Does International Mobility of High-Skilled Workers Aggravate Between-Country Inequality?*

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Abstract

This paper theoretically and empirically analyzes the interaction of international migration of high-skilled labor and relative wage income between source and destination economies of expatriates. We develop an overlapping-generations model which suggests that international integration of the market for skilled labor aggravates between-country inequality by harming those which are source economies to begin with while benefiting host economies. The result is robust to allowing governments to optimally adjust productivity-enhancing investments which could potentially attenuate brain drain. Optimal public investment tends to decrease in response to higher emigration. Consistent with our main hypothesis, we provide empirical support that an increase in emigration rates of skilled workers causes an increase in the relative wage income of high-skilled workers in destination to source countries.

Key words: Brain drain; Between-country wage differences; Public investment; Total factor productivity.

JEL classification: F22; O30; H40.

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1 Introduction

In the year 2000, 20.4 million tertiary educated immigrants lived in OECD countries, up from about 12.5 million in the year 1990 (Docquier and Marfouk, 2006). Half of the skilled migrants resided in the US and about a quarter in other Anglo-Saxon countries. Liberalization of international labor markets continues, particularly for high-skilled workers. New regulation in developed countries, such as the “blue card” scheme adopted by the Council of Europe in May 2009, tends to reduce immigration barriers for high-skilled labor. Thus, the outflow of skilled individuals from developing countries may further increase in the near future. The European Commission has also raised concerns, however, that high-skilled emigration could harm developing regions which are already suffering from brain drain such as the Caribbean, Central America and Sub-Saharan Africa.

This paper examines the impact of increasing mobility of high-skilled workers on international migration and relative wage income between source and destination economies of expatriates. At the same time, we account for the fact that cross-country differences in wages for skilled workers are an important determinant of high-skilled migration in the first place (e.g., Lucas, 2005; Grogger and Hanson, 2008). Thus, we focus on the dynamic interaction of between-country wage differences for the skilled and brain drain from poor to rich countries. We develop an overlapping-generations model with endogenous educational and locational choice of individuals, where brain drain has detrimental effects on total factor productivity (TFP) in an economy. Declining mobility costs for high-skilled workers lead to further emigration. It thus reduces TFP in countries already facing brain drain. Consequently, and contrary to conventional wisdom from standard (one-sector) models, even skilled workers in source countries lose.1

Our theoretical considerations suggest that income differences for skilled labor across countries and between-country income inequality widen in response to increased migration of skilled workers. We empirically examine the impact of an increase in the level of high-skilled emigrants between pairs of source and destination countries on differences in (log) wage income of skilled workers and per capita income between country pairs. We

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1 This does not rule out that disposable income rises in source economies, for instance, due to remittances. We focus on the effects of high-skilled migration on market incomes.
propose a wide range of instrumental variables to address the potential reverse causality problem which arises from the two-way relationship between emigration and wage differences between countries.

Source countries may respond with different policies to mitigate brain drain if advanced economies open up their labor markets for skilled migrants. In view of our focus on the effects of high-skilled migration on productivity differences across countries, we ask whether source countries should try to attenuate brain drain by raising public expenditure for productivity-enhancing measures, like publicly financed investments in infrastructure or basic education.\(^2\) Our analysis on the optimal policy response of source countries suggests that developing countries may not want to implement such a policy change to mitigate the brain drain problem. We argue that, from the perspective of non-migrants in source economies, it rather tends to be optimal that public investment expenditure is reduced if international labor markets for skilled workers further integrate.\(^3\) The result may hold true even if governments can run public deficits to finance public investment. In any case, the analysis again suggests that declining mobility costs do not only trigger emigration in source economies. They also fuel future emigration pressure, by reducing wage income even for skilled non-migrants. Thus, our main result is robust to allowing for endogenous public investment responses. While in this paper’s empirical analysis we focus on the main prediction of the model, Grossmann and Stadelmann (2009) provide evidence for a negative impact of higher emigration rates of skilled workers on public investment.

The remainder of this paper is organized as follows. Section 2 discusses related literature. Section 3 presents the basic model. Section 4 analyzes the relationship between emigration and relative wage income between source and destination. Section 5 extends the basic model to account for an optimal adjustment of public investment. Section

\(^2\)Justman and Thisse (1997, 2000) examine the implications of increasing mobility of high-skilled labor on publicly financed higher education. They analyze a non-cooperative game between two symmetric, advanced countries. In contrast, we assume that (higher) education is private and focus on the perspective of a developing country which faces brain drain to a more advanced country.

\(^3\)The result is not due to a decrease in the tax base stemming from additional outflows. It also holds if individuals are forced to pay taxes in their country of birth, irrespective of their residency. In the present paper, we examine the optimal government response as a robustness check for our main result on the two-way relationship between migration and wages.
confronts the main theoretical hypothesis with empirical evidence. The last section provides concluding remarks.

2 Related Literature

In line with seminal papers on brain drain like Bhagwati and Hamada (1974), we emphasize adverse effects of outward migration for the source economy. In contrast to this earlier literature, we focus on the dynamic interaction between emigration and between-country inequality through adverse productivity effects of brain drain. More recently, scholars pointed to potential brain gain effects for the sending country (e.g., Mountford, 1997; Stark, Helmenstein and Prskawetz, 1997, 1998; Beine, Docquier and Rapoport, 2001). They show that if emigration prospects of skilled workers in developing countries are uncertain due to immigration quotas in advanced countries, a higher quota (better emigration prospect) fosters incentives to acquire education. The drain effect from higher outflows may then be dominated by an increase in the domestic skilled labor force. While not denying this possibility, our theoretical analysis does not emphasize such a mechanism.\(^4\) We also abstract from potential gains for source economies from remittances since we are interested in first-order effects of migration flows of high-skilled workers on the global distribution of income earned in the source country.

The theoretical part of our paper may be most closely related to Miyagiwa (1991) and Mountford and Rapoport (2007). Miyagiwa (1991) aims to explain why countries like the US can pay high wages to skilled professionals and therefore attract the best immigrants from abroad. He assumes that there are increasing returns to education, which implies that the wage level of educated workers rises with the amount of skilled labor. In contrast, we endogenously derive effects of migration on TFP on the grounds of new growth and new trade theory and provide empirical evidence. Mountford and Rapoport (2007) analyze the interaction between migration flows, human capital formation in

\(^4\)In our model, migration possibilities are known ex ante to individuals and taken into account in the education decision. However, there is no explicit immigration quota, albeit there exist migration costs. In fact, the empirical relevance of a potential brain gain mechanism seems to be confined to poor countries with rather low levels of human capital and low emigration rates of the skilled (Beine, Docquier and Rapoport, 2001, 2008).
the presence of human capital externalities, and fertility. In their model population size increases in poor countries which suffer from brain drain due to fertility responses. Consequently, between-country inequality is predicted to rise in the longer run for a very different reason than in our model.

Our empirical analysis complements two recent papers. First, Grogger and Hanson (2008) examine the impact of higher wage differences for skilled workers between source and destination as well as the impact of higher differences in skill premia on bilateral migration patterns of skilled labor. Second, Beine, Docquier and Ozden (2010) show that, in addition, the total stock of emigrants already living in a source country is an important determinant for subsequent emigration for skilled and unskilled labor. This suggests that there exist mobility-cost reducing network effects from communities of people from the same nation and from friends and relatives already living abroad (see also Massey et al., 1993). In contrast to these contributions and by focussing on adverse brain drain effects, we investigate the other direction of the relationship between income differences and emigration flows, namely the role of bilateral migration patterns for income differences between source and destination countries.

Finally, there is a large literature on wage effects of immigration which uses microdata (surveys are provided by Borjas, 1994, and Card, 2009). The effects seem generally to be negative and of small magnitude if all immigrants are considered. According to Borjas (2003), immigrants with college degree, however, may have a positive, albeit again a small impact on wages for college-educated natives in the US. This is consistent with the international evidence we provide in this paper.

3 The Basic Model

Consider a small overlapping generations economy. Individuals live two periods and are endowed with one unit of time. Each period, a unit mass of individuals is born. In the first period of life, each individual decides whether to become high-skilled, which requires \( e \in (0, 1) \) units of time, or to remain low-skilled. High-skilled individuals may emigrate at some cost which may differ among individuals. In order to focus on migration patterns
of high-skilled workers, we assume that low-skilled labor is immobile.\textsuperscript{5} Time not used for education is inelastically supplied to a perfect labor market. Individuals may also save (or borrow) freely in an international financial market at an exogenous world market interest rate, \( r \). In the second period of life, individuals retire and live off their savings.

Let \( c_{t,y}(i) \) and \( c_{t+1,o}(i) \) denote the consumption level of a homogenous final good of individual \( i \) in period \( t = 1, 2, ... \) (when young) and \( t + 1 \) (when old), respectively. Preferences are represented by the intertemporal utility function

\[
U_t(i) = \log \tilde{c}_{t,y}(i) + \rho \log \tilde{c}_{t+1,o}(i),
\]

with discount factor \( \rho \in (0, 1) \), where

\[
\tilde{c}_y(i) = \begin{cases} 
  c_y(i) & \text{if } i \text{ does not migrate,} \\
  \frac{c_y(i)}{1 + \theta(i)} & \text{if } i \text{ migrates;}
\end{cases}
\]

the definition for \( \tilde{c}_o(i) \) is analogous.\textsuperscript{6} That is, if an individual chooses to work abroad, the consumption level is discounted in both periods.\textsuperscript{7} Parameter \( \theta(i) \) captures, for instance, individual-specific costs of living in a foreign social environment and the treatment of foreigners by administrative bodies. It is distributed according to a continuous p.d.f. \( \varphi(\theta) \), with support \( \Theta \), where \( \inf \Theta \geq 0 \). The c.d.f. of \( \theta \) is denoted by \( \Phi(\theta) \). It turns out that in order to avoid the possibility of multiple long-run equilibria, it is sufficient (but not necessary) to assume that

\[
\varphi'(\theta) \geq 0 \text{ for all } \theta \in \Theta. \tag{A1}
\]

When deciding whether or not to become skilled, individuals take both migration incentives and costs into account. The disposable wage income in \( t \) of a skilled migrant

\textsuperscript{5}This can be motivated by the fact that migration costs are higher for people with lower education as they are more likely to have difficulties in finding a job, learning a foreign language and integrating in the foreign society. Furthermore, institutional barriers in potential host economies may prevent migration of low-skilled workers.

\textsuperscript{6}Time index \( t \) is omitted whenever this does not lead to confusion.

\textsuperscript{7}For a similar way of modelling migration costs, see Stark, Helmenstein and Prskawetz (1997).
abroad (net of possible taxes in the destination country and a possible emigration tax) is exogenously given by $\bar{y}_t$.

