Ifo Institute for Economic Research at the University of Munich

ifo Working Papers

Education, unemployment and migration

Wolfgang Eggert
Tim Krieger
Volker Meier

Ifo Working Paper No. 78

August 2009

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Abstract

This paper studies a two-region model in which unemployment, education decisions and interregional migration are endogenous. The poorer region exhibits both lower wages and higher unemployment rates, and migrants to the richer region are disproportionally skilled. The brain drain from the poor to the rich region is accompanied by stronger incentives to acquire skills even for immobile workers. Regional shocks tend to affect both regions in a symmetric fashion, and skilled-biased technological change reduces wages of the unskilled. Both education and migration decisions are distorted by a uniform unemployment compensation, which justifies a corrective subsidization.

JEL Code: H23, I20, J61, J64, R10.
Keywords: Brain drain, brain gain, education, unemployment, interregional migration, externalities.

Wolfgang Eggert
Department of Economics
University of Paderborn
Warburger Str 100
33098 Paderborn, Germany
Phone: +49(0)5251/60-5002
wolfgang.eggert@uni-paderborn.de

Tim Krieger
IDepartment of Economics
University of Paderborn
Warburger Str 100
33098 Paderborn, Germany
Phone: +49(0)5251/60-2117
tim.krieger@notes.uni-paderborn.de

Volker Meier
Ifo Institute for Economic Research
at the University of Munich
Poschingerstr. 5
81679 Munich, Germany
Phone: +49(0)89/9224-1371
meier@ifo.de

1 Introduction

This paper deals with skill formation in a context with endogenous migration and an imperfect labor market, thereby providing new insights into the interaction of education, migration and unemployment in an interregional context. We explore the mechanisms creating a *brain drain* out of a poor sending region and identify channels of how those left behind in the poor region may experience a counteracting *brain gain* via higher propensities to acquire human capital induced by the equilibrium effects on wages. Moreover, we indicate how regional and national economic shocks affect educational decisions and interregional migration. Given that education and migration subsidies are frequently used as active labor market policies in many countries, we also aim at rationalizing the different policies from a welfare perspective. Our discussion of the relevant externalities casts some doubt on the efficiency of these policies. We argue that while subsidies for both education and migration may be justified in general, subsidies at a rate of one hundred per cent seem doubtful.

It is frequently observed that substantial interregional wage differentials within a country exist, where the low-wage regions are also characterized by comparatively high unemployment rates. For example, in Germany unit labor costs in manufacturing in the East were at 65 per cent of the national average in 2004, while the unemployment rate in East Germany of around 20 per cent exceeded the national unemployment rate by more than 8 percentage points (Institut der deutschen Wirtschaft, 2006). In the same year, unemployment in Southern Italy stood at around 14.5 percent, exceeding the national average by 6.5 percentage points, despite low labor costs of less than 85 per cent of the national average in manufacturing. A third example is Southern Spain, with an unemployment rate of 16 per cent in 2004, five percentage points higher than the national average. Again, this region of high unemployment displays relatively low labor costs of less than 90 per cent of the Spanish average in manufacturing (Eurostat, 2007). In an international context, the average unemployment rate in the 10 poorest OECD countries in 2003 was 7.3%, while in the ten richest OECD economies it was only 4.2% (OECD 2009). In all these cases, similar relations hold for longer time spans, often without clear tendencies of convergence. It has to be noted, however, that international migration is often restricted by the rich countries.

Further, high-wage regions tend to have a higher share of high-skilled individuals in their workforce. Due to a high demand for qualified workers, they offer attractive jobs to natives and foreigners alike, the latter inducing a brain drain out of poorer regions. The recent literature and data on the brain drain (Carrington and Detragache, 1998; Beine et al., 2008; and Docquier et al., 2009) confirms these features. When comparing the 10 richest and poorest OECD countries in terms of GDP per capita in the year 2000, we observe that in the bottom-10 (top-10) countries 13% (47%) of the labor force have tertiary education; that the emigration rate of individuals with tertiary education is 13% (11%); and that of the stock of immigrants 21% (48%) are high-skilled.[1] As expected from theoretical analyses, the propensity to migrate is stronger for high-skilled individuals than for the low-skilled (Sjaastad, 1962; Borjas, 2000; Wildasin, 2000). Finally, a higher formal qualification is always associated with a reduced unemployment risk in the data, confirming the prediction of theory (e.g. McKenna, 1996; Becker, 1993; Lindbeck and Snower, 1988).

Our model captures all these stylized facts. We consider two regions in which workers take decisions on acquiring skills and migration to the other region. Migration will arise in only one direction, from the poor to the rich region. It is a mechanism that reduces the interregional wage and unemployment differentials, albeit not in a perfect fashion. There is a persistent technological gap between the regions that is not explained. By contrast, the higher mobility of skilled workers is an endogenous result. Unemployment arises according to an efficiency wage argument of the shirking type. While the shirking model allows for a particularly simple analysis of the issues involved, it should be noted that the main messages of our study will also turn out with alternative explanations of unemployment.

Our first main result shows that, though starting from a symmetric skill distribution across regions, the share of skilled workers among the emigrants exceeds the corresponding share among those left behind. The driving force behind this result is a higher skill premium in the rich region, allowing for higher migration costs to make relocation of skilled workers still worthwhile.[2] Moreover, we extend the recent brain drain literature by introducing a new channel for a brain gain of the poor region, working through

[1] Own calculations based on Docquier et al. (2009) and OECD (2009).

[2] A similar stratified outcome is derived in Anderberg and Andersson (2007), who consider educational decisions of young individuals when skilled jobs are rationed and matching frictions induce permanent residential segregation. This in turn generates a lower expected return to skill acquisition for individuals from adverse social environments, making them less likely to invest in education.

an equilibrium effect on wages. Since the skill premium rises with a smaller aggregate labor supply due to outmigration, medium ability workers now acquire skills. This affects even those workers who never plan to migrate due to high migration costs. This distinguishes our finding from the previous literature which stresses stronger incentives to invest in education upon expecting some positive probability of emigration (Mountford, 1997; Stark et al., 1997, 1998; Vidal, 1998; Beine et al., 2001). Although the emigrants are disproportionally skilled, the share of skilled workers among those staying in the poor region may increase, implying a brain gain. The traditional brain drain literature discusses some elements of this story in models with a traditional and a modern sector (Bhagwati and Hamada, 1974; McCulloch and Yellen, 1975; Rodriguez, 1975), but remains more pessimistic.

