

Growth (Rate) Effects of Migration*

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1. Introduction

Large income gaps between developed and developing countries have for a long time created a large potential for migration flows, which have been, until now, more or less strictly controlled by migration barriers. Two recent events have contributed to an even larger potential for migration flows. On the one hand, deepening and enlargement of regional integration (e.g. in the European Union) allow for more freedom of movement of labor. On the other hand, since the collapse of the communist regimes in Eastern Europe, a large potential for migration in an East-West direction has emerged.

Straubhaar/Zimmermann (1992) estimate that potentially about 60 million people want to migrate to the developed countries. According to *Layard et al.* (1992) roughly 13 million Eastern European migrants can be expected to try to move into the developed European countries from Eastern Europe in the next 15 years. Therefore, the discussion of the impact of migration streams on the host as well as on the source country is of growing importance.

The analysis of the effects on the economies involved can also provide the grounds for the assessment of existing migration policies and the establishment of future ones. The question arises not only about the extent of the in- or outflow but also whether or under what circumstances a selective migration policy as practiced to a certain extent in the U.S. [cf. *Borjas* (1991)] might be sensible and feasible.

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This paper aims to analyze the long-term effects of migration. We look at the growth effects of migration in the host as well as in the source country. By using a two-country, endogenous growth framework, we are able to analyze the impact of migration on the steady-state growth rates. Growth rate effects can be far more important than the level effects [cf. *Romer (1990)*].

By investigating the growth effects of migration, we attempt to fill a gap in the economic analysis of migration flows. The existing economics literature is almost entirely of static nature. The trade literature treats various issues concerning the effects of migration – such as its impact on factor prices [cf. e.g. *Gerking/Mutti (1983)*], on international specialization patterns, and on the welfare of the country of origin [cf. e.g. *Rivera-Batiz (1982)*] as well as the source country [cf. e.g. *Grossman (1984)*]. There are also a number of papers dealing with migration policy issues [cf. e.g. *Kuhn/Wooton (1987)*]. In a recent contribution, *Glomm (1992)* analyzes the relation between international migration and growth. But, in his framework, migration only increases the speed of convergence towards the steady-state. The steady-state growth rate, however, is unaffected by migration in his approach.

Another branch of the literature related to our approach is the “brain drain literature”. Brain drain describes the migration of skilled people from developing countries to industrial nations. These papers are mainly concerned with the welfare effects of brain drain on the source country [cf. e.g. *Kenen (1971)*, *Bhagwati/Hamada (1974)*, and *Hamada/Bhagwati (1975)*]. A general conclusion is that in the absence of any distortion emigration of a large number of skilled people reduces the welfare of those left behind. Brain drain might, however, be beneficial to the remaining residents in the source country in the presence of distortions. *Goldfarb et al. (1984)*, for example, discuss the beneficial effects of remittances from emigrated skilled persons while allowing for distortions in the developing country. In more recent papers, *Kwok/Leland (1982)* and *Miyagiwa (1991)* investigate the causes of brain drain. By endogenizing skill formation, *Miyagiwa (1991)* uses an approach rather closely related to our approach. In his model, however, investment in education is analyzed in a static framework. We extend the existing literature in various aspects. First, we endogenize skill formation in an intertemporal framework. Current costs of education are contrasted with future earnings. Second, we provide a self-selection mechanism of migration. People of different abilities and educational backgrounds experience different gains from migration. Gradual liberalization of migration impediments acts as a screening device. We provide a further explanation of brain drain. Expected gains from migration are larger for educated, high ability people than for other population groups. Third, and most importantly, we concentrate on the dynamic effect (the growth rate effect) of migration in the source as well as in the host country.

Our dynamic general-equilibrium framework rests upon two pillars. First, it relies on the investment decisions of people during their education to become skilled workers. Thereby, we adapt the approach of *Findlay/Kierzkowski* (1983). Individuals face the alternative of investing in education and becoming skilled workers, or not investing and thus remaining unskilled workers. We extend this approach by introducing two types of people. These two types differ in their respective productivity levels in the educational process. Using this difference, it is possible to assess which type of individuals will migrate after a gradual relaxation of migration policies. Furthermore, we can address the implications of migration in different situations. The second pillar is the assumption of knowledge-creating externalities in the educational sector. Here, we pursue two ideas. On the one hand, we use the idea that migration is accompanied by a transfer of human capital and might, therefore, contribute positively to the growth process in the host country. By relying on average human capital as the main determinant of the knowledge accumulation process, we exclude pure size effects of migration. On the other hand, we endogenize the composition of the labor endowment in each country by modeling investment decisions in education.

We prove that migration acts as a screening device. Migration is, in most cases, positively selective. Therefore, we can endogenize the characteristics of migrants, depending on the economic situation prevailing in host and source country. We model this selection process in a dynamic general-equilibrium framework. This contrasts with *Borjas* (1987) who employs a static and partial-equilibrium approach.

We show that migration can have positive as well as negative effects on the growth rates of the countries. The sign of the growth rate effect depends on, among other things, the initial specialization patterns of the two countries. The overall growth rate can rise as a consequence of migration. We argue that by taking growth effects into account, migration could make everybody better off.

The plan of the paper is as follows. In the next section, the basic model is outlined. In section 3, the existence and uniqueness of the steady-state equilibrium is derived. In section 4 we show that the liberalization of migration policy acts as a self-selection mechanism. Thereby, we determine the group of individuals which will migrate given the economic situation in host and source country. Section 5 analyzes the growth-rate effects of migration. In section 6 we look at the welfare implications of migration. The last section gives a brief summary of the main findings.

2. The Basic Set-Up

We provide a endogenous growth model for two countries. To keep the analysis simple, we assume that due to technological differences country *A* specializes in the production of good *Y* whereas country *B* specializes in the production of the other final good, *Z*. Initially the two countries are separated by impenetrable migration barriers. These migration barriers can be interpreted as natural migration costs or artificial restrictions imposed by the countries' governments. Later on, we will gradually relax these barriers and investigate the long-term implications of migration for the source as well as the host country. The gradual relaxation of migration barriers may either reflect a liberalization of migration barriers or an exogenous reduction of natural migration costs (e.g. the convergence of culture between the two countries).