The final good is chosen as numeraire. In $t$, output $Y_t$ is produced under perfect competition, according to the technology

$$Y_t = (X_t)^\alpha (A_t H_{Y,t})^\beta (A_t L_{Y,t})^{1-\alpha-\beta};$$

(3)

$\alpha, \beta \in (0,1)$. $H_Y$ and $L_Y$ is the high-skilled and low-skilled labor input, respectively, $A$ measures the efficiency of labor, and $X$ denotes the input of a manufactured (composite) capital good.

There is a perfectly competitive sector which produces the capital good by combining $n$ intermediate inputs according to the CES-production function

$$X_t = \left[ \int_0^{n_{t-1}} x_{t-1}(j)^\alpha dj \right]^{\frac{1}{\alpha}},$$

(4)

where $x(j)$ denotes the quantity of the intermediate input produced in sector $j \in [0,n]$.\(^8\) The time lag of one period in the input-output relationship (4) captures that the capital good has to be produced in advance of using it as an input in the final goods sector. As in endogenous growth theory and new trade theory, each intermediate input $j$ is produced by a monopolistic firm. Intermediate goods producers can transform one unit of foregone consumption into one unit of output, i.e., the marginal cost is equal to the interest rate $r$. There is a large number of potential intermediate goods producers in the economy. Entry is free but requires a fixed amount of $f > 0$ units of skilled labor (e.g. administrative and managerial overhead requirement) each period.\(^9\) The number of firms in $t \geq 1$, $n_t$, is endogenously determined via free entry, whereas $n_0 > 0$ is given.

For a given amount of resources employed in production, TFP is increasing in $n$. To see this, consider an equilibrium where all firms produce the same amount, $x(j) = x$ (which will be shown to hold in the present context). The economy’s “capital stock” is

\(^8\)According to (3) and (4), there are constant-returns to scale in the production of both the final good and the capital good.

\(^9\)Assuming instead that the labor requirement is partly or exclusively in terms of low-skilled labor is inconsequential for the main results.
given by \( K \equiv n x \). Thus, we have \( Y = B K^\alpha (H_Y)^\beta (L_Y)^{1-\alpha-\beta} \), where TFP is given by \( B \equiv (An)^{1-\alpha} \) and increasing in \( n \). In other words, since the marginal productivity of each intermediate good is declining, an increase in the number of intermediate goods leads to specialization gains which in turn boost TFP. This mechanism has been emphasized by monopolistic competition models in new trade theory (e.g., Ethier, 1982) and endogenous growth theory (e.g., Romer, 1990). It is adopted here to endogenize adverse productivity effects of brain drain in the source economy.

The measure \( A \) for the efficiency of labor is held constant in the basic model. In section 4, we extend the analysis to examine if the main insights change if (benevolent) national governments can react to declining mobility costs (and possibly larger migration flows), by raising public investment, which in turn affects \( A \). We will assume that public investment is financed by proportional income taxation. For the moment, suppose the income tax rate in each period, \( \tau_t \in [0,1) \), is exogenous.\(^{10}\)

### 4 Equilibrium Analysis

In this section we analyze the equilibrium from a developing country’s perspective which will face brain drain in equilibrium. Immigration could be treated analogously, but is not considered here for the sake of brevity (see Grossmann and Stadelmann, 2008, for a way this can be done).

An individual \( i \) with disposable income \( y_t(i) \) in the first period of life, \( t \), maximizes intertemporal utility (1) subject to the constraint

\[
c_{t+1,0}(i) = (1 + r) [y_t(i) - c_{t,y}(i)].
\]

Observing the definition of \( \bar{c}_{t,y}(i) \) and \( \bar{c}_{t+1,0}(i) \), it is easy to show that this leads to the

\(^{10}\)We may assume that the tax revenue is spent for a public good which enters the utility function in an additive fashion. In this case, public good consumption does not affect any decision.
indirect utility function

\[ U_t(i) = \begin{cases} (1 + \rho) \log y_t(i) + b \equiv v(y_t(i)) & \text{if } i \text{ does not migrate}, \\ (1 + \rho) \log \left( \frac{y_t(i)}{1 + \theta(i)} \right) + b & \text{if } i \text{ migrates}, \end{cases} \tag{6} \]

where \( b \equiv \rho [\rho (1 + r)] - (1 + \rho) \log (1 + \rho) \) is an unessential constant.

In equilibrium, as all workers have the same time costs \( e \) to acquire education, net wage income for high-skilled and low-skilled workers must be proportional in the domestic economy.\(^ {11} \) Formally, denoting by \( w_H \) and \( w_L \) the gross wage rate for high-skilled and low-skilled labor, respectively, in equilibrium we have

\[ w_H (1 - e) = w_L. \tag{7} \]

The capital goods sector maximizes the present discounted value (PDV) of profits. In period \( t - 1 \), it solves

\[
\max_{X_t, x_{t-1}(j), j \in [0, n_{t-1}]} \left\{ \frac{P_t X_t}{1 + r} - \int_0^{n_{t-1}} p_t(j) x_{t-1}(j) dj \right\} \quad \text{s.t.} \quad (4), \tag{8}
\]

taking the price of the capital good, \( P \), as well as intermediate input prices, \( p(j), j \in [0, n] \), as given. The first-order conditions and the fact that \( P \) equals the marginal product of the capital good, \( \alpha Y/X \), implies the following inverse demand function for intermediate input \( j \):

\[ p_{t-1}(j) = \frac{\alpha}{1 + r} \frac{Y_t}{(X_t)^\alpha} x_{t-1}(j)^{\alpha - 1}. \tag{9} \]

Recalling that intermediate input firms have marginal cost \( r \), profits (sales revenue

\(^ {11} \)The assumption that time costs to become skilled are identical across individuals is made for simplicity and does not affect the main results of this paper. However, as a result of heterogeneity in education costs, brain drain would have effects on domestic wage inequality. Such effects would also arise if the number of skilled and unskilled workers were exogenous. Modeling the education decision intends to take a longer run view. This is natural in our context where we emphasize productivity effects of brain drain. See, for instance, Yabuuchi and Chaudhuri (2007) for a theoretical analysis of the effects of migration on domestic wage inequality when education levels are exogenous.
minus production costs minus fixed costs) of firm $j$ in $t - 1$ are given by

$$
\pi_{t-1}(j) = \max_{p_{t-1}(j), x_{t-1}(j)} \left\{ \left( p_{t-1}(j) - r \right) x_{t-1}(j) - w_{H,t-1} f \right\} \quad \text{s.t. (9).} \tag{10}
$$

It is easy to show that prices are set according to $p_{t-1}(j) = r / \alpha$.

In equilibrium, due to free entry, the zero-profit condition $\pi_{t-1}(j) = 0$ for all $j$ and $t$ must hold. Finally, labor markets must clear. Denote the total number of skilled and unskilled natives by $H$ and $L$, respectively, i.e., $H + L = 1$, and the mass of skilled emigrants by $m$. $H$, $L$ and $m$ are endogenously determined.

The labor market clearing conditions read\(^{12}\)

\begin{align*}
L_Y &= L, \quad (11) \\
H_Y + n f &= (1 - e)(H - m). \quad (12)
\end{align*}

Moreover, disposable income $y(i)$ of a skilled non-migrant is $w_{H}^{n_{\text{et}}} \equiv (1 - \tau)w_H$ whereas emigrants earn $\bar{y}$ abroad. Thus, according to indirect utility function (6), a skilled worker $i$ migrates if and only if $w_{H}^{n_{\text{et}}} \geq (1 + \theta(i))\bar{y}$. This condition can be rewritten as $\theta(i) \leq \bar{y}/w_{H}^{n_{\text{et}}} - 1$. Thus, if $\bar{y} \geq w_{H}^{n_{\text{et}}}$, the number of emigrants is given by

$$
m = \Phi \left( \frac{\bar{y}}{w_{H}^{n_{\text{et}}} - 1} \right). \quad (13)
$$

Making use of equilibrium conditions and derived relationships we find that the following result holds:

**Lemma 1.** In equilibrium, the wage rate for skilled labor is given by

$$
w_{H,t} = \gamma A_t n_{t-1}, \quad (14)
$$

$$
\gamma = \beta^{1 - \alpha} \left( \frac{1 - \alpha - \beta}{1 - e} \right)^{1 - \alpha - \beta / (1 + r)} \left( \frac{\alpha^2}{(1 + r)^r} \right)^{1 - \alpha} \quad \text{. The number of intermediate good firms evolves}
$$

\(^{12}\)Recall that there are $H_Y$ skilled workers in the final goods sector and each of the $n$ intermediate good firms employs $f$ skilled workers. Also recall that skilled individuals work only a fraction $1 - e$ of their time and that there are $H - m$ skilled workers remaining in the economy after emigration.
according to the first-order difference equation

\[ n_t = \frac{1 - e}{f} \left[ 1 - \Phi \left( \frac{\bar{y}_t}{(1 - \tau_t)\gamma A_t n_{t-1}} - 1 \right) \right] - \frac{1 + r}{\alpha} n_{t-1} \equiv Z(n_{t-1}). \] (15)

We have \( Z(0) = 0, \lim_{n \to 0} Z'(n) \to \infty, \lim_{n \to \infty} Z'(n) < 0 \) and, under assumption (A1), \( Z''(n) < 0 \). The number of firms in \( t - 1, n_{t-1}, \) is negatively associated with the number of emigrants in \( t \):

\[ m_t = \Phi \left( \frac{\bar{y}_t}{(1 - \tau_t)\gamma A_t n_{t-1}} - 1 \right). \] (16)

All proofs are relegated to the Appendix.

Wage rates positively depend on the number of firms, \( n \), due to specialization gains which arise if more intermediate goods are available, as discussed above. The model thus proposes a novel microfoundation for the notion that brain drain reduces productivity in an economy. The mechanism runs through the adverse effects of brain drain on the number of founded firms.

We now make use of Lemma 1 to examine the impact of a decrease in mobility costs (further international integration of the market for skilled labor) on emigration, the number of intermediate good firms, TFP, and wages. A decrease in mobility costs is defined as a shift in the c.d.f. of \( \theta \), from \( \Phi_0(\theta) \) to \( \Phi_1(\theta) \), such that \( \Phi_1(\theta) > \Phi_0(\theta) \) for all \( \theta \) in the interior of support \( \Theta \) (i.e., \( \Phi_0(\theta) \) first-order stochastically dominates \( \Phi_1(\theta) \)). In words: for any given \( \theta \), the share of individuals with mobility costs higher than \( \theta \) declines and the share of individuals with costs lower than \( \theta \) increases. This leads to the main result of this paper.

**Proposition 1.** Suppose that \( \xi \equiv \frac{\bar{y}_t}{(1 - \tau_t)\gamma A_t} \) is time-invariant and (A1) holds.\(^{13}\) Then:

(i) There is a single interior steady state equilibrium value for the number of firms, \( n^* \).

(ii) If mobility costs decline, the steady state value of both the number of firms (\( n^* \))

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\(^{13}\)For instance, \( \xi \) is time-invariant if the tax rate \( \tau \) is time invariant and net income abroad, \( \bar{y} \), grows with the same rate as productivity measure \( A \).
and the wage rate for skilled labor \( w_H = \gamma A n^* \) decreases, whereas the steady state number of emigrants \( m^* = \Phi (\xi / n^* - 1) \) increases.