Improving educational attainment by training programs and promoting migration to more prosperous regions are frequently used policy instruments to reduce unemployment. Our second main result is related to the question whether such labor market policies can be justified on efficiency grounds. From an allocative perspective, the presence of unemployment tends to distort the decisions of individuals. It may induce overinvestment (Kodde, 1988; Charlot et al., 2005; Albrecht and Vroman, 2002) or underinvestment (Dellas, 1997; Laing et al., 1995; Acemoglu, 1996; Cahuc and Michel, 1996; Cubitt and Hargreaves Heap, 1999) in education, where similar arguments can be made for migration. In our model, due to the unemployment rate differential across skill groups within a region and across regions for a given skill group, the incentives to acquire human capital and to migrate to the rich region both tend to be too strong, as measured by the productivity differentials of employed workers. This view suggests to tax rather than to subsidize education and migration. However, we argue that the differentials in unemployment levels need also be taken into account by a social planner in any second-best allocation. Only changes of unemployment rates represent externalities of education and migration decisions. By contrast, unemployment benefits will reduce the incentive to become a skilled worker and lower interregional mobility. Correcting for the latter distortions may require an education subsidy and some mobility premium. If we neglect the presumably small general equilibrium externalities in our model, it turns out that education or migration subsidization should not be given at a 100% rate for marginal individuals. This result holds because each type of human capital investment decision always needs to be associated with a gain in expected wage income. Clearly, this observation casts some doubt on active labor market policies pursued in many countries.[3]

The remainder of the paper is organized as follows. After introducing the model in Section 2, the following Section 3 characterizes equilibria and investigates issues of stability and the interaction of wages. Section 4 comprises some comparative statics. Section 5 is concerned with a welfare analysis of the equilibria and discusses policies to overcome the resulting inefficiencies. Finally, Section 6 concludes and indicates directions for future research.

2 The model

Basic assumptions We consider two regions $i \in \{A, B\}$. The mass of individuals born in region i is denoted by n_i. Individuals are characterized by their place of birth, their cost of acquiring human capital $c \in (0, \infty)$ and their cost of migration $d \in (0, \infty)$ to the other region. The education and migration costs are to be interpreted as equivalent to a utility loss of that size per unit of time. The density function $\varphi(c, d)$ that describes the distribution of costs is the same in both regions and has support on $(0, \infty)^2$. Let c, d be statistically independent. We denote by $f(c)$ the density function and by $F(c) = \int_0^c f(x)dx$ the cumulative distribution function with respect to the human capital acquisition cost c for any given migration cost d.

We analyze a framework in which individuals recognize that migration and education decisions are interdependent. In the initial stage at date $t = 0$ individuals choose their skill level between h (high) and l (low) and their residence region. Education may take place in either region, and skills are perfectly transferable across regions. In the subsequent production stage, running from date $t = 0$ to infinity, jobs are randomly allocated among all individuals supplying labor of a specific type on regional labor markets. Firms produce a homogeneous numeraire good from labor and set the wage in order to give employed individuals an incentive not to shirk. The numeraire good is traded on a competitive market across regions. Individuals have perfect foresight with respect to second stage wages and unemployment rates when

[3] Our sceptical view on active labor market policies and education programs bears some relation to Saint-Paul (1994, 1996). He points out that when skill-specific wages depend on the respective unemployment rates, an increase in the relative supply of skilled workers will not only increase total output, but also the skill-specific unemployment rates. As the share of individuals with the lower unemployment rate increases, aggregate unemployment may move in either direction. Hence, education policy has a negative general equilibrium effect that may more than offset the immediate gain in reducing unemployment.

they make their decisions in the first stage. In the following we characterize individual choices in the first stage and then describe production decisions.

Let p_i^k be the unemployment probability of an individual of skill type k living in region i in any period. Suppose that the unemployed in either region regardless of their skill type receive a uniform unemployment benefit b. As we do not want to stress distortions arising from taxation of labor, let the benefit be financed by a lump-sum tax on residual income. The latter is assumed to always exceed aggregate claims of the unemployed. The value of living in region i as an individual of skill type k per unit of time is

$$v_i^k = [(1 - p_i^k)[u(w_i^k) - e] + p_i^k u(b)], \tag{1}$$

where preferences u satisfy the properties $u(0) = 0$, $u' > 0$, $u'' \leq 0$. The wage for skill type k in region i is denoted by w_i^k. Without loss of generality, we assume that region A is the high-wage region. The required effort at the workplace $e > 0$ is identical for all jobs.

Individuals' migration and education decisions In the first stage, a pair of costs (c, d) and the place of birth determines choices. An individual of type k will stay in her birth region i if $v_j^k \leq v_i^k$. Clearly, all individuals within the group of non-migrants are indifferent to invest in education whenever

$$v_i^l = v_i^h - \hat{c}_i. \tag{2}$$

This means that individuals in the group of non-migrants with higher costs than the cutoff level $\hat{c}_i$ choose not to invest in education.

Let us next characterize the decisions of migrants. They are all born in B; consider first the case where $c < \hat{c}_B$. These low education cost types will acquire skills and are indifferent whether to stay in region B or move to region A when

$$v_B^h = v_A^h - \hat{d}^h. \tag{3}$$

For any threshold $\hat{d}^h > 0$, the high-wage region A is the place of residence for a set of individuals born in B with costs $d < \hat{d}^h$. Consider next education cost types born in region B with $\hat{c}_B < c < \hat{c}_A$. These individuals clearly will not invest in education in region B, but they may obtain skill after migration anticipating the high wage in region A. Specifically, individuals born in region B are indifferent between migration with education versus no migration and no education whenever the sum of costs just equals the sum

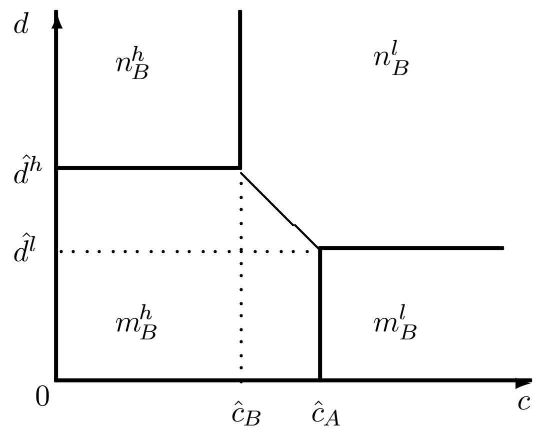

Figure 1: Migration and education thresholds of individuals born in region B.

of the two cutoff values

$$c + d = \hat{d}^h + \hat{c}_B = \hat{d}^l + \hat{c}_A, \tag{4}$$

where $\hat{d}^l = v_A^l - v_B^l$ is the cutoff level of migration costs for low-skilled individuals. The second equality can easily be verified by using the definitions of the threshold values. Lemma 1 collects the results on the choices of the individuals.

