Labor market integration and migration: Impacts on skill formation and the wage structure[*]

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Abstract

We analyze the impacts of labor market integration and migration on skill formation, wage structures, and per capita GDP of host and source countries. To do so, we propose a model in which heterogeneous agents invest in the acquisition of skills, and in which final good production exhibits increasing returns to scale in the range of available skills. Labor market integration, by allowing for migration in response to wage differentials, changes the wage structures and, therefore, the incentives to become skilled in both host and source countries.

We show that our model can largely replicate the empirical evidence concerning international migration, the widening international income dispersion, the narrowing national income dispersion, and the divergence in the rates of skill formation in host and source countries.

Keywords: labor market integration; migration; skill heterogeneity; skill formation; income inequalities

JEL Classification: F22; J24; J31; J61

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1   Introduction

The potential impacts of globalization have been heatedly debated these last decades, during which a large share of the world's countries became increasingly more open. The questions of whether increasing integration may exacerbate income inequalities both within and between nations has, in particular, attracted a lot of attention, both in the public opinion and in the political arena. Although the main focus has traditionally been on goods and capital market integration, labor market integration has recently become again a hot topic in most industrialized countries.[1] How does this type of integration affect the wage structures within and between countries? And who is likely to benefit from such an integration? Are countries of immigration and of emigration affected in similar ways and should they cooperate to control immigration flows?

The renewed interest in these questions should not mask the fact that both international market integration and migration have since long been important fields of theoretical and applied research in the economics of labor markets. From a theoretical perspective, Borjas (1995, 1999) analyzes the impacts of immigration on the wage structure of the host country using a perfectly competitive setting with skilled and unskilled labor as production factors. He shows that an inflow of migrants negatively affects the returns to substitutive factors, whereas it positively affects the returns to complementary factors. For instance, when capital is excluded from the analysis or when its price is fixed, immigration raises (resp., lowers) the wage rate of skilled workers if the skilled workers' share among immigrants is lower (resp., higher) than its share among natives. Besides the standard redistributive effects due to changes in the wage structure (i.e., relative wages), the total returns to native factors of production rise in the perfectly competitive setting. Put differently, the host country as a whole still benefits from immigration via the *immigration surplus*.[2]

The potential impacts of immigration on the wage structure of the host country have also been intensively examined empirically (see Friedberg and Hunt, 1995; Borjas, 1999, 2003; Longhi *et al.*, 2004; Card, 2001, 2005).

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[1]In the case of the European Union (EU), the sensitivity of the public opinion to issues of labor market integration has recently been illustrated by the so-called Bolkestein directive, which attempted to liberalize the provision of services within the EU. Another illustration in several countries is the rise of right-wing extremist parties which would like to significantly reduce immigration flows (Friedman and Hunt, 1995).

[2]Note the similarity of these results with those obtained in standard perfectly competitive trade theory (see, e.g., Feenstra, 2004).

Unfortunately, the broader picture that seems to emerge is far from clear: the estimated effects of immigration on wages in the host country vary widely from study to study, and the conclusions for the same country are moreover likely to change with the dataset used. While Card (2001) and Borjas (2003) find an overall negative effect of immigration on US wages, Card (2005, p. F300), using the updated version of the same dataset, concludes that "evidence that immigrants harm native opportunities is slight".

In this paper, we propose a framework that captures a potential benefit from immigration that does not materialize in the standard models: *the availability of a wider range of skills, allowing for a finer division of labor in the host country.* The idea is that skilled labor is heterogeneous and that immigration of skilled workers therefore expands the range of available skills. This in turn raises the productivity of native workers via a Marshallian externality.[3] In such a setting, both skilled *and* unskilled workers may actually benefit from immigration in the long-run.[4] Yet, this is not the end of the story: *migration, by changing the skill composition of the workforce, has also an impact on agents' choices to invest in skills.* Stated differently, immigration has a two-tier effect: (i) it directly affects the skill composition of the work force in the short-run via the inflow of migrants; and (ii) it indirectly affects skill composition in the long-run by changing native workers' incentives to invest in skills (via changes in the host country's wage structure). Hence, the positive effects of migration on the host economy may materialize in the long-run by raising the rate of native skilled workers there. In this respect, our paper is related to Brezis and Krugman (1996), who show that migration may well depress local wages in the short-run, whereas it raises them in the long-run by providing incentives for (physical or human) capital accumulation.

At first sight, such a story may seem inconsistent with some existing empirical studies that find a negative impact of immigration on host country wages (e.g., Borjas 1999, 2003; Card 2001). This apparent inconsistency is, in our opinion, mainly due to differences in the temporal dimension of

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[3]Possible micro-foundations for such externalities, e.g., sharing, matching and learning mechanisms, have for example been highlighted in the urban economics literature (see Duranton and Puga, 2004, for a recent survey).

[4]That real wages may rise in the long-run when there are external effects is well-known in the literature (see, e.g., Brezis and Krugman, 1996; Borjas, 1996). Unfortunately, the empirical evidence on the relationship between immigration and growth in the presence of external effects or increasing returns is ambiguous (Friedberg and Hunt, 1995). Yet, more recently the view that immigration benefits the host country in the long-run via increases in available skills has been supported by Ottaviano and Peri (2005), who show that US cities have benefitted from the increases in cultural diversity.

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the analyses. Whereas the above-mentioned studies examine the short-run effects of immigration, we focus on the long-run effects that are likely to materialize only after a longer period because it takes time to acquire, develop, and integrate new skills into the production system.[5] We believe that, by focusing on the long-run impacts of immigration on wages and skill formation, our study provides a framework that is largely complementary to the existing literature.

Although immigration may in the long-run be beneficial to all factors in the host country, its impacts on the *source* country may be quite different. To provide an answer to the question of how international income inequalities evolve in the presence of increasing migration, we therefore also need to investigate in more detail the potential impacts of *emigration*. We shed some new light on this issue by showing that the evolution of international and intranational income inequalities in our model is consistent with the actual evolution reported in recent works by Korzeniewicz and Moran (1997) and Bourguignon and Morrison (2002). The notable feature here is that, in the presence of immigration and skill heterogeneity, the between-country inequalities rise, the within-country inequalities fall, and the total inequalities rise since the former effect dominates the latter (inequality being measured by the standard Theil index). A by-product of such an evolution is that the host country experiences a faster increase in its share of skilled workers than the source country does, which is consistent with the evidence reported by Barro and Lee (2001).

The remainder of the paper is organized as follows. In Section 2, we present a static model and analyze the impacts of labor market integration on the host and the source country. Section 3 casts the model into a sequential framework in which agents first choose to acquire skills, then migrate, and finally replicate the population according to some fertility rule. In Section 4 we present a calibrated numerical examples that replicates the available empirical evidence. Section 5 concludes.