(iii) If the economy was initially in steady state, then \( w_H \) declines and \( m \) rises also in the subsequent period after labor markets integrate.

< Figure 1 >

Fig. 1 graphically illustrates the impact of a decrease in mobility costs on the evolution of the number of firms when the economy is initially in steady state equilibrium. A decline in mobility costs implies a shift of function \( Z \) from \( Z_0 \) to \( Z_1 \). We distinguish two cases in which the economy converges to a unique stable steady state. In the left panel we have \( Z_0'(n_0^*) \in (0, 1) \) at the initial steady state value \( n_0^* \). In this case, a decrease in mobility costs implies that \( n \) gradually declines from \( n_0^* \) to the new steady state value \( n_1^* \), i.e., emigration rises gradually over time until the economy adjusts to the new steady state. In the right panel, where \( Z_0'(n_0^*) \in (-1, 0) \), the economy fluctuates while converging to the new steady state. In both cases, the model predicts that the steady state level of emigration rises in an economy already facing brain drain.\(^{14}\)

## 5 Government Response to Brain Drain

Does the main theoretical prediction in Proposition 1 (higher \( m \) is associated with a decrease in \( w_H \)) prevail if the government can respond to the productivity loss caused by higher brain drain? One obvious response would be an emigration tax (e.g., Bhagwati and Hamada, 1974; Bhagwati and Wilson, 1989).\(^{15}\) In our model, such a tax would reduce the net difference in earning opportunities for migrants, by lowering \( \bar{y} \). It thus would mitigate brain drain, according to (16). Here we want to focus on an alternative policy question. We examine whether it is desirable to change the level of publicly

\(^{14}\)Since \( Z(0) = 0 \), there is also always an unstable steady state equilibrium at \( n = 0 \), which however is economically irrelevant when starting at \( n_0 > 0 \) (recall \( \lim_{n \to 0} Z'(n) > 1 \)).

\(^{15}\)See, for instance, Wildasin (2000), Andersson and Konrad (2003) and Andersen (2005) for other aspects of the question how mobility of skilled labor may change the tax system.
financed investment, in order to alleviate the adverse productivity effects from higher brain drain.

We assume that an increase public spending, $G$, raises the efficiency of labor, i.e.,

$$A = a(G),$$

(17)

where $a' > 0$, $a'' < 0$. For instance, we may think about publicly financed infrastructure expenditure or spending for basic education.\(^{16}\) To simplify the analysis, we furthermore assume that emigrants still have to pay their taxes in the source country.\(^{17}\) Also suppose that income $\bar{y}$ of skilled emigrants is time-invariant.

We distinguish two cases. First, in the next subsection, we assume that the government faces the constraint to balance the budget. To find the optimal policy requires the definition of a government objective. We assume that the government maximizes welfare of the median voter. As emigration rates are nowhere above 50 percent, we focus on the case that the median voter is a non-migrant. Second, we allow governments to incur public debt. In this scenario, we assume that the government is not only concerned about the present generation of non-migrants but also about the public deficit, which future generations have to repay. Similarly, we capture a concern for future generations also by assuming that the level of emigration may enter the government objective, due to adverse productivity effects of emigration.

5.1 Balanced Budget

Suppose first that the government budget is balanced each period. Thus, the government budget constraint for financing public spending reads $G = \tau[w_L L + (1 - e)w_H H]$. Using equilibrium conditions $w_L = (1 - e)w_H$ and $H + L = 1$, we have $\tau w_H = \frac{G}{1 - e}$. Thus,

\(^{16}\)Our formulation reflects full depreciation of public investment over time, which we assume for simplicity. According to the model, in the case of public education spending, there is literally full depreciation since individuals only work for one period and there is no intergenerational human capital transmission.

\(^{17}\)The main insights of our analysis would not change if we assumed that emigrants do not pay taxes at home. However, there would be additional effects which complicate the analysis, since the tax base would shrink due to emigration.
after-tax wage income of a skilled non-migrant is given by

\[ w_{H,t}^{\text{net}} = w_{H,t} - \tau w_{H,t} = \gamma a(G_t)n_{t-1} - \frac{G_t}{1 - e} \equiv w(G_t, n_{t-1}), \quad (18) \]

according to (14) and (17). We find partial derivatives \( w_n > 0, w_{GG} < 0, w_{Gn} > 0. \) Property \( w_n > 0 \) reflects the specialization gains implied by a larger number of intermediate goods producers, discussed after Lemma 1. The property that net wage income is strictly concave as a function of \( G \) (recall \( a'' < 0 \)) ensures an interior optimal value of \( G \), as will become apparent. Property \( w_{Gn} > 0 \) will be of particular importance: If net wage income declines due to a decrease of the number of firms \( n \) (for instance, triggered by a reduction in mobility costs), then the marginal impact of an increase in \( G \) on net wages also declines. This property is an outcome of three features of the model. First, the capital good \( (X) \) is complementary to the efficiency units of labor in final goods production, according to (3). Second, the efficiency of labor, \( A \), is rising in public investment, \( G \), according to (17). Third, due to specialization effects the output of the capital good, \( X \), depends on the number of intermediate good firms, \( n \). Taken together, a higher number of firms raises the impact of an increase in public investment on wages.

It is useful to write

\[ m = \Phi \left( \frac{\bar{y}}{w_{H}^{\text{net}}} - 1 \right) = \chi q(w_{H}^{\text{net}}), \quad (19) \]

where \( q \) is a function fulfilling \( q' < 0 \) and, under (A1), \( q'' > 0 \), and \( \chi \) is a shift parameter which reflects the degree of the integration of the market for skilled labor. That is, an increase in \( \chi \) raises the number of migrants for any net wage rate \( w_{H}^{\text{net}} < \bar{y} \). Using (18) and (19), the difference equation for the evolution of \( n \), (15), can be rewritten as

\[ n_t = \frac{1 - e}{f} [1 - \chi q(w(G_t, n_{t-1}))] - \frac{1 + r}{\alpha} n_{t-1} \equiv \Gamma(G_t, n_{t-1}, \chi). \quad (20) \]

Thus, in a steady state, the number of intermediate good firms is implicitly given by

\[ n^* = \Gamma(G, n^*, \chi) \quad (21) \]
as a function of $G$ and $\chi$. Note that under the assumptions of Proposition 1, there is a single interior solution of (21) for any $(G, \chi)$, which we denote by function $\hat{n}(G, \chi)$. Since $\Gamma_n < 1$ holds in a stable equilibrium (which is the case we focus on) and $\Gamma_\chi < 0$, we have $\hat{n}_\chi(G, \chi) < 0$; that is, labor market integration reduces the steady state number of firms for a given level of $G$, as we know already from part (ii) of Proposition 1.

Using (6) and (7), in equilibrium, welfare for all non-migrants is $v((1-e)w^\text{net}_{H,t})$, which in $t$ is maximized if $w^\text{net}_{H,t} = w(G_t, n_{t-1})$ is maximized. Since the number of emigrants is adversely related to the after-tax wage rate (see (19)), the government therefore aims to minimize emigration.

Suppose that initially the economy is in its steady state and the initial degree of labor market integration is represented by $\chi_0$. Also suppose that, in the initial period, the public investment level maximizes long run welfare. Define

$$W(G, \chi) \equiv w(G, \hat{n}(G, \chi)). \quad (22)$$

Initially, the level of public investment is thus given by

$$G^*_0 \equiv \arg\max_G W(G, \chi_0). \quad (23)$$

The corresponding initial number of firms is $n_0 = \hat{n}(G^*_0, \chi_0)$. Since $\Gamma_\chi < 0$, an increase in parameter $\chi$ from $\chi_0$ to $\chi_1 > \chi_0$ (decline in mobility costs) lowers the number of firms in the next period: $n_1 = \Gamma(G^*_0, n_0, \chi_1) < n_0$ (see also Fig. 1). We can show the following.

**Proposition 2.** Suppose (A1) holds and the government needs to balance its budget. When the economy is initially in a stable steady state and mobility costs decline (increase from $\chi_0$ to $\chi_1 > \chi_0$), the following holds:

(i) The optimal public investment level is lower than initially both in the subsequent period after labor market integration and in the new steady state, i.e.,

$$G^*_0 > G_1 \equiv \arg\max_G w(G, n_1), \quad (24)$$

$$G^*_0 > G^*_1 \equiv \arg\max_G W(G, \chi_1). \quad (25)$$
Both in the subsequent period after the shift and after full adjustment to the new steady state the after-tax wage rate for skilled labor ($w_{net}$) decreases and the number of emigrants ($m$) increases.

Proposition 2 suggests that governments which care about non-migrants choose to lower the level of public investment when facing higher brain drain. The result follows because the marginal gain from public investment declines if there are less specialization gains ($w_{Gn} > 0$), where the reduction in the number of intermediate good firms in source economies is induced by labor market integration. Because not only the after-tax wage rate declines but also the tax payment ($G$) does, the gross wage rate $w_{H}$ declines as well.

We can thus conclude that, as in the basic model, declining mobility costs accentuate both migration flows and income differences among economies also when public investment spending levels adjust optimally. This holds true even with respect to wage income for skilled workers, which declines in the source economy along with higher brain drain.

We can show an additional, interesting result which highlights the role of TFP for migration patterns, where TFP depends on the number of intermediate good firms.

**Corollary 1.** In steady state, the optimal long run public investment level, $G^*$, maximizes the long run number of firms, i.e., $G^* = \arg\max_G \hat{n}(G, \chi)$.

The result shows that, in the long run, minimizing the number of emigrants via public investment policy is equivalent to maximizing the steady state number of firms and thus wages.

### 5.2 Debt Finance

Now we allow the government to finance public investment also by incurring a deficit. Denoting tax revenue by $T$, analogously to the previous subsection, we have $\tau w_{H} = \frac{T}{1-e}$. The amount of government borrowing is $B = G - T$. Hence, $\tau w_{H} = \frac{G-B}{1-e}$ and,

---

The result may not hold for all periods during the transition to a new steady state, as the economy may fluctuate in the transition, as shown in panel (b) of Figure 1.
consequently,
\[ w_{H,t}^{\text{net}} = \gamma a(G_t) n_{t-1} - \frac{G_t - B_t}{1 - e} \equiv \bar{w}(G_t, B_t, n_{t-1}). \] (26)

A higher amount of borrowing defers costs for current public investment to the future and thus raises current wage income, \( \bar{w}_B > 0 \). Similarly to the balanced budget case, we find \( \bar{w}_n > 0, \bar{w}_{GG} < 0, \bar{w}_{Gn} > 0 \). Moreover, \( \bar{w}_{Bn} = \bar{w}_{BG} = \bar{w}_{BB} = 0 \), i.e., the marginal impact of higher borrowing on net wage rates of non-migrants does not depend on the number of firms, the level of public investment, or the amount of borrowing.