Besides the consumption goods sectors an education sector exists in each country. Individuals have to decide whether they will invest in training at the beginning of their working-life or work for their entire life-span as unskilled workers. In the education sector they obtain skills which enable them to work as skilled workers. Hence, the total number of individuals in each country $i (i = A, B)$, L_i , is split up into individuals deciding to work as unskilled workers, L_i^U and individuals investing in education, $L_i^S (L_i^S = L_i - L_i^U)$. The level of skills obtained in the education process will be determined later on. An essential component in our model is the heterogeneity of agents. There are two classes of individuals in each country i , differing with respect to their respective productivity coefficient $a_j (j = 1, 2)$ in the skill formation process.¹ Type 1 has a relative advantage in the human-capital formation process compared to type 2 ($a_1 > a_2$). This limitation to only two classes of individuals keeps the model simple and still enables us to elaborate on the main economic issues at stake. Let L_{ji} denote the absolute number of people of type j in country i . We assume that the relative number of people of type 1 in the entire population in the respective country, $\lambda_i = L_{1i}/L_i$, is stationary over time and equal in both countries. A possible justification for stationarity is the fiction that abilities are specific to families.² For our purposes, however, it suffices that in the long run abilities

¹ The subscript $j (j = 1, 2)$ characterizes variables related to the respective group of individuals, whereas the subscript $i (i = A, B)$ represents the respective country. We omit country subscripts if the respective variable is identical across countries.

² On this point, see also *Becker et al.* (1991). There it is argued that the parents' human capital positively influences the human-capital endowment of the children. The present specification can therefore be interpreted as a two-stage education. In the first stage, childhood, parents with higher abilities in human-capital formation pass on to their children a better starting position for the subsequent (higher) education process (the second stage) than parents with fewer skills by means of education at home, higher preferences for education, genes, etc. Here, only the second stage is explicitly modeled.

do not converge to each other. The assumption of a stationary distribution then seems to be a valid approximation. The assumption that abilities are distributed non-uniformly is employed in a variety of migration models [cf., e.g., *Miyagiwa* (1991)]. Relaxing the assumption of an equal distribution of abilities in each country – which serves mainly to simplify the analysis – would not affect our qualitative results.

There is no natural population growth in either country. Each individual lives for Γ -periods. Fertility and mortality rates just balance out. Each individual inelastically supplies one unit of time in each period either for production purposes or for training in the education sector.

Individuals maximize their identical intertemporal utility function at time t :

$$(1) \quad U_t = \int_t^{t+\Gamma} e^{-\rho(\tau-t)} (\sigma \ln C_Y(\tau) + (1-\sigma) \ln C_Z(\tau)) d\tau, \quad 0 < \sigma < 1,$$

with C_Y and C_Z denoting consumption of the respective good. Both goods are freely traded. Consequently the prices of the two goods, p_Y and p_Z , are the same across countries. The static aggregate demand functions can be expressed as:

$$(2a) \quad \sigma E = p_Y C_Y,$$

$$(2b) \quad \text{and } (1-\sigma)E = p_Z C_Z,$$

with E , the worldwide consumption expenditures. Individuals investing in education have investment outlays at the beginning of their life and higher income while working as skilled workers in the later part of their life. Through a publicly secured consumption-loan market, individuals can smooth their consumption over time. We allow for free movement of financial capital between A and B . Hence, a uniform international rate of interest at time t , $r(t)$ prevails. Maximizing the intertemporal utility function by taking the intertemporal budget constraint into account yields the familiar Euler equation representing the optimal aggregate consumption expenditure path:³

$$(3) \quad \frac{\dot{E}}{E} = r(t) - \rho.$$

Since the monetary part of the model is not specified, it is feasible to normalize prices such that $E = 1$. Hence, $r = \rho$ holds at every moment in time.

³ Dots over variables denote time rates, and hats delineate growth rates.

The group of L_i^S -individuals consists of those still in the education process (as students), L_i^E , and those who have already completed their studies, L_i^C . That is, $L_i^S = L_i^E + L_i^C$. The latter have two employment opportunities. One subgroup, L_i^W , works in the production process of consumption goods (as white collar workers). The other subgroup, L_i^T , is employed in the education sector as teachers ($L_i^C = L_i^T + L_i^W$). Let us denote by h_{ji} the skills of each individuals of type j in country i resulting from the education process. Average skills are the weighted average of skills of people of different type having invested in education: $h_i = (h_{1i}L_{1i}^C + h_{2i}L_{2i}^C)/(L_{1i}^C + L_{2i}^C)$, with L_{ji}^C , the number of skilled workers of type j in country i .⁴ Furthermore, we denote the human capital input employed per student of type j in country i as $m_{ji} = h_i L_{ji}^T / L_{ji}^E$, with L_{ji}^T representing the number of teachers employed by students of type j in country i (L_{ji}^E). Teachers in country i are, on average, endowed with the skill level h_i . Furthermore, we define $m_i = (m_{1i}L_{1i}^E + m_{2i}L_{2i}^E)/(L_{1i}^E + L_{2i}^E)$, the average human capital employed across the different types j investing in education in country i .

Both consumption goods are produced with linear-homogenous production functions using skilled labor and unskilled workers. The input of skilled labor is equal to the number of skilled workers, L_i^W , weighted by their respective average skills, h_i :

$$(4a) \quad Y = K_Y (h_A L_Y^W)^\alpha (L_Y^U)^{1-\alpha}, \quad 0 < \alpha < 1,$$

$$(4b) \quad \text{and } Z = K_Z (h_B L_Z^W)^\nu (L_Z^U)^{1-\nu}, \quad 0 < \nu < 1,$$

with K_Y and K_Z denoting the stock of knowledge used in the respective production process. We use the notion of country-specific spillovers, i.e., $K_Y = K_A$ and $K_Z = K_B$. The notion of local knowledge spillovers has been stressed by empirical studies (cf. *Glaeser et al.* (1992) and *Jaffe et al.* (1993)).⁵

We assume that the stock of knowledge emerges as an externality from the human-capital-formation sector. We distinguish – as is common in the literature of knowledge-driven endogenous growth (cf. *Grossman/Helpman* (1991)) – between knowledge, which is not specific to a particular factor, and human capital. The latter term refers to skills embodied in skilled workers. There are two important differences between disembodied knowledge and human capital (skills). First, the former is a dynamic externality which is not compensated by the market, whereas costly investment in hu-

⁴ We assume in the rest of the paper that average skills are the same in the final-goods production as well as in the education sector.