2 Static model

We consider an economy with a total mass N of workers, each of whom supplies inelastically one unit of labor. Let U and S denote the mass of unskilled and of skilled workers, respectively, so that $N \equiv U + S$. Unskilled labor is perfectly homogeneous, whereas skilled labor is assumed to be char-

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[5]Since we take into account agents' choices regarding skill formation, we may reasonably assume that our focus is on a time span covering several generations.

acterized by the existence of a continuum of horizontally differentiated types (think, e.g., of specialized tasks). We denote by f the distribution of skill types with support on $[0, S]$. The aggregate production function is assumed to be given by:

$$Y = \xi L_u^\alpha \int_0^S \left[S f(j) l_s(j) \right]^{1-\alpha} dj, \qquad (1)$$

where L_u stands for the total input of unskilled labor; $l_s(j)$ stands for the skilled labor input per worker of type j; $0 < \alpha < 1$ is a positive constant; and $\xi > 0$ denotes the economy's total factor productivity (henceforth, TFP). We assume, for simplicity, that skills are uniformly distributed: $f(j) = 1/S$ for all $j \in [0, S]$. The production function (1) then reduces to

$$Y = \xi L_u^\alpha \int_0^S l_s(j)^{1-\alpha} dj.$$

It is readily verified that this production function exhibits *increasing returns to scale in variety* (e.g., Ethier, 1982). To see this, assume that $P < S$ and that $l_s(j) = S/P$ for all $j \in [0, P]$ and $l_s(j) = 0$ otherwise. In words, the skill range is restricted to P and skills are uniformly distributed on this restricted range. Clearly, $Y = \xi L_u^\alpha P^\alpha S^{1-\alpha}$ in this case, which is increasing in the skill range P. The presence of such externalities has been repeatedly highlighted in the theoretical and empirical literature dealing with urban labor markets (e.g., Duranton and Puga, 2004; Ottaviano and Peri, 2005). Finally, it can also be verified that, for a given mass of skilled labor S, efficiency requires the firm to always use all types of skills in the same quantity. Hence $l_s(j) = l_s$ holds for all j.

In what follows, we assume that the final good is produced under perfect competition and sold in a perfectly competitive world market. We choose it as the numéraire and normalize its price to one. Let w_u and w_s stand for the skilled and unskilled wages, respectively. Given symmetry in skilled labor input, the first-order conditions for profit maximization are given by

$$w_u = \alpha \xi S \left(\frac{l_s}{L_u} \right)^{1-\alpha} \qquad w_s = (1-\alpha)\xi \left(\frac{L_u}{l_s} \right)^\alpha. \qquad (2)$$

Because labor is supplied inelastically, labor market clearing requires $L_u = U$ and $l_s = 1$. Substituting these conditions into (2), we finally obtain

$$w_u = \alpha \xi S U^{\alpha-1} \qquad w_s = (1-\alpha)\xi U^\alpha. \qquad (3)$$

Conditions (3) highlight the external effect of a larger range of skilled labor types: unskilled wages increase in S, because a larger range of skills increases

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unskilled productivity. Note also that, in our specification, the external effect exactly offsets the negative endowment effect of a larger skilled labor pool. Thus, the skilled wage w_s is independent of S.

2.1 Immigration and wage changes

We first analyze the impacts of immigration on the host country. What happens to its labor market as immigration occurs?

To capture both the direct and indirect consequences of immigration, it is useful to distinguish between the short- and the long-run effects. Indeed, in the short-run immigration is unlikely to affect the rate of skill formation in the host country, so that changes solely operate through the wage structure. Yet, in the long-run, by changing the returns to skilled labor, immigration has an impact on the rate of skill formation, which has itself further impacts on wages. Hence, in what follows, the shares of unskilled and skilled workers are assumed to be fixed in the short-run, whereas it is assumed that migration and skill formation are jointly determined in the long-run.

Short-run: In the short-run, there is no skill formation so that the ratio of skilled to unskilled labor is fixed. Assume that $\Delta N = \Delta U + \Delta S$ workers migrate to the host country. Before migration occurs, the wage rates in the host country are given by (3). After migration, they change to

$$\widetilde{w}_u = \alpha \xi \, (S + \Delta S) \, (U + \Delta U)^{\alpha - 1} \qquad \widetilde{w}_s = (1 - \alpha) \xi \, (U + \Delta U)^{\alpha}. \qquad (4)$$

Since $\Delta U > 0$ by definition, we clearly have $\widetilde{w}_s > w_s$. Furthermore, comparing (3) and (4) we see that

$$\widetilde{w}_u > w_u \qquad \Leftrightarrow \qquad 1 + \frac{\Delta N}{N} \frac{\Delta S / \Delta N}{S / N} > \left(1 + \frac{\Delta N}{N} \frac{\Delta U / \Delta N}{U / N} \right)^{1 - \alpha}.$$

This inequality always holds when the share of skilled immigrants $(\Delta S / \Delta N)$ exceeds the share of native skilled (S / N). In contrast, if $\Delta S / \Delta N$ is significantly smaller than S / N, $\widetilde{w}_u < w_u$ so that unskilled wages fall.

Proposition 1 *In the short-run, immigration raises the wage rate of skilled workers in the host country. When the share of skilled immigrants is sufficiently smaller than that of the host country, immigration decreases unskilled wages; whereas it raises them otherwise.*

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Proposition 1 highlights the well-known result that the skill composition of the immigrant flow crucially matters for assessing the impact on the host country's labor market (e.g., Borjas, 1999; Dustmann et al., 2005). Yet, it also shows that immigration need not lead to a reduction of the returns to one factor when there is a positive externality. Stated differently, everyone in the host country may gain, provided the unskilled share of immigrants is not too large.[6]

Long-run: In the long-run, agents decide whether or not to invest in the costly acquisition of skills. In other words, the distribution of total population N between skilled S and unskilled U is now endogenous. To keep things simple, we assume that an unskilled worker can become skilled by incurring once a fixed training cost $0 < c < 1$. This training cost differs across agents, who are heterogeneous in terms of their ability to get trained. We further assume that training costs are uniformly distributed, so that c also denotes the share of workers who become skilled: $S = cN$ and $U = (1 - c)N$. Inserting these expressions into (3) yields the wages w_s and w_u as a function of the rate of skill formation c:

$$w_u = \alpha \xi c (1 - c)^{\alpha - 1} N^\alpha \qquad w_s = (1 - \alpha)\xi(1 - c)^\alpha N^\alpha. \qquad (5)$$

The equilibrium rate of skill formation c^* is determined by worker arbitrage between skilled and unskilled labor:

$$w_u(c^*; N) + c^* = w_s(c^*; N). \qquad (6)$$

Note that the threshold c^* corresponds to the training costs of the marginal worker, i.e., workers with training costs lower (resp., higher) than c^* become skilled (resp., remain unskilled). Using expression (5), condition (6), which we henceforth refer to as the *skill formation condition*, can be rewritten as follows:

$$\Gamma(c^*) = \xi N^\alpha \qquad \text{with} \qquad \Gamma(c^*) \equiv \frac{c^*(1 - c^*)^{1 - \alpha}}{1 - \alpha - c^*}. \qquad (7)$$

It is readily verified that

$$\Gamma' > 0, \qquad \Gamma(0) = 0 \qquad \text{and} \qquad \lim_{c^* \to 1 - \alpha} \Gamma(c^*) = +\infty,$$

which establishes that there is a unique solution $c^* \in (0, 1 - \alpha)$.

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[6]This result is again closely related to the issue of income distribution in models of international trade with increasing returns and product differentiation (e.g., Helpman and Krugman, 1985, ch. 9).

To see how migration affects the share of skilled workers in the long-run, totally differentiate (7) to obtain:

$$\frac{dc^*}{dN} = \frac{\alpha c^*(1-c^*)(1-\alpha-c^*)}{(1-\alpha)\left[\alpha c^* + (1-c^*)^2\right]} N^{-1} > 0. \tag{8}$$

The same can be done with respect to TFP to yield:

$$\frac{dc^*}{d\xi} = \frac{\alpha c^*(1-c^*)(1-\alpha-c^*)}{(1-\alpha)\left[\alpha c^* + (1-c^*)^2\right]} N^{\alpha} > 0. \tag{9}$$

Comparing (8) and (9), we see that the impacts of immigration and TFP on the rate of skill formation differ via the term N. Whereas the effect of immigration is decreasing in N, the effect of TFP is actually increasing. This in turn suggests that, in the long-run, the impacts of immigration on skill formation get exhausted, whereas they do not with respect to TFP.