Lemma 1 *A combination (c, d) and the place of birth characterizes individuals. Let region A be the high-wage region for a given skill group and $v_i^h > v_i^l$. Then:*

i) Individuals born in region A choose:
i.a) $c < \hat{c}_A$: education;
i.b) $c > \hat{c}_A$: no education.

ii) Individuals born in region B choose:
ii.a) $d > \hat{d}^h \wedge c < \hat{c}_B$: education without migration (n_B^h);
ii.b) $d + c < \hat{d}^h + \hat{c}_B \wedge d < \hat{d}^h \wedge c < \hat{c}_A$: education with migration (m_B^h);
ii.c) $d + c > \hat{d}^h + \hat{c}_B \wedge d > \hat{d}^l$, $c > \hat{c}_B$: no migration, no education (n_B^l);
ii.d) $d < \hat{d}^l$, $c > \hat{c}_A$: migration without education (m_B^l).

Population structure Figure 1 compiles the structure of decisions in region B. Individuals with characteristics associated with field n_B^h acquire skills and stay in region B due to high costs of migration. Individuals with high costs of education and low costs of migration will migrate as low-skilled to region A (mass m_B^l). The choice between staying as low-skilled in B (mass n_B^l) or becoming high-skilled in region A (m_B^h) is governed by the sum of the costs c and d as discussed in Lemma 1 in *ii.b* and *ii.c*. The diagonal in Figure 1 has a slope of -1 between field n_B^l to the right and m_B^h because education and migration costs cause an equivalent utility loss per unit of time. Furthermore, Lemma 1 in *ii.b* and *ii.c* implies that the diagonal in Figure 1 contains the points $\left(c_B, d^H\right)$ and $\left(c_A, d^L\right)$. Hence, it is impossible to change one of the four threshold values independent of the three other ones. Denote by n_A^k the mass of individuals of type k located in region A. To obtain n_A^k add the migrants from the other region m_B^k and the number of natives in region A of type k.

Some general results are summarized in Proposition 1.

Proposition 1 *(i) The share of individuals acquiring skills in region B is smaller than in region A. (ii) The share of skilled workers among the migrants to region A exceeds the share of skilled workers remaining in region B. (iii) The share of skilled workers among those staying in region B is smaller than the corresponding share among the natives in region A. (iv) In a migration equilibrium, the share of skilled workers in region A is higher than the corresponding share in region B. (v) In a migration equilibrium, the share of skilled workers among the immigrants exceeds the share of skilled workers among the natives in region A.*

Proof. See Appendix A. ∎

The incentive to acquire skills is stronger in the rich region due to a higher absolute expected wage premium. The larger weighted wage differential is also relevant for the migrants to the rich region and corresponds with a stronger migration incentive for skilled workers. Therefore, a smaller share of individuals born in the poor region become skilled workers, and the share of skilled workers among those left behind falls short of the share of skilled workers among the migrants to the rich region. The migrants represent a positive selection in terms of qualification from the original population of the poor region. Taking this selection effect together with the result that the share of educated workers among the natives of region A exceeds the corresponding share of those being born in region B explains why this relation also holds in any migration equilibrium. Moreover, the selectivity of migrants more than offsets the smaller incentive to acquire skills in the sending region, resulting in a higher "quality" (Borjas, 1985) of immigrants compared to the natives in the receiving region. In our framework, the welfare state tends to discourage particularly migration of low-skilled workers, which adds to the market-based pattern of stronger migration incentives for the high-skilled.

Note that contrary to most of the literature we *endogenously* derive the higher propensity to migrate of skilled workers. Further, the differences in the expected wage premia also arise endogenously. The mere existence of skilled migrants in the sorting equilibrium implies that the skill premium in the rich region must be higher than in the poor region, and that the migration premium of skilled workers must exceed the migration premium of unskilled workers. Otherwise, some marginal types would find it more profitable either to become skilled worker in the poor region or to migrate as an unskilled worker.

At given education and migration thresholds it can be argued that the poor region suffers from a brain drain, marked by the higher average skill level of the emigrants. Moreover, with a fixed education threshold $\hat{c}_B$, the share of unskilled workers in the poor region is higher in the migration equilibrium than in the absence of migration. However, migration from the poor to the rich region makes labor scarcer in the poor region. Consequently, wages and the expected absolute wage premium of skilled workers in the poor region will be driven upwards. As this yields a higher education threshold, the brain drain will be associated with a brain gain. Conversely, migration tends to bring wages and the skill premium in the rich region down, which in turn reduces the incentive to migrate.

An example in which the share of skilled workers in the poor region increases after moving from a closed border to a free migration regime can be constructed as follows. Suppose there are three groups of workers in region B with population shares n_i characterized by migration costs $c_1 < c_2 < c_3$ and migration costs $d_1 < d_2 \leq d_3$. Individuals of the high-cost type 3 never become skilled and always stay in the poor region. By contrast, individuals of the low-type cost group always become skilled and will migrate if migration is allowed. Finally, the medium type 2 individuals never migrate and acquire skills only if foreseeing emigration of type 1 individuals resulting in a higher skill premium in region B. The brain gain result is obtained if the population shares satisfy $n_1/(n_1+n_2+n_3) < n_2/(n_2+n_3)$.

This channel of a brain gain has previously been neglected in the literature. The standard argument of a brain gain states that the expected skill premium rises with the possibility of emigration when people expect to migrate with some positive probability. While this line of reasoning remains true, even those who know beforehand that they will remain in the poor region tend to have a higher incentive to become skilled due to general equilibrium effects affecting the structure of wages. These effects may even be more pronounced when skilled labor and unskilled labor are complements, as the brain drain then further increases the skill premium.

Production and unemployment Let L_i^h and L_i^l denote total employment of high-skilled and low-skilled labor in region i, respectively. While Proposition 1 also holds for more general technologies, we confine our attention in the following to the case in which the two types of labor are perfect substitutes. The production function is given by $G_i(L_i^h, L_i^l) = \beta_i G(\sigma L_i^h + L_i^l)$ with $\beta_A > \beta_B > 0$, where G is a strictly concave function with decreasing returns, and one unit of skilled labor is equivalent to $\sigma > 1$ units of unskilled labor.