⁵ Allowing international knowledge spillovers would leave most of our results unaltered.

man capital is undertaken only if it leads to higher remuneration of the investing individuals in the future. Second, and even more importantly, human capital depreciates completely with the end of the life of the individual it is embodied in. The evolution of disembodied knowledge does not hinge on the life-time of individuals.

Skill-formation of type j individuals is the outcome of a production process that uses skilled labor weighted with their skills as well as students' time. Hence, we can write the per-capita human-capital-production function as:

$$(5) \quad h_{ji} = Q(\theta)a_j(m_{ji})^\epsilon, \quad 0 < \epsilon < 1,$$

whereby θ denotes the given periods of time students spend in the education sector. Productivity of students time is measured by the productivity coefficient $Q(\theta)$. Later on, we show that endogenizing θ does not change matters.

We follow *Lucas* (1988) and *Stokey* (1991) by introducing average rather than total human capital as the explanatory variable in the accumulation equation of knowledge. This avoids pure size effects of migration. The evolution of knowledge in each country is a linear-homogenous function of the value of average human-capital employed per student and the stock of existing knowledge (K_i). Hence, we can write:

$$(6) \quad \frac{\dot{K}_i}{K_i} = F_i[m_i] \quad \text{with} \quad F'_i > 0, F''_i < 0.$$

Therefore, K_i can be regarded as ideas resulting from basic research that is created as joint-production of the human-capital formation sector.⁶

The formulation of the spillover effect in (6) is rather similar, at least in spirit, to other formulations of externalities in the endogenous growth literature [cf., e.g., *Grossman/Helpman* (1991), *Romer* (1990), *Lucas* (1988), and *Uzawa* (1965)]. The formulation of disembodied knowledge chosen here avoids, however, the rather artificial assumption of individuals with infinite lifetimes used in other human-capital-accumulation models [cf. *Uzawa* (1965), *Lucas* (1988)]. *Burda* and *Wyplosz* (1991) also stress the importance of average human capital in the course of migration. In their model average human capital creates a static production externality. They do not look at the effects of migration on the steady-state growth rate.

Looking at the factor- and goods-market clearing conditions, we find for the latter (see (2)):

⁶ See on the concept of joint-production *Rosen* (1972).

$$(7a) \quad \sigma = p_Y Y,$$

$$(7b) \quad \text{and } (1 - \sigma)E = p_Z Z,$$

By deriving the profit-maximizing demand of human capital by producers of Z and Y , we can write the market-clearing condition for skilled labor in each country with the help of (4) and (7) as:

$$(8) \quad h_{1i}L_{1i}^C + h_{2i}L_{2i}^C = \frac{\kappa_i}{w_i^s} + m_{1i}L_{1i}^E + m_{2i}L_{2i}^E,$$

with $\kappa_A = \alpha\sigma$, $\kappa_B = (1 - \sigma)\nu$ and w_i^s being the wage rate for skilled labor in country i in efficiency units. The *LHS* represents the supply of human capital. The *RHS* consists of the demand for human capital for production and in the education sector. Market clearing with respect to unskilled labor, $L_i^U (L_i^U = L_i - L_i^C - L_i^E)$, requires that the demand for unskilled labor, derived from (4), just matches the supply of unskilled workers:

$$(9) \quad L_i - L_i^E - L_i^C = \frac{\xi_i}{w_i^u},$$

with $\xi_A = (1 - \alpha)\sigma$, $\xi_B = (1 - \nu)(1 - \sigma)$ and w_i^u the wage rate for unskilled labor.

3. The Steady-State Equilibrium

In the steady-state equilibrium with a constant intersectoral factor allocation, the wage rates for unskilled and skilled labor are constant (see (8) and (9)). Each individual faces a basic question: whether or not to invest in skill-formation at all. She has two alternatives: either to work unskilled in country i during the entire (working) lifespan Γ , receiving the wage rate w_i^u , or to attend school θ -periods and work from θ to Γ as a skilled person and be remunerated with a higher wage income. The benefits of this choice (receiving $w_i^s h_{ji}$ from θ to Γ) are contrasted with the costs. These are the opportunity costs of not working as an unskilled worker from 0 to Γ and the costs of schooling. Therefore, the discounted gain of investment in education for the individuals of type j can be expressed by

$$(10) \quad G_{ji} = \int_{\theta}^{\Gamma} w_i^s h_{ji} e^{-\rho t} dt - \int_0^{\theta} w_i^s m_{ji} e^{-\rho t} dt - \int_0^{\Gamma} w_i^u e^{-\rho t} dt.$$

By choosing m_{ji} , the individuals with ability a_j in country i maximize the function G_{ji} . By using (5) in (10), we can derive the optimal

$$(11) \quad m_{ji} = (a_j Q \epsilon)^{\frac{1}{1-\epsilon}} \left(\frac{e^{-\rho\theta} - e^{-\rho\Gamma}}{1 - e^{-\rho\theta}} \right)^{\frac{1}{1-\epsilon}} = (a_j Q \epsilon)^{\frac{1}{1-\epsilon}} \Lambda.$$

Equation (11) reveals that individuals with a comparative advantage in human-capital formation demand more human capital inputs in the education sector. They attend schools with better teacher/student ratios. Together with (5), this implies that after attending school they are better endowed with human capital than their fellow students.