Combining (8) and (9) with (6), one can check that

$$\frac{d\left(w_s - w_u\right)}{dN} > 0 \qquad \text{and} \qquad \frac{d\left(w_s - w_u\right)}{d\xi} > 0.$$

Thus, both immigration and technological change may increase the skilled-unskilled wage gap. Yet, the impact of TFP is stronger, which suggests that technological change is likely to be a more important explanation for the wage gap than immigration.[7] Moreover, from (5) we see that

$$\frac{dw_u}{dN} > 0 \qquad \text{and} \qquad \frac{dw_u}{d\xi} > 0, \tag{10}$$

which then directly implies that

$$\frac{dw_s}{dN} > 0 \qquad \text{and} \qquad \frac{dw_s}{d\xi} > 0. \tag{11}$$

Hence, both increases in population size and TFP raise the returns to all factors in the long-run. Finally, it is of interest to investigate how the average wage, given by

$$\overline{w} = c^* w_s + (1-c^*)w_u = \xi c^*(1-c^*)^{\alpha} N^{\alpha}, \tag{12}$$

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[7]This finding is closely related to the one in the international trade literature, which should not come as a surprise since trade in goods is an alternative way of trading factor services as, e.g., with migration. As is well known, international trade often leads to an unequal distribution of the gains from trade, increasing the earning differences between production factors, e.g., skilled and unskilled labor. Yet, empirical work largely finds that (skill-biased) technological change is more likely to be at the origin of rising wage inequalities than international trade (see, e.g., Feenstra, 2004, Ch. 4, for further references).

changes with immigration and technological progress. Some straightforward calculations show that

$$\frac{d\overline{w}}{dN} = \frac{\xi\left[1 - (1+\alpha)c^*\right]N^\alpha}{(1-c^*)^{1-\alpha}}\frac{dc^*}{dN} + \alpha\xi c^*(1-c^*)^\alpha N^{\alpha-1} > 0,$$

$$\frac{d\overline{w}}{d\xi} = \frac{\xi\left[1 - (1+\alpha)c^*\right]N^\alpha}{(1-c^*)^{1-\alpha}}\frac{dc^*}{d\xi} + c^*(1-c^*)^\alpha N^\alpha > 0,$$

where the strict inequality comes from $c^* \in (0, 1-\alpha)$. Let us summarize our findings regarding the effects of immigration as follows.

Proposition 2 *In the long-run, immigration increases: (i) the share of skilled workers in the host country; (ii) the wages of skilled and unskilled workers; (iii) the wage gap between skilled and unskilled workers; and (iv) the average wage.*

2.2 Labor market integration and wage inequality

The previous section has exclusively focused on the effects of migration on the host country. We now turn to the question as to how migration also affects the source country via the international wage distribution.

In what follows, we assume that there are two countries $i = 1, 2$ and we focus on the long-run case only. Variables associated with each country will be subscripted accordingly. We further assume, without loss of generality, that $\xi_1 N_1^\alpha \geq \xi_2 N_2^\alpha$. This condition can roughly be interpreted as country 1 being 'larger' in terms of 'labor efficiency units'.

In autarky, the level of skill formation c_i^* in each country is determined by condition (7), whereas the wage rages w_{si} and w_{ui} are determined by condition (5). Consider the case where the labor markets for skilled workers are *partially integrated*. By partial labor market integration we refer to a situation where skilled workers are a priori free to choose the country they want to work in, yet incur migration costs when switching location.[8],[9]

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[8]Without being exhaustive, migration costs may include: the cost of physically moving; the cost of losing the social network in the source country and of having to build a new one in the host country; the cost of eventually aquiring work permits in the host country; the cost of eventually learning the host country's language, etc. Since every migration entails costs (which may actually be quite significant), perfect labor market integration does not exist. This may also partly explain why international migration flows remain relatively small (SOPEMI, 2003).

[9]The assumption that only skilled workers migrate is of course not innocuous, since it masks the potentially adverse effects of unskilled immigration on native wages. In fact, though the skilled workers are in general more mobile than the unskilled, the skill

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We assume that agents have heterogeneous levels of migration costs. More precisely, the migration costs of agent j are given by $m(j)M$, where $M > 0$ is a constant. In each country, m is assumed to be Pareto distributed on $[0, +\infty)$ with cumulative density $G(m) = 1 - [\gamma/(\gamma + m)]^{\lambda}$ and $\gamma, \lambda > 0$.

Skilled workers migrate between the two countries until skilled wages net of migration costs are equalized. By doing so, they modify the existing incentives for skill formation, i.e., they impact on the values of c_i^*. Thus, the arbitrage by skilled workers determines: (i) the international distribution (N_1, N_2) of workers between countries; (ii) the levels (c_1^*, c_2^*) of skill formation and, therefore, the intranational distributions (S_i, U_i); and finally (iii) the wage rates w_{si} and w_{ui}.

Conditions (11) suggest that the larger country 1 has the higher skilled wage rate. Straightforward calculation, using (5) and (7), shows that this is indeed the case:

$$\frac{dc^*}{d(\xi N^\alpha)} = \frac{(1-c^*)^\alpha (1-\alpha-c^*)^2}{(1-\alpha)\left[\alpha c^* + (1-c^*)^2\right]} > 0,$$

$$\frac{dw_s}{d(\xi N^\alpha)} = \frac{(1-c^*)^\alpha \left[\alpha c^* + (1-\alpha)(1-c^{*2})\right]}{\alpha c^* + (1-c^*)^2} > 0.$$

Hence, $w_{s1} > w_{s2}$ and migration always flows from country 2 to country 1, a property that will simplify the subsequent developments. Indeed, given our assumption on migration costs, we can determine the value m^* for the marginal migrant by solving the condition

$$w_s(N_1 + G(m^*)N_2; \xi_1) - w_s((1 - G(m^*))N_2; \xi_2) = m^*M. \qquad (13)$$

The three equations given by (6) and (13) can be solved for a *static equilibrium* (c_1^*, c_2^*, m^*). Note that in such an equilibrium the decisions on migration and skill formation are taken simultaneously. In Section 3 we focus on a *sequential equilibrium*, in which skill formation occurs before migration decisions are taken.

North-North migration: Let us start with a simple special case to illustrate the main mechanisms at work. Assume that $\xi_1 = \xi_2 = \xi$. This case can be interpreted as both countries having access to the same technology, which may be seen as a characteristic feature of the developed world. Hence, we

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distribution of US immigrants is bimodal, with a large share of (very) unskilled and a large share of (very) skilled immigrants (Friedberg and Hunt, 1995). In this respect, our model should be viewed as better describing the actual migration patterns between developed countries ('North-North' migration), which are mostly composed of skilled workers and constitute the 'high skill' mode of the distribution.
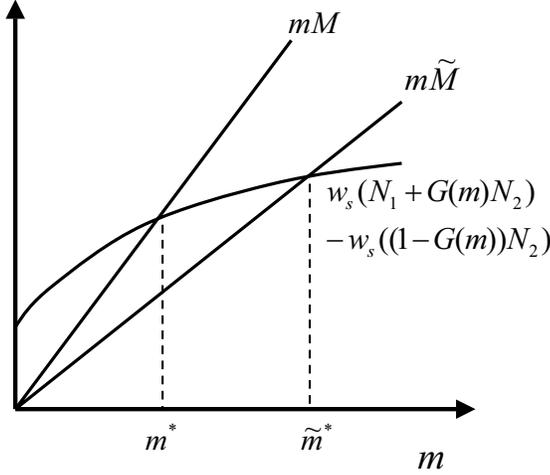
Figure 1: A stable equilibrium

call this case the 'North-North migration case'. When both countries have access to the same technology, the left-hand side of (13) is strictly positive at $m = 0$, and it is increasing in m. Moreover, it has a finite limit when m goes to infinity. Hence, as shown by Figure 1, equation (13) has at least one solution. Moreover, there is at least one (locally) stable migration equilibrium, where stability requires that a small deviation does not generate incentives of migration in the same direction as the initial deviation.