We consider the standard shirking model of Shapiro and Stiglitz (1984) to motivate the existence of unemployment. Individuals are infinitely lived and choose whether or not to shirk. Let us denote by r the discount rate, s is the exogenous separation rate, and a is the job acquisition rate. The probability that a shirker is caught and fired immediately is q. The asset equations of employed shirkers (denoted by superscript S), employed non-shirkers (N) and unemployed (U) are

$$rW_i^{kS} = u(w_i^k) + (s+q)(W_i^{kU} - W_i^{kS}), \tag{5}$$
$$rW_i^{kN} = u(w_i^k) - e + s(W_i^{kU} - W_i^{kN}), \tag{6}$$
$$rW_i^{kU} = u(b) + a(W_i^{kE} - W_i^{kU}), \tag{7}$$

with $W_i^{kj}, j \in \{S, N, U\}$ representing the value of being in state j, and $W_i^{kE} = \max\{W_i^{kN}, W_i^{kS}\}$. Rearranging terms and using the flow equilibrium condition $ap_i^k = s(1-p_i^k)$ gives the minimum wage to induce effort $W_i^{kN} \geq W_i^{kS}$ from

$$u(w_i^k) - e \geq u(b) + r\frac{e}{q} + \frac{s\,e}{q\,p_i^k}. \tag{8}$$

Cost minimization of the firm implies that the no-shirking condition (8) holds with strict equality. This allows us to establish an inverse relationship between the wage and unemployment,

$$\frac{dp_i^k}{dw_i^k} = -\frac{u'(w_i^k)\left(p_i^k\right)^2}{s\,e/q} < 0. \tag{9}$$

Inspection of (5) and (6) shows that an employed worker earns the information rent $W_i^{kE} - W_i^{kU} = e/q$. Labor of type k is employed until the marginal product equals the wage,

$$\frac{\partial G_i(L_i^h, L_i^l)}{\partial L_i^k} - w_i^k = 0. \tag{10}$$

Skilled workers have a higher marginal productivity than unskilled workers at any given combination of employment of both skill groups, i.e., $\partial G_i/\partial L_i^h > \partial G_i/\partial L_i^l$. This implies that the unemployment rate of skilled workers always falls short of the unemployment rate of unskilled workers.

3 Equilibria, stability, and wage effects

The assumption of perfect substitutability of skilled and unskilled labor drives some results as a higher labor supply through education or migration tends to reduce all wages and to increase all unemployment rates in the respective region, and vice versa. These general equilibrium externalities may take a different sign when high-skilled and low-skilled workers are complements.

Recall that n_i^h and n_i^l denote total labor supply of high-skilled and low-skilled workers in region i in a post-migration situation. The no-shirking condition (8) holds for each skill type and region. Due to this condition, w_i^l, the wage rate of low-skilled workers in region i, determines p_i^h and p_i^l, the unemployment rates of skilled and unskilled workers in region i. Consequently, the threshold values are functions of the wage for the low-skilled in a region. Hence, we have $p_i^h(w_i^l), p_i^l(w_i^l), \hat{c}_A(w_A^l),\ \hat{c}_B(w_B^l),\ d^H(w_A^l, w_B^l)$ and $d^L(w_A^l, w_B^l)$. It then turns out that the model boils down to a system of two equilibrium conditions $f_1(w_A^l, w_B^l) = 0$ and $f_2(w_A^l, w_B^l) = 0$ with

$$f_1 = \beta_A G' \left[(1-p_A^h)\sigma n_A^h + (1-p_A^l) n_A^l \right] - w_A^l, \tag{11}$$

$$f_2 = \beta_B G' \left[(1-p_B^h)\sigma n_B^h + (1-p_B^l) n_B^l \right] - w_B^l, \tag{12}$$

which determines w_A^l and w_B^l. Recall that n_i depicts initial population size in region i. Further, Lemma 1 together with the accounting equation $\hat{d}^h + \hat{c}_B = \hat{d}^l + \hat{c}_A$ imply that n_A^h and n_A^l are determined by three threshold values. Specifically, we can write $n_A^h = n_A^h(n_A, n_B, \hat{c}_A, \hat{d}^h, \hat{d}^l)$, $n_A^l = n_A^l(n_A, n_B, \hat{c}_A, \hat{d}^l)$ in (11) and $n_B^h = n_B^h(n_B, \hat{c}_B, \hat{d}^h)$, $n_B^l = n_B^l(n_B, \hat{c}_B, \hat{d}^h, \hat{d}^l)$ in (12). The dynamics of the system is described by

$$\dot{w}_A^l = h_1 \left[f_1(w_A^l, w_B^l) \right], \tag{13}$$

$$\dot{w}_B^l = h_2 \left[f_2(w_A^l, w_B^l) \right], \tag{14}$$

with $h_1(0) = h_2(0) = 0$, $h_1' > 0$ and $h_2' > 0$. Thus, the wage in a region increases when the marginal product of labor exceeds the wage rate, and vice versa.

The equilibrium (w_A^l, w_B^l) of the system of equations (13)-(14) is locally asymptotically stable only if $\frac{\partial \dot{w}_A^l}{\partial w_A^l} + \frac{\partial \dot{w}_B^l}{\partial w_B^l} \leq 0$, and $\frac{\partial \dot{w}_A^l}{\partial w_A^l}\frac{\partial \dot{w}_B^l}{\partial w_B^l} - \frac{\partial \dot{w}_A^l}{\partial w_B^l}\frac{\partial \dot{w}_B^l}{\partial w_A^l} \geq 0$ hold at the equilibrium point. We replace the former condition by the slightly more restrictive $\frac{\partial \dot{w}_A^l}{\partial w_A^l} \leq 0$ and $\frac{\partial \dot{w}_B^l}{\partial w_B^l} \leq 0$, and assume that all three conditions hold with strict inequality.

These conditions are then equivalent to $\frac{\partial G_A'}{\partial w_A^l} - 1 < 0$, $\frac{\partial G_B'}{\partial w_B^l} - 1 < 0$, and

$$\Delta = \left[\frac{\partial G_A'}{\partial w_A^l} - 1 \right] \left[\frac{\partial G_B'}{\partial w_B^l} - 1 \right] - \frac{\partial G_A'}{\partial w_B^l}\frac{\partial G_B'}{\partial w_A^l} > 0. \tag{15}$$

Hence, considering a perturbation of the migration equilibrium, the increase of the marginal product of labor upon a rising wage will fall short of the wage increase after adaptation of skill-specific unemployment rates, education and migration decisions. Moreover, the product of cross effects of wage increases on the resulting marginal productivity of labor in the other region has to be comparatively small.