We assume that the government care about life-time utility of non-migrants, as before. Moreover, in order to capture potential concerns about future generations, it dislikes borrowing. Possibly, it also dislikes brain drain per se. In order to capture such potential concerns about future generations formally, suppose the objective function in \( t \) reads

\[ v((1 - e)w_{H,t}^{\text{net}}) - \xi(m_t) - \psi(B_t), \] (27)

where \( \xi' \geq 0, \psi' > 0, \xi'' \geq 0, \psi'' \geq 0 \) is assumed. The next proposition shows that the basic relationship between wages and migration still prevails if governments in source economies can run public debts when adjusting to declining mobility costs.

**Proposition 3.** Suppose (A1) holds and the government maximizes objective function (27) with respect to \((G, B)\).\(^{19}\) When the economy is initially in a stable steady state and mobility costs decline (increase from \( \chi_0 \) to \( \chi_1 > \chi_0 \)), the following holds:

(i) The optimal level of public investment is lower and the public deficit is higher than initially in the subsequent period after labor market integration. Long run effects on investment and deficit are ambiguous.

(ii) The result in part (ii) of Proposition 2 is maintained.

The short run effect of declining mobility costs is similar to the effect without the possibility that the government can incur a deficit (part (i)). Since the number of firms declines in an economy facing brain drain, the impact of an increase in public

\(^{19}\)Concavity of the objective function is presumed.
investment, \( G \), on domestic wages declines. Analogously to the balanced budget case in the previous subsection, this follows from property \( \tilde{w}_{Gn} > 0 \). The amount of borrowing, \( B \), is increasing. Intuitively, the government wants to mitigate the increased current migration pressure by reducing the tax burden.

As shown in the appendix (proof of Proposition 3), also in the long run the marginal impact of higher public investment on welfare again declines with further integration. Moreover, the marginal impact of higher debt on welfare increases. Formally, analogously to (22), we can express long-run welfare (27) as a function of \( G, B \), and the level of labor market integration, \( \chi \) (see the proof of Proposition 3). Denote this function by \( W(G, B, \chi) \). We show in the appendix that, as claimed, \( W_{G\chi} < 0 \) and \( W_{B\chi} > 0 \) hold. These effects would suggest that also in the long run non-migrants may benefit from both lower public investment and higher debt when markets for skilled labor further integrate. However, it turns out that public investment and deficits are complementary for welfare; i.e., \( W_{GB} > 0 \). The reason is the following. A higher deficit raises the number of firms for a given public investment level, since current after-tax wage income increases. Thus, emigration incentives are mitigated. In turn, this raises the marginal impact of higher public investment on wages (since \( \tilde{w}_{Gn} > 0 \)) and gives rise to property \( W_{GB} > 0 \). Consequently, the total long run effect of labor market integration on both public investment and the public deficit remain ambiguous.

Most importantly, however, our main result prevails (part (ii)). Also with the possibility of adjustment of public investment policy, declining mobility costs lower wages even for skilled workers in the source country and aggravate the brain drain. The main hypothesis derived from the basic model thus seems to remain robust to responses in public investment policy and debt finance.

6 Empirical Evidence

Our theoretical analysis has highlighted the interaction between emigration of high-skilled labor and the wage income gap to potential host economies of expatriates. This interaction is reflected by Proposition 1, which applies to given public investment, and
in Propositions 2 and 3, which account for endogenous adjustment of public investment and debt finance to a change in migration costs. To recall, on the one hand, emigration depends on relative wage income to potential destination economies; formally, the number of emigrants in the theoretical model is \( m = \Phi (\bar{y}/w_{H}^{net} - 1) \), where \( \Phi \) is the c.d.f. of mobility costs in the population and \( \bar{y}/w_{H}^{net} \) is relative net wage income of skilled workers abroad. On the other hand, higher emigration of skilled labor induces productivity effects. The number of firms decreases if the number of high-skilled emigrants increases. The resulting productivity decline in the source economy raises wage income differences to the destination economy.

The first direction, from income differences to migration outflows, has been examined empirically elsewhere. Two recent papers are notable. First, Grogger and Hanson (2008) provide convincing evidence for the critical role of wage differences between country pairs on emigration patterns of tertiary educated workers.\(^{20}\) Second, Beine, Docquier and Ozden (2010) show that, in addition to wage differences, network effects are important for the migration decision for both high-skilled and low-skilled workers. That is, emigrants already living in the destination country positively affect migration flows in a causal way.

Inspired by endogenous growth and new trade theory, our empirical analysis will, in contrast, focus on the direction from emigration to relative wage income. It thereby aims to complement previous literature by investigating the main novel hypothesis of our paper on productivity effects in the context of mobility of skilled labor: increased migration of high-skilled workers from source to host countries raises (log) income differences between country pairs even for skilled workers.

### 6.1 Data and Estimation Strategy

The emigration rate of high-skilled individuals is our main explanatory variable. Docquier and Marfouk (2006) have established a dataset of emigration stocks and rates by educational attainment for the years 1990 and 2000. The authors count as emigrants all

\(^{20}\)In the working paper version of this article (Grossmann and Stadelmann, 2008), we presented evidence for the interaction between emigration flows and income changes using a structural equation model. However, we looked at the impact of a higher aggregate emigration stock of a country on its per capita income. That is, we did not consider bilateral relationships.
foreign-born individuals aged at least 25 who live in an OECD country and class them by educational attainment and country of origin. Thus, only emigration into OECD countries is captured, approximately 90 percent of educated migrants in the world.\footnote{See Docquier and Marfouk (2006) for a detailed discussion concerning data collection and construction issues.}

As we are interested in the bilateral migration pattern of high-skilled individuals, we focus on emigration of the high educational category provided in an extended dataset by Docquier, Marfouk and Lowell (2007). We construct the high-skilled emigration rate from country $i$ to $j$ in year $t$, denoted by $M_{ij,t}$, as the stock of skilled emigrants from country $i$ living in (OECD) country $j$ divided by the stock of skilled residents in (source) country $i$ in year $t$.

Denote by $y_{i,t}$ the income measure in country $i$ in year $t$, which is further specified below. We estimate, for a country pair ($i, j$):

$$
\log \left( \frac{y_{j,t}}{y_{i,t}} \right) = \beta_0 + \beta_1 M_{ij,t} + \mathbf{x}'_{ij,t-1} \beta_\mathbf{x} + u_{ij,t}.
$$

Equation (28) is theoretically motivated by Propositions 1-3, which suggest that in steady state higher emigration due to lower mobility costs are negatively associated with wage rates and therefore positively related to relative wages abroad. Thus, the theoretical model predicts for its empirically reduced form (28) that $\beta_1 > 0$. $\mathbf{x}_{ij}$ is a vector of other controls potentially affecting log income differences between $i$ and $j$ (like relative school enrolment rates, relative investment rates, relative urban population shares, and fixed effects for the source country to capture institutional differences to OECD destination countries). These controls are lagged in the estimation to reduce endogeneity bias. We focus on (the log of) relative wage income in the year 2000 as dependent variable and take the lag to be 10 years. $u_{ij}$ is an error term.

Moreover, we also account for transitional dynamics towards the steady state in the theoretical model. This requires to replace $M_{ij,t}$ in (28) by a lagged emigration rate $M_{ij,t-1}$. To see this, recall that the theoretical model suggests that emigration of high-skilled workers reduces the number of intermediate good firms contemporaneously. In turn, this leads to a decline in wages for skilled workers in the next period, according to
As an empirical measure of (log) relative wage income, \( \log \left( \frac{y_{i,t}^{j}}{y_{i,t}} \right) \), we would ideally use (log) differences in wages by the education category defined for our main explanatory variable \( \text{Mig}_{ij,t} \), i.e. we would like to use (log) wages differences for high-skilled individuals. Since incomes by education category are not available to us, we use three different empirical measures. Freeman and Oostendorp (2000) have collected information on earnings by occupation and industry from the International Labor Organization’s (ILO) October Inquiry Survey from 1983-1998. Due to the non-standard nature of the database and to correct for differences in how countries report earnings, Freeman and Oostendorp (2000) use a standardization procedure to make the data comparable across countries and time. In 2005 they provided an update for their earnings measures for the 1983-2003 ILO October Inquiry data using an improved version of the standardization procedure and the application of country-specific data type correction factors.\(^{22}\) For each country, we take Freeman and Oostendorp’s earnings measures corresponding to the 80th and the 90th percentile as two measures for wages of high-skilled workers.\(^{23}\) For most countries, data are available for a just a few years. Thus, for each country we take the mean across the period between the years 1995 to 2003 and create a dataset of 89 destination and 23 source countries for the year 2000.\(^{24}\) The two constructed (log) relative wage variables for the 80th and the 90th percentile are denoted by \( \text{RelWage}_{80ij,t} \) and \( \text{RelWage}_{90ij,t} \). Productivity effects of brain drain as captured in our theoretical model may also be reflected when looking at differences in (log) relative GDP per capita. We estimate the effects of bilateral migration on this additional dependent variable, denoted by \( \text{RelGDP}_{ij,t} \).

Variable definitions, data sources and summary statistics of the employed variables are presented in Tab. 1.

\(^{22}\) A detailed technical documentation of the standardization procedure for the 1983-2003 ILO October Inquiry data is available online on http://www.nber.org/oww/.

\(^{23}\) Freeman and Oostendorp report different series of their earnings. We use the series “country-specific calibrations with imputation in US$”.

\(^{24}\) We also included Turkey where data for the year 1994 was used.
While recent empirical literature has focussed on the impact of income differences on migration patterns, we aim to examine the opposite channel. Thus, the empirical analysis needs to address potential endogeneity bias. In a first attempt to deal with endogeneity regarding the relationship of interest, we replace the high-skilled emigration rate in 2000 by the lagged one in 1990 in OLS regressions.

Second, and more importantly, we instrument the high-skilled emigration rate for the year 2000. We use the lagged rate of total expatriates who emigrated from country $i$ to $j$, $TotalMig_{ij,t-1}$, as an instrument for $Mig_{ij,t}$ thereby predicting the rate of high-skilled emigrants by the lagged rate of all emigrants. This is motivated by the notion that a larger percentage of emigrants from a certain source country already living abroad act as a signal to potential high-skilled migrants concerning openness, treatment of foreigners by administrative bodies, and perceived social links in the destination. Moreover, a higher rate of emigrants to a certain destination creates mobility-cost reducing network effects for emigrants of small source countries.\textsuperscript{25} $TotalMig_{ij,t-1}$ also measures other intangible factors unrelated to income such as reputation, cultural proximity, and social openness to migrants of the destination as perceived by emigrants of the source country.

