

Walz, Uwe

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On the growth (rate) effects of migration

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**Wirtschaftswissenschaftliche Fakultät
der Eberhard-Karls-Universität Tübingen**

**On the Growth (Rate) Effects
of Migration**

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**On the Growth (Rate) Effects
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Abstract*

Problems related to labor migration on a large scale in South-North as well as in East-West direction are high on the agenda. This paper presents an endogenous growth model for two regions with human capital formation as the engine of growth. The model is used to analyze the growth (rate) effects of migration in the host as well as in the source country. Thereby, two types of migrating individuals which differ in their ability in the human capital formation process are distinguished and the long-run effects of their respective migrations assessed. It can be shown that under certain circumstances migration increases the rate of growth in both regions. Furthermore, it will be argued that the mobility of only one type of individuals tends to equalize interregional factor rewards not only for skilled but for unskilled labour as well.

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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 more or less strictly controlled by migration barriers. Two rather recent events have contributed to an even larger potential for migration flows in the future. These are, on the one hand, the deepening and enlargement of regional integration (e.g. in the European Community and in North America) which allow in certain stages for more freedom of movement of labor. In the case of the EC, the EEC-treaty of 1968 has provided for the removal of all barriers for the migration of workers. With the deadline of the beginning of 1993 residents of all member states are able to work at any place in the Community without any restrictions. On the other hand, since the collapse of the communist regimes in Eastern Europe a large potential for migration in East-West direction has come to a surface.

Straubhaar/Zimmermann (1992) estimate that there is a potential of about 60 million people wanting to migrate towards the developed countries. According to *Layard et al.* (1992) roughly 13 million migrants can be expected aiming to move into the EC from Eastern Europe in the next 15 years. Therefore, the discussion of the impacts of migration streams on the host as well as the source country are of growing importance. The analyses of the effects on the involved economies can also provide the ground for the establishment of future migration policies and assessment of existing ones.

With respect to migration policy the question arises not only about the extent of the in- or outflow but also whether or under which circumstances a selective migration policy as it is practised to a certain extent in the U.S. [cf. *Borjas* (1991)] might be sensible. In this context, it seems to be important, too, to investigate the consequences on the source country of the outflow of its most talented people.

This paper aims to analyse the long-run effects of migration in general and of migration streams of particular groups of people. It looks at the growth effects of migration in the host as well as the source country. The use of a two-regional endogenous growth model makes it feasible that migration from one region to the other influences the two regions' growth performance in the sense that it changes the respective steady-state growth *rates*. This happens not simply because the size of each region's factor endowment is effected by the movement of labor, but rather as a consequence of a changed composition of regions' factor endowments. The growth rate effect can be far more important than the level effects [cf. *Romer* (1990)].

By looking at the long-run effects of migrations, this paper somewhat tries to fill partly a gap in the economic analysis of migration flows. The existing economics literature, mainly established in the area of international trade theory, is almost entirely of static nature. This literature treats various issues, like the effects of migra-

tion 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)]. Growth models in the Solowian tradition dealing with factor mobility consider the mobility of capital only [cf. *Wang* (1990)]. A recent exception considering growth and labor mobility is *Bertola* (1992). But, in his approach permanent growth stems from externalities related to the capital stock. Therefore, labor migration does not have any effect on the rate of growth at all.

In order to be able to analyze the possible effects of labor movements on growth rates, an endogenous growth model in which human capital formation represents the engine of growth will be outlined and used as a framework. To make this framework compatible with finite-living individuals the notion of disembodied knowledge rather than in human capital embodied knowledge [the latter is used e.g. by *Lucas* (1988)] will be adopted. If individuals have only finite lifetimes, knowledge, embodied in people can not grow without bound, but disembodied knowledge might be able to do so. Despite the fact that each individual can only acquire a finite amount of skills, the value of human capital (skills combined with the stock of knowledge) might increase indefinitely as these skills are brought together with an always increasing stock of knowledge. This somewhat semantic difference [cf. *Grossman/Helpman* (1991, p. 114)] will prove to be rather important for the subsequent endogenous human capital formation process [see on the importance of distinctions in this area *Romer* (1992)].

The growth framework which will be developed and used to analyze the effects of migration on the growth rate rests on two pillars. First, on the endogenous investment decisions of people in human capital. Thereby, the rather simple approach of *Findlay/Kierzkowski* (1983) will be adapted to the present purpose. There, individuals face the alternative of investing in human capital and becoming a skilled worker or without investment working as an unskilled worker. Here, this approach will be extended by introducing two different types of people. They differ with their respective productivity levels in the human capital formation process. Through this distinction it is possible to assess the implications of different kinds of migrants (of the ones with a relative advantage and of the ones having a relative disadvantage in the human capital production process)¹. The second pillar is the assumption of knowledge-creating externalities in the human capital production sector. In a later part of the paper, situations, where such externalities arise from other sources

¹ *Markusen* (1988) presents a model which treats somehow similar issues, but in a static framework. He analyzes migration in a setting in which skilled as well as unskilled labor exists. He argues that the emigration of skilled labor reduces welfare in the source country but is welfare improving for the host country.

will be treated. The externality driven growth model is rather similar to the one of Ziesemer (1992), but in his model externalities stem from the goods producing sector of the economy.

Within the framework to be developed, it can be shown that migration can have positive as well as negative effects on the growth rates of the affected regions, depending, among other things on the type of individuals which are actually migrating. It becomes obvious that growth can rise in both regions. Another result, that contrasts with the findings in other papers is that in the long-run, due to the endogenous determination of human capital formation, the perfect mobility of just one group of individuals tends to equalize factor prices the other, immobile group faces, too. Under certain circumstances, perfect mobility of one “factor” leads to perfect equalizations of factor prices, the other “factor” is confronted with.

The plan of the paper is as follows. In the next section, the basic model is outlined and in section 3 the existence and uniqueness of the steady-state equilibrium will be derived. Section 4 analyzes the growth rate effects of migration and the factor price effects of perfect mobility of a single group of individuals. In section 5 some basic assumptions will be relaxed. The last section gives a brief summary of the main findings.