The cross derivatives are

$$\frac{\partial G_A'}{\partial w_B^l} = G_A'' \left[\left(1 - p_A^h\right) \left[\frac{\partial n_A^h}{\partial \hat{d}^h} \frac{\partial \hat{d}^h}{\partial w_B^l} + \frac{\partial n_A^h}{\partial \hat{d}^l} \frac{\partial \hat{d}^l}{\partial w_B^l} \right] + \left(1 - p_A^l\right) \frac{\partial n_A^l}{\partial \hat{d}^l} \frac{\partial \hat{d}^l}{\partial w_B^l} \right] > 0, \tag{16}$$

$$\frac{\partial G_B'}{\partial w_A^l} = G_B'' \left[\left(1 - p_B^h\right) \left[\frac{\partial n_B^h}{\partial \hat{d}^h} \frac{\partial \hat{d}^h}{\partial w_A^l} \right] + \left(1 - p_B^l\right) \left[\frac{\partial n_B^l}{\partial \hat{d}^h} \frac{\partial \hat{d}^h}{\partial w_A^l} + \frac{\partial n_B^l}{\partial \hat{d}^l} \frac{\partial \hat{d}^l}{\partial w_A^l} \right] \right] > 0. \tag{17}$$

Notice that $\partial n_A^h / \partial \hat{d}^h > 0$, $\partial n_A^h / \partial \hat{d}^l > 0$, $\partial n_A^l / \partial \hat{d}^l > 0$, $\partial n_B^h / \partial \hat{d}^h < 0$, $\partial n_B^l / \partial \hat{d}^h < 0$ and $\partial n_B^l / \partial \hat{d}^l < 0$ hold from Lemma 1, as can also be verified by inspecting Figure 1. It is straightforward to see that the migration thresholds decrease with a smaller wage differential. Thus, $\partial \hat{d}^k / \partial w_A^l > 0$ and $\partial \hat{d}^k / \partial w_B^l < 0$ for $k \in \{h, l\}$.

The impact of a higher wage in the rich region A on the wage in the poor region B is unambiguously positive. The rising interregional wage differentials increase the migration incentives for both high-skilled and low-skilled workers. In addition, some individuals will choose to become educated and to migrate as high-skilled workers rather than staying as low-skilled workers in the poor region. This reduces the supply of both types of workers in the poor region.

The impacts of a higher wage in the poor region B on the wage in the rich region A are analogous. A decreasing interregional wage differential reduces migration of low-skilled and high-skilled workers to the rich region. Consequently, aggregate labor supply in the rich region declines, inducing a higher wage.

For the comparative static analysis, we take the natural assumption that the threshold education costs are increasing monotonously in the respective wage levels, that is, when determining education decisions, the increasing skill premium upon a rising wage always dominates the possibly shrinking unemployment differential.

4 Comparative statics

Proposition 2 collects the results of changing parameters on the migration equilibrium.

Proposition 2 *A higher initial population in the rich or the poor region, n_A or n_B, will induce (i) lower wages, (ii) higher skill-specific unemployment rates, and (iii) smaller education cost thresholds in both regions. A rising productivity factor in the rich or the poor region, β_A or β_B, yields an increase of the wage rate and smaller group unemployment rate in both regions. A rising productivity factor of skilled workers σ will decrease the wage of low-skilled workers in both regions and increase their regional unemployment rates.*

Proof. See Appendix B. ■

A population increase in one region may best be interpreted as migration from abroad that is regionally concentrated. Such a concentration can occur due to the possible existence of networks for migrants in only one region. At given education and migration thresholds and fixed unemployment rates, an increasing population in the rich region A raises employment of workers of both types in this region, thereby reducing the wage rate w^l_A. The falling wage reduces the migration thresholds in region B, contributing to a rising labor supply and a falling wage in region B. Thus, all threshold costs fall, which is depicted by a move from the initial situation with solid lines in Figure 2 to the new equilibrium marked by dotted lines. Since the no-shirking condition dictates that wage cuts are always associated with more unemployment, all skill-specific unemployment rates rise.

A rising population in the poor region B at given migration thresholds directly increases employment of both types of labor in both regions, implying a falling wage in both regions. The cross effects of wages on each other are always positive, reinforcing the downward pressure. This in turn increases the skill-specific unemployment rates and reduces the education thresholds.

A higher productivity of workers in the rich region directly increases the wage there. This wage increase yields stronger migration incentives in the poor region, leading to an outflow of workers of both types. Due to the reduction in labor supply, the wage rate in the poor region will also go up. Hence, workers in the poor region will be affected by a technological shock occuring in the high-wage region in the same direction. In sum, both migration thresholds and both education thresholds rise, as shown in the left panel of Figure 3. If the productivity of labor in the poor region increases, for example due to a successful imitation, there is a direct positive effect on the wage in the poor region. This wage increase reduces the migration

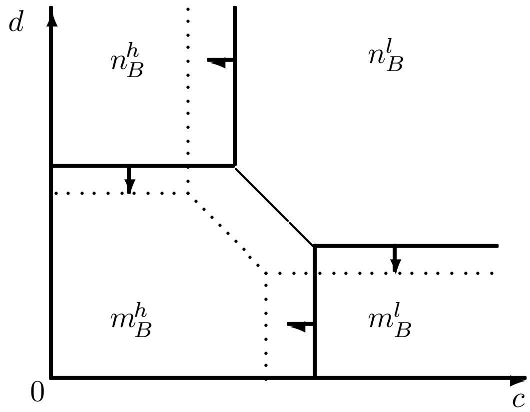

Figure 2: Impact of a rising n_A on migration and education thresholds.

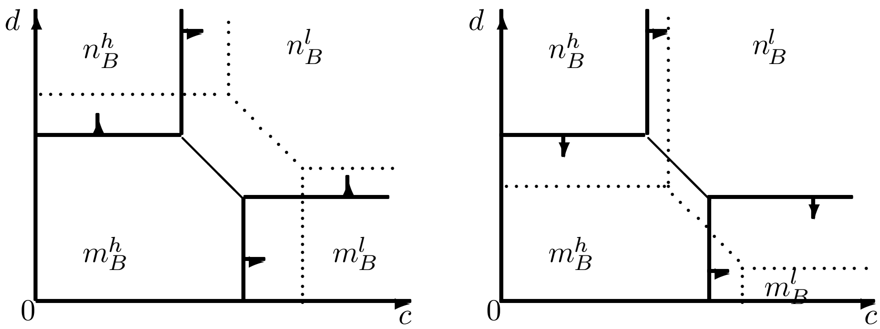

Figure 3: Effects of a variation in β_A and β_B on migration and education thresholds.

incentive to the high-wage region, which contributes to rising wages across the board. This is illustrated in the right panel of Figure 3, where both education thresholds rise and both migration thresholds decline.