North-South migration: Assume next that both countries have access to a different technology (and, therefore, a different TFP). In particular, assume that $\xi_1 > \xi_2$, $N_1 < N_2$ and $\xi_1 N_1^\alpha > \xi_2 N_2^\alpha$. Such a setting seems realistic when interpreting country 1 as the developed world ('North') and country 2 as the developing world ('South'). North has an overall larger supply of labor, when measured in efficiency units, although South has a larger total population. The marginal migrant m^* is again determined by condition (13). Since $\xi_1 N_1^\alpha > \xi_2 N_2^\alpha$, it is readily verified that the left-hand side of (13) is positive at $m = 0$, and that it is increasing in m. Moreover, it has a finite limit when m goes to infinity. Therefore, we again have at least one (locally) stable migration equilibrium so that this case can again be illustrated by Figure 1.

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Since the 'North-North migration' and 'South-North migration' cases can both be illustrated by Figure 1, we work on this figure in the following. Consider two levels of migration costs $M > \widetilde{M}$. From Figure 1, we see that this implies that

$$m^* M < \widetilde{m}^* \widetilde{M}. \tag{14}$$

Combining this finding with Proposition 2, we obtain the following result.

Proposition 3 *Decreasing migration costs raise the number of migrants, which in turn raises the share of skilled workers in the host country and decreases the share of skilled workers in the source country.*

From Proposition 3 and condition (11), the change in the average wage difference *between countries* is given by:[10]

$$\overline{w}(N_1 + G(m^*)N_2; \xi_1) - \overline{w}((1 - G(m^*))N_2; \xi_2)$$
$$< \overline{w}(N_1 + G(\widetilde{m}^*)N_2; \xi_1) - \overline{w}((1 - G(\widetilde{m}^*))N_2; \xi_2).$$

As to wage difference *within countries*, conditions (10) and (11) show that

$$w_s(N_1 + G(m^*)N_2; \xi_1) - w_u(N_1 + G(m^*)N_2; \xi_1)$$
$$< w_s(N_1 + G(\widetilde{m}^*)N_2; \xi_1) - w_u(N_1 + G(\widetilde{m}^*)N_2; \xi_1),$$

and

$$w_s((1 - G(m^*))N_2; \xi_2) - w_u((1 - G(m^*))N_2; \xi_2)$$
$$> w_s((1 - G(\widetilde{m}^*))N_2; \xi_2) - w_u((1 - G(\widetilde{m}^*))N_2; \xi_2).$$

These findings may be summarized as follows.

Proposition 4 *Lower migration costs increase: (i) the average wage gap between countries; (ii) the wage gap between skilled and unskilled within the host country; whereas they (iii) decrease the wage gap between skilled and unskilled workers in the source country.*

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[10]Note that

$$\overline{w}(N_1; \xi_1) > \overline{w}(N_2; \xi_2),$$

which results from (11) and from

$$\frac{d\overline{w}}{d(\xi N^\alpha)} = c^*(1 - c^*)^\alpha + \frac{\partial \overline{w}}{\partial c} \frac{dc^*}{d(\xi N^\alpha)} > 0.$$

To conclude this section, it is of interest to note that the static equilibrium is not necessarily unique. Indeed, multiple equilibria may arise quite naturally due to the complementarity between the skilled and the unskilled. Consider, e.g., the case of two identical countries. By construction, symmetry without migration is obviously an equilibrium. Yet, this equilibrium may be unstable when the migration of a small mass of agents from country 2 to country 1 raises the returns to skilled labor there. If this is the case, the initial perturbation becomes self-reinforcing and, therefore, triggers more migration. The cumulative process stops once the migration costs of the agents remaining in country 2 exceed the international wage gap.[11],[12]

3 Sequential model

The model developed in Section 2 is purely static since skill formation and migration are jointly determined. Yet, it seems a priori reasonable to assume that skill formation and migration occur sequentially. People first invest in skills when they are young, and then make their migration decisions when adult.[13] In this section, we adapt the framework developed in the previous section to such a sequential setting. Furthermore, we enrich it by allowing for population growth and extend it to capture the well-documented fact that the rate of human capital formation significantly influences the fertility rate of a country, which itself affects the rate of skill formation and international migration. The relationship between the level of human capital and the fertility rate has been investigated in the literature of economic growth. Its notable message is that there is a trade-off for parents between having many children and educating them well. Hence, the fertility rate is thought to have a negative correlation with the level of human capital (e.g., Becker *et*

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[11]In this respect, our analysis is related to the so-called 'new' economic geography, which emphasizes the cumulative processes of migration and agglomeration in the presence of increasing returns (Krugman, 1991). See also Tabuchi and Thisse (2002) for a model of interregional migration with heterogeneous migration costs.

[12]As a numerical illustration, consider the following case: $\alpha = 0.8$, $\lambda = 0.5$, $\gamma = 1.1$, $M = 0.9$ and $N_1 = N_2 = 50$. We then have (up to a symmetry) the following equilibria: (1) $N_1 = N_2 = 50$, $m = 0$, $c_1 = c_2 = 0.192$; (2) $N_1 = 75.6199$, $N_2 = 24.3801$, $m = 3.5266$, $c_1 = 0.19416$, $c_2 = 0.18612$. It can be further verified numerically that the symmetric equilibrium is unstable.

[13]This seems to be especially true in the context of international migration, where there are usually legal restrictions concerning the age of migrants. These restrictions may also cover other aspects of migration like familiy reunification (EU member states may, e.g., restrict the immigration of minors when there is presumption of forced marriages). Note that these restrictions are less likely to hold at the interregional level.

al., 1990; Ehrlich and Lui, 1997).

Although our model does not provide a framework in which agents are forward-looking and fully optimizing their intertemporal equilibrium paths, we will see that even a simple model with myopic agents can replicate a great deal of the empirical facts. In what follows, we superscript variables by a time index (t). The populations N_1 and N_2 in the initial period (0) are taken as exogenously given. Each period (t) of the model is subdivided into the following sequence of events (see Appendix A for a more technical description of steps [1]–[3]):

[1] Skill formation: Given the population distribution $(N_1^{(t-1)}, N_2^{(t-1)})$ of the previous period, agents decide whether or not to become skilled. Hence, the short-run equilibrium rates $c_i^{(t)*}$ of skill formation are determined in each country.

[2] Migration: Given the current short-run equilibrium rates $c_i^{(t)*}$ of skill formation, agents choose whether or not to migrate between the two countries. The short-run equilibrium rate of migration $m^{(t)*}$ is determined at this stage.

[3] Replication: Given the new (after migration) population, i.e., the 'old natives' and the 'new migrants', the population in each country replicates itself according to some exogenously specified rule. The 'old generation' dies and the new generation $(N_1^{(t)}, N_2^{(t)})$ becomes the starting point for the next period of the process. For the sake of simplicity, we choose the following replication function

$$f\left(N_i^{(t)}\right) = \cos\left[c_i^*\left(N_i^{(t-1)} + I_i^{(t)}\right)\right] + \rho$$

where $I_i^{(t)}$ stands for the net migration flow of country i in period (t), and where $\rho \geq 1$ is a scaling parameter that will be selected numerically to avoid explosive population growth or excessive population decay.[14] Note that $f' < 0$, i.e., a higher level of skill formation reduces the population's fertility rate, a property largely supported by the empirical evidence.[15]

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[14]Values such that $f(c) = 1$ lead to a one-to-one replication of the population, which would correspond to a fertility rate of two children (per couple). Our choice of a replication function is such that there is a positive growth rate of population for all rates of skill formation below some threshold $\bar{c} < 1$, whereas population growth gets negative for values above that threshold. Such a choice is largely supported by the empirical evidence.