2 A two-regional endogenous growth model

This section provides a simple endogenous growth models for two region, A and B, which produce two tradeable consumption goods, Y and Z. Due to e.g. rather dissimilar factor endowments it is assured that each region specializes completely in the production of one good. Say for matter of concreteness, region A specializes in good Y and region B in Z. In addition, there exists an education sector in every region. There is no natural population growth in either region. A constant number of individuals with finite life-times implies that fertility and mortality rates just balance. Each individuals in every region lives T periods as an adult ² and supplies inelastically one unit of time in each period either for production purposes or for training in the education sector. Before the education decisions are considered, the consumption decisions are derived.

At each period in time, individuals try to maximize their intertemporal utility function which is identical across regions:

$$\max U_t = \int_{\tau=t}^T e^{-\rho(\tau-t)} (\sigma \ln C_Y(\tau) + (1 - \sigma) \ln C_Z(\tau)) d\tau. \quad (1)$$

²These periods can be interpreted as the periods excluding a given length of childhood. In childhood, individuals are unproductive in the explicit sense of the model.

Since both goods are freely traded, prices are the same across region's borders. From the homotheticity of static utility in (1) one can derive the static demand functions. Since all preferences are identical and the two goods are freely traded, they can immediately be read as the aggregate demand functions:

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

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

where E delineates worldwide consumption expenditures. The optimal consumption path over time is therefore

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

Since the monetary part of the model is not specified, it is possible to use E as numeraire. E will be normalized to unity. This implies that $r = \rho$ holds at every moment in time. Both goods are produced with linear-homogenous production functions. Good Y is produced with human capital and unskilled labor, whereas in the production of Z , in addition, a factor in fixed supply M , e.g. land is used.

$$Y = (A^Y H^Y)^\beta L^{1-\beta} \quad (4a)$$

$$Z = (A^Z H^Z)^\nu (L^Z)^\alpha M^{1-\nu-\alpha}, \quad (4b)$$

where L^Y (L^Z) is the amount of unskilled labor used in Y (Z) production. H^Y and H^Z represent the amount of human capital (or skilled labor) used in the respective production process. Neither the stock of skilled nor the stock of unskilled labor is given exogenously in every region but are endogenously determined by educational investment decisions. In order to justify the complete specialization patterns of the regions, it is assumed that only region B is endowed with a given M . (4a) and (4b) also contain the crucial element in the present growth analysis, that is, that the amount of knowledge A^Y and A^Z is used in the production process. The stock of knowledge is used by skilled workers (the product will be called the value of human capital) in the respective production process. In the main part of this paper the notion of regional-specific spillovers is used, i.e. $A^Y = A^A$ and $A^Z = A^B$.

It is assumed in the main part of the paper, that the level of knowledge and it's evolution emerge from an externality created in the human capital formation sector. Human capital formation is the outcome of a production process which uses skilled labor (e.g. teachers) and people devoting their time for training.

$$H_i^t = \Gamma(\bar{\theta}) a_i (H_i^H)^\epsilon (L_i^E)^{1-\epsilon}, \quad (5)$$

where H_i is the human capital output of the L_i^E individuals with the exogenously given production coefficient a_i by devoting $\bar{\theta}$ periods of time (which results in the

productivity coefficient Γ) in the education sector. At any time there are two classes of individuals in either region, differing with respect to their respective coefficient a_i ; ($i=1,2$)³. Group 1 has a relative advantage in the human capital formation process compared to group 2 of individuals ($a_1 > a_2$). This limitation to only two classes of individuals allows to analyze different kind of migration flows with a rather simple model and still being able to elaborate the main economic issues at stake. Behind this formulation lies the fiction that the comparative advantage or disadvantage is specific to particular families⁴.

Dividing (5) by L_i^E yields the per-capita human capital production function:

$$h_i = \Gamma a_i (h_i^H)^\epsilon, \quad (5')$$

where $h_i^H = H_i^H/L_i^E$ is the human capital per student employed in the education sector.

The evolution of knowledge follows by assumption a linear-homogenous function of the value of human capital per student ($A^i H^{Hi}/L^{Ei}$) and the stock of existing knowledge⁵:

$$\frac{\dot{A}^i}{A^i} = T^i(h^{Hi}) \quad \text{with} \quad T^{i'} > 0, T^{i''} < 0. \quad (6)$$

Therefore, A^i can be regarded as ideas resulting from basic research which is created as a side-product of the human capital forming sector. Despite the fact that A^i is a public good, its inputs get at least partly remuneration from the market system. Therefore, in contrast to e.g. *Shell* (1967) the expenses of basic research need not be financed by the state.

The formulation of the spillover effect in (6) is rather similar, at least in spirit, to other formulation of externalities in the endogenous growth literature [cf. e.g. *Grossman/Helpman* (1991a), *Romer* (1990), *Lucas* (1988), *Uzawa* (1965) and *Ziesemer* (1992)]. 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 [*Uzawa* (1965), *Lucas* (1988)].

The specification used in (6) is in accord with the average human capital specification employed in other approaches [cf. *Lucas* (1988), *Stockey* (1991)]. Not the

³Subscripts characterize variables related to the respective group of individuals, whereas superscripts represent the respective region.

⁴See on this point 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, the childhood, parents with higher abilities in human capital formation "inherit" their children with a better starting position by means of education at home, higher preferences for education, genes etc. to their children for the subsequent (higher) education process (the second stage) than parents with less skills. Here, only the second stage is modelled explicitly.

⁵Dots over variable denote time rates and hats delineate growth rates.

total amount of human capital is relevant, but rather human capital employed per head. In the context of this paper, this formulation also has the significant advantage of avoiding pure size effects. Therefore, migration can not influence growth rates simply because it changes the size of the total factor endowment of host and source country. This would represent a rather odd pattern, taking the empirical fact that the largest countries are not necessarily those with the largest growth rates, but rather the ones with the largest relative human capital endowment, into account [cf. *Grossman (1990)*].