The past total emigration rate should not influence contemporaneous income differences beyond the impact exerted by high-skilled emigration itself. The simultaneous use of two or more instruments allows us to check the empirical validity of this condition through J-tests. We employ indicators for geographical factors ($Dist_{ij}$, $Contig_{ij}$) and linguistic proximity ($ComLang_{ij}$) which are typically used in the literature on migration as additional instruments. These instruments are supposed to capture mobility costs, an important determinant of high-skilled migration in our theoretical model.

In a third attempt to address potential endogeneity bias, we use the total emigration rate in 1960, which, however, cannot be readily observed. We construct two proxies for the total emigration rate. Denote by $NetMig_{i,1960}$ the total net emigration rate (number of emigrants minus number of immigrants divided by population size) in country $i$ in

\textsuperscript{25} Another way to capture the effect of mobility-cost reducing network effects is to use stocks instead of rates (e.g. Massey et al., 1993; Beine, Docquier and Ozden, 2010). In supplementary material (available upon request), we also provide estimates with the (log) stock of total emigrants. Results are basically unchanged.
the year 1960, provided by the United Nations Population Division. The first proxy of bilateral total emigration rates in 1960 is defined by

\[
TotalMigP_{ij,1960} := \frac{NetMig_{i,1960} \times Pop_{j,1960}}{Pop_{i,1960}},
\]

where \( Pop_{i,1960} \) is the population in the source \( i \) and \( Pop_{j,1960} \) is the population in the destination \( j \) in the year 1960. As argued by Beine, Docquier and Rapoport (2001), one may use countries’ population sizes to reflect immigration quotas. \( NetMig_{i,1960} \times Pop_{j,1960} \) thus is a proxy for the net stock of emigrants from country \( i \) received in country \( j \) in 1960. As our empirical strategy focuses on emigration rates rather than stocks, we divide this measure by the population of the source country \( i \) to obtain an estimate for the past bilateral emigration rate. As a good instrument, the past total emigration rate should be correlated with the high-skilled emigration rate in 2000, \( Mig_{ij,t} \). This is supported by calculating partial correlations. The fraction of high-skilled migrants before 1960 was comparatively low and thus potential effects of past migration should only work through induced high-skilled emigration. In other words, the instrument should be uncorrelated with the dependent variable which is supported by J-tests.

We also construct a second proxy of bilateral emigration rates. We explain the observed the bilateral (log) total emigration stock in 1990 in a linear regression model with the following variables: distance between two countries \( (Dist_{ij}) \), common language \( (ComLang_{ij}) \), diplomatic representations between 1946 and 1960 as well as the total number of militarized interstate dispute between the same period from the Correlates of War Project (Ghosn, Palmer and Bremer, 2004). Using the resulting coefficient values without a constant, we predict total bilateral emigration from \( i \) to \( j \) from the estimated model and add the value of the product \( NetMig_{i,1960} \times Pop_{j,1960} \). The sum is divided by the population of the source country \( i \) in 1960 \( (Pop_{i,1960}) \) to obtain a second proxy for

\[26\] Countries with negative net emigration in are coded to have an emigration rate equal to zero.

\[27\] The construction of the first proxy is inspired by Beine, Docquier and Ozden (2010). They use a similarly constructed proxy as an instrument for the total diaspora of migrants in 1990 (rather than the high-skilled emigration rate).

\[28\] Like the corresponding emigration rate, \( TotalMig_{ij,t-1} \), the variable is provided in Docquier, Marfouk and Lowell (2007).
the bilateral emigration rate in the year 1960. This proxy thus accounts for geographical factors and historical factors. It is denoted by $TotalMigP_{ij,1960}$.

### 6.2 Results

Reported standard errors from all estimates account for destination clusters, following Grogger and Hanson (2008), among others.29

< Table 2>

Tab. 2 presents OLS estimates of equation (28). Columns (1), (4), and (7) estimate the effect of the high-skilled emigration rate in the year 2000 ($Mig_{2000,ij}$) for the dependent variables (log of) relative wages in the 80th percentile, relative wages in the 90th percentile, and relative GDP per capita ($RelWage_{80,ij,t}$, $RelWage_{90,ij,t}$ and $RelGDP_{ij,t}$, respectively). The coefficient of interest, $\beta_1$, is always positive and significantly different from zero at the one percent level. The other columns in Tab. 2 report results when using the lagged high-skilled emigration rate, for 1990 ($Mig_{1990,ij}$). This accounts for transitional dynamics and also serves as a first step to account for potential endogeneity. The sizes of coefficient $\beta_1$ in these estimations are similar. Thus, an increase in the high-skilled emigration rate raises (log) income differences between countries as suggested by our theoretical model. The control variables of all estimates include the lagged relative school enrolment (primary and tertiary), the relative capital investment and the relative urban population share as well as source fixed effects. The controls have the expected signs apart from primary schooling which is not significant. The relative investment rate and the relative urban population share are typically significantly different from zero. In columns (3), (6) and (9) we exclude the insignificant school enrolment variables and only include significant controls. This increases the number of available country pairs. The coefficients of the high-skilled emigration rate remain significant and increases slightly for all estimates compared to the other results.

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29 We use the Huber-White method to adjust the variance-covariance matrix from our least squares results, to correct for heteroscedasticity and for correlated observations from cluster samples.
The results in Tab. 2 also show that the size of $\beta_1$ is similar across specifications for wages in the 80th and 90th percentile. To get a feeling for quantitative effects, with a coefficient $\beta_1$ around 0.2, as suggested by our estimates, doubling the high-skilled emigration rate ($Mig_{ij,t}$) from its mean level of 0.025 (see Tab. 1) implies that relative wages rises by approximately 0.5 percent ($= 0.2 \times 0.025$). This effect is rather small, consistent with the microeconomic estimates of the effect of high-skilled immigration on wages for the high-skilled inside the US by Borjas (2003). What is important, however, is that, contrary to conventional wisdom, the effect is positive rather than negative.

<Table 3>

Tab. 3 deals with the potential reverse causality problem by providing IV-estimations of (28). In columns (1), (5) and (9) we use the total emigration rate from country $i$ to $j$ in 1990 ($TotalMig_{ij,t-1}$) as single instrument. In the other regressions, measures of geographical factors and linguistic proximity are used as instrument in addition to $TotalMig_{ij,t-1}$. As in Tab. 2 and the following tables, we still control for lagged relative values of school enrolment, investment and urbanization and include source country fixed effects (results not shown). In some wage regressions, we additionally control for the (log of) relative public investment level per capita in 1990. This accounts for the fact that, according to wage equation (14) and the assumption that productivity $A$ rises in $G$, according to (17), wages for skilled workers may positively depend on the level of public investment. There is a particular difficulty to identify productive spending among government expenses (see, e.g., Easterly, Irwin and Servén, 2008, for a discussion). To ensure high data quality with respect to comparability across countries, we first employ the OECD measure of public investment (government gross fixed capital formation; see columns (3) and (6)). This induces a large drop in the number of included countries (15 instead of 66) and therefore in the number of observations. In columns (4) and (7), we employ the IMF measure of public investment (public capital expenditure). The measure is available for a broader but still rather limited set of countries (we can only include 42

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30 In fact, between 1990 and 2000 the number of tertiary educated immigrants living in OECD countries almost doubled (Docquier and Marfouk, 2006).
countries). Thus, again, the number of observations drops considerably. For this reason and the data quality issue, we abstain from including relative public investment in the regressions reported in Tab. 4 and 5 below.

The upper panel of Tab. 3 reports second stage results while the lower panel reports the partial correlations of the additional instruments in the first stage. Columns (1)-(4) present results for relative wages in the 80th percentile. The first column uses the total emigration rate in 1990, \( \text{TotalMig}_{ij,t-1} \), as a single instrument for the high-skilled emigration rate, \( \text{Mig}_{ij,t} \), in 2000. The first stage results indicate that the total emigration rate in 1990 is well correlated with \( \text{Mig}_{2000,ij} \). According to second stage results in column (1), \( \beta_1 \) is again positive and significantly different from zero at the one percent level. Thus, the instrumented high-skilled emigration rates point to a causal effect of emigration on log wage differences between source and destination countries. In columns (2)-(4) we use the bilateral geographical distance between \( i \) and \( j \) (\( \text{Dist}_{ij} \)), an indicator for a common border (\( \text{Contig}_{ij} \)) and an indicator for common language of source and destination country (\( \text{ComLang}_{ij} \)) as additional instruments for \( \text{Mig}_{ij} \). The coefficient estimate of \( \beta_1 \) is again significant, positive and of similar size as in column (1), also when including the public investment measures. A F-test for the first stage results shows that the instruments are significantly related to the emigration rate.\(^{31}\) Adding public investment expenditure suggests that, in OECD countries, higher public investment may raise wages for skilled labor. However, possibly due to the limited sample size, the coefficient is not significantly different from zero when using the OECD data. The results also Columns (5)-(9) confirm the results for the dependent variable (log) relative wage in the 90th percentile. The effect of the instrumented high-skilled emigration rate on wage differences is positive and significant in all estimates. Columns (9) and (10) show results with (log) relative GDP differences as a dependent variable. The instrumented \( \text{Mig}_{ij,t} \) again turns out to have a positive and significant effect. None of the J-statistics in Tab. 3, which deal with the overidentifying restrictions, point to problems with the instruments.

\(^{31}\)That contiguity (variable \( \text{Contig}_{ij} \)) has a negative effect on high-skilled emigration in our first-stage estimate parallels a similar finding as in Grogger and Hanson (2008). They explain the result by selection and sorting effects.
Overall, the first stage results suggest that factors potentially unrelated to income such as a destination’s reputation, network effects, language and geography drive the high-skilled emigration rate. More importantly, the results of the IV-regressions support our main hypothesis of a causal effect of higher emigration on log wage differences to host economies. Interestingly, the coefficients on the instrumented variable $Mig_{ij,t}$ in Tab. 3 are more than twice as high than in OLS regressions (Tab. 2). This suggests that migrants who arrive through social networks have a particularly high impact on wages. According to columns (1)-(4) in Tab. 3, doubling the high-skilled emigration rate ($Mig_{ij,t}$) from its mean level implies that the relative wage of high-skilled workers abroad rises by 1.5 percent ($= 0.6 \times 0.025$).