[15]We can develop a model with endogenous fertility decision in which the national fertility rate declines as the skilled labor share increases. However, doing so significantly complicates the model without adding additional insights. For expositional simplicity we, therefore, use a reduced-form replication function.

This sequential model, although well behaved (see Appendix A for more technical details), is too complicated to allow for a detailed analytical investigation. Therefore, in what follows, we restrict ourselves to some numerical illustrations of possible equilibrium trajectories. In particular, we are interested in investigating whether our model can replicate a few salient facts concerning international migration, changes in the international wage structure, and changes in the rates of skill formation. We are particularly interested in changes in *within* and *between* country wage inequalities, and their evolution in the presence of international migration.

4   Illustration and evidence

We now present a numerical illustration, discuss the results in the light of the available evidence, and show that our model is broadly able to replicate the salient empirical facts. We restrict ourselves to the analysis of the 'North-South migration' case, since this is empirically by far the most relevant.

Figures 2 to 5 illustrate an example in which the two economies experience a partial divergence due to skilled labor migration, keeping the migration cost M *constant*.[16] In this example, country 1 represents the developed 'North', whereas country 2 is the developing 'South'. Over a period of 300 iterations, both countries experience population growth from

$$N_1^{(0)} = 150 \qquad \text{to} \qquad N_1^{(300)} = 413.429$$

and from

$$N_2^{(0)} = 500 \qquad \text{to} \qquad N_2^{(300)} = 1135.25$$

in the long-run.[17] During that same period, the fertility rates (see footnote 13) decline from

$$f_1^{(0)} = 0.999 \qquad \text{to} \qquad f_1^{(300)} = 0.974,$$

and from

$$f_2^{(0)} = 1.039 \qquad \text{to} \qquad f_2^{(300)} = 1.010.$$

Hence, in the long-run the fertility rate in the 'North' becomes too low for the population to replicate itself (which is, e.g., currently the case for Germany in 2005), whereas in the 'South' population growth is also curbed, yet

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[16]The parameter values are set as follows: $\alpha = 0.2$, $\lambda = 0.2$, $\gamma = 1$, $M = 15$, $\rho = 1.69$, $\xi_1 = 1.6$, $\xi_2 = 1$, $N_1 = 150$ and $N_2 = 500$. The Mathematica program used for the computations is avaible from the authors upon request.

[17]Convergence requires more than 300 iterations, yet the values for $t = 300$ are already very close to the limit values.
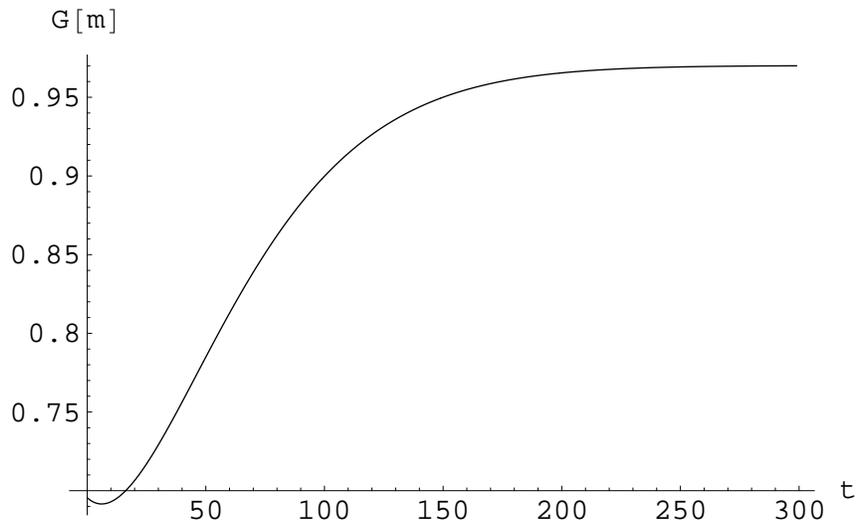
Figure 2: Evolution of the source country's emigration rate

remains significantly positive. Stated differently, *in the long-run the 'North' has actually a negative rate of population growth, so that the population size can only be kept constant through immigration from the 'South'.* This can be clearly seen from Figure 2, where the long-run rate of emigration from 'South' stabilizes around 0.95%. Although this figure is higher than the 0.3% observed in the data (see Figure 6 below), the general trend is the same: the emigration rate rises at a decreasing rate.

Figures 3 and 4 depict the evolution of average wages, as well as the within-, between-, and total-wage inequalities in the host and source country (as measured by the Theil index; see Appendix B). Figure 3 shows that average wages are first increasing in both countries, whereas they keep increasing in the 'North' and become roughly constant in the 'South' around $t = 100$. This happens when, as can be seen from Figure 5 the rate of skill formation in the 'South' becomes constant, whereas it still rises in the 'North'. The reason underlying this evolution is that increasing migration from the 'South' to the 'North' raises the payoff to the acquisition of skills there, whereas it lowers that same pay-off in the 'South', therefore leading to the emigration of skilled (*brain-drain*). Figure 4 reveals that the wage inequalities within countries fall on average. In fact, the Theil index in the 'North' declines from 0.015 to 0.011 and that in the 'South' declines from 0.009 to 0.006. Figure 4 also shows that the wage inequalities between
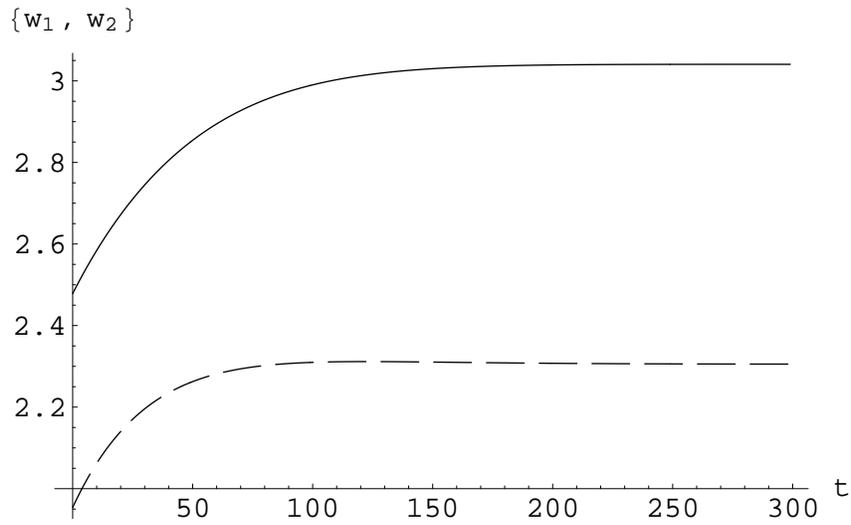
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Figure 3: Evolution of average wages
Note: The line (dashed line) describes the average wage $\bar{w}_1$ ($\bar{w}_2$) in the host (source) country.
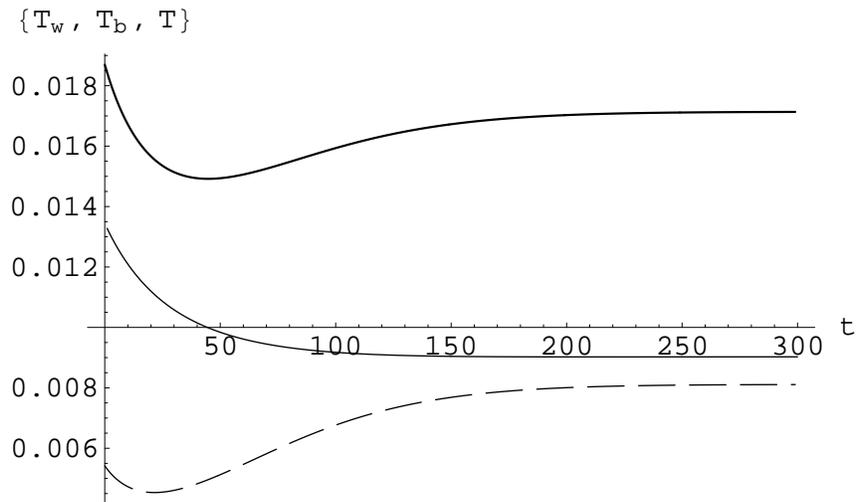

Figure 4: Wage inequality measured by the Theil index
Note: The bold line describes the total wage inequality of the economy measured by the Theil index T. The line (dashed line) describes the within-component T_w (between-component T_b) of T.