Using (11) it is possible to rewrite (10) as:⁷

$$(10') \quad G_{ji} = \frac{1}{\rho} [w_i^s R_{ji} - w_i^u (1 - e^{-\rho\Gamma})],$$

with $R_{ji} = (e^{-\rho\theta} - e^{-\rho\Gamma})^{(1/(1-\epsilon))} (1 - e^{-\rho\theta})^{(\epsilon/(\epsilon-1))} (Q a_j \epsilon)^{(1/(1-\epsilon))} (1 - \epsilon) \equiv \bar{R}(a_j)^{(1/(1-\epsilon))} > 0$. Due to free entry into the human capital sector, there are always individuals willing to invest in education if the net present value for an additional student is non-negative. To show that a_1 individuals in general have more incentives to invest in education than a_2 individuals we use:

$$(12) \quad G_{1i} - G_{2i} = \frac{w_i^s}{\rho} \bar{R}((a_i)^{\frac{1}{1-\epsilon}} - (a_2)^{\frac{1}{1-\epsilon}}) > 0.$$

We can distinguish two cases. In the first one, incentives for training peter out before all a_1 -individuals have chosen to become skilled workers, i.e. $L_{2i}^E = 0$. In the second case, all a_1 -individuals and some of group 2 invest in education, i.e. $L_{1i}^U = 0$ and $L_{2i}^E > 0$.

Equations (3)-(11) determine the endogenous variables w_i^s , w_i^u , Y , Z , p_Y , p_Z , m_i , L_i^E , \hat{K}_i , h_i , and r . Furthermore, a steady-state equilibrium requires a specific relation between L_j^E and L_j^C in each country. The number of skilled workers "leaving" the factor market must just be matched by the number of new skilled workers leaving school. Hence,

$$(13) \quad L_{ji}^C = L_{ji}^E \left(\frac{\Gamma - \theta}{\theta} \right)$$

must hold.

⁷ Endogenizing θ by introducing a concave relationship between Q and θ does not change our analysis. Maximizing (10') with respect to θ yields the first order condition which can be written as: $Q'Q^{-1} - \rho((1 - e^{-\rho(\Gamma-\theta)})^{-1}) + \epsilon(e^{\rho\theta} - 1)^{-1} = 0$. The optimal choice of θ does not depend on endogenous variables. If Q is sufficiently concave, the LHS decreases in θ , ensuring a unique optimal solution.

By using (5), (11), and (13), the factor market clearing conditions can be rewritten:

$$(14a) \quad L_i = \frac{\xi_i}{w_i^u} + L_i^E \frac{\Gamma}{\theta}$$

$$(14b) \quad \text{and } \gamma_1 L_{1i}^E + \gamma_2 L_{2i}^E = \frac{\kappa_i}{w_i^s},$$

with $\gamma_j = (\epsilon^{-1} \Lambda^{\epsilon-1} (\Gamma - \theta) / \theta - 1) \Lambda(a_j \epsilon Q)^{(1/(1-\epsilon))} > 0$. Using the free-entry condition in (10'), we get, together with (14a) and (14b), three equations describing the long-term equilibrium in each country. These equations determine, for either of the two mentioned cases separately, the steady-state values of w_i^s , w_i^u and L_i^E in each country. In the steady-state, L_i^U and L_i^E have to be positive. With $L_i^U = 0$ or $L_i^E = 0$, either infinite wages would violate the free-entry condition or factor market clearing does not take place. Together with (13) this implies $L_i^C > 0$ as well.

In case I, $G_{1i} = 0$ holds in equilibrium, and, with L_{2i}^E being zero, L_i^E equals L_{1i}^E in (14a) and (14b). In case II, $G_{2i} > 0$ for $L_{2i}^E = 0$ and, hence, all type 1 individuals invest in human capital, i.e. $L_{1i}^E = \lambda L_i \theta / \Gamma$. Which of the two cases emerges depends first of all on the human capital intensity of production in the respective country (see (14)).⁸ Combining (14a) and (10') with $G_{ji} = 0$ yields in a general form all w_i^s - L_{ji}^E -combinations that provide simultaneously for factor-market clearance for unskilled labor and free-entry in the education sector:

$$(15) \quad \left\{ L_i - \sum_{j=1}^{j'} L_{ji}^E \left(\frac{\Gamma}{\theta} \right) \right\} w_i^s = \frac{\xi_i (1 - e^{-\rho \Gamma})}{R_{j'}}.$$

With case I prevailing in country i , $j' = 1$ and $L_{2i}^E = 0$. In case II, $j' = 2$ and $L_{1i}^E = \lambda L_i \theta / \Gamma$. Together with (14b), (15) determines the full steady-state equilibrium. Eq. (15) can be expressed by an upward sloping line ($\mu\mu'$) in the w_i^s - L_{ji}^E -space drawn in figure 1. The other equilibrium condition (14b) is represented by the downward sloping curve $\delta\delta'$.

The point of intersection in figure 1, B, depicts the unique steady-state equilibrium.

We can establish

Proposition 1: In each country a unique steady-state equilibrium emerges. In this equilibrium a positive number of skilled as well as of unskilled workers exists. Whether type 2 individuals invest in education or not de-

⁸ We exclude from our considerations a third case by assuming that, for $L_{2i}^C = 0$ and $L_{1i}^U = 0$, $G_{2i} \geq 0$ holds.

pendes on the human-capital intensity of production in the respective country.

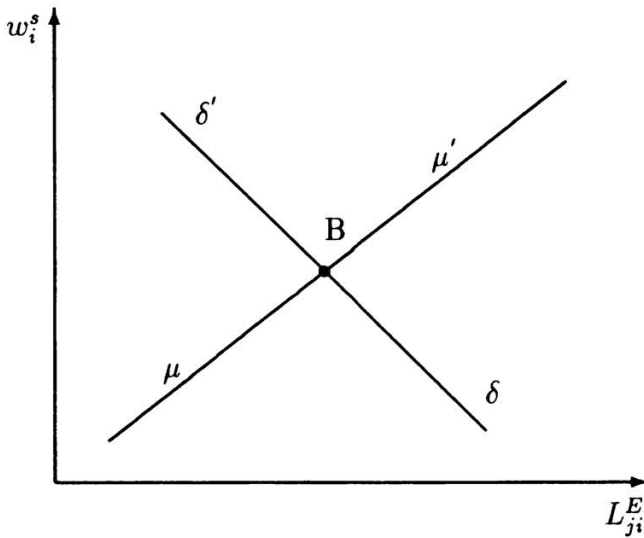


Figure 1: The steady-state equilibrium

Growth originates from the permanent build-up of knowledge according to (6). This in turn leads to permanent productivity increases in the production sector. In the steady-state, the number of skilled and unskilled workers as well as the skills of each member of the skilled labor force are constant. Therefore, output of each sector increases with $\hat{Y} = \hat{K}_A \equiv g_A$ and $\hat{Z} = \hat{K}_B \equiv g_B$. Since consumers' total expenditures on each good are constant, prices fall at the same rate as output grows, $\hat{Y} = -\hat{p}_Y$ and $\hat{Z} = -\hat{p}_Z$, benefiting consumers irrespective of their location. Since m_i is positive in both countries the rate of growth is positive in both countries as well (see (6) and *Proposition 1*).