Table 4

Lagging the total emigration rate as an instrument by more than ten years is supposed to strengthen the argument of the exogeneity of high-skilled emigration rates for between-country income differences. Thus, we examine whether the positive impact of an increase in high-skilled emigration on our relative income measures still holds when total emigration rates in 1960 are used as an instrument. As described above, we use two proxies of bilateral emigration rates in 1960 for data availability reasons. The results are reported in Tab. 4. The upper panel shows second stage results while the lower panel presents partial correlations of the instruments in the first stage. Columns (1)-(3) focus on (log) relative wage differences in the 80th percentile. As shown in the lower panel, the constructed proxies $TotalMigP_{1ij,1960}$ and $TotalMigP_{2ij,1960}$ for the bilateral total emigration rate in 1960 are well correlated with $Mig_{ij,t}$ and seem to serve as good instruments (see F-tests for columns (1)-(3) and J-test for column (2)). Column (1) again indicates that the relative wage effect of increasing the instrumented high-skilled emigration rate is positive and significant at the one percent level. The same holds when geographical instruments are used together with the proxy variable $TotalMigP_{1ij,1960}$, as reported in column (2). Column (3) shows that the size of the coefficient $\beta_1$ drops by half when the second proxy variable $TotalMigP_{2ij,1960}$ is used as instrument. However, the effect remains positive and significant at the 5 percent level. According the columns
(4)-(6), the impact of $M_{ij,t}$ on wage differences in the 90th percentile is qualitatively and quantitatively similar to the results for the 80th percentile. The significance level is even always at one percent. Finally, columns (7)-(9) report results for (log) relative GDP per capita differences as a dependent variable. According to the estimates, $\beta_1$ is again positive and significantly different from zero in all specifications using different instruments (once at the 10 percent level, if many instruments are included, and otherwise at the one percent level).

We conducted further sensitivity analysis which is available on request. First, instead of using source fixed effects we include regional dummies and a dummy variable which indicates whether also the source country belongs to the OECD. Second, we take past migration stocks rather than rates as instruments for the contemporaneous high-skilled emigration rate. Third, we employ an alternative emigration data set by Defoort (2006) while constructing the migration proxies in a similar way as in Tab. 4. Significance and size of the coefficients of interest remain similar in all of these alternative estimations.

< Table 5 >

Finally, we instrument the high-skilled emigration rate in 1990 ($M_{ij,1990}$) rather than the one in 2000 ($M_{ij,2000}$) to capture transitional dynamics in the theoretical model, again employing the proxies for total emigration in 1960. By doing so, we address potential endogeneity problems in the estimates in Tab. 2 using $M_{ij,1990}$, which may arise despite the lag of 10 years to the dependent variable. The results are presented in Tab. 5. They show similar results to Tab. 4. Again, the size of the coefficient of interest, $\beta_1$, in the IV-estimates are higher than those in the OLS-estimates of Tab. 2.

7 Concluding Remarks

In this paper we analyzed the dynamic interaction between migration of high-skilled workers and relative wage income between source and destination economies of expatriates. Our theoretical model showed that a decline in mobility costs not only intensifies the emigration pressure for economies already suffering from brain drain, but also ad-
versely affects total factor productivity in the source economy and therefore may give rise to future emigration. Theoretically, this holds true also if economies optimally adjust their productivity-enhancing public expenditure levels. We also provided empirical support which is consistent with the main predictions of the proposed theory. Using a data set on bilateral emigration of skilled workers, our results suggests that an increase in high-skilled emigration rates reduces wage income for skilled workers in the source country relative to that in the destination country.

Our analysis therefore suggests that integration of labor markets for high-skilled workers accentuates between-country wage income inequality. Therefore, the recent movement of the EU to attract high-skilled workers may have first-order detrimental effects even for skilled workers in developing countries. One cannot rule out, however, that countries which have seen a large outflow of skilled workers in the more recent past may benefit in the longer run from return migration, remittances, or increased education levels. Such effects take time and may not yet have been reflected in our empirical analysis.

Appendix

Proof of Lemma 1. Factor prices in the final goods sector equal marginal productivities; thus, $w_H = \beta Y / H_Y$ and $w_L = (1 - \alpha - \beta) Y / L_Y$. Using (7), we find that the relative input of the two types of labor in the domestic economy is independent of the level of migration:

$$\frac{H_Y}{L_Y} = \frac{\beta(1 - e)}{1 - \alpha - \beta}.$$  \hfill (30)

From the inverse demand function of any intermediate good firm $j$, optimal price $p(j) = r / \alpha$ and the production function in the final goods sector (3) we find

$$x_{t-1}(j) = \left( \frac{\alpha^2}{(1 + r)r} \right)^{\frac{1}{1 - \alpha}} \left( \frac{H_{Y,t}}{L_{t,Y}} \right)^{\frac{\beta}{1 - \alpha}} A_y L_{Y,t} \equiv \bar{x}_{t-1}.$$  \hfill (31)
The production function for the capital good, (4), implies that \( X_t = n_{t-1} (\bar{x}_{t-1})^{1/\alpha} \)
Substituting this into (3) and using both (30) and (31) leads to

\[
Y_t = n_{t-1} \left( \frac{\alpha^2}{(1 + r)r} \right)^{\frac{\alpha}{1 - \alpha}} \left( \frac{\beta(1 - e)}{1 - \alpha - \beta} \right)^{\frac{\beta}{1 - \alpha}} A_t L_Y t.
\]  

Substituting (32) into \( w_L = (1 - \alpha - \beta) Y/L \) and combining the resulting expression with \( w_H = \frac{w_L}{1 - e} \) from (7) confirms (14).

Expression (16) follows from substituting (14) into (13) and using \( w_{net}^H = (1 - \tau) w_H \).

To confirm (15), first, insert \( H = 1 - L \) in (12) and use both (30) and (11) to find

\[
L_Y = L = \frac{1 - \alpha - \beta}{1 - \alpha} \left( 1 - m - \frac{nf}{1 - e} \right).
\]  

Next, we employ the zero-profit condition for intermediate good firms, \( \pi(j) = 0 \), or \( (p(j) - r) x(j) = w_H f \), according to (10). Substituting into the latter equation \( p(j) = \frac{r}{\alpha} \), the expression for \( x(j) \) in (31) and the expression for \( w_H \) in (14), as well as using (30) and (33) leads to

\[
\frac{\alpha(1 - e)}{1 + r} \left( 1 - m_t - \frac{n_tf}{1 - e} \right) = n_{t-1} f.
\]  

Substituting (16) into (34) and solving for \( n_t \) we obtain (15). From (15), it it is straightforward to derive the claimed properties of function \( Z(n) \).

**Proof of Proposition 1.** According to Lemma 1, function \( Z \) starts at zero and initially has a slope above unity which eventually turns negative. Because we know that, in addition, \( Z'' < 0 \) holds under (A1), there is a single non-zero value \( n^* \) which fulfills \( Z(n^*) = n^* \). This confirms part (i). To confirm part (ii), note from the definition of \( Z \) in (15) that the value of \( Z \) decreases for each \( n > 0 \) if mobility costs decline and employ Fig. 1. Part (iii) can immediately be inferred from Fig. 1.

**Proof of Proposition 2.** First, note from the definition of \( G_1 \) that it is given by \( w_G(G_1, n_1) = 0 \) (recall \( w_{GG} < 0 \)). Recalling \( n_1 < n_0 \) and \( w_{Gn} > 0 \) confirms (24).
In steady state, the first-order condition to the maximization of $W(G, \chi)$ reads

$$[W_G(G, \chi) = ] w_G(G, \hat{n}(G, \chi)) + w_n(G, \hat{n}(G, \chi))\hat{n}_G(G, \chi) = 0, \quad (35)$$

according to (22). Applying the implicit function theorem to (21), we obtain:

$$\hat{n}_G(G, \chi) = \frac{\Gamma_G(G, \hat{n}, \chi)}{1 - \Gamma_n(G, \hat{n}, \chi)}. \quad (36)$$

Note that the denominator is positive in a stable steady state equilibrium ($\Gamma_n(G, \hat{n}, \chi) < 1$). Moreover, from (20) we find

$$\Gamma_G(G, \hat{n}, \chi) = -\frac{1 - e}{f} \chi q'(w(G, \hat{n})) w_G(G, \hat{n}). \quad (37)$$

Substituting (36) into (35) and using (37), we can rewrite the first-order condition to

$$w_G(G, \hat{n}) \left[ 1 - \frac{1 - e}{f} \chi q'(w(G, \hat{n})) \frac{w_n(G, \hat{n})}{1 - \Gamma_n(G, \hat{n}, \chi)} \right] = 0. \quad (38)$$

Define $G^*(\chi) \equiv \arg \max_G W(G, \chi)$ as the optimal log-run public investment level. Suppose that $G^*$ is given by first-order condition (35). (It will become apparent that the second-order condition indeed holds.) As the term in squared brackets in (38) is positive, we find that $G^*$ is given by

$$w_G(G^*, \hat{n}(G^*, \chi)) = 0. \quad (39)$$

Thus, we also have $\hat{n}_G(G^*, \chi) = 0$, according to (36) and (37).

We next show that the second-order condition holds, i.e., $W_{GG}(G^*, \chi) < 0$. To see this, note that $\hat{n}_G(G^*, \chi) = 0$ implies that $W_G(G^*, \chi) = w_G(G^*, \hat{n}(G^*, \chi))$ when $G^*$ is given by first-order condition (35). Hence,

$$W_{GG}(G^*, \chi) = (w_{GG} + w_{Gn}\hat{n}_G)|_{G=G^*}. \quad (40)$$

Using again $\hat{n}_G(G^*, \chi) = 0$, we thus have $W_{GG}(G^*, \chi) = (w_{GG})|_{G=G^*}$. Recalling that $w_{GG} < 0$ confirms that the second-order condition holds.
Moreover, we have
\[ W_{G\chi}(G^*, \chi) = (w_{Gn}\hat{n}_\chi)|_{G=G^*}. \] (41)

Thus,
\[ \frac{dG^*(\chi)}{d\chi} = -\frac{W_{G\chi}(G^*, \chi)}{W_{GG}(G^*, \chi)} = \left( -\frac{w_{Gn}\hat{n}_\chi}{w_{GG}} \right)|_{G=G^*}. \] (42)

Since \( w_{GG} < 0, w_{Gn} > 0 \) and \( \hat{n}_\chi < 0 \), we find that \( G^* \) is decreasing with \( \chi \), which confirms (25) and concludes the proof of part (i).

To prove part (ii), recall first that \( w_n > 0 \). Since public investment is chosen optimally before and after the change in the degree of labor market integration (\( w_G(G_1, n_1) = w_G(G_0, n_0) = 0 \)) and \( n_1 < n_0 \), we have \( w(G_1, n_1) < w(G_0, n_0) \) for the net wage rate. For the level of emigration, according to (19) and property \( q' < 0 \), this implies
\[ m_1 = \chi_1 q(w(G_1, n_1)) > \chi_0 q(w(G_0, n_0)) = m_0. \] (43)

This confirms the result for the subsequent period after labor market integration.

Now write \( G^*(\chi) \) as the function which is implicitly defined by \( \hat{n}_G(G^*, \chi) = 0 \) and define \( W^*(\chi) \equiv W(G^*(\chi), \chi) \). \( W^*(\chi) \) is the steady state value of the net wage rate \( w_{\text{net}} \) when \( G \) is chosen optimally. We find that
\[ \frac{dW^*}{d\chi} = W_G(G^*, \chi) \frac{dG^*}{d\chi} + W_\chi(G^*, \chi). \] (44)

Note that \( W_G(G^*, \chi) = 0 \) and \( W_\chi(G^*, \chi) = w_n\hat{n}_\chi|_{G=G^*} < 0 \), where the latter is implied from using definition (22) together with \( \hat{n}_G(G^*, \chi) = 0 \). Thus, \( dW^*/d\chi < 0 \). Moreover, note that the steady state number of migrants is given by
\[ m^*(\chi) \equiv \chi q(W^*(\chi)), \] (45)

under the optimal choice of \( G \). Using \( q' < 0 \) then implies that \( m^* \) is increasing in \( \chi \). This concludes the proof.