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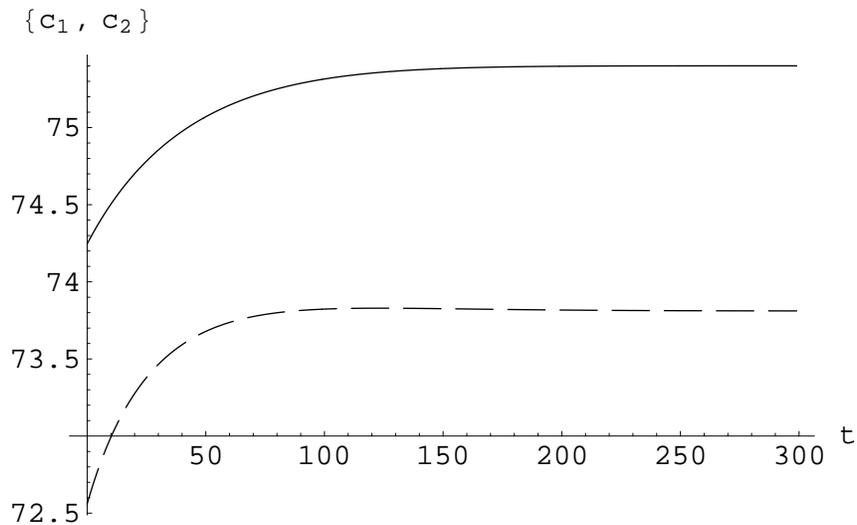
Figure 5: Evolution of skill formation
Note: The line (dashed line) describes the skilled labor share c_1 (c_2) in the host (source) country.

countries rise (yet, these inequalities stabilize in the long-run). Hence, *wages converge on average within both countries as measured by the Theil index, whereas they diverge between them.*

One word of caution concerning the evolution of within-country inequalities is in order. As shown in the static model of Section 2, the wage gap between skilled and unskilled workers actually *increases in our model due to international migration of skilled workers.*[18] This result is consistent with the actual trend of the rising wage gap in developed countries (see, e.g., Katz and Autor, 1999, Table 9). Hence, our argument complements the existing literature on the causes of the rising wage gap in developed countries which highlights, among other things, skill-biased technological change (e.g., Acemoglu, 1998) or international trade (e.g., Feenstra, 2004). Yet, at the same time the share of skilled also rises (resp., falls) in the host (resp., the source) country due to migration. Therefore, the population in both countries may on average become more similar in the sense that more workers are skilled (resp., unskilled), yet it may become more dissimilar in the sense that the wage gap still widens in absolute terms. When the former 'distribution effect' dominates the latter 'scale effect', as it does in our model, the index of

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[18]Note, however, that due to the presence of a complementarity between skilled and unskilled, the gap does not necessarily increase because of falling wages of the unskilled.

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within-country income inequality falls.

The numerical example developed in the above relies on the strong assumption of a constant migration cost. Yet, numerous studies show that the world has experienced rising levels of international migration during the last three decades, suggesting that the costs of migration have decreased (e.g., SOPEMI, 2003, Table A.2.1). Since migration costs are largely determined by legal barriers, transportation-, and information-technology, all of which can be periodically subject to rapid change, this decrease has not been gradual.[19] However, a discrete shock to migration costs does not change the qualitative results of our simulations.[20] More precisely, as shown in Appendix C, the general tendency remains the same, i.e., there is divergence whether there is a shock or not; but the the shock amplifies this tendency by irreversibly widening the international gaps and speeding up the divergence process. Stated differently, decreasing migration costs play a role in determining the magnitude and the speed of divergence, but are not necessary for this divergence to occur in the first place.

How do the qualitative predictions of our model compare with the trends in the available data? In the following, we compare the actual and the simulated trends by focusing on three key aspects: *migration, skill formation, and income inequalities.*

Migration: The World Bank (2005) data on international migration reveals that, as expected, net migration occurs from lower to higher income countries. In fact, high income countries have experienced some significant immigration, whereas both low- and middle-income countries have experienced emigration during the last four decades. Figure 6 depicts the trends in the emigration rates of low- and middle-income countries and highlights that: (i) the developing (resp., developed) countries have played the role of source (resp., host) countries; and (ii) the emigration rates have risen rapidly during 1980s and 90s. As already pointed out before, these trends, especially during the 1980s and 90s, are roughly comparable with what we obtain in our numerical example (see Figure 2). Furthermore, it is easily verified that immigration is an increasingly important component of population growth for the 'North' in our model, which is consistent with the empirical evidence for the US (Friedberg and Hunt, 1995, p. 26).

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[19]Think, e.g., of a change in the legal framework which makes migration easier or, alternatively, the emergence of Internet, which reduces the 'psychological costs' of migration by making instantaneously available information in almost all languages almost everywhere.

[20]The numerical results of the model with an exogenous shock to migration costs are available from authors upon request.

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Figure 6: Emigration rates (%) of low and middle income countries (Source: World Bank, 2005).

Skill formation: Figure 7 depicts the actual trends in higher education, which we may take as a rough proxy for skill formation. As can be readily seen, the share of people with higher education than the secondary level has increased steadily in both developed and developing countries. The notable feature here is that it has increased at a higher rate in the developed countries than in the developing countries, thus accentuating the existing 'skill gap'. This fact is consistent with the simulated evolution as depicted in Figure 5, where the share of skilled workers rises faster in the host than in the source country. As already pointed out before, this evolution is due to the short-run effect of immigration, and the long-run effect of higher incentives for natives to become skilled.

Income inequalities: Based on a sample of 121 countries, Korzeniewicz and Moran (1997) computed the Theil index of world income inequality, as well as its within and between decomposition. Figure 8 depicts the recent trends in the evolution of total income inequality. As can be seen from this figure, there has been a continuous increases in total income inequality, a fact that has been reconfirmed with more recent data reported by Bourguignon and Morrison (2002). Comparing Figures 4 and 8, we see that this rise in
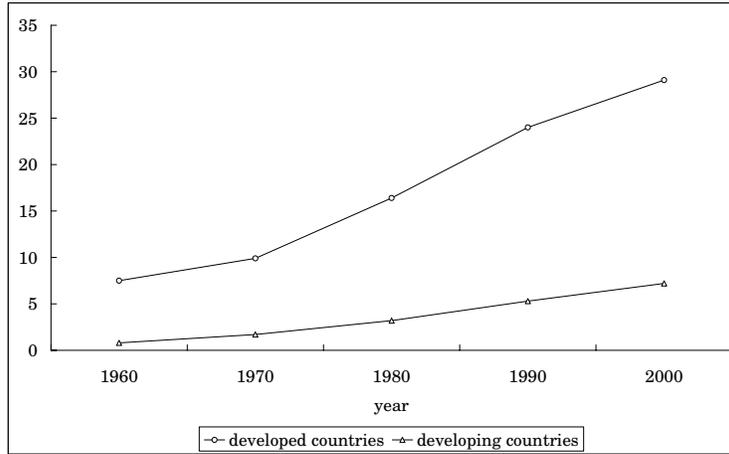
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Figure 7: Share of people (%) with educational attainments higher than the secondary level (Source: Barro and Lee, 2001, Table 3).

total income inequality is consistent with our simulated example. A finer decomposition of the Theil index, also depicted in Figure 4, shows that the overall increase in income inequality is, in fact, driven by the increase in the inequality between countries. Korzeniewicz and Moran (1997) also provide a between and within decomposition of the Theil index for the years 1965 and 1992.[21]

Theil index			
year	between-country	within-country	total
1965	0.902	0.243	1.145
1992	1.131	0.190	1.321

Table 1: Income inequality between and within countries. Source: Korzeniewicz and Moran (1997), Table 2.