We can establish

Proposition 2: The rate of steady-state growth is positive in both countries. Consumers in both countries benefit from the growth process in either country via a permanently decreasing price level and a permanently rising real income.

4. Migration as a Self-Selection Mechanism

Let country *A* have higher wages for unskilled as well as skilled workers.⁹ This can be due to the fact that country *A* has a smaller population in relation to its share of overall demand for good *Y* than country *B* in comparison to its demand for *Z*. Since prices of consumption goods are equal internationally, a potential for migration exists. The combination of natural migration costs and artificial costs created by state-imposed impediments to migration is, however, larger at the beginning than discounted gains from migration. The costs of migration are the same for all individuals. Reducing state-imposed barriers to migration or lower natural migration costs makes migration more and more attractive. We will look at a situation where, after the gradual relaxation of barriers to migration, migrating from *B* to *A* pays for some people.

The decisive question is whether there exists a group of people who benefit most from migrating. And if such a group exists, who are those individuals? By answering this question, we are able to find out in which situation which group will actually migrate from *B* to *A* in response to a reduction in barriers to migration. If migration pays most for a certain fraction of the population in *B*, given the economic situation in *A* and *B*, liberalization of migration barriers acts as a screening device. Policy makers may not need to employ a selective migration policy if the most wanted migrants are automatically selected via the economic incentives for migration. Since a selective migration policy based on unobservable variables like the migrants' abilities to perform in the education sector is very difficult to implement, this facilitates the task for policy makers very much.

In order to analyze the possibility of migration acting as a screening device, we make a distinction based on the economic situations in the host as well as the source country.¹⁰ We differentiate between four possible situations which arise from combining case I or II in country *A* and *B*. We exclude regime switches due to migration.

Let us begin with the symmetric cases. Suppose that case I prevails in both countries. Hence, $G_{1A} = G_{1B} = 0$. Type 2 individuals work as unskilled workers in both countries. They achieve the largest net present gain if they migrate in period 0, i.e. at the beginning of their working life.¹¹

⁹ The analysis in this section was suggested to me by an anonymous referee.

¹⁰ There is an extensive literature on screening devices and self-selection mechanisms. For the labor market, Weiss (1980) shows that different contracts can be used for the selection of workers with different, albeit unobservable, skills. A similar selection mechanism can be applied in the credit market. By using an appropriate combination of collateral and interest rates banks can select different risk of borrowers [cf. Bester (1985)].

$$(16) \quad \Delta_2(0) = \rho^{-1}(1 - e^{-\rho\Gamma})(w_A^u - w_B^u) .$$

With respect to type 1 individuals, matters are slightly more complicated. There are two points in time at which migration might be sensible. Either type 1 individuals migrate at time 0 or at θ , after having finished school. Migrating at 0 earns them just the same discounted income differential as type 2 individuals ($\Delta_1(0) = \Delta_2(0)$). There are no productivity differences in the unskilled sector between the two groups of the population. By migrating at θ , type 1 individuals' income differential discounted to θ is:

$$(17) \quad \Delta_1(\theta) = \rho^{-1}e^{\rho\theta}h_1(e^{-\rho\theta} - e^{-\rho\Gamma})(w_A^s - w_B^s) .$$

Note that the level of skills is independent of country-specific parameters (see (5) and (11)). Rewriting $G_{1A} - G_{1B} = 0$ with the help of (10') gives us:

$$(18) \quad h_1(e^{-\rho\theta} - e^{-\rho\Gamma})(w_A^s - w_B^s) = m_1(1 - e^{-\rho\theta})(w_A^s - w_B^s) + (1 - e^{-\rho\Gamma})(w_A^u - w_B^u) ,$$

revealing $\Delta_2(0) = \Delta_1(0) < \Delta_1(\theta)$ (see (16)-(18)). The gains from migration are largest for type 1 individuals who have just finished their education. They benefit from lower education costs and higher wages for skilled workers in country A. In addition, educated, high-ability individuals benefit from the positive discount effect. They realize the gains immediately rather than having to wait after the completion of education.

Gradually relaxing migration barriers such that migration costs just fall below $\Delta_1(\theta)$ will attract these individuals. Migration is positively selective if case I prevails in the source as well as in the host country.

If case II applies to both countries, we get the same results. To see this, we note that $G_{2A} - G_{2B} = 0$. Hence,

$$(19) \quad h_2(e^{-\rho\theta} - e^{-\rho\Gamma})(w_A^s - w_B^s) = m_2(1 - e^{-\rho\theta})(w_A^s - w_B^s) + (1 - e^{-\rho\Gamma})(w_A^u - w_B^u)$$

The gains for migration are largest for type 2 individuals if they migrate after having finished school. They receive the income differential:

$\Delta_2(\theta) = \rho^{-1}e^{\rho\theta}(e^{-\rho\theta} - e^{-\rho\Gamma})h_2(w_A^s - w_B^s)$. But type 1 individuals having just finished educational training realize an even larger discounted gain from migration:

$$(20) \quad \Delta_1(\theta) = \rho^{-1}e^{\rho\theta}(e^{-\rho\theta} - e^{-\rho\Gamma})h_1(w_A^s - w_B^s) > \rho^{-1}e^{\rho\theta}(e^{-\rho\theta} - e^{-\rho\Gamma})h_2(w_A^s - w_B^s) = \Delta_2(\theta) ,$$

¹¹ We compare steady-state situations only. With a very small influx of migrants this is a reasonable approximation.

since $h_1 > h_2$ (see (5) and (11)). Type 1 individuals who have already completed their educational training realize the largest gains from migration. They are selected by a reduction of migration barriers. Migration acts as a screening device.