**Proof of Corollary 1.** Using (36) and (37) together with \( w_G(G^*, \hat{n}) = \hat{n}_G(G^*, \chi) = 0 \), it is easy to confirm that \( \hat{n}_{GG}(G^*, \chi) < 0 \), by utilizing property \( w_{GG} < 0 \). This shows
that $G^\ast$, which is given by (39), maximizes $\hat{n}(G, \chi)$. □

**Proof of Proposition 3.** Analogously to (20), by using (26), the difference equation for the evolution of $n$ can be written as

$$n_t = \frac{1 - e}{f} \left[ 1 - \chi q(\bar{w}(G_t, B_t, n_{t-1})) \right] - \frac{1 + r}{\alpha} n_{t-1} \equiv \tilde{\Gamma}(G_t, B_t, n_{t-1}, \chi). \quad (46)$$

For a given fiscal policy, $(G, B)$, the steady state number of firms, $n^\ast$, is implicitly defined by $n^\ast = \tilde{\Gamma}(G, B, n^\ast, \chi)$, where stability requires that $\tilde{\Gamma}_n(G, B, n^\ast, \chi) < 1$. $n^\ast$ is a function of $(G, B, \chi)$ which is denoted by $\hat{n}(G, B, \chi)$. Substituting $m = \chi q(w_{net}^H)$ and (26) into (27), long run welfare can be written as

$$W(G, B, \chi) \equiv v((1 - e)\bar{w}(G, B, \hat{n}(G, B, \chi))) - \xi(\chi q(\bar{w}(G, B, \hat{n}(G, B, \chi)))) - \psi(B). \quad (47)$$

Since the economy is initially in a stable steady state, initially, fiscal policy is given by

$$(G_0^\ast, B_0^\ast) \equiv \arg \max_{(G, B)} W(G, B, \chi_0). \quad (48)$$

Thus, the initial number of firms is $n_0 = \hat{n}(G_0^\ast, B_0^\ast, \chi_0) = \tilde{\Gamma}(G_0^\ast, B_0^\ast, n_0, \chi_0)$. Moreover, if labor market integration shifts from $\chi_0$ to $\chi_1 > \chi_0$, we have $n_1 = \hat{n}(G_1^\ast, B_0^\ast, n_0, \chi_1) < n_0$, according to (46). Also define

$$\tilde{W}(G, B, n) \equiv v((1 - e)\bar{w}(G, B, n)) - \xi(\chi q(\bar{w}(G, B, n))) - \psi(B) \quad (49)$$

and

$$(G_1, B_1) \equiv \arg \max_{(G, B)} W(G, B, n_1). \quad (50)$$

First-order conditions to the maximization problem in (50) are:

$$\tilde{W}_G = [\nu'(1 - e)\bar{w})(1 - e) - \xi'(\chi q(\bar{w}))\chi q'(\bar{w})] \bar{w}_G = 0, \quad (51)$$

$$\tilde{W}_B = [\nu'(1 - e)\bar{w})(1 - e) - \xi'(\chi q(\bar{w}))\chi q'(\bar{w})] \bar{w}_B - \psi'(B) = 0. \quad (52)$$
Since the term in squared brackets in (51) and (52) is positive (recall $v' > 0$, $\xi' > 0$, $q' < 0$), we have $\bar{w}_G(G_1, B_1, n) = 0$. Together with $\bar{w}_{GB} = 0$, we thus find that $W_{GB}(G_1, B_1, n_1) = 0$. Moreover, $W_{GG}(G_1, B_1, n_1) < 0$ and $W_{Gn}(G_1, B_1, n_1) > 0$ since $\bar{w}_{GG} < 0$ and $\bar{w}_{Gn} > 0$, respectively. Thus, $G_1$ is decreasing in $n_1$. Since $n_1 < n_0$, it follows that $G_1 < G_0$. Moreover, we have

$$\bar{w}_{BB} = [(1-e)^2v'' - \xi''(\cdot)\chi q' - \xi'\chi q''] (\bar{w}_B)^2 - \psi'' < 0, \quad (53)$$

$$\bar{w}_{Bn} = [(1-e)^2v'' - \xi''(\cdot)\chi q' - \xi'\chi q''] \bar{w}_n \bar{w}_B < 0 \quad (54)$$

(recall $\bar{w}_{BB} = 0$, $v'' < 0$, $\xi'' \geq 0$, $q'' > 0$, $\psi'' \geq 0$). Thus, $B_1$ is decreasing in $n_1$. Since $n_1 < n_0$, it follows that $B_1 > B_0^*$. It remains to be shown that long run effects are ambiguous. The first-order conditions to the problem of maximizing long run welfare (47)), $W(G, B, \chi)$, with respect to $(G, B)$, are:

$$W_G = [v'((1-e)\bar{w})(1-e) - \xi'(\chi q(\bar{w}))\chi q'(\bar{w})] (\bar{w}_G + \bar{w}_n \bar{n}_G) = 0, \quad (55)$$

$$W_B = [v'((1-e)\bar{w})(1-e) - \xi'(\chi q(\bar{w}))\chi q'(\bar{w})] (\bar{w}_B + \bar{w}_n \bar{n}_B) - \psi'(B) = 0. \quad (56)$$

According to (46), we have

$$\bar{n}_G = -\frac{1-e}{1-\Gamma} \chi q'(\bar{w}) \bar{w}_G \quad \text{and} \quad \bar{n}_B = -\frac{1-e}{1-\Gamma} \chi q'(\bar{w}) \bar{w}_B > 0. \quad (57)$$

The latter inequality follows from $\Gamma < 1$ (which holds in stable steady state), $q' < 0$ and $\bar{w}_B > 0$. Using (57) in (55) and (56), we can write

$$W_G = \Omega \Theta \bar{w}_G = 0, \quad (58)$$

$$W_B = \Omega \Theta \bar{w}_B - \psi'(B) = 0, \quad (59)$$
where

\[
\Omega \equiv [v'((1 - e)\bar{w})(1 - e) - \xi'(\chi q(\bar{w}))\chi q'(\bar{w})]|_{n=n^*},
\]

\[
\Theta \equiv \left(1 - \frac{1 - e}{1 - \Gamma_n}\right)|_{n=n^*}.
\]

Note that $\Omega > 0$ and $\Theta > 0$. Thus, at the optimal long run levels $(G^*, B^*)$, it holds that $\bar{w}_G = \bar{n}_G = 0$. This implies

\[
W_{GG}|_{(G^*, B^*)} = \Omega \Theta \bar{w}_{GG} < 0,
\]

\[
W_{GB}|_{(G^*, B^*)} = \Omega \Theta (\bar{w}_{GB} + \bar{w}_{Gn}\bar{n}_B) > 0,
\]

where the inequality in (62) follows from $\bar{w}_{GG} < 0$ and the one in (62) from $\bar{w}_{GB} = 0$, $\bar{w}_{Gn} > 0$, $\bar{n}_B > 0$. Moreover,

\[
W_{G\chi}|_{(G^*, B^*)} = \Omega \Theta \bar{w}_{Gn}\bar{n}_\chi < 0,
\]

where the inequality follows from $\bar{w}_{Gn} > 0$ and

\[
\bar{n}_\chi = -\frac{1 - e}{f}\frac{q(\bar{w})}{1 - \Gamma_n} < 0.
\]

Next, note that

\[
\frac{\partial \Omega}{\partial B} = [(1 - e)^2v'' - \xi''\chi^2q'(\cdot)^2 - \xi'\chi q''(\cdot)](\bar{w}_B + \bar{w}_n\bar{n}_B),
\]

\[
\frac{\partial \Omega}{\partial \chi} = (1 - e)^2v''\bar{w}_n\bar{n}_\chi - \xi''\chi q'[g + \chi q'\bar{w}_n\bar{n}_\chi] - \xi'[q' + \chi q''\bar{w}_n\bar{n}_\chi],
\]

\[
\frac{\partial \Theta}{\partial B} = -\frac{1 - e}{f}\chi (\bar{w}_B + \bar{w}_n\bar{n}_B)(1 - \Gamma_n) + q'(\bar{\Gamma}_{nB} + \bar{\Gamma}_{nn}\bar{n}_B)
\]

\[
\frac{\partial \Theta}{\partial \chi} = -\frac{1 - e}{f}\left[q' + \chi q''\bar{w}_n\bar{n}_\chi\right] (1 - \Gamma_n) + \chi q'(\bar{\Gamma}_{n\chi} + \bar{\Gamma}_{nn}\bar{n}_\chi).
\]

From $v'' < 0$, $\xi'' \geq 0$, $q' < 0$, $\xi' \geq 0$, $q'' > 0$, $\bar{w}_B > 0$, $\bar{w}_n > 0$, $\bar{n}_B > 0$, $\bar{n}_\chi < 0$, we find

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that \( \partial \Omega / \partial B < 0 \) and \( \partial \Omega / \partial \chi > 0 \). Moreover, using the definition of \( \tilde{\Gamma} \) in (46), we have

\[
\tilde{\Gamma}_n = -\frac{1-e}{f} \chi q'(\tilde{w}) \tilde{w}_n - \frac{1+r}{\alpha}.
\]

Thus, recalling \( \tilde{w}_B > 0, \tilde{w}_n > 0, \tilde{w}_{nn} = 0, \tilde{n}_B > 0, \tilde{n}_\chi < 0, q' < 0, q'' > 0 \), we find

\[
\tilde{\Gamma}_{nB} = -\frac{1-e}{f} \chi q''(\tilde{w}_B + \tilde{w}_n \tilde{n}_B) < 0,
\]

\[
\tilde{\Gamma}_{nn} = -\frac{1-e}{f} \chi [q''(\tilde{w}_n)^2 + q' \tilde{w}_{nn}] < 0,
\]

\[
\tilde{\Gamma}_{n\chi} = -\frac{1-e}{f} q' \tilde{w}_n > 0.
\]

Thus, \( \partial \Theta / \partial B < 0 \) and \( \partial \Theta / \partial \chi > 0 \). Recalling \( \tilde{w}_{BB} = \tilde{w}_{Bn} = 0 \) and \( \psi'' \geq 0 \), we then have

\[
W_{BB} = \frac{\partial \tilde{\Omega}}{\partial B} \tilde{w}_B + \Omega \frac{\partial \tilde{\Theta}}{\partial B} \tilde{w}_B + \Omega \tilde{\Theta} (\tilde{w}_{BB} + \tilde{w}_{Bn} \tilde{n}_B) - \psi''(B) < 0,
\]

\[
W_{B\chi} = \frac{\partial \tilde{\Omega}}{\partial \chi} \tilde{w}_B + \Omega \frac{\partial \tilde{\Theta}}{\partial \chi} \tilde{w}_B + \Omega \tilde{\Theta} \tilde{w}_{Bn} \tilde{n}_\chi > 0.
\]

Note that concavity of \( W \) as a function of \((G, B)\) requires that \( W_{GG} W_{BB} - (W_{GB})^2 > 0 \). According to Cramer’s rule, we then have

\[
\text{sgn} \left( \frac{dG^*}{d\chi} \right) = \text{sgn} \left( -W_{G\chi} W_{BB} + W_{BG} W_{B\chi} \right)_{|_{(G^*, B^*)}},
\]

\[
\text{sgn} \left( \frac{dB^*}{d\chi} \right) = \text{sgn} \left( -W_{GG} W_{B\chi} + W_{GB} W_{G\chi} \right)_{|_{(G^*, B^*)}}.
\]

Thus, using the previous results on the signs of the second derivatives on the right hand sides of (75) and (76) confirms that long run effects of labor market integration on fiscal variables are ambiguous. This confirms part (i).