There are three simplifying assumptions behind (4), (5), and (6). First, it is assumed that the number of periods spent by individuals in the education sector (θ) is fixed, irrespective of wages and individual characteristics. Later on [see footnote (7)] it is argued that θ can be treated as an optimally chosen variable. Second, the assumption of the non-existence of spillover of knowledge across regional borders will be relaxed in a later part of the paper. Furthermore, in (5), human capital is produced with human capital and students time alone. That is, there are no additional inputs like school buildings, libraries, laboratories etc.. These inputs will be added in section 5.

After the general set-up has been described, the human capital investment and production decisions can be addressed. Since (5) describes a constant returns-to-scale technology for the human capital formation sector, perfect competition prevails in this sector. Therefore, it is legitimate to argue as if every individual would produce its optimal inputs. By choosing h_i^{Hi} , the individuals with ability a_i in region i maximize: $w_s^i h_i^i - w_s^i h_i^{Hi}$, where w_s^i is the wage rate of skilled labor in region i . Using (5') the optimal demand for h_i^{Hi} can be derived as

$$h_i^{Hi} = (a_i \Gamma \epsilon)^{\frac{1}{1-\epsilon}}. \quad (7)$$

Equation (7) reveals that individuals with a comparative advantage in human capital formation demand more human capital inputs in the education sector, i.e. they attend schools with better teacher/student ratios. Together with (5') this implies that they are afterwards better endowed with human capital.

Each individual faces a more basic question: whether to invest in human capital formation at all. He or she has two alternatives: either to work unskilled during the entire (working) lifespan T , receiving the wage rate w_u each period, or to attend school θ -periods and work from θ to T as a skilled person. The latter will be chosen if the net discounted gains from education is non-negative. The benefits of this choice (receiving w_s from θ to T) are contrasted with the costs. These are the opportunity costs of not working as an unskilled worker from 0 to T and the costs of schooling. Therefore, the discounted net gain for the individuals of type i ($i=1,2$) in either region can be expressed by

$$NG_i^i = \int_{t=\theta}^T w_s^i h_i^i e^{-rt} dt - \int_{t=0}^{\theta} w_s^i h_i^{Hi} e^{-rt} dt - \int_{t=0}^T w_u^i e^{-rt} dt. \quad (8)$$

Due to free entry into the human capital sector, there always will exist individuals willing to invest in education if the net present value for an additional student is nonnegative. It is rather straightforward to show (and also somehow intuitive) that a_1 individuals have more incentives to invest in education in principle than a_2 individuals. This holds in both regions. Differentiating (8) with respect to a and taking the free entry condition ($NG_i^i = 0$) into account, gives

$$\frac{\partial NG_i^i}{\partial a} = (a_i(1 - \epsilon))^{-1} \int_0^T w_u^i e^{-rt} dt > 0. \quad (9)$$

Therefore, a_1 -individuals will invest in education as long as $NG_1^i > 0$. Through the wage rate effects (w_s^i will go down and w_u^i up as more people become skilled workers, thereby reducing the unskilled labor force) eventually NG_1^i will equal zero after all a_1 -individuals are engaged in the education sector. In this case NG_2^i might be positive leaving an incentive for training for a_2 -individuals ⁶. Hence, it is possible to distinguish two cases. In the first one, the incentives for training are petering out (through the wage rate effect) before all a_1 - individuals have chosen to become skilled workers, thereby implying $L_2^E = 0$. In the second case all a_1 -individuals and some of group two invest in education, i.e. $L_1^U = 0$ and $L_2^E > 0$, where L_1^U are the number of unskilled workers of group 1. Obviously, one can exclude corner solutions with either $L^E = 0$ and $L^U = 0$. In these cases, supply of one type of labor would be zero, implying an infinite wage rate for this factor. A glance at (8) reveals that this can not constitute an equilibrium.

In order to close the model it is necessary to analyze the factor and goods market clearing conditions. The latter are immediately derived from (2):

$$\sigma E = p_Y Y \quad (10a)$$

$$\text{and} \quad (1 - \sigma)E = p_Z Z. \quad (10b)$$

Human capital market clearing requires that the demand for human capital for production and educational purposes matches total supply. Let's call the number

⁶Since we are looking at heterogeneous agents with different degrees of efficiency in human capital formation, there exists a free entry equilibrium, in which there remain positive net present values for group one, after all individuals of this group are engaged in training. At the same time, it might very well be that the net present gains for group two are a negative number creating a corner solution with respect to both groups. Later, for sake of analytical convenience, this situation will be excluded by a parameter restriction from the main analysis. The results for this case will be reported in footnotes.

of individuals of class i which have finished the education process L_i^H with $L^H = L_1^H + L_2^H$. By deriving the profit-maximizing demand of human capital by producers of Z and Y with the help of (4) and using (7'), the human capital market clearing condition in each region can be written as

$$h_1^i L_1^{Hi} + h_2^i L_2^{Hi} = \frac{\kappa^i}{w_s^i} + (a_1 \Gamma \epsilon)^{\frac{1}{1-\epsilon}} L_1^{Ei} + (a_2 \Gamma \epsilon)^{\frac{1}{1-\epsilon}} L_2^{Ei}, \quad (11)$$

with $\kappa^A = \beta\sigma$ and $\kappa^B = (1-\sigma)\nu$. The LHS represents the supply of human capital, whereas the RHS consists of demand for production (either Y or Z) and the demand for human capital in the education sector. Market clearing with respect to unskilled labor requires that the remaining number of people (after subtracting L^{Ei} and L^{Hi} from the the fixed number of people in each region, \bar{L}^i) just equals demand for unskilled labor, derived from profit-maximization and (4):

$$\bar{L}^i = \frac{\xi^i}{w_u^i} + L^{Ei} + L^{Hi}, \quad (12)$$

with $\xi^A = (1-\beta)\sigma$ and $\xi^B = \alpha(1-\sigma)$. Equations (3)-(12) determine the endogenous variables $w_s^i, w_u^i, Y, Z, p_Y, p_Z, h^{Hi}, L^{Ei}, \hat{A}^i, h^i$, and r .