With asymmetry between the two countries we can, once again, distinguish two cases. First, suppose that case II (I) prevails in country A (B). This is the most realistic set-up since it implies that the ratio of educated people is larger in the high-income than in the low-income country. The maximum discounted gain from migration for type 2 individuals is $\Delta_2(0)$. Since the relaxation of migration barriers is an unexpected event, it is not feasible for type 2 individuals to invest in education in anticipation of the change in migration policy. In the case under consideration, $G_{1A} - G_{1B} > 0$. We get:

$$h_1(e^{-\rho\theta} - e^{-\rho\Gamma})(w_A^s - w_B^s) > m_1(1 - e^{-\rho\theta})(w_A^s - w_B^s) + (1 - e^{-\rho\Gamma})(w_A^u - w_B^u).$$

In this setting, too, type 1 individuals with a finished education are selected by migration ($\Delta_1(\theta) > \Delta_1(0) = \Delta_2(0)$). Once again, a relaxation of migration barriers acts as a screening device.

The reverse case with case II (I) in country B (A) is less clear-cut. $G_{2B} = G_{1A} = 0$ holds. The income differential of migrating type j individuals is either $\Delta_j(\theta)$ when they migrate at θ , or $\Delta_j(0)$ when leaving B at time 0. Since $G_{1A} - G_{1B}$ and $G_{2A} - G_{2B}$ are both negative, it depends on parameter values which of the points in time proves to be more attractive for migration for each type of individual. If it is more attractive for individuals of type 1 to migrate after having finished education, they receive higher discounted gains than their type 2 counterparts (see (16) and (20)). It is, however, never possible that migration at θ is more attractive for type 2 whereas type 1 individuals receive their highest income differential from migrating at 0. With $\Delta_2(\theta) > \Delta_2(0)$, $\Delta_1(\theta) > \Delta_2(\theta)$ (see (20)) always implies $\Delta_1(\theta) > \Delta_1(0) = \Delta_2(0)$. In the setting where both types gain most by migrating at 0, migration does not act as a screening device, since $\Delta_1(0) = \Delta_2(0)$.

This fourth case is, however, less realistic. It implies that the ratio of educated people is higher in the low-wage country than in the high-wage nation. Therefore, we do not treat this case explicitly in the following analysis.

We can summarize our findings in:

Proposition 3: Migration acts as a screening device. Gradual relaxation of barriers to migration attracts type 1 individuals who have already finished their education. Brain drain takes place. The only exception to this can arise in a situation where type 2 individuals invest in education in the source but not in the host country.

The positive selection of migrants provides an explanation for the empirical observation that immigrants eventually have higher earnings than native borns [cf. *Chiswick* (1978)]. We should stress, however, that this result was derived under two important assumptions. First, full employment takes place all the time. Second, skills acquired in the source country are perfectly applicable in the host country. Relaxing these assumptions would weaken our argument. In the extreme, if skills acquired in country B are not at all transferable to country A, it does not pay to invest in education before migrating. Then, migration is most profitable for young people at the beginning of their working life. With both countries being in the same situation, migration does not act anymore as a screening device. That is, our screening argument hinges on a sufficient degree of transferability of skills across countries.

5. The Long-Term Implications of Migration

Let us now turn to the long-term effects of a gradual relaxation of barriers to migration. Section 4 revealed which individuals will migrate in the respective situations. We exclude from our analysis in this section the rather unrealistic scenario with case II (I) prevailing in country B (A). The analysis of this case, which unfolds in various subcases, is straightforward but does not add much valuable additional insight. Thus, three cases remain. In all situations under consideration, the gradual relaxation of migration barriers will attract educated, high-ability people.

First, let us consider the symmetric cases. It suffices to look at the host country only. The effects in B are symmetric with opposite sign.

With case I prevailing in country A, (14b) and (15) hold with $L_{2A}^E = 0$. An inflow of individuals of type 1 leaves $\delta\delta'$ in figure 1 unchanged and shifts $\mu\mu'$ to the right. In the new long-run equilibrium more a_1 -individuals in A become skilled workers. The wage rate for skilled as well as unskilled labor decreases (see (10')). To understand the economic reasoning behind this result, it is helpful to suppose that L_A^S stays constant or decreases. This, in turn, calls for an increase in L_A^U when migration occurs, i.e. $dL_A > 0$ ($L_A^U = L_A - L_A^S$). With a larger number of unskilled workers, w_A^u declines (see (14)). This would create the possibility of positive net gains in the education sector in the new steady-state (see (10')). Hence, this cannot display an equilibrium situation. But if L_A^S increases, L_A^C as well as L_A^E have to be larger in the new steady-state equilibrium, too (see (13)).

In the new steady-state more a_1 -individuals invest in education. This, in turn, brings w_A^s down, too (see (14b)). The growth rate in country A is un-

changed. The ratio governing the growth process in country A , m_A , is, in general

$$(21) \quad m_A = \frac{m_{1A}L_{1A}^E + m_{2A}L_{2A}^E}{L_{1A}^E + L_{2A}^E},$$

with $m_{1A} > m_{2A}$ (see (11)). In case I, this reduces to m_{1A} . Migration leaves (21) and hence, the growth rate in A , unchanged. The same is true for country B . We do not observe any growth rate effect when type 1 individuals emigrate and case I prevails in B . In our symmetric scenario, the overall growth rate effect of a relaxation of migration barriers and the accompanied influx of high-ability individuals is zero.