To prove part (ii), first note that analogously to the proof of part (ii) of Proposition 2, \( n_1 < n_0 \) implies that \( w_H^{net} \) declines and \( m \) increases in the period subsequent to labor market integration. To show the result for the steady state, define \( W^*(\chi) \equiv \)
\[ W(G^*(\chi), B^*(\chi), \chi) \]. We find that
\[
\frac{dW^*}{d\chi} = W_G(G^*, B^*, \chi) \frac{dG^*}{d\chi} + W_B(G^*, B^*, \chi) \frac{dB^*}{d\chi} + W_{\chi}(G^*, B^*, \chi),
\]  
(77)

where \( W_G = W_B = 0 \) at \((G^*, B^*)\) and, according to (47),

\[
W_{\chi} = (1 - e)v'\tilde{w}_n\tilde{n}_\chi - \xi'[q + \chi q'\tilde{w}_n\tilde{n}_\chi] < 0.
\]  
(78)

Thus, \( dW^*/d\chi < 0 \). Analogously to the proof of Proposition 2, together with (45) for the steady state level of migration, this concludes the proof. ■

References


Figure 1
Dynamic adjustment of the number of intermediate good firms to a decline of mobility costs

Note: Subscripts “0” and “1” refer to the initial and new steady state, respectively.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description and source</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
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<tbody>
<tr>
<td>Mig2000&lt;sub&gt;ij&lt;/sub&gt;</td>
<td>Stock of emigrants of educational category “high” aged 25+ born in country &lt;i&gt;i&lt;/i&gt; and living in OECD country &lt;i&gt;j&lt;/i&gt; in year 2000 [1990] divided by stock of residents of educational category “high” in country &lt;i&gt;i&lt;/i&gt; in year 2000 [1990]. Stock of emigration and stock of residents of educational category “high” from Docquier, Marfouk and Lowell (2007).</td>
<td>3052</td>
<td>0.0246</td>
<td>0.1909</td>
</tr>
<tr>
<td>RelWage80&lt;sub&gt;ij&lt;/sub&gt;</td>
<td>Log of wage in 80th percentile of country &lt;i&gt;j&lt;/i&gt; minus log of wage in 80th percentile of country &lt;i&gt;i&lt;/i&gt; in year 2000. Wage data from Occupational Wages around the World (OWW) Database.</td>
<td>1247</td>
<td>1.2650</td>
<td>1.4945</td>
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<tr>
<td>RelWage90&lt;sub&gt;ij&lt;/sub&gt;</td>
<td>Log of wage in 90th percentile of country &lt;i&gt;j&lt;/i&gt; minus log of wage in 90th percentile of country &lt;i&gt;i&lt;/i&gt; in year 2000. Wage data from Occupational Wages around the World (OWW) Database.</td>
<td>1247</td>
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<td>RelGDP&lt;sub&gt;ij&lt;/sub&gt;</td>
<td>Log of GDP per capita of country &lt;i&gt;j&lt;/i&gt; minus log of GDP per capita of country &lt;i&gt;i&lt;/i&gt; in year 2000. GDP data from Penn World Table Version 6.2.</td>
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<td>Primary school enrolment in country &lt;i&gt;j&lt;/i&gt; divided by primary school enrolment in country &lt;i&gt;i&lt;/i&gt; in year 1990. Primary school enrolment rate from Global Development Finance &amp; World Development Indicators.</td>
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<td>Investment share in country &lt;i&gt;j&lt;/i&gt; divided by investment share in country &lt;i&gt;i&lt;/i&gt; in year 1990. Investment share from Penn World Table Version 6.2.</td>
<td>3052</td>
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<td>RelUrban1990&lt;sub&gt;ij&lt;/sub&gt;</td>
<td>Urban population share in country &lt;i&gt;j&lt;/i&gt; divided by urban population share in country &lt;i&gt;i&lt;/i&gt; in year 1990. Urban population share from Global Development Finance &amp; World Development Indicators.</td>
<td>3013</td>
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<td>Log of public investment per capita of country &lt;i&gt;j&lt;/i&gt; minus log of public investment per capita in country &lt;i&gt;i&lt;/i&gt; in year 1990. Public investment measured as government gross fixed capital formation from OECD Economic Outlook.</td>
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<td>667</td>
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<td>1.2264</td>
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<td>TotalMig&lt;sub&gt;ij&lt;/sub&gt;</td>
<td>Emigrant population from country &lt;i&gt;i&lt;/i&gt; living in country &lt;i&gt;j&lt;/i&gt; divided by population in 1000 of country &lt;i&gt;i&lt;/i&gt; in year 1990. Docquier, Marfouk and Lowell (2007).</td>
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<td>11.1509</td>
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<tr>
<td>Dist&lt;sub&gt;ij&lt;/sub&gt;</td>
<td>Log geodesic distance in kms between country &lt;i&gt;i&lt;/i&gt; and &lt;i&gt;j&lt;/i&gt;. Mayer and Soledad (2006).</td>
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<tr>
<td>Contig&lt;sub&gt;ij&lt;/sub&gt;</td>
<td>Dummy variable capturing if country &lt;i&gt;i&lt;/i&gt; and &lt;i&gt;j&lt;/i&gt; are contiguous. Mayer and Soledad (2006).</td>
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Notes: The range, mean and standard deviations are not weighted and based on the respective number of observations. Destination countries are the 30 OECD members. Total number of observations depends on data availability for destination and source countries. An observation is excluded if bilateral data is not available or source country does not have any emigrant in destination country.
**Table 2**

Effect of high skilled emigration rates on income differences between countries

<table>
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<tr>
<th>Variable</th>
<th>OLS (1)</th>
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**Notes:** Robust clustered standard errors in parenthesis. * indicates a significance level of below 1 %; b indicates a significance level between 1 and 5 %; c indicates significance level between 5 and 10 %.
Table 3
Effect of high skilled emigration rates on income differences between countries (instrumental variable estimations)

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<th>IV (3)</th>
<th>IV (4)</th>
<th>IV (5)</th>
<th>IV (6)</th>
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Notes: Robust clustered standard errors in parenthesis. * indicates a significance level of below 1 %; b indicates a significance level between 1 and 5 %; c indicates significance level between 5 and 10 %. All estimations include RelPrimSchool1990ij, RelTertSchool1990ij, RelInvest1990ij and RelUrban1990ij as additional control variables.
### Table 4
Effect of high skilled emigration rates on income differences between countries (use of proxies)

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Notes: Robust clustered standard errors in parenthesis. * indicates a significance level of below 1%; b indicates a significance level between 1 and 5%; c indicates significance level between 5 and 10%. All estimations include RelPrimSchool1990ij, RelTertSchool1990ij, RelInvest1990ij, and RelUrban1990ij as additional control variables.
Table 5
Effect of high skilled emigration rates in 1990 on income differences between countries (use of proxies)

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First stage results (partial correlations)

| TotalMigij         | 0.0002a | 0.0002a | 0.0015a | 0.0002a | 0.0002a | 0.0015a | 0.0001a | 0.0001a | 0.0011a |
| Distij             | -0.0162 | -0.0162 | -0.0162 | -0.0162 | -0.0162 | -0.0162 | -0.0266a | -0.0266a | -0.0266a |
| ComLangijij        | 0.1522b | 0.1522b | 0.1522b | 0.1522b | 0.1522b | 0.1522b | 0.1147a | 0.1147a | 0.1147a |
| Contigijij         | -0.0628 | -0.0628 | -0.0628 | -0.0628 | -0.0628 | -0.0628 | -0.0674b | -0.0674b | -0.0674b |

Notes: Robust clustered standard errors in parenthesis. * indicates a significance level of below 1 %; b indicates a significance level between 1 and 5 %; c indicates significance level between 5 and 10 %; d indicates significance level between 10 and 15 %. All estimations include RelPrimSchool1990ij, RelTertSchool1990ij, RelInvest1990ij, and RelUrban1990ij as additional control variables.
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<th>IV (^{(2)})</th>
<th>IV (^{(3)})</th>
<th>IV (^{(4)})</th>
<th>IV (^{(5)})</th>
<th>IV (^{(6)})</th>
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<td>0.1957(^{a})</td>
<td>0.1922(^{a})</td>
<td>0.1554(^{a})</td>
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<td>-0.4530(^{a})</td>
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Notes: Robust clustered standard errors in parenthesis. \(^{a}\) indicates a significance level of below 1 %; \(^{b}\) indicates a significance level between 1 and 5 %; \(^{c}\) indicates significance level between 5 and 10 %.
### Table S2
Effect of high skilled emigration rates on income differences between countries (log emigration stock as instrument)

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Notes: Robust clustered standard errors in parentheses. * indicates a significance level of below 1%; <sup>b</sup> indicates a significance level between 1 and 5%; <sup>c</sup> indicates significance level between 5 and 10%.
Table S3  
Effect of high skilled emigration rates on income differences between countries (Proxy constructed with Defoort, 2006 emigration rates)

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<th>(5)</th>
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<td>Adj. R2</td>
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<td>0.8531</td>
<td>0.8516</td>
<td>0.8508</td>
<td>0.9424</td>
<td>0.9424</td>
</tr>
<tr>
<td>Destination clusters</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>F-Test (first stage)</td>
<td>15.22</td>
<td>17.33</td>
<td>15.22</td>
<td>17.3</td>
<td>14.804</td>
<td>14.43</td>
</tr>
<tr>
<td>J-Test</td>
<td>0.9377</td>
<td>0.7770</td>
<td>0.7770</td>
<td>0.4656</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: Robust clustered standard errors in parenthesis. \(^a\) indicates a significance level of below 1%; \(^b\) indicates a significance level between 1 and 5%; \(^c\) indicates significance level between 5 and 10%. Instruments constructed as described in text but with Defoort (2006) data on emigration instead of the United Nations Population Division.