If the productivity of high-skilled workers increases, which can be interpreted as skill-biased technological change, this yields more employment in both regions at given decision thresholds, leading to a lower wage for the low-skilled. The increasing wage differential between workers of different skill types implies rising propensities to acquire skills in both regions. Again, this tends to increase employment of labor in efficiency units and to decrease wages. All these effects are reinforced by the positive interdependence of wages across regions. The regional unemployment rates of the low-skilled rise because the motive to replace low-skilled workers by high-skilled workers to avoid shirking is strengthened.

5 Welfare analysis and policy implications

Taking as given that the flat unemployment benefit b exists, it may be asked whether the individuals' economic decisions in combination yield an efficient allocation. In the following, the marginal utility of consumption is set constant to keep the analysis as simple as possible. The unemployment rates that occur due to avoid shirking do not reflect a market failure. The social planner maximizes total output,

$$\begin{aligned} &\beta_A G\left[(1-p_A^h)\sigma n_A^h + (1-\psi_A)\, n_A^l\right] \\ &+\beta_B G\left[(1-p_B^h)\,\sigma n_B^h + (1-p_B^l) n_B^l\right], \end{aligned} \tag{18}$$

net of costs of effort, education and migration, subject to the no-shirking constraints (8) and wage determination by the marginal productivity rule (10). The no-shirking constraints can be read to explain the group unemployment rates as increasing functions of labor supply in that region, that is $p_i^k\left(n_i^l, \sigma n_i^h\right)$ with $\frac{\partial p_i^k}{\partial n_i^h} = \frac{\left(1-p_i^h\right)\sigma}{\left(1-p_i^l\right)}\frac{\partial p_i^k}{\partial n_i^l} > 0$. From a social point of view, education should be purchased if the cost of acquiring human capital is justified by the weighted gain in utility, corrected for general equilibrium externalities. An analogous consideration holds for migration decisions.

Changes in regional aggregate labor supply create general equilibrium externalities. The migrant ignores the positive effects of lower aggregate labor supply on unemployment in the region of origin and the negative effect of increased aggregate labor supply on unemployment at destination. By contrast, the change in the wage levels is an example of a pecuniary externality which does not constitute a market failure.

Migration of a worker of type $k \in \{h, l\}$ from region B to region A yields a net general equilibrium externality

$$\begin{aligned}\Gamma^k &= \frac{\partial p_B^h}{\partial m_B^k}\Big[\sigma u(w_B^l) - e\Big]\, n_B^h + \frac{\partial p_B^l}{\partial m_B^k}\Big[u(w_B^l) - e\Big]\, n_B^l \\ &\quad - \frac{\partial p_A^h}{\partial m_A^k}\Big[\sigma u(w_A^l) - e\Big]\, n_A^h - \frac{\partial p_A^l}{\partial m_A^k}\Big[u(w_A^l) - e\Big]\, n_A^k.\end{aligned} \tag{19}$$

The sign of Γ^k hinges on two counteracting effects. While the reaction of the unemployment rate to an increase in labor supply tends to be larger in the poorer region, the expected loss in utility from an additional unemployed is higher in the rich region. Migration reduces skill-specific unemployment rates in the sending region and increases these group unemployment rates in the receiving region.

Considering education in region i, the general equilibrium externality in terms of utility reads

$$\begin{aligned}\Gamma_i &= -\Bigg[\left(\frac{\partial p_i^h}{\partial n_i^h} - \frac{\partial p_i^h}{\partial n_i^l}\right)\Big(\sigma u(w_i^l) - e\Big)\, n_i^h \\ &\quad + \left(\frac{\partial p_i^l}{\partial n_i^h} - \frac{\partial p_i^l}{\partial n_i^l}\right)\Big(u(w_i^l) - e\Big)\, n_i^l\Bigg] < 0.\end{aligned} \tag{20}$$

When a worker acquires skills, aggregate labor supply in efficiency units in the region increases. At given group unemployment rates, total employment increases, depressing the marginal product of labor. Due to the no-shirking conditions the resulting falling wages will be accompanied by higher group unemployment rates.

Thus, migration of an individual of type k from region B to region A is efficient if

$$\Big(1 - p_A^k\Big)\Big[u(w_A^k) - e\Big] - \Big(1 - p_B^k\Big)\Big[u(w_B^k) - e\Big] - d + \Gamma^k > 0. \tag{21}$$

Similarly, the social planner will choose to qualify those workers being born in region A for whom

$$\left(1-p_A^h\right)\left[u(w_A^h)-e\right]-\left(1-p_A^l\right)\left[u(w_A^l)-e\right]-c+\Gamma_A>0 \tag{22}$$

is valid. Finally, a worker born in region B should acquire human capital if

$$\begin{aligned}&\max\Big\{\left(1-p_B^h\right)\left[u(w_B^h)-e\right]-\left(1-p_B^l\right)\left[u(w_B^l)-e\right]-c+\Gamma_B,\\&\left(1-p_A^h\right)\left[u(w_A^h)-e\right]-\left(1-p_B^l\right)\left[u(w_B^l)-e\right]-c-d+\Gamma_B+\Gamma^h\Big\}\\>&\ 0\end{aligned} \tag{23}$$

holds. Comparing the conditions (21)-(23) to the individuals' criteria reveals that the unemployment benefit is a second source of distortion. As the probability of receiving this benefit is higher for low-skilled workers, the number of workers who acquire skills is too small. As with given skills the share of unemployed is higher in the poor region, the number of migrants is also too small from a social point of view. This consideration is slightly modified by the general equilibrium externalities.

Proposition 3 *A corrective region-specific education subsidy σ_i that achieves a perfect internalization is characterized by $\sigma_i=\left(p_i^h-p_i^l\right)u(b)+\Gamma_i$, while the optimum type-specific migration subsidy ρ^i can be written as $\rho^i=\left(p_B^i-p_A^i\right)u(b)+\Gamma^i$. The level of the respective subsidy always falls short of the full education or migration cost of the marginal individual.*

Proof. See Appendix C. ■

Neglecting the presumably small general equilibrium externalities, Proposition 3 can be interpreted as follows. The higher the unemployment differential across skill groups or regions is, the higher the optimal subsidy will be. As a reduction in the overall unemployment rate will typically decrease these differentials, we may also expect that such subsidies tend to be higher in countries with a higher national unemployment rate.

The second part of Proposition 3 shows that the marginal individual will always have to bear part of the investment or migration cost. This is of course a natural consequence of the fact that each type of human capital investment decision is always associated with a gain in expected wage income. However, it also indicates that it generally does not make sense to subsidize education and migration at a rate of 100% for the individuals with the highest cost level. Otherwise, we would end up with only skilled workers, who all choose to live in the rich region A.