More interesting is the setting in which a_2 -individuals also invest in human-capital formation. Once again, we look at the effect on country A explicitly. An inflow of a_1 -individuals shifts $\delta\delta'$ to the origin. All “new” a_1 -individuals invest in education. The curve $\mu\mu'$ remains unchanged. In the new equilibrium, wage rates are lower, L_{1A}^E has reached a higher, and L_{2A}^E a lower level. In country A , immigration increases the number of educated people of type 1. This is also true in the long run, since all type 1 people invest – by definition of our case – in education. The larger supply of skilled labor leads to a drop in w_A^s . The perturbations of the free-entry condition (10') for a_2 -individuals creates a disincentive for a_2 -individuals to invest, i.e. L_{2A}^E decreases. Due to the larger supply of unskilled labor, w_A^u also decreases. The effects on A 's growth rate can be derived from (16). Differentiation of m_A in case II with respect to L_{1A}^E and L_{2A}^E reveals that $\partial m_A / \partial L_{1A}^E > 0$ and $\partial m_A / \partial L_{2A}^E < 0$. Hence, the rate of growth in country A increases. The reverse is true for emigration from country B if case II prevails there. The outflow of its most talented people leads to a decrease in the growth rate of country B .

With case II in both countries, migration decreases (increases) B 's (A 's) growth rate. The effect on the overall growth rate which also governs the dynamic effect on consumers' welfare in both countries is not clear-cut. The overall growth rate of static utility g^w is the weighted sum of the countries' growth rates: $g^w = \sigma g_A + (1 - \sigma)g_B$ (see (1), (2), and (4)).

The overall growth rate effect, however, is positive in the asymmetric situation with country A (B) in situation II (I). The immigration of high ability individuals fosters growth in country A . The outflow of type 1 individuals leaves the growth rate in B unaltered, as our analysis above has shown. The two partial effects add to a larger overall growth rate. We find a positive dynamic effect of a relaxation of barriers to migration. This is especially important since this scenario displays the most realistic one: the ratio of edu-

cated people is larger in the high-wage country than in the low-wage country.

Our analysis reveals that the reduction of barriers to migration has, via induced migration of high ability individuals, an impact on the growth performance of host and source country given that case II prevails. The effect on overall steady-state growth can be positive.

Furthermore, our analysis suggests a more general pattern. Migration acts as a mechanism which selects high ability migrants. Given that in the high-wage country a higher proportion of people find it worthwhile investing in education, migration will lead to faster overall growth. The inflow of high-ability individuals changes the composition of the labor force in the dynamic sector such that average human capital in this sector increases. The brain drain, i.e. the outflow of high ability individuals, does not affect average human capital in B's dynamic sector since the labor force in the less developed country's dynamic sector exclusively consists of high ability individuals anyway.

We can establish:

Proposition 4: Migration has no impact on the growth performance of the country in which only high ability workers invest in education (case I). Given that case II prevails in country A, immigration of high ability individuals fosters growth in A. With case I taking place in B at the same time, overall growth increases. If, however, type 2 individuals invest in education in both countries, the growth rate effects in the two countries are of opposite sign. The overall growth rate effect of migration is ambiguous.

6. Welfare Effects of Migration

Migration affects the well-being of all individuals in both countries. As in static models, migration alters the level of individual income and prices. In addition we observe a *growth rate effect* of migration which influences the well-being of individuals. This growth rate effect affects consumers in both countries via a permanent decrease in the price level. Instead of carrying out a complete welfare analysis of all possible set-ups, we want to ask whether it might be possible that migration makes *everybody* better off. In such a situation, transfers between winners and losers are not necessary to make migration politically acceptable.

To keep the analysis tractable, we only look at the change between the steady-states which occur before and after migration. Furthermore, we look at the change in welfare of a young individual who realizes possible growth

effects for his entire life-span. Positive growth effects contribute less to the well-being of an "old" person who lives less than Γ -periods.

Wage rates and the growth rates are constant in the respective steady-state. Each individual receives wages as the only source of life-income. People not investing in skills consume their respective income each period, i.e. they do not save. Hence, for those candidates we get with (2) the individual functions: $p_Y C_{Yi} = \sigma w_i^u$ and $p_Z C_{Zi} = (1 - \sigma)w_i^u$. The life-time income of people investing in skills is linked to unskilled wages through the free-entry condition (10'). In situation I, the life-time incomes of skilled and unskilled workers are the same since the productivity of unskilled workers does not differ between the two groups of individuals. In situation II, however, matters are slightly different. There, we can relate life-time income, I_j , of the two groups through $I_1/I_2 = R_1/R_2 > 1$ which is derived with the help of (10') and the free-entry condition $G_2 = 0$. We proceed by pursuing the welfare analysis for type 2 individuals and note that in situation II, the above relation for type 1 individuals holds.

We have the time path for prices: $p_Y(t) = p_Y(0)e^{-g_A t}$ and $p_Z(t) = p_Z(0)e^{-g_B t}$. Inserting the individual demand functions into (1) and using the time paths of prices, we get by integrating (1)

$$(22) \quad U_i(0) = \omega(\phi + \ln w_i^u - \sigma \ln p_Y(0) - (1 - \sigma) \ln p_Z(0)) + \omega^*(\sigma g_A + (1 - \sigma)g_B),$$

with $\phi = \sigma \ln \sigma + (1 - \sigma) \ln(1 - \sigma)$, $\omega = \frac{(1 - e^{-\rho \Gamma})}{\rho}$ and $\omega^* = \frac{1}{\rho}(\omega - \Gamma e^{-\rho \Gamma})$.

We can derive the cost-minimizing final-goods prices as

$p_Y(0) = a(K_A(0))^{-1}(w_A^s)^\alpha (w_A^u)^{1-\alpha}$ and $p_Z(0) = b(K_B(0))^{-1}(w_B^s)^\nu (w_B^u)^{1-\nu}$ with positive constants a , and b . The wage rate effects of migration are negative in the host and positive in the source country as has been shown in the previous section. The income effect overcompensates the price effect of the good produced in the respective country. This can be seen by inserting the cost-minimizing prices into (22) and by taking the constant relationship between w_i^s and w_i^u into account. Hence, individuals in the source country (including the migrants) are definitively better off if the growth rate effect delineated in the second bracket of (22) is positive. The price-level effect for good Y is positive as are the sum of income effect and price-level effect of Z. In the host country negative-level effects (through lower income and higher import prices) are contrasted with growth rate effects.