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[21]Since Korzeniewicz and Moran (1997) use a dataset with a smaller sample size than the one referred to in Figure 8 for their within-between decomposition, we cannot plot this decomposition in a single figure.
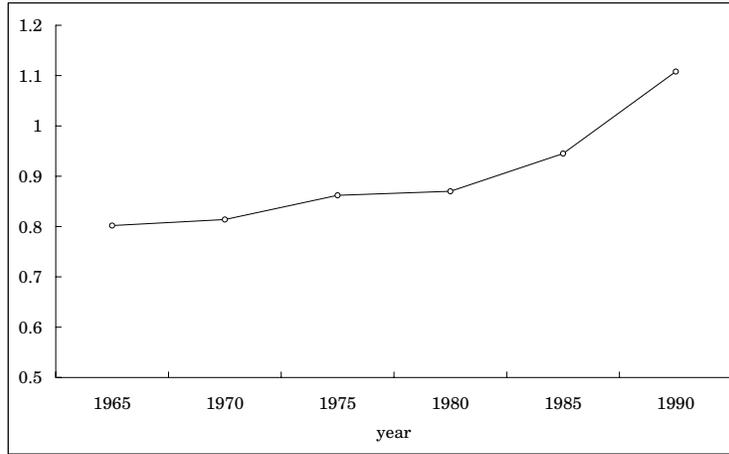
Figure 8: Income inequality measure, Theil index (Source: Korzeniewicz and Moran, 1997, Table 3).

Table 1 summarizes the decomposition and shows that the between-country inequality has risen, whereas the within-country inequality has fallen. As can be seen from Figure 4, our example replicates both of these trends, which have also recently been reconfirmed by Bourguignon and Morrison (2002, Table 2).

5 Conclusions

We have presented a static and a sequential model and have investigated the various relationships between labor market integration, skill acquisition, international migration, and changes in the wage structure.

In the context of the static model, the presence of increasing returns to scale in the range of available skills implies that migration may actually raise (resp., decrease) returns to all factor in the host country (resp., source country): in the short-run there is the standard direct effect on wages, whereas in the long-run migration has an indirect effect on skill formation.

In the sequential model, we have shown that a numerically calibrated example can broadly replicate the following observed trends in the inter-

national data: (i) the rate of immigration in host countries rises; (ii) skill formation increases in both developed and developing countries, whereas the 'skill gap' gets larger; (iii) total- and between-country income inequality rises, whereas within-country income inequality falls according to the Theil index; and (iv) the maximal wage gap within countries gets larger, whereas the skill level of the population becomes more homogeneous, both in developed and in developing countries.

We believe that our model sheds some additional light on why the maximal income gap in developed countries has risen during the last three decades, whereas within-country inequalities have fallen according to some measures. This apparent contradiction may be resolved by separating the short- and the long-run impacts of international migration, which affect wages directly and indirectly (via changes in the skill distribution) in quite different ways. In the end, only empirical work will allow to assess the magnitudes of the external effects and the strength of complementarities between skilled and unskilled workers. Should these be relevant and strong, the payoffs to having a coherent immigration policy might be quite substantial for developed countries.

Note, finally, that one possible extension of our model is to make the total factor productivity endogenous and to assume that the rate of technological progress depends on the skilled labor share, as in Galor and Moav (2000). Doing so would enable us to analyze more fully the interaction among immigration, economic growth, skill formation and the wage structure.

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Appendix A: Iterative process

In this appendix, we present in more detail the equations underlying the sequential model developed in Section 3, and we discuss some of its numerical properties.

[1] Skill formation: At period t, equilibrium skill formation in both countries is governed by the conditions

$$w_u(c_1^{*(t)}, N_1^{(t-1)}; \xi_1) + c_1^{*(t)} = w_s(c_1^{*(t)}, N_1^{(t-1)}; \xi_1)$$

$$w_u(c_2^{*(t)}, N_2^{(t-1)}; \xi_2) + c_2^{*(t)} = w_s(c_2^{*(t)}, N_2^{(t-1)}; \xi_2)$$

which are a natural extension of (6) and which can be easily rewritten as follows:

$$c_1^{*(t)}(1 - c_1^{*(t)})^{1-\alpha} = (1 - \alpha - c_1^{*(t)})\xi_1 \left[N_1^{(t-1)}\right]^{\alpha}$$

$$c_2^{*(t)}(1 - c_2^{*(t)})^{1-\alpha} = (1 - \alpha - c_2^{*(t)})\xi_2 \left[N_2^{(t-1)}\right]^{\alpha}$$

As shown in Section 2, there always exists a unique solution for $c_1^* \in (0, 1-\alpha)$ and $c_2^* \in (0, 1-\alpha)$. Hence, solving these two equations (by taking the initial population levels $N_1^{(t-1)}$ and $N_2^{(t-1)}$ as given) yields the unique equilibrium rates $c_1^{*(t)}$ and $c_2^{*(t)}$ of skill formation.

[2] Migration: International migration of skilled workers is governed by condition (13), which can be expressed as

$$w_s(N_1^{(t-1)} + G(m^{*(t)})N_2^{(t-1)}; \xi_1) - w_s((1 - G(m^{*(t)}))N_2^{(t-1)}; \xi_2) = m^{*(t)}M$$

in the sequential model. Using the equilibrium expressions (3) for the wages, and letting $G(m) = (\gamma/(m + \gamma))^\lambda$ for the Pareto distribution, the wage equalization condition can be rewritten as follows:

$$(1 - \alpha) \left\{ (1 - c_1^{*(t)})^\alpha \left[N_1^{(t-1)} + N_2^{(t-1)} \left(1 - \left(\frac{\gamma}{m^{*(t)} + \gamma} \right)^\lambda \right) \right]^\alpha \right.$$

$$\left. - (1 - c_2^{*(t)})^\alpha \left[N_2^{(t-1)} \left(\frac{\gamma}{m^{*(t)} + \gamma} \right)^\lambda \right]^\alpha \right\} = m^{*(t)}M,$$

where the expressions in square brackets correspond to the 'new' (i.e., migrant inclusive) populations of the two countries. As shown in Section 2, there always exists a unique solution to this equation which yields the rate of migration $m^*(t)$.

[3] Replication: After skill formation and migration occurred, the current generation replicates itself according to the exogenously given rule:

$$N_1^{(t)} = f(c_1^{*(t)}) \left[N_1^{(t-1)} + G(m^{*(t)})N_2^{(t-1)} \right]$$

$$N_2^{(t)} = f(c_2^{*(t)}) \left[(1 - G(m^{*(t)}))N_2^{(t-1)} \right],$$

where f is the 'replication function' as given in Section 3, which depends on the current level of skill formation in each country. After replication occurred, the 'old' generation dies and the process starts at step [1] using the new population distribution.