This observation casts some doubts on active labor market policies pursued in several countries. It is not unusual that education and training programs for the unemployed are sponsored by national employment agencies at a rate of 100%. When reinterpreting our distribution of education costs as distribution of success probabilities, we should expect that too many people participate in highly subsidized education and training programs. Thus, it is not astonishing that evaluation studies often find zero or small impacts of such programs on subsequent employment probabilities and earnings of the participants (see, e.g., Heckman et al., 1999; Bergemann et al., 2004; Lechner et al., 2005; Albrecht et al., 2005).

Under a perfect information scenario, it is always possible to achieve a Pareto improvement on the resulting allocation without subsidies. This is obviously true because total output net of all costs increases. The Pareto improvement would be implemented by taxing residual income and distributing the proceeds as type-specific transfers to workers. Neglecting the changes in residual income, all workers in the rich region lose by moving to an allocation with efficient investment levels. The necessary transfers to ensure the status quo level of expected utility will be highest for the marginal types who still invest in education or migration. It cannot be excluded that negative minimum transfers arise for individuals in the poor region who do not change their education decision.

By contrast, if the government cannot observe the type of the individual, it will generally no longer be possible to implement a self-financing mechanism that induces all individuals to take the efficient investment decisions and makes everybody better off (see Kolmar and Meier, 2005, for a more general discussion). In this situation, transfers for revealing the type or inducing particular decisions have to be high enough to ensure a gain in expected utility for the most unfortunate type. Unlike the perfect information scenario, low-cost types cannot be deterred from taking up these high transfers. In other words, education and migration subsidies cannot be restricted to individuals close to the threshold levels. Thus, due to the windfall profits arising for individuals with a low cost of education or a low cost of migration, it is generally impossible to design a tax-transfer system that induces efficient decisions and is preferred by everyone to the status quo.

Another possibility to reduce distortions arises when the unemployment benefit is considered as an additional policy variable. Again ignoring general equilibrium externalities, a slight differentiation of unemployment benefits according to type and region in the direction of a constant replacement rate tends to reduce underinvestment in education and migration. It may even be possible to fully offset the distortions by appropriately specified unemployment benefits. However, recalling that unemployment rates will increase in the average level of the benefit, the optimum policy in a framework without risk aversion clearly is to cut all unemployment benefits to zero. In such a situation, only the general equilibrium externalities are present, which can be tackled by taxing education and taxing or subsidizing migration.

Applying our analysis to an international brain drain context has some interesting implications. Given that unemployment benefits are typically far higher in rich destination countries, a social planner aiming at maximizing world output would tend to tax rather than to subsidize international migration from poor to rich countries. The main justification of such a migration tax is to reduce overinvestment in migration due to taking unemployment benefits into account. This line of reasoning is clearly totally different from the traditional goal of a brain drain tax of compensating those left behind in the sending countries for their losses by the brain drain. At the same time, the same social planner would tend to subsidize migration between rich countries (say, from Germany or France to the US) if the emigration country pays relatively high unemployment benefits.

6 Conclusions

We have developed a framework that mirrors the stylized facts of regional wage and employment patterns, where the low-wage regions display disproportionally high unemployment rates. The possibility of migration to a richer region encourages human capital acquisition. As the absolute skill premium adjusted by the incidence of unemployment and unemployment benefits is higher in richer regions, the interregional adjusted wage differentials will be higher for skilled individuals. This yields some brain drain out of poor regions. The outflow of labor then drives the skill premium in poor regions up and increases incentives for human capital acquisition also for those who choose not to migrate.

Regional shocks tend to be distributed symmetrically across all regions. Additional international migration to rich regions will offset interregional migration. Hence, labor supply, wages and unemployment rates tend to display similar reactions in all regions. Skill-biased technological change tends to yield stronger incentives for human capital accumulation and interregional migration and will bring down wages of the unskilled.

In a political perspective, apart from presumably small general equilibrium effects, unemployment yields two distortions on human capital acquisition and migration that work in opposite directions. The skill-specific and interregional unemployment differentials cause too strong incentives, compared to a full employment situation. These are not relevant for politics when unemployment is not associated with externalities. In contrast, unemployment benefits can be received with a higher probability when recipients are unskilled or located in poorer regions. As savings on aggregate unemployment benefits are not taken into account by individuals, education and migration incentives are associated with positive fiscal externalities. The existence of such externalities calls for some subsidization of education and migration. At the same time, the extremely high subsidies in some education and training programs of active labor market policies seem to be exaggerated. We stress that these messages remain valid if alternative explanations of unemployment are considered, like matching frictions, wage-setting by unions, statutory minimum wages or insider-outsider relations.

An obvious alternative to the current setup would be a framework with a stochastic success of education. People would then be differentiated according to their success probability instead of their cost of education. Such a change is not expected to bring about qualitatively different results, however. A more serious shortcoming may be seen in the absence of savings decisions and changes of technology. Imitation and investment in physical capital may reduce interregional differences in the productivity of labor, which would bring down both unemployment rates and interrregional migration. On the other hand, technological progress will primarily be achieved in rich regions due to the concentration of skilled labor, which in turn also attracts investment of physical capital. Hence, while integrating such dynamic factors tends to bring aggregate unemployment down, it is unclear in advance how they affect the size of interregional differences.

Appendix

A: Proof of Proposition 1

The threshold education cost in region B is equal to $\hat{c}_A$ for $d \in [0, \hat{d}^l]$, and lower than $\hat{c}_A$ for any $d > \hat{d}^l$. This implies claim (i). The threshold education cost in region B equals $\hat{c}_B$ for $d \geq \hat{d}^h$, and is higher than $\hat{c}_B$ for any $d < \hat{d}^h$, which proves claim (ii). The share of skilled workers among the stayers in B is bounded from above by $F(\hat{c}_B) = \int_0^{\hat{c}_B} f(c)\,dc$. The share of skilled workers among the natives in region A is $F(\hat{c}_A)$. Recalling that $\hat{c}_A > \hat{c}_B$ and $f(c) > 0$ for $c \in [\hat{c}_B, \hat{c}_A]$ then proves claim (iii). Further, (ii) and (iii) imply claim (iv). Finally, the share of skilled workers among migrants with migration cost $d \in [0, \hat{d}^l]$ is $F(\hat{c}_A)$, and all migrants with migration cost $d > \hat{d}^l$ are skilled, which proves claim (v).