By looking at a situation where the growth rate is positive, we can investigate circumstances more clearly under which individuals in A are also better off after migration. Given that A is in situation II whereas B is in situation I, type 1 individuals migrate. The growth rate effect is definitively posi-

tive. A 's growth rate increases, B 's stays constant. Let us briefly deduce the wage effects in both countries and the growth effect in country A . Since relative wage rates of unskilled labor and skilled labor are always constant, it suffices to investigate the effect on w_i^u . Through migration the total number of people in A (B) increases (decreases), i.e. $dL^A = -dL^B > 0$. Using (14b), (15) and (6) we get:

$$(23a) \quad \frac{d \ln w_A^u}{dL_A} = - \left(\left(L_A - L_{1A}^E \frac{\Gamma}{\theta} \right) \frac{\gamma_2}{\gamma_1} + L_{1A}^E \frac{\Gamma}{\theta} \right)^{-1} < 0,$$

$$(23b) \quad \frac{dg_A}{dL_A} = \left[\left(\Lambda(Q\epsilon)^{\frac{1}{1-\Gamma}} (a_1^{\frac{1}{1-\Gamma}} - a_2^{\frac{1}{1-\Gamma}}) \right) \left(\frac{\frac{\theta}{\Gamma} (L_{2A}^E + L_{1A}^E / (\frac{\gamma_2}{\gamma_1} + z))}{(L_{1A}^E + L_{2A}^E)^2} \right) \right] F' > 0,$$

$$(23c) \quad \frac{d \ln w_B^u}{dL_A} = \frac{1}{L^B} > 0,$$

with $z = (R_2 \kappa_A \Gamma) / (\theta \xi_A \gamma_1 (1 - e^{-\rho \Gamma}))$. The growth effect is larger the larger the productivity difference between the two groups. Eventually $(a_1 - a_2)$ is sufficiently large that the overall welfare effect of migration is positive.

That is, migration improves welfare of *all* (young) individuals only under certain conditions. In addition, we would like to stress that by taking the growth effect into account, migration does not necessarily deteriorate the welfare-position of workers in the host country. Furthermore, it is important to note that if the growth effect of migration is positive, the winners of migration can potentially compensate the eventual losers, i.e. total welfare increases. This follows from the fact that migration leads to a more efficient international resource allocation.

We establish

Proposition 5: If migration increases the overall growth rate, welfare of all (young) individuals can be improved through migration. The positive dynamic welfare effect can overcompensate the static welfare effect, which is negative for the individuals living initially in A . Since the static welfare effect of those left behind is positive anyway, a non-negative growth effect makes individuals in B definitively better off. Brain drain is welfare-improving for the source country.

The positive static welfare effect of the brain drain for the source country does not rely on any externalities. It stems only from the reduction of the factor supply in B . Due to endogenous skill formation all individuals remaining in B benefit from brain drain.

In our setting with an endogenous determination of factor supply, factor prices in each country change in the same rather than in opposite direction, as it does in conventional analysis. This implies, on the one hand, that all individuals in the host country share the same interests, and on the other hand, that migration of one type of individuals reduces the migration pressure of the other type of people since their factor income increases as well.

7. Summary

The purpose of our analysis was to investigate the long-term effects of migration flows. We have shown that through the indirect transfer of human capital by means of the migration of 'finikly-lived' people from one country to the other, migration may have an effect on the growth rate of the host as well as of the source country. This is not due to a simple change in the size of factor endowments, but, rather, to a different composition of the labor force in each country after migration has taken place. It is possible for permanent migration to lead to an increase in one country's growth rate while leaving the rate of growth of the other country unchanged. Hence, overall growth increases. Consumers in both countries experience a positive dynamic welfare effect. The relative abilities of migrants with regard to the average abilities of people employed in the growth-generating sector of the economy proved to be the essential factor with respect to the long-term effects of international labor movements.

Our analysis revealed that migration acts as a screening device. Liberalization of migration barriers selects educated, high-ability migrants in most situations. The gains of migration are larger for these individuals than for any other group of B's population. Hence, we provided an explanation for brain drain. With migration being a self-selection mechanism, a selective migration policy is not necessary. By pursuing a more liberal migration policy, politicians can implicitly select migrants. This disentangles policy makers from the very difficult task of selecting migrants explicitly according to their (unobservable) abilities and/or their skills. It should, however, be kept in mind that this result is restricted by our specific model set-up, especially the assumptions of full employment and transferability of skills across countries. Therefore, drawing too general conclusions from our analysis would certainly be overbold.

In addition, we argued that with positive growth rate effects of migration, welfare gains of migration are larger, eventually leaving everybody better off. Due to the endogenous formation of human capital all individuals in either country share the same interests with respect to migration. Given a

non-negative dynamic effect, brain drain is welfare-improving for the source country.

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Zusammenfassung

Internationale Wanderungen von Arbeitskräften und ihre Implikationen für Gast- und Herkunftsland stellen ein aktuelles wirtschaftspolitisches Problem dar. In dieser Arbeit werden auf der Basis eines Modells endogenen Wachstums die Wirkungen der Migration auf die Wachstumsrate der beteiligten Länder untersucht. Migrationspolitik erweist sich als ein Selbst-Selektionsmechanismus, der zur Wanderung ausgebildeter Arbeitskräfte führt. Es wird gezeigt, daß Migration zu einer Erhöhung der weltweiten Wachstumsrate führen kann. Desweiteren werden die Wohlfahrtswirkungen der Wanderungsströme, unter Berücksichtigung der Wachstumseffekte, untersucht.

Abstract

Problems related to labor migration are high on the agenda. This paper presents an endogenous growth model for two countries which enables us to analyze the growth (rate) effects of migration in the host as well as in the source country. Skill formation of heterogeneous individuals is endogenous. Migration policy turns out to be a screening device which selects high-ability migrants. We show that migration can lead to a higher world-wide growth rate. Furthermore, we carry out an analysis of the welfare effects of migration.

JEL-Klassifikation: F22, O15, O40