Note finally that, even if as shown in Section 2 the static equilibrium involving jointly the equations of steps [1], [2] and [3] does not necessarily have a unique solution, the sequential model is well-behaved. Given a feasible set of parameters and the initial values $N_1^{(0)}$ and $N_2^{(0)}$, the sequential model may be computed numerically without having to worry about non-existence or possible selection problems in the case of multiple solutions. This makes numerical simulations easy and straightforward.

Appendix B: Theil index

This appendix provides a brief description of the measure of wage inequality used in this paper, i.e., the Theil index. Let w_{ji}, $\overline{w_i}$, and $\overline{w}$ describe the wage rate of an individual j in country i, the average wage rate in country i, and the average wage rate of the whole economy. The Theil index is then defined by

$$T \equiv \frac{1}{N_1 + N_2} \sum_{i=1}^{2} \sum_{j=1}^{N_i} \frac{w_{ji}}{\overline{w}} \ln \frac{w_{ji}}{\overline{w}},$$

which can be decomposed as follows (see e.g., Theil, 1979):

$$
\begin{aligned}
T &= T_b + T_w, \\
T_b &\equiv \sum_{i=1}^{2} \frac{N_i}{N_1 + N_2} \frac{\overline{w_i}}{\overline{w}} \ln \frac{\overline{w_i}}{\overline{w}}, \\
T_w &\equiv \sum_{i=1}^{2} \frac{N_i}{N_1 + N_2} \frac{\overline{w_i}}{\overline{w}} \sum_{j=1}^{N_i} \frac{1}{N_i} \frac{w_{ji}}{\overline{w_i}} \ln \frac{w_{ji}}{\overline{w_i}}.
\end{aligned}
$$

In the above, T, T_b, and T_w represent the total wage inequality of the global economy, the inequality between countries, and the inequality within countries, respectively.

Appendix C: Migration cost shock

In this appendix, we briefly summarize the results of the model with an exogenous shock to migration costs (we use the same numerical example as
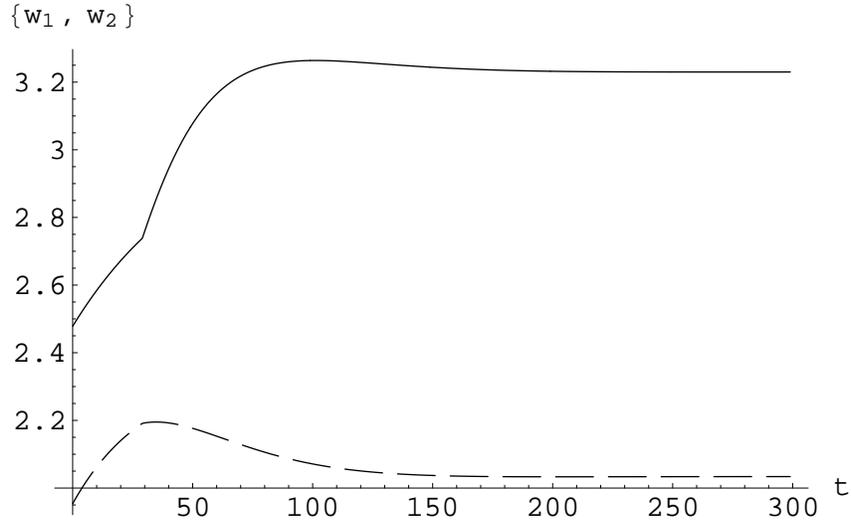
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Figure 9: Evolution of average wages with cost shock at $t = 30$
Note: The line (dashed line) describes the average wage $\bar{w}_1$ ($\bar{w}_2$) in the host (source) country.

in Section 4; see footnote 16 for the parameter values).

Assume that there is a one-time shock to migration costs. More precisely, assume that $M = 15$ for all periods $t \leq 30$, whereas $M = 7.5$ for all $t > 30$ (i.e., a 50% reduction in migration costs). Comparing Figures 9–11 with Figures 3–5 in Section 4, we note that the general tendency remains unchanged. Yet, as can be clearly seen, the migration cost shock amplifies this tendency by irreversibly widening the gap between the countries and by speeding up the divergence process.
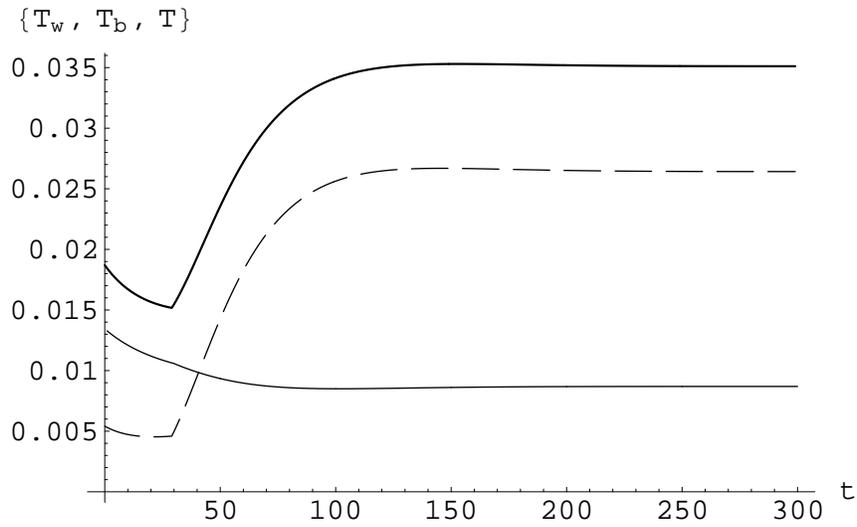
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{T_w, T_b, T}

Figure 10: Wage inequality measured by the Theil index with cost shock at $t = 30$
Note: The bold line describes the total wage inequality of the economy measured by the Theil index T. The line (dashed line) describes the within-component T_w (between-component T_b) of T.
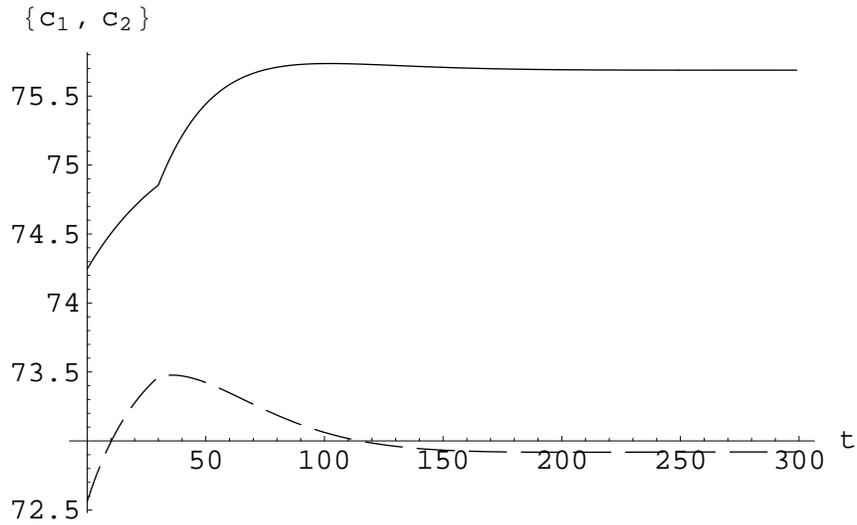
{c_1, c_2}

Figure 11: Evolution of skill formation with cost shock at $t = 30$
Note: The line (dashed line) describes the skilled labor share c_1 (c_2) in the host (source) country.