B: Proof of Proposition 2

Using the implicit function theorem gives $\frac{dw_i^l}{dn_j} = -\frac{\Delta_{n_j w_i^l}}{\Delta}$, where $\Delta_{n_j w_i^l}$ is the determinant of the Jacobian of the system (11)-(12), where the column vector of derivatives with respect to w_i has been replaced by the column vector of derivatives with respect to n_j. Using $L_i \equiv \sigma L_i^h + L_i^l$, the latter column vectors are

$$\begin{bmatrix} \beta_A G''(L_A)\left((1-p_A^h)\sigma\frac{\partial n_A^h}{\partial n_A} + (1-p_A^l)\frac{\partial n_A^l}{\partial n_A}\right) \\ 0 \end{bmatrix}$$

and

$$\begin{bmatrix} \beta_A G''(L_A)\left((1-p_A^h)\sigma\frac{\partial n_A^h}{\partial n_B} + (1-p_A^l)\frac{\partial n_A^l}{\partial n_B}\right) \\ \beta_B G''(L_B)\left((1-p_B^h)\sigma\frac{\partial n_B^h}{\partial n_B} + (1-p_B^l)\frac{\partial n_B^l}{\partial n_B}\right) \end{bmatrix}$$

for derivatives with respect to n_A and n_B, respectively. As $\beta_B\frac{\partial G'(L_B)}{\partial w_B^l} - 1 < 0$ and $\Delta > 0$ have been assumed to satisfy the stability conditions, it follows that

$$\begin{aligned}
\operatorname{sgn}\left[\frac{\partial w_A^l}{\partial n_A}\right] &= \operatorname{sgn}\left\{\beta_A G''(L_A)\left[\left(1-p_A^h\right)\sigma\frac{\partial n_A^h}{\partial n_A}+\left(1-p_A^l\right)\frac{\partial n_A^l}{\partial n_A}\right]\right\}<0,\\
\operatorname{sgn}\left[\frac{\partial w_B^l}{\partial n_A}\right] &= \operatorname{sgn}\left\{\beta_A G''(L_A)\left[\left(1-p_A^h\right)\sigma\frac{\partial n_A^h}{\partial n_A}+\left(1-p_A^l\right)\frac{\partial n_A^l}{\partial n_A}\right]\beta_B\frac{\partial G'(L_B)}{\partial w_A^l}\right\}\\
&= -\operatorname{sgn}\left[\beta_B\frac{\partial G'(L_B)}{\partial w_A^l}\right]<0,\\
\operatorname{sgn}\left[\frac{\partial w_A^l}{\partial n_B}\right] &= -\operatorname{sgn}\left\{\beta_A G''(L_A)\left[\left(1-p_A^h\right)\sigma\frac{\partial n_A^h}{\partial n_B}+\left(1-p_A^l\right)\frac{\partial n_A^l}{\partial n_B}\right]\right.\\
&\quad *\left[\beta_B\frac{\partial G'(L_B)}{\partial w_B^l}-1\right]\\
&\quad \left.-\beta_B G''(L_B)\left[\left(1-p_B^h\right)\sigma\frac{\partial n_B^h}{\partial n_B}+\left(1-p_B^l\right)\frac{\partial n_B^l}{\partial n_B}\right]\beta_A\frac{\partial G'(L_A)}{\partial w_B^l}\right\}<0,\\
\operatorname{sgn}\left[\frac{\partial w_B^l}{\partial n_B}\right] &= -\operatorname{sgn}\Delta_{n_B w_B^l}<0.
\end{aligned}$$

Unemployment rates change inversely to the wage rates according to (9). Further, c_i decreases with a falling wage w_i^l by assumption.

The column vectors of derivatives of the system of equations (11)-(12) with respect to β_A, β_B, and σ are

$$\begin{bmatrix} G'(L_A) \\ 0 \end{bmatrix}, \quad \begin{bmatrix} 0 \\ G'(L_B) \end{bmatrix},$$

and

$$\begin{bmatrix} \beta_A G''(L_A)\left[\left(1-p_A^h\right)n_A^h\right] \\ \beta_B G''(L_B)\left[\left(1-p_B^h\right)n_B^h\right] \end{bmatrix}.$$

Taking into account the assumptions to satisfy the stability conditions, the implicit function theorem yields

$$\operatorname{sgn}\left[\frac{\partial w_A^l}{\partial \beta_A}\right] = \operatorname{sgn}\left[G'\left(L_A\right)\right] > 0,$$

$$\operatorname{sgn}\left[\frac{\partial w_B^l}{\partial \beta_A}\right] = \operatorname{sgn}\left[\beta_B \frac{\partial G'(L_B)}{\partial w_A^l} G'(L_A)\right] > 0,$$

$$\operatorname{sgn}\left[\frac{\partial w_A^l}{\partial \beta_B}\right] = \operatorname{sgn}\left[\beta_A \frac{\partial G'(L_A)}{\partial w_B^l} G'\left(L_B\right)\right] > 0,$$

$$\operatorname{sgn}\left[\frac{\partial w_B^l}{\partial \beta_B}\right] = \operatorname{sgn}\left[G'\left(L_B\right)\right] > 0,$$

$$\operatorname{sgn}\left[\frac{\partial w_A^l}{\partial \sigma}\right] = \operatorname{sgn}\left[\beta_A \frac{\partial G'(L_A)}{\partial w_B^l} \beta_B G''(L_B)\left(1 - p_B^h\right) n_B^h - \left(\beta_B \frac{\partial G'(L_B)}{\partial w_B^l} - 1\right) \beta_A G''(L_A)\left(1 - p_A^h\right) n_A^h\right] < 0,$$

$$\operatorname{sgn}\left[\frac{\partial w_B^l}{\partial \sigma}\right] = \operatorname{sgn}\left[\beta_B \frac{\partial G'(L_B)}{\partial w_A^l} \beta_A G''(L_A)\left(1 - p_A^h\right) n_A^h - \left(\beta_A \frac{\partial G'(L_A)}{\partial w_A^l} - 1\right) \beta_B G''(L_B)\left[\left(1 - p_B^h\right) n_B^h\right]\right] < 0.$$

Unemployment rates change inversely to the wage rates according to (9).

C: Proof of Proposition 3

Comparing the individuals' choice criteria to the conditions describing the socially optimal investment in education and migration immediately shows that σ_j and ρ^i exactly offset the distortions. The threshold costs in the social optimum are defined by

$$c_j^* = \left(1 - p_j^h\right)\left[u(w_j^h) - e\right] - \left(1 - p_j^l\right)\left[u(w_j^l) - e\right] + \sigma_j \tag{24}$$

and

$$d^{i*} = \left(1 - p_A^i\right)\left[u(w_A^k) - e\right] - \left(1 - p_B^i\right)\left[u(w_B^k) - e\right] + \rho^i. \tag{25}$$

As we always have $p_j^h < p_j^l$, $p_A^i < p_B^i$, $w_j^h > w_j^l$, and $w_A^k > w_B^k$, it follows that $0 < \sigma_j < c_j^*$ and $0 < \rho^i < d^{i*}$.

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