By embracing an endogenous human capital formation process, the model determines the endogenous division of the total labor force in skilled and unskilled labor. In the following section, the steady-state equilibrium of the endogenous growth path will be analyzed more closely.

3 The steady-state equilibrium

By looking at the steady-state equilibrium with a constant intersectoral factor allocation, one is able to analyze the long-run functioning of the two-regional model. This requires a constant wage rate for unskilled and skilled labor (see (11) and (12)). Hence, it is possible to rewrite (8) as:

$$NG_i^i = \frac{1}{\rho} \left[w_s^i ((e^{-r\theta} - e^{-rT}) \Gamma a_i (a_i \Gamma \epsilon)^{\frac{\epsilon}{1-\epsilon}} - (a_i \Gamma \epsilon)^{\frac{1}{1-\epsilon}} (1 - e^{-r\theta})) - w_u^i (1 - e^{-rT}) \right]. \quad (8')$$

For the derivation of this equation, (7) was taken into account⁷.

⁷Endogenizing θ by introducing a concave relationship between Γ and θ (Γ being twice continuously differentiable with $\Gamma' > 0$ and $\Gamma'' < 0$, does not change matters at all. By maximizing (8) with respect to θ and taking (5') into account, yields the first order condition: $\Gamma'(1 - e^{-r(T-\theta)}) - \Gamma(\theta)(1 + \epsilon) = 0$. Due to the concavity of $\Gamma(\theta)$, the LHS is decreasing in θ , ensuring a unique optimal solution for θ which is only a function of exogenous parameters. That is, treating the number of periods spent in the education sector as a parameter is perfectly consistent with the underlying optimization process.

Furthermore, a steady-state equilibrium requires a specific relation between L_i^{Ei} and L_i^{Hi} . This relation guarantees that the outflow of L_i^{Hi} employees after T periods (here, they actually die) is compensated by the inflow of L_i^{Ei} skilled workers leaving the education sector and entering the skilled labor force. Every period in time L_i^{Hi}/T of each type of skilled labor, in each region "leaves" the factor market, whereas L_i^{Ei}/S skilled workers leave school. In order to establish a constant pool of L_i^{Hi} in the steady-state, $L_i^{Hi}/T = L_i^{Ei}/S$ must hold. Hence,

$$L_i^{Hi} = L_i^{Ei} \frac{T}{S}. \quad (13)$$

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

$$\bar{L}^i = \frac{\xi^i}{w_u^i} + L^{Ei} \left(1 + \frac{T}{S}\right) \quad (14a)$$

and

$$\gamma_1 L_1^{Ei} + \gamma_2 L_2^{Ei} = \frac{\kappa^i}{w_s^i}, \quad (14b)$$

with $\gamma_i = \Gamma(a_i(\frac{T}{S}) - 1)(a_i \epsilon \Gamma)^{\frac{1}{1-\epsilon}} > 0$. The free-entry condition applied to (8), represents together with (14a) and (14b) three equations in each region. These equations determine, for either of the two mentioned cases separately, the steady-state values of w_s^i , w_u^i and L^{Ei} in each region.

In case I, $NG_1^i = 0$ holds in equilibrium and with L_2^{Ei} being zero, L^{Ei} equals L_1^{Ei} in (14a) and (14b). In case II, $NG_2^i = 0$ and $L_1^{Ei} = \lambda_1^i \bar{L}^i / (1 + T/S)$ ⁸. Solving (14a) for w_u^i , inserting into (13), and bearing the above relations for the two cases in mind yields in the respective case all $w_s^i - L_i^{Ei}$ -combinations which provide for market equilibrium for unskilled labor and free entry equilibrium in the education sector in the steady-state.

$$\left\{ \bar{L}^i - (L_1^{Ei} + L_2^{Ei}) \left(1 + \frac{T}{S}\right) \right\} w_s^i = \Omega_i^{-1} \quad \text{with} \quad (15)$$

$$\Omega_i = \left\{ (e^{-\rho\theta} - e^{-\rho T})(\Gamma a_i)^{\frac{1}{1-\epsilon}} (\epsilon)^{\frac{1}{1-\epsilon}} - (a_i \epsilon \Gamma)^{\frac{1}{1-\epsilon}} (1 - e^{-\rho\theta}) \right\} \left\{ (1 - e^{-\rho T}) \xi^i \right\}^{-1} = \tilde{\Omega}_i / \xi^i.$$

⁸By assuming that in each region

$(1 - e^{-\rho T})^{-1} [(e^{-\rho\theta} - e^{-\rho T}) a_2^{\frac{1}{1-\epsilon}} (\Gamma \epsilon)^{\frac{1}{1-\epsilon}} - (a_2 \epsilon \Gamma)^{\frac{1}{1-\epsilon}} (1 - e^{-\rho\theta})] > \gamma_1 \xi^i \lambda_1^i \{(1 + T/S)(1 - \lambda_1^i)\}^{-1}$ holds, with λ_1^i being the proportion of a_i -individuals in region i , at least some a_2 -individuals will invest in education in case II. This technical assumption guarantees that for $L_2^E = 0$ and all a_1 -individuals investing in human capital, $NG_2^i > 0$ holds. The case mentioned in footnote (7) can not occur. This assumption excludes, so to speak, a third, knife-edge case which will be treated in the following section in footnotes. But this parameter condition does not influence the other two cases.

Together with (14b), (15) determines the full steady-state equilibrium. The $w_s^i - L^{Ei}$ -combinations fulfilling (15) can be expressed by an upward sloping line ($\mu\mu'$) in $w_s^i - L^{Ei}$ -space drawn in figure 1. The other equilibrium condition, that is (14b), is represented in figure 1 by the downward sloping curve $\delta\delta'$ which intercepts the L^{Ei} axes at $\lambda_i^i \bar{L}(1 + T/S)$.

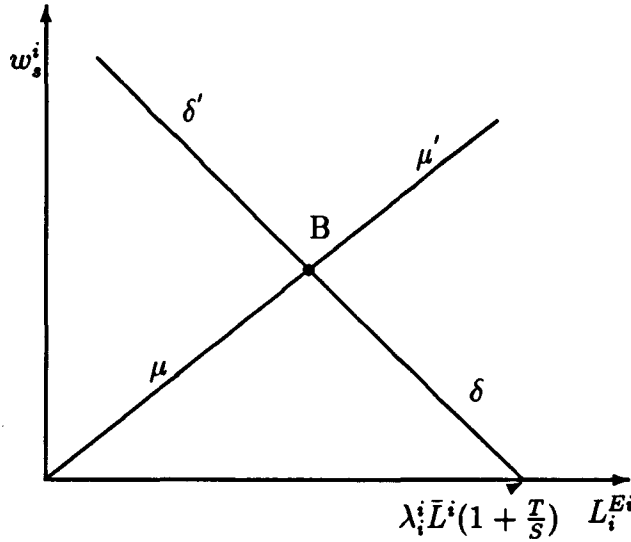


Figure 1: The steady-state equilibrium

The point of intersection in figure 1, B, depicts the unique steady-state equilibrium. A steady-state equilibrium with positive investment in education always exists. To show this, suppose a steady-state equilibrium with positive investment in education would not exist. In this case, L^{Hi} would at a certain time approach zero. This, in turn, implies, given the production functions (4) that w_s^i would approach infinity. No matter, what the parameters look like, it then becomes worthwhile to invest in education and become a skilled worker. Investment comes to a standstill, when NG_1 or NG_2 equals zero. Therefore, there always exists a steady-state equilibrium with positive investment in education. Since the curves in figure 1 intersect only once, this equilibrium is unique.

Which one of the two cases actually arises in the two regions depends on production parameter values and the factor endowment in either region. A glance at (14a) and (14b) reveals that with a constant intersectoral factor allocation, wage rates in both regions are constant in the steady-state. Growth originates from the permanent build-up of knowledge according to (6). This in turn leads to permanent productivity increases of the value of human capital 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 increase with $\hat{Y} = \beta \hat{A}^A$ and $\hat{Z} = \nu \hat{A}^Z$. Since consumers total expenditures towards 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. Despite the constant nominal wages, real wages increase permanently in equilibrium making individuals in both regions better off. This latter fact has the side-effect that every change in the growth rate of either region will influence the well-being of inhabitants of the other region as well.

4 The long-run implications of migration

Using the model developed so far opens up the possibility to analyze the long-run effects of migration. For matters of concreteness assume that region A has higher wages than region B. This might be due to the fact that region A has a smaller population in relation to its share of world-wide demand for good Y than B in relation to demand for Z . Unequal factor prices are compatible with the notion of complete specialization.

In this analysis, migration flows follow differences in real wages. In the absence of migration costs, this is equal to the idea of migration following utility differentials. This is a standard assumption in many approaches towards migration [cf. e.g. Bertola (1992)]. Since both goods are traded, nominal wage differentials translate into real wage gaps between the two regions.

In the first part of the analysis a situation is considered in which barriers to migration are removed gradually. The marginal and discriminating lifting of the restriction towards migration flows leads to a marginal inflow of a_1 or a_2 individuals. The restriction to marginal inflows has the advantage that regime-switches (from situation I to II or vice versa) can be excluded. The complete removal of the migration barriers and the implications for factor prices in both regions is considered later on. All migrants and their offsprings stay permanently. Since the advantages or disadvantages in the human capital formation process are inherited, the migration of a_i -individuals from region B to region A increases (decreases) A's (B's) number and share of a_i -individuals. In order to address the growth effects of migration flows properly, it proves to be sensible to analyze the two cases of steady-state equilibria separately.

Beginning with case I, the effects of a marginal inflow of migrants into region A will be considered first. (14b) and (15) hold with $L_2^{EA} = 0$. In this setting, an inflow of individuals of class I leaves $\delta\delta'$ unchanged and shifts $\mu\mu'$ to the right [see figure 2a].

At the equilibrium point C, there are more a_1 -individuals in A that are becoming

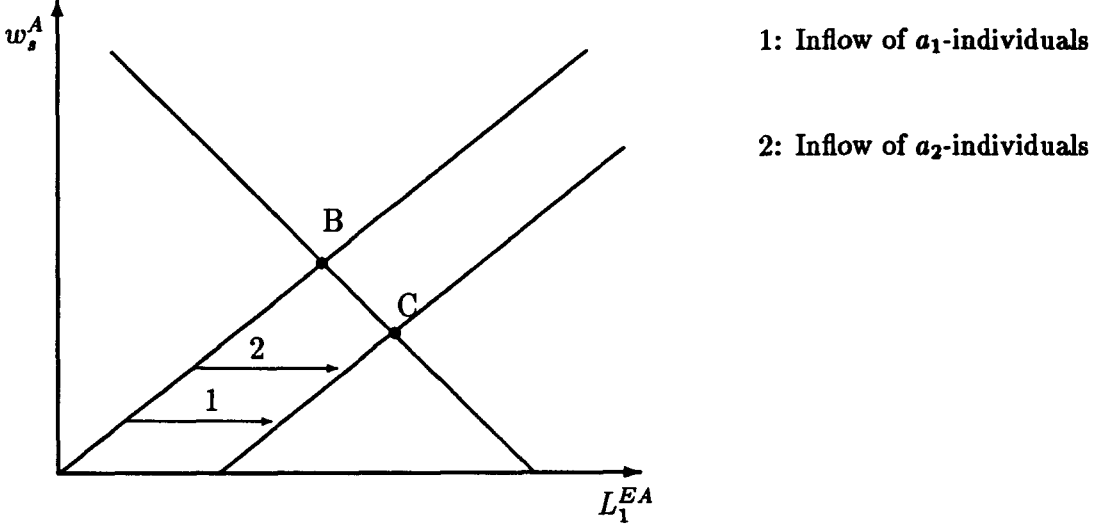


Figure 2a: Case I: The effects of migration

skilled workers. The wage rate for skilled as well as unskilled labor decreases [see (8)]. The intuition behind this is rather straightforward. An inflow of a_1 -individuals implies that, if the migrants decide not to invest in education, a simple expansion in the unskilled labor force takes place, leading to a decline in w_u^A . This would create a disequilibrium in the education sector with positive net gains [see (8)]. In order to restore equilibrium, some of the a_1 -individuals have to invest in education. This, in turn, brings w_s^A down, too. Finally, the free entry equilibrium in the education sector holds once more.

By all this, the growth rate in region A is unchanged. This can be seen as follows. The ratio governing the growth process in country A, h^{HA} can be written as:

$$h^{HA} = \frac{h_1^{HA} L_1^{EA} + h_2^{HA} L_2^{EA}}{L_1^{EA} + L_2^{EA}}, \quad (16)$$

with $h_1^{HA} > h_2^{HA}$ [see (7)]. In case I, this reduces to h_1^{HA} . Migration leaves this term, (16), and hence, the growth rate in A unchanged. The same is true if one considers movements of a_2 -individuals. Their immigration into A leads to a decrease in the wage rate of unskilled labor opening an incentive for a larger number of a_1 -individuals in A to invest in education. But the average human capital employed in the human capital forming sector remains the same. Graphically, the inflow of a_2 -individuals also leads to a shift of $\mu\mu'$ in figure 2a. The reverse patterns can be

observed in the source region, if B happens to be in situation I as well. Wage rates increase, but the growth rate is unaffected ⁹.

More interesting (and also somewhat more realistic, as will be argued later), is the second case, in which a_2 individuals invest in human capital formation, too. In this setting, as a consequence of an inflow of a_1 -individuals, $\delta\delta'$ in figure 2b shifts to the left. Since all "new" a_1 -individuals will invest in education, the curve $\mu\mu'$ remains unchanged, because $(\bar{L}^A - L_1^{EA}(1 + T/S))$ is not changed. In the new equilibrium, wage rates are lower, L_1^{EA} has reached a higher, and L_2^{EA} a lower level. This can be explained as follows. The corner solution with respect to a_1 -individuals' educational investment decisions results in the decision of the a_1 -migrants to invest in education by themselves. This, in turn, leads by means of a larger supply of skilled labor to a drop in w_s^A . The perturbations of the free-entry condition (8) for a_2 -individuals starts an adjustment process after which fewer a_2 -individuals will invest, i.e. L_2^{EA} decreases. Due to the larger supply of unskilled labor, w_u^A also decreases. The effects on A's growth rate can be derived from (16). Differentiation of h^{HA} in case II with respect to L_1^{EA} and L_2^{EA} reveals that $\partial h^{HA}/\partial L_1^{EA} > 0$ and $\partial h^{HA}/\partial L_2^{EA} < 0$. Hence, the rate of growth in region A increases unambiguously as a consequence of the immigration of a_1 -individuals.

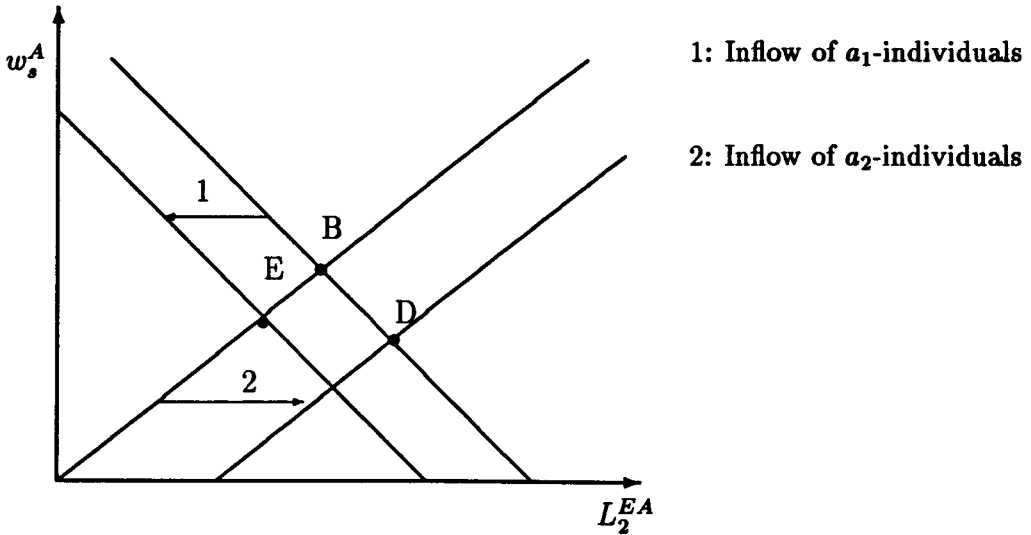


Figure 2b: Case II: The effects of migration

⁹In the knife-edge case, pretty much the same takes place. In the case of an inflow of a_2 -migrants, however, L_1^{EA} might not increase.

Just the reverse is true if some a_2 -individuals migrate into A as a result of relaxed barriers to migration for this group. This shifts $\mu\mu'$ to the right [see figure (2b)]. $\delta\delta'$ remains unchanged. The new steady-state is an equilibrium with lower wages, more a_2 -individuals investing in the human capital sector and hence less growth [see (16)] since this lowers the average human capital composition of the sector which contributes to the growth process. The larger number of a_1 -individuals is "distributed" in the new equilibrium in the skilled and unskilled labor market segments in such a way that (8) holds in the new equilibrium. In case II as well as in case I just the reverse holds for the source country (B). Case II where different types of individuals are investing in training seems to be more important, especially if one thinks about the fact that realistically one should have far more than only two classes of people. From this rather simple modelling approach, we can derive a more broader conclusion, however. As a consequence of migration the growth rate of the host country will increase if these migration flows lead to an increase in the average human capital composition of the sector contributing to ongoing growth. This is most likely if the migrants' abilities in human capital formation are higher than the average ability of people initially investing in human capital. The reverse is true for the source country.

Up to now it has been implicitly assumed that both regions are in the same situation. Relaxing this assumption and using the results just obtained, gives the impact of migration on the worldwide growth rate. The worldwide growth rate g^w is here the weighted sum (the weights being the consumption shares of the regions' respective goods, σ and $(1 - \sigma)$ of the regions' growth rates).

Table 1 gives an overview on the worldwide growth rate effects of migration. It shows that migration can lead to an increase as well as to a decrease in overall growth. This occurs when the two regions' human capital is composed differently. Then, migration increases (decreases) worldwide growth unambiguously if it effects the growth rate of one region positively (negatively) and the one of the other not at all. Since consumers in each region are not just effected by the respective region's growth performance but also by the one of the other region, worldwide growth and its change in the course of migration is an important issue with respect to individuals well-being, irrespective of their location.

For the rest of this section, the complete removal of the barriers of migration, i.e. a world with free mobility for one group of persons will be considered. It is assumed that the other group is interregionally immobile. This is a standard procedure e.g. in urban and regional economics [cf. e.g. *Wildasin* (1991)].

Suppose only the a_1 -individuals are mobile. They will migrate from B to A until i.) $w_s^A = w_s^{B10}$ or ii.) all mobile individuals have left region B. If $w_s^A = w_s^B$ prevails

¹⁰Since in steady-state at least some individuals will invest in training, there is always an incentive to migrate as long as $w_s^A \neq w_s^B$. The same is not necessarily with respect to w_u (see the

<div> <div>host country in</div> <div>source country in</div> </div>	situation 1	situation 2
situation I	<div> <div>migration of $a_1 \Rightarrow dg^w = 0$</div> <div>migration of $a_2 \Rightarrow dg^w = 0$</div> </div>	<div> <div>migration of $a_1 \Rightarrow dg^w > 0$</div> <div>migration of $a_2 \Rightarrow dg^w < 0$</div> </div>
situation II	<div> <div>migration of $a_1 \Rightarrow dg^w < 0$</div> <div>migration of $a_2 \Rightarrow dg^w > 0$</div> </div>	<div> <div>migration of $a_1 \Rightarrow dg^w \geq 0$</div> <div>migration of $a_2 \Rightarrow dg^w \geq 0$</div> </div>

Table 1: The effects of migration on the worldwide growth rate

in the free mobility equilibrium this leads in the majority of cases to $w_u^A = w_u^B$, too. As long as $NG_1^A = NG_1^B = 0 \Rightarrow \tilde{\Omega}_1 = w_u^i/w_s^i \quad \forall i$ free mobility of group 1 ensures factor price equalization for unskilled as well as skilled workers. In this case, the factor price gap closes for both factors, i.e. the incentive for migration will cease to exist¹¹.

The only exception to factor price equalization for both types of labor in a situation with only one group of individuals being mobile, is, when different regimes hold in the two region in the free mobility equilibrium. If case I prevails in region A and case II in B and only a_1 -individuals are mobile, it follows from (8) that

$$\text{in A: } \Omega_1 > \frac{w_u^A}{w_s^A}, \quad \Omega_2 = \frac{w_u^A}{w_s^A} \quad \text{and in B: } \Omega_1 = \frac{w_u^B}{w_s^B}, \quad \Omega_2 < \frac{w_u^B}{w_s^B} \Rightarrow w_u^B > w_u^A, \quad (17a)$$

argumentation below).

¹¹This contrasts somewhat with the findings of *Gerking/Mutti* (1983). In their model, migration leads to increasing pressure for capital to cross borders, thereby widening the gap between the two wage rates even further.

and if case II takes place in A and I in B

$$\text{in A: } \Omega_1 = \frac{w_u^A}{w_s^A}, \quad \Omega_2 < \frac{w_u^A}{w_s^A} \quad \text{and in B: } \Omega_1 > \frac{w_u^B}{w_s^B}, \quad \Omega_2 \frac{w_u^B}{w_s^B} \Rightarrow w_u^A > w_u^B, \quad (17b)$$

There is a tendency towards factor price equalization for both types of labor in this setting, but complete factor price equalization does not occur with respect to the second factor. The same is true for ii.), following the above arguments. All the qualitative results go through if only a_2 -individuals migrate and either $w_u^A = w_u^B$ or $L_2^{UB} = 0$.

Hence, the findings of the second part of this section can be summed up briefly. It was shown, that in contrast to other models being concerned with factor mobility, the outflow of one type of individuals did not lead to a drop but rather to an increase in the price of the other factor. This is due to the endogenous determination of either type of labor in this model, in contrast to other approaches where the supply of the immobile factor is fixed. Thus, factor prices of the immobile factors will decrease. This can be seen most clearly by referring to the fixed immobile factor, M in this model. As a consequence of the outflow of either e_1 or e_2 -individuals the marginal productivity and hence, the factor price of M goes down. All this implies that the migration of one group of individuals makes the other group better off. Furthermore, it became obvious that the unrestricted mobility of individuals of only one group leads at least to a tendency towards factor price equalization for the other group as well.

5 Extensions

In the last section, the long-run effects of migration were derived from a simple model. Thereby, a couple of specific assumptions have been imposed. In this section various of these assumptions are relaxed or modified and the consequences of these changes will be analyzed. By doing this, the implication of the model can embrace a wider spectrum of situations.

Specifically, three main points will be addressed here. First, the specific formalization of the externalities arising from the human capital formation process which has been at the heart of the growth process will be widened to a larger range of specifications and the implications of other scenarios in this regard will be examined. Second, the spillover effect will be extended from a regional to a worldwide scale. The third extension, briefly taken into account is the possibility of an additional input in the human capital formation process, besides human capital itself and students time.

With regard to the formulation of the externality generating process, there are, if one accepts the notion and importance of average human capital as the driving

force behind growth [see on this point *Lucas* (1988) and *Sala-i-Martin* (1990)], various other possibilities can be spelled out to specify (6). The main three sensible alternatives are: H/L^H , that is human capital per skilled person, H^Y/L_Y^H , human capital per head in the production sector and H/L , the total average human capital endowment. The second alternative, for example, which can be interpreted as the case in which the externalities are generated through firms' *R&D*-investments is used in *Ziesemer* (1992).

The first two have the same implications for the effects of migration than the one chosen in the main part of the paper. In case I, the ratio is independent of L_1^H as well as L_1^{HY} . In the second case, the following partial derivation can be derived and signed, using the fact that $h_1 > h_2$:

$$\frac{\partial H/L_H^H}{\partial L_1^H} > 0, \quad \frac{\partial H/L_H^H}{\partial L_2^H} < 0, \quad \text{and} \quad \frac{\partial H^Y/L_Y^H}{\partial L_{Y1}^H} > 0, \quad \frac{\partial H^Y/L_Y^H}{\partial L_{Y2}^H} < 0. \quad (18)$$

Due to the steady-state condition $L_i^E = L_i^H(\frac{S}{T})$, the same results as in section 2 arise if H/L^H is used. Taking into account that w_s falls in the event of migration and therefore, more skilled workers are demanded in the production sector, one can also observe the results in section 4, if H^Y/L_Y^H is used in (6). Only, if one relates the externality generating process to the *overall* average human capital the results change. All results are ambiguous and dependent on the relative weight of skilled compared to unskilled workers. It is possible, however, to conclude that the results derived in section 4 are rather robust with regard to the endogenous growth formulation as long as human capital is related to some number of skilled worker or those becoming it in the future.

The spillover effects can be extended across regional borders by writing the knowledge used in the regions' production processes as $A^Y = A^A + \phi A^B$ and $A^Z = \phi A^A + A^B$ with $0 \leq \phi \leq 1$. In the case of $\phi = 1$, there are perfect international spillovers. The worldwide growth rate governs the regional growth performances. The derived results of migration on the worldwide growth rates [see table 1] can be directly applied to each region.

Let's finally introduce as a last extension an additional factor input X in the human capital formation process (like schools, libraries, laboratories etc.). Suppose this factor is in fixed supply in each region (\bar{X}^i). By doing this (5') must be changed to

$$h_i^i = \Gamma a_i (h_i^{Hi})^\epsilon \left(\frac{\bar{X}^i}{L_i^{Ei}} \right)^\psi, \text{ with } \epsilon + \psi < 1. \quad (5'')$$

Since the opportunity cost of the X -factor are zero, it is optimal to employ X^i fully in each region. The optimal demand for skilled people in the education sector therefore becomes

$$h_i^{Hi} = \left[\Gamma a_i \epsilon \left(\frac{\bar{X}^i}{L_i^E} \right)^\epsilon \right]^{\frac{1}{1-\psi}}. \quad (7')$$

The amount of h_i^{Hi} employed and the quality of training is therefore higher in the region where the endowment with X per student is highest. Inserting (7') into NG_i yields $NG_i(L_i^E)$ with $\partial NG_i / \partial L_i^E \leq 0$ at constant wages, thereby reinforcing the wage rate effects on NG_i as L_i^E increases. But (7') reveals an additional possible impact of migration. If individuals migrate from a region relatively little endowed with X^i per head, the migrant can accumulate more human capital in the host country than in the source country. He or she benefits from the higher stock of X^i present in the source country. On the other hand, however, the increase of L^E in the host country leads to a decrease of the average endowment of the existing students. A glance at (7') shows that e.g. in case I, the total amount of human capital in the host country increases, since $\epsilon + \psi < 1$. But this effect just described contributes in the present growth formulation negative to the growth rate in the host country since *average* human capital decreases. But it must be stressed that the fixed supply of X^i irrespective of the size of the human capital formation sector is certainly somewhat oversimplistic, so that one must be careful to draw immediate conclusions from this brief treatment.

Further qualifications with regard to a more detailed enquiry into the long-run effects of migration might include the changes of technologies and product quality [e.g. along the lines of *Grossman/Helpman* (1991, chapter 3 and 4)] and the inclusion of a learning-by-doing process on the job [see *Liang et al.* (1992)].

6 Summary

The main aim of this paper was to investigate possible long-run effects of migration flows. Thereby, the focus has been on the growth rate rather than the level effects of migration. The analysis has shown that even without the transfer of knowledge by means of migration of finite-living people from one region to the other, migration may have an effect on the growth rate of host as well as of source country. This is not due to a simple change of the size of factor endowments, but rather to a different composition of the labor force in each region after migration has taken place. It is possible for permanent migration to lead to an increase in one region's growth rate while leaving the rate of growth of the other region unchanged. The relative abilities of migrants with regard to the average abilities of people being employed in the growth generating sector of the economy proved to be the essential factor with respect to the long-run effects of interregional labor movements. Population growth being zero, implies that an increase in the absolute worldwide growth rate is equivalent to a higher per capita worldwide rate of growth.

Due to the endogenous determination of the size of the skilled as well as the unskilled labor force, migration of only one group of people tends to equalize the factor prices the other group is remunerated with, as well.

The analysis points somewhat in the direction of a selective migration policy, in which, however, the specific situation in the host as well as the source region has to be taken into account. Otherwise, since migrants do not take the impact of their decisions on the externalities and therefore the growth process into account, migration could lead to a situation in which the inhabitants of both regions including the migrants are worse off. But, one must be somewhat careful to draw straightforward policy conclusions from the present analysis without investigating the issues further. This paper should, however, provide a certain step in this direction.

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