

# **Mobility of skilled labour and skill formation**

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# 1 Preface

Mass emigration of educated workers is a phenomenon observed for many developing economies nowadays. It is often associated with fears that a continuing outflow of the most skilled professionals will impair the development prospects of these economies. This is further nourished by growth theory, which stresses the importance of human capital as a driving force of economy-wide growth.

However, in recent times, some economists have questioned this pessimistic point of view from a dynamic perspective. They refer to the channels of return migration and technology transfer as potential growth opportunities created through emigration. In addition, some authors claim that increased opportunities for qualified workers to outmigrate could exert a positive impact by raising the willingness of members of the young generation to invest into education. Within especially designed frameworks, some of these authors are able to identify situations where reducing emigration barriers actually raises the stock of human capital in the economy. This result is then often used to justify *laissez-faire* migration policies as development tools.

Hence, given the relevance of this argument within the policy arena and its strong opposition to conventional wisdom, a thorough examination of its consistency is definitely worthwhile. This seems even more necessary as the designs of the existing frameworks used for its elaboration are neither built upon empirical research nor strictly based on the set of assumptions used by standard microeconomic theory.

The main topic of this thesis will therefore be to analyze the development implications of the schooling-migration nexus within a more general framework of economic thinking. To this end, the first part will examine the long- and short-run impact of facilitating the emigration of highly-skilled workers on the accumulation of worker skill in a small sending economy. It will turn out that the basic result propagated by the advocates of new “brain drain” theory is overturned completely. This fact has important consequences for related aspects of development economics, which will subsequently be discussed by extending the framework into various directions. As a policy application, we analyze the effect of introducing lump-sum subsidies to schooling within such a scenario.

Afterwards, we will analyze the interplay between schooling, emigration and the presence of borrowing constraints in the small economy. This is then used to introduce intergenerational transfers as another channel through which the schooling decision of one generation can affect the schooling decision of its offspring. The rest of the work is then devoted to a discussion of the implications for international trade, which is done by transferring our scenario to a two-sector world. This allows us to make further propositions on the role of sectoral specialization as well as on its impact on the intensity of skilled worker outflow.

## 2 Migrant selection and the stock of human capital

### 2.1 Motivation

In a globalizing world, the competition for the most qualified professionals seems to have steadily grown in intensity over the last decades. For Sub-Saharan Africa, estimates provided by Haque & Jahangir (1999) report an average number of 1,800 high-skilled emigrants per year for the period 1960-1975, while an annual average of 23,000 is estimated for the period 1974-1987. Concerning more recent evidence, the number of visas per year granted by US authorities to foreign high-skilled workers as part of the H-1B program has experienced an increase from 110,200 in the year 1992 to 355,600 in 2000 (Docquier & Marfouk (2006)). In a comparison on the international level, harmonized data collected by Docquier & Marfouk (2006) shows that countries in the regions of Sub-Saharan Africa, Central America and surrounding the Caribbean Sea have exhibited the highest number of high-skilled emigrants relative to total workers with tertiary education in the year 2000. For instance, within the group of countries with more than 5 Million citizens, remarkably high rates have been identified for Haiti (83.6%), Ghana (46.9%) and Nicaragua (29.6%).

On a global scale, this puts developing countries into the role of net exporters of skilled labour. Within these countries, this has triggered public fears that an ongoing loss of intellectual resources might seriously hamper growth, thus endangering the process of catching-up.

Besides, even in the absence of a direct impact on the growth rate, there are immediate severe consequences for vital areas like medical treatment. Calculations undertaken by Moullan (2009) based on OECD data for 2004 yield an average emigration rate of 7.2% for physicians from low-income countries compared to a rate of only 3.5% for high-income countries. Focusing on Sub-Saharan countries alone, this rate goes up to 19%. Such a development can be viewed as disastrous, as it is apt to further widen the gap in the quality of healthcare in terms of the number of physicians per capita. This number is with 0.16 per thousand people in Sub-Saharan countries dramatically lower than in high-income countries with an average of 1.86. Regarding its consequences, Bhargava & Docquier (2008) estimate that a doubling of this emigration rate would cause a 20% increase in the number of deaths from AIDS in African countries.

Nevertheless, economic research in recent years has come up with some ideas why such a seemingly devastating outflow might at least provide some benefits to the population of the sending country in the long term. One mentioned aspect is the potential role emigrants can play in terms of international technology transfer. If emigrants create diasporas abroad which remain closely linked to their home countries via social networks, an informal channel can emerge through which an underdeveloped country gains access to the latest innovations emerging within technologically advanced countries (Kapur (2001), Seguin et al. (2006)). At the same time, an exchange of information also occurs in the opposite direction. The formation of business networks between migrants and host country employers might give host country firms important information on the economic environment within sending countries, possibly inducing some of them to engage in direct investments within these countries (Kugler & Rapoport (2005), Javorcik et al. (2011)).

The knowledge acquired by emigrants in their host country could also be transferred through the channel of return migration. Whether this can lead to some form of net gain for the sending country is dependent on the migrant's choice of the optimal migration duration, as analyzed by a small literature within migration research (e.g. Stark et al.

(1997), Dustmann (2003)).

Recently, an increasingly popular strand of literature has emerged which seeks to link emigration prospects with incentives for skill accumulation by the young population within sending countries. The foundations of this strand go back to the theory of endogenous growth (Romer (1986), Lucas (1988)). It is regarding the accumulation of knowledge as one of the main driving forces of aggregate growth. The idea is that the chance of emigrating to countries offering higher rewards to skilled labour tomorrow increases the expected returns to education of domestic students today. In this way, an outflow today is thought to exert a positive impact on school participation, implying a higher number of skilled graduates tomorrow. Depending on the extent of outmigration, researchers even claim that such an effect could yield a long-term rise in a developing country's stock of human capital despite an ongoing emigration surge. In this regard, a 'brain drain' could initiate a "brain drain" fostering growth opportunities of sending countries.

Concerning an empirical assessment of the net effect, a lack of available cross-country data has for a long time prevented an analysis of the relationship between a country's rate of GDP growth and the emigration rate among the skilled. Beine et al. (2001) were the first to test the existence of a causal linkage in this regard. After controlling for the inflow of remittances as well as for the general level of education, they detected no significant impact of migration rates on aggregate growth. At the same time, in another regression explaining the general level of education, they estimated the impact of an increase in the share of emigrants to be positive and significant for those countries with a GDP per capita lower than 15% of the average one of the G7 countries. This result is regarded as some degree of confirmation for the hypothesis of a positive linkage between migration propensities and incentives for educational investment. However, the stylized nature of their empirical approach calls the validity of their results into question. First, they rely on cross-sectional data, even though the theoretical predictions to test are explicitly dynamic. Second, due to the lack of a harmonized international database on skill levels, estimates are based on overall emigration rates instead of emigration rates of high-skilled workers.

In a follow-up paper, Beine et al. (2003) improved on that by drawing on migration data differentiated by education levels collected by Carrington & Detragiache (1998). They first used this data to test a causal relationship between gross investment into human capital and the emigration rate of the highly skilled. Just like in the first approach, a positive effect of emigration on skill formation was claimed to be confirmed. Then, the contribution of human capital to GDP growth was tested and the resulting coefficients were used to predict the potential growth performance of a country in case of an emigration rate of zero. Interestingly, for some countries showing comparatively low emigration rates, this potential growth rate turned out to be lower than the actual present one. The authors identify this as a sign for the capability of a "brain drain" to generate a positive net effect on growth.

More recently, the same estimation strategy was applied to the more comprehensive dataset provided by Docquier & Marfouk (2006), with qualitatively very similar results (Beine et al. (2008)). Specifically, while the net effect is for the majority of countries estimated to be negative and losses are of higher average magnitude than gains, gains are nevertheless shown to dominate in aggregate terms. To some extent, this is based on the fact that with India and China the set of winners comprises the two largest sending countries.

However, before accepting this as clear-cut evidence of a "brain gain" effect, one needs

to be aware that human capital is here purely measured in numbers of educated workers (identified through years of schooling). In this regard, the results do strictly speaking not represent evidence of a gain in aggregate efficiency of the remaining skilled workforce, which eventually marks the central welfare target. Hence, it is unable to account for the phenomenon of self-selection of emigrants observed by the empirical migration literature. For instance, Islam & Choudhury (1990) and Bailey (1993) at the local level as well as Liebig & Souza-Posa (2004) and Chiquiar & Hanson (2005) at the international level yield results that hint at a positive self-selection of movers compared to stayers. Migrants exhibit an average number of years of schooling significantly higher than the total average within the sending country or region. This heterogeneity can not be fully captured by roughly assigning workers to distinct skill groups, as Beine et al. (2008) have done.

Moreover, taking this argument a little further, there is no reason to believe that a positive selection should merely occur along the lines of formal education. Instead, some degree of heterogeneity in the mobility of workers with equivalent schooling can be expected to be explained by personal characteristics. In this respect, skilled workers endowed with a superior bundle of work-related talents exhibit a higher earning potential, which implies that any given level of monetary migration costs is of lower harm to them (Chiswick (1999)).

In a way, this deficiency of the empirical approaches is consistent with the theoretical literature, as it is likewise based on the idea of a migration lottery randomly assigning domestic skilled workers to the pool of emigrants. However, as we will demonstrate in this chapter, if a mechanism of self-selection is incorporated into the common model design, the central theoretical result of the literature no longer emerges as a long-run outcome. Since this directly concerns the way the central hypothesis should be tested, it also has important implications for empirical research. Besides, such a mechanism is also shown to yield valuable insights into the distribution of individual welfare responses to an improved environment for outmigration.

The structure of the remainder of this chapter is then the following: In 2.2, we provide an overview on the origins and current stand of the literature analyzing the repercussions of emigration decisions on domestic skill formation. Specifically, we will point to the deficiencies of the common modelling frameworks and use this to set the stage for our alternative approach. In 2.3, we present our basic model structure and demonstrate the impact of talent heterogeneity on the central long-term results of reducing barriers to the mobility of skilled labour. In 2.4, we switch to a short-run perspective and focus on the transition path initiated by an unexpected drop in migration costs. Afterwards, we analyze how individual welfare is affected by this shock, both across the dimensions of time and talent. As it will turn out, talent heterogeneity produces a more sophisticated picture of welfare effects than what is obtained from frameworks with homogeneous individuals. In 2.5, we discuss some policy implications in the form of a simple, tax-financed subsidy to education. In this regard, we demonstrate numerically that after accounting for migrant selection such a policy scheme is not necessarily successful in terms of its goal to raise the stock of domestic skill. As an alternative, we propose to complement this policy option by the commitment to refund the subsidy in case of going abroad. This is demonstrated to have a significant impact on the outcome within our experiment. Finally, this chapter closes with a summary of our results in 2.6.

## 2.2 The literature on skill formation and emigration

The first authors that explicitly discussed the implications of a human capital outflow for the sending country within an economic framework were Grubel & Scott (1966). Under the premise of competitive markets, they argue that such an outflow should essentially be neutral with respect to the welfare of those left behind. The argument is that by leaving the country, emigrants not only take away their contribution to national GDP, but also lose their personal claim of national income. Provided that workers are paid according to their marginal product and that the outflow is merely of marginal magnitude, this claim is equivalent to their productivity measured in real income. While there might be redistribution effects among workers of complementary skill, the authors conclude from this that welfare of non-emigrants in aggregate terms should remain unaffected. The only reason for a general decline in well-being would thus have to be grounded in the presence of short-run adjustment costs, which might cause temporary unemployment in the course of restructuring the economy after a sudden outflow.

In principle, the empirical relevance of this conclusion can be tackled with respect to at least two aspects omitted in this way of thinking: The persistence of market imperfections on labour markets that open additional channels for adverse welfare effects and the presence of dynamic repercussions on factor accumulation (and its related external effects) in the economy. The first line of attack was already brought up shortly after, prominently by a range of papers initiated by the contribution of Bhagwati & Hamada (1974).

They propose a static framework with imperfect labour markets, in the sense that the real wage of skilled workers is exogenously fixed as a consequence of unionization. Changes in wages of unskilled workers, in turn, are directly tied to changes in wages of skilled workers, which is justified by referring to the existence of “leap-frogging” incentives in the wage bargaining process within this skill segment. The result is persistent unemployment in both segments. The central assumption of free mobility between skill groups then implies an equalization of the expected income of skilled and unskilled workers.

In the absence of wage changes, an exogenous increase in the amount of skilled workers leaving the country exerts no impact except for a decrease in absolute unemployment levels among domestic skilled workers. If, however, the fact that emigrants earn higher wages abroad creates pressure to raise the domestic wage rate for skilled labour, domestic employment will drop. If the supply elasticity is above unity, domestic unemployment is even predicted to increase. Given the assumption of leap-frogging in wage formation, a similar development is predicted to occur within the unskilled segment, resulting in a decline of national income per capita.

This framework can be criticized in terms of its negligence of the intertemporal costs associated with becoming a skilled worker. These imply welfare comparisons purely based on static income levels to be potentially misleading. In this regard, Rodriguez (1975) transferred some of the underlying assumptions into a dynamic context, but he still did not address educational investment as an intertemporal problem.

For assessing the dynamic welfare effects of intensified outmigration, it is however essential to grasp how the perspective on skill accumulation as part of the general process of lifecycle decision-making is changed by the possibility to go abroad. This notion has further been nourished by the consolidation of the theory on endogenous growth during the 80s, which pronounced the essential role of knowledge creation and diffusion in the development process of an economy.

Nevertheless, it took economists until the late 1990s to analyze the implications of this fact for the evaluation of observed emigration patterns in developing countries. Stark et al. (1998) made a seminal contribution in this regard. They integrate emigration motives into the most simple lifecycle framework of homogeneous agents living for two periods. The process of skill formation is borrowed from Galor & Stark (1993). In their first period of life, agents decide on the amount of time allocated to learning instead of going to work. In the second period, they experience an increase in their productive potential, which is expressed as an increase in their endowment with efficiency units of the single productive factor labour. This increase, in turn, is a function positively related to the time spent learning.

Migration opportunities enter the education decision by improving the return received from generating any additional efficiency unit of labour. By assuming the foreign wage rate to exceed the domestic one, offering individuals the possibility to emigrate in their second period of life raises their income received from each efficiency unit, while the opportunity costs of its production in terms of domestic income remain the same. The problem of a missing barrier against a complete outflow of workers is then circumvented by presuming that only a fixed share of domestic workers is in the position to find a job abroad. This assumption is commonly justified by referring to the presence of search costs or to an immigration quota set by the foreign country in mind. In this way, an increase in this emigration share is shown to exert a non-monotonic long-term influence on the domestic labour endowment. While for high initial values a further increase produces the standard result of a decline of the aggregate stock, the opposite holds true for low initial values, generating the counterintuitive result of a rise in the supply of skilled labour as a result of intensified emigration.

The chosen setup is rudimentary in the sense that wages are fixed and the dynamics resulting from sudden changes in migration quotas are left aside. Nevertheless, the mechanism presented was appealing enough to produce a large series of follow-up and parallel papers investigating the validity of the hypothesis in richer frameworks. Mountford (1997) added a growth perspective by assuming total factor productivity to be positively linked to the share of educated workers on the total workforce of the economy. In addition, agents are heterogeneous in terms of inborn talent. Under these conditions, he proves the existence of an optimal level of the brain drain (i.e. an optimal share of emigrating workers) that maximizes aggregate growth of the sending economy. A similar result is obtained by Beine et al. (2001), who instead focus on aggregate stocks as a source of the externality. This level, however, remains an exogenous parameter in Mountford's setup, as endogenous repercussions on migration incentives are not accounted for.

Vidal (1998) specifically focused on the situation of an underdeveloped country by adding a threshold externality with regards to human capital accumulation: If the stock owned by today's generation exceeds a certain level, it raises the productivity of the next generation's learning efforts. If the probability of emigrating is high enough, the country is shown to leave the underdevelopment trap. Moreover, in discussing the multicountry dimension, he demonstrates that convergence in human capital stocks between countries differing in their initial skill endowment is obtained as long as the migration probability exceeds a certain level.

Stark & Wang (2002), in contrast, proposed an external effect of skilled labour on the production of final output. In the closed economy case, the result would be a socially inefficient rate of skill accumulation. Emigration is then proven to mitigate this effect,

the migration propensity at which social welfare is maximized is shown to be unambiguously positive. Based on this result, promoting outmigration in a skill-scarce country is considered to be a reasonable alternative to the subsidization of public schooling by the authors.

More recent contributions to this line of modelling enriched the basic framework by adding network effects among migrants (Kanbur & Rapoport (2005)), incentives for tax avoidance (Haupt & Janeba (2009)) and labour market frictions (Fan & Stark (2007)). The two central building blocks of the literature were however left untouched: The assumption that the services of workers of different skill are perfect substitutes in production and the assumption that no sorting of emigrants according to personal productivity takes place (either by assuming the migration process as such to be probabilistic or by assuming it to be guided by a person's random draw from some migration cost distribution).

The advantage of such a modelling strategy lies obviously in its possibility to circumvent the problems of formulating consistent optimality conditions for a simultaneous analysis of schooling and migration decisions. At the same time, it is suitable to capture possible uncertainties related to the migration decision from the perspective of a young individual, like possible changes in personal attitudes or the situation in the receiving country. However, in terms of logical coherence, it can not be considered to be fully convincing. Personal ability is directly influencing the schooling decision either by affecting costs or returns to education, while the fact that one person is migrating is, by assumption, a result of pure chance. This is the case even though most of the models explicitly state that the net gains resulting from moving abroad positively depend on a person's level of talent.

It is important to note that this assumption of talent-neutrality is essential for the validity of the results, as first pointed out by Commander et al. (2003). If we instead assumed the migration probability to be a function positively related to personal talent (e.g. as a consequence of discriminatory rules imposed by recipient countries), any supportive impact of a general rise of this probability on school participation would be weakened. The reason is that the comparatively low talent level of agents so far unattracted to education would imply them to face a low probability of enjoying the net gains from working abroad in case of becoming skilled. In this way, any potentially positive impact of a 'brain drain' on domestic skill formation would be mitigated or even reversed. However, they did neither specify the conditions under which such a reversal could take place nor did they propose any further microfoundation for such a process of selection-based emigration.<sup>1</sup> To avoid the arbitrariness in defining functional terms for the dependence of migration probabilities on talent, we instead turn to a different way of thinking by regarding skilled migration as a completely deterministic process.

Another caveat concerns the second central assumption of perfect substitutability between skill types. Essentially, this implies these models to rely on a one-factor or (in case of adding physical capital) two-factor world for explaining the level of educational attainment. Ignoring the real-world complementarity between tasks carried out by skilled and tasks carried out by unskilled workers is far from being innocent with respect to

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<sup>1</sup>Chen (2008) presented a setup that features an endogenous emigration probability. However, he links it to the average level of human capital in the economy, not to individual attributes. A selection effect is thus not taken into account. Lien & Wang (2005), on the other hand, relate the probability to the outcome of some individual entry test imposed by the recipient country, which is however assumed to be independent of personal productivity.



aggregate results. For instance, considering the consequences of a sudden boost to skilled worker emigration, one would have to take its side effect of a corresponding decrease in the productivity of manual labour into account. This decrease would reduce the wage level of the domestic unskilled workforce, potentially inducing more young ones to invest into education. Hence, by affecting individual rationales through the wage channel, any exogenous event influencing emigration or schooling rates is able to have repercussions that are closely related to the degree of complementarity between different skill types.

This channel is omitted in the aforementioned models. Even in those setups augmented by physical capital, the wage rate is implicitly set constant by considering the case of a small economy with unlimited access to international capital markets at a fixed rental rate. Previous attempts to add the realistic feature of wage fluctuations have been made by Wong & Yip (1999), Pieretti & Zou (2006) and de la Croix & Docquier (2010), which all split aggregate labour into a high-skilled and a low-skilled part. However, these contributions do not cover the issue of talent-biased emigration incentives, which makes them ineligible for discussing the implications of self-selection in the emigration process of skilled labour.

In what follows, we will aim to set up an OLG model suitable to analyse the situation of a small developing country confronted with an outmigration of high-skilled individuals to the technologically superior rest of the world. In order to address the issues discussed, it is designed as a three-factor model with heterogeneous agents facing choices both concerning schooling and migration.

## 2.3 The structure of the model

### 2.3.1 Basic setup

Consider a small open economy populated by an infinite amount of agents with lifespans comprising three model periods. The period of life is indexed by  $i \in \{y, m, o\}$ , distinguishing between young ( $y$ ), middle-aged ( $m$ ) and old ( $o$ ) individuals. Each period  $t$ , a new generation of these agents of standardized mass  $m = 1$  is born. Thus, members of three different generations constitute the economy's population at each point in time. For now, the possibility of bequests is excluded in this basic specification. Instead, the initial endowment of a newborn agent purely consists of the capability to supply one marginal unit of unskilled labour  $l$  per time period. In her first period of life, she chooses between the options of fully exploiting this capability, i.e. supplying her one marginal unit on the domestic labour market and receiving a wage rate  $w^l$ , or devoting a fraction  $\epsilon$  of her time to schooling. Schooling is assumed not to be associated with any further costs of resource usage.

Agents are heterogeneous in terms of their ability to generate marketable skills from studying. Each individual is endowed with a specific level of talent measured by the random variable  $a$ . It is intended to summarize all important aspects concerning heredity and family environment. As common in the literature on schooling choices within OLG models, we define  $a$  to be uniformly distributed.

In addition, we introduce a measure of learning efficiency denoted with  $\phi$  in the following way: An agent with talent  $a$  faces the opportunity to supply  $1 + a\phi$  marginal efficiency units of skilled labour  $h$  on next periods' labour market conditional on choosing to participate in the schooling program. This additional parameter allows us to standardize the boundaries of the distribution of talent, we hence assume the exact distribution of  $a$  to

be  $U(0, 1)$ . As a consequence,  $\phi$  measures the extent by which the wage received by the most talented worker would exceed the wage received by the least talented one in relative terms, provided that both decided to participate in the schooling program. Hence, values for this parameter can be chosen to reproduce empirical patterns of income variation within the group of high-skilled workers. The corresponding wage rate per efficiency unit is denoted by  $w^h$ , which is then equal to the potential remuneration received by the least talented members in the workforce in case they are investing in education.

On the other hand, workers who opted against education continue to supply their one marginal unit of unskilled labour in their second period of life and receive the wage rate  $w^l$ . Educational status will henceforth be indexed by  $s \in \{h, l\}$ .

The second major decision within the lifecycle is restricted to the educated part of the workforce (referred to as skilled workers in the following): Workers who graduate from the school program face afterwards the decision about supplying their acquired human capital on the domestic market and receiving a wage of  $w_{t+1}^h$  per efficiency unit, or migrating abroad, where they would receive an exogenously given remuneration of  $w^{h^f}$  per efficiency unit. When migrating, they face one-off direct costs  $c_{mig}$  that reflect the monetary and psychological costs of moving as well as opportunity costs of job search. These costs are assumed to be identical among all skilled workers.<sup>2</sup> Thus, emigration is only worthwhile for those high-skilled workers who can expect a wage differential that is large enough to cover the migration costs.

For unskilled workers, migration is not considered to be an option here, as the discussion is primarily focused on the issue of a “brain drain”. Basically, we assume immigration agencies in countries of the developed world to be willing and to be efficient enough to filter out low-educated applicants.

In the third period, all individuals retire. Since a pension system is not included in this version of the model, they must live on accumulated savings in the last part of their lives.

To sum up, there are three endogenously determined types of workers in the model: Unskilled workers, skilled workers that remain in the country and skilled workers who migrate abroad. Individuals self-select into those groups according to their inborn talent endowment. This selection mechanism is supposed to be driven by an agent’s desire to maximize her personal lifetime utility.

Concerning production, we will stick in this chapter with a one-sector framework as common in the literature. We specify the aggregate production level to be determined by the joint efforts of both skill types and physical capital as a third factor of production. The technology is assumed to exhibit constant returns to scale and satisfies the following

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<sup>2</sup>While in reality some costs like foregone wages from job search can be viewed as being closely related to talent-based productivity differences, other costs like e.g. the grief arising from the loss of the familiar environment should rather expected to be uncorrelated to these characteristics. To ensure consistency with our model mechanism, it is sufficient that at least some kind of cost exists that is not individual-specific in that sense.

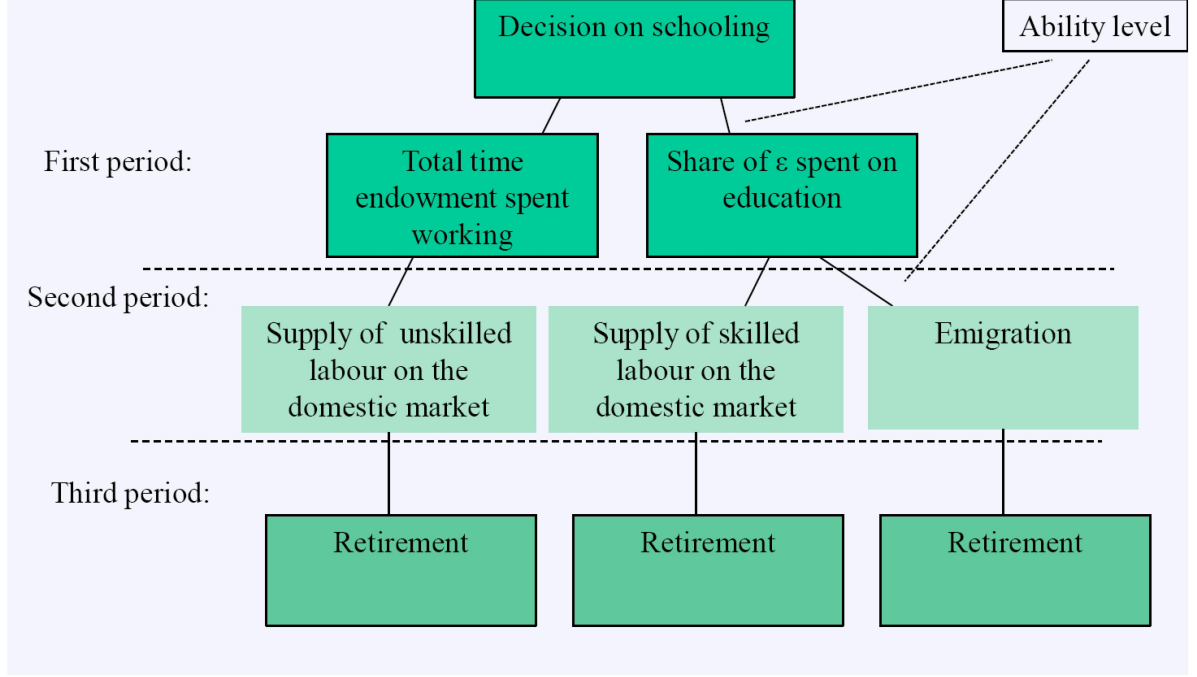


Figure 2.1: Structure of the basic setup

properties:

$$Y_t = F(H_t, L_t, K_t) \quad (2.1)$$

$$\frac{\partial F}{\partial H_t} > 0, \quad \frac{\partial F}{\partial L_t} > 0, \quad \frac{\partial F}{\partial K_t} > 0 \quad (2.2)$$

$$\frac{\partial^2 F}{\partial H_t^2} < 0, \quad \frac{\partial^2 F}{\partial L_t^2} < 0, \quad \frac{\partial^2 F}{\partial K_t^2} < 0, \quad \frac{\partial^2 F}{\partial H_t \partial L_t} > 0 \quad (2.3)$$

$$\lim_{H_t \rightarrow 0} \frac{\partial F}{\partial H_t} = \infty \quad \lim_{L_t \rightarrow 0} \frac{\partial F}{\partial L_t} = \infty \quad . \quad (2.4)$$

Conditions (2.3) exclude the special case of perfect substitutes, as our reasoning is strongly based on the idea of complementarity between workers of different skill level. The Inada conditions (2.4) will be required for the determination of participation rates later on.

The aggregate sector comprises an infinite number of price-taking firms adjusting demand for each factor according to the profit maximization principle of equalizing marginal productivity to the factor price:

$$r = \frac{\partial F}{\partial K_t} \quad w_t^h = \frac{\partial F}{\partial H_t} \quad w_t^l = \frac{\partial F}{\partial L_t}. \quad (2.5)$$

Due to the limitations to labour mobility, the relevant wage rates for both skill types are determined on the domestic market and are thus subject to potential fluctuations over time. In contrast, physical capital is assumed to be internationally tradable at no costs. Precisely, we postulate the existence of a world capital market on which domestic agents can borrow and lend unrestricted amounts at a given rental rate  $r$ . This is justifiable by considering the economy to be infinitely small compared to the outside world.

Concerning the individual's migration decision, no intertemporal issues have to be dealt with, since each emigrant's employment in the foreign country comprises only one

period. The migration decision is thus simply based on income comparisons net of migration costs:

$$(1 + a\phi) \cdot w^{h^f} - (1 + a\phi) \cdot w_t^h \geq c_{mig}. \quad (2.6)$$

Since the level of migration cost itself is assumed to be identical for all potential emigrants, the larger income gap faced by more talented students implies that the returns to emigration rise with personal talent. Hence, there exists a critical level  $a^m$ , which defines the minimal talent level required to experience net gains from going abroad. This is the level at which condition (2.6) holds with equality.

$$a_t^m = z \left( \frac{c_{mig}}{\phi (w^{h^f} - w_t^h)} - \frac{1}{\phi} \right) \quad (2.7)$$

$$\text{with } z(x) = \max. \{0; \min. \{x; 1\}\} \quad (2.8)$$

In this way, the model features an endogenous self-selection mechanism of emigrants. The group of emigrants consists of those high-skilled workers who are able to benefit the most from a technology advantage of the rest of the world with respect to skill-intensive tasks.

Similarly, as the returns to education are positively related to talent, a critical level of talent  $a^e$  above which studying yields net gains can be determined. Given the assumption of perfect capital markets, the utility maximizing schooling choice boils down to a direct comparison of the present value of income streams received in case of participating and in case of not participating in the schooling program. Concerning the calculation of this level, the immobility of unskilled workers ensures that the level of second-period income in case of non-participation is determined by the domestic wage rate. In case of participation, in contrast, the income level obtained after graduation is intertwined with the decision to migrate, as the existence of positive migration costs allows foreign and domestic wages of skilled workers to differ. However, to determine the equilibrium level of  $a^e$ , it is sufficient to analyze the income potential expected by the least talented among all actual students in the economy. Since the Inada conditions (2.4) imply that a total exodus of all professionals would result into  $w^h \rightarrow \infty$  (and thereby eliminating all emigration incentives), complete outmigration can never be an equilibrium solution. Thus, the least talented students are always disinclined to leave. Therefore, it is sufficient to compare present values for those who stay, as all future emigrants are benefiting from schooling anyway. Consequently, an individual will opt for education if

$$w_t^l + \frac{E_t w_{t+1}^l}{(1+r)} \leq (1-\epsilon)w_t^l + \frac{(1+a\phi)E_t w_{t+1}^h}{(1+r)}. \quad (2.9)$$

By equalizing both income streams and taking care of the domain, the critical level  $a_t^e$  can be derived below which investment in education does not pay off:

$$a_t^e = z \left( \frac{E_t w_{t+1}^l + (1+r)(\epsilon w_t^l)}{\phi E_t w_{t+1}^h} - \frac{1}{\phi} \right). \quad (2.10)$$

Hence, a worker born in  $t$  with  $a = a_t^e$  is indifferent concerning her participation choice. From this, we can see that the migration channel operates in two ways in our model: It can both affect the returns to education via the anticipation of future higher skill premia (i.e. by raising the return to education) and via a reduction of the payment of

low-skilled jobs in the present (i.e. by reducing the opportunity costs of participating in the schooling program). Thus, in our setup it is not an exogenous improvement in the returns to emigration itself, but rather the endogenous response of the domestic labour market that can positively affect schooling.

Having determined both critical levels, we are able to express the aggregate stocks of skilled and unskilled labour as functions of these two selection measures. Here, the potential of outflows requires us to distinguish between two kinds of stocks of human capital. If we just focus on the amount of graduates produced by the domestic program each period, the relevant stock is simply a function negatively related to the cut-off level in education. In what follows, this stock is denoted by  $H^{Tot}$ .

$$H_t^{Tot} = \int_{a_{t-1}^e}^1 h_t^m(a) da = \int_{a_{t-1}^e}^1 (1 + \phi a) da = (1 - a_{t-1}^e) + 0.5 \cdot \phi \left(1 - a_{t-1}^e{}^2\right) \quad (2.11)$$

If we are instead interested in the total mass of skilled labour supplied on the domestic market, the cut-off level concerning migration needs to be taken into account as well. Since we generally refer to domestic stocks in discussing the evolution of aggregate human capital, this measure is simply denoted by  $H$ .

$$H_t = \int_{a_{t-1}^e}^{a_t^m} h_t^m(a) da = \int_{a_{t-1}^e}^{a_t^m} (1 + \phi a) da = (a_t^m - a_{t-1}^e) + 0.5 \cdot \phi \left(a_t^m{}^2 - a_{t-1}^e{}^2\right) \quad (2.12)$$

$$= (a_t^m - a_{t-1}^e) \left[1 + 0.5\phi (a_t^m + a_{t-1}^e)\right] \quad (2.13)$$

Note that the total supply in  $t$  is provided by the middle-aged generation born in  $t - 1$ . Given our choice for the talent distribution, a possible interpretation for this measure is the mass of least talented workers required to be employed as skilled workers in order to provide a contribution of equivalent productivity.

In the same fashion, we can proceed with the calculation of the aggregate stock of unskilled labour at each point in time. From the discussion above it follows that:

$$L_t = \int_0^1 l_t^y da + \int_0^1 l_t^m da = a_t^e + (1 - \epsilon) \cdot (1 - a_t^e) + a_{t-1}^e. \quad (2.14)$$

$l_t^y$  and  $l_t^m$  denote unskilled labour supply of a member of the young and of the middle aged generation in  $t$ , respectively. Hence, with the size of each generation equal to unity, the stock is measured relative to the maximal potential contribution of members of one generation (i.e. when none of them would invest in education). Likewise, the stock of skilled labour can be ascertained by aggregating over all individuals endowed with the necessary degree of talent.

We can get a first impression on how the self-selection of emigrants shapes the effects of intensified outmigration by calculating the marginal effect of an equal drop in both critical levels. This is similar to the analysis of an exogenous increase in the migration

probability within a probabilistic model.

$$\begin{aligned}
-\frac{\partial H_t}{\partial a_t^m} &= -\left((1 + 0.5\phi(a_t^m + a_{t-1}^e) - 0.5\phi(a_t^m - a_{t-1}^e))\right) = -(1 + \phi a_t^m) < 0 \\
-\frac{\partial H_t}{\partial a_{t-1}^e} &= (1 + 0.5\phi(a_t^m + a_{t-1}^e) - 0.5\phi(a_t^m - a_{t-1}^e)) = (1 + \phi a_{t-1}^e) > 0 \\
-\left(\frac{\partial H_t}{\partial a_t^m} + \frac{\partial H_t}{\partial a_{t-1}^e}\right) &= -\phi(a_t^m - a_{t-1}^e) < 0
\end{aligned}$$

Since  $a_t^m > a_{t-1}^e$  is guaranteed to hold, we can conclude that the net impact of a simultaneous marginal decrease of  $a^m$  and  $a^e$  on the supply of skilled labour in the economy is unambiguously negative. This is obviously due to the heterogeneity involved. The increase in the number of students is based upon individuals at the lower end of the ability range, which means that it is not able to compensate for the loss of top talented individuals. In a probabilistic context, this effect would occur in weaker form, as the average ability level of emigrants would not necessarily be larger than that of the domestic pool of skilled workers. In the following, we refer to this effect as the **selection effect**.

For the given technology, endogenous selection is paired with an additional mechanism, which is apt to put any positive net effect of skilled emigration into question: The positive dependance of skilled worker productivity on the domestic provision of manual labour. In this respect, the prospect of boosting skill accumulation through higher school participation is not only limited by the relative inefficiency of domestically employed graduates, but also by the danger of further stimulating push effects in skilled emigration. Since this is grounded on the complementarity of skill types in the production technology, we refer to this effect in the following as the **complementarity effect**. Formally, it can be demonstrated by showing that a one-time marginal decrease in the educational talent threshold today is able to lower the corresponding threshold in emigration one period later:

$$-\frac{\partial a_t^m}{\partial a_{t-1}^e} = -\frac{\partial a_t^m}{\partial w_t^h} \frac{\partial w_t^h}{\partial L_t} \frac{\partial L_t}{\partial a_{t-1}^e} < 0. \tag{2.15}$$

Hence, by considering school participation to lower the domestic returns to skill, the migration-schooling channel here also operates in an opposite direction. This is left aside by the probabilistic migration models of the literature, which essentially view emigration rates to be largely independent of domestic wage fluctuations.

However, to take a simultaneous endogeneity of enrollment rates and emigration patterns into account we need to turn to a general equilibrium analysis.

### 2.3.2 The long-run impact of dismantling migration barriers

In the common probabilistic framework, the parameter of main concern is obviously the probability of emigrating. According to the law of large numbers, it is equal to the actual share of skilled workers going abroad. This means, changing this parameter simply imposes an exogenous shock on the level of outflows, which is, by construction, unaffected by any adjustments to follow.

In contrast, our strategy is to focus on changes in the level of the costs associated with emigrating. Since we account for the fact that this cost level is not the sole determinant

of emigration incentives, we obtain changes to the size of migration flows as endogenous responses within our model. To determine the sign of these changes, we will make use of comparative statics.

In line with the perspective taken by most of the literature, the discussion within this section is devoted to a derivation of long-term results concerning the economy's aggregate variables. The system defining the conditions for a long-run equilibrium is obtained by combining the definitions of cut-off levels in schooling (2.7) and migration (2.10) with the aggregate labour supply equations ((2.13) and (2.14)) and the equations defining factor rewards (2.5). Since no mechanism was introduced that could generate long-term growth, the nature of a potential steady-state has to be stationary. Time subscripts will hence be dropped during the subsequent analysis.

Before turning to the comparative statics of a migration cost shock, it will prove convenient to eliminate physical capital from the system first. In general terms, this can be accomplished by solving the production technology (2.1) for  $K_t$  and plugging the result into (2.5). The resulting terms then determine the equilibrium payments made to the two skill types as functions of labour supply only. More precisely, in accordance with the general properties of constant returns to scale technologies, the only endogenous expression left that matters for the determination of wage rates is then the skilled-to-unskilled labour supply ratio.

$$w^h = f\left(\frac{H}{L}\right) \quad w^l = f\left(\frac{H}{L}\right)$$

This employment ratio of skill types in turn represents a function that is positively related to the cut-off level in migration and negatively related to the cut-off level in education.

$$\frac{H}{L} = f\left(a^e, a^m\right)$$

Totally differentiating the reduced system with respect to the migration cost level yields the following set of equations:

$$\begin{aligned} dw^h &= w^{h'}\left(\frac{H}{L}\right) \cdot d\left(\frac{H}{L}\right) \\ dw^l &= w^{l'}\left(\frac{H}{L}\right) \cdot d\left(\frac{H}{L}\right) \\ d\left(\frac{H}{L}\right) &= \frac{H'}{L}(a^e) \cdot da^e + \frac{H'}{L}(a^m) \cdot da^m \\ da^e &= a^{e'}(w^h) \cdot dw^h + a^{e'}(w^l) \cdot dw^l \\ da^m &= a^{m'}(w^h) \cdot dw^h + a^{m'}(c_{mig}) \cdot dc_{mig}. \end{aligned}$$

Solving for the ratio in labour supply enables us to establish an unambiguous result for its long-term change.

$$\frac{d\left(\frac{H}{L}\right)}{dc_{mig}} = \frac{\frac{H'}{L}(a^m) a^{m'}(c_{mig})}{1 - \left(\frac{H'}{L}(a^e) \left(a^{e'}(w^h) w^{h'}\left(\frac{H}{L}\right) + a^{e'}(w^l) w^{l'}\left(\frac{H}{L}\right)\right) + \frac{H'}{L}(a^m) a^{m'}(w^h) w^{h'}\left(\frac{H}{L}\right)} \geq 0$$

Provided that migration costs are low enough to observe any outmigration at all, reducing migration barriers thus leads to a decline in the relative supply of skilled labour. While this alone already marks an important deviation from the literature, it does not say whether this is due to an excessive outflow of professionals or to a depression of school participation. This can be ascertained by looking at the signs of changes in the domestic wage rates:

$$\frac{dw^h}{dc_{mig}} \leq 0 \quad \frac{dw^l}{dc_{mig}} \geq 0.$$

Hence, a decrease of migration costs yields an increase in the domestic skill premium as long as  $a^m < 1$  holds (i.e. migration takes place). As a further consequence, the cut-off level in schooling shrinks in response to a drop of  $c_{mig}$ , accounting for the fact that the generally higher wage rate of skilled labour implies schooling now to become worthwhile at even lower levels of talent:

$$\frac{da^e}{dc_{mig}} \geq 0.$$

In this regard, our setup shares with previous models the basic result that an improvement of migration opportunities raises the domestic returns to education in the long-run. The mechanism which generates this outcome is however a completely different one: While in a context of stochastic emigrant selection the rising chances to earn the higher foreign wage induce an increase in the emigration probability to attract additional students, this is not the case in our model. Here, the cut-off workers are perfectly aware that the given technology is unable to yield a set of wage rates that would render them better-off when choosing to go abroad. Instead, it is the anticipated increase in the mobility of other, more productive graduates that causes cut-off workers to expect a higher personal remuneration, plainly as a result of reduced domestic competition.

Concerning the consequences of this mechanism for the evolution of factor stocks, some differentiation is appropriate. Since the level of schooling is positively influenced by a migration cost decline, the total stock of skilled labour generated by the learning efforts of a domestic cohort can be inferred to increase in the long-run. Since this implies a loss of manual labour, the stock of unskilled labour is affected with opposite sign.

$$\frac{dH^{Tot}}{dc_{mig}} \leq 0, \quad \frac{dL}{dc_{mig}} \geq 0$$

In determining the implications for the accumulation of skilled labour actually employed domestically, the effect on emigration rates needs to be taken into account as well. In this regard, the result of a decline in the skilled-to-unskilled labour supply ratio does imply the long-run effect of lifting migration barriers to be detrimental: Given that unskilled labour supply decreases as a consequence of risen school participation, skilled labour supply has to decrease as well to obtain the result of a shrinking skill intensity. Hence, we can conclude:

$$\frac{dH}{dc_{mig}} \geq 0.$$

This result marks a significant departure from the literature: strengthening the opportunities of skilled workers to emigrate does result into an unambiguous deterioration of the



economy's stock of human capital, even though positive implications for school participation are considered by the model structure. To understand this result, one needs to refer to the two-fold process of self-selection ignored by previous work. According to this, the increase in the number of graduates is unable to compensate the loss stemming from the increased outflow, as the students additionally attracted represent an inferior selection in terms of productive efficiency compared to the ones pulled abroad. Quite the opposite, as the students motivated to join the school program are themselves disinclined to emigrate, the only underlying reason for their motivation is the increased scarcity of skilled labour. Hence, following a shock to the emigration pattern, an increase in school participation is inevitably associated with a downfall in aggregate skill provision.

While it is evident how this central result is shaped by the presence of a **selection effect**, it remains to be demonstrated which role the second force introduced above, the **complementarity effect**, has in determining the long-run outcome. To specify the degree of this complementarity as a parameter of interest, we will in the following be more explicit about the production technology. To focus on the extent of labour-to-labour substitutability, we impose a two-stage nesting structure. On the upper level, physical capital is combined with a labour composite in a Cobb-Douglas manner, with  $\alpha$  denoting the output elasticity of the labour composite. On the lower level, the labour composite is split up according to a general CES form, with  $\gamma$  denoting a shift parameter and  $\sigma$  denoting the elasticity of substitution between the two skill types.

$$Y_t = \left( \left( \gamma H_t^{\frac{\sigma-1}{\sigma}} + (1-\gamma)L_t^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \right)^\alpha K_t^{1-\alpha} \quad (2.16)$$

For the extreme case of  $\sigma \rightarrow \infty$ , the complementarity effect breaks down, i.e. conditions (2.3) would no longer hold. This situation is equivalent to a treatment of skill upgrading common in the literature, where acquiring formal education is simply interpreted as creating an efficiency gain in performing one and the same task as unskilled workers do. As a consequence, wage rates would be identical and fixed by the assumption of an exogenous rental rate of capital. Hence, applying this limiting case to our framework of deterministic emigration would imply that boosting the outflow of skilled labour would not exert any impact on school participation.

While the presence of labour complementarity thus proves not to be a necessary requirement for lower migration costs to generate a net loss of skill, the fact that professionals and manual workers are in reality not perfectly substitutable should nevertheless influence the extent of this net loss. To illustrate this dependence, we go on with simulating a range of long-run equilibria for different levels of  $\sigma$  and migration costs  $c_{mig}$ . This requires us to select parameter values first, which will also be made use of in later sections.

The foreign wage rate for high-skilled labour  $w^{hf}$  is set equal to unity. In this way, all domestic wage rates are expressed in relation to what the least talented domestic workers could earn when working as a skilled worker abroad. Concerning the output elasticity of labour, we choose a value of  $\alpha = 0.6$ , a level which is in line with various sources of empirical evidence (Munnell (1990), Crafts (1992), Denis et al. (2002), Barras (2009)). In determining the market interest rate  $r$ , we must be aware that for the given three-generations-structure each model period comprises a whole stage of an individual's life. Since early childhood and states prior to the attendance of higher schooling in general are not included in the model structure, it is appropriate to think of one period

to comprise about 20 years. With an annual interest rate chosen to equal 4%, this leads to a value of  $r = 1.04^{20} - 1 = 1.1912$  for the relevant rate used in discounting the income streams received under the given alternatives. Concerning the elasticity of labour-to-labour substitution  $\sigma$ , the value  $\sigma = 1.4$  is deliberately chosen to be rather high compared to recent estimates (Antras (2004)). This is done in order not to overrate the **complementarity effect** on education patterns. The value will be subject to variation during the analysis.

In addition, there are three parameters lacking sensible real-life estimates: Learning efficiency  $\phi$ , the migration cost level  $c_{mig}$ , the shift parameter  $\gamma$  and the relative time consumption of studying  $\epsilon$ . Conditional on our choice of other parameter values, we calibrate these three such that a plausible magnitude for the share of agents enrolled into higher education, the level of outmigration, the income share of skill types as well as for the degree of income variation within the group of skilled workers is reproduced. The benchmark situation used for calibration is that of a long-run equilibrium.

Our concept of higher education employed in the analysis is closer related to the acquisition of a general level of skill than to the occupation- or qualification-specific skills accumulated through tertiary education. Hence, it is more meaningful to fit a baseline value for  $a^e$  to observed completion rates of upper secondary schooling. Within the group of emerging market economies, OECD estimates of this rate for 2009 vary significantly. They lie within a range from close to 20% for India to slightly more than 60% for Brazil (OECD (2012)). As a compromise, we choose a benchmark value of 40%. This implies that  $a^e = 0.6$  is specified to be the outcome for the educational cut-off in the benchmark case.

To specify the benchmark situation for the emigration pattern, we stick to Docquier & Marfouk (2007). By making use of their comprehensive dataset on net emigration to OECD countries by professionals from net sending countries, they estimate the average emigration rate to be 7.3%. Adjusted for our specified share of participants in higher schooling within the benchmark economy in total, this translates into a benchmark value for the migration cut-off of 0.971.

In addition, another condition imposed is that the initial steady-state is supposed to reflect a distribution of labour income which assigns to both skill types the same share of income, implying the condition  $w^h H = w^l L$ .

Concerning the income variation among graduates, a dimensionless measure appropriate for our model calibration is the standard deviation of log income ( $sd_{log}$ ). Applied to our modelling framework, it is calculated as follows:

$$sd_{log} = \int_{a^e}^{a^m} \left( \log \left( (1 + a\phi) w^h \right) - \log \left( (1 + \bar{a}^e \phi) w^h \right) \right)^2 da.$$

where  $\bar{a}^e$  denotes the average talent level among the individuals investing into education, which is obviously also a function of the cut-off. As a benchmark used in calibration, we choose the estimate of 0.361 provided by Freeman & Schettkatt (2001).

With the help of these three side conditions, values for  $\epsilon$ ,  $\phi$ ,  $\gamma$  and  $c_{mig}$  can be determined such that a long-run equilibrium consistent with these conditions is obtained. The values resulting from this calibration setup are:  $\epsilon = 0.76$ ,  $\phi = 2.82$ ,  $\gamma = 0.493$ ,  $c_{mig} = 1.82$ . These values are then applied in the simulations that follow.

Figure 2.2 depicts the resulting pattern for the variables of main interest.

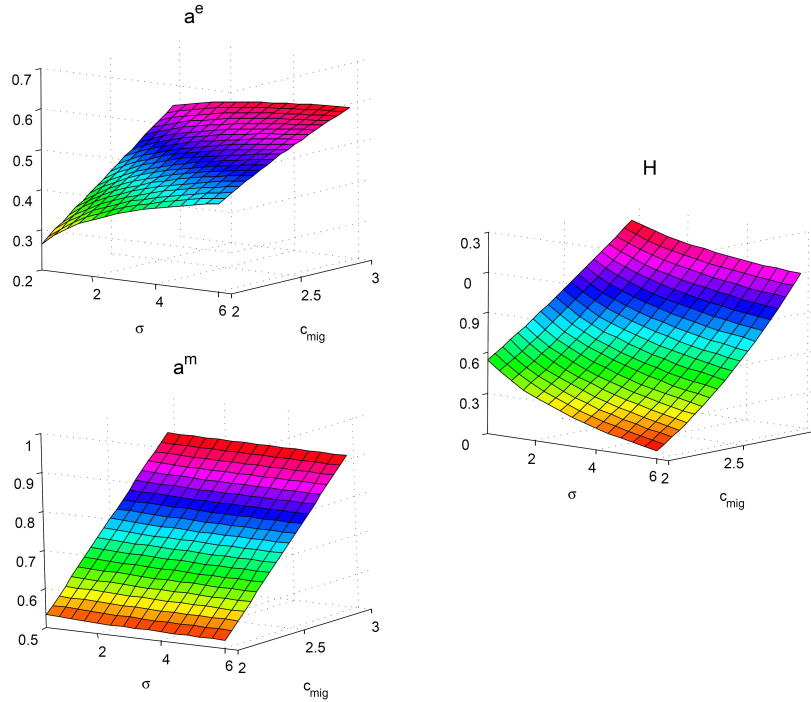


Figure 2.2: Long-run equilibria and labour-to-labour substitutability

First, focusing on the sensitivity of school participation to changes to the strength of migration barriers, figure 2.2 indicates that for lower degrees of labour-to-labour substitutability the educational cut-off  $a^e$  is more sensitive to the level of migration costs. This is in line with basic complementarity considerations: Encouraging outmigration of professionals reduces the marginal productivity of unskilled workers and thus the opportunity costs of education. This effect is the more substantial the higher the mutual dependance of skill classes with regards to their efficiency in production. As a consequence, at each level of migration costs the long-run stock of human capital takes on higher values for lower degrees of substitutability between skill types. This beneficial impact of skill complementarity positively interacts with the degree of openness: The lower the strength of migration barriers, the greater the domestic scarcity of skill. In turn, greater scarcity implies that unskilled worker productivity (and hence school participation) becomes even more sensitive to the degree with which skills are substitutable.

## 2.4 Transitional dynamics and welfare

### 2.4.1 The adjustment process in response to a migration cost decline

The focus so far has exclusively been on the aggregate long-term effects of lifting migration barriers. For an analysis of its normative implications, the results obtained are insufficient for two main reasons. First, the individual welfare outcome is obviously highly sensitive to the level of personal talent. It both determines the personal income response and the ability of an agent to switch her status in order to participate in the intertemporal gains (or to avoid the losses) of a certain status group. In this regard, it is very unlikely

that a migration-induced shift in aggregate stocks should result into either a pareto-improvement or -worsening, as the earnings of the two skill classes have been shown to move into opposite directions. Weighing these individual outcomes with different signs in turn requires a quantitative assessment of the extent of welfare change at the individual level. Second, a focus on pure long-term changes can be misleading with regards to the situation faced by generations born right after the shock. As it will turn out, the economy does not immediately switch into a new long-run equilibrium after an unforeseen shock to migration costs. Since the periods of adjustment are in our setup measured in terms of generations instead of in terms of years, the short-run evolution actually comprises a large timespan. This implies that the effect on the well-being of at least one generation should be more sensitive towards the nature of transition paths than towards long-term shifts.

Concerning the treatment of dynamics, many authors of the brain drain literature rely on simple steady-state comparisons (Beine et al. (2001), Kanbur & Rapoport (2005), Fan & Stark (2007)). Among the exemptions, Vidal (1998) was the first to focus on the adjustments of aggregate human capital in the economy in response to an identified outflow. As mentioned earlier, results of his model are however strongly reliant on the combined assumption of a fixed emigration rate and perfect substitutability between skill types. On the other hand, alternative transition-focused approaches either restrict their analysis to the case of homogeneous individuals (Wong & Yip (1999), Lundborg & Rechea (2002)) or neglect the impact on educational incentives by dealing with exogenous growth rates for skilled and unskilled labour (Pieretti & Zou (2009)). Alternatively, they assume a fixed share of workers to invest into education (de la Croix & Docquier (2010)). In this respect, our contribution concerning the brain drain dynamics will be to add a new perspective on transition by focusing on the interplay between heterogeneity in emigration and school participation.

Consistent with our long-run analysis, the type of shock we have in mind is a decrease in the costs of emigrating. To be precise, the economy is assumed to have reached a long-term equilibrium in period  $t = 0$ . In  $t = 1$ ,  $c_{mig}$  unexpectedly drops by 10 %. This is supposed to reflect unforeseeable events from the perspective of the small developing economy, such as unexpected international agreements on labour market openness or less strict policies of law enforcement on the part of developed country's authorities.

First, we derive the time paths for all aggregate variables on their way to a new stationary steady state. For that matter, stability as well as uniqueness of such a path are first needed to be confirmed. To gain a clearer picture of the dynamics at work here, the system of model equations can be reduced by first inserting the definitions of factor stocks (2.13) and (2.14) into the profit maximization conditions (2.5). Then, the resulting terms for factor prices can be plugged into the cut-off conditions (2.7) and (2.10). In this way, the dynamic system is reduced to two (nonlinear) difference equations linking the two cut-off levels, which fully determines the evolution of factor stocks in the economy over time. The structure of these functional relations is the following:

$$a_t^m = f^1(a_t^m, a_t^e, a_{t-1}^e) \quad (2.17)$$

$$a_t^e = f^2(E_t a_{t+1}^e, a_t^e, a_{t-1}^e, E_t a_{t+1}^m, a_t^m). \quad (2.18)$$

Both cut-off variables can hence in terms of their dynamic properties be described to have both a forward-looking and a backward-looking component.

The current migration threshold does, on the one hand, depend on expectations concerning future migration propensities. Through its impact on the future domestic skill premium, the expected size of future outflows affects educational incentives and hence the stock of unskilled labour today. As this in turn affects the current domestic wage rate, it also influences today's cross-border wage differential. On the other hand, the level of outmigration also hinges on migration volumes observed one period before: Past emigration flows have influenced the unskilled wage rate the generation currently deciding on emigrating has been facing when being young. In this way, they have affected school participation and hence the degree of domestic competition between professionals today.

Based on the same linkages, the current educational cut-off is a function of both past and expected future enrollment rates. Given the irreversibility of past education and migration decisions, this constitutes an element that prevents the occurrence of an immediate jump of the state variables into their new steady-state levels at the time the unanticipated shock hits the economy.

Due to the non-integer powers present in the production technology, the functional relations (2.17) and (2.18) can not further be simplified. Convergence over time is then checked by numerically performing a linear approximation around the old steady-state and determining the eigenvalues of the system matrix for the resulting linearized system. For the given structure, the dimension of this matrix is  $3 \times 3$ , 3 eigenvalues are hence to be determined. With 2 forward-looking variables, the Blanchard-Kahn conditions (Blanchard & Kahn (1980)) require exactly two of them to lay outside the unit circle, which is numerically confirmed to be the case. In addition, the rank condition is verified as well. The exact path is then computed by assuming that sufficient convergence to the new steady state is achieved within 20 periods, such that the cut-offs are assumed to return to their steady state levels in  $t = 20$ . Figure 2.3 displays the resulting paths.

We observe either an over- or an undershooting in the adjustment process of each variable and a convergence to the new long-run equilibrium values that is rapid, at least in terms of model periods.<sup>3</sup> This is intuitive by considering the situation in  $t = 1$ . Here, the total stock of human capital owned by the native labour force  $H^{Tot}$  is still a product of optimizing decisions based on the circumstances of the pre-shock world. Based on the unexpectedness of the shock, the individuals that constituted the young generation in  $t = 0$  could not foresee the decline in migration costs one period later.

Nevertheless, there is an immediate response in terms of domestic supply to be noted. As soon as native professionals become aware of the more favourable conditions for migrating, the economy is facing an abrupt outflow of human capital. The resulting scarcity raises the wages of domestic high-skilled workers. At the same time, the income earned by complementary low-skilled workers is depressed by the same effect. The willingness to invest into education among the less talented young individuals born in  $t = 1$  thus rises for two reasons. First, a lower present wage rate for unskilled labour implies lower opportunity costs associated with participating in the schooling program. Second, facilitating the outflow of skilled labour implies that potential students can expect lower competition in the high-skilled segment of the domestic job market for the time after graduation. In turn, the resulting rise in the number of graduates in the following period leads to a reversed change in relative wage rates. This change is, however, of a lower magnitude than the initial one. The reason is that the share of emigrants within the population continues

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<sup>3</sup>Nevertheless, "rapid" does not refer to the number of real-world years. Remember that, depending on the estimated length of each stage of life, each period comprises up to 25 years.

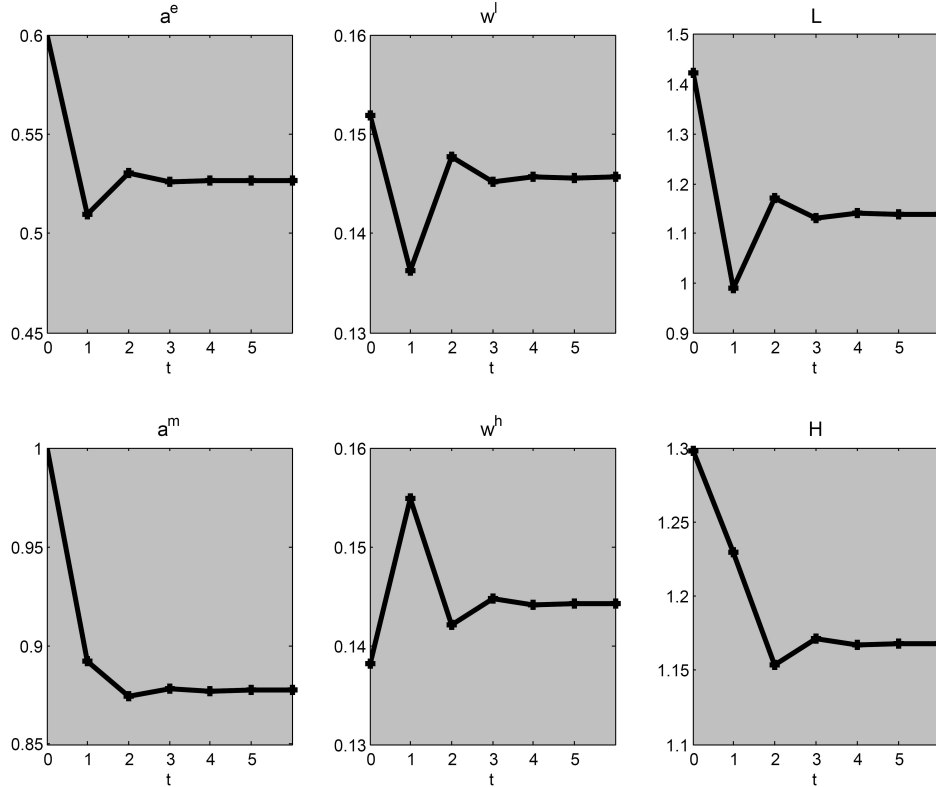


Figure 2.3: Transition dynamics after an unexpected decline in migration costs

to rise, given that highly-talented workers respond to the further decline in skilled worker payment by outmigration. As a result, domestic human capital in aggregate terms is only to a minor degree able to recover from the initial shock in the subsequent period  $t = 2$ .

From this period onwards, no further significant adjustments in domestic variables take place. The working population then only consists of workers born in the aftermath of the shock, as the generation that was caught by surprise retires. In this way, the distortion introduced by the planning mistakes of this generation starts to loose impact at a fast pace. The small economy hence settles down to its new long-run equilibrium, which is marked by a higher emigration rate and a lower endowment with skilled labour.

The results strongly suggest that the variation in individual welfare outcomes is not merely sensitive to the distribution of inborn talent, but also to differences in the agent's period of birth relative to the occurrence of the shock. This will be taken into account in the next section, where we will develop our welfare measure and apply it to a normative analysis of the same shock.

#### 2.4.2 The normative implications of dismantling migration barriers

Since a focus on long-term consequences prevails in the positive analysis of the “brain drain” issue, the same can be stated for the way normative statements are derived in the literature. Papers like Stark et al. (1998) and Lien & Wang (2003) interpret changes in the amount of human capital supplied as indicators of the economy's welfare level. In aggregate terms, this has some justification with regards to the existence of economy-wide positive externalities attributable to a higher stock of human capital (Romer (1986)). In

individual terms, it nevertheless neglects the dependance of personal welfare outcomes on the individual's draw from the talent distribution. In the standard setup with fixed wage rates, this does not represent an issue. There, individual welfare changes are solely determined by two things: The number of efficiency units gathered of the uniform factor of labor and the exogenous migration probability. This means, uneducated workers whose status would not be affected by a migration-related shock are already *ex ante* defined to be indifferent towards any of those shocks.

However, our results from above suggest that accounting for the existence of skill complementarity is likely to introduce a considerable degree of variation into the welfare distribution. Specifically, given the contrary evolution of wage rates for the two skill classes over time, changes in the well-being of individuals within each generation should in any case be disparate in their signs. In this respect, establishing a quantitative criterion of individual pleasure will be necessary for producing general welfare results. Approaches in this direction are within this strand of modelling still astonishingly scarce. Fan & Stark (2007) postulate a welfare function consisting of the discounted sum of average income over generations. Such a measure however neither allows for an intragenerational welfare comparison nor is necessarily related to the individual's preferred time structures in consumption. In contrast, Pieretti & Zou (2006) explicitly compare welfare effects of intensified outmigration of skilled labour on domestic skilled and unskilled workers for different degrees of skill complementarity. A shortcoming of their analysis lies in the fact that skill levels are assumed to be *ex ante* given and emigrants at the same time selected according to some fixed share. Hence, they ignore the effects of endogenous self-selection on the distribution of welfare.

The papers that come closest to a full-fledged welfare analysis are Wong & Yip (1999) and Lundborg & Rechea (2002). They explicitly consider the well-being of generations born at different points on the time path of transition after a "brain drain" has been initiated. Their central result is that nonmigrating skilled workers should benefit and unskilled workers should suffer from intensified outmigration of professionals. However, their analyses differ from ours to the extent that they preclude any *ex ante* heterogeneity of agents within each generation. In an intertemporal context, their result does not need to carry over to a world of heterogeneous workers. Especially with regards to the least talented among the domestic graduates, a decrease in first-period income experienced through a decline in unskilled worker productivity could just as well overturn the positive effect of higher future rewards to schooling.

To come to a conclusion on this point, we first need to specify the intertemporal preferences of agents. In this regard, we choose a standard additive and time separable function with constant intertemporal elasticity of substitution:

$$U_t = \sum_{b=0}^2 \beta^b \cdot u(c_{t+b}) \quad (2.19)$$

$$u_c = \frac{c^{1-\eta} - 1}{1 - \eta} \quad (2.20)$$

$$\beta = \frac{1}{1 + \rho}. \quad (2.21)$$

where  $\beta$  denotes the discount factor,  $\rho$  the rate of time preference and  $\eta$  the inverse of the intertemporal elasticity of substitution. Each individual is maximizing her intertemporal

utility subject to her intertemporal budget constraint, which is specific to the individual choices concerning schooling and migration:

$$c_t^y + \frac{c_{t+1}^m}{1+r} + \frac{c_{t+2}^o}{(1+r)^2} = PVI_t^s. \quad (2.22)$$

where  $PVI_t^s$  denotes the present value of lifetime labour income of a worker choosing status  $s$ .

From the perspective of workers born after the occurrence of the shock, an appropriate welfare measure would simply be the difference in these present value incomes before and after the shock, since the presence of perfect capital markets allows these workers to reallocate period income according to their needs. For the generation born in  $t = 0$ , however, the welfare outcome is not insensitive to the nature of intertemporal preferences. Since the shock has not been anticipated, they will suffer from a misallocation of resources whose extent does depend on their willingness to substitute present for future consumption. To obtain an interpretable measure for individual welfare that both captures the dimensions of time and talent heterogeneity, we apply an intertemporal equivalence criterion of the following kind: We compute the amount of liquid assets  $K_t^{EV}$  required to be transferred to an agent of certain ability born prior to  $t = 0$  (and thus not affected by the shock) in her first period of life in order to render her as well-off as in the counterfactual case of being born  $t$  periods after the shock. In other words, we determine the minimal premium a person born in  $t$  would demand to receive before giving her approval to be displaced into a stationary pre-shock world. Thus, a positive value reflects a welfare increase associated with the shock for an individual of given talent and period of birth. Since the values of capital stocks are measured in relation to the foreign wage rate  $w^{h,f}$ , the interpretation of this measure corresponds to the equivalent number of periods the least talented workers in the economy would have to spend working abroad to attain the same amount of real income from working.

In computing this amount, we also need to consider the effect such a counterfactual payment would exert on the time patterns of consumption for the compensated individual. Therefore, counterfactual values for period consumption as functions of the equivalence measure are jointly calculated with  $K_t^{EV}$ . Formally, the measure is thus determined based upon the following condition:

$$U_{-1}^{EV} \left( c_{-1}^{1:EV} \left( w_{-1}^l, w_{-1}^h, K_t^{EV} \right), c_{-1}^{2:EV} \left( w_{-1}^l, w_{-1}^h, K_t^{EV} \right), c_{-1}^{3:EV} \left( w_{-1}^l, w_{-1}^h, K_t^{EV} \right) \right) = U_t.$$

In simulating the results, the same parameter values are used as in the simulations carried out above.

In addition, values for the preference parameters  $\eta$  and  $\rho$  need to be specified here. Concerning the intertemporal elasticity of substitution, empirical estimates show a high degree of variation. While some authors like Hall (1988) and Patterson & Pesaran (1992) estimate values for  $\rho$  that are significantly smaller than one, more recent studies like Gruber (2006), Hamori (1996) and Ogaki & Reinhart (1998) yield values exceeding unity. We choose with 1.25 a value slightly larger than one, implying a coefficient of risk aversion of  $\eta = 0.8$ .

In contrast, the rate of time preference is not chosen, but calibrated. Under the premise that this rate is identical for consumers in the small economy and consumers in the rest



of world, we ask which  $\rho$  is required to generate a wage rate of  $w^{hf} = 1$  in the rest of the world, accounting for the effects on  $r$  through capital accumulation. The resulting value is  $\rho = 0.689$ , implying an annual rate of time preference of about  $(1 + 0.689)^{\frac{1}{20}} - 1 = 2.65\%$ .

Figure 2.4 graphs the marginal amounts of this equivalence measure calculated over the talent distribution for generations born at different points of time during transition.

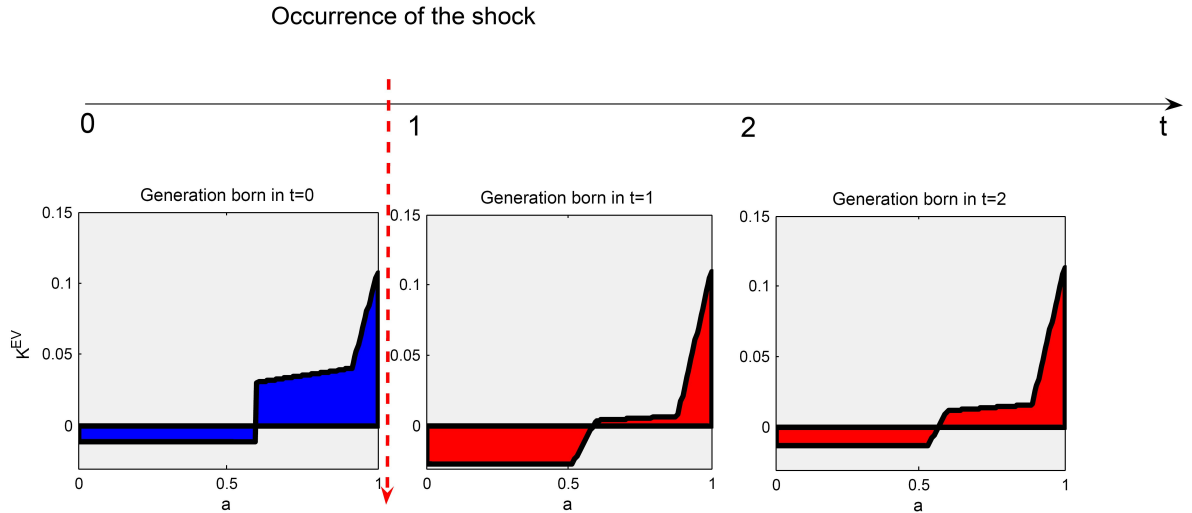


Figure 2.4: The dynamic welfare impact of an unexpected migration decline

First, when focusing on the impact on the generation born one period in advance of the shock ( $t = 0$ ), one can notice a clear separation of individual effects between members of the two skill classes. Low-talented agents that in the initial state chose to remain unskilled are clearly made worse-off, as their productivity is depressed by the sudden emigration wave of the domestic elite. Agents whose talent endowment enabled them to participate in schooling are instead all benefiting from the migration cost decline, not just the ones that actually represent the pool of emigrants. While the group of emigrating professionals experiences a direct gain through the cost decline, the non-emigrants profit from increased scarcity entailed by the emigration wave. Obviously, this is an effect that could not have been observed in a standard framework lacking a reference to the complementarity idea. In addition, given that this generation is caught by surprise, the distribution of equivalence payments over the talent range is discontinuous. Apparently, some of the agents that decided to abstain from schooling in  $t = 0$  would prefer to correct their decisions with hindsight, as the rise in the domestic skill premium would have made them better-off when becoming a skilled worker.

With respect to the generations born after the occurrence of the shock, individual effects are of higher complexity. Here, an agent's well-being is not only passively affected through wage adjustments, but also by her opportunity to respond to these adjustments by selecting a different career path than in the absence of the border shock. However, the ability to evade its detrimental consequences is again related to talent, opening a second channel through which the personal welfare outcome is affected by the inborn bundle. In this regard, the least endowed within each generation are unwilling to switch to a higher education status despite the drop in the remuneration of manual work. This is the case

because their low efficiency in learning implies that the rise in the skill premium is insufficient to cover the first-period opportunity costs associated with schooling. Compared to low-talented workers born one period before the cost decline, welfare losses are even more severe, as the labour income earned in the first stage of life is now impaired as well.

At the same time, among the young ones sufficiently endowed, this further raises incentives for educational investment. However, this incentive change is mainly driven by a relative increase in well-being as a result of becoming a professional. Hence, it does not need to imply that agents induced to deviate from their potential pre-shock choices are actually made better-off through the occurrence of the shock. Instead, we can observe the least talented within the class of skilled workers even to loose in intertemporal terms. In the end, this is grounded in the type of heterogeneity analyzed. It implicates that an increase in the scarcity of skilled labour does not need to lead to a general welfare improvement among the owners of this factor, as the weight of this scarcity premium in shaping intertemporal utility differs according to personal efficiency.

Concerning the situation for highly-talented emigrants, this group is revealed to gain throughout the generations. Within each one, they exhibit the largest net gains from the cost shock. This is again explicable by the endogeneity of their status type. The fact that each of them represents a positive selection of the domestic skilled workforce would lead them to be the greatest beneficiaries of an increase in the domestic skill premium if they alternatively decided to stay. Hence, the observation that nevertheless some workers are starting to go abroad who would not have done so under the higher migration cost level implies that the cost decrease associated with migrating is of even higher benefit for them.

Nevertheless, a difference in the absolute level of this superior gain is related to the time dimension. The intertemporal welfare improvement for emigrants born in  $t = 0$  is of higher magnitude, as they are in the position to reap the benefits from the cost increase without facing part of its detriments through deteriorating income perspectives when being young.

The pattern of welfare changes becomes even more evident when we summarize results in the form of average equivalence payments (in marginal units) for the different classes agents select into. In figure 2.5,  $l_h$  represents switchers from an uneducated to an educated state as an outcome of the shock, while  $h_f$  stands for workers which are motivated to emigrate as a consequence of the shock.

The scenario documented so far was that of a country facing a sudden emigration surge after previously being completely isolated from the international competition for intellectual capital. It remains to be demonstrated which welfare pattern emerges from a similar shock imposed on an economy which is already characterized by some persistent level of skilled labour flow in its original long-term state. To this end, we analyze for the same parameter constellation the welfare effect resulting from a further 10% reduction in migration costs when starting from the new long-run equilibrium obtained after the initial reduction. Figure 2.6 unifies the results attained from applying the same equivalency measure to this subsequent shock with the ones resulting from the initial decline.

Evidently, the broad picture of the dependance of welfare effects on both individual heterogeneity and the amount of time passed after the shock is identical in both scenarios. Allowing the group of emigrants to consist of both switchers and non-switchers in response to the shock thus does not destroy the general pattern of a monotonicity of welfare gains in personal talent. A difference to the no-initial-outflow case is just introduced by the

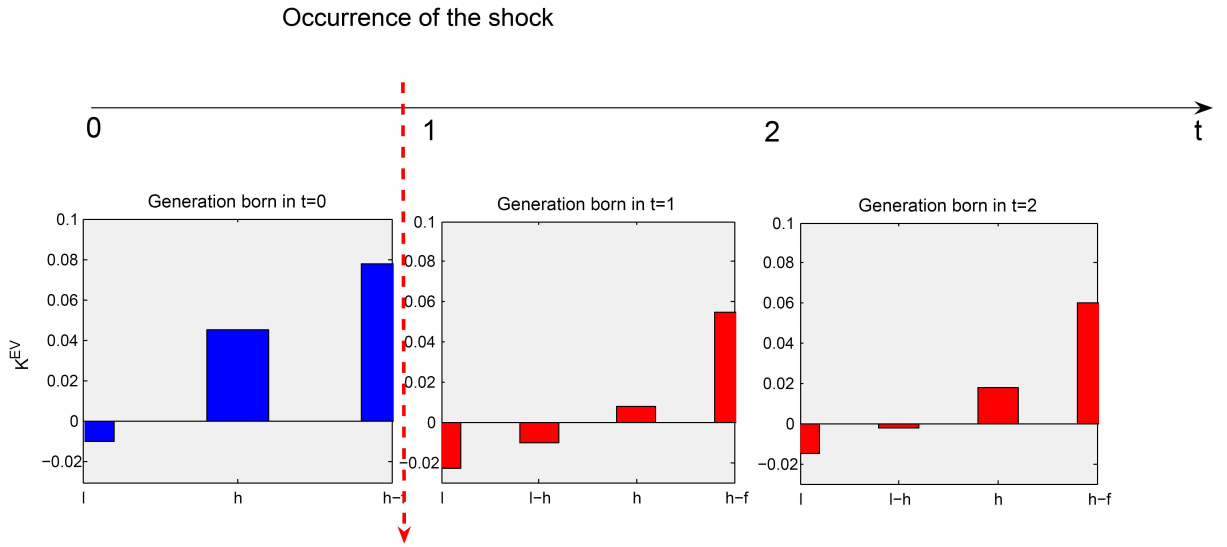


Figure 2.5: The welfare impact of a migration cost decline across status groups

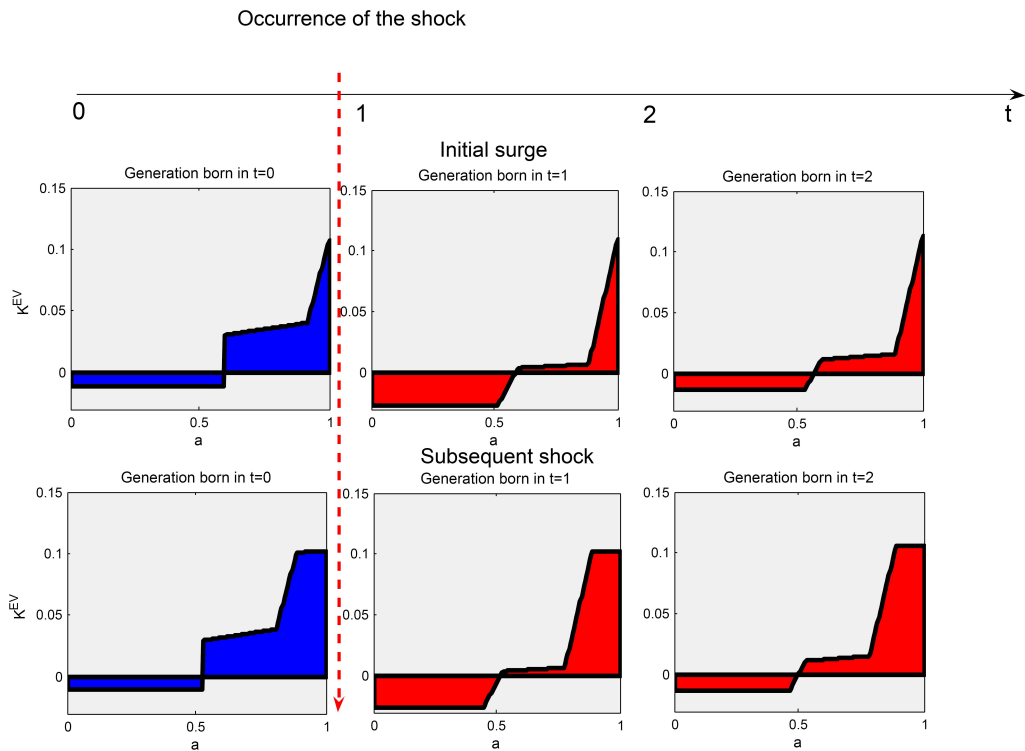


Figure 2.6: The welfare impact with and without initial outmigration

fact that the equality in the welfare response observed among the least talented workers is now met by a similar equality among the most talented. Since workers at the top end of the distribution would have gone abroad under the initial policy regime as well, their personal change in second-period net income is exclusively driven by the cost decrease, whose degree is assumed not to vary with individual productivity.

Hence, as one observes increased outmigration to yield an increase in the gap of well-being between high- and low-talented workers within a sending country, this might raise public demand for corrective policies designed to mitigate the net loss of human capital in the context of labour market integration. One of the most commonly discussed recipes in this regard will represent the topic of the next section.

## **2.5 Skilled worker migration and subsidies to education**

### **2.5.1 Effects of a one-off payment**

The fact that a system of rigorous border controls is both associated with high administrative costs and low public acceptance raises the question which alternative measures could be taken by a sending country's authorities. An obvious one would be to tackle the issue by offering public support to those investing into higher education. If such a subsidy is financed by a linear income tax, low-talented workers will merely make a small contribution in case of becoming skilled compared to the high-talented ones, as their income potential is lower. When neglecting any repercussions on wage rates, this contributes to a rise of skilled labour supply through a boost to school enrollment.

However, if the increase in the number of graduates exerts downward pressure on the domestic wages earned by skilled workers, such a rise would be matched with increased outmigration, implying an unobvious net effect. Besides, it is not guaranteed that workers attracted to studying as a consequence of receiving the subsidy end up actually being better-off. The reason is that personal well-being is not solely a function of the net contribution made to the system, but of the response of the skill premium to the policy shock as well.

Previous papers that analyzed the effects of educational policies in similar frameworks featuring outmigration are Wong & Yip (1999), Chiswick (2005) and Docquier et al. (2008). Docquier et al. (2008) deal with the scenario of a subsidy financed by general income taxes. They discuss the optimal strategy of fiscal adjustment in response to a fiscal loss caused by intensified outmigration. If the government's primary goal is to maximize the human capital stock, they prove that raising the tax rate is a better strategy than lowering the amount of subsidies. However, emigration is undertaken with a fixed probability in their setup, which means that they do not account for any repercussions such a policy change would again have on the incentives to go abroad.

Wong & Yip (1999) consider a scenario in which education is provided by the state. In their model, the level of skill that is achieved by one generation through schooling is beside the level inherited from the preceding generation also positively dependent on the number of educators hired by the government. The payments made to these educators are financed by a proportional income tax. The state is then shown to be able to counter the harmful effects of a brain drain by an increase in the student-teacher ratio, which is achieved by raising the tax rate. This result is however critically relying on the concept of homogeneous individuals.

Chiswick (2005) instead argues that providing unlimited access to resources of higher

education essentially implies a reduction in the selectivity of students, as the free provision also attracts some who can only expect modest returns from schooling. As a result, the existence of opportunities to emigrate implies that a further increase in the level of public subsidization is not guaranteed to raise the level of skill in the economy. Since it further reduces the selectivity, this can have detrimental effects on overall education quality or absorption capacities of domestic labour markets, thus being likely to stimulate the emigration incentives among the brightest graduates.

This is in line with our argumentation concerning the effects of talent-biased emigration. However, in our setup, the occurrence of this effect does not require a reference to limited absorption capacities, but instead operates directly through wage changes. By integrating subsidies into our framework, we are able to assess the state's role after combining the concept of talent heterogeneity applied by Docquier & Rapoport (2007) with the complementarity idea of Wong & Yip (1999). Talent heterogeneity has important implications for the division of agents into net recipients and net payers. The least talented among the group students represent the group of net recipients, as they face lower future tax obligations. Net payers are surely agents with talent too low to invest into education, but not necessarily the most talented among the skilled workers, as they have the perspective to evade part of their tax obligations by going abroad after graduation. The first question to be answered in the following is which consequence this has for the efficiency effect of an educational subsidy concerning its goal to raise the stock of human capital. In a further step, we will focus on its distributional impact.

To keep our focus on the basic mechanism introduced by public interference, the scheme considered is reduced to one of the simplest possible forms, adopted from Docquier & Rapoport (2007). Governmental support is assumed to consist of a lump-sum subsidy to education, which is equally spread among its recipients.<sup>4</sup> Each young individual that joins the schooling program is immediately rewarded with  $S$  marginal units of output, regardless of personal talent and without any obligation of repayment in this first scenario. This subsidy is financed by levying proportional taxes on the labour income of all workers, with  $\tau$  denoting the uniform tax rate. The government is legally prevented from any kind of net borrowing, the national budget is therefore required to be balanced at each point in time. A consequence is that policy-makers can not decide on the tax rate and the degree of subsidization independently. We will presume that the authorities face some degree of uncertainty concerning the actual number of eligible recipients of such a subsidy in each period. Therefore, to keep the total volume of public spending in check, they fix the tax rate and let  $S$  respond endogenously. The amount of the subsidy distributed to a student born in  $t$  then becomes a function of  $\tau$  that can be represented as total tax revenues divided by the mass of students from the same generation:

$$S_t = \frac{\tau (w_t^h H_t + w_t^l L_t)}{(1 - a_t^e)}. \quad (2.23)$$

Then, the existence of this support scheme influences the condition under which an individual opts for education in the following way:

$$(1 - \tau)w_t^l + \frac{(1 - \tau)w_{t+1}^l}{1 + r} \leq (1 - \tau)(1 - \epsilon)w_t^l + S_t + \frac{(1 - \tau)(1 + a\phi)w_{t+1}^h}{1 + r}. \quad (2.24)$$

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<sup>4</sup>The underlying idea is here that local authorities are unable to observe innate talent differences and are therefore not in the position to allocate the respective funds on a discriminatory basis.

which implies the following updated talent threshold in education:

$$a_t^e = z \left( \frac{(1+r)\epsilon(1-\tau)w_t^l + (1-\tau)w_{t+1}^l}{\phi w_{t+1}^h} - \frac{1}{\phi} \right). \quad (2.25)$$

In this first scenario, we assume that the support obtained is not conditional on any rules of behaviour or repayment obligations subsequent to graduation. The sole direct channel through which this scheme influences the migration decision is then a reduction in domestic net income received by high-skilled workers. Since the policy choice is restricted to the small economy in isolation (i.e. is not coordinated internationally), this implies an increase in international earning differentials, providing professionals with incentives to engage in tax evasion via outmigration. The updated migration threshold thus becomes:

$$a_t^m = z \left( \frac{c_{mig}}{\phi (w_f^h - (1-\tau)w_t^h)} - \frac{1}{\phi} \right). \quad (2.26)$$

This linkage differs from the one sketched by Chiswick (2005), as it does not require a crowding-out effect on domestic labour markets in order to generate the result that educational subsidies promote skilled emigration.

To assess the implications of this two-fold effect of the support scheme, we will focus on the dynamics following a sudden unexpected tax introduction. Precisely, our starting equilibrium in  $t = 0$  is the one obtained as a long-run response to the migration shock analyzed in 2.4. Local authorities in the small economy are then assumed to counter the long-run loss of human capital caused by the gradual border opening by introducing an education tax of 20% ( $\tau = 0.2$ ). Its revenues are immediately distributed to students in  $t = 1$ . The presence of dynamics is then attributable to the fact that the tax introduction was unexpected by the generation born in  $t = 0$ , therefore guaranteeing some inertia in the convergence to a long-run equilibrium with ongoing subsidization.

The structure of adjustment is similar to the basic case, albeit complemented by additional dynamics:

$$a_t^m = f^1(a_t^m, a_t^e, a_{t-1}^e) \quad (2.27)$$

$$a_t^e = f^2(E_t a_{t+1}^e, a_t^e, a_{t-1}^e, E_t a_{t+1}^m, a_t^m, S_t) \quad (2.28)$$

$$S_t = f^3(a_t^m, a_t^e, a_{t-1}^e). \quad (2.29)$$

Since we do not consider any intertemporal redistribution of tax revenues (remember that the state budget is required to be balanced at each point in time), the volume of the subsidy is merely a function of the size of today's domestic factor stocks, not of those of the periods before. Hence, today's thresholds show no direct dependence on preceding ones that reach more than one period back into the past. In this way, each threshold still features one lag and one lead, which allows one to split them into one forward-looking and one backward-looking variable. The subsidy volume itself is merely related to its own value one period ahead and one period back into the past: Schooling decisions (and hence the size of tax contributions) today are partly based on students' expectations concerning school participation tomorrow, as this influences the degree of competition they would expect to face in the future when remaining unskilled. Expectations on school enrollment, in turn, are closely related to the expected volume of

subsidization. In addition, the tax revenues that can be allocated to subsidy flows today are obviously related to the volume allocated in the period before, as this partly determines the supply of high-income workers in the economy today. Thus, we end up with 3 forward-looking variables. After linearization, the resulting system matrix is thus required to have exactly three eigenvalues outside the unit circle for stability and uniqueness to be met. This is numerically confirmed to be the case. Figure 2.7 displays the resulting transition paths.

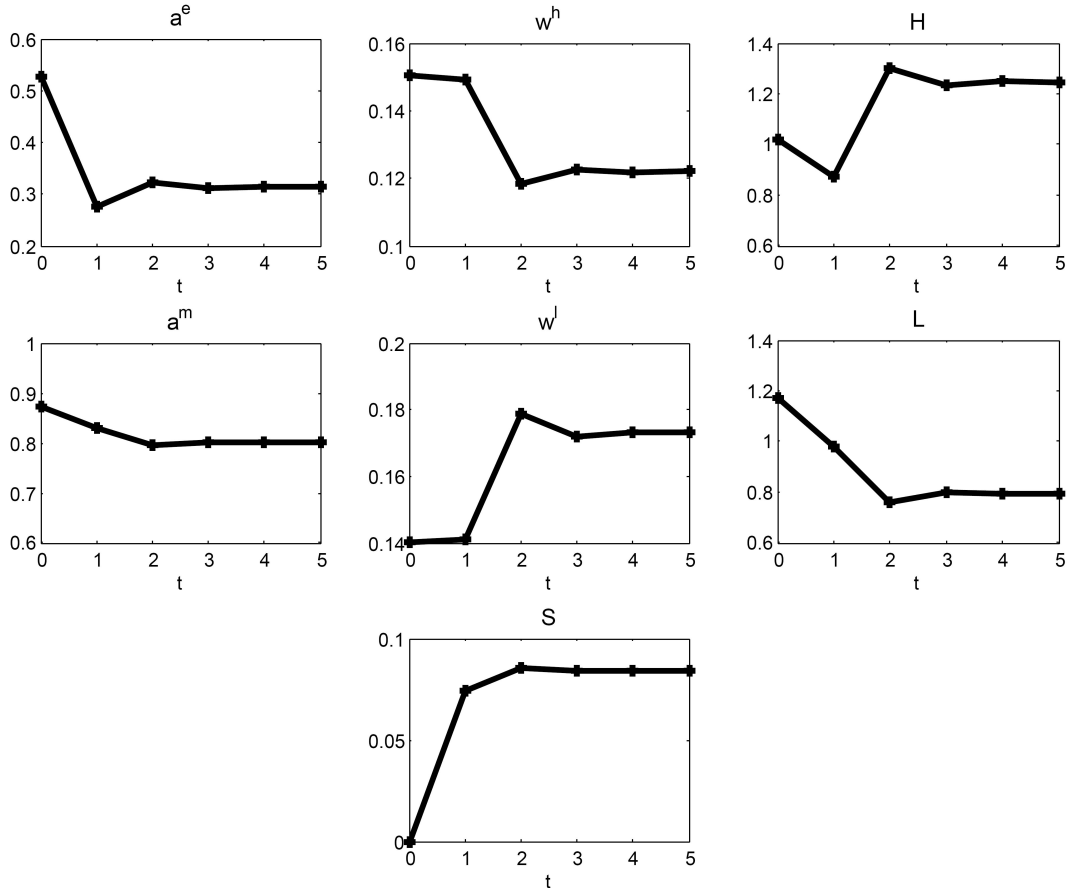


Figure 2.7: Transition dynamics in response to the tax introduction

The immediate response to the tax introduction in  $t = 1$  is as desired an increase in school enrollment among members of the generation born in the introductory period. This is based on the fact that less talented agents now receive an additional compensation for the opportunity costs of studying besides a comparatively low future income increase. For the fraction of time they devote to the efforts of learning, these agents are hence not available as manual workers for domestic firms. This loss of manpower translates into a decrease of aggregate supply of unskilled labour in  $t = 1$ . At the same time, emigration incentives among skilled members of the preceding generation are enhanced despite a rise in domestic skilled worker remuneration. The reason is that their domestic net income is negatively affected by the tax introduction, without being in the position to receive a share of the collected funds themselves. In consequence, the immediate response to the policy scheme is an undesired drop in human capital supply.

In the subsequent period, however, this negative net impact is more than reversed, as those graduates being attracted by the subsidy now start to enter the domestic labour market. This supply increase is in conjunction with the growing scarcity of unskilled labour responsible for the fact that the domestic skill premium is experiencing a significant decline in this period. As a consequence, the rate of school participation among the following young generation is lowered to some degree, but does not return to its pre-shock level. The reason is a further increase in subsidy payments financed by the tax contributions of the growing mass of high-wage/high-skill workers in the economy. To some extent, this acts as a buffer against a lower market capitalization on skill.

Of course, this means at the same time that incentives for skilled workers to evade taxes by going abroad are maintained.  $a^m$  thus experiences a further decline. This increased outflow undermines to some extent the goal of the subsidy, but the net effect on skilled labour supply nevertheless starts to adopt a positive sign in this period. This gain can be maintained over the following periods, as the partial recovery of domestic high-skilled wages sets limits to a further rise of outmigration. Hence, distortions in the migration cut-off taper off rapidly after  $t = 2$ . The same is observed for the cut-off level in education, as subsidy volumes are not subject to any significant fluctuations after the period of tax introduction. The least capable within the domestic skilled workforce thus receive similar levels of support throughout the generations, which maintains their willingness to invest. This persistence in subsidy flows is the net result of two opposing effects. A stabilization of the tax base after  $t = 1$  resulting from increased schooling participation and a destabilization caused by the decrease in these workers' pre-tax income.

Regarding long-run implications, the main objective of encouraging domestic skill formation is achieved. However, this result does not imply that the additional workers dragged into schooling are actually the ones who are benefiting the most at the individual level. To see this, one needs to be aware that any increase in their first-period income through the subsidy payment is at the same time impaired by the opportunity costs of education. Unlike in case of more talented workers, these costs would not have accrued without the imposition of the subsidy. Besides, it is not even clear that the group of students attracted is benefiting at all. In fact, as they represent a negative selection compared to those that would already have invested in pre-shock times, their future income potential as a skilled worker is comparatively low. Since at the same time net income of unskilled workers is negatively affected by the tax payments needed to finance the subsidy, their switch to education could purely be motivated by avoiding more severe losses when remaining unskilled. In that sense, an increase in school participation should not carelessly interpreted as a blessing for skilled workers in general.

To analyze the implications of this reasoning, we again make use of our compensation based welfare measure  $K^{EV}$  introduced in the context of measuring the welfare effects of a decline of migration costs. Adapted to this scenario, it now measures the amount of capital stock required to be transferred to an individual born prior to  $t = 0$  such that she reaches the same level of intertemporal utility as if she was born in  $t \geq 0$ . Figure 2.8 depicts the variation in this measure both across time and talent, again with  $t = 1$  referring to the period of the tax introduction.

What is immediately striking is the strong discontinuity of the welfare outcome with respect to the period of birth. Among the workers born prior to the tax introduction, no one receives an improvement in well-being as a consequence of the policy shock. To a large part, this is obviously due to the fact that these workers are excluded from the



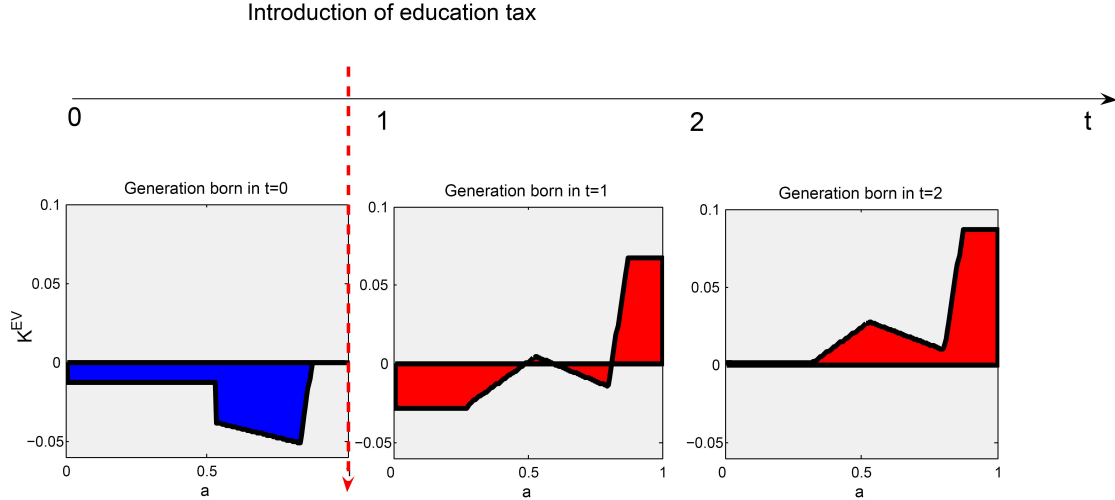


Figure 2.8: The welfare impact of an educational tax

group of recipients of the subsidy, while still being forced to finance the payments made to school participants within the young generation in  $t = 1$ . The only agents unaffected are the ones at the top end of the talent distribution, as the positive net gains they face from going abroad allow them to avoid the payment of taxes via outmigration.

Then, for the generations born in  $t = 1$ , the subsidy is able to trigger a welfare increase, but only for agents with sufficient talent. Concerning the other group, agents at the bottom end of the ability scale are experiencing the most severe losses in well-being through the tax introduction. In contrast, among the set of winners it is the group of workers with highest talent level which can draw the largest benefits out of the policy shock. Hence, an immediate consequence of this policy implementation is a growing inequality in well-being among the members of the generation born in the period of the tax introduction. Then, for the generations born in later periods, the general welfare perspective turns out to become more optimistic. To a large part, this is obviously due to the general increase in first-period pre-tax income: The run into education implies young low-qualified workers to face less competition within their labour market segment. Since students themselves are considered here to be at least part-time workers, not merely nonstudents are benefiting from the increasing shortage of manual labour. Within our policy experiment, this even implies the least talented within the generation born in  $t = 2$  to turn to winners of the policy reform, even though their own inferior capabilities exclude them from the group of recipients of the subsidy. Since the process of wage adjustments is almost completed during this stage, similar predictions can be made for the generations to follow.

Nevertheless, regarding intragenerational equality, the result that the most gifted within the workforce are profiting the most persists as a general outcome also for later generations. This is in so far at odds with expectation, as the efficiency goal of raising school enrollment is explicitly targeting agents at the bottom end of the talent distribution, given that the others would have invested anyway. Hence, when complemented by a financing scheme that requires higher absolute contributions by high-income/high-talent-workers, a decrease in inequality should rather be expected as a distributional side effect

of the policy.

In explaining why this is not the case, one can first refer to the direct impact of wage adjustments as such: The fact that domestic high-skill remuneration is on the decline renders a welfare increase for workers attracted to schooling as a consequence of being subsidized less likely. In addition, the indirect effect of these net adjustments on the incentives for agents to choose a status different than in the absence of the policy shock (“status switchers”) shapes the welfare outcome both for themselves and for others. It thus proves insightful again to compare average values of the equivalence measure for different status groups across the time dimension, as depicted in figure 2.9.

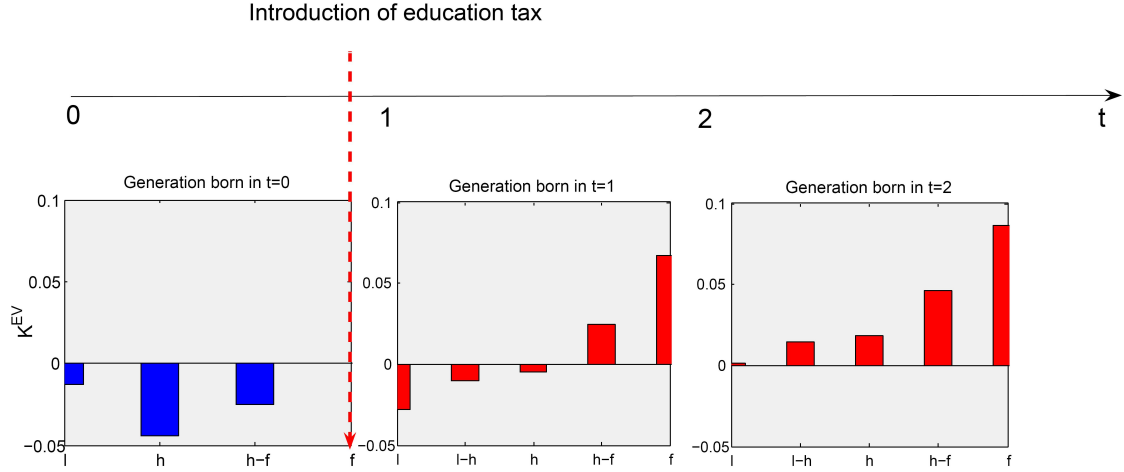


Figure 2.9: The welfare impact of the tax across status groups

Focusing on the situation in  $t = 1$ , the most severe losses are faced by workers which remain unskilled even after the tax introduction, implying them to become net contributors to the system. Second, workers who join schooling as a consequence of the policy scheme are part of the group of losers as well, for the reasons laid out above. The basic complementarity between skill types is responsible for the decrease in pre-tax income earned by domestic skilled workers, as the withdrawal of manual labour lowers their personal efficiency. An additional factor contributing to a deterioration is, of course, the effect of the tax wedge on net income.

In this regard, main beneficiary should be the group of workers whose returns from emigrating are significant enough to allow them to escape from both the decline of the skill premium and the tax burden by leaving the country. Hence, it is no surprise to see that members of groups (h-f) and (f) are experiencing intertemporal gains.<sup>5</sup> However, even within this group, there is a discrepancy in the extent of this gain between workers of different talent to be noted. The reason is that the process of tax evasion is subject to a cost in the form of the expenditures related to emigrating. Since the most talented among those now emigrating would even have done so in a pre-shock stage, this cost do not impair their intertemporal gains from being subsidized. In contrast, for workers that

<sup>5</sup>The exception are the ones born right before the tax introduction, whose sole motivation to emigrate is tax evasion.

switch to the status of emigrants, this cost represents an extra burden reducing their personal increase in net lifetime income.

In sum, one can state that accounting for wage changes in a framework with selective emigration creates the possibility for subsidies to cause reallocations in well-being different from what can be concluded from the changing patterns of labour market participation. This implies that not necessarily those workers explicitly targeted by policy-makers are benefiting the most, if at all, but rather those which are not reliant on public support in order to draw positive returns from schooling. A consequence is that any equity goal pursued by the support scheme is surely not met.<sup>6</sup>

Regarding the enforceability of this policy measure, the results indicate that at least among the generation born in the period of the implementation no general consensus on the usefulness of the subsidy seems achievable. In the end, it thus boils down to an issue of adequate weightation in aggregating individual welfare outcomes, where not only the appropriate choice of weightation factors, but also the question whether emigrants should be considered part of the set of agents whose well-being is aimed to be maximized or not is open to debate. Since this touches upon fundamental issues related to societal values that reach beyond economic analysis, we will leave it at that. Rather, we will investigate the consequences of a modification which is apt to mitigate the spread in well-being associated with this policy instrument, thus increasing its enforceability.

### **2.5.2 A one-off payment with conditional obligation to refund**

From both an economical and ethical point of view, the results of the previous subsection seem to provide justification for supplementing the support scheme by measures that force emigrants to bear part of the welfare costs imposed on others by evading taxes themselves. A corresponding proposal was first elaborated by Bhagwati & Dellafar (1973), since then referred to as the “Bhagwati tax”. Unfortunately, its lack of feasibility due to the administrative problems of international coordination has prevented the actual implementation of such a policy in its intended form yet.

Recently, Wilson (2008) has proposed a way to overcome this infeasibility by constructing a tax scheme that grants return migrants a tax credit, provided that they had agreed to make voluntary contributions immediately before leaving the country. In combination with education grants, another possibility of implementing such a scheme becomes available for policy-makers, if one imagines this tax to take the form of a repayment obligation of the grants received when being young. Besides serving egalitarian goals, this can in our framework be expected to exert positive side effects on skill formation through two channels. First, by lowering the incentives of highly-talented workers to go abroad. Second, by collecting additional state revenues from those not prevented from emigrating, which can be used to enhance the level of public support granted to students in subsequent generations.

In a first theoretical analysis of the effects of a Bhagwati tax on a sending country, Bhagwati & Hamada (1974) came to the conclusion that even though per capita income

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<sup>6</sup>While our modelling here is based on the case of perfect capital markets, the basic argumentation carries over to imperfect ones exhibiting credit rationing all the same. As will be elaborated in the following chapter, the introduction of borrowing constraints does not alter the monotonicity of educational returns in talent. Hence, even if a shortage of skilled labour is primarily due to a lack of sufficient access to credit, measures providing public support to students are merely successful in attracting agents which represent a worse selection compared to those investing anyway.

might under some circumstances be raised by the tax introduction, the effect on domestic supply of skilled labour is unambiguously negative. However, the framework applied differs from ours in at least two critical aspects: First, they stick with the assumption of workers being *ex ante* homogeneous, which means that conditional on acquiring skill everyone emigrates with the same probability. A Bhagwati tax thus lowers the expected income obtained after choosing to become a skilled worker from the perspective of all agents, which implies lower student numbers in equilibrium. In our setup, this direct effect is absent: Since workers with talent level close to the educational cut-off have no incentive to emigrate, their returns to education are not immediately affected by a penalty tax on emigration, any effect hence operates only indirectly through wage adjustments. Second, they do not consider the opportunity to redistribute the tax revenues in the form of subsidies to education.

By integrating an equivalent tax scheme into the heterogeneous agents framework proposed by Stark & Wang (2002), Scalera (2009) comes up with a more differentiated picture: The introduction of a Bhagwati tax is predicted to cause a decrease of the domestic level of human capital only in the absence of any additional policies encouraging schooling. If instead a tax on emigration is coupled with a subsidy to education, this combined scheme is able to trigger a rise. However, in his setup, this result is not based on a redistribution of emigration tax revenues to students, but is due to an indirect effect: For the purpose of being re-elected, the government has an incentive to raise subsidies under the presence of increased outmigration, as the additional revenues required to finance this can be generated by levying taxes on a group which is assumed to have itself no voting rights (i.e. the emigrants).

In contrast, we will consider the direct effect of penalizing emigration by fiscal means, in the way that we assume graduates to be forced to repay the full amount of subsidies received when leaving the country. In this manner, the critical talent level separating emigrants from non-emigrants becomes a function of the volume of subsidies as well:

$$a_t^m = z \left( \frac{c_{mig} + S_{t-1}}{\phi (w_f^h - (1 - \tau)w_t^h)} - \frac{1}{\phi} \right). \quad (2.30)$$

The repayments collected by the state from those who are nevertheless not prevented from leaving are then immediately redistributed to the students within the current young generation. Hence, adding this obligation is specified to have the two-fold effect on domestic skill accumulation mentioned above. In terms of the total volume distributed, the corresponding formula has to be adjusted as follows:

$$S_t = \frac{\tau (w_t^h H_t + w_t^l L_t) + S_{t-1} (1 - a_t^m)}{(1 - a_t^e)}. \quad (2.31)$$

In isolation, an increase in the outflow of skilled labour thus no longer has an unambiguously negative effect on the public support provided to current students, as the fact that it yields additional public revenue works against the diminution of the domestic tax base. The implication for the dynamic structure of the reduced system is that the dependance on

past support volumes adds additional lags:

$$a_t^m = f^1(a_t^m, a_t^e, a_{t-1}^e, S_{t-1}) \quad (2.32)$$

$$a_t^e = f^2(E_t a_{t+1}^e, a_t^e, a_{t-1}^e, E_t a_{t+1}^m, a_t^m, S_t) \quad (2.33)$$

$$S_t = f^3(a_t^m, a_t^e, a_{t-1}^e, S_{t-1}) \quad (2.34)$$

The number of forward-looking variables is unchanged and thus the requirements of the Blanchard-Kahn conditions as well. Consistent with this, 3 eigenvalues are for the given parameter constellation numerically confirmed to have a modulus larger than one.

In the following, we determine the transition obtained from imposing the same policy shock of an introduction of a 10% income tax in  $t = 1$  as in case of a missing repayment obligation (henceforth referred to as the “basic scheme”). Figure 2.10 presents the results for both scenarios.

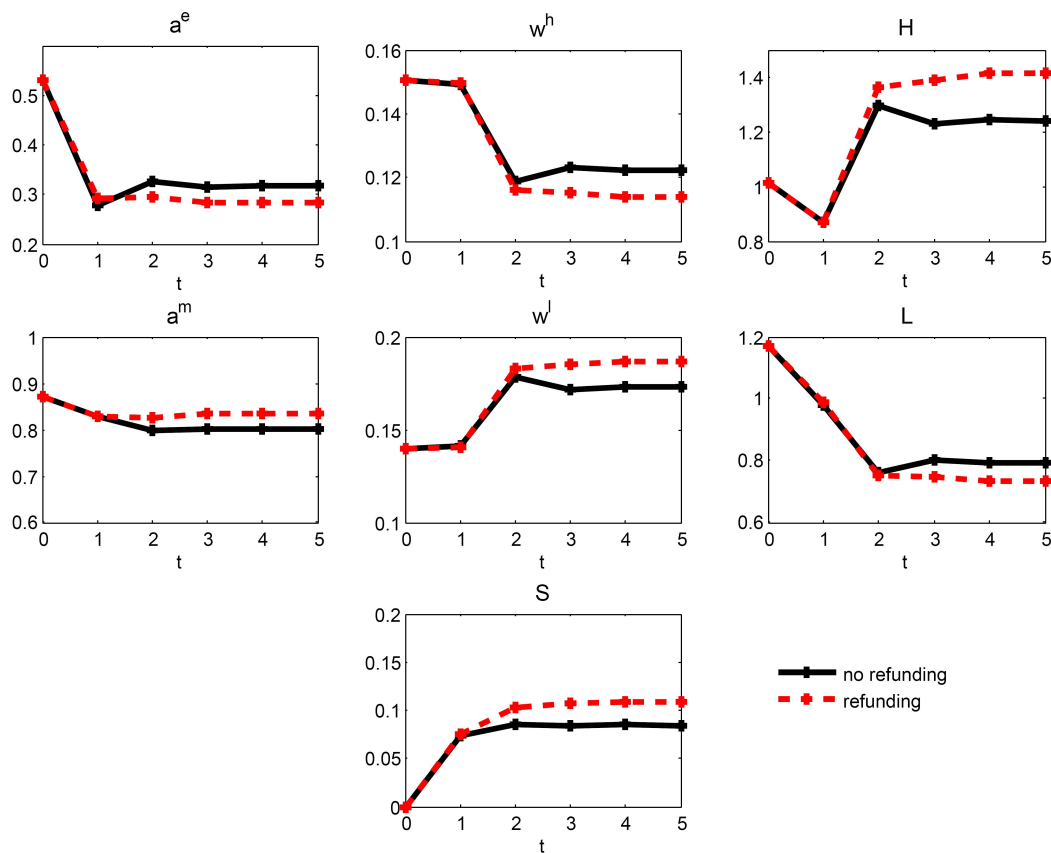


Figure 2.10: Transition dynamics with and without a repayment obligation

First note that in  $t = 1$  the generation born one period before the tax introduction is facing almost the same situation under a repayment regime as after the implementation of the basic scheme. Since the shock is likewise unexpected, the number of graduates from the schooling program is identical. At the same time, migration incentives are yet unimpaired by any compulsory side payments, given that this generation of graduates has not enjoyed any public support which they could be asked to repay. The immediate

response of the stock of human capital is thus also a decline resulting from intensified outmigration. The reason for this change in the emigration pattern is likewise given by an increase in schooling participation, which reduces the stock of the complementary factor unskilled labour.

This increase is in this first period, however, less pronounced under the repayment regime, a fact that is explained by the rational expectations of potential students. The low-talented members of this cohort expect a less significant future increase in emigration rates among high-talented members as a consequence of the repayment obligation. Hence, future competition among graduates should be comparatively fiercer, leading to a more severe depression of the domestic skill premium. This implies that the minimal threshold defining the willingness to invest first takes a higher level than under the basic scheme.

In later periods, this difference is however reversed despite the fact that migration thresholds adopt permanently higher levels under the repayment regime. The cause of this development is to be seen in the increase in the volume of subsidies granted to students. Hence, the repayment scenario is besides meeting its objective of limiting the outflow of the most talented graduates also successful in stimulating domestic skill accumulation through its revenue side: The higher stock of human capital in comparison to the basic scheme implies higher tax revenues, while at the same time additional contributions to the fund derive from repayments made by emigrants. In this way, supplementing the support scheme by such a mechanism of enforced refunding indeed significantly alters the subsidy's impact on skill formation within our policy experiment, both in terms of lower emigration rates and boosted school enrollment. However, this gain is not immediately achieved, but requires one generation to realize. This means that even more than in presence of the basic scheme individuals born in different stages after the policy switch can be expected to be affected differently, requiring a separate welfare analysis for different generations.

Figure 2.11 reports which consequences this has for the evolution of our welfare measure  $K^{EV}$  over time.

In line with the transition dynamics of aggregate variables, there is no qualitative difference regarding the welfare outcome for generations born prior to the tax introduction between the two schemes detectable. What is more insightful is the effect on the generation to follow, which constitutes the first whose aggregate supply of skilled labour exceeds its pre-shock level under the repayment regime. As we can observe, this fact does not exert a genuinely positive impact on their members well-being. Instead, non-emigrants experience a welfare loss from implementing the adjusted support scheme, whose distribution pattern over the talent range is similar to what the same generation experiences under the basic scheme. At the same time the positive impact on this generation's emigrants is weakened by the repayment obligation.

The generation born in  $t = 2$  is then the first which is in the position to extract the gains stemming from an improved provision of skill. When being young, agents unanimously benefit from the resulting productivity gains in terms of first-period income, and participants in the schooling program additionally profit from the higher level of subsidies primarily based on the tax contributions made by skilled workers. As convergence of wage rates to their new long-run levels is in this stage already almost fully achieved, an equivalent pattern is obtained for subsequent generations.

As a consequence, the implementation of migration-related repayment rules is from this generation onwards not only predicted to lead to outcomes superior to the basic scheme from the perspective of a wide range of workers. It is also predicted to yield a

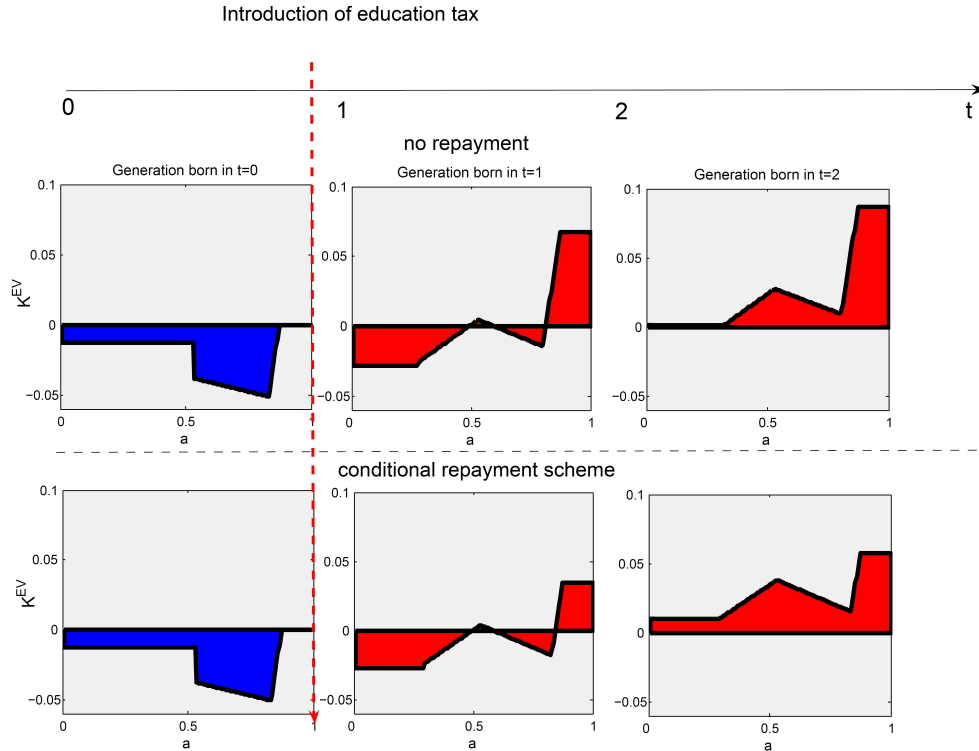


Figure 2.11: The welfare impact with and without a conditional repayment obligation

Pareto-improvement within this generation compared to a scenario in which schooling is not subsidized at all. The only class of agents for which the gains are still of lower magnitude under the repayment scheme are the emigrants. Nevertheless, what is perhaps more intriguing is the fact that in this scenario they are actually better-off than in the absence of subsidization at all, despite inevitably becoming net contributors with respect to transfer payments made to the system. In the end, this is grounded in the exclusive capability of high-talent workers in each generation to make the best out of the wage adjustments resulting from the growing demand for education. They are able to reap the benefits from public subsidization, while afterwards escape the decline in skilled worker remuneration through emigration.

Thus, in a summarizing comparison of the two modes of subsidization, we can state that in terms of the goal to raise aggregate skill provision an approach featuring a repayment obligation actually performs better in our policy experiment. However, a positive impact does not materialize immediately after the tax introduction, but takes at least one generation to be realized. Concerning the effect on within-generation inequality of well-being, heterogeneity of talent implies in conjunction with a talent-biased potential to outmigrate an increase in inequality in our experiment. This is the case even though it is the members of low-income classes which receive an upgrade of their skill level as a consequence of the subsidy. In this regard, supplementing the scheme with repayment requirements does dampen, but not reverse the welfare spread. The main reason for this is that high-talented workers are, while representing the group that is forced to make repayments, are at the same time benefiting from a higher amount of subsidization based on the repayments made by emigrants within the preceding generation.

## 2.6 Conclusion

We were able to develop and solve an OLG model that takes account of some of the deficiencies associated with influential approaches of modelling the consequences of high-skilled emigration in the literature. Our model features a simple but consistent simultaneous analysis of education and migration decisions in a three-factor world made up of individuals that differ with respect to ability and age. In this regard, the most important result derived from the two-fold selection mechanism at work is that an improvement of emigration opportunities for skilled workers is shown never to result in a long-run increase of the domestic supply of skilled workers. This is the case even though positive repercussions on schooling incentives are explicitly accounted for, which marks a clear deviation from the current opinion expressed by large parts of the literature. A “brain drain” is thus incapable of generating a long-run “brain gain”. The cause is the amplified importance of individual heterogeneity based on our deterministic approach for analysing migration decisions. Additionally, a transitional analysis has revealed that a net loss of domestic skill is also to be observed during adjustment in the short-run.

Concerning empirical research, this questions the use of human capital measures relying on a comparison of the number of workers of equivalent schooling. Instead, it points to the necessity of choosing measures of human capital which better account for personal worker characteristics (e.g. proxied by personal labour income (Jeong (2002))).

Regarding the implications for individual welfare, our results tend to confirm previous work to the degree that skilled workers are more favourably affected by a decrease in the costs associated with skilled migration than unskilled workers. However, by accounting for the heterogeneity within skill classes, we demonstrated that this does not imply that skilled workers are actually better-off as a consequence of the shock. Instead, the fact that some agents experience an improved educational status is partly driven by the decrease in their first-period income, which lowers the opportunity costs of schooling.

As a policy experiment, we have dealt with the case of a lump-sum subsidy to education financed by a proportional income tax. It has been demonstrated numerically that the introduction of such an education tax is rather apt to widen the spread in well-being resulting from the international integration of markets for professionals. This is the case even though it targets low-talented individuals which would not have invested into education otherwise. A central explanation lies in the capability of high-talented agents to engage in tax avoidance via outmigration. Finally, we have shown that this deficiency can principally be overcome by supplementing the policy scheme with rules of mandatory repayment in case the graduate decides to go abroad. At the same time, given that it is the most talented workers which will come into the position to make such repayments, this is also apt to reduce any undesirable effect of the policy scheme on individual inequality.

While the framework presented offers some important insights, it might be viewed as overly restrictive in the sense that it neglects some important real-life aspects of intertemporal decision-making, primarily concerning the situation in developing countries. One of these aspects is surely the malfunctioning of credit markets, which we did not take into account so far. In this regard, it will be especially important to demonstrate in which respect the selection mechanism is influenced by the effect of borrowing restrictions on educational investment. A related question is how the role of transfer payments between generations as a substitute for formal credit is intertwined with the intensity of skilled worker emigration. Besides, by augmenting our one-sector model to reflect the case of a multisector world producing goods with different skill intensities, it will become possible



to analyze the implications of creating emigration opportunities for sectoral specialization and hence the structure of labour demand in the sending economy. These points will be addressed in the form of extensions of the basic approach in the two chapters to follow.

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## 3 Skilled migration and intergenerational support

### 3.1 Motivation

Clearly, one of the most serious obstacles young human beings typically face in reaping the benefits from their inborn bundles of individual gifts lies in the malfunctioning of credit markets. The basic issue underlying this relationship is that most inborn abilities do not immediately translate into marketable skills, but instead require some formal or informal education or training in order to acquire the practical knowledge that qualifies for a job at the top end of the skill ladder. Concerning formal education, especially at high-level institutions such as universities and occupation-specific academies, access is commonly granted conditional on the the payment of some kinds of tuition fees. Particularly in developing countries, these fees easily exceed all present income sources a candidate is capable of drawing on. With unlimited access to capital markets that feature high degrees of competition as well as complete information, students could at least in principle always fill the gap by borrowing at a given market rate. This is profitable as long as future gains in terms of income increases can be expected to outweigh the costs of capital service and repayment.

In this way, the question of skill acquisition becomes an intertemporal investment problem that is independent of an individual's initial endowment with liquid assets and therefore ensures a sorting of individuals into skill groups that is purely based on talent.

In contrast, as it better describes reality, if students refrain from borrowing due to excessive transaction costs or high risk premia, the selection process would at least in part turn out to be distorted. In a renowned study carried out for the US, Behrman et al. (1989) investigated the importance of access to financing for the degree of educational attainment as measured in years of schooling: By comparing World War II veterans, who were part of a program that guaranteed equal access to higher education, with their children, they detected that for the former group no significant relation between the number of siblings and years of schooling was existent. For their children, however, this relation turned out to be inverse and significant, indicating problems of accessing formal credit as an alternative to parental aid in financing education. Concerning comparative evidence for the situation in less developed countries, Flug et al. (1998) estimated that differences in the formation of formal credit markets (as proxied by the ratio of liquid liabilities to GDP) do together with income volatility account for about 45 percent of the differences in school enrollment rates between Latin American and industrial countries. Similar evidence is presented by De Gregorio (1996).

In principle, educational policy could meet this issue by abolishing any pre-graduate charges imposed by public educational institutions in favor of a system of financing that is based on subsequent modes of payment such as downstream fees or taxation. It is nevertheless important to note that this alone will not guide the economy into an optimal allocation of educational resources when limitations to borrowing persist. Even without direct payments associated with enrollment, formal as well as informal training commonly entails costs in the form of income losses arising from foregone working opportunities during the time that is filled with studying. If restrictions related to borrowing impede a young person's capacity to compensate these income losses by debt financing of present consumption, this might render higher education unattractive.

From the perspective of a developing economy, another important aspect related to this issue is a possible linkage between capital market imperfections and the outflow of human

capital. A question is how the inability to borrow might affect an individual's decision about acquiring schooling first and possibly leaving the country afterwards. Provided that credit limitations actually decrease participation rates in schooling, it could be reasoned that cutting access to consumer credit might reduce the outflow of skilled labour both in absolute terms and relative to the number of domestic professionals. The argument is that under sufficient wage flexibility, growing scarcity of high-level skill should manifest itself in domestic wage increases, which would depress the returns to emigration.

However, in elaborating this argument, it will be inevitable to come to speak about an opposite link leading from migration flows to the severeness of borrowing constraints as well. This link is driven by the striking empirical phenomenon of transfer flows made from emigrants to their relatives in the source country. Regarding its magnitude, the World Bank states that recorded remittances sent into developing countries were on an aggregate basis almost three times as large as the amount of official foreign aid in 2009. At the same time, they were about as large as total FDI inflows (World Bank (2011)). Impressive figures like this have been the impetus for a by now extensive range of empirical applications investigating the various ways in which migrant remittances can represent a remedy for existing barriers to external resource access. Among the channels examined are a diversification gain regarding migrant remittances as a means to insure household income against agricultural income risks (Agrawal & Horowitz (2002), Yang & Choi (2007)), the promotion of investments into tangible assets (Adams (1998), Taylor & Wouterse (2008)), the improvement of health conditions (Frank & Hummer (2002), Hildebrandt & McKenzie (2005)), and, most relevant in this context, an increase in the educational attainment of children. Concerning the impact of labour market integration, a potential inflow of liquid assets can thus be expected to add to the general positive effect of increased emigration on skill acquisition analyzed in the last chapter.

Growing evidence gathered in recent years seems to confirm this intuition. In a study for El Salvador, Edwards & Ureta (2003) estimated that remittances significantly lower the hazard rate of leaving school, with this effect being ten times as large as the effects of other sources of income. Lately, Bredl (2011) discovered a similar correlation for Haiti. As a further indication of the impact of migrant resources on skill accumulation in their families, Hanson & Woodruff (2003) found for Mexico that children in migrant households tend to accumulate significantly more years of schooling.

Hence, for an economy characterized by an ongoing outflow of skilled labour, there also exists an indirect effect of credit constraints on a country's skill endowment. If a higher domestic skill premium indeed prevents the outflow of some well-trained workers, this would also reduce a future inflow of remittances, thus further worsen the liquidity issues of future generations.

In terms of aggregate outcomes, it is however not a priori clear in which direction this indirect effect operates. First, whether or not such an additional impairment of educational incentives contributes to a net loss of effective human capital is again a question of selectivity. Second, the common focus on international transfers neglects the existence of general transfer motives in the economy. In other words, if potential emigrants are made to stay in their source country, this should not affect their general incentives to support the educational careers of their descendants. Quite the opposite, preventing a loss of communication quality through distance should rather imply stronger financial ties between members of different generations.

In this chapter, we will incorporate general altruistic preferences in the process of

lifecycle decision-making to reflect this fact. In doing this, we need to take into account that the net effect of borrowing constraints on transfer volumes is directly linked to the change in domestic wages. A simultaneous analysis of all the relevant linkages hence asks for a dynamic general equilibrium setup. To reflect the selectivity issue, we will again make use of our way of modelling heterogeneity in terms of inborn talent. In this way, we will be able to examine the consequences of shocks both concerning the willingness to emigrate and the extent with which borrowing restrictions impact on the economies aggregates.

The further outline is then the following: In the next section 3.2, we discuss the evolution and current state of the literature addressing the impact of capital market imperfections on school participation with and without labour mobility. This is done to clarify the extent to which our approach is able to add content to that literature. In 3.3, we present the basic model structure and provide results on the long-term consequences of amplified credit rationing measured in terms of an increase in the share of loan amount required to be covered by current income. In 3.4, we introduce emigration incentives and examine the impact of shocks both related to the severity of borrowing limitations and the mobility costs for skilled labour when this channel is accounted for. Afterwards, in 3.5, we add a general transfer motive to assess the role of intergenerational altruism in influencing the outcome for school enrollment and emigration rates. In 3.6, we turn to an investigation of the dynamics of the system in response to a border shock both in case of altruistic and in case of non-altruistic workers. This is then used as a basis for performing a welfare analysis of a migration cost decline at the individual level. There, we differentiate according to the individual's position in the talent distribution as well as according to it's period of birth. Finally, 3.7. presents a summary of our results.

## **3.2 The literature on educational choices under borrowing constraints**

The dynamic implications of real-life limitations to borrowing capacities became soon after the emergence of the class of OLG models one of the central concerns of this literature. Early contributions in this regard exclusively focused on the distortions of savings decisions and thus of the accumulation of physical assets. Around the same time, starting with the seminal work of Becker (1962), lifecycle approaches evolved which were devoted to the specific issues of human capital accumulation as the outcome of lifecycle strategies.

The first attempt to merge these two strands of OLG literature was made by Loury (1981), who deals with a scenario in which parents allocate resources to training programs for their children. As a consequence of varying income potentials of mature workers, this form of intergenerational transfer turns out to be unequally distributed among the offspring and hence some share of the most talented members of the workforce is prevented from obtaining a sufficient level of training. As the analysis remains at the level of single dynasties, it does not provide a characterization of the evolution of aggregate stocks.

Extending this to an economy-wide perspective, Galor & Zeira (1993) seek to shed light on the role of credit market imperfections. They modify the setup such that members of the young generation decide themselves on the amount of resources devoted to education. However, credit market distortions in the form of borrowing rates exceeding lending rates entail a dependance on parental givings to compensate the loss of present income associated with studying. This, in turn, is used to explain an insufficient use

of educational resources by the poor. One shortcoming of this setup is that it captures individual heterogeneity only in terms of unequal parental support, not in terms of differences in learning ability. That is, it does not state how limits to debt financing impede the process of talent-based self-selection into schooling.

In this respect, Torvik (1993) complements this approach by extending heterogeneity to a second dimension covering differences in learning ability. Here, agents are assumed to live just one period and bequeath a fixed share of their income at the end of the period to the next generation. The sorting of individuals into skill groups turns out to be disoptimal from a societal perspective, as the exclusion of highly talented poor individuals from higher education reduces the economies growth potential. However, by reducing an agents lifespan to one period and thus ignoring all intertemporal aspects of income allocation, the restriction imposed on the agent's consumption plans by the higher borrowing rate is independent of personal talent. The amount with which students take a borrower position is purely determined by the magnitude of education costs and the individual's draw from the bequest lottery. In reality, however, the desired loan amount should rise with increasing expected returns from education, as the prospect of generating higher income gains in the future raises the amount of future income the individual is willing to reallocate to present consumption. In this respect, it should be the most talented students that are harmed the most by barriers to credit access.

De Gregorio & Kim (1994) take account of the dependance of education decisions on the degree of impatience in consumption. Growing impatience is associated with shrinking aggregate investments into schooling here, which overturns any positive growth effects associated with increasing accumulation of physical capital. Nevertheless, their approach does not consider the basic complementarity among different skill types of labour: Dragging individuals at the lower end of the ability distribution out of schooling and into low-skilled jobs creates opportunities for the remaining group of high-skilled workers to focus their activities on the core competencies acquired through the process of formal education. This means, a potential increase of the productivity of highly-talented workers resulting from a larger pool of manual workers is not taken into account.

Garcia-Penalosa & Wälde (2000) as well as Fender & Wang (2003) improve on that by extending the technology to include both skilled and unskilled labour as complementary factors within a single aggregate production technology. However, both papers share the shortcoming that all consumption is generally assumed to be postponed to periods after graduation, thereby avoiding any statement on the implications of a preference for consumption smoothing. The demand for loans is here simply traced back to the existence of monetary costs related to education. Given the assumption of a complete absence of income sources during the first stage of life, these costs imply liquidity constraints to bind irrespective of personal talent.

Benabou (2002) allows for interactions of credit demand with individual time preferences within a general equilibrium framework featuring idiosyncratic productivity shocks as well as skill complementarity. Individuals are however not considered to differ here in terms of their educational productivity, which again means that no account is taken of the fact that more talented workers suffer from more severe constraints to consumption.

Finally, Akyol & Athreya (2005) have constructed a similar setup incorporating both skill complementarity and talent-based differences in educational returns, which in principle would allow to clarify this omitted aspect. Nevertheless, they do not analyze the impact of changes to wealth limits on factor stocks, as skill-dependent credit constraints



are intentionally set such that they are always binding for members of both skill groups. Any forms of interaction between self-selection into schooling and the operativeness of constraints are thus not investigated. In this vein, the contribution made by De Gregorio (1996) is helpful in providing a flexible formulation for the strength of borrowing constraints, but his setup does not feature heterogeneous agents.

In this chapter, we will use the existing gap as a motivation to adjust our framework of the last chapter in a way that allows us to establish conditions under which liquidity constraints are relevant for skill formation. In this way, we will provide some insight into the interactions of the effectiveness of the constraints and the talent-based sorting of individuals into skill groups. Built on this, we will analyze the effects of marginal changes to the extent of these constraints.

The second part will then be devoted to discussing the role of liquidity constraints in influencing skill accumulation when at the same time emigration incentives of qualified workers are accounted for. In this regard, by affecting the degree of competition potential skilled emigrants would face from the less talented members of their cohort on domestic markets, an additional channel emerges through which short- and long-term shocks to borrowing opportunities can affect the evolution of a countries pool of skilled labour.

The first paper addressing the links between migration decisions and the existence of credit market imperfections in the source region was Stark & Levhari (1982). They stress the insurance element of sending out family members to earn part of the family income by working abroad, which is regarded as a means to diversify the risk associated with familial investments. More recent approaches have linked the issue of credit rationing to migration itself, by considering the case of a lack of opportunities to finance the costs of moving abroad (Rapoport (2002), Docquier et al. (2006)). All of these models, however, do not deal with skill accumulation as an additional part of household decision-making, hence do not allow for a simultaneous analysis of occupation and migration decisions. In this regard, Mesnard (2004) made an innovative contribution by suggesting liquidity constraints to increase optimal migration duration in a scenario in which individuals expect positive returns from self-employment. Under limited access to credit, workers are forced to spent longer times working abroad in order to finance the investments required to set up their own businesses after returning home. This approach does however neglect any impact on activities related to skill accumulation prior to emigration.

Cinar & Docquier (2002) were then the first to derive the conditions under which facilitating the outflow of skilled labour can be predicted to result into a “brain gain” for a scenario exhibiting two realistic features: For one thing, agents are both making endogenous choices about whether to acquire schooling and about leaving the country, and, for another, both of these options are subject to one-off costs required to be financed out of own wealth. In this respect, inherited wealth is set to represent the only source of heterogeneity within a generation. However, this also means that a sorting of emigrants does only take place along this wealth dimension, and not with reference to personal productivity: All domestic professionals are presumed to experience positive returns from leaving, but only those whose initial wealth endowment exceeds the level of associated costs are in the position to realize them. Moreover, the setup is restricted to a partial equilibrium analysis, any side effect of migration on the skill premium is thus ignored.

Further modifications within this line of modelling introduced by Rapoport & Docquier (2006) and Bertoli (2006) do not help to overcome these specific deficiencies, but instead focus on adding a transfer motive. To the best of our knowledge, the only setup

that features an endogenous treatment of wage rates in an environment where credit constrained households heterogeneous in terms of talent are deciding about relocating labour supply abroad is Docquier et al. (2006). Nevertheless, they impose a substantial restriction by taking factor stocks owned by households as given. What is missing compared to the previously mentioned approaches is hence any reference to repercussions on schooling.

With this in mind, by augmenting the setup presented in the first part, our contribution made in the second part of this chapter can be summarized as taking the literature on the interplay between credit constrained schooling choices and emigration incentives to a general equilibrium dimension. In this regard, our model's unique properties consist of allowing for a simultaneous consideration of the impact of talent heterogeneity on the sorting of individuals into skilled and unskilled as well as emigrating and non-emigrating workers. By determining the resulting net impact of labour market integration, we will obtain a more detailed picture than previous studies on a backward country's prospects for catching-up through skill formation under integrated factor markets.

In a further step, we will add an additional mode of interaction consisting of preferences for intergenerational support. This is done mainly for the purpose of clarifying in how far our setup is able to undermine the basic causality suggested by previous models analyzing the dynamic gains from remittance flows. As it will turn out, taking account of the general equilibrium implications of the household's decision problems does also in this respect yield results that differ from those obtained from an isolated discussion of the role of international transfers.

### 3.3 The framework in the absence of migration flows

#### 3.3.1 Basic setup

As a basic framework to analyze the effect of credit market failure on the schooling-migration nexus, we adopt the structure of a small economy populated by overlapping generations of individuals heterogeneous in talent from the last chapter. For the distribution of this talent level among the members of each generation, it is again suitable to choose a standardized uniform distribution  $U(0, 1)$ . Concerning the sequence of decision-making, we likewise stick to the assumption that agents during their first period of life decide on participating in a given schooling program of length  $\epsilon$ .

In a first step, in order to focus on the effects of liquidity constraints on schooling, we will abstract in this chapter from the possibility of international emigration, such that all workers irrespective of skill level are forced to supply their labour endowment domestically. In the third period, again, all agents retire and henceforth purely live on accumulated savings.

Thus, the consumer side of the model is marked by the interplay of decisions on education and intertemporal income allocation. However, as has been the basis of the last chapter, this interplay works for the limiting case of perfect capital markets only in one direction. If markets allow for unrestricted borrowing and lending, the timing of consumption can be separated from the timing of income generation. Therefore, all that an individual will care about in making decisions concerning her educational career will be the maximization of the present value of her expected stream of lifetime labour income  $PVI_t^s$ . For the given model structure, participating in schooling then again turns out to

be beneficial under the following condition:

$$E_t PVI_t^l \leq E_t PVI_t^h \quad (3.1)$$

$$w_t^l + \frac{E_t w_{t+1}^l}{(1+r)} \leq (1-\epsilon)w_t^l + \frac{(1+a\phi)E_t w_{t+1}^h}{(1+r)}. \quad (3.2)$$

The corresponding threshold level of talent above which school participation yields positive net returns is then again determined as the level at which condition (3.2) is fulfilled with equality:

$$a_t^{e*} = z \left( \frac{E_t w_{t+1}^l + (1+r)(\epsilon w_t^l)}{E_t w_{t+1}^h \phi} - \frac{1}{\phi} \right). \quad (3.3)$$

This level is now marked with an asterisk, we will refer to it as a benchmark in discussing the impact of credit market failure on schooling. For the standardized range of our talent distribution, this value is tantamount to the share of members of the generation born in  $t$  that refuses to invest in education. Obviously, this share will fall with more optimistic expectations on future skill premia, with rising efficiency in schooling (shrinking  $\epsilon$ ) and with lower costs associated with converting future income rises into present consumption (lower  $r$ ).

Regarding the modelling of borrowing constraints, a variety of distinct approaches is circulating in the literature. One basic distinction can be made concerning the question if credit rationing emerges as an endogenous outcome of the model structure or just takes the form of an additional part of the bundle of assumptions on agent's interactions in the economy. The former approaches mostly take a micro focus, i.e. they seek to shed light on the specific problems of asymmetric information arising in lender-borrower-relationships on the individual level. Bencivenga & Smith (1993) model interactions on credit markets as the explicit decision of lenders about granting loans to a single borrower carrying out risky investment projects, whose degree of entrepreneurial talent is unknown to them. Here, insufficient access to credit is the combined result of the limitedness of lenders funds and a process of adverse selection. Other models focus on post-agreement incentive problems: Piketti (1997) constructs credit rationing as the outcome of a moral hazard problem with borrowers possessing the ability to shirk instead of applying for a job. As shirking incentives increase with credit volume, young workers end up being effectively constrained.

While being able to account for the existence of upper limits to the credit volume offered, most of these information concerned approaches share the drawback that individual demand for loans is exogenized by postulating quite extreme assumptions on agents' time preferences, e.g. by artificially confining consumption needs to later stages in life. Besides, the model structure is in many cases so carefully adjusted to reflect the specific source of the issue in mind that it does not allow for a consistent reduction to a limiting case in which informational problems vanish, i.e. to the case of perfect capital markets.

Other approaches avoid an explicit modelling of the underlying causes of malfunctions and simply introduce the problem of borrowing limits either by neglecting the existence of any type of lending institutions at all (De Gregorio & Kim (2000)) or by attaching collateral requirements to the provision of loans. In this regard, a large number of models analyzing the economy-wide effects of credit rationing do not discriminate among different sources of wealth, but instead deal with the issue in a much simpler manner by defining a lower limit for an agents total net wealth left at the end of each period. This takes the

form of an additional constraint to the consumer's optimization problem in an otherwise more or less standard neoclassical model environment (Deaton (1991), Daniel (1993), McGarry (1999)). To obtain a clear view on the extent with which educational incentives are impaired by the existence of credit market imperfections, we will follow this route.

At this point, the task to select economically meaningful values for a lower wealth limit remains. A common choice is zero, such that the complete amount of outstanding debt must be backed by a portfolio of assets of at least equivalent value at each point in time. Daniel (1993) seeks to give some intuitive justification for this by suggesting the notion of very generous bankruptcy laws that allow debtors to default at no costs other than the loss of their current assets, which does quite naturally deter all potential lenders from contracting with insufficiently endowed borrowers. Since, in reality, additional costs like seizure of future income flows are associated with defaulting, one could think of a negative minimal wealth level as having a higher degree of plausibility. In this respect, the limit of zero can be interpreted as representing one of the most severe degrees of distortion in the credit market and should therefore be regarded as a worst-case scenario.

In principle, the implementation of such a lower boundary to period wealth would require us to specify two additional constraints for the first two periods within an agent's lifespan. In practice, however, a second-period constraint can be omitted as a consequence of our assumption that old agents purely live on accumulated savings. Imperfect substitutability of aggregate consumption across time therefore assures that the second-period constraints are not binding regardless of the agents relative position on the ability scale: the need to consume positive amounts of output in each period will prevent agents from fully exhausting consumption opportunities in the second stage of their lifecycle.

With this in mind, we are allowed to focus our formal analysis exclusively on the first period limitations a gifted young student faces when planning to extract a fraction of her higher future income for the purpose of present consumption. In our framework, the extent of these limitations is on the one hand linked to market-determined factors like skill premium and interest rate. On the other hand, in the event of school enrollment, it is also dependent on personal ability. More talented students can expect steeper rises in labour income after graduation, which results into a stronger desire for credit financed consumption in their first stage of life. Since this relationship is monotonic with respect to talent, we can define an additional talent threshold that leaves a young agent at the borderline between being effectively constrained or not, conditional on investing into education. This critical level called  $a^c$  implies that the first-period constraints for all agents with  $a \leq a^c$  turn out to be unbinding in case of participation in schooling, while for all agents with  $a > a^c$  they become binding in case of participation.

In our model, the income potential of uneducated workers is presumed to be homogeneous. Hence, the existence of such a threshold implies that any adverse effect of borrowing limitations on the personal returns to education will be the largest for the most talented members of any generation. Heterogeneity in skilled worker efficiency can therefore be expected to amplify any adverse effects of credit rationing on the educational incentives of this group.

Depending on the time paths of wages, credit constraints could in principle also bind for workers refusing to invest in education, reducing the utility experienced in this case as well. For deriving the minimal talent levels associated with schooling for the range of possible scenarios, imagine a worker born at time  $t$  with ability level  $a = a_t^{e*}$  (i.e. who would be indifferent towards schooling under perfect capital markets) facing a net wealth

constraint. Basically, we need to distinguish between 4 cases:

(I) The constraint will only bind when acquiring education, (II) it will bind with or without acquiring education, (III) it will only bind without acquiring education and (IV) it will not bind in either situation.

Situation (IV) is especially easy to handle: Imposing unbinding liquidity constraints on an otherwise indifferent worker does not affect her indifference towards schooling. This implies that all agents with talent superior to hers still face net gains from participation, let them face binding constraints or not. Hence, collateral requirements do not have any impact on enrollment rates in this case. In contrast, in the event that wealth constraints are operative for an agent with ability  $a = a_t^{e*}$ , they will also be operative for the complete subgroup of agents with  $a > a_t^{e*}$ . At the same time, agents with ability less than  $a_t^{e*}$  could only, if at all, profit from receiving education when being confronted with binding constraints both in case of participation and non-participation. Thus, in cases (I)-(II) all actual students will end up being effectively constrained.

In determining these cut-off levels, the structure of individual preferences with respect to timing and substitutability of consumption matter, as the timing of income generation and its spending can no longer be separated within the analysis. Hence, departing from the notion of unlimited access to credit requires us to specify how individuals weigh consumption at different points of their lifetime. In a first step, we seek to keep the assumptions on the structure of intertemporal preferences as general as possible.

Consider an agent born in  $t = 1$ . Since we concluded that second-period constraints are generally not binding, we can restrict our focus on the allocation of lifetime income between first-period consumption  $c_1$  and a (not further specified) composite of second- and third-period consumption  $\tilde{C}_{2,3}$ . Preferences are assumed to be linear homogeneous, as well as strictly konvex and additively separable. This yields the following structure for intertemporal utility  $V$ :

$$V_1 = u(c_1) + \beta u(\tilde{C}_{2,3}) \quad (3.4)$$

$$u'(c_1) > 0, u'(\tilde{C}_{2,3}) > 0, \quad u''(c_1) < 0, u''(\tilde{C}_{2,3}) < 0. \quad (3.5)$$

In the absence of credit constraints, an agent chooses the consumption path that maximizes her intertemporal utility according to the following optimal rule:

$$\frac{u'(c_1)}{\beta u'(\tilde{C}_{2,3})} = \frac{1}{\psi(r)}, \quad \psi'(r) < 0 \quad (3.6)$$

where  $\psi$  denotes the relative price of composite  $\tilde{C}$ , which is in any case a function inversely related to the level of market interest rate  $r$ . In case of a binding constraint to first-period consumption, the worker exhibits a first-period consumption level lower than optimal. Since this corresponds to a high marginal utility, the following relation holds here:

$$\frac{u'(c_1)}{\beta u'(\tilde{C}_{2,3})} > \frac{1}{\psi(r)}. \quad (3.7)$$

Specific to her status choice, the agent additionally faces the following side constraints to consumption, where  $x \leq 0$  denotes the minimal level of wealth an individual is forced to

end up with at the end of each period:

$$c_1^s + \psi \tilde{C}_{2,3}^s = PVI_1^s \quad (3.8)$$

$$c_1^s \leq I_1^s - x. \quad (3.9)$$

This allows us to show how an isolated increase in the severeness of the borrowing constraint influences the minimal talent level above which school participation becomes worthwhile. Specifically, we determine the utility differential between the two status choices for an agent whose level of talent was previously exactly at the cut-off. In this regard, we need to deal with each of the three situations stated above separately. First, it is easy to see that situation (III) with binding constraints only in case of non-participation can be excluded from the range of possible outcomes. Since first-period income is in case of non-participation with  $\epsilon \geq 0$  always at least as large as in case of participation, maximal consumption levels are likewise at least as large. In turn, a higher first-period consumption level in case of non-participation would require a lower consumption level in the later stages to ensure cut-off workers to be equally well-off. This, however, is incompatible with homothetic preferences, given that opportunity costs  $\psi$  of present consumption are in both cases the same. Figure 3.1 illustrates this situation, with  $\hat{c}_1^s$  denoting the maximal values of first-period consumption under educational status  $s$ .

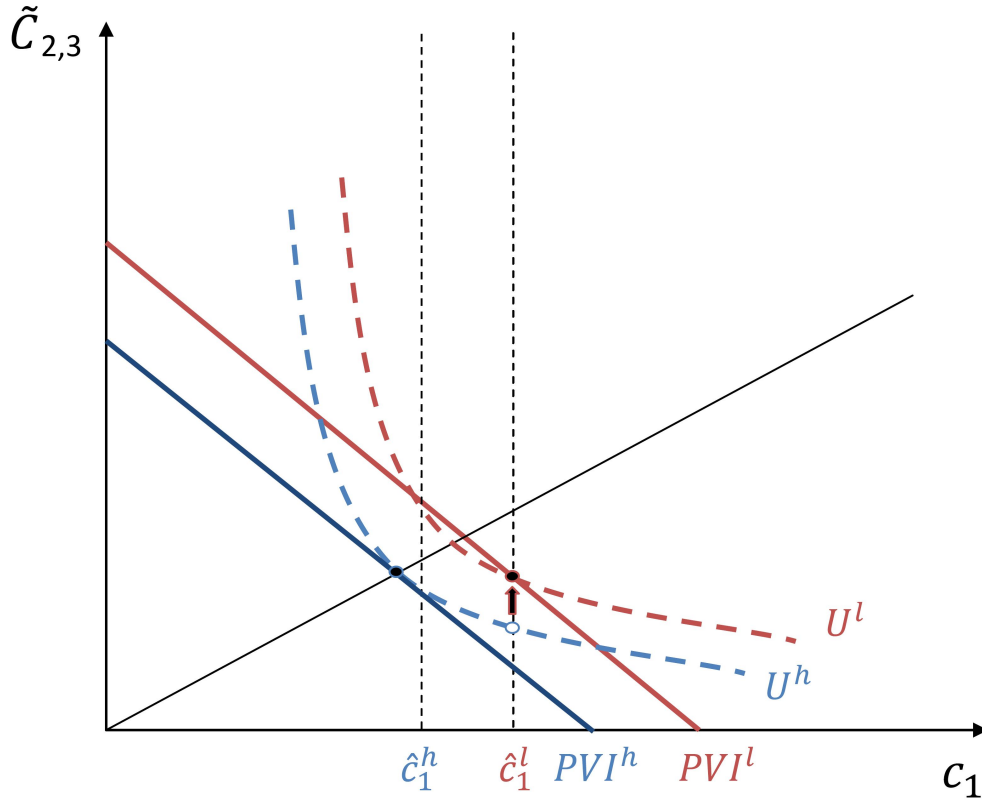


Figure 3.1: The situation in case of constraints only binding under non-participation

Then, we have to examine situation (I), in which constraints are only binding in case of acquiring education. Here, optimality condition (3.6) only holds for unskilled workers.

Hence, we can proceed with differentiating consumption levels and cut-off  $a^{e;I}$  within the following system of equations with respect to  $x$ :

$$u(c_1^l) + \beta u(\tilde{C}_{2,3}^l) = u(c_1^h) + \beta u(\tilde{C}_{2,3}^h) \quad (3.10)$$

$$\frac{u'(c_1^l)}{\beta u'(\tilde{C}_{2,3}^l)} = \frac{1}{\psi} \quad (3.11)$$

$$c_1^h + \psi \tilde{C}_{2,3}^h = (1 - \epsilon) \bar{w}_1^l + \frac{(1 + a_1^{e;I}) \bar{w}_2^h}{1 + r} \quad (3.12)$$

$$c_1^l + \psi \tilde{C}_{2,3}^l = \bar{w}_1^l + \frac{\bar{w}_2^l}{1 + r} \quad (3.13)$$

$$c_1^h = (1 - \epsilon) \bar{w}_1^l - x. \quad (3.14)$$

The resulting total differential of  $a_1^{e;I}$  with respect to  $x$  is:

$$\frac{da_1^{e;I}}{dx} = - \frac{(1 + r) \left( \beta u'(\tilde{C}_{2,3}^h) - \psi u'(c_1^h) \right)}{\beta u'(\tilde{C}_{2,3}^h) \bar{w}_2^h} > 0 \quad (3.15)$$

where the positive sign results from inequality (3.7).

If we instead focus on situation (II), in which constraints are binding in either case, the relevant system is:

$$u(c_1^l) + \beta u(\tilde{C}_{2,3}^l) = u(c_1^h) + \beta u(\tilde{C}_{2,3}^h) \quad (3.16)$$

$$c_1^h + \psi \tilde{C}_{2,3}^h = (1 - \epsilon) \bar{w}_1^l + \frac{(1 + a_1^{e;II}) \bar{w}_2^h}{1 + r} \quad (3.17)$$

$$c_1^l + \psi \tilde{C}_{2,3}^l = \bar{w}_1^l + \frac{\bar{w}_2^l}{1 + r} \quad (3.18)$$

$$c_1^h = (1 - \epsilon) \bar{w}_1^l - x \quad (3.19)$$

$$c_1^l = \bar{w}_1^l - x. \quad (3.20)$$

The sign of the resulting total differential is likewise clear from our assumption on preferences:

$$\frac{da_1^{e;II}}{dx} = - \frac{(1 + r) \left( \beta \left( u'(\tilde{C}_{2,3}^h) - u'(\tilde{C}_{2,3}^l) \right) \right) + \psi \left( u'(c_1^l) - u'(c_1^h) \right)}{\beta u'(\tilde{C}_{2,3}^h) \bar{w}_2^h} > 0 \quad (3.21)$$

where the fact  $c_1^l > c_1^h$  ensures that the sign is positive. Hence, the isolated impact of changes to the extent of wealth constraints on school enrollment is proven to be monotonic. Graphically, the consequences of a (discrete) increase in  $x$  are made evident in figure 3.2.

In addition, the effect of a change in the pattern of an agent's time preferences is of unambiguous sign as well, as can be shown by differentiating the same sets of conditions

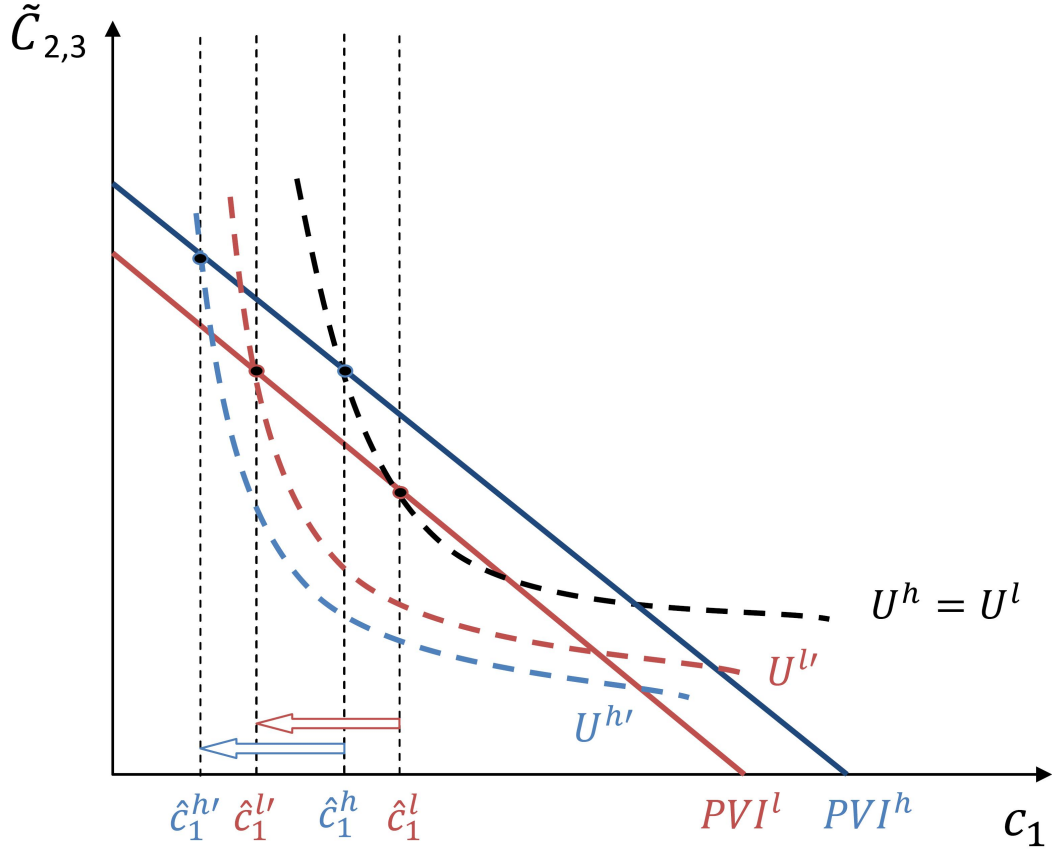


Figure 3.2: Impact of an increase in  $x$  on the cut-off worker

with respect to  $\beta$ :

$$\frac{da^{e*}}{d\beta} = 0 \quad (3.22)$$

$$\frac{da^{e;I}}{d\beta} = -\frac{\psi(1+r)u(\tilde{C}_{2,3}^h)}{\beta u'(\tilde{C}_{2,3}^h w_2^h)} < 0 \quad (3.23)$$

$$\frac{da^{e;II}}{d\beta} = -\frac{\psi(1+r)\left(u(\tilde{C}_{2,3}^l) - u(\tilde{C}_{2,3}^h)\right)}{\beta u'(\tilde{C}_{2,3}^h w_2^h)} < 0 \quad (3.24)$$

Concerning the impact of isolated shocks to income levels, changes in expected future wage rates have unambiguous effects on school participation independent of the severeness of the constraint. In any situation, an expected increase in the skilled-to-unskilled wage ratio one period in the future lowers the educational cut-off today.

However, what is not free of ambiguity for the whole range of parameter constellations is the impact of changes to low-skilled wages today. On the one hand, an increase in the wage rate paid to manual labour raises the opportunity costs of school enrollment and thus exerts a negative influence on the returns to education. On the other hand, provided that constraints are binding for students, there is an additional positive effect on educational



returns associated with an increase in low-skilled wages. The reason is that a higher present income is valued more by students than by non-students, as it contributes to a partial lifting of their consumption constraint, expressed by a higher marginal utility of present consumption. Hence, for deriving analytical results we will focus on the case of  $\epsilon = 1$ , i.e. the case where the time requirements of studying are equivalent to those of a full-time job. In this situation, educational investments are exclusively motivated by income expectations concerning the periods after graduation. In the numerical analysis, we will instead deal with cases in which present income does exert an influence on school participation by calibrating  $\epsilon$  to values less than unity.

To analyze the reverse effect, i.e. how the size of the domestic skill premium is affected by the strength of liquidity constraints, we are again asked to close the model by fixing the production side of our economy. In this regard, we stick to the same simple set of assumptions been utilized in the previous chapter and restrict the focus to one aggregate sector employing low-skilled labour  $L$ , high-skilled labour  $H$  and physical capital  $K$  to produce output  $Y$  under a general constant returns to scale technology with the following properties:

$$Y_t = F(H_t, L_t, K_t) \quad (3.25)$$

$$\frac{\partial F}{\partial H_t} > 0, \quad \frac{\partial F}{\partial L_t} > 0, \quad \frac{\partial F}{\partial K_t} > 0 \quad (3.26)$$

$$\frac{\partial^2 F}{\partial H_t^2} < 0, \quad \frac{\partial^2 F}{\partial L_t^2} < 0, \quad \frac{\partial^2 F}{\partial K_t^2} < 0 \quad (3.27)$$

$$\lim_{H_t \rightarrow 0} \frac{\partial F}{\partial H_t} = \infty, \quad \lim_{L_t \rightarrow 0} \frac{\partial F}{\partial L_t} = \infty, \quad . \quad (3.28)$$

The sector comprises an infinite number of price taking firms determining demand for each factor according to the profit maximizing principle of price equals marginal productivity:

$$r = \frac{\partial F}{\partial K_t} \quad w_t^h = \frac{\partial F}{\partial H_t} \quad w_t^l = \frac{\partial F}{\partial L_t}. \quad (3.29)$$

While wages are determined on the domestic labour market, interest rates are exogenously given, as a mutual implication of the assumption of free worldwide capital flows and of our economy being small. Hence, as all borrowers have unrestricted access to global capital markets, our analysis sets the focus on the effects of globally rather than locally grounded bottlenecks in the provision of liquidity, since domestic agents can avoid entering malfunctioning local credit markets by directly accessing international capital.

Aggregate factor stocks can be inferred from our fundamental assumptions on population mass and distribution of talent in the population. Given the choice of units, the economies stock of unskilled labour can be expressed as:

$$L_t = \int_0^1 l_t^y da + \int_0^1 l_t^m da = a_t^e + (1 - \epsilon)(1 - a_t^e) + a_{t-1}^e \quad (3.30)$$

where  $l_t^y$  denotes the contributions of the young generation and  $l_t^m$  the contribution of the middle-aged generation in period  $t$ . Hence, with the size of each generation equal to unity, the stock is measured relative to the maximal potential contribution of members of one generation (i.e. when none of them would invest in education). Likewise, the stock

of skilled labour can be ascertained by aggregating over all individuals endowed with the necessary degree of talent.

$$H_t = \int_{a_{t-1}^e}^1 h_t^m(a) da = \int_{a_{t-1}^e}^1 (1 + \phi a) da = (1 - a_{t-1}^e) + 0.5\phi(1 - a_{t-1}^e)^2 \quad (3.31)$$

Note that the total supply in  $t$  is provided by the middle aged generation born in  $t - 1$ .

Given these specifications, we are in the position to determine the general equilibrium effects of marginal changes to the strength of liquidity constraints on aggregate supply of skill types in the economy.

### 3.3.2 Long-run equilibria without migration

First of all, we are interested in how far gradual changes in the severeness of the borrowing constraint both affect the skill structure of labor supply and the skilled-unskilled wage differential. Before we devote our attention to studying the transitional pattern resulting from shocks to the credit system, we focus on differences in stationary long-run levels associated with distinct magnitudes of collateral requirements. A real world equivalent to this could for instance be seen in persistent and (internationally coordinated) efforts to modify the legislation on banking supervision (e.g. to prevent financial turmoil), rather than in generally less persistent changes to the risk perception of lenders on the world capital market.

So far we made the assumption that preferences are strictly konvex, additively separable as well as linear homogeneous. For a more detailed analysis of cut-off levels, we now assign an explicit CES form to the intertemporal preferences:

$$U_t = \sum_{b=0}^2 \beta^b \cdot u(c_{t+b}) \quad (3.32)$$

$$u(c_t) = \frac{c_t^{1-\eta} - 1}{1-\eta}, \quad \beta = \frac{1}{1+\rho}. \quad (3.33)$$

where  $\eta$  is the inverse of the intertemporal elasticity of substitution,  $\rho$  denotes the rate of time preference and  $c_t$  individual consumption in the given period. Solving the resulting optimization problem for consumption levels (as done in appendix 3.A), the value of the talent cut-off above which an agent is effectively liquidity constrained when investing into education can be determined. This is the level at which optimal first-period consumption is exactly equal to its maximally feasible level for the given constraint:

$$a_t^c = z \left( \frac{\zeta \left( (1-\epsilon)w_t^l (1+r) \right)}{xw_{t+1}^h \phi} - \frac{1}{\phi} \right) \quad (3.34)$$

$$\zeta = \left( (\beta^{\frac{1}{\eta}}(1+r)^{\frac{1-\eta}{\eta}})^2 + (\beta^{\frac{1}{\eta}}(1+r)^{\frac{1-\eta}{\eta}}) \right). \quad (3.35)$$

where  $\zeta$  is a parameter combination that reflects the degree of patience in consumption. Obviously, more extensive collateral requirements (rising  $x$ ) implicate a smaller  $a^c$ . It is also straight forward to grasp that it is decreasing with rising impatience in consumption (falling  $\zeta$ ).

Analogously, a similar condition for non-students being effectively constrained can be derived as:

$$E_t w_{t+1}^l > (1+r) \left( \zeta w_t^l - (1+\zeta)x \right) \quad (3.36)$$

Plugging the results for consumption levels together with these side constraints into the utility function yields maximized utility for both states, as presented in appendix 3.A. This allows us to determine the relevant cut-off levels for situations (I) and (II) by equating the corresponding parts of the indirect utility functions. In total, the educational cut-off can thus be represented as a piecewise function of the following form:

$$a_t^e = \begin{cases} a_t^{e*} & a_t^{e*} < a_t^c \\ a_t^{e;I} & a_t^{e*} \geq a_t^c \quad \text{and} \quad E_t w_{t+1}^l \leq (1+r) (\zeta w_t^l - (1+\zeta)x) \\ a_t^{e;II} & a_t^{e*} \geq a_t^c \quad \text{and} \quad E_t w_{t+1}^l > (1+r) (\zeta w_t^l - (1+\zeta)x) \end{cases} \quad (3.37)$$

Before turning to comparative statics, it will again prove convenient to eliminate physical capital from the system first. This can be done by solving the production technology (3.25) for  $K_t$  and plugging the result into (3.29). As a consequence, the long-run wage levels can be represented as functions of the skilled-to-unskilled labour supply ratio:

$$w^h = f \left( \frac{H}{L} \right) \quad w^l = f \left( \frac{H}{L} \right). \quad (3.38)$$

Obviously, this long-run supply ratio is itself a function of the cut-off level in education, whose size is again based on the relative wage levels and the minimal wealth level  $x$ . In this regard, we restrict our focus in this first analytical approach to the case of a full-time schooling program ( $\epsilon = 1$ ). Under these circumstances, as explained above, the isolated effect of a long-run change in low-skilled wages on the rates of school enrollment is unambiguously negative.

Hence, the following functional relations can be added:

$$\frac{H}{L} = f \left( \frac{a^e}{-} \right) \quad a^e = f \left( \frac{w^h}{-}, \frac{w^l}{+}, \frac{x}{+/0} \right). \quad (3.39)$$

Taking the total differential of these expressions with respect to a marginal increase in the minimal wealth level delivers the following result for the educational cut-off:

$$\frac{da^e}{dx} = \frac{a^{e'}(x)}{1 - \left( a^{e'}(w^h) w^{h'} \left( \frac{H}{L} \right) + a^{e'}(w^l) w^{l'} \left( \frac{H}{L} \right) \right) \frac{H'}{L} (a^e)} \geq 0. \quad (3.40)$$

According to this weak inequality, a tightening of borrowing constraints will cause the minimum talent level to rise under the condition that the isolated impact of the shock as such is already sufficient to induce enrollment rates to drop. Therefore, the proposition that impediments to the provision of consumer credit are up to a certain extent neutral with respect to school participation remains valid when allowing for wage repercussions in this scenario.

Hence, adjustments will not take place as long as allocation decisions of those workers at the critical margin are unaffected ( $a_t^c > a_t^{e*}$ ), which simply leaves them indifferent and all superiorly talented individuals ex ante better-off when choosing to study. Only in the event of a shock strong enough to cut first period consumption of the critical agent, this neutrality will be broken and a different long-run equilibrium with a lower skilled-to-unskilled worker ratio in the economy will emerge. The sign of wage adjustments is then obvious from (3.38):

$$\frac{dw^h}{dx} \geq 0 \quad \frac{dw^l}{dx} \leq 0. \quad (3.41)$$

Given these intuitive conclusions on the sign of long-run adjustments in the economy, we additionally need to address the case of  $\epsilon < 1$ . To this end, we carry on with illustrative simulations of the economy's long-term equilibria over a range of wealth minima.

The specific technology assumed for this and all following simulations in this chapter is the same as in the last one: A two-stage nested CES technology, with capital and a labour composite combined in Cobb-Douglas form on the upper level and the skill types of labour combined in a general CES structure on the lower level.

$$Y_t = \left( \left( \gamma H_t^{\frac{\sigma-1}{\sigma}} + (1-\gamma) L_t^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \right)^\alpha K_t^{1-\alpha} \quad (3.42)$$

Parameter values are chosen as follows: To determine the per-period rental rate on assets, we start with presuming an annual interest rate of 4%. Given our 3-generation framework (and considering the fact that years of primary education are not included), one model period can be thought of as comprising around 20-22 years. Hence,  $r$  is chosen as  $r = 1.04^{20} - 1 \approx 1.191$ .

Simulations are carried out for three different values of the time preference parameter  $\rho$ . Besides the case of a preference for perfect consumption smoothing, i.e. the case in which the rate of time preference is set equal to the interest rate in order to match the opportunity costs of consumption ( $\rho = 1.191$ ), we additionally consider two situations: First, one in which the annual rate of time preference is equal to 5% (implying  $\rho = 1.05^{20} - 1 \approx 1.653$ ) and thus being slightly larger than the rents gained by holding assets. This stimulates the desire to consume a larger chunk of lifetime income in the earlier stages of life. Second, the scenario of an annual rate of 3% (yielding  $\rho \approx 0.806$ ) is considered, where the agents seek to postpone the consumption of the larger part of lifetime income to the future.

All remaining parameter values are adopted from the last chapter ( $\epsilon = 0.76$ ,  $\phi = 2.82$ ,  $\sigma = 1.4$ ,  $\eta = 0.8$ ,  $\alpha = 0.6$ ).

Figure 3.3 depicts the results of the range of simulations carried out for the three distinct values of  $\rho$ , expressed as percentage deviations from the equilibrium obtained in the absence of any lower boundaries to wealth.

A tightening of borrowing restrictions remains neutral with respect to school enrollment up to a time preference-specific threshold for  $x$  in all three scenarios. After reaching this threshold, any further increase in  $x$  provokes a continuous decline in the supply ratio of skilled to unskilled labour and an accompanying rise of the average skill premium. Higher impatience is shown to magnify this pattern, as labour supply responds more strongly and already at lower minimum wealth constraints for higher values of  $\rho$ . For

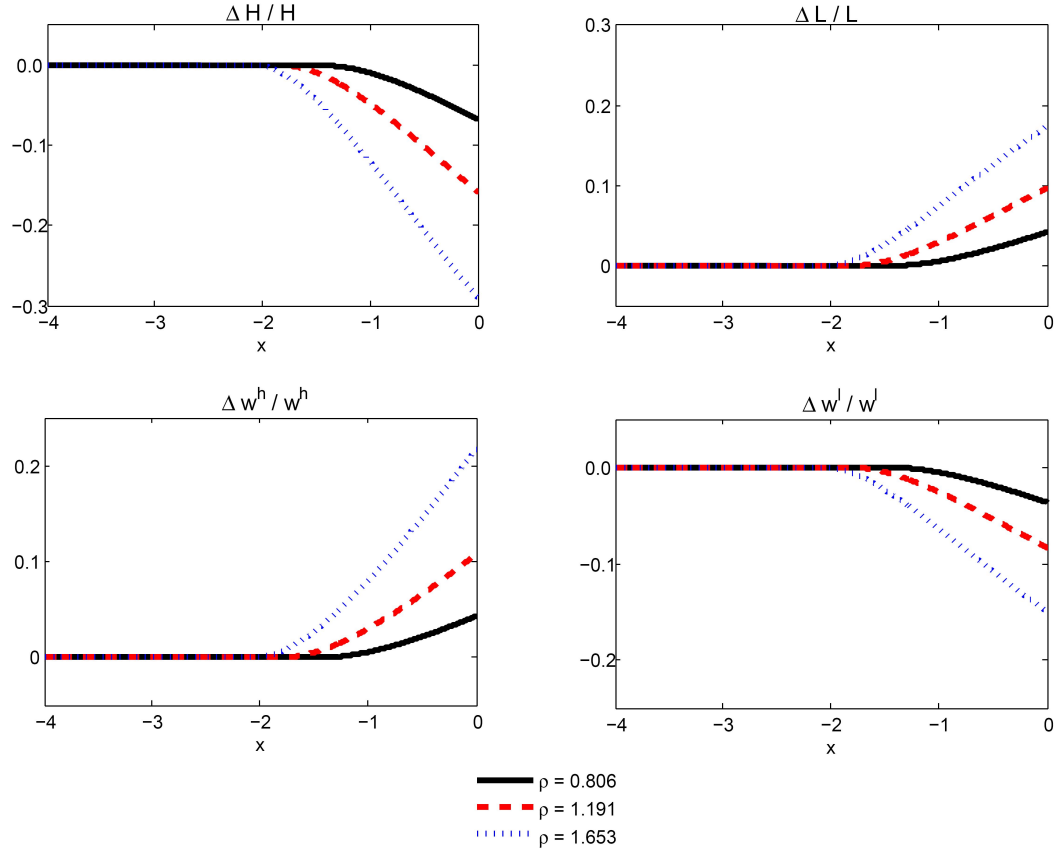


Figure 3.3: Long-run deviations from an equilibrium with zero collateral requirements

this reason, the ties between human capital formation and the quality of credit market institutions can in general assumed to be stronger in societies whose cultural tradition or institutional background implies its average member to exhibit a higher preference for present consumption.

This emphasizes the need to consider historical differences in saving behaviour. Those economies having shown significantly lower average savings rates among members of young age groups in the past are accordingly more vulnerable towards shocks to borrowing restrictions.

Certainly, any negative effect on aggregate output growth in this direction might in the end be outweighed by a higher growth rate of physical capital resulting from a rise in net savings enforced by the borrowing constraint (an issue discussed in detail by Jappelli & Pagano (1994) and De Gregorio (1996)). However, with capital markets tending to be much more integrated than labour markets, a small economy would not experience much compensation from this fact as long as the rates at which domestic agents are able to borrow on international markets are not affected.

Instead, an aspect more worthy to investigate in this regard is the role of borrowing restrictions in determining the location choice of human capital for a scenario of comparatively footlose domestic graduates. As it will turn out, the inclusion of this so far largely unexamined channel will widen our perspective on the general equilibrium dimension of

lifecycle constraints. Specifically, it challenges the idea of a monotonic relation between the quality of lending institutions and the rate of skill accumulation.

### 3.4 Skill-biased emigration with imperfect capital markets

#### 3.4.1 Coping with credit market failure: The role of labour mobility

As has been extensively discussed in the chapters before, net emigration of skilled workers constitutes an equally undeniable and persistent reality for many developing economies as the existence of severe limitations in the access to consumer loans does. A further similarity is that both phenomena have been shown to exert negative long-run impacts on skill formation in isolation. Concerning our classification of domestic workers according to their inborn capabilities, a distinction merely concerns the group of individuals affected. While it is the less talented members within each cohort that, given their lower expected skill premia, refrain from education in consequence of cutting access to educational credit, it is the group of the most talented workers which are attracted by the option to go abroad.

In this way, both phenomena are characterized by a withdrawal of intellectual resources from domestic labour markets, which is likely to go in line with additional dynamic disamenities arising from the absence of positive externalities attributable to the presence of skilled workers (see Romer (1986)). This creates the impression that accounting for emigration incentives in the given framework should result in a further deterioration of the prospects of lagging economies for catching-up. While on one side some of the existing intellectual potential is wasted through inefficiencies in credit allocation, another part of it is removed by outmigration as a reflection of existing international technology gaps.

However, the interdependencies present in a general equilibrium structure do not suggest that the two effects should simply add up. Instead, adding international labour mobility to the presence of credit constraints can be expected to produce a significant degree of interaction, given that both effects operate through the same channel: adjustments of the domestic skill premium.

In the following, we consider this by integrating our concept of skilled migration developed in the last chapter into the present setup. Hence, an individual having completed the schooling program at the end of her first period of life is at the beginning of the following period confronted with the decision whether to sell her acquired efficiency units of skilled labour at home (and receiving the domestic wage rate  $w^h$ ), or abroad, where she would attain the (exogenous) foreign wage rate  $w^{h^f}$  and incur a fixed migration cost  $c_{mig}$  in units of the numeraire. Since we do not treat emigration as an intertemporal process here (in the post-migration period the emigrant retires), the occurrence of positive net returns from leaving in any case prerequisites that migration costs can be financed out of own labour income earned abroad. Hence, the existence of liquidity constraints does not interfere with the necessary (and sufficient) condition under which an individual with talent level  $a$  will outmigrate:

$$(1 + \phi a)w^{h^f} > (1 + \phi a)w_t^h - c_{mig}. \quad (3.43)$$

The cut-off level defining an agent to be exactly indifferent between the two options is then again obtained as:

$$a_t^m = z \left( \frac{c_{mig}}{\phi (w^{h^f} - w_t^h)} - \frac{1}{\phi} \right). \quad (3.44)$$

Given the fulfillment of the Inada condition (3.28), the schooling decision of a worker with talent at the educational cut-off will, independent of nature and extent of borrowing restrictions, always remain to consist of a comparison of domestic wage rates. This is guaranteed by the fact that the existence of finite wage rates in the domestic economy requires such a worker to be disinclined to emigrate at any point in time. Hence, equation (3.37) still defines the share of workers engaging into education within a given generation.

In this context, the question arises if a reduction of migration barriers for graduates is capable of mitigating the issue of borrowing constraints in skill formation. A corresponding rationale is that the perspective of earning higher foreign wages might increase the willingness within the young generation to accept the restrictions imposed on present consumption when choosing to study, provided that any additional monetary obstacles e.g. in the form of monetary tuition fees can be handled.

However, when considering the talent-based differences in efficiency among the groups of workers that are expected to switch, the fact that the cross-border allocation of domestic labour is said to represent the outcome of a positive selection among qualified workers renders a positive net effect on the value of aggregate stocks unlikely. Even if some additional individuals are made to enter schooling as a consequence of facilitating cross-border flows, these are generally the less productive ones, while the societal costs consist of the loss of the most productive ones. In this regard, the international coordination of labour market policies is predicted to represent no substitute for tackling institutional problems on credit markets.

Instead, our point is, when one does take account of the basic complementarity between skill types, the mechanism might work in the opposite way, i.e. in the sense that the presence of a stream of net emigration could attenuate the downturn of domestic human capital resulting from a tightening of borrowing constraints. To illustrate this idea, we next turn to a discussion of the implications of a temporary credit crunch for skill accumulation in this augmented framework.

### **3.4.2 Examining the impact of a credit crunch**

By affecting lifecycle accumulation decisions of individuals, a sudden drop in the general accessibility of external funds through formal credit markets can have long lasting effects on the production capacities of an economies real sectors, even though the underlying financial turmoil is itself just of a temporary nature. While lacking a unique definition, 'credit crunch' is the most commonly used term for describing the macro dimension of such a temporary and typically unexpected decline in the availability of credit. Regarding the dynamics of its impact on the economies aggregates, a vast macroeconomic literature has by now established (e.g. Bernanke & Lown (1991), Kiyotaki (1998), Aghion et al. (2001)), whose contributions however strongly differ in their perceptions of the mechanism underlying the phenomenon (market-based vs. non-market based, supply-side based vs. demand-side based).

In the following, we adhere to the definition favored by the Council of economic advisors (1991), according to which a credit crunch is said to occur when there is a change in the relationship between credit availability and market interest rates. As a consequence, imbalances between the demand for credit and the volumes invested are no longer systematically eliminated through adjustments of market returns. This can take both the form of an increase in lending rates (wedge between lending rates and risk-free assets) or a direct quantity rationing in the allocation of credit. In the latter case, market rates

start to lose their role as indicators of scarcity of the funds provided. Addressing the reasons for such a failure of market forces, Ding et al. (1999) identify on the one hand a reallocation channel based on banks readjusting their investment strategies away from risky lending contracts with the private sector towards government securities. This is said to reflect a generally more adverse attitude towards risk in times of crisis. On the other hand, they expect banks to follow a flight-to-quality strategy in their lending policies within private sector lending, i.e. banks are presumed to increasingly cherry-pick their customers in order to lower overall lending risk in a generally insecure environment. The relevance of this channel was confirmed by empirical work by Lang & Nakamura (1995) for the US.

Given that in our framework an increase in minimal wealth requirements could be used to reflect such a temporary lending crisis, this flight-to-quality channel can serve as a suitable basis for interpreting a shock to credit supply. This means, we imagine to start with a situation in which a sudden change in the risk perception of international lenders due to some event that is exogenous to our small economy causes them to temporarily enhance their collateral requirements. Since we stick with our assumption of lenders being unable to observe the level of innate talent (and hence the future income potential) of their debtors, this ties the volume of credit taken and thus the consumption levels of agents closer to the amount of first-period income.

The scenario is then the following: In the initial equilibrium in  $t = 0$ , lower limits to the value of period-end wealth are inexistent ( $x = -\infty$ ). In  $t = 1$ , the shock to lender-borrower relations expresses itself in a jump of this lower barrier to zero ( $x = 0$ ), implying the necessity of a complete coverage of all outstanding debt by current assets. This jump is assumed to be unexpected by the individuals raised in  $t = 0$ , setting the stage for adjustments in the model variables. Then, in  $t = 2$ , the crisis causing the flight-to-quality rationing is assumed to be overcome and  $x$  returns to its pre-shock value. Other parameter values (which remain constant throughout) are chosen in accordance with the previous simulation in this chapter ( $r = 1.19122$ ,  $\rho = 1.19122$ ,  $\epsilon = 0.76$ ,  $\phi = 2.82$ ,  $\sigma = 1.4$ ). To assess the impact of distinct degrees of openness with regards to labour flows, simulations are carried out for three different levels of migration costs, where at the highest level  $c_{mig} = 3$  the initial equilibrium is characterized by a zero outflow.

With these parameter values given, the worker at the educational cut-off is in the initial equilibrium effectively unconstrained. As discussed above, the outcome in terms of schooling participation and migration rates is thus equivalent to a scenario with perfect capital markets. The aim is then to observe how the system responds when the given discrete shock induces an aggravation of credit rationing that forces young workers at the margin to restrain their consumption requests.

For that matter, stability as well as uniqueness of such a path are first needed to be confirmed. In this regard, the system can be reduced by plugging the definitions of factor stocks (3.30) and (3.31) into the profit maximization conditions (3.29). These expressions can then be used to replace the wage rates within the cut-off conditions (3.36) and (3.42). In this way, we obtain a system of two nonlinear difference equations, whose functional structure can be represented as follows:

$$a_t^m = f^1(a_t^m, a_t^e, a_{t-1}^e) \quad (3.45)$$

$$a_t^e = f^2(E_t a_{t+1}^e, a_t^e, a_{t-1}^e, E_t a_{t+1}^m, a_t^m). \quad (3.46)$$

Convergence for each of the three scenarios is then checked by numerically performing a



linear approximation around the initial equilibria in  $t = 0$  and determining the eigenvalues of the system matrix. In each case, we obtain two unstable eigenvalues, which is equivalent to the number of forward-looking variables. Besides, the rank conditions hold as well.

Figure 3.4 then documents the results for our simulation scenarios, with the upper graphs depicting the absolute change in cut-off levels <sup>7</sup> and the lower graphs representing relative changes in aggregate domestic stocks of both skill types. Given the length of our periods, 'temporary' actually refers to quite a long period of real-life time, as it affects a whole generation. Hence, it is of no surprise to see that also its after-effects are quite long lasting in terms of real-life years.

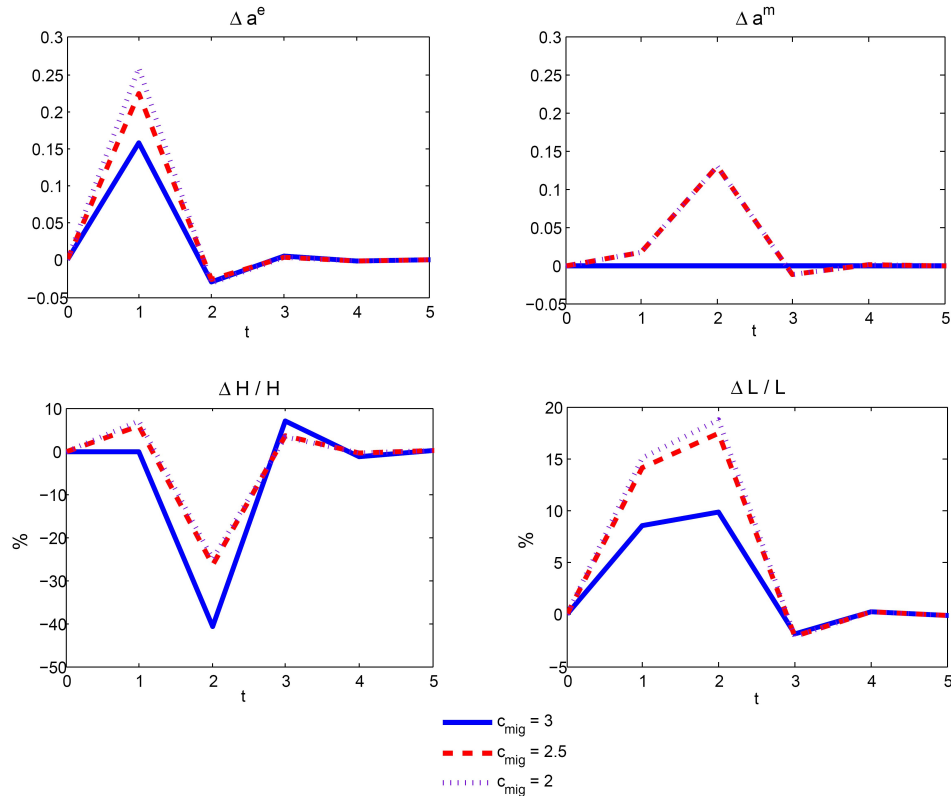


Figure 3.4: Effect of a temporary introduction of a lower wealth limit

One interesting aspect that is immediately noticeable is the occurrence of a qualitative shift in the time patterns of changes in labour supply as soon as migration costs are low enough to observe emigration. For  $c_{mig} = 3$ , the absence of emigration incentives implies the nonexistence of an immediate response of skilled labour supply in  $t = 1$ , which, in  $t = 2$ , is followed by a steep decline resulting from the negative impact on schooling incentives of the generation born in 1. This turns out to be the starting point of cyclical fluctuations that taper off over time. They find their counterpart in corresponding fluctuations of the stock of unskilled labour, both a consequence of the effects of factor complementarity on the remuneration (and thus the opportunity costs of education) of young (unskilled) workers.

<sup>7</sup>i.e. the change in absolute numbers of schooling participants and migrants relative to the whole population of one generation

For  $c_{mig} = 2.5$ , a level at which outflows are present, we obtain a significantly different picture: Despite a negative effect on schooling participation that even exceeds the downfall in the no-migration scenario, the tightening of borrowing constraints causes the stock of human capital to rise as an immediate impact in  $t = 1$ . The reason for this is to be found in the increase of the migration cut-off, causing some share of the most talented professionals to refrain from emigrating, which more than compensates the shrinkage of schooling incentives. For the same reason, the subsequent drop of domestic human capital in  $t = 2$  is of considerably lower magnitude than in the first scenario. It is important to note that the mechanism underlying both of these results represents the exact opposite to the one established in the context of dismantling migration barriers. While in the former case facilitated outmigration entails a scarcity of qualified labour that induces participation rates to rise, it is here the fall in participation rates caused by the credit crunch that implicates a rise in skilled worker compensation, as it enlarges the reservoir of workers available for carrying out manual tasks.

In this vein, it is the fact that the talent level of those skilled workers prevented from outmigrating exceeds those whose lack of access to credit discourages them from investing into education at all, which ensures a dominance of changes in migratory flows over changes in schooling participation. In case of a credit crunch, this mechanism that is operating in favour of the small countries skill endowment.

Based on this, a further observation is that, in contrast to the closed border scenario, the time paths of the stocks of skilled and unskilled labour can actually move in the same direction. This is a fact that mitigates the fluctuations in labour supply in the aftermath of the temporary shock: the presence of aligned movements in the supply of the complementary factor contributes to a smoothing of oscillations in skilled labours marginal productivity over time.

The idea that under sufficient mobility of skilled labour a small economy could at least temporarily experience an upgrading of its skill endowment through a seemingly adverse event like a downturn in credit access has previously remained unmentioned in both the literature on skilled migration and in the one on lifecycle accumulation under wealth constraints. This is of no surprise, as previous setups refrained from exploiting the full dimension of worker heterogeneity in terms of both education and migration decisions.

In this sense, this is coherent with the results obtained for a shock to migration barriers in chapter 2. More talented workers are more seriously constrained in realizing their desire for consumption smoothing than less talented, but are at the same time in terms of their educational career less sensitive to any macro-based variations in credit supply. Their decision on contributing to local stocks hence boils down to a decision about emigrating or not.

However, this alone does not provide information on the long-run impact of a permanent worsening of credit market failure if migratory flows are accounted for. Moreover, the effects of an alternative shock influencing the strength of migration barriers remain to be determined for this scenario. These issues which will be addressed in the next subsection.

### **3.4.3 The long-run effects of borrowing constraints under mobile skilled labour**

We begin by examining the long-run effects of an increase in the limitations individuals face in accessing credit for a scenario with skilled labour being sufficiently mobile to observe partial outflows, i.e. for a subset of migration cost levels for which  $a_t^m < 1$  holds in

the initial equilibrium. To this end, we now focus on a permanent rise of the required collateral share  $x$ . When taking account of the possibility of outflows, the total differential of long-run equilibrium values in response to an exogenous shock to  $x$  becomes the following:

$$\begin{aligned}
dw^h &= w^{h'} \left( \frac{H}{L} \right) \cdot d \left( \frac{H}{L} \right) \\
dw^l &= w^{l'} \left( \frac{H}{L} \right) \cdot d \left( \frac{H}{L} \right) \\
d \left( \frac{H}{L} \right) &= \frac{H'}{L} (a^e) \cdot da^e + \frac{H'}{L} (a^m) \cdot da^m \\
da^e &= a^{e'}(w^h) \cdot dw^h + a^{e'}(w^l) \cdot dw^l + a^{e'}(x) \cdot dx \\
da^m &= a^{m'}(w^h) \cdot dw^h.
\end{aligned}$$

Solving for the marginal impact on skill intensity generates an expression of unambiguous sign.

$$\frac{d \left( \frac{H}{L} \right)}{dx} = \frac{\frac{H'}{L} (a^e) a^{e'}(x)}{1 - \left( \frac{H'}{L} (a^e) \left( a^{e'}(w^h) w^{h'} \left( \frac{H}{L} \right) + a^{e'}(w^l) w^{l'} \left( \frac{H}{L} \right) \right) + \frac{H'}{L} (a^m) a^{m'}(w^h) w^{h'} \left( \frac{H}{L} \right)} \leq 0$$

Provided that wealth constraints are binding for cut-off workers, the numerator corresponds to the direct effect of the tightening of wealth constraints for given wage rates: the utility loss stemming from the growing inability of students to extract parts of a future income rise for the purpose of present consumption. This alone would lead to an increase in the educational cut-off level. The consequential decline in the skill intensity of aggregate labour supply is then mitigated by its repercussions on wage formation, as the denominator reveals. The familiar indirect effect on educational incentives through higher skill premia is here complemented by the additional force, the partial prevention of skilled worker emigration. However, even both forces jointly are not in the position to reverse the negative net sign for the long-run change in skill intensity.

Eventually, this is based on the fact that with or without endogenous location choices a higher relative remuneration of qualified labour is here in equilibrium always coupled with a lower supply ratio, independent of the domestic talent distribution. This implies the following results for wage rates:

$$\frac{dw^h}{dx} \geq 0 \quad \frac{dw^l}{dx} \leq 0. \tag{3.47}$$

Concerning absolute stocks, these had been shown to evolve in opposite directions in the closed border scenario. To figure out how they evolve now, we first have to note that a decrease in skill intensity can only be compatible with diminishing migration rates if the net effect on school participation is at the same time negative:

$$\frac{da^m}{dx} \geq 0, \Rightarrow \frac{da^e}{dx} \geq 0 \Rightarrow \frac{dL}{dx} \geq 0. \tag{3.48}$$

Therefore, at least with respect to unskilled labour, the long-run prediction is free of ambiguity. This does, however, not provide any conclusion on the behaviour of aggregate

skill endowment as such. Instead, according to this result a fall in skill intensity could be coupled with both an increase or decrease of skilled labour supply in efficiency terms. Hence, the hypothesis that a tightening of borrowing constraints can improve a small sending country's stock of human capital can not be rejected on these grounds.

In order to demonstrate that there is indeed a so far undiscovered ambiguity at work here, we again make use of numerical analysis. In this respect, we confine ourselves here to the presentation of long-run values of  $H$  over a range of collateral shares for two values of  $c_{mig}$  that produce contrary results (with parameter values identical to the ones used above). To focus on differences over the parameter range, numbers are again expressing relative changes, here in terms of deviations from the baseline case of inexistent liquidity constraints ( $x = 0$ ).

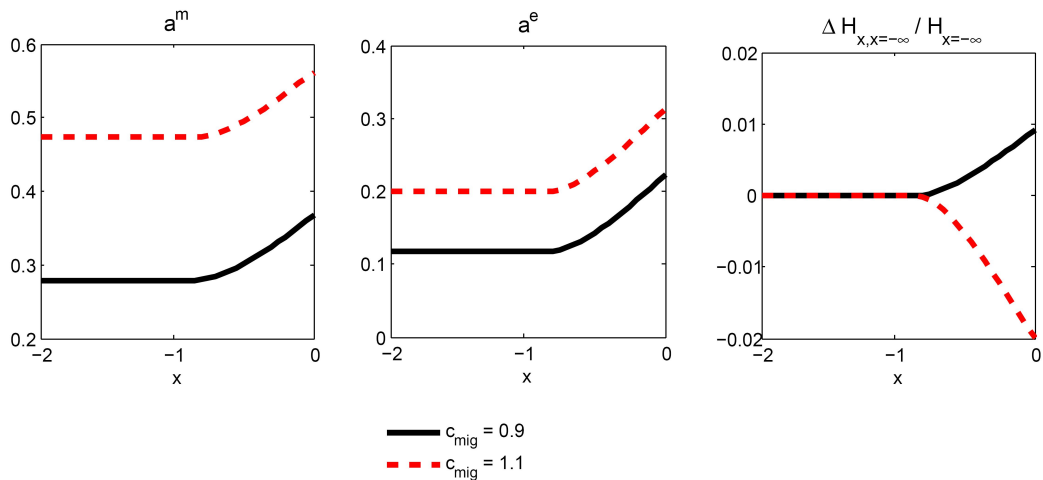


Figure 3.5: An example of ambiguity in the effect of wealth constraints

Hence, aggregate effects seem to be strongly sensitive to the actual degree of openness. The next step is then to analyze how the opposite channel of a migration cost-induced outflow of professionals feeds back on domestic stocks under the existence of borrowing constraints. This means, we are interested in how a decline of migration barriers manifests itself in long-run labour supply for a given wealth limit of zero.

Now, when totally differentiating the migration cut-off, one needs to take account of the direct impact of changes to migration costs as well:

$$da^m = a^{m'}(w^h) \cdot dw^h + a^{m'}(c_{mig}) \cdot dc_{mig}.$$

As argued above, there is no reason to believe that the introduction of a lower wealth limit should overthrow our central finding that any positive repercussion on schooling incentives is unable to make up for the loss of the most qualified workers in efficiency terms. This is already evident by referring to one of our preliminary results, the unbroken monotonicity of intertemporal gains from education in the level of personal talent, implying a qualitatively similar kind of selection effect being at work as in the perfect capital market scenario.

$$\frac{d\left(\frac{H}{L}\right)}{dc_{mig}} = \frac{\frac{H'}{L} (a^m) a^{m'} (c_{mig})}{1 - \left( \frac{H'}{L} (a^e) \left( a^{e'}(w^h) w^{h'} \left( \frac{H}{L} \right) + a^{e'}(w^l) w^{l'} \left( \frac{H}{L} \right) \right) + \frac{H'}{L} (a^m) a^{m'}(w^h) w^{h'} \left( \frac{H}{L} \right)} \geq 0$$

Just like in case of a change in  $x$ , a long-run decline of aggregate skill intensity is here tantamount to a rise of the domestic skill premium. However, the central difference to a shock affecting borrowing restrictions is to be seen in the fact that the decline in skill intensity is here unambiguously accompanied by a decline in the absolute stocks of skilled labour as well. The reason is that this shock is not operating through the credit market, but is affecting migration patterns directly. For unchanged collateral requirements, a higher domestic skill premium is thus clearly inducing enrollment rates to rise in response to the shock. In turn, a shrinking supply of unskilled labour is required to be matched with a more than proportional decrease of skilled labour in order to ensure the skill intensity of the workforce as a whole to fall. Hence, the long-run stock of human capital declines with increasing mobility of skilled workers.

$$\frac{dw^h}{dc_{mig}} \leq 0 \Rightarrow \frac{da^e}{dc_{mig}} \geq 0 \Rightarrow \frac{dH}{dc_{mig}} \geq 0 \quad (3.49)$$

While increased mobility as such thus maintains its detrimental impact on skill provision under the terms of credit rationing, it remains to be of interest how the relevance of this linkage is dependent on the existence of credit market imperfections. Figure 3.6 documents this by depicting a range of long-run equilibria over the migration cost space for situations with and without effective borrowing constraints.

For prohibitive levels of migration costs, there exists no mechanism to mitigate the impact of credit market failure. Hence, for this range are the largest differences in human capital stocks between the two scenarios to be noted. For shrinking migration barriers, this difference gradually vanishes, even though the minimum talent requirement for receiving net benefits from education is permanently higher under the regime with borrowing restrictions. This is based on the fact that in the scenario with operative constraints a lower level of migration costs is needed to generate an actual outflow of professionals. This holds because the emigration pressure stemming from domestic competition is here generally less intense. Hence, emigration rates are permanently lower than in the basic case, with the exception of the range of very low migration costs. Here, emigration incentives are that high that the resulting scarcity of skill does induce everyone within the young generation to invest into education. This is a situation in which wealth constraints can be considered to be neutral with respect to the aggregate outcome, the two scenarios thus collapse into one.

A message to be drawn from this comparison for empirical research might be that the phenomena of bottlenecks in credit provision and of outmigration of professionals should not, as previously done so, be analysed in isolation, but rather be checked for existing complementarities. This is of special importance for assessing the efficiency of alternative policy strategies in promoting a brain gain. In this respect, our results would point to the need for a coordinated approach, as any policy focusing on just one of the channels is concluded to amplify the challenges policy-makers are confronted with regards to the

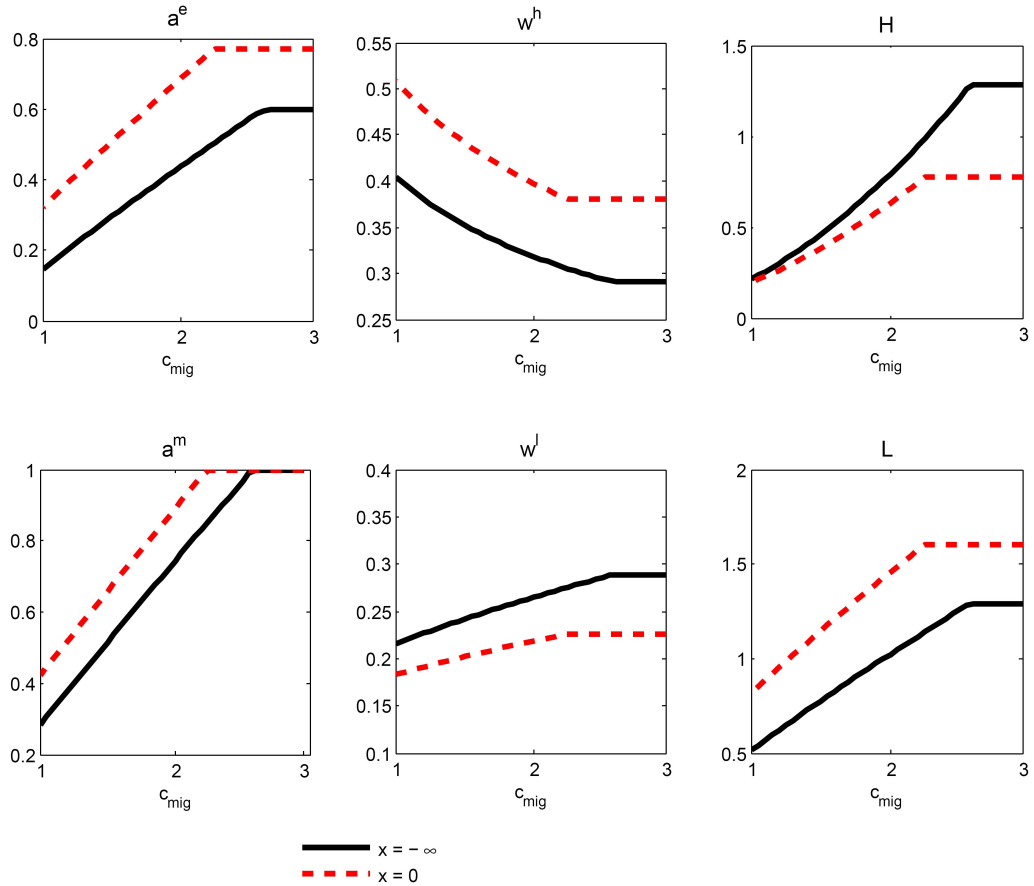


Figure 3.6: The dependance of long-run equilibria on the strength of migration barriers

other. For instance, a policy aiming at increasing the level of participation in higher education by means of publicly provided educational loans is predicted to fuel the brain drain issue and vice versa.

This subsection closes with a sensitivity check. Since our intuition for the counterintuitive increase in skill accumulation is in the end based on the idea that a rise in unskilled labour supply is apt to boost the productivity of domestically employed skilled workers, the nature of our results should turn out to be strongly dependent on the actual degree of complementarity between skill types. This is confirmed by figure 3.7, which depicts the relative differences between long-run equilibrium stocks of skilled and unskilled labour for a range of migration costs and labour-to-labour substitutability  $\sigma$ .

Accordingly, restricting access to credit can only enhance the aggregate stock of embodied knowledge if both migration costs and the degree of substitutability between skill types are sufficiently low. In contrast, the stock of unskilled labour is predicted to rise for the whole range of migration cost levels displayed. This means, technology and its evolution over time (especially in terms of manual labour replacement technologies) represent additional factors important to consider in discussing the impact of liquidity constraints.

However, one important aspect has not been mentioned so far that might put the observed effect into question. The dependence of educational investment on transfers made by emigrants. If credit rationing really induces emigration rates to fall, a corresponding

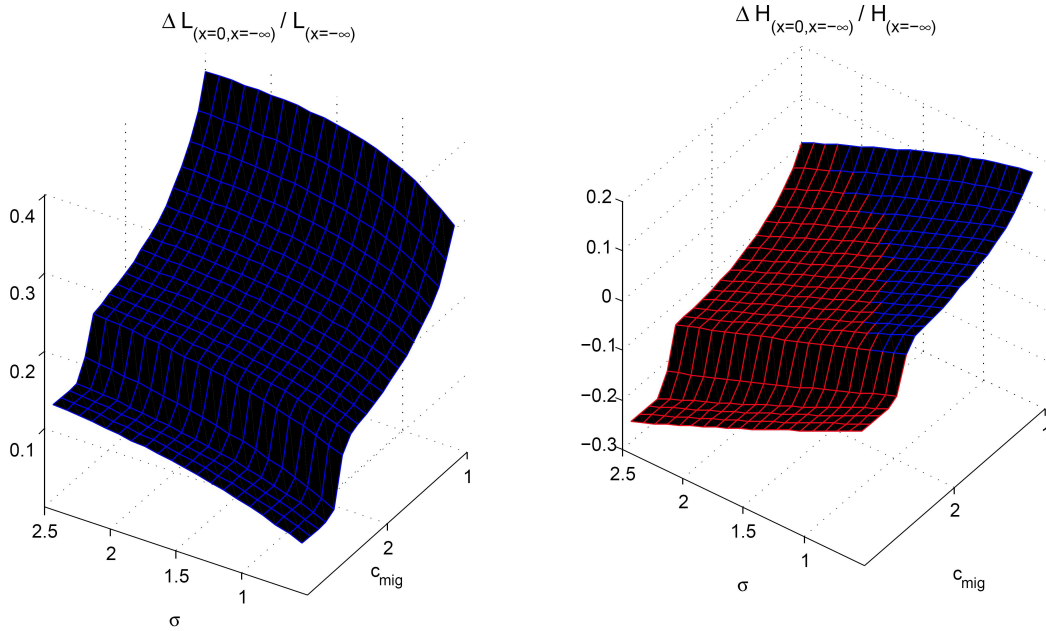


Figure 3.7: The sensitivity of the long-term effects of borrowing constraints on labour-to-labour substitutability

drop of cross-border transfer payments could be expected to cause an additional decline of school enrollment rates. The reason is that access to remittance flows can represent a substitute for formal credit. To see this, we need a model that explains how the pattern of transfers exactly responds to shocks affecting labour mobility. For the purpose of consistency with intertemporal optimization behaviour, we will seek to place remittances into a broader context of altruistic attitudes of individuals towards subsequent generations.

### 3.5 Endogenous migration and intergenerational transfers

#### 3.5.1 Introducing transfer motives into our framework

As mentioned in the introduction, the reception of a steady stream of transfers from emigrated relatives is generally regarded as a crucial element in compensating the absence of unrestricted opportunities to borrow for many families in less developed countries. The beneficial impact of migrant remittances (henceforth simply referred to as remittances) does not only take the form of a means to insure against domestic risks, but is likewise manifested in the ability to raise the skill level of agents facing access barriers to higher education. This is of special importance when individual barriers are not primarily the result of a lack of talent, but of liquidity shortages in the form of short-term income losses associated with going to school instead of going to work.

The theoretical literature dealing with the intertemporal aspects of remittance flows has only quite recently begun to focus on this second channel. In general, existing approaches dealing with the impact of emigrant transfers on lifecycle decisions can be differentiated according to the mechanism through which transfer amounts are determined. In many cases, remittances are simply treated in the form of exogenous inflows, where a

macroeconomic response to unanticipated variations in these inflows is examined (Djajic (1986), Quibria (1997)). In other setups, the volume of intrafamilial transfers from abroad is explicitly related to the level of outmigration in the economy, but this level is again not determined as an endogenous outcome of individual decision-making (Rapoport & Docquier (2006), Bertoli (2006)). Instead, migrants are randomly selected according to some given quota. This means, there is no scope for an analysis of a potential feedback effect of the size of remittance flows on emigration rates, e.g. operating through an impact on relative wages an individual is facing in making her location decision. In addition, the core element of these models, the determination of the amount of transfer contributed by the single emigrant lacks a microfoundation in the sense that it is not explicitly derived from an individual allocation rationale. Instead, it is often simply based on postulating remittances to make up a fixed share of foreign income.

Notable exceptions to this are McCormick & Waba (2000) and, more recently, Ukueva (2010), which both allow for endogenous migration choices and a micro-based determination of remittance volumes, but on the other hand ignore any repercussions on schooling choices. While the former setup is purely static and only features fixed endowments for each skill group, Ukueva (2010) restricts his focus on the dynamics of technology adoption.

In addition, by maintaining a narrow-eyed focus on transfer relations between migrants and non-migrants, previous approaches have neglected the important role played by intergenerational transfers in providing liquidity for intertemporal investments within a society in general. In this respect, it is hard to justify why crossing a border should represent a prerequisite for workers to show some interest in the needs of their offspring. In the end, this surely leads these setups to overrate the impact of emigrant remittances, as they ignore the alternative transfer volumes that would have been contributed by emigrants if they had chosen not to leave.

Instead, a consistent approach should discuss remittance flows within the broader context of people making intertemporal choices on educational investment and workplace on the one hand, and on the division of income between own consumption and support provided to their heirs on the other hand. Concerning the general equilibrium implications of intergenerational support, these are subject to the investigations of a by now vast literature on the importance of bequest motives for overlapping generations of liquidity constrained individuals. Within this literature, a more recent strand is explicitly focusing on the effects on schooling choices of individuals differing in their learning ability (Caballe (1995), Josten (2001)). The widespread result is that transfer flows are actually effective in reducing skill shortages that are due to insufficient loan supply to students.

However, what none of these models feature is again a channel of endogenous emigration choices, limiting the discussion to domestic support relationships. Hence, what is missing is a framework that allows for mutual interactions between migrant selection, remittance flows and school enrollment rates within a lifecycle context. To this end, we will treat remittances as part of a general mechanism generating intergenerational transfers. This mechanism will be introduced into our previous model structure, thereby allowing for interlinkages between all possible channels.

As a first step, one needs to decide on the way a motivation for transfers is introduced into a model with otherwise completely selfish agents being focused on maximizing their own lifetime utility. In this regard, the literature is characterized by a range of different attempts, each linked to a different philosophy of intrinsic motivation. One of the earliest and most popular techniques is to assume agents to gain pleasure from the procedure



of making transfers as such, irrespective of the allocation decisions of the recipients. This view is commonly referred to as joy-of-giving or warm-glow approach (Hurd (1989), Sanchez-Losada (2000)). Well-being is here simply viewed as an increasing function of the amount of total transfer volume sent.

An alternative setup that is linked closer to the notion of a direct form of altruism suggests the utility of parents to be explicitly related to the consumption levels of their heirs. In case of strictly convex preferences, this implies higher transfer payments made by parents when future consumption opportunities for children are low (Abel (1987), McGarry (1999)). This requires parents to be informed about both the income potential and the time preferences of their offspring. Concerning its empirical plausibility, the available evidence however points against the validity of such a correlation (Wilhelm (1996), Crumpler & Grossman (2008)). Besides, applying this to a framework of agents being heterogeneous with respect to inborn abilities entails the need to make more or less arbitrary assumptions on inheritance patterns of unobservable characteristics like talent. For the same reason, a third strand of models determining transfer flows as the outcome of a bargaining game between family members (Bernheim et al. (1985)) seems likewise inadequate for our purposes.

Hence, we choose to stick with the joy-of-giving approach and model intergenerational support as simply another component added to the streams of personal consumption in the intertemporal utility function. The related discount factor  $\vartheta$  then tells us about the degree of altruism in intertemporal spending. In order to separate this information from the role of time preferences, we will slightly deviate from the simple additive structure preferred by the literature and choose a nesting structure of the following form instead:

$$U_t = \frac{c_t^{1-\eta}}{1-\eta} + \beta \left( \frac{c_{t+1}^{1-\eta} + \vartheta b_{t+1}^{1-\eta}}{1-\eta} \right) + \beta^2 \left( \frac{c_{t+2}^{1-\eta} + \vartheta b_{t+2}^{1-\eta}}{1-\eta} \right). \quad (3.50)$$

While  $c$  again represents the level of own consumption,  $b$  indicates here the amount of transfer payments made in the given period. Its recipients are specified to be the members of the young generation born in  $t$ . Hence, the given structure implies agents to care for both their children and grandchildren, while the absence of a transfer motive in the first period of life defines this relationship to be non-mutual. Regarding the distribution of these amounts over the set of agents, the absence of explicit family ties in the model structure lets us prefer to spread them equally among the given generation. In the end, this is tantamount to assuming talent distributions of family members to be completely uncorrelated over time, i.e. to exclude talent from the set of inheritable assets. In this way, each member of the young generation receives an equal share of the transfers made by the middle-aged ( $m$ ) and the old ( $o$ ) generation. With the total mass of a generation being equal to one, the amount received by each member (in marginal units) is then obtained as:

$$B_t = \int_0^1 b_t^m da + \int_0^1 b_t^o da. \quad (3.51)$$

Then, this allows us to formulate the optimization problem a household is facing in pres-

ence of liquidity constraints and transfer motives:

$$\max U_t^s \quad (3.52)$$

$$\text{s.t. } c_t^{1,s} + \frac{c_{t+1}^{2,s}}{(1+r)} + \frac{b_{t+1}^{2,s}}{(1+r)} + \frac{c_{t+2}^{3,s}}{(1+r)^2} + \frac{b_{t+2}^{3,s}}{(1+r)^2} = PVI_t^s + B_t \quad (3.53)$$

$$k_t^{1,s} = I_t^{1,s} + B_t - c_t^{1,s} \geq x \quad (3.54)$$

$$c_t^{1,s} \geq 0, c_{t+1}^{2,s} \geq 0, c_{t+2}^{3,s} \geq 0, b_{t+1}^{2,s} \geq 0, b_{t+2}^{3,s} \geq 0. \quad (3.55)$$

Solving this problem, Appendix 3B derives the results for the optimal consumption patterns of agents of educational status  $s$ . What is helpful in assigning an interpretation to the altruism parameter  $\vartheta$  is that in the absence of any transfers made from children to their parents second-period constraints are guaranteed to remain inoperative, as this again forces agents to purely live on accumulated savings in their last stage of life. In this way, the choice of  $\vartheta$  fixes for a given degree of intertemporal substitutability the ratio between the volumes of the two existing alternatives of wealth allocation:

$$\vartheta^{\frac{1}{\eta}} = \frac{b_{t+1}^{2,s} + b_{t+2}^{3,s}}{c_{t+1}^{2,s} + c_{t+2}^{3,s}}. \quad (3.56)$$

Hence, empirical data which sets bequests or inter vivo transfers in relation to other types of expenditures can be used to select a plausible magnitude for this parameter.

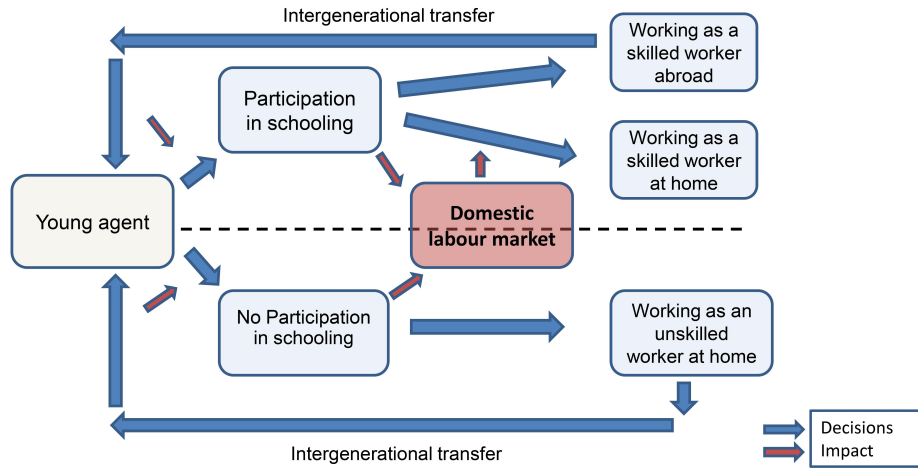


Figure 3.8: The interplay of transfers, education and migration in lifecycle decision-making

The optimal consumption patterns can then be used to update the critical talent level above which the desired first-period consumption of a skilled worker exceeds the maximal amount that is feasible under the given borrowing conditions. This is now not only a function of wage rates and the extent of collateral requirement, but of the amount of transfer payments as well.

$$a_t^c = z \left( \frac{\zeta^B ((1-\epsilon)w_t^l + B_t) (1+r)}{\phi x E_t w_{t+1}^h} - \frac{1}{\phi} \right) \quad (3.57)$$

$$\zeta^B = \left(1 + \vartheta^{\frac{1}{\eta}}\right) \left( (\beta^{\frac{1}{\eta}} (1+r)^{\frac{1-\eta}{\eta}})^2 + (\beta^{\frac{1}{\eta}} (1+r)^{\frac{1-\eta}{\eta}}) \right) \quad (3.58)$$

From this, we can see that, disregarding any effects on wage levels, the general presence of joy-of-giving motives contributes to a reduction of the supply gap on credit markets in two ways: First, it raises the liquidity endowment of young recipients and hence their consumption opportunities in absence of borrowing. Second, it lowers their willingness to consume in early stages of life, given that they have an incentive to save in order to finance future support of their descendants as well. This indirect effect is represented here by the increase of the patience parameter  $\zeta$  with increasing degree of altruism. A similar relation is obtained when we update the condition under which first-period constraints of unskilled workers are operative.

$$E_t w_{t+1}^l > (1+r) \left( \zeta^B (w_t^l + B_t) - (1 + \zeta^B)x \right) \quad (3.59)$$

By inserting the optimal consumption levels in case of school participation and in case of non-participation into lifetime utility, we are again able to derive cut-off levels in education  $a_t^e$  conditional on whether credit constraints bind in the two situations. The impossibility of achieving a situation in which unskilled workers are effectively constrained and skilled workers not carries over to a scenario with transfer flows. In this regard, we can refer to our reasoning made in 3.3.2. Hence, besides the (unchanged) cut-off for a scenario in which the least talented among all actual students are not affected by the constraint, there are again only two further cut-offs  $a_t^{e;I}$  and  $a_t^{e;II}$ , each valid for a different range of wage combinations, to be considered.

$$a_t^e = \begin{cases} a_t^{e*} & a_t^{e*} < a_t^c \\ a_t^{e;I} & a_t^{e*} \geq a_t^c \quad \text{and} \quad E_t w_{t+1}^l > (1+r) \left( \zeta^B (w_t^l + B_t) - (1 + \zeta^B)x \right) \\ a_t^{e;II} & a_t^{e*} \geq a_t^c \quad \text{and} \quad E_t w_{t+1}^l \leq (1+r) \left( \zeta^B (w_t^l + B_t) - (1 + \zeta^B)x \right) \end{cases}$$

Appendix 3.B presents the exact terms of the updated cut-offs. Regarding the impact of transfers, the intuitive result is that in isolation a higher transfer volume lowers the minimal talent requirement as long as credit constraints are binding in case of school participation.

$$\frac{\partial a_t^e}{\partial B_t} = \begin{cases} 0 & a_t^{e*} < a_t^c \\ < 0 & a_t^{e*} \geq a_t^c \end{cases}$$

In turn, by influencing schooling choices and hence domestic skilled worker competition, intergenerational support is able to change the pattern of skilled emigration as well. Hence, a desire to remit today exerts an impact on the level of outmigration and hence the volumes of remittance flows tomorrow. In this way, a link from transfer flows (including international remittances) back to emigration decisions is created, implying a mutual dependance which has not been dealt with by the probabilistic models.

A discussion of the direction of this further linkage and its impact on the economies stock of skilled labour will be the topic of the next subsection.

### 3.5.2 A credit crunch with altruistic agents

While on an individual level, the provision of external transfers can represent a partial substitute for formal credit in satisfying the consumption needs of students, a higher

degree of altruism does not need to imply an increase in the economies aggregate stock of skilled labour as soon as emigration incentives are taken into account. In this respect, our setup points to a reason why the existence of a transfer motive might be less beneficial for skill formation when labour mobility is taken into account: The fact that transfers made by highly-talented workers in one generation generally impose a negative externality on the elite within the following cohort by affecting the schooling choices of the less productive ones.

To elaborate this point, we again turn to our example of an unanticipated temporary credit crunch, whose effects over time are analyzed for different degrees of labour market openness. Precisely, we present results for two levels of migration costs, where  $c_{mig} = 3$  refers to a scenario with zero outflow of skilled labour (both before and after the shock) and  $c_{mig} = 2.5$  to a scenario where a stable emigration pattern is already present in advance of the shock. In addition, we distinguish for both scenarios between a situation in where a bequest motive is present and one in where it is not, implying us to differentiate between four distinct parameter constellations in all. Concerning our choice of  $\vartheta$  in reflecting a transfer motivation, data from the OECD indicates that the share of remittances on total migrant spendings makes up a worldwide average of about 10%. Applying this to transfers in general, the use of (3.53) implies given our choice of  $\eta = 0.8$  a value of  $\vartheta = 0.1792$  for the altruism parameter.

As a starting point in  $t = 0$ , we again assume wealth constraints to be inexistent. This means, the initial long-run equilibria for a given level of migration costs are identical, a fact that ensures to maintain a focus on the pure interaction between transfer payments and openness. In  $t = 1$ , due to financial turmoil young individuals are assumed to be temporally unable to borrow in excess of their period income, expressed by a wealth constraint of  $x = 0$ . This turmoil is assumed to have been unexpected by the individuals born in zero, implying a distortion in their lifecycle planning. This reveals itself in terms of wage oscillations, which can be expected to deviate between the scenarios based on the fact that tighter borrowing constraints imply different adjustment paths when endogenous bequests are considered. These fluctuations then taper off over time as a consequence of assuming the economy to return to an ideal world of unrestricted borrowing in  $t = 2$ .

To guarantee that the system returns to its initial steady-state after credit constraints are relaxed again, convergence is tested by first applying the same transformations as described in 3.4. This yields, written in a general way, functional relations of the following form:

$$a_t^m = g^1(a_t^m, a_t^e, a_{t-1}^e) \quad (3.60)$$

$$a_t^e = g^2(E_t a_{t+1}^e, a_t^e, a_{t-1}^e, E_t a_{t+1}^m, a_t^m, B_t) \quad (3.61)$$

$$B_t = g^3(B_{t-1}, B_{t-2}, a_t^e, a_{t-1}^e, a_{t-2}^e, a_t^m, a_{t-1}^m). \quad (3.62)$$

Hence, our way of modelling transfer motives introduces additional lags into the system, given that individual decisions on the amount remitted to relatives are, on the one hand, dependent on own labour income earned in present and past (and hence on the cut-off levels defining domestic labour supply now and in the past), and, on the other hand, on the amount of support they themselves received during their first stage of life.

After carrying out a linear approximation and redefining lags in order to attain a first-order form, the system matrix of the resulting system of difference equations has the dimension  $7 \times 7$ . Of the 7 eigenvalues to be calculated, 2 turn out to be explosive. Since the number of forward-looking variables is unchanged compared to the scenario without

transfer payments, uniqueness and stability of transition paths are thus guaranteed to be fulfilled for this scenario as well. Equivalently, the condition that the new steady-state is forced to be reached in  $t = 50$  is then used to compute the adjustment path starting from the old steady-state.

In figure 3.9, we compare the percentage changes in variable values with respect to their values in  $t = 0$  over time for the different scenarios.

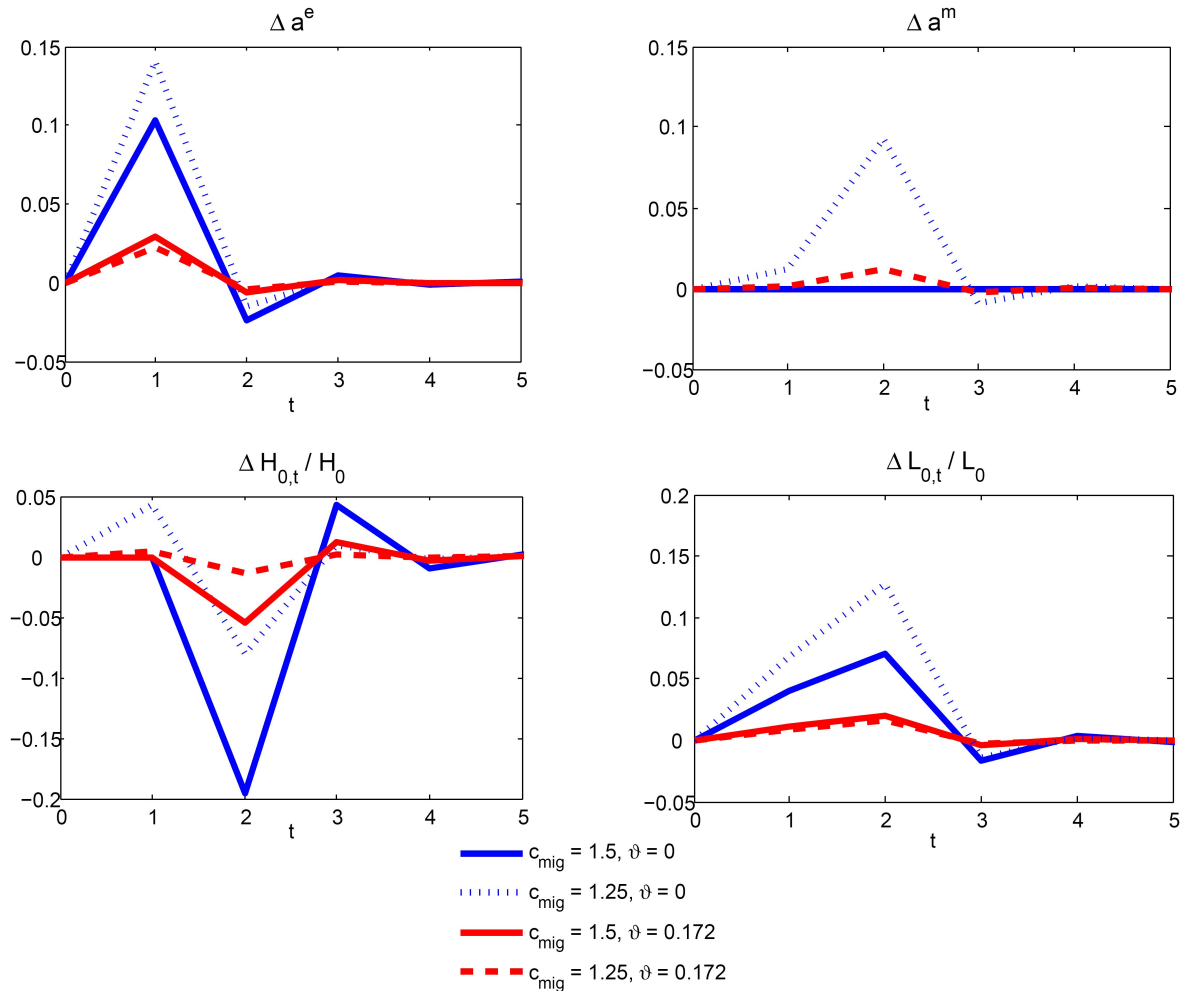


Figure 3.9: The effect of a temporary wealth limit in presence of inter vivo transfers

The blue lines represent again the time paths of variables in absence of transfer motifs. Here, the central result is again that for the lower level of  $c_{mig}$  the existence of feedback effects on migration patterns of skilled workers implies that, on the one hand, interperiod fluctuations in the aftermath of the shock are less intense and, on the other hand, the immediate impact can actually be positive.

In analyzing the role of intergenerational support in this regard, it is suitable to start with a comparison of paths for the high-cost case (full lines), in which the migration channel is not present yet. While the absence of migration incentives has the natural implication that independent of transfers volumes the first-period stock is still predetermined by pre-shock considerations, the paths differ in their behaviour starting from  $t = 2$ . The obvious reason is that the rise in the educational cut-off in the period where the shock

hits the economy turns out to be of smaller scale when the role of transfers is considered. Even though constraints become operative in both cases (otherwise we would not observe any effect at all), the reception of transfers when being young at least provides some opportunity for consumption smoothing. In this way, the impact of the bottleneck in credit provision is mitigated.<sup>8</sup> With this initial impact being smaller, the evolution of factor stocks in the following periods is then also subject to smaller variations: A smaller initial distortion of the skill composition of labour supply translates into less intense fluctuations in relative wages and hence less severe distortions of educational incentives of future generations.

While this result confirms the literature, the innovation becomes apparent when we compare the dashed lines representing scenarios with an actual outflow of skilled labour. First, one has to note that transfer flows continue to smooth the fluctuations in the stock of skilled labour when considering skilled workers to be internationally mobile. However, this also implies that any positive short-run impact of a tightening of borrowing constraints on human capital discussed above is weakened as well. This is obviously at odds with the standard result established for the role of bequests as representing a means to support skill formation through encouraging school participation (Caballe (1995), Cinar & Docquier (2004)).

In this regard, the inclusion of transfer motives can at a high degree of openness still be predicted to attenuate the detrimental impact of a decline in credit supply on educational incentives. However, a deviation from the literature is introduced by the fact that the impact on emigration rates is lower as well. The reason is that the existence of transfer payments implies that a credit crunch is less successful in reducing the migration premium received by domestic high-talent workers, since it mitigates the adverse impact of a credit crunch on enrollment rates. Hence, the pool of complementary unskilled labour is at the same time enlarged to a lower extent in response to the shock. According to this mechanism, it is exactly this positive feedback effect of intergenerational support on educational incentives that qualifies our main finding of a short-run increase in human capital.

What is left unanswered is whether it is primarily the endogenous selection of emigrants as such, or the dependance of transfer volumes on the size of migratory flows which is responsible for this effect. For this reason, it is meaningful to contrast our findings with a scenario in which transfers only occur in the form of migrant remittances. This is a route we will follow in the next section, where we will examine the long-run interplay between borrowing restrictions and openness in the presence of transfer flows. In this manner, we will also become capable of assessing the importance of regarding remittances as part of a general transfer motif for drawing conclusions on the impact of remittance flows on the skill composition of a countries workforce.

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<sup>8</sup>This marks a significant deviation of our approach from the popular family of stylized models on educational loans mentioned earlier (Glomm & Ravikumar (1992), Fender & Wang (2003)), whose ad-hoc assumption of a first-period consumption level of zero implies that a stream of transfers only exerts an impact if it is of sufficient magnitude to cover the exogenously given tuition fee. This means, the relevance of transfer payments is in these models restricted to the case in which they actually cause liquidity constraints to become inoperative.

### 3.5.3 The long-run effects of borrowing constraints under outmigration revisited

An obvious next step consists of analysing which implications the smoothing effect of transfers has for the impact of a border shock affecting labour mobility. As long as constraints for workers at the educational cut-off remain inoperative, the answer is: none at all. The motivation to remit as such does not affect the migration decisions of skilled workers, as these are made at times at which individuals have no longer any incentive for taking up debt. This means, the fact whether foreign income is immediately spent on own consumption or allocated to remittances now or in the future does not have an influence on the utility differential the individual is facing in her location decision. An impact can only be expected for situations in which borrowing constraints are effective, i.e. in which a rise in the domestic wage rate of skilled labour initiated by an outflow increases the gap between actual and desired consumption patterns for students.

In this way, the strength of the indirect impact of credit rationing on migration decisions is dependent on the general degree of altruism. Given its generally positive impact on educational incentives, societies characterized by closer financial ties between generations face, all else being equal, higher outflows of skilled workers for given levels of openness. A question is how this shows up in the net effect on aggregate stocks. Conventional wisdom supported by previous models (Docquier & Rapoport (2003), Bertoli (2005)) would, in ignoring the dimension of worker heterogeneity, stress the beneficial impact of increased remittance flows. This would imply that our result of human capital stocks unambiguously shrinking with greater openness might be overturned as soon as we depart from the notion of selfish individuals. However, two factors that have been neglected by the literature, but are present in our setup, stand against this.

First, we can refer to the point made above that remittances in reality only represent a part of the total amount of transfer flows. Hence, in determining the net effect of an increased inflow of remittances resulting from a rise in emigration rates, the potential decline in within-country transfer volumes is required to be taken into account as well. Second, as long as talent and inherited wealth are not negatively correlated, heterogeneity of talent implies that an improved access to external liquidity only affects the schooling decisions of workers with talent below the previous cut-off. This does imply a decrease in average efficiency of the domestic skilled workforce.

Unfortunately, analytical means are no longer able to determine the long-run effect of labour market integration as soon as endogenous transfer flows are taken into account. This is intuitively clear by the fact that the occurrence of endogenous adjustments in transfer volumes implies that the skilled-to-unskilled wage ratio is no longer necessarily required to rise in order to enhance schooling participation. In this way, higher student numbers do not have to be associated with a shrinking skill intensity of domestic labour supply in any long-run equilibrium. Whether this really affects equilibrium outcomes is examined by means of numerical analysis.

To be able to judge whether the first or the second mentioned factor contributes the most to a deviation of our results from the literature, we split our simulation setups into three scenarios:

- Credit rationing in absence of altruistic ties between generations ( $\vartheta = 0$ ): All parameter values are identical to the scenario presented in figure 3.6.
- Credit rationing coupled with a general joy-of-giving motivation: the same model

is simulated for a positive  $\vartheta$ . To prevent any overestimation of the differences between the scenarios, the value of the altruism parameter is according to (3.53) here chosen such that transfer volumes only make up 5% of grown-up agents total expenditures. ( $\vartheta = 0.09$ ) All remaining parameter values are unchanged.

- Credit rationing with remittances only: in focusing purely on the effects of the endogenous migration channel, this scenario adopts from Cinar & Docquier (2004) the assumption that intergenerational support is merely taking place in the form of international remittances representing a fixed share of emigrants income (net of migration costs) earned abroad. Hence, any general bequest motive is excluded from the discussion ( $\vartheta = 0$ ). For consistency, we assume this fixed share to be equal to 5%. Since we stick with our assumption that aggregate volumes are equally spread between all members of the young generation, the volume (in marginal units) received by an agent born in  $t$  is then determined as follows:

$$B_t = 0.05 \left( \int \sum_{a_t^n}^1 (1 + \phi a) w^{h^f} da - c_{mig} \right). \quad (3.63)$$

All remaining parameter values are unchanged.

For consistency, constraints are again set such that outstanding debt is required to be 100% asset-backed ( $x = 0$ ). Figure 3.10 depicts the evolution of long-run equilibrium values of the variables determining the composition of domestic labour supply over a range of migration costs.

Thus, integrating transfer flows within national boundaries into a framework of endogenous remittance flows entails a more optimistic outlook on school participation for the long-run as well. At the same time, however, this implies higher emigration incentives than with purely selfish individuals. In consequence, as figure 3.10 shows, the scenario featuring a general transfer motive yields for prohibitively high migration costs the highest level of human capital, but this difference shrinks for lower migration costs, as skilled workers become increasingly footloose.

To demonstrate which implications this dependence has for the long-run impact of restricting access to credit under different degrees of openness, we turn to a comparison between long-run equilibrium stocks of skilled labour obtained in case of a zero wealth limit ( $x = 0$ ) and in case of a perfect capital market ( $x = -\infty$ ) for all the three scenarios discussed. Figure 3.11 plots the relative difference between these long-run stocks for different levels of  $c_{mig}$ .

This tells us that the existence of bottlenecks in the provision of credit has in any case less harmful effects on skill formation if migration costs are low, irrespective of whether transfer motives are considered or not. The scenarios however differ in the quantitative extent of this sensitivity: While the comparatively low magnitude of transfer flows in the remittance-only scenario yields a pattern similar to the one in the basic scenario, the existence of a general form of altruism seems to imply that the impact of credit market imperfections on skilled labour supply is considerably less sensitive to the strength of barriers to migration.

This is rooted in the smoothing effect of intergenerational support: In case of a completely isolated national labour market, transfer payments are capable of reducing the harmful long-run effects of credit constraints on skill formation, as they effectively reduce



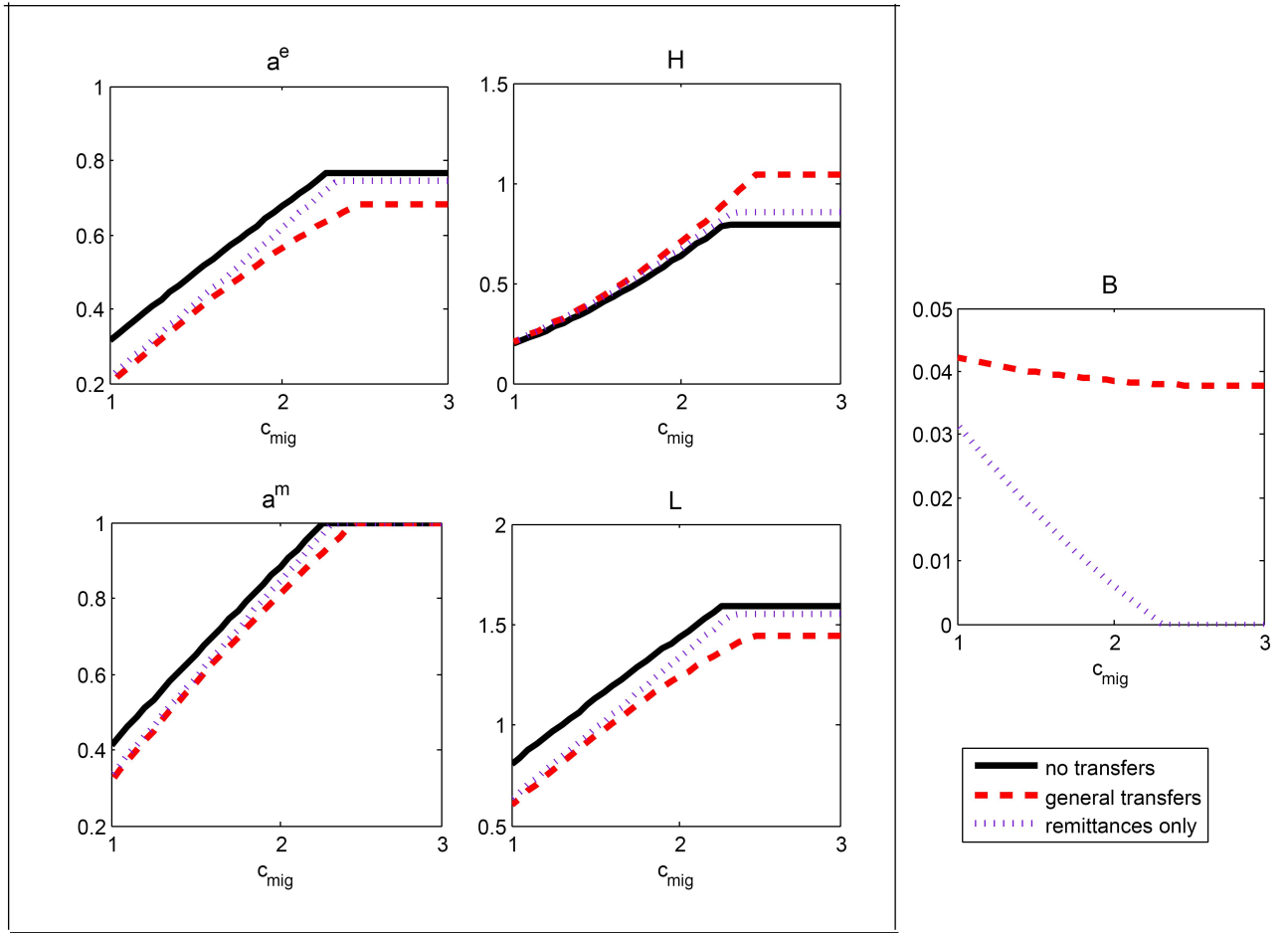


Figure 3.10: Long-run equilibria for different forms of transfers

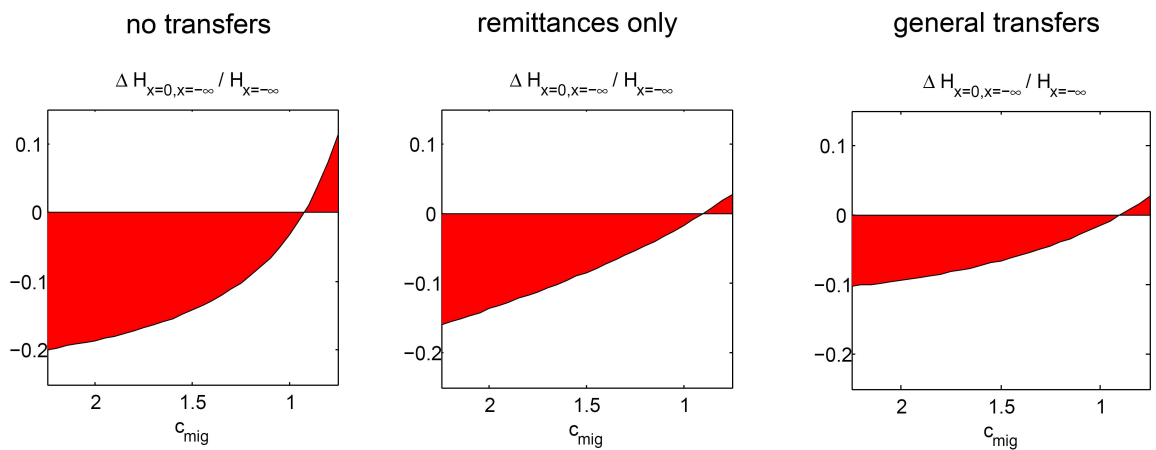


Figure 3.11: Long-run effects of borrowing constraints for different degrees of openness

the liquidity shortage associated with studying. However, for shrinking migration costs, this effect is increasingly overshadowed by the additional indirect boost of transfer payments to emigration incentives. For very high degrees of openness, our simulations show

that the existence of a wealth constraint even exerts a less favourable long-run impact on skill formation if the effect of transfer flows is taken into account.

Hence, if a small open economy is populated by at least partially altruistic agents, it is on the one hand less vulnerable to credit market imperfections, but on the other hand also less able to benefit from any positive feedback effects of these imperfections on the extent of outmigration, up to the point where bequest motives actually could turn to become obstacles to skill accumulation.

Nevertheless, this does not mean that there could not be any individuals that do profit from a decline in migration costs. Given the finite lifetime of agents, the individual impact of dismantling barriers to labour mobility should be highly sensitive to the time span between the occurrence of the shock and the period the affected individual is born into. This requires us first to determine the transition path towards a new steady-state before being able to discriminate between the welfare effects on different generations.

### 3.6 Welfare analysis

Having laid out the systems long-run properties for different degrees of altruism across generations, it remains to be seen whether the observed disparities between the scenarios have any implications for the nature of adjustment paths in response to a shock to labour mobility. To focus on the qualitative distinction made by introducing the opportunity for skilled workers to cross the border, the starting point marks a situation in which migration costs are prohibitive even from the perspective of the most talented professionals.

Specifically, the migration cost level is for a scenario of a zero wealth constraint ( $x = 0$ ) (and non-altruistic preferences) chosen such that the skilled worker with the highest ability in the economy is in the initial equilibrium exactly indifferent between going abroad or supplying her efficiency units of skilled labour at home ( $a^m = 1$ ). Given our other parameter choices, this is fulfilled for the following level of migration costs:  $c_{mig} = 2.58$ . This initial steady state is then shocked in the form of an unanticipated 20% decline in migration costs at the beginning of the period  $t = 1$  and the process of adjustment towards a new stationary equilibrium is computed.

In order to assess the role of transfers, the same parameter values are then applied to calculate an initial equilibrium with workers experiencing joy from giving, requiring us to define a positive value for the altruism parameter  $\vartheta$ . To come up with a real-life interpretation that does not tend to overemphasize the influence of inter vivo transfers in this regard, we assume these flows to account for 5% of the total spendings of workers in their post-education periods. According to (3.52), this implies for the given choice  $\eta = 0.8$  a value of  $\vartheta = 0.094$ . The same shock is then imposed on this initial equilibrium as well, and the resulting adjustment paths are determined.

Figure 3.12 depicts this transition for both scenarios.

Comparing the initial situations, enrollment rates are in consistence with our previous analysis higher in case of altruistic preferences. Then, in  $t = 1$ , lowering the costs of going abroad initiates an outflow of skilled labour in both cases, which is, due to the delayed response of human capital formation, not met by any adjustments to domestic supply of unskilled labour yet. We can observe that this immediate outflow consists of a higher share of professionals for the scenario featuring transfer payments. This is based on the fact that the competitive pressure initiated by higher participation rates represents an additional boost to emigration incentives as soon as border-crossing becomes an affordable

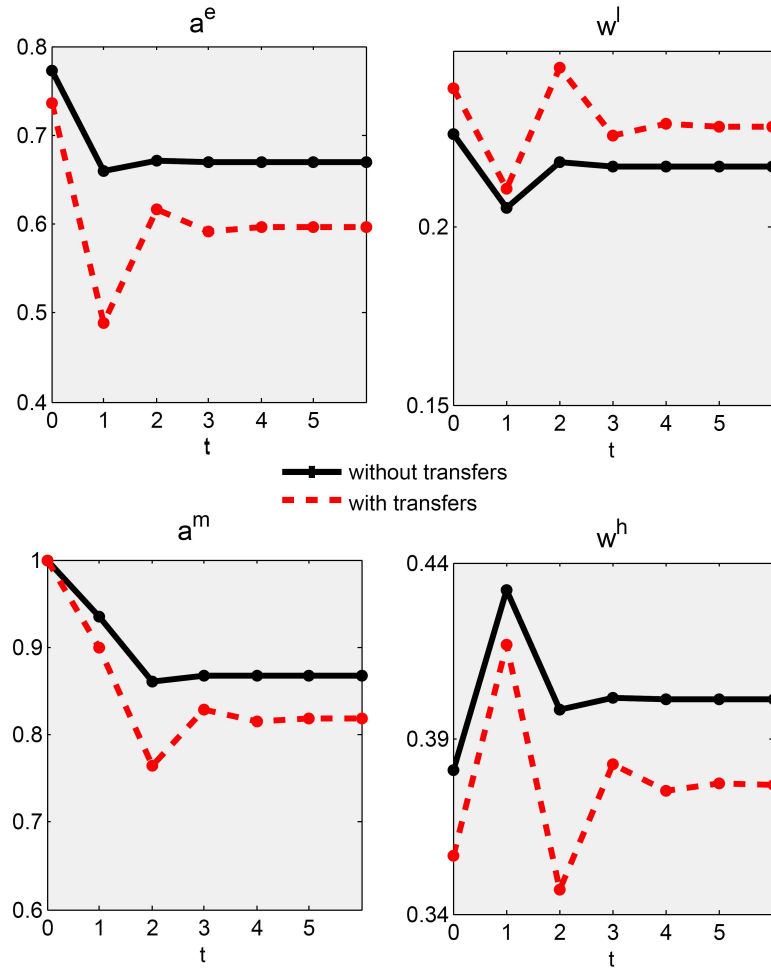


Figure 3.12: Dynamic adjustments following a decrease of migration costs

option.

As a consequence, the expectation of a decline in competitive intensity one period ahead increases the willingness of relatively less talented individuals to invest into education today. In this regard, as emigration incentives are boosted by the presence of transfer flows, the impact on school enrollment is more pronounced as well. In terms of employment opportunities for skilled workers, these adjustments made to labour supply imply a reduction of the availability of the complementary factor.

In the following periods, the resulting productivity decline partially eliminates the scarcity-based rise of skill premia, implying wage rates to exhibit overshooting behaviour. The implication is that even more outmigration takes place in  $t = 2$ . This is of special significance for the scenario featuring transfer flows, given that the feedback effect exerted by rising enrollment rates is more intense. Thus, migration volumes systematically diverge between the two scenarios in the first two post-shock periods. Afterwards, this process is brought to a halt by the increased scarcity of complementary unskilled labour, where the upward pressure on payments to manual labour sets limits to an increase in student numbers over the generations.

Hence, the highest sensitivity of welfare effects with respect to the time dimension should be observed in a comparison of generations born right before and right after its occurrence, when fluctuations in the levels of labour income are the most pronounced.

As a measure of the welfare change at the individual level, we again turn to our intertemporal equivalence criterion applied in the previous chapter. Hence, we determine the amount of capital one would need to transfer to an individual of certain talent born prior to  $t = 0$  in order to make her as well-off as when she was born  $t$  periods after the shock. In contrast to a scenario without borrowing restrictions, we need to be more precise here about what we regard as a pre-shock state than simply referring to the period of birth. Under binding liquidity constraints the actual reception of such a payment could potentially not only bias the intertemporal allocation of income, but decisions on schooling and migration as well (and hence wage rates). Therefore, to adhere to a comparison of actual equilibrium states, we add the restriction that any such payment would not affect the status decisions of the respective agent.

$$U_{-1}^{EV} \left( c_{-1}^{1;EV} \left( w_{-1}^l, w_{-1}^h, K_t^{EV} \right), c_{-1}^{2;EV} \left( w_{-1}^l, w_{-1}^h, K_t^{EV} \right), c_{-1}^{3;EV} \left( w_{-1}^l, w_{-1}^h, K_t^{EV} \right) \right) = U_t$$

To correctly assess the implications the existence of borrowing restrictions as such has for individual welfare outcomes, we first abstract from the role of intergenerational transfers and focus on the base case scenario of purely selfish agents facing a zero wealth constraints, whose transition path is reported in figure 3.11. The welfare impact on individuals born during this transition is then compared with the results obtained for an equivalent shock to migration costs in the absence of credit constraints, as already presented in chapter 2. Figure 3.13 graphs the densities of our equivalence measure over the talent distribution for different points on the timeline (and hence different generations).

First, it is apparent that the central result that welfare impacts vary significantly across the range of personal talent persists in a world characterized by malfunctioning lending institutions. In general, individuals more extensively endowed with talent face a more beneficial (or less adverse) change in intertemporal well-being in response to the shock. However, in comparing the two scenarios, the difference made by introducing borrowing restrictions seems to consist of a change in the extent of these variations in the distribution of welfare within generations.

Primarily, this results from a reduction of the gains of the most talented workers, while those at the bottom end of the distribution are only minorly affected by the interaction of the cost shock with the restrictions to credit access. Intuitively, this is due to the fact that effectively constrained in their consumption decisions, differences between the two scenarios can thus only be based on differences in the adjustment paths attained for the wage rates of unskilled workers. The qualitative pattern of overshooting wage rates is however strikingly similar to the one obtained in the absence of credit constraints, implying the extent of their welfare decline to be only minorly dependent on the quality of lending institutions. In contrast, for both emigrating and non-emigrating skilled workers, gains appear to be severely lower than in absence of the wealth constraint, as it prevents them from capitalizing sufficiently on both the lower efforts of moving and the resulting higher domestic skill premia. This becomes more evident when we summarize results in the form of average welfare changes (in marginal units) for the different classes agents select into in figure 3.14. Here,  $l - h$  again represents switchers from an uneducated to an educated state as an outcome of the shock.

Given that for switchers into education wealth constraints are likewise binding, their

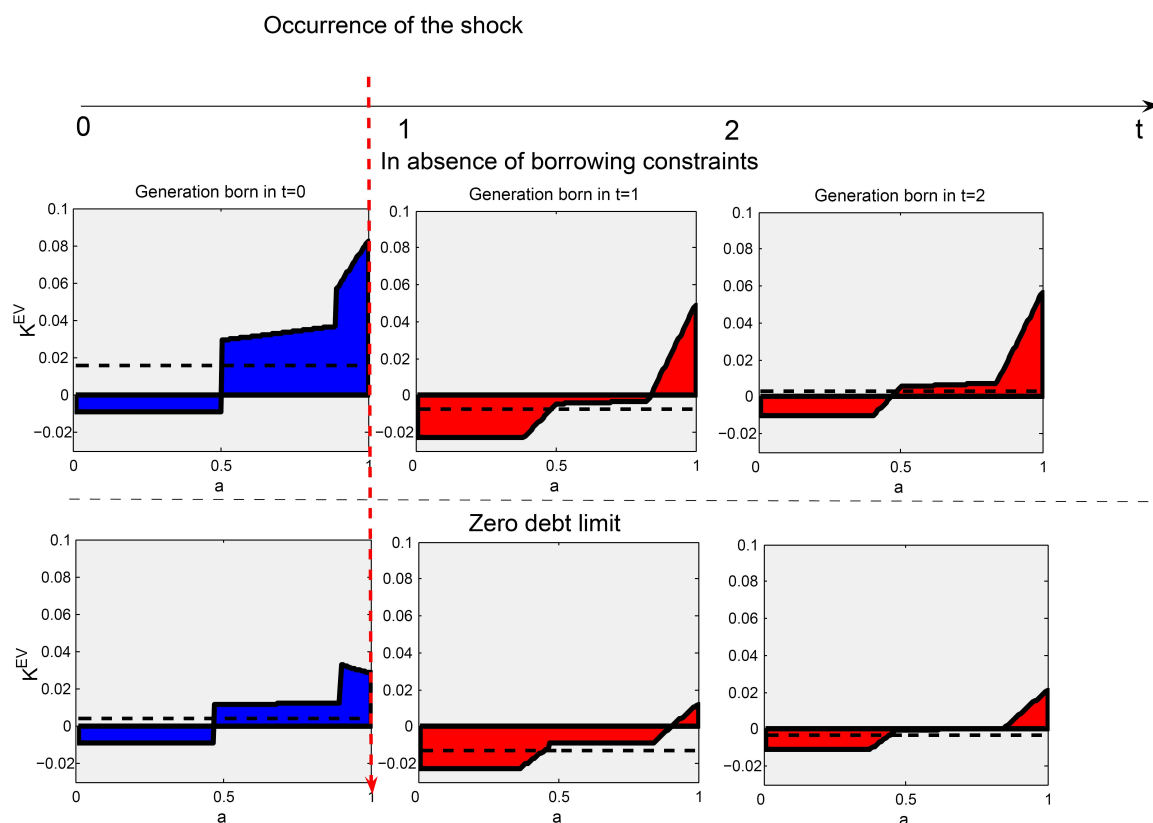


Figure 3.13: The welfare impact of a migration cost decline in two dimensions

personal welfare change is revealed to be adversely affected by the presence of credit rationing as well.

Besides, this implicates that our second major result obtained for the scenario of perfect capital markets remains valid in the new environment: Individuals switching to the status of a skilled worker as the outcome of the shock (i.e. who would not have participated in the schooling program when being born before its occurrence) can not simply deduced to be better-off than in a pre-shock world as a consequence of entering a higher income class after the status switch. Instead, as the observation of more agents engaging into education is here partly due to a decline in the market price of unskilled labour, their behaviour can largely be traced back to the incentive of avoiding an even greater welfare loss incurred in case of remaining unskilled.

In sum, we can state that a decrease of migration costs still tends to widen economy-wide inequality in welfare within and across generations when lifetime accumulation is subject to credit constraints, but, following from the restrictions imposed on the winners from labour market integration, to a lesser extent.

From the perspective of a policy-maker, it would be helpful to judge the desirability of this mixed outcome according to some social welfare criterion. To this end, we apply an adjusted version of the Kaldor criterion (Kaldor (1939)), i.e. we try to answer the question if the gains received by the winners from the border shock are of sufficient magnitude in order to fully compensate all losers. This would imply the achievement of a Pareto-improvement as an outcome of dismantling migration barriers if such a compensation

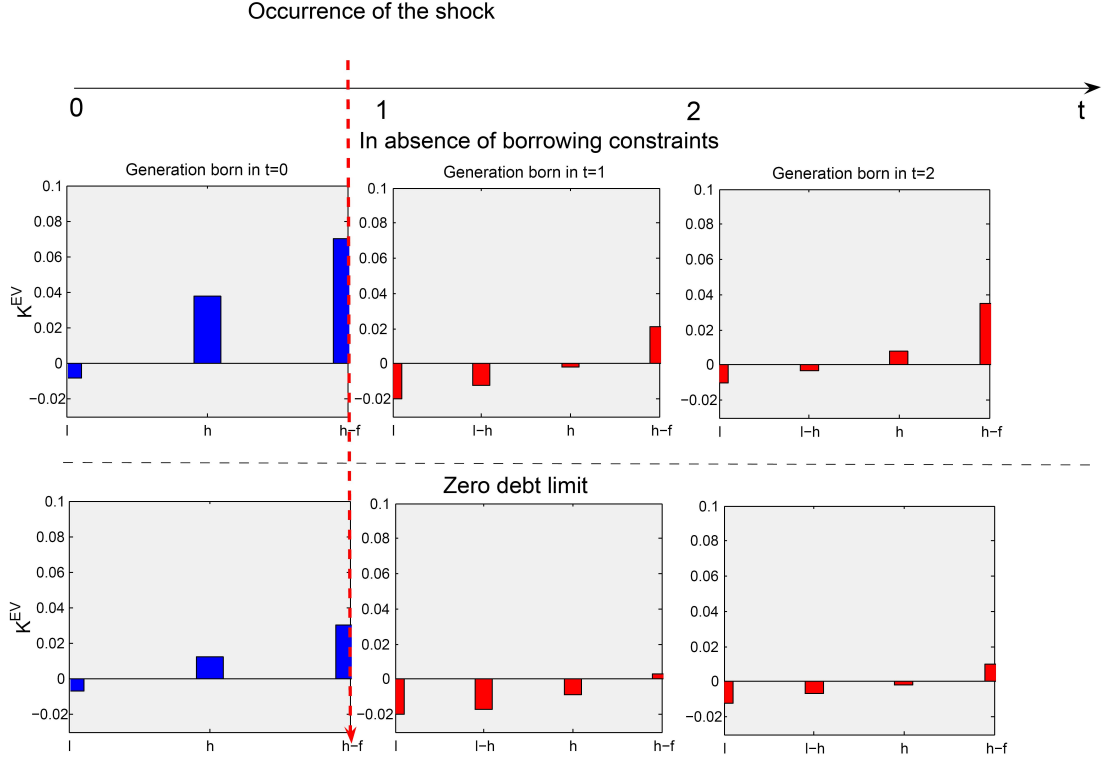


Figure 3.14: Welfare impact of a migration cost decline for different subgroups

mechanism could actually be enforced.

In this regard, one point to clarify is the time structure of matching contributors and recipients. Complexity arises here from the two-dimensionality of welfare effects, allowing one to analyze not only payments from high-talented to low-talented workers of the same generation, but also the possibility of net compensation of the members born right after the shock by subsequent generations. To avoid an arbitrary choice of a key for distributing gains across generation, we restrict our focus on the existence of opportunities for compensating losers through present gains.

Specifically, the scenario in mind is that winners in their second period of life (i.e. after gains in terms of labour income have been realized) are forced to transfer the maximal amount of liquid assets that would not render them worse-off than in the pre-shock state to losers within the same age group. If the aggregate value of these assets is sufficient to make none of the recipients in any generation to become worse-off than before the shock, aggregate welfare could be inferred to rise according to this criterion. The maximal amount provided by one winner is then determined as the modulus of a compensating variation  $K_t^{CV}$ , which corresponds to the amount of assets required to be transferred to an middle-aged individual born  $t$  periods after the shock such that she becomes exactly as well-off as in a pre-shock state. In calculating this amount, we take account of the fact that consumption levels should themselves be sensitive to the extent of compensation:

$$U_t^{CV} \left( c_t^{1:CV} \left( w_t^l, w_{t+1}^l, w_{t+1}^h, K_{t+1}^{CV} \right), c_{t+1}^{2:CV} \left( w_t^l, w_{t+1}^l, w_{t+1}^h, K_{t+1}^{CV} \right), c_{t+2}^{3:CV} \left( w_t^l, w_{t+1}^l, w_{t+1}^h, K_{t+1}^{CV} \right) \right) = U_{-1}.$$

Integrating over the contributions made by beneficiaries within each generation and dis-

tributing the aggregate amount within the group of losers delivers the following compensation flow  $K_t^{Rec}$  (in marginal terms) received by an agent in  $t$ , with  $a_t^W$  representing the talent threshold for agents born in  $t$  above which they experience a welfare increase as a consequence of the shock:

$$K_t^{Rec} = \frac{\int_{a_{t-1}^W}^1 |K_t^{CV}(a)| da}{a_{t-1}^W}. \quad (3.64)$$

where we exploit the properties of the uniform distribution.

In practical terms, the range of difficulties encountered in implementing this mechanism would surely include the lack of enforceability of mandatory payments with respect to the subgroup of winners exhibiting the highest gains: the emigrants. When establishing an efficiency criterion that builds upon opportunities to compensate certain groups of people, one should also check the sensitivity of this criterion towards the likely event that not all winners can be forced to contribute. For this reason, we further consider the additional case in which the set of contributors merely consists of non-emigrants:

$$K_t^{Rec*} = \frac{\int_{a_{t-1}^W}^{a_t^m} |K_t^{CV}(a)| da}{a_{t-1}^W}. \quad (3.65)$$

Figure 3.15 compares the amount of compensation received together with the amount of compensation required for the set of agents getting worse-off within each generation, for the cases with and without contributions by emigrants.

Independent of the fact whether emigrants take part in the scheme, we can conclude that such a compensation mechanism is only apt to eliminate all individual welfare losses for the generation born in the period before the shock hits the economy: The amount of compensation affordable by beneficiaries born after the shock is not sufficient to prevent a deterioration of the lifetime utility of low-talented agents within the same cohorts. This means that if such a scheme could actually be enforced by legal authorities within that country in parallel to the migration cost decline, only the distribution of well-being between members of the generation born in  $t = 0$  would be subject to a Pareto-improvement. Hence, in general terms, a system purely based on solidarity within a given cohort does not guarantee increased outmigration to generate pareto-superior allocations, a result that coincides with our findings for the welfare effect under perfect capital markets in chapter 2.

Instead, if borrowing is unrestricted by any lower wealth limit, it is only the generation born right after the shock for which this scheme would fail<sup>9</sup>, while it fails here for every post-shock generation. Obviously, this is again caused by the lack of opportunities for students to realize the intertemporal gains associated with lifting migration barriers in terms of present consumption. The exception is the cohort being in its first stage of life one period before the occurrence of the shock, which is primarily a consequence of the concurrence of two facts: For one thing, first-period income is not yet impaired by an increase in the scarcity of skilled labour. This means that both students and non-students to maintain consumption opportunities exceeding those of subsequent generations. For

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<sup>9</sup>see results of part 2.4.2

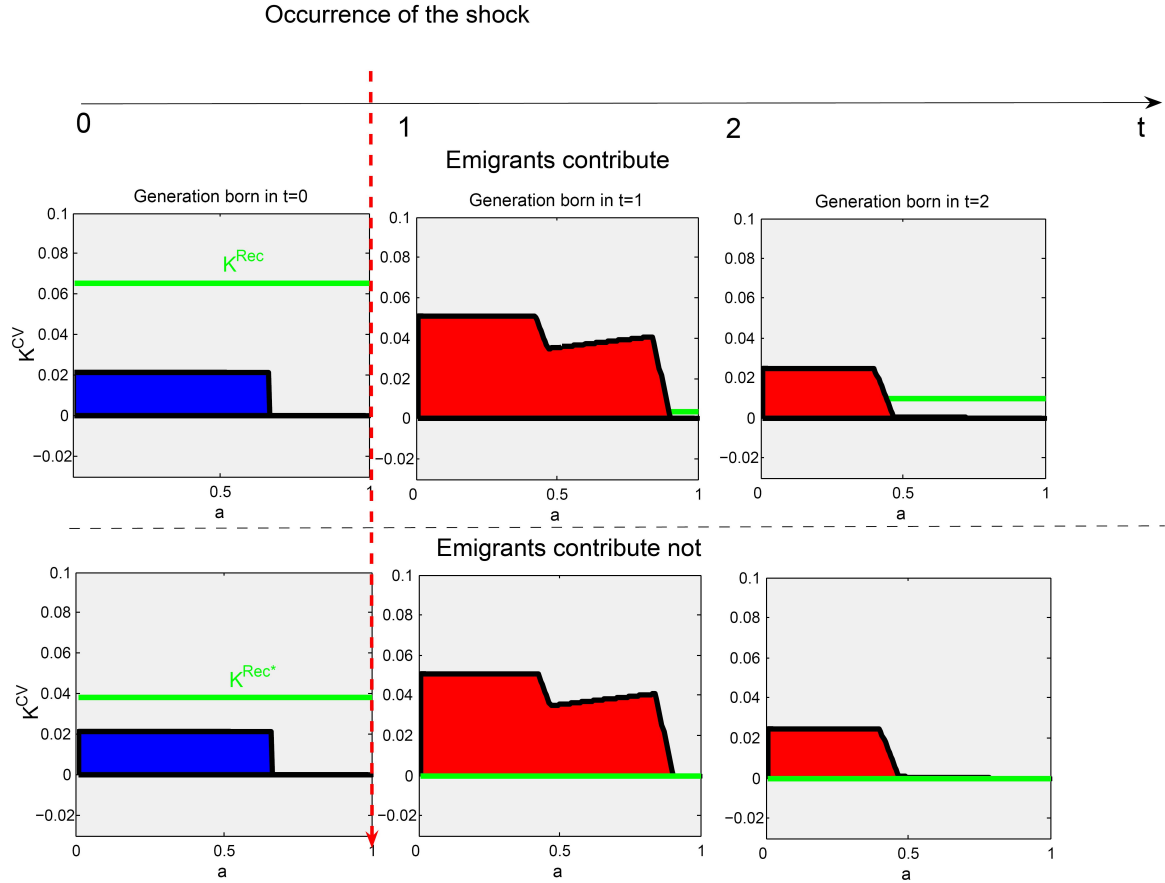


Figure 3.15: Compensation opportunities along the lines of Kaldor

another thing, the overshooting pattern obtained for wages implies domestic skilled workers within this generation to profit the most compared to later born individuals. They are in the position to close the gap in labour supply arisen from enhanced outmigration of the most productive elite without facing any additional competition resulting from higher rates of school enrollment yet.

Nevertheless, if we further exclude emigrants from the program, the lower graphs in 3.15 tell us that not even within this generation adequate amounts of compensation could be retrieved.

Of course, the question whether the possibility to transmit gains across distinct cohorts might represent a way to fully compensate at least some of the losers in this scenario remains. Practically, however, centrally imposed compensation schemes across generations are likely to encounter even more severe obstacles with respect to public acceptance and constitutional conformity than if reallocations are restricted to individuals within the same age group. Rather, we should focus on the role intergenerational support of a voluntary kind plays as a compensating mechanism in the aftermath of the shock. This is of particular appeal as under joy-of-giving preferences transfer flows can be associated with mutual gains in well-being for recipients as well as contributors.

Therefore, we carry on with presenting the welfare implications of the transition ob-



tained under an (otherwise equivalent) scenario featuring transfer motives. Figure 3.16 depicts again results for the welfare measure that determines the amount of assets which, when passed on to agents born in periods far in advance of the shock, would render them exactly as well-off as if they were born  $t$  periods after its occurrence. The upper graphs represent the results for the previous case of credit constraints without altruism and the lower graphs the same situation with altruistic preferences.

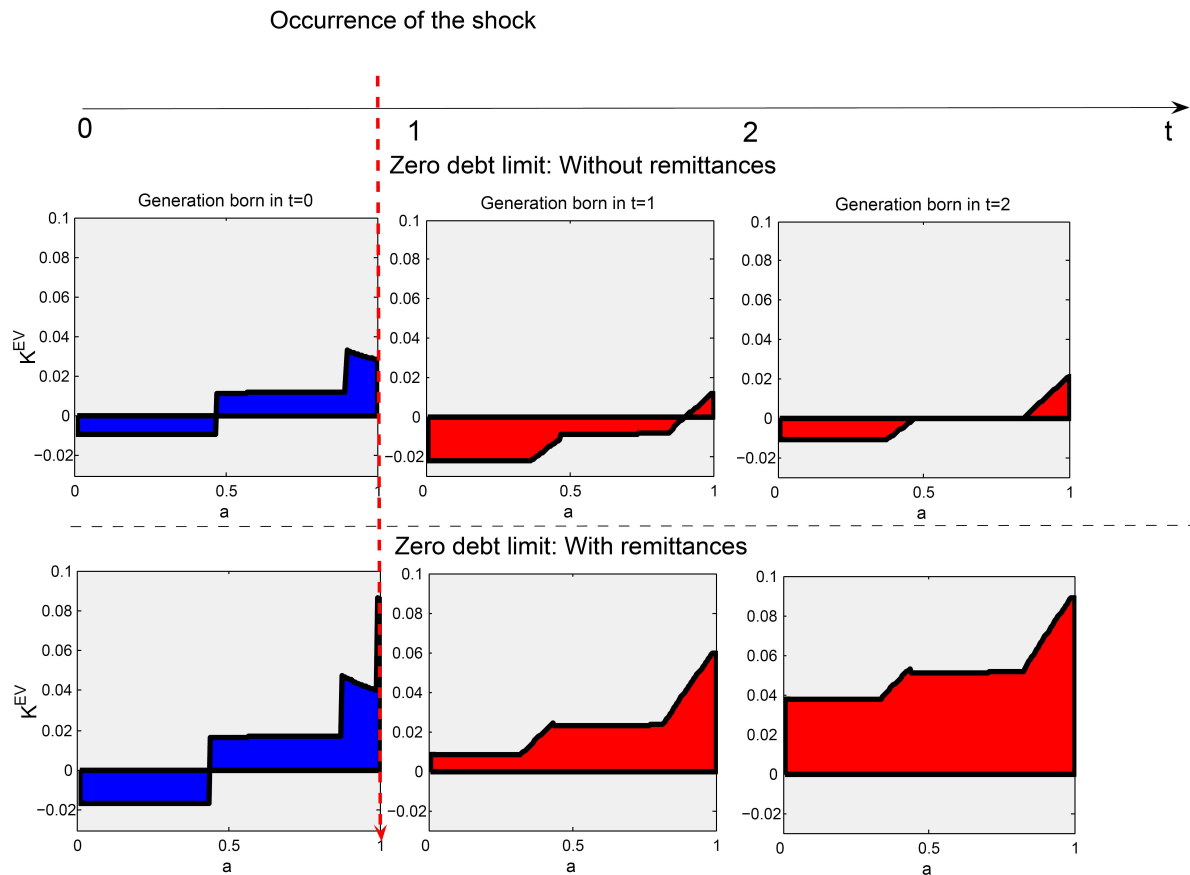


Figure 3.16: The welfare impact of a migration cost decline with and without transfer flows

To begin with, in order to focus on the pecuniary effects of wage fluctuations as such, we can note that for the generation born in  $t = 0$  the qualitative evolution of the effects on individual welfare over the range of talent is broadly unaltered by the presence of transfers. This is obviously due the fact that the amount of transfers received by agents born before an unanticipated shock is yet unaffected by its future labour market impact.

This changes quite drastically when we compare the scenarios with respect to the generations to follow. Even for the given modest expenditure share of 5% for transfers does the introduction of altruistic networks between generations impose a remarkable improvement on the effect of the border shock on individual welfare across all talent levels. Despite shrinking payments received from low-qualified jobs, individuals at the bottom end of the ability distribution are in this scenario actually better-off than prior to the migration cost decline. As the only explanation for this can serve an increase in the volume of transfers received in the first period, which is more than compensating the

decrease of own labour income. Higher transfer volumes are, in turn, a consequence of the unexpectedly high education premium received by high-talented individuals in the previous generation, a gain they are willing to share with their offspring.

Under our assumption of a completely even distribution of transfers over the young population, this means that high-skilled workers in post-shock times tend to become to an even larger extent net contributors to the informal system of support as a side effect of facilitating outmigration. Nevertheless, their own gains in comparison to the pre-shock level are not diminished by the drain of transfer payments, but are even of higher magnitude if altruism is considered. This holds even more for generations born from  $t = 2$  onwards, where the positive effect of enhanced intergenerational exchange is only to a lower degree impaired by the drop in first period labour income.

In the end, it is the nature of joy-of-giving preferences that implies mutual gains for contributors and recipients associated with the positive externality of an increase in transfer volumes. In addition, this has the consequence that another central implication is not overturned by the introduction of bequest motives: Better migration opportunities result in a rise of inequality in individual happiness within generations. At the same time, the presence of intergenerational transfers renders welfare results even more sensitive to the exact timing of the shock, as those born directly before the shock are in this respect not only effectively excluded from information on wage adjustments, but also from the increase in transfer volumes.

Figure 3.17 in Appendix 3.C depicts the two dimensions of welfare effects in the form of a 3D graph. In sum, we can state that among the members of all generations born after  $t = 0$  a Pareto-improvement in the course of the economies adjustment process is observable. Only unskilled workers born immediately before a migration shock remain to be negatively affected when intergenerational support is taken into account. Considering the extent of the gains of all other individuals, conceiving a scheme to effectively compensate this subgroup should not represent a major issue under these circumstances. This implies that the application of a Kaldor criterion here obviously produces the result of an intertemporal improvement in aggregate welfare as an outcome of enhancing the mobility of skilled labour.

### 3.7 Conclusion

Our approach has been to set up a model that combines educational investment decisions of liquidity constrained individuals with endogenous migration of skilled workers within a common lifecycle framework. In this regard, we add depth to the literature dealing with the positive repercussions of a “brain drain” on educational incentives by allowing for an additional feedback effect of enrollment rates on the tendencies of high-talented individuals to outmigrate.

This has the implication that the result of stochastic migration models that a rise of emigration rates of professionals is able to mitigate a skilled labour shortage based on credit market failure is overturned. While one still observes a positive impact of skilled worker mobility on schooling in both short- and long-run, it is likely to be outweighed by the increased outflow of the most productive professionals. This is based on the deterministic character of migration, which implies emigrants to represent a positive selection of the domestic workforce that is not easily replaceable through an increase in the number of graduates.

In addition, we had taken a closer look at the welfare implications of this outcome on the individual level. We had seen that across all generations personal effects on happiness are strongly positively related to the agents' inborn level of talent and the corresponding choice of a status group. In assessing the opportunities for implementing a compensation scheme designed to attenuate the resulting increase in inequality, we had come to the conclusion that a system based on intragenerational settlement would not be sufficient to result into a pareto-improving outcome.

Moreover, as an additional counterintuitive result specific to an environment with footlose skilled labour, we had demonstrated that under sufficiently moderate migration costs a tightening of borrowing constraints can evoke an improvement in the general skill level of the domestic workforce despite its detrimental impact on educational incentives. This is due to the fact that the reduction of competitive pressure creates a crowding-in effect that effectively prevents some of the most talented workers from going abroad.

In analyzing the same issues under the presence of transfer motives, we extended the theoretical literature on the effects of remittances on lifecycle decision-making to the scenario of a general flow of transfers across generations. This was shown to exert a smoothing impact on fluctuations in aggregate factor stocks in response to a temporary credit crunch. In terms of long-run effects, the presence of transfers induces an increase in minimal wealth requirements to have less harmful effects on skilled labour supply for high levels of migration costs. However, it also weakens a potentially positive impact for sufficiently footlose skilled labour. In this respect, our approach is also shedding a different light on the role of remittances, by stressing the sensitivity of this channel to the degree of openness.

Regarding the impact of a reduction of migration costs, introducing intergenerational support did not change our central result of a decline in the small country's skill endowment with shrinking migration barriers. However, a crucial difference is marked by the individual welfare implications of the mobility increase. Taking the mutual gains of contributors and recipients of transfers into account, workers from post-shock generations across the whole talent range experience an increase in well-being resulting from a migration cost decline when intergenerational transfers are accounted for. The reason is the increase in aggregate transfer volumes observed in the aftermath of this shock. In our simulation experiment, this actually implies intensified outmigration to generate a Pareto-improvement under these circumstances.

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## Appendix 3.A: Derivation of cut-off levels

The maximal first-period consumption level is defined as follows:

$$c_t^1 \leq I_t^{1,s} - x = \bar{c}_t^{1,s}.$$

Therefore, the Lagrangian can be written as:

$$La_t^s = \sum_{b=0}^2 \beta^b \frac{c_{t+b}^{1-\eta} - 1}{1-\eta} + \lambda_t^s \left( PVI_t^s - \sum_{b=0}^2 \frac{c_{t+b}}{(1+r)^b} \right) + \mu_{1t}^s (\bar{c}_t^{1,s} - c_t^1) \\ + \mu_{2t}^s c_t^1 + \mu_{3t}^s c_{t+1}^2 + \mu_{4t+2}^s c_{t+2}^3$$

with  $\lambda_t^s$  as the Lagrange variable and  $(\mu_{1t}^s, \mu_{2t+1}^s, \mu_{3t}^s, \mu_{4t+1}^s)$  as the slack variables of the inequality constraints. Deriving the Kuhn-Tucker conditions gives:

$$\frac{\partial La_t^s}{\partial c_t^1} = c_t^{1-\eta} - \lambda_t^s - \mu_{1t}^s + \mu_{2t}^s \stackrel{!}{=} 0 \\ \frac{\partial La_t^s}{\partial c_{t+1}^2} = \beta c_{t+1}^{2-\eta} - \lambda_t^s \frac{1}{1+r} + \mu_{3t+1}^s \stackrel{!}{=} 0 \\ \frac{\partial La_t^s}{\partial c_{t+2}^3} = \beta^2 c_{t+2}^{3-\eta} - \lambda_t^s \frac{1}{(1+r)^2} + \mu_{4t+2}^s \stackrel{!}{=} 0 \\ \frac{\partial La_t^s}{\partial \lambda_t^s} = PVI_t^s - \sum_{b=0}^2 \frac{c_{t+b}}{(1+r)^b} \stackrel{!}{=} 0 \\ \mu_{1t}^s (\bar{c}_t^{1,s} - c_t^1) = 0 \quad \mu_{2t}^s c_t^1 = 0 \quad \mu_{3t+1}^s c_{t+1}^2 = 0 \quad \mu_{4t+2}^s c_{t+2}^3 = 0.$$

**Solving for  $c_t^{1,s}, c_{t+1}^{2,s}, c_{t+2}^{3,s}$ :**

In case of  $\mu_{1t}^s = 0$ : We obtain the standard Euler equation

$$c_t^{1-\eta} = c_{t+1}^{2-\eta} \beta (1+r) = c_{t+2}^{3-\eta} \beta^2 (1+r)^2.$$

Plugging this into the wealth constraint yields

$$c_t^{1,s} = \frac{PVI_t^s}{1+\zeta} \quad c_{t+1}^{2,s} = \frac{(\beta(1+r))^{\frac{1}{\eta}} PVI_t^s}{1+\zeta} \quad c_{t+2}^{3,s} = \frac{(\beta(1+r))^{\frac{2}{\eta}} PVI_t^s}{1+\zeta} \\ \text{with } \zeta = \left( (\beta^{\frac{1}{\eta}} (1+r)^{\frac{1-\eta}{\eta}})^2 + (\beta^{\frac{1}{\eta}} (1+r)^{\frac{1-\eta}{\eta}}) \right).$$

In case of  $\mu_{1t}^s > 0$ : Combining  $c_t^{1,s} = I_t^{1,s} - x$  with the wealth constraint gives

$$c_{t+1}^{2,s} = \frac{(\beta(1+r))^{\frac{1}{\eta}} \left( \frac{I_{t+1}^{2,s}}{1+r} + x \right)}{\zeta}.$$

This leads to

$$c_{t+2}^{3,s} = \frac{(\beta(1+r))^{\frac{2}{\eta}} \left( \frac{I_{t+1}^{2,s}}{1+r} + x \right)}{\zeta}.$$



Inserting optimal consumption plans into the intertemporal utility function yields:

(Nonmigrating) Skilled workers

$$U_t^h = \begin{cases} (1 + \zeta)^\eta \frac{\left(\frac{(1 + a\phi)w_{t+1}^h}{1 + r} + (1 - \epsilon)w_t^l\right)^{1-\eta}}{1 - \eta} & \text{if } \frac{\left(\frac{(1 + a\phi)w_{t+1}^h}{1 + r} + (1 - \epsilon)w_t^l\right)}{1 + \zeta} \leq (1 - \epsilon)w_t^l - x \\ \frac{\left((1 - \epsilon)w_t^l - x\right)^{1-\eta}}{1 - \eta} + \zeta^\eta \frac{\left(\frac{(1 + a\phi)w_{t+1}^h}{1 + r} + x\right)^{1-\eta}}{1 - \eta} & \text{if } \frac{\left(\frac{(1 + a\phi)w_{t+1}^h}{1 + r} + (1 - \epsilon)w_t^l\right)}{1 + \zeta} > (1 - \epsilon)w_t^l - x \end{cases}$$

Unskilled workers

$$U_t^l = \begin{cases} (1 + \zeta)^\eta \frac{\left(\frac{w_{t+1}^l}{1 + r} + w_t^l\right)^{1-\eta}}{1 - \eta} & \text{if } \frac{\left(\frac{w_{t+1}^l}{1 + r} + w_t^l\right)}{1 + \zeta} \leq w_t^l - x \\ \frac{\left(w_t^l - x\right)^{1-\eta}}{1 - \eta} + \zeta^\eta \frac{\left(\frac{w_{t+1}^l}{1 + r} + x\right)^{1-\eta}}{1 - \eta} & \text{if } \frac{\left(\frac{w_{t+1}^l}{1 + r} + w_t^l\right)}{1 + \zeta} > w_t^l - x \end{cases}$$

. Equating the corresponding parts of the utility functions for skilled and unskilled workers and solving for the talent levels delivers the cut-offs valid for situations in which constraints are only binding in case of participation ( $a_t^{e:I}$ ) and for situations in which they are binding with or without participation ( $a_t^{e:II}$ ).

$$a_t^{e:I} = \frac{(1 + r) \left( \left( \frac{1 + \zeta}{\zeta} \right)^\eta \left( \frac{E_t w_{t+1}^l}{1 + r} + w_t^l \right)^{1-\eta} - \left( \zeta^{\frac{\eta}{1-\eta}} \left( (1 - \epsilon)w_t^l - x \right) \right)^{1-\eta} \right)^{\frac{1}{1-\eta}}}{\phi E_t w_{t+1}^h} - \frac{(1 + r)x}{\phi E_t w_{t+1}^h} - \frac{1}{\phi} \quad (3.66)$$

$$a_t^{e:II} = z \frac{(1 + r) \left( \frac{(1 - (1 - \epsilon)^{1-\eta})}{\zeta^\eta} w_t^l - x^{1-\eta} + \left( \frac{E_t w_{t+1}^l}{1 + r} + x \right)^{1-\eta} \right)^{\frac{1}{1-\eta}}}{\phi E_t w_{t+1}^h} - \frac{(1 + r)x}{\phi E_t w_{t+1}^h} - \frac{1}{\phi}. \quad (3.67)$$

### Appendix 3.B: Derivation of cut-offs under altruistic preferences

The maximal level of first-period consumption is updated as follows:

$$c_t^1 \leq \left( I_t^{1,s} + B_t \right) - x = \bar{c}_t^{1,s}.$$

The optimization problem then becomes:

$$L a_t^s = \frac{c_t^{1-\eta} - 1}{1 - \eta} + \sum_{b=1}^2 \beta^b \left( \frac{c_{t+b}^{1-\eta} - 1}{1 - \eta} + \vartheta \frac{b_{t+b}^{1-\eta} - 1}{1 - \eta} \right) + \lambda_t^s \left( P V I_t^s + B_t - \sum_{b=0}^2 \frac{c_{t+b} + b_{t+b}}{(1 + r)^b} \right) + \mu_{1t}^s (\bar{c}_t^{1,s} - c_t^1) + \mu_{2t}^s c_t^1 + \mu_{3t}^s c_{t+1}^2 + \mu_{4t+2}^s c_{t+2}^3 + \mu_{5t+1}^s b_{t+1}^2 + \mu_{6t+1}^s b_{t+2}^3.$$

The optimality conditions are updated as:

$$\begin{aligned}
\frac{\partial La_t^s}{\partial c_t^1} &= c_t^{1-\eta} - \lambda_t^s - \mu_{1t}^s + \mu_{2t}^s \stackrel{!}{=} 0 \\
\frac{\partial La_t^s}{\partial c_{t+1}^2} &= \beta c_{t+1}^{2-\eta} - \lambda_t^s \frac{1}{1+r} + \mu_{3t+1}^s \stackrel{!}{=} 0 \\
\frac{\partial La_t^s}{\partial c_{t+2}^3} &= \beta^2 c_{t+2}^{3-\eta} - \lambda_t^s \frac{1}{(1+r)^2} + \mu_{4t+2}^s \stackrel{!}{=} 0 \\
\frac{\partial La_t^s}{\partial b_{t+1}^2} &= \vartheta \beta b_{t+1}^{2-\eta} - \lambda_t^s \frac{1}{1+r} + \mu_{5t+1}^s \stackrel{!}{=} 0 \\
\frac{\partial La_t^s}{\partial b_{t+2}^3} &= \vartheta \beta^2 b_{t+2}^{3-\eta} - \lambda_t^s \frac{1}{(1+r)^2} + \mu_{6t+2}^s \stackrel{!}{=} 0 \\
\frac{\partial La_t^s}{\partial \lambda_t^s} &= PVI_t^s + B_t - \sum_{b=0}^2 \frac{c_{t+b} + b_{t+b}}{(1+r)^b} \stackrel{!}{=} 0 \\
\mu_{1t}^s (\bar{c}_t^{1,s} - c_t^1) &= 0 \quad \mu_{2t}^s c_t^1 = 0 \quad \mu_{3t+1}^s c_{t+1}^2 = 0 \\
\mu_{4t+2}^s c_{t+2}^3 &= 0 \quad \mu_{5t+1}^s b_{t+1}^2 = 0 \quad \mu_{6t+2}^s b_{t+2}^3 = 0.
\end{aligned}$$

**Solving for  $c_t^{1,s}, c_{t+1}^{2,s}, c_{t+2}^{3,s}, b_{t+1}^{2,s}, b_{t+2}^{3,s}$ :**

In case of  $\mu_{1t}^s = 0$ , we attain the following optimal allocation rules:

$$c_t^{1-\eta} = c_{t+1}^{2-\eta} \beta (1+r) = c_{t+2}^{3-\eta} \beta^2 (1+r)^2 = b_{t+1}^{2-\eta} \beta \vartheta (1+r) = b_{t+2}^{3-\eta} \beta^2 \vartheta (1+r)^2.$$

Plugging this into the wealth constraint yields

$$\begin{aligned}
c_t^{1,s} &= \frac{PVI_t^s}{1 + \zeta^B} & c_{t+1}^{2,s} &= \frac{(\beta(1+r))^{\frac{1}{\eta}} PVI_t^s}{1 + \zeta^B} & c_{t+2}^{3,s} &= \frac{(\beta(1+r))^{\frac{2}{\eta}} PVI_t^s}{1 + \zeta^B} \\
b_{t+1}^{2,s} &= \frac{(\beta \vartheta (1+r))^{\frac{1}{\eta}} PVI_t^s}{1 + \zeta^B} & b_{t+2}^{3,s} &= \frac{(\beta \vartheta (1+r))^{\frac{2}{\eta}} PVI_t^s}{1 + \zeta^B} \\
\text{with } \zeta^B &= \left(1 + \vartheta^{\frac{1}{\eta}}\right) \left( (\beta^{\frac{1}{\eta}} (1+r)^{\frac{1-\eta}{\eta}})^2 + (\beta^{\frac{1}{\eta}} (1+r)^{\frac{1-\eta}{\eta}}) \right).
\end{aligned}$$

In case of  $\mu_{1t}^s > 0$ : Combining  $c_t^{1,s} = I_t^{1,s} + B_t - x$  with the wealth constraint gives

$$c_{t+1}^{2,s} = \frac{(\beta(1+r))^{\frac{1}{\eta}} \left(\frac{x-1}{x}\right) \left(\frac{I_{t+1}^{2,s}}{1+r} + x\right)}{\zeta^B}.$$

This leads to

$$\begin{aligned}
c_{t+1}^{2,s} &= \frac{(\beta(1+r))^{\frac{1}{\eta}} \left(\frac{x-1}{x}\right) \left(\frac{I_{t+1}^{2,s}}{1+r} + x\right)}{\zeta^B} & b_{t+1}^{2,s} &= \vartheta^{\frac{1}{\eta}} \frac{(\beta(1+r))^{\frac{1}{\eta}} \left(\frac{x-1}{x}\right) \left(\frac{I_{t+1}^{2,s}}{1+r} + x\right)}{\zeta^B} \\
b_{t+2}^{3,s} &= \vartheta^{\frac{1}{\eta}} \frac{(\beta(1+r))^{\frac{2}{\eta}} \left(\frac{x-1}{x}\right) \left(\frac{I_{t+1}^{2,s}}{1+r} + x\right)}{\zeta^B} & & \frac{(\beta(1+r))^{\frac{2}{\eta}} \left(\frac{x-1}{x}\right) (PVI_t^s + B_t)}{\zeta^B}.
\end{aligned}$$

**Inserting optimal consumption plans into the intertemporal utility function yields:**

**(Nonmigrating) Skilled workers**

$$U_t^h = \left\{ \begin{array}{l} \frac{(1 + \zeta^B)^\eta \left( \frac{(1 + a\phi)w_{t+1}^h}{1+r} + B_t + (1 - \epsilon)w_t^l \right)^{1-\eta}}{1 - \eta} \\ \text{if } \frac{\left( \frac{(1 + a\phi)w_{t+1}^h}{1+r} + B_t + (1 - \epsilon)w_t^l \right)}{1 + \zeta^B} \leq \left( (1 - \epsilon)w_t^l + B_t - x \right) \\ \frac{\left( (1 - \epsilon)w_t^l + B_t - x \right)^{1-\eta}}{1 - \eta} + \zeta^{B\eta} \frac{\left( \frac{(1 + a\phi)w_{t+1}^h}{1+r} + x \right)^{1-\eta}}{1 - \eta} \\ \text{if } \frac{\left( \frac{(1 + a\phi)w_{t+1}^h}{1+r} + B_t + (1 - \epsilon)w_t^l \right)}{1 + \zeta^B} > \left( (1 - \epsilon)w_t^l + B_t - x \right) \end{array} \right\}$$

**Unskilled workers**

$$U_t^l = \left\{ \begin{array}{l} (1 + \zeta^B)^\eta \frac{\left( \frac{w_{t+1}^l}{1+r} + B_t + w_t^l \right)^{1-\eta}}{1 - \eta} \quad \text{if } \frac{\left( \frac{w_{t+1}^l}{1+r} + B_t + w_t^l \right)}{1 + \zeta^B} \leq \left( w_t^l + B_t - x \right) \\ \frac{\left( w_t^l + B_t - x \right)^{1-\eta}}{1 - \eta} + \zeta^{B\eta} \frac{\left( \frac{w_{t+1}^l}{1+r} + x \right)^{1-\eta}}{1 - \eta} \quad \text{if } \frac{\left( \frac{w_{t+1}^l}{1+r} + B_t + w_t^l \right)}{1 + \zeta^B} > \left( w_t^l + B_t - x \right) \end{array} \right\}$$

Equating the corresponding parts of the utility functions yields the updated cut-off levels:

$$a_t^{e;I} = \frac{(1+r) \left( \left( \frac{1 + \zeta^B}{\zeta^B} \right)^\eta \left( \frac{E_t w_{t+1}^l}{1+r} + w_t^l + B_t \right)^{1-\eta} - \left( \zeta^{B \frac{\eta}{\eta-1}} \left( (1 - \epsilon)w_t^l + B_t - x \right) \right)^{1-\eta} \right)^{\frac{1}{1-\eta}}}{\phi E_t w_{t+1}^h} - \frac{(1+r)x}{\phi E_t w_{t+1}^h} - \frac{1}{\phi} \quad (3.68)$$

$$a_t^{e;II} = \frac{(1+r) \left( \frac{\left( w_t^l + B_t - x \right) - \left( (1 - \epsilon)w_t^l + B_t - x \right)}{\zeta^{B\eta}} + \left( \frac{E_t w_{t+1}^l}{1+r} + x \right)^{1-\eta} \right)^{\frac{1}{1-\eta}}}{\phi E_t w_{t+1}^h} - \frac{(1+r)x}{\phi E_t w_{t+1}^h} - \frac{1}{\phi} \quad (3.69)$$

## Appendix 3.C: 3D visualization welfare impact

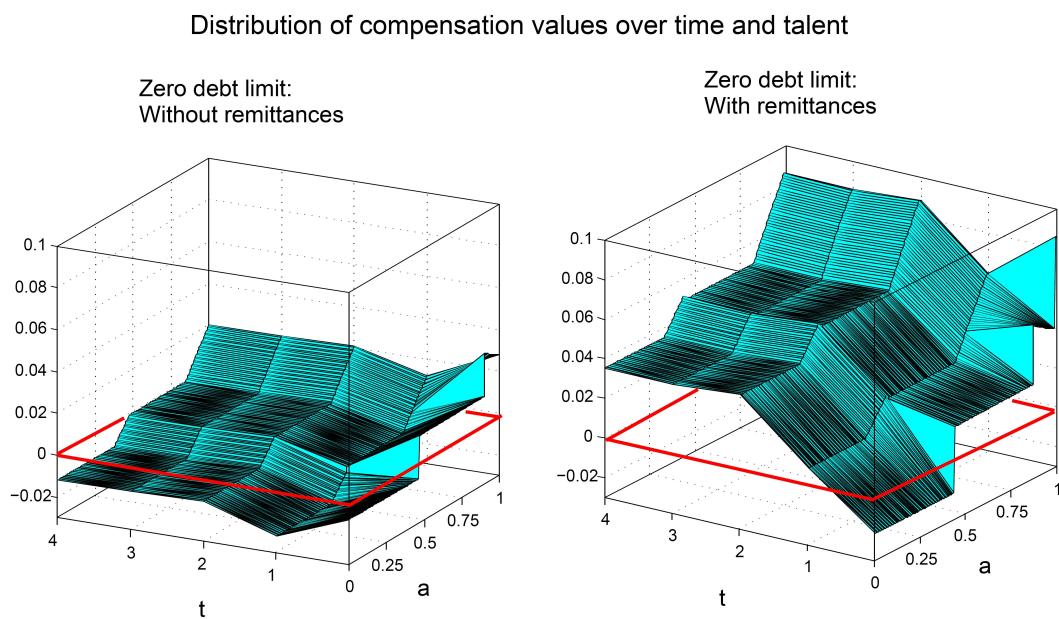


Figure 3.17: The welfare impact of a migration cost decline with and without transfer flows (3D)

## 4 Skill accumulation, trade and factor mobility

### 4.1 Motivation

Within the branch of economic research dealing with the specific issues of developing countries, there are few topics that are debated such heatedly as the relationship between development perspectives and openness to international trade. While in the context of the dissemination of the Heckscher-Ohlin framework in the late 1940s (Samuelson (1948), Rybczynski (1955), Lancaster (1957)) an optimistic view on openness emphasizing the productivity gains from fostering specialization began to prevail among mainstream trade economists, a considerable level of scepticism remained on the side of development economists (Edwards (1993)). This scepticism was primarily driven by doubts concerning the ability of least developed countries to reach sustainable growth in an environment of possibly fierce international competition with companies from the developed world. Most frequently, the 'infant industry' argument (dating back to as far as 1790 and most prominently picked up by Friedrich List (1841)) was cited in the context of justifying protectionist policies. According to its logic, companies operating in industries being in early development stages require protection from international competitors, as their initially low degree of competitiveness would otherwise prevent them from enjoying the scale economies essential for initiating any industry growth at all.

Other caveats consisted of worries that, by divesting local legal authorities of important revenue sources, premature opening might undermine important societal goals with regards to the formation of elementary institutions, e.g. of a well-functioning educational system, the provision of basic health care and the construction of a reliable transport infrastructure. As a consequence, most of these economists advocated the use of import substitution policies as explicit planning tools. In reality, these were typically comprising a variety of measures including import tariffs, quotas, export promotion policies and subsidies to private investment, all designed to meet the objective of speeding up industrialization (Prebisch (1959)).

This general degree of pessimism was subject to some change in the 1970s, as first empirical evidence in the form of detailed country studies questioning the usefulness of import substitution policies for promoting long-run growth in less developed economies was presented (Little et al. (1970), Balassa (1971), Krueger (1978)). In particular, criticism focused on the one-dimensionality of the target of a rapid industrialization. Results predominantly documented a severe decline of agricultural output as a response to this agenda. This was met by a massive underutilization of the existing capital stock in manufacturing, thereby taking the goal of investment promotion ad absurdum. At the same time, the alternative option of an export-oriented strategy gained empirical support by a number of studies (Balassa (1978), Tyler (1981)) suggesting a positive link between export volume and aggregate growth for many developing countries.

Since then, the considerably less policy-centered view started to spread that an economy could already in an infant stage benefit from partaking in a global system of labour division. Under the premise that the exposure to foreign competition causes a gradual shift in production towards manual labour intensive activities, an economy could without need for any governmental guidance become a competitive exporter on world markets. In a second step, by raising local purchasing power and investment capabilities, this could also contribute to a widening of the industrial basis, i.e. assisting progress in industrialization as well. This view was in part fueled by further econometric evidence provided

by authors like Kavoussi (1984), Edwards (1992) and, more recently, Wacziarg & Welch (2008), which were applying more sophisticated methods to analyze the relation between trade and growth.

However, when looking for a solid justification for implementing a laissez-faire trade policy, their results should be taken with some degree of caution. First, some of these studies make use of export volumes in measuring openness, which does not need to coincide with measures focusing on imports. Second, as stressed by Greenaway et al. (2002), there is a great deal of inconclusiveness concerning the composition of indicators of openness prevailing in the literature. Third, as in many strands of empirical research, the issue of causality and its direction is not finally clarified. Jung & Marshall (1985) were the first to raise doubts on the validity of the inferences made by this literature. In testing for Granger causality in a time series of trade and GDP volumes for a range of developing countries, they do reject the existence of a causal link from export volumes to aggregate growth for most of the countries under observation.

Fourth, considering the limitedness of the time horizon of such studies, they can not give a final answer to the question whether a detected positive contribution to growth is sustainable or not. On the contrary, with respect to the dynamic implications of specialization for the accumulation of growth-contributing factors, one could even argue that short-term productivity gains like these might reverse in the long-run.

This can be reasoned with regards to the importance of technological externalities for the perspective of catching-up, as emphasized by works in the field of endogenous growth (Romer (1986), Grossman & Helpman (1991)). Precisely, the presence of a sectoral bias in the ability to reap positive learning externalities from production could represent a source of divergence. In this regard, the distribution of comparative advantage between more and less advanced economies suggests that the growth perspectives of the least developed might fall victim to such a bias, given that their relative abundance of basic factors makes them ideal candidates for specializing in the production of standardized goods. In this way, as specialization curtails the development potential of those young industries which are the most dependent on (and at the same time most productive in using) a steady provision with new techniques, the economy as a whole might experience a slowdown in its productivity growth. Since this would further manifest the present structure of comparative advantage, a vicious cycle of underdevelopment might be the result. This hypothesis was first formally worked out by Redding (1999), who conceived the scenario of domestic production being permanently stuck in manufacturing low-tech goods.<sup>10</sup>

Since skill-dependent activities are thus effectively curtailed by the forces of trade, this is also likely to dispromote educational investments, as local firms have increasing need for a pool of flexible manual workers rather than for narrowly trained specialists.

With respect to our central issue of the last chapters, one might nevertheless come to think about one possible positive aspect related to trade: limiting the loss of professional manpower through emigration. Within the homogeneous goods environment of classic trade theory, trade in commodities and trade in factors can be shown to represent perfect substitutes. In the presence of adverse effects of trade on school participation, this would,

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<sup>10</sup>Of course, a view like this could be contested by considering the opportunities related to cross-border knowledge diffusion through trade. However, notwithstanding the substantial role of international R & D spillovers for the technological take-off of emerging market economies like China and India in general, there is a lack of convincing evidence for the relevance of the trade channel as opposed to other modes of interaction (like foreign direct investment), as researchers like Keller (1998) and MacGarvie (2005) pointed out.

from a societal point of view, raise hopes for a compensation of shrinking enrollment rates through a dampening of the outflow of professionals.

However, this suggestive notion of wage equalization relies critically on the homogeneity assumption for the types of goods traded. If international price gaps for goods of seemingly equivalent use are not a sign of unexploited opportunities for arbitrage, but are instead revealing inherent differences in product quality or specific features by customers, the convergence story starts to lose coherence. A sign for the real-world presence of within-industry product differentiation is generally seen in the steady growth of intra-industry trade over the last decades, a phenomenon most prominently investigated by Grubel & Lloyd (1975) for a range of industrial countries.<sup>11</sup>

This is where New Trade Theory took its starting point. As a result of the introduction of micro-level heterogeneity in terms of commodities sold (Lancaster (1980), Krugman (1981)), consumer tastes (Tabuchi & Thisse (2002)) and firm productivity (Melitz (2003)), the classical linkage between national wage rates is broken. Against this background, there remains no reason why salaries paid by distinct firms located in different countries should necessarily equalize in response to market integration, maintaining incentives to relocate. Quite the opposite, as demonstrated by Krugman (1991), adding labour mobility to this idea of a market structure can imply that a reduction of trade barriers is at least temporarily apt to stimulate the occurrence of self-reinforcing worker migration. This would, in a sense, even point to a complementarity of labour and commodity flows.

The empirical literature so far has not contributed much evidence apt to settle this dispute. Historically, Faini et al. (1999) pointed out that periods of rapidly increasing trade volumes like the late nineteenth century and the 1960s were usually also periods of strong expansion of international labour migration. Considering recent econometric approaches, Gonzalez & Maloney (2005) found in a study on the effects of NAFTA a significant negative impact of trade volumes on interregional labour flows in Mexico. In contrast, Kohli (1999) did detect strong signs for complementarity between import volumes and presence of nonresident workers for the case of Switzerland. What can be inferred from this is that the paradigm of wage convergence should at least in its strictest sense better be dropped when discussing the role of trade openness for the growth perspectives of a developing country.

Therefore, a model appropriate for judging the development perspectives of countries in an integrating world should both allow for intra- and inter-industry trade. In this spirit, we will extend our basic approach of modelling the dynamic linkages between schooling and emigration to the case of 2 consumption goods reflecting comparative advantage issues, while at the same time assuming these goods to be only imperfect substitutes with respect to the range of products offered by the rest of the world. In doing so, our task within this chapter is to answer major questions on the dynamic interlinkages between comparative advantage-based trade and the schooling-migration nexus. To keep a narrow focus on market-related transmission channels, we will abstract here from the empirically

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<sup>11</sup>With regard to developing countries, evidence is considerably scarcer. Those studies existing (Civan & Havrylyshyn (1985), Lee & Stone (1995)) detected substantially lower shares of intra-industry trade on total volumes both for trade between developing and developed countries and within the developing world. In line with this, Balassa & Bauwens (1987) discovered a positive and significant relationship between the Grubel & Lloyd index and the levels of income per capita of the trading countries. However, this also means for firms located in least developed economies that during the economies industrial development the strategy of differentiating their product lines should gain in importance: A convergence of international factor stocks would reduce the scope for trade merely based on factor cost differentials.

indisputable presence of capital market imperfections that had been object of intensive discussion in the chapter before. Instead, we are interested in how the stocks of human capital in both sending and destination country evolve in response to reducing migration barriers for skilled workers for a situation in which the distribution of comparative advantage is itself endogenously determined.

This distribution is then interpreted as the outcome of two conflicting forces. On the one hand, in line with approaches like Findlay & Kierzkowski (1982), cross-country differences in the rates of skill accumulation are considered to reveal underlying differences in the efficiency of educational institutions. Against this background, we will discuss the consequences of an upgrading of domestic learning efficiency, emphasizing the links between educational policy and trade policy. On the other hand, sectoral specialization is shown to be shaped by the extent of differentiation in the traded goods as well.

The further outline for this chapter is then the following: In subsection 4.2, we trace out previous attempts to discuss issues of labour migration and sectoral specialization within a common framework. Afterwards, it is stated how our approach fits into this literature and clarified in which respect it is able to add further insights to it. In 4.3., we present our model structure and derive analytical results for a small country facing a rest of the world that is opening its markets for trade in consumption goods and physical capital, but not yet for labour inflows. The focus is here on the interplay between educational efficiency, specialization patterns and the degree of product differentiation in international trade.

In section 4.4., we let graduates not only choose in which type of domestic sector, but also in which country to work in, i.e. we incorporate our theoretical concept of skill-dependent emigration into the given multisector setup. In particular, we demonstrate how a cautious liberalization of the access to foreign markets for skilled labour is likely to shape schooling participation and sectoral production levels in the sending country, again at first by taking the perspective of a small developing country. Additionally, we examine if the existence of opportunities for skilled workers to earn their living abroad has a significant impact on our results for the success of shifts in educational policy. In 4.5, the case of a 2-country world is introduced, allowing us for the first time to analyze repercussions of human capital flows on the structure of labour supply in both sending and destination country as well as to gain some insight into the effects of these flows on the distribution of comparative advantage. Some attention is subsequently paid to the question of convergence of actual average labour income as opposed to convergence of wage rates in the presence of a heterogeneous workforce.

The conclusion in 4.6 finally seeks to summarize the results obtained and discusses possible implications for our general understanding of development opportunities for open economies.

## **4.2 The literature on migration and comparative advantage**

For a long time, the literature on comparative advantage-based trade relied on sectoral reallocations of factors within countries as a primary approach to explain trade patterns. At the same time, the role of cross-country factor flows in explaining sectoral specialization was largely neglected. This was partly due to the fact that the stylized 2-factor/2-commodities structure of the Heckscher-Ohlin workhorse model and its homogeneity assumption concerning the goods produced in different countries establishes a clear correspondence between goods and factor prices. This implies that any trade-driven



price equalization does in the absence of technology gaps simultaneously result in the elimination of migration incentives through wage equalization. The exact conditions for this to occur were first formally stated by Samuelson (1948) in his renowned factor price equalization theorem.

Starting from this idea, Mundell (1957) pointed out that the real-world coexistence of trade in commodities and trade in factors can only be reconciled with this framework by allowing for the presence of trade barriers. In this regard, trade impediments increase in the absence of technology barriers the incentives of workers in labour-abundant economies to emigrate to ones where labour is relatively scarce. On the other hand, he made clear that setting up barriers to labour mobility is eligible to promote trade, as it manifests existing endowment differences. This implies a strong mutual substitutability between commodity trade and migration.

However, Markusen (1983) demonstrated that the coherence of Mundell's argumentation is heavily reliant on the critical properties of the Heckscher-Ohlin setup. By introducing technological differences in a way that one country is generally more productive in producing one of the two tradable goods, he showed that allowing for factor mobility does for each country always induce an inflow of the factor that is used relatively intensively in the production of the export good. In this way, trade in goods and trade in factors are no longer mutually exclusive. Quite the opposite, migration here even contributes to a widening of the cross-country gap in factor supply. Hence, tearing down borders to labour mobility does even foster trade in consumption goods, as it fosters comparative advantage.

Nevertheless, Markusen's result does also not possess the character of a universal theorem in the sense that it is specific to the assumed form of technological bias, as Wong (1986) in a more general analysis of distinct productivity patterns revealed. In addition, Schiff (2006) demonstrated that while Mundell's substitutability result holds for all initial tariff rates, the validity of Markusen's complementarity result is limited to low initial tariffs.

Other approaches circumvented the law of factor price equalization by adjusting the number of production factors in relation to the number of traded goods. Rivera-Batiz (1982) simply redefined one of the two commodities to be nontradable. Lopez & Schiff (1998) set up a three-factor model by differentiating between skilled and unskilled labour as complementary factors to physical capital, where they additionally assumed unskilled workers to face financial constraints in the context of migrating. As a consequence, gradual trade liberalization promotes migration of unskilled workers despite a rise of unskilled wages in the sending country, as these higher wages contribute to a relaxation of the financial constraint. As simultaneously migration of the unconstrained skilled workers is weakened through wage equalization, they identify a substitutability relationship between trade and migration of skilled workers.

Waltz (1998) introduced an additional input in the form of an intermediate good produced in an R&D-sector for the scenario of a trading bloc consisting of two countries and a technologically disadvantaged third country. Here, the effect of trade liberalization on intensity as well as direction of labour movement is strongly dependent on the distribution of skill intensity in production between the countries. Only if production in the lagging country is initially more skill-intensive, migration flows of skilled workers will take place from this country into the integration area, which, by raising the productivity of the R&D-sector, enhances productivity of manufacturing within the integration area

and thereby promotes trade.

What can be learned from such mixed results is that attempts to modify the basic H-O structure by adjusting it to settings of very specific form are unable to yield general statements on the relation between trade and migration. Aside from this, another reason why these frameworks might produce a misleading picture is the fact that they do not consider the dynamic implications of trade and migration on factor accumulation.

If, instead, one again consults the recent strand of development literature that is focusing on the repercussions of emigration incentives on skill formation (Vidal (1998), Stark (2004)), this gives no direct hint at a possible complementarity. In these models, an initial “brain drain” has the potential to increase the aggregate endowment of skilled labour in a skill-scarce sending country. The possibility that an exodus of professionals induces a long-run increase in that country's stock of human capital would undermine its comparative advantage in the production of goods with low skill content. This, in turn, could be predicted to reduce intersectoral trade. On the other hand, intensified trade coupled with increasing specialization in manual labour-intensive goods would in these models also exert a mitigating impact on the absolute outflow of skilled labour, as educational incentives are on the decline. In this way, the basic result of a mutual substitutability of commodity and factor flows would be restored, provided that the costs of migrating for low-skilled workers can indeed be considered prohibitive.

However, the argumentation is closely tied to the assumption that emigrating professionals do not differ from non-emigrating ones in any productivity-related aspect, but simply represent a random selection of the domestic skilled workforce. If this is not fulfilled and, as the findings of the empirical literature on migrant selection seem to suggest (Chiquiar & Hanson (2005), McKenzie & Rapoport (2010)), emigrants are on average more productive than their domestic counterparts, this could imply that an increase in school enrollment is not able to make up for the loss of the most productive workers. Nevertheless, the nature of the interplay remains unclear in so far as according to this logic a larger export sector would still imply a lower emigration pressure on the side of skilled workers: The higher demand for unskilled labour would bring about a decline in educational participation that decreases competitive intensity on domestic labour markets from the perspective of the most productive professionals.

Hence, as soon as worker heterogeneity is fully accounted for, predictions are no longer a matter of straight forward intuition, but require explicit modelling to determine which of the contrary forces dominates. Unfortunately, the theoretical brain drain literature has yet no approach to offer that extends the core mechanism to the dimension of several sectors.

In this regard, a third strand of modelling starting with the seminal contribution made by Findlay & Kierzkowski (1982) does provide a synthesis of trade-induced production patterns with questions of skill accumulation in an Overlapping Generations framework: Individuals in the first stage of life decide on acquiring education, while in the second stage graduates choose the sector to work in. The main proposition derived from this is a dynamic equivalence of the famous Rybczynski theorem in stating that the country with the more efficient educational system will specialize in skill-intensive products. Several extensions added features like talent heterogeneity (Borsook (1986)), physical capital (Wooton (1991)) as well as technological progress (Eicher (1999)) to this setup, endogenous migration choices, however, have not been implemented yet. This is obviously due to the strong affiliation of these models to basic Heckscher-Ohlin theory. This implies

them to face the same difficulties in coping with the presence of international factor flows as static trade models do.

The few attempts to integrate migration into a multisector model with human capital investments that have been made choose rather simplistic strategies to avoid the consequences of the factor price equalization theorem. Chau & Stark (1999) did allow for wage flexibility in analyzing the cases of one small and two large economies in a two-sector setup, but assumed these two sectors to produce an identical good, albeit under the regime of distinct technologies: One under sole use of skilled, the other under sole use of unskilled labour. In this way, the skill premium is guaranteed to respond endogenously to both changes in the patterns of migration and school enrollment. Nevertheless, as a consequence of fixed terms of trade, it does not respond to changes in the structure of consumer demand. In this respect, the model merely features a one-way causality leading from migration incentives to trade patterns and does not yield information on how different extents of sectoral specialization translate into different rates of skill accumulation.

Kar & Beladi (2004) chose a different path by proposing a model with three factors and two (distinct) tradable goods, but abstract from any microfoundation with respect to skill accumulation. While they are allowing for repercussions of sectoral shocks on schooling, skill formation is here not treated as the outcome of dynamic optimization by heterogeneous individuals. Instead it is simply the result of a static allocation of factors between the educational sector and final goods production according to fixed world market prices. Beladi et.al. (2011) introduced a further differentiation of skill types into this framework, but did not change the basic structure.

Hence, a gap still awaiting to be filled is the development of a multisector framework that integrates a mechanism reflecting the mutual dependancies between skill acquisition and migration decisions in a way consistent with individual optimization. In the following, we will construct such a setup by implementing an extension to the Heckscher-Ohlin environment different from those proposed before.

Instead of adding complexity to the model structure by increasing the number of sectors or factors, we introduce within-sector differentiation at the international level by postulating consumers to discriminate between products according to their place of origin. Hence, we treat same-sector goods produced in different countries as only imperfect substitutes, a modelling idea dating back to Armington (1969).

Besides serving as a tool to ensure the persistence of wage gaps between countries, this also allows us to reflect the empirical observation of a positive correlation between the share of intra-industry trade and the stage of development (Civan & Havrylyshyn (1985), Rossini & Burattoni (1996)), and its consequences for migration patterns. In this regard, after an initial opening of goods and factor markets, an increase in the extent of product differentiation could be considered here to represent a third stage in the process of integrating a backward country into the world economy. We will demonstrate that, by affecting the international wage differential through changes in consumer price sensitivity, the size of migration flows hinges upon the degree of product differentiation. At the same time, through its impact on school enrollment, a reduction in the substitutability of country-specific varieties exerts an additional distortionary effect on the sectoral structure. This, in turn, affects migration incentives in an indirect manner.

Moreover, by allowing countries to differ in terms of learning efficiency, we further analyze the aggregate effects of shocks to the efficiency of skill generation as the dynamic equivalence of endowment changes. This will enable us to compare the effects of inter-

with those of intrasectoral trade-driven shocks on migration incentives and production patterns.

In what follows, we will seek to disentangle the multitude of channels present by first presenting the model structure and providing long-run solutions for a small economy scenario with skilled labour confined to be internationally immobile. Then, the feature of selective migration of skilled workers is introduced.

## 4.3 Endogenous education choices and intrasectoral trade

### 4.3.1 The augmented framework

We start with examining the case of a 2-sector / 2-types-of-labour model taking the perspective of one small open economy. Both sectors  $j = A, B$  are made up of atomistic firms, producing a consumption good that is homogeneous within the domestic sector, with  $Q^j$  denoting total sectoral output. No sorts of barriers to market entry are existent. Production is undertaken with the help of physical capital  $K^j$ , skilled labour  $H^j$  and unskilled labour  $L^j$  aggregated under a nested constant returns to scale technology. On the upper level, capital is combined with a labour aggregate  $M^j$ . We specify the technology combining these factors to be Cobb-Douglas and to be identical across sectors, in order to ensure that the sectoral distribution of the two types of labour is unaffected by fluctuations in the amount of capital compensation. On the lower level, the labour aggregate is decomposed into the two skill types according to a not further restricted sector-specific constant returns to scale technology:

$$Q_t^j = M_t^{j\alpha} K_t^{j1-\alpha} \quad (4.1)$$

$$M_t^j = f(H_t^j, L_t^j) \quad (4.2)$$

$$\lim_{H_t^j \rightarrow 0} \frac{\partial M_t^j}{\partial H_t^j} = +\infty \quad \lim_{L_t^j \rightarrow 0} \frac{\partial M_t^j}{\partial L_t^j} = +\infty. \quad (4.3)$$

where  $\alpha$  represents the output elasticity of the labour aggregate. While labour supply is bounded by domestic accumulation, the capital good is from the perspective of domestic firms accessible in infinite amounts at a given rental rate  $r$  on the world capital market. To restrict the focus on the factor allocation among the two consumption goods, production of this capital good is assumed to exclusively take place in the rest of the world in this first specification. In contrast, the price of both skill types of labour is set on the domestic labour market. Additionally, each worker independent of her educational background is supposed to be freely mobile across sectors. This ensures that firms in both sectors face the same wage rates in equilibrium.

Domestic firms sell their output to customers on the world market, a process in which no trade costs are assumed to accrue. This world market consists of consumers from an infinite number of small countries, whose mass is denoted by  $n$ . The single domestic firm can be regarded as a price taker. Hence, the decision about the profit maximizing input combination can be thought of as to consist of two steps: First, determining the (sector-specific) employment mix of skill types that minimizes the costs necessary to generate the equivalence of one unit of the labour aggregate. Second, choosing the profit-maximizing input amounts of this labour aggregate as well as of physical capital such that each factor's marginal product is equated to its real price. Solving the sectoral marginal products of

physical capital for  $K_t^j$  and expressing them as ratios, one obtains:

$$\frac{K_t^A}{K_t^B} = \left( \frac{p_t^A}{p_t^B} \right)^{\frac{1}{\alpha}} \frac{M_t^A}{M_t^B} \quad (4.4)$$

$$\frac{Q_t^A}{Q_t^B} = \left( \frac{p_t^A}{p_t^B} \right)^{\frac{1-\alpha}{\alpha}} \frac{M_t^A}{M_t^B}. \quad (4.5)$$

To derive explicit statements on the sectoral distribution of workers, we rewrite sectoral labour demand in terms of shares on total demand:

$$L_t^A = s_t^l L_t \quad H_t^A = s_t^h H_t. \quad (4.6)$$

where  $s_t^l$  and  $s_t^h$  denote the shares of unskilled and skilled labour employed in sector A, respectively. At the same time, this implicitly introduces the condition of labour market clearance at each point in time into our model. The ratio of the sectoral labour composites can then be expressed as a function of these shares and the ratio of aggregate skilled-to-unskilled labour supply in the economy:

$$M_t^A = f \left( s_t^h H_t, s_t^l L_t \right) = f \left( s_t^h \frac{H_t}{L_t}, s_t^l \right) \quad (4.7)$$

$$M_t^B = f \left( (1 - s_t^h) H_t, (1 - s_t^l) L_t \right) = f \left( (1 - s_t^h) \frac{H_t}{L_t}, (1 - s_t^l) \right) \quad (4.8)$$

$$\frac{M_t^A}{M_t^B} = f \left( s_t^h, s_t^l, \frac{H_t}{L_t} \right). \quad (4.9)$$

Plugging this into (4.5) then allows us to write the output ratio as a function of the aggregate employment mix and its relative distribution across sectors.

Given that unit demand for skill types is a function of relative wages, the sectoral labour shares themselves are functions of the supply ratios of skilled and unskilled labour:

$$s_t^h = f \left( \frac{w_t^h}{w_t^l}, \frac{M_t^A}{M_t^B} \right) = f \left( \frac{w_t^h}{w_t^l}, \frac{H_t}{L_t} \right) \quad (4.10)$$

$$s_t^l = f \left( \frac{w_t^h}{w_t^l}, \frac{M_t^A}{M_t^B} \right) = f \left( \frac{w_t^h}{w_t^l}, \frac{H_t}{L_t} \right). \quad (4.11)$$

The production side is closed by determining the relationship between output and factor prices. This is done by postulating free market entry in both sectors, thereby guaranteeing output prices not to exceed the levels of unit costs in any instantaneous equilibrium:

$$p_t^j = W_t^{j\alpha} r^{1-\alpha} \quad (4.12)$$

$$W_t^j = \tilde{H}_t^j \left( \frac{w_t^h}{w_t^l} \right) w_t^h + \tilde{L}_t^j \left( \frac{w_t^h}{w_t^l} \right) w_t^l \quad (4.13)$$

$$\frac{\tilde{H}_t^A}{\tilde{L}_t^A} > \frac{\tilde{H}_t^B}{\tilde{L}_t^B}. \quad (4.14)$$

where  $W_t^j$  stands for the (sector-specific) price of (i.e. the minimal expenditures required to generate) one unit of the labour composite and  $H_t^j$  and  $L_t^j$  for the respective unit employment of the two skill types. Then, condition (4.14) states that production in sector  $A$  is restricted to be relatively more skill-intensive for all combinations of factor prices, i.e. we explicitly exclude the possibility of skill intensity reversals. In this way, a positive one-to-one correspondence between the relative price of the  $A$ -sector good and the skilled-to-unskilled wage ratio is established.

$$\frac{p_t^A}{p_t^B} = \left( \frac{W_t^A}{W_t^B} \right)^\alpha = f \left( \frac{w_t^h}{w_t^l} \right) \quad (4.15)$$

The intuition for this is that an increase in the rewards to skill formation does increase units costs of  $A$ -sector firms to a larger extent than unit costs of  $B$ -sector firms, as  $A$ -sector firms constantly exhibit a higher employment share of qualified labour.

Plugging (4.9) into (4.5) yields relative output levels as a function of the following form:

$$(Q^A/Q^B) = f^1 \left( \underset{+}{s^h}, \underset{+}{s^l}, \underset{+}{(p^A/p^B)}, \underset{+}{(H/L)} \right). \quad (4.16)$$

Accounting for differences in skill intensities alone represents only one part of the mechanism through which workers heterogeneous in terms of acquired productive knowledge are allocated between sectors. Analyzing how differences in the idiosyncratic features of the commodities produced impinge on the price sensitivity of demand makes up another. In case of close substitutability, demand and hence equilibrium output can be predicted to respond strongly to changes in relative prices induced by shocks to the average skill level of workers in the economy. As a consequence, situations are conceivable in which the large bulk of professionals is concentrated in the less-skill intensive sector. Therefore, closing the system requires in contrast to the previous one-sector models an explicit specification of consumer preferences.

We do not take account of country-specific peculiarities in terms of tastes and needs. Preferences are assumed to be homothetic. Since international trade is associated with no costs, total demand by members of a certain generation can be modelled as the outcome of the decision-making process of just one representative agent. In accordance with the one-sector approach, this agent is chosen to have a lifespan of three periods. The modelling of her preferences is similar to the one-sector model as well, differing just in terms of the introduction of a nesting structure concerning sector and country of origin of the commodities available:

$$U_t = \sum_{b=0}^2 \beta^b \frac{C_{t+b}^{1-\eta} - 1}{1-\eta} \quad (4.17)$$

$$C_t = C_t^{A\mu} C_t^{B^{1-\mu}} \quad (4.18)$$

$$C_t^j = \left( \int c_t^j(i)^{\frac{\sigma^j-1}{\sigma^j}} di \right)^{\frac{\sigma^j}{\sigma^j-1}}. \quad (4.19)$$

Aggregate consumption  $C_t$  in each period is decomposed into sectoral consumption levels  $C_t^A$  and  $C_t^B$ , with elasticity  $\mu$  indicating to what extent  $A$ -goods are preferred over

*B*-goods. Sectoral consumption is itself an artificial CES composite of commodities produced in the same sector by firms located in distinct economies, with  $c_{i,t}^j$  denoting total demand for goods from sector  $j$  produced in country  $i$ . The number of these countries is supposed to be infinite and their total mass given with  $n$ . In this respect, we make use of the Armington assumption (Armington (1969)), which, in short, postulates that products meeting similar needs are nevertheless distinguishable by certain characteristics specific to their country of origin. This turns them into less than perfect substitutes from the perspective of customers. The degree of this substitutability manifests itself in the corresponding elasticity of substitution  $\sigma^j$ . It is this potentially imperfect substitutability that constitutes a departure from the common model environment of the literature on trade and skill formation.

As exclusive investment opportunity, we consider a real investment taking the form of the acquisition of the internationally tradable capital good  $K$ . One unit of  $K$  bought in period  $t$  is rented out to firms at the beginning of  $t + 1$  for which investors receive a rent  $r$  at the end of the period.

In the following, we are not exclusively concerned with the effects of changes to the degree of effort associated with going abroad. Instead, we are likewise interested how local differences in the infrastructure of human capital creation between countries impact on both trade and migration patterns. For this purpose, the educational technology needs to be specified such that educational achievement not solely represents a function of individual attributes. In this regard, we can draw upon our basic setup and reflect country-based heterogeneity in learning efficiency by just one dimensionless parameter called  $\phi$ . Again, this is assumed to shape learning success in such a way that the amount of efficiency units of human capital received by an agent of talent level  $a$  through schooling is equal to  $(1 + a\phi)$ .

Adopting the previous distributional assumption of a standardized uniform distribution  $U[0, 1]$  of innate ability levels,  $\phi$  measures by how much the potential wage received by the most talented agents when choosing to become a skilled worker exceeds the potential wage of the least talented in percentage terms. A generally higher level of efficiency of the educational sector is in this regard presumed to result into a divergence in terms of learning efficiency. To some degree, this reflects the fact that more talented workers are due to their higher cognitive abilities more apt to profit from improvements in the learning environment.

Given the absence of capital market imperfections, the minimal level of talent above which schooling yields positive returns can again be determined by a simple comparison of the present value of lifetime incomes with and without participation in the educational program. Participation in the schooling program of length  $\epsilon$  is from the perspective of a young person with ability  $a$  now worthwhile if the following holds:

$$w_t^l + \frac{E_t w_{t+1}^l}{(1+r)} \leq (1-\epsilon)w_t^l + \frac{(1+a\phi)E_t w_{t+1}^h}{(1+r^n)}. \quad (4.20)$$

The critical value at which the condition is fulfilled with equality is then:

$$a_t^e = z \left( \frac{E_t w_{t+1}^l + (1+r)(\epsilon w_t^l)}{E_t w_{t+1}^h \phi} - \frac{1}{\phi} \right). \quad (4.21)$$

Trivially, a higher efficiency of the educational system leads for given wage rates to an unambiguous rise in school participation (lower  $a_t^e$ ), as everyone is now able to extract

a more efficient bundle of skills from schooling, while bearing the same time effort (and thus the same amount of opportunity costs). A general equilibrium analysis does however need to include feedback effects on wage rates. To this end, we continue with defining the aggregate supply of skilled and unskilled labour:

$$H_t = \int_{a_{t-1}^e}^1 (1 + a\phi) da = (1 - a_{t-1}^e) + 0.5\phi (1 - a_{t-1}^e)^2 \quad (4.22)$$

$$L_t = \left( \int_0^1 l_t^y da + \int_0^1 l_t^m da \right) = (a_t^e + (1 - \epsilon) \cdot (1 - a_t^e) + a_{t-1}^e). \quad (4.23)$$

To achieve a harmonization with the formal expressions in this section so far, we also write the determinants of labour supply in terms of ratios:

$$\frac{H_t}{L_t} = \frac{(1 - a_{t-1}^e) + 0.5\phi(1 - a_{t-1}^e)^2}{(a_t^e + (1 - \epsilon) \cdot (1 - a_t^e) + a_{t-1}^e)}. \quad (4.24)$$

The ratio of skilled-to-unskilled labour supply in the economy is inversely related to the minimal talent level  $a^e$ , and not only to its current one, but also to its first lag reflecting schooling choices of the generation born one period before. In this way, this multisector approach gains a dynamic dimension.

Before turning to an analysis of endogenous location choices, we will make a start with determining the general equilibrium effects of unanticipated shocks to this aggregate supply when the adjustments can be attributed to changing rates of skill accumulation alone. Workers in general are thus for the time being assumed to be geographically immobile. This means that the relative level of accumulated skilled labour as expressed by (4.24) always coincides with the actual relative supply on domestic markets, a fact that closes the model. As a next step, we are seeking to explain the impact of sudden variations to the efficiency of schooling on the model's endogenous variables in the long-run.

### 4.3.2 The long-run interplay of trade and education

The derivation of a closed-form solution is here out of reach, due to the non-integer powers with which aggregate stocks are weighed in the sectoral production functions. Instead, we devote our attention to the response of long-run equilibrium levels with respect to marginal changes in  $\phi$ . In the absence of general technological progress or externalities related to the stock value or production level of human capital, unbounded growth of sectoral output is impossible to achieve. This allows us to drop time subscripts. In this way, the stationarized versions of (4.10), (4.11), (4.15), (4.16), (4.21) and (4.24) establish a system of 6 equations in 6 unknowns. This can, in turn, be easily simplified if we make use of the one-to-one relationship between price ratios and relative wage levels implied by the zero profit condition (4.14) and eliminate wage levels from the system by replacing them with output prices. The remaining long-run functional expressions can hence be



characterized in qualitative terms as:

$$\begin{aligned}
(Q^A/Q^B) &= f^1(s^h, s^l, (p^A/p^B), (H/L)) \\
s^h &= f^2((p^A/p^B), (H/L)) \\
s^l &= f^3((p^A/p^B), (H/L)) \\
(H/L) &= f^4(a^e, \phi) \\
a^e &= f^5(\phi, (p^A/p^B)).
\end{aligned}$$

By taking the total differential with respect to  $\phi$ , we can proceed with an analysis how marginal improvements in the local infrastructure of human capital generation translate into changes of the skill structure of the domestic workforce. For the limiting case of no adjustments to output prices at all, it is an easy task to reproduce the result of a dynamic equivalence to the static Rybczynski theorem derived by Findlay & Kierzkowski (1982). In this vein, a long-run increase in relative production of the more skill-dependent  $A$ -sector firms can be observed:

$$\frac{d\left(\frac{Q^A}{Q^B}\right)}{d\phi} = (f_{s^h}^1 f_{H/L}^2 + f_{s^l}^1 f_{H/L}^3 + f_{H/L}^1) \cdot (f_{a^e}^4 f_{\phi}^5 + f_{\phi}^4) > 0. \quad (4.25)$$

A rise in the productivity of skill accumulation through formal education increases the aggregate stock of skilled labour and triggers a shift in production towards the skill-intensive  $A$ -sector. The increase in effective supply of human capital is therefore met by an upward shift of the skilled labour demand curve, which is in this fixed price scenario not mitigated by any supply-induced fall in the relative price of the skill-intensive good.

Returning to our more general specification of consumer' preferences, however, one has to acknowledge the inability of the scenario  $\sigma^i \rightarrow \infty$  to account for real world fluctuations in a countries terms of trade. As soon as goods produced by firms located in different countries are only slightly distinguishable in the eyes of customers, production levels of domestic suppliers as a whole do exert a measurable impact on the price at which the given variety of the differentiated good is traded on world markets. An economy can then still considered to be small provided that domestic demand makes no significant contribution to aggregate worldwide demand. This does exclude the possibility of spillovers of domestic labour supply adjustments on equilibrium production through the demand channel. Worldwide demand for a certain variety, however, does require an explicit specification within our model if world supply and world prices are no longer exogenous from the perspective of domestic producers.

To implement this demand-side sensitivity of equilibrium production to changes in relative prices, the problem of utility maximization of the representative consumer as set out in (4.17)-(4.19) needs to be solved. Similar to a firm's decision problem, the nesting structure entails a multilevel optimization process: On the highest level, the consumer maximizes her intertemporal well-being by allocating consumption of the aggregate good between her three periods of life. The composition of this consumption aggregate is determined by choosing the combination of sector-specific composites that minimizes the

expenditures necessary to generate one unit of the aggregate. On the lowest level, the consumer decides to which extent each sector-specific bundle of consumption goods is made up of varieties produced in certain countries, again by minimizing expenditures for each bundle.

The homotheticity of preferences implicates here that the question of the composition of consumption bundles and hence the ratios between demand for any two distinct varieties is unrelated to the savings decisions. We can therefore directly draw on the expenditure minimization problem to determine the demand-side impact on domestic factor allocation across sectors. Due to the symmetry of preferences, minimizing  $\int p_t^j(i) c_t^j(i) di$  subject to  $C_t^j = 1$  delivers an easy-to-handle unit demand  $\tilde{c}_t^j(i)$  for the variety produced by firms in sector  $j$  in country  $i$  at time  $t$ :

$$\tilde{c}_t^j(i) = \left( \frac{p_t^j(i)}{P_t^j} \right)^{-\sigma^j}. \quad (4.26)$$

with  $P_t^j = \int p_t^j(i) \tilde{c}_t^j(i) di$  denoting the price of one unit of the optimally composed basket including all goods produced worldwide in a certain sector. To determine the total amounts consumed of each variety  $c_t^j(i) = \tilde{c}_t^j(i) C_t^j$ , we are first asked to work out how aggregate consumption is optimally split across sectors. Based on our homotheticity assumption, the number of units of each sectoral bundle consumed at time  $t$  is then determined as a function of the ratio of sectoral price indices times aggregate consumption  $C_t$ :

$$C_t^A = \left( \frac{\mu}{1-\mu} \frac{P_t^B}{P_t^A} \right)^{1-\mu} \cdot C_t \quad (4.27)$$

$$C_t^B = \left( \frac{1-\mu}{\mu} \frac{P_t^A}{P_t^B} \right)^\mu \cdot C_t. \quad (4.28)$$

Goods markets are assumed to clear at any point in time. From the perspective of the small open economy, the demand ratio between the two varieties produced domestically (which coincides with the output ratio in market equilibrium) is given by:

$$\frac{c_t^A}{c_t^B} = \frac{Q_t^A}{Q_t^B} = \frac{\left( \frac{p_t^A}{P_t^A} \right)^{-\sigma^j} \cdot C_t^A}{\left( \frac{p_t^B}{P_t^B} \right)^{-\sigma^j} \cdot C_t^B} = \left( \frac{p_t^A}{p_t^B} \right)^{-\sigma^j} \left( \frac{\mu}{1-\mu} \right) \left( \frac{\bar{P}_t^B}{\bar{P}_t^A} \right)^{1-\sigma^j}. \quad (4.29)$$

The bar signs indicate that the sectoral price indices can be viewed as constant in the sense that they are virtually unaffected by domestic price setting. This is due to the fact that the domestic variety in each sector only makes an infinitely small contribution to aggregate worldwide output. In this manner, a finite elasticity of substitution provides an additional (and negative) direct correspondence between the relative price of domestic products and relative output in the given sectors, denoted in terms of its long-run impact

here as:

$$\frac{Q^A}{Q^B} = f^6 \left( \frac{p^A}{p^B} \right). \quad (4.30)$$

Adding this to our system of equations and thereby endogenizing prices, the long-run impact of a marginal increase in educational effectiveness on the sectoral pattern of production becomes:

$$\frac{d\left(\frac{Q^A}{Q^B}\right)}{d\phi} = \frac{(f_{s^h}^1 f_{H/L}^2 + f_{s^l}^1 f_{H/L}^3 + f_{H/L}^1) \cdot (f_{a^e}^4 f_{\phi}^5 + f_{\phi}^4)}{1 - \frac{f_{p^A/p^B}^1 + f_{s^h}^1 f_{p^A/p^B}^2 + f_{s^l}^1 f_{p^A/p^B}^3 + (f_{s^h}^1 f_{H/L}^2 + f_{s^l}^1 f_{H/L}^3) f_{a^e}^4 f_{p^A/p^B}^5}{f_{p^A/p^B}^6}} > 0. \quad (4.31)$$

Hence, one of the central statements embedded in the dynamic version of the Rybczynski theorem is transferable to the more general case of a world consisting of countries engaging in intrasectoral specialization: An isolated increase in schooling efficiency in one country induces its skill-intensive sector to expand relative to low-skill production in the long-run.

This is as such already a previously unstated result in this context. However, our main concern with regards to the evolution of aggregate skill intensity should undoubtedly be the shocks' impact on the market premium paid for acquiring skills, as this allows us to infer the response of the rates of enrollment into higher education.

Given that any long-run expansion of  $A$ -sector production is, through its effect on world market equilibrium, inevitably linked to a fall of the relative price of the  $A$ -sector variety, this skill premium is according to (4.15) required to fall as well in order to let  $A$ -firms break even. As a consequence, the long-term effect on participation rates in schooling is indetermined. On the one hand, the opportunity for students in general to generate even more productive capacity from their natural endowments through schooling contributes to a rise in participation rates. On the other hand, as competition among graduates becomes fiercer, the same contribution to a companies pool of deployable skills is now valued less by the market. This could just as well cause a crowding-out of the less talented workers from the skilled workforce. However, even without further knowledge about changes in the division of the workforce into skill groups, the sign of the long-term evolution of the aggregate stock of skilled relative to unskilled labour can be determined. In fact, it has to be positive. To see this, we express marginal changes in the output ratio as functions of the ratios of changes in prices and factor stocks by making use of the relationships given by (4.10), (4.11) and (4.15):

$$d\left(\frac{Q^A}{Q^B}\right) = \underbrace{(f_{s^h}^1 f_{p^A/p^B}^2 + f_{s^l}^1 f_{p^A/p^B}^3 + f_{p^A/p^B}^1)}_{>0} d\left(\frac{w^h}{w^l}\right) + \underbrace{(f_{s^h}^1 f_{H/L}^2 + f_{s^l}^1 f_{H/L}^3 + f_{H/L}^1)}_{>0} d\left(\frac{H}{L}\right).$$

According to this, a long-run fall of the equilibrium skilled-to-unskilled wage ratio can only be accompanied by a shift towards more skill-intensive production, if aggregate skill intensity is rising as well. The marginal effect of enhanced schooling productivity can

thereby deduced to be positive:

$$d\left(\frac{Q^A}{Q^B}\right) / d\phi > 0 \cap d\left(\frac{w^h}{w^l}\right) / d\phi < 0 \Rightarrow d\left(\frac{H}{L}\right) / d\phi > 0.$$

The economic reasoning behind this can be outlined as follows: For given wage rates, improved educational efficiency raises the aggregate level of skill of professionals working in the economy. Firms in the more skill-intensive sector can reap the highest productivity gains from this fact, thereby inducing an excess supply of  $A$ -sector goods. With demand for domestic varieties being less than infinitely elastic, this brings about a decline in the relative price of the skill-intensive good. This, in turn, translates via the zero-profit-condition into a lower skill premium. To put it differently, the fact that demand curves on the world market are insensitive to domestic factor prices implies that a domestic reduction in the relative price of skilled labour requires a higher skill intensity to generate an increase in skill-intensive production. Figure 4.1 illustrates this long-run relationship.

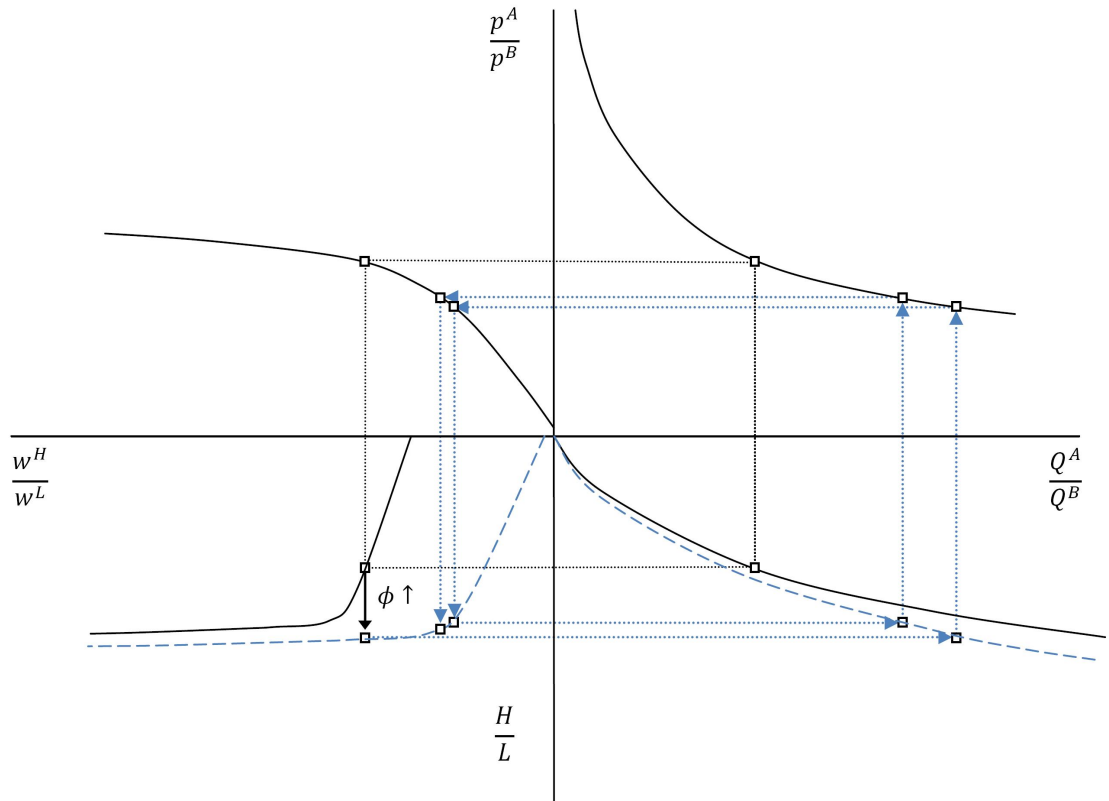


Figure 4.1: Long-run effect of shock to learning efficiency

To sum up, a rise of educational efficiency does with or without national product differentiation result in a shift of national production towards sectors which make more intense use of human capital. The foundations for this development are laid by an economy-wide gain in effective high-skilled labour. This gain is, however, at least for the case of differentiated products not necessarily attributable to higher rates of schooling participation.

What remains to be of interest is the role of the intensity of product differentiation (as expressed by the elasticity parameter  $\sigma^j$ ) in shaping the industrial structure of a small open economy through endogenous skill accumulation. This issue will gain additional relevance in the next section, when the existence of sufficiently large international wage differentials will be essential for the discussion of endogenous migration incentives.

We first examine the partial derivative of the long-run ratio of worldwide demand between the two domestic varieties with respect to  $\sigma^j$ . In doing this, we have to take account of the fact that changes to this elasticity could in this framework have implications for equilibrium prices in the rest of the world (ROW) and thus the sectoral price indices as well. We are thus forced to make more in-depth statements about the nature of what we call 'the rest of the world' than that it consists of an infinite set of countries with consumers exhibiting identical preference structures.

To obtain a unique point of reference, we complement our assumptions by specifying that all remaining countries share the same technologies in the production of consumption goods belonging to a certain sector. For the given symmetric preferences, this implies that each one of these ROW countries also exhibits the same equilibrium price ratio between its country-specific varieties, which is, in turn, equal to the ratio of aggregate price indices. Under these circumstances, ROW prices are insensitive to any shift of the elasticity of substitution, as customers anyway prefer to consume equal amounts of all ROW varieties as a consequence of uniform prices. In this way, the partial derivative for the case of our small economy takes the following form:

$$\partial \left( \frac{Q^A}{Q^B} \right) / \partial \sigma^j = - \left( \frac{p^A}{p^B} \right)^{-\sigma^j} \left( \frac{\bar{P}^B}{\bar{P}^A} \right)^{1-\sigma^j} \ln \left( \frac{p^A}{p^B} \cdot \frac{p^{B;ROW}}{p^{A;ROW}} \right) \frac{\mu}{1-\mu}.$$

The sign of this derivative is determined by the fact whether the price ratio of national varieties is larger or smaller than the given ratio of sectoral price indices, which, in turn, represent a weighted average of the prices of all varieties produced by the rest of the world. Making use of the one-to-one correspondence between equilibrium prices and production levels, we can therefore state:

$$\partial \left( \frac{Q^A}{Q^B} \right) / \partial \sigma^j \leq 0 \text{ iff } \frac{Q^A}{Q^B} \leq \frac{Q^{A;ROW}}{Q^{B;ROW}}.$$

The partial effect of a change in the extent of intrasectoral specialization is thus crucially dependent on the initial degree of intersectoral specialization of our small open economy compared to the rest of the world. To account for the response of factor prices as well, we again refer to the total differential of our system, this time with respect to changes in the elasticity of substitution:

$$\begin{aligned} d \left( \frac{Q^A}{Q^B} \right) / d\sigma^j = & - \frac{f_{\sigma^j}^6}{f_{p^A/p^B}^6} \left[ f_{s^h}^1 (f_{H/L}^2 f_{a^e}^4 f_{p^A/p^B}^5 + f_{p^A/p^B}^2) + f_{s^l}^1 (f_{H/L}^3 f_{a^e}^4 f_{p^A/p^B}^5 + f_{p^A/p^B}^3) \right] \\ & \cdot \left( - \frac{f_{\sigma^j}^6}{f_{p^A/p^B}^6} \right) \left[ f_{a^e}^4 f_{p^A/p^B}^5 f_{H/L}^1 + 1 \right]. \end{aligned} \tag{4.32}$$

Recalling the signs of the corresponding partial derivatives, one can start with recognizing the fact that the term in brackets is unambiguously positive. As the negativity of the partial

demand effect  $f_{p^A/p^B}^6$  is likewise obvious, signs of partial and total effect hence always coincide. Accordingly, a higher  $\sigma^j$  is thus predicted to result in a higher degree of sectoral specialization in the production of consumption goods compared to a worldwide average. At the same time, this tells us that if an ongoing trend towards product differentiation does manifest itself in goods becoming more complementary with respect to their country of origin, this trend is apt to reduce the intensity of sectoral specialization in an economy after taking account of dynamic responses in skill accumulation.

Considering our case of a technologically lagging country, the opportunity for domestic producers to differentiate from foreign competitors in terms of product characteristics provides the country with opportunities to increase its share of knowledge-intensive production despite its low price competitiveness in these areas.

This has the expected implications for the process of skill formation in the economy, given that the same condition for the presence of a positive effect does apply:

$$d\left(\frac{Q^A}{Q^B}\right) / d\sigma^j \begin{matrix} \leq 0 \\ \geq 0 \end{matrix} \quad \text{iff} \quad \frac{Q^A}{Q^B} \begin{matrix} \leq \\ \geq \end{matrix} \frac{Q^{A;ROW}}{Q^{B;ROW}}. \quad (4.33)$$

Hence, in a scenario describing a world consisting of many small economies, a process of intensified product differentiation at the national level is accordingly, all else being equal, not only characterized by smaller international differences in the sectoral allocation of factors, but also by smaller differences in the relative abundance of skilled labour.

Since we did not postulate any interrelation between product diversity and the efficiency of schooling systems here, this can only be attributed to an effective long-run convergence in the relative number of skilled workers and hence in the rates of school enrollment.

The underlying cause of this trend is to be seen in the lower sensitivity of consumers towards price differences in national varieties. This implies for firms in a countries more competitive sector a reduction in their potential to translate cost advantages into higher sales, as consumer behaviour now tends to be less price-oriented. Efficiency-based high supply volumes of these goods are thus hardly absorbed by customers and will thereby result in comparably low relative market prices, causing market exit in these industries and a corresponding transfer of productive resources to the less competitive sector. Given that relative intensities in the use of these resources differ between activities, the consequential shift in labour demand induces an economy-wide drop in demand for the relatively abundant skill type. Through the channel of educational investments, this results into a reduction of long-term supply.

Furthermore, the degree of product differentiation can exert considerable second-order effects. Foremost, this concerns the interplay of specialization and learning efficiency. In this regard, we can analyze in how far the positive effect of a higher productivity in learning on skill-intensive production revealed in (4.25) depends on  $\sigma^j$ . Again, such an effect has to operate via the influence on the price sensitivity of worldwide consumer demand. The higher the elasticity of substitution, the stronger the negative impact of a relative price increases on relative consumption:

$$\frac{\partial f_{p^A/p^B}^6}{\partial \sigma^j} < 0. \quad (4.34)$$

Given that the supply increase for the skill-intensive good  $A$  resulting from the existence of more efficient skilled workers yields a decline in its relative price, a higher sensitivity

of consumer demand further contributes to the resulting increase in the production of  $A$ .

$$\partial \left( d \frac{Q^A}{Q^B} / d\phi \right) / \partial \sigma^j > 0 \quad (4.35)$$

Hence, product differentiation can serve as an additional demand stimulus in this situation, which supports a country in reaching higher long-run levels of skill-intensive production. In this way, it also boosts the impact on long-run supply of skilled labour:

$$\partial \left( d \frac{H}{L} / d\phi \right) / \partial \sigma^j > 0. \quad (4.36)$$

In the extreme case of perfect substitutability with world market goods ( $\sigma^i \rightarrow \infty$ ), improvements in the technology of skill generation have no impact on relative price levels. For this reason, relative wages also remain fixed at their previous level. In this situation, the long-run influence of learning efficiency on specialization in the skill-intensive good is the most pronounced, as the economy does not experience any supply-induced decline of the skill premium. For the same reason, a higher learning efficiency also exerts the strongest impact on school participation in this situation.

## 4.4 The interplay between trade and skilled migration for a small economy

### 4.4.1 The framework with migration

One important lesson that can be drawn from the analysis of the last section is that the pecuniary effects of free trade as such can already represent an obstacle to human capital formation in developing economies. A specialization in low-technology goods with limited innovative potential could in this way not only constitute a development trap concerning the range of opportunities to innovate, but also because the low-skill intensity of these goods implies a smaller range of job opportunities in the high-skilled segment for talented young people in subsequent generations. This can have the consequence that many of them prefer to stick to low-qualified jobs in low-tech industries instead of making efforts to climb the skill ladder through formal education. The real-life presence of market imperfections like the existence of costs with regards to job turnover (loss of firm-specific human capital, costs of relocating) or of malfunctioning credit markets with risk-averse lenders should even be expected to reinforce the tendency of sectoral restructuring to harm educational incentives.

It remains to be analyzed, however, if the option of emigrating could represent a remedy in this regard: it guarantees access to working opportunities offering adequate returns to learning efforts, which are independent of domestic structural change. From a societal point of view, this could turn out to be beneficial provided that a considerable number of those students attracted by this perspective would in the end not actually leave the country. However, the major result of the last chapters had been throughout that the selectivity of migrants according to talent implies a short- and long-run net loss of effective human capital despite a lasting increase in enrollment rates.

Taking a multisector perspective, one could nevertheless come to think about a force working against this scenario: Higher enrollment rates could in subsequent periods lead

to an improvement of the competitiveness of the domestic skill-intensive sector. If this sector attracted more productive resources, this could, in turn, result into higher domestic demand for high-qualified workers. It is, however, also possible to take up a contrary position and expect the migration channel to be powerful enough to drag developing economies deeper into mass production of low-skilled goods. If skilled emigration impairs production capacities of knowledge-intensive sectors to such an extent that some share of the remaining human capital is redirected to other activities, the negative net effect of an emigration wave on economy-wide demand for professionals could as well be imagined to even worsen the initial loss by impairing educational incentives.

To make a stand on this issue, we adopt the concept of skilled migration of the last chapters and imagine freshly graduated students to make a choice between accepting domestic job offers or going abroad and receiving an exogenous ROW wage  $w^{hROW}$ . Again, those agents not joining the schooling program are excluded from this possibility. To accomodate the selectivity issue, migration is costly, though. Crossing the border involves the consumption of  $c_{mig}$  units of physical capital. An individual will then opt for migration if the following holds:

$$(1 + a\phi)w^{hROW} - \bar{p}^K c_{mig} \geq (1 + a\phi)w_t^h. \quad (4.37)$$

Since investment goods produced in different countries are assumed to be perfectly homogeneous,  $p^K$  takes the role of a world market price for capital, which is unaffected by production plans in the small sending country. To obtain the relevant threshold level, we again determine the ability level at which the condition above holds with equality:

$$a_t^m = z \left( \frac{\bar{p}^K c_{mig}}{\phi (w^{hROW} - w_t^h)} - \frac{1}{\phi} \right). \quad (4.38)$$

Note here the negative influence of schooling quality  $\phi$ , implying that a higher efficiency in schooling is for given wage rates coupled with higher outflows of skilled workers, a point we will return to later on. Aggregate supply of human capital in each period, here adjusted for a possible cut-off of the top end of the worker's ability distribution through emigration, is then given by:

$$H_t = \int_{a_{t-1}^e}^{a_t^m} (1 + a\phi) da = (a_t^m - a_{t-1}^e) \left( 1 + \frac{\phi (a_t^m + a_{t-1}^e)}{2} \right). \quad (4.39)$$

The direct impact of  $\phi$  (i.e. if migration and schooling rates were not affected) is here positive, of course. This already indicates that the implications of a rise of skill-biased emigration for the countries endowment with qualified labour might be less adverse when it is due to higher efficiency instead of lower costs of moving. Other equilibrium conditions were already specified above and require no further adjustments. This is due to the fact that, as a consequence of the small economy assumption, any reallocations of domestic budgets originating from emigration incentives do not impinge on aggregate variables. Figure 4.2 illustrates the interlinkages present in this augmented framework and the existing scope for external shocks.



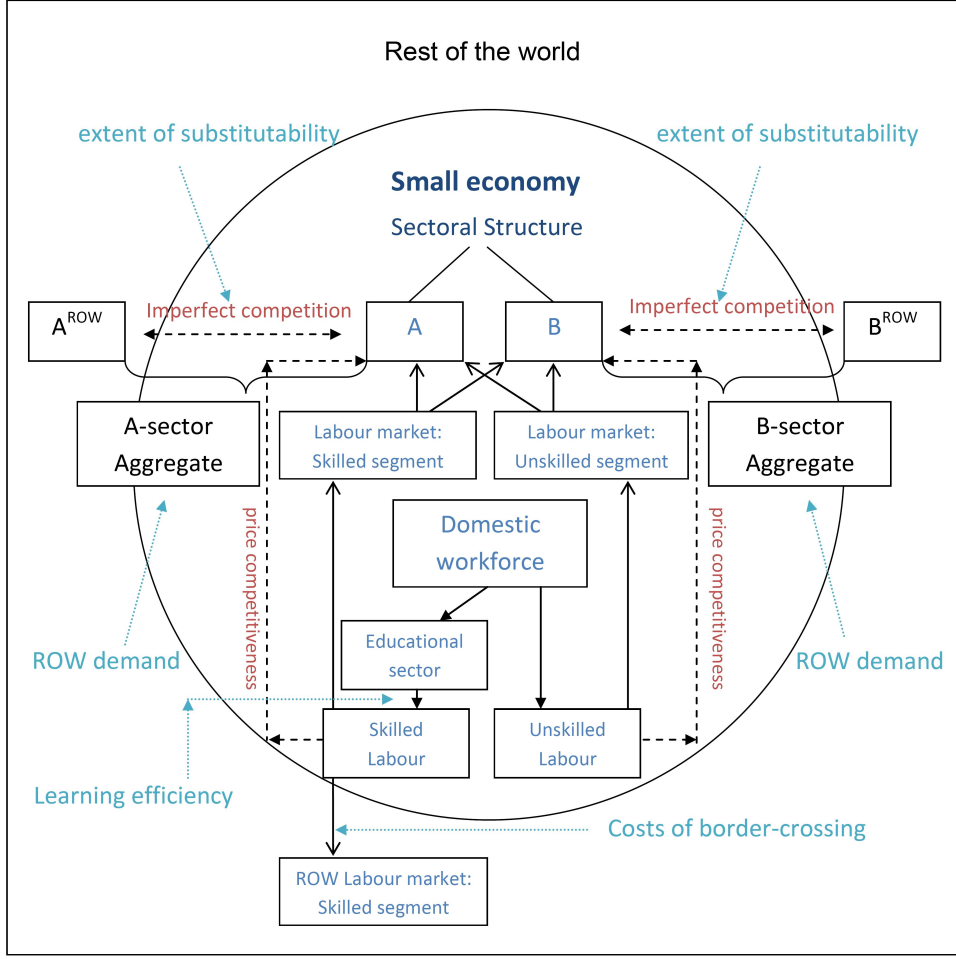


Figure 4.2: Structure of the augmented framework

#### 4.4.2 The long-run impact of the strength of migration barriers

We now turn to a long-run analysis of the impact of a reduction in the costs of emigrating on the model variables. Introducing migration incentives to the system of steady-state conditions in 4.2.2. yields functional relationships that can be summarized as follows:

$$\begin{aligned}
 (Q^A/Q^B) &= f^1(s^h, s^l, (p^A/p^B), (H/L)) \\
 s^h &= f^2((p^A/p^B), (H/L)) \\
 s^l &= f^3((p^A/p^B), (H/L)) \\
 (H/L) &= f^4(a^e, a^m) \\
 a^e &= f^5((p^A/p^B)) \\
 (Q^A/Q^B) &= f^6(p^A/p^B) \\
 a^m &= f^7(c_{mig}, p^A/p^B).
 \end{aligned}$$

In this formulation, we have again made use of the one-to-one correspondence of wages and prices manifested in the zero-profit-condition (4.15).

Before addressing the both empirically more relevant and analytically more insightful case of differentiated products, examining the limiting case of homogeneity will provide us with a benchmark for the analysis to follow. In order to make this scenario eligible for a discussion of endogenous migration at all, some exogenous difference in production technologies between the designated sending economy and those economies forming the receiving rest of the world has to be postulated. We assume the country under observation to be technologically inferior in a sense that even under complete cross-country price equalization induced by goods trade, the nominal wage rate paid to a worker of comparable skill would still be lower than abroad. This could be simply due to the fact that more skilled workers are needed for the production of one unit of any good, which in turn requires lower wage levels to fulfill the zero-profit-condition. With this scenario as a starting point, we examine the signs of the long-run effects of a marginal shock to migration costs.

If products are completely homogeneous ( $\sigma^i \rightarrow \infty$ ), emigration does not exert any impact on domestic prices, as these are anyway determined on the world market. Wages are thus likewise fixed, eliminating any repercussions on educational incentives. Lower barriers to skilled emigration hence inevitably lead to a reduction of the number of professionals available. This entails that some share of resources will be diverted to the less skill-dependent  $B$ -good until demand for skilled labour has fallen to a level that allows to sustain the given wage rates and thereby also to maintain the competitiveness of domestic  $A$ -sector firms. In this vein, all possible sources of dynamics are also eliminated, since all intertemporal allocation plans remain unaffected by this event.

As mentioned in the introduction, migration starts to lose its neutrality in this regard as soon as the production decisions of domestic manufacturers as a whole can effectively influence the prices at which their goods are sold internationally. Then, by changing the balance of relative output prices in the economy, an increase in relative scarcity of single factors can likewise affect relative factor rewards and thus dynamic accumulation decisions. To achieve this within our framework, all we are asked to do is to declare the degree of substitutability among the range of varieties available worldwide to be imperfect ( $\sigma^i < \infty$ ). Then, the following results can be derived from the total differential.

Our main focus is here obviously on the response of the domestic skill intensity, which can be written in a way that provides an intuitive interpretation in the form of a multiplier:

$$\frac{d\left(\frac{H}{L}\right)}{dc_{mig}} = \frac{f_{a^m}^4 f_{c_{mig}}^7}{1 - \frac{(f_{s^h}^1 f_{H/L}^2 + f_{s^l}^1 f_{H/L}^2 + f_{H/L}^1) M^S}{M^D}} \geq 0 \quad (4.40)$$

$$M^S = f_{a^e}^4 f_{p^A/p^B}^5 + f_{a^m}^4 f_{p^A/p^B}^7 > 0 \quad (4.41)$$

$$M^D = f_{p^A/p^B}^6 - \left( f_{p^A/p^B}^1 + f_{s^h}^1 f_{p^A/p^B}^2 + f_{s^l}^1 f_{p^A/p^B}^3 \right) < 0. \quad (4.42)$$

First, the numerator can be understood as expressing the immediate impact of a rise in the costs of moving abroad on domestic labour supply. A drop of these costs hence initiates a potential for increased outflows, as the minimal level of talent required to make

the efforts of learning worthwhile is decreasing. To assess the equilibrium effects of the corresponding downfall of the economy-wide skill intensity, the denominator needs to be analyzed. For given wage rates, the loss of skilled labour would cause a particularly strong output decline in the skill-intensive  $A$ -sector, with the isolated effect of a relative price increase of domestic  $A$ -sector varieties. The terms summarized in  $M^S$  and  $M^D$  can then be interpreted as reflecting two contrary channels through which this pressure on output prices exerts feedback effects on the stocks of labour. In this respect, they represent multipliers of the immediate response.

On the one hand, a higher relative price of the  $A$ -good would translate into higher skill premia, thereby attenuating the initial impact both through higher schooling incentives and lower emigration rates. This constitutes the supply-side effect summarized in  $M^S$ . On the other hand, domestic skill-intensive varieties become less affordable compared to foreign ones, the resulting negative demand shock exerts some downward pressure on the rewards to domestic skilled workers through the demand side of the labour market. This is summarized in  $M^D$ , indicating the change in relative excess demand for the  $A$ -good as triggered by a marginal increase in relative prices. Depending on which of the two effects dominate, the existence of price flexibility does amplify or restrain the initial response in the long-run. In either case, as both effects operate only indirectly through changes in the system of output prices, the long-term net impact of shrinking migration barriers on the skill intensity of the domestic workforce is clearly negative.

Linked to this is a decline in the competitiveness of the skill-intensive  $A$ -sector firms, it is hence no surprise to see production to shift to the  $B$ -variety as a side effect of intensified emigration:

$$\frac{d\left(\frac{Q^A}{Q^B}\right)}{dc_{mig}} = \frac{\left(f_{s^h}^1 f_{H/L}^2 + f_{s^l}^1 f_{H/L}^2 + f_{H/L}^1\right) f_{a^m}^4 f_{c_{mig}}^7 f_{p^A/p^B}^6}{M^D - \left(f_{s^h}^1 f_{H/L}^2 + f_{s^l}^1 f_{H/L}^2 + f_{H/L}^1\right) M^S} \geq 0. \quad (4.43)$$

Having established results on the change in relative endowments, we would also like to say something about the evolution of the absolute stock of human capital. Since domestic producers choose their output levels along a given demand curve which is itself unaffected by any changes to domestic labour income, a shift away from skill-intensive production must be associated with an increase in the relative price of the  $A$ -good. This is again only compatible with profit maximization if at the same time the relative remuneration of skilled workers goes down:

$$\frac{d\left(\frac{Q^A}{Q^B}\right)}{dc_{mig}} \geq 0 \Rightarrow \frac{d\left(\frac{p^A}{p^B}\right)}{dc_{mig}} \leq 0 \Rightarrow \frac{d\left(\frac{w^h}{w^l}\right)}{dc_{mig}} \leq 0. \quad (4.44)$$

A decrease of migration costs hence generates a long-run increase in the domestic skill premium, implying a rise of educational incentives. The stock of unskilled labour is therefore guaranteed to decline.

This is, in turn, only consistent with our result of a falling general skill level of the domestic labour force if the effective supply of skilled labour in the economy falls as well. Thus, it has to be accompanied by intensified emigration:

$$\frac{dL}{dc_{mig}} \geq 0 \Rightarrow \frac{da^m}{dc_{mig}} \geq 0, \quad \frac{dH}{dc_{mig}} \geq 0. \quad (4.45)$$

We can summarize our results as follows: Enhanced international mobility of skilled workers maintains its supportive effect on school enrollment when production is split into 2 sectors, which are to different degrees dependent on the use of skilled labour. This is just like in the one-sector scenario not sufficient, though, to compensate the losses stemming from the outflow of the most talented. Consequences for the general pattern of production are thus from the perspective of a country scarce in human capital predicted to be similar to those of trade expansion: Encouraging the concentration of production in standardized goods with low innovative capacity. Besides the immediate negative impact of an exodus of the countries productive elite, further obstacles to economic development could in this respect arise in the form of a limitation of opportunities of knowledge generation through R&D or learning-by-exporting (Bernard & Jensen(1999)).

It is important to grasp why also in this scenario a migration-induced boost to schooling can merely alleviate, but not fully compensate the losses. The crucial point is that in a small, export-oriented economy, in which local consumers make no significant contribution to the aggregate sales of local firms, any shock related to strength of migration barriers can only operate through the supply-side. In other words, the observed increase in the returns to education can only be initiated by rendering human capital more scarce. In this way, the counterintuitive phenomenon in the context of emigration waves can appear that enrollment rates in tertiary education rise, even though jobs in skill-intensive areas are cut. Or, to put it differently: Modern, technology-based sectors could be observed to shrink despite higher numbers of well-trained graduates. In the end, both aspects constitute adjustments to one and the same underlying cause.

The rationale behind the schooling choices of relatively low talented workers is then simply the prospect of taking the jobs of those leaving. These jobs are less in number, but at the same time better paid than before as a result of reduced competition. One lesson that could be drawn from this might be that one should be careful not to confuse causes and consequences with respect to changes in school enrollment rates, as these could as well just constitute symptoms of opposing trends in emigration incentives.

#### 4.4.3 The long-run impact of educational efficiency

A different question is if we can conclude from this that innovations related to the educational system resulting in more efficient learning processes can be expected to evoke effects of a similar nature, i.e. creating an emigratory pressure through intensified competition among professionals that is strong enough to drive the economy into an equilibrium with manufacturing concentrating in activities with low skill content. Taking the total differential with respect to  $\phi$ , this notion can be rejected:

$$\frac{d\left(\frac{H}{L}\right)}{d\phi} = \frac{f_{a^e}^4 f_{\phi}^5 + f_{\phi}^4}{1 - \frac{\left(f_{s^h}^1 f_{H/L}^2 + f_{s^l}^1 f_{H/L}^2 + f_{H/L}^1\right) M^S}{M^D}} > 0. \quad (4.46)$$

The initial decrease of the ability threshold  $a^e$  caused by the positive effect of the efficiency boost on educational returns unambiguously translates into a long-run increase of the aggregate skill intensity. Note that, as a multiplier, we obtain the same expression as in the analysis of shocks to migration barriers. The reason for this is that both shocks

originate from adjustments to individual labour supply. These adjustments entail in both cases similar repercussions on production levels and wages.

The increase in the efficiency of knowledge transmission improves the competitive position of domestic firms in the  $A$ -sector, thus causes resources to shift to the  $A$ -variety with the following equilibrium implication for the domestic pattern of production:

$$\frac{d\left(\frac{Q^A}{Q^B}\right)}{d\phi} = \frac{\left(f_{sh}^1 f_{H/L}^2 + f_{sl}^1 f_{H/L}^2 + f_{H/L}^1\right) \left(f_{\phi}^5 f_{a^e}^4 + f_{\phi}^4\right) f_{p^A/p^B}^6}{M^D - \left(f_{sh}^1 f_{H/L}^2 + f_{sl}^1 f_{H/L}^2 + f_{H/L}^1\right) M^S} > 0. \quad (4.47)$$

This is all in line with our findings in 4.3, where we were conducting the same analysis for the case of insurmountable barriers to labour mobility.

What remains to be of interest is the long-run net effect on migration incentives. In this regard, a direct link between migration and sectoral specialization is established by the common interaction with goods prices. In order to increase sales volumes, local  $A$ -good producers are forced to cut prices, which implies a decrease in their willingness to pay for qualified labour. Given that these firms make up a large part of total demand for skilled labour, the salaries received by professionals will unambiguously fall. The result of them receiving lower payment for offering the same performance levels is finally an unambiguous increase in emigration rates, a relationship that can be formally derived as follows:

$$da^m = \underbrace{\frac{f_{p^A/p^B}^7}{f_{p^A/p^B}^6}}_{\leq 0} d\left(\frac{Q^A}{Q^B}\right). \quad (4.48)$$

Hence, as long as the costs associated with emigrating remain the same and international wage differences are significant enough to support any skilled migration at all, a shift in manufacturing towards skill-oriented production is in the long run always coupled with increasing outmigration of skilled workers.

Improvements in the quality of educational institutions today are therefore predicted to lead to higher future outflows of the most promising talents. Nevertheless, we have seen that the aggregate skill intensity of labour supply is at the same time on the rise. This means we have finally come across a scenario in which more emigration is not only compatible with, but, in fact, a direct consequence of an increase of the average skill level of workers in the economy. It is in this case the higher competitive pressure that drives those workers with sufficient incentives to cope with the efforts of going abroad out of the economy.

Just from this, however, one can not infer that accumulating skills becomes a less favourable option for members of the young generation under these circumstances. There is still the personal gain in productivity originating from the efficiency increase to be mentioned that is opposing a reduced remuneration of workers of given productivity. For this reason, comparative statics do not deliver a clear sign for the effect of the productivity increase on  $a^e$ .

#### 4.4.4 The long-run impact of the degree of product differentiation

We had discovered above that an increase in the substitutability of national product varieties can contribute to an attenuation of sectoral specialization, which in turn has

positive effects on schooling participation. One question of concern in this section is if this could also represent a means to curb an excessive drain of qualified workers. As a result of aggregate demand becoming less sensitive to international price differentials, firms in the relatively less competitive sector could be able to enforce higher prices for their varieties than before. By expanding their output levels, demand for skilled labour could rise as well, possibly preventing some graduates from looking for jobs abroad. The total differential of the migration threshold with respect to the elasticity of substitution among varieties  $\sigma^i$  delivers here the following:

$$\frac{da^m}{d\sigma^i} = \frac{f_{\sigma^i}^6 f_{p^A/p^B}^7}{\left( f_{s^h}^1 f_{H/L}^2 + f_{s^l}^1 f_{H/L}^2 + f_{H/L}^1 \right) M^S - M^D}. \quad (4.49)$$

The denominator and the partial effect of the output price ratio on  $a^m$  are clearly positive (see (4.33)). Then it is up to the partial effect of a change in this elasticity on relative production levels to determine the sign of the change in emigration rates. If it is negative, i.e. a *reduction* of substitutability leads to an *increase* of skill-intensive production in relative terms, the effect of a falling  $\sigma^j$  on the migration threshold is positive, thereby reducing the outflow by creating more domestic jobs for professionals. We had stated above that this is true for countries showing the tendency of specializing in the low-skill segment in comparison to the rest of the world. As they are in large parts congruent with the group of net sending countries, one could indeed attest a mitigating effect on migratory flows to the process of shrinking product substitutability. Concerning the implications for educational incentives, the following relation can be derived:

$$\frac{da^e}{d\sigma^i} = \underbrace{\frac{f_{p^A/p^B}^6}{f_{p^A/p^B}^7}}_{<0} \frac{da^m}{d\sigma^i}. \quad (4.50)$$

From this, it follows that for the group of countries discussed an additional positive impact on human capital formation in the form of enhanced schooling participation arises. This is clear to the extent that both effects can be traced back to the same fact: an increase in the domestic skill premium. