{r'\in R_2} \frac{\delta(r',r)}{N-1} e_2^{r'} \right\} \\ &= \sum_{r\in R_1} n_2^r. \end{aligned}$$

But $\tilde{n}_2^r > n_2^r$ for all $r \in R_1$ ■

B Figures

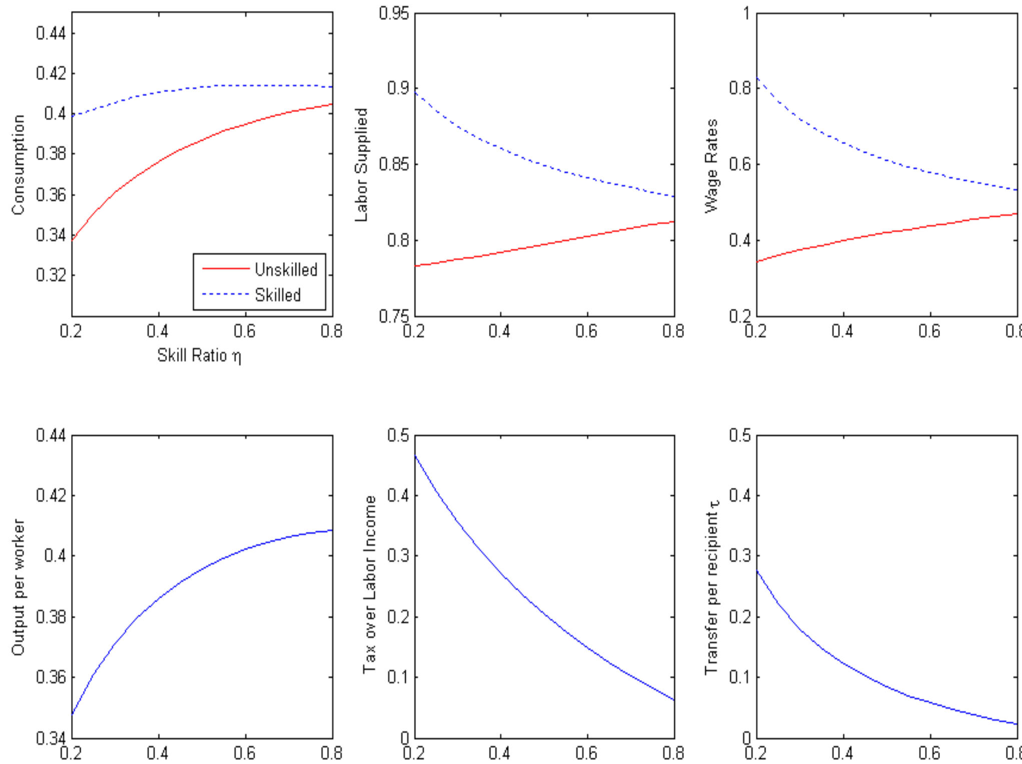

Figure 1: Second Best Allocations and Competitive Equilibria as a function of the Skill Ratio n_2/n_1

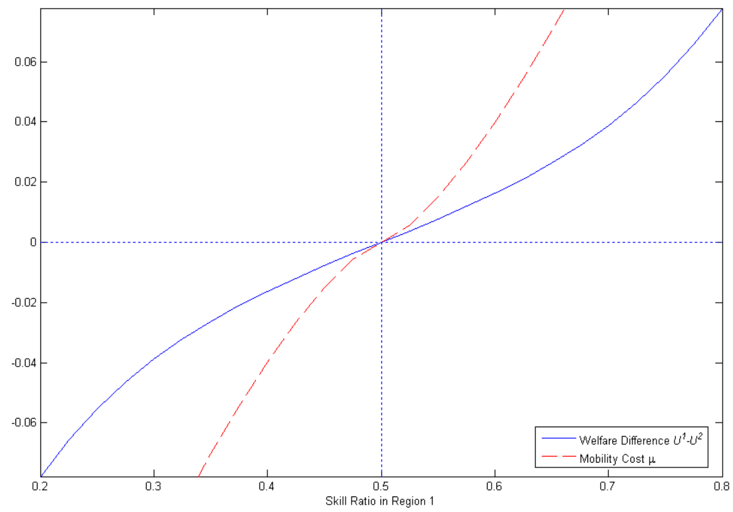

Figure 2: Two-Region Equilibrium: Symmetric Regions with High Mobility Costs

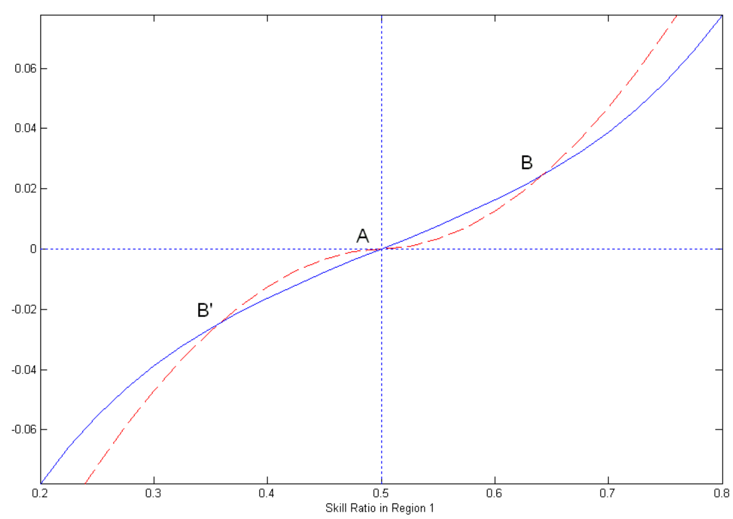

Figure 3: Two Region Equilibrium: Symmetric Regions with Low Mobility Costs

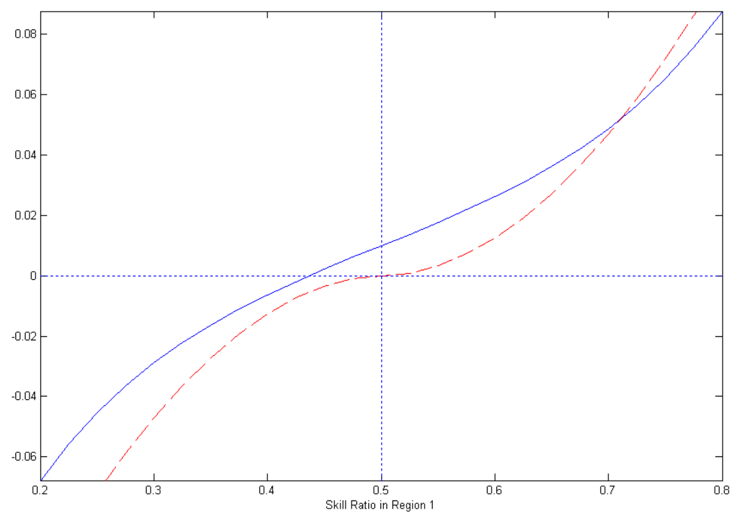

Figure 4: Two-Region Equilibrium: Technology Differences $\left(\theta^1 > \theta^2\right)$

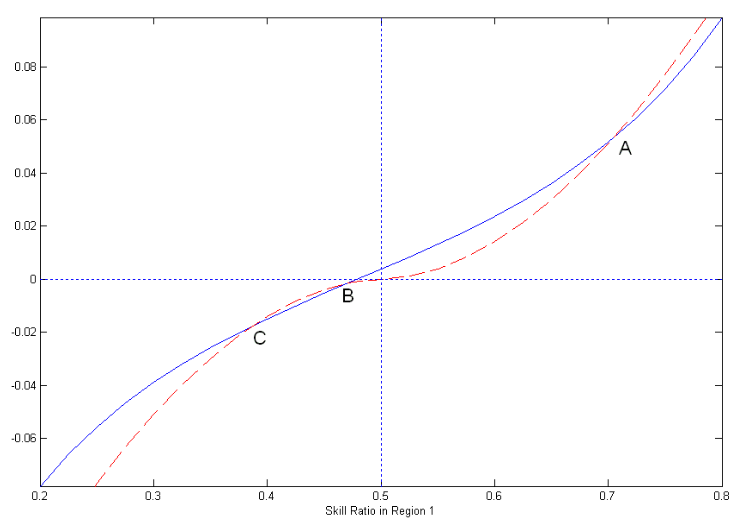

Figure 5: Two-Region Equilibrium: Technology Differences $\left(\theta^1 > \theta^2, \alpha^1 < \alpha^2\right)$

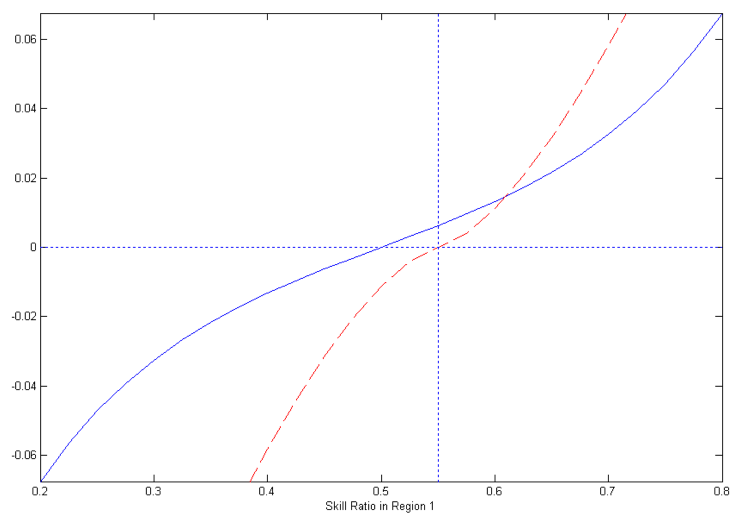

Figure 6: Two-Region Equilibrium: Endowment Differences $e_2^1 > e_2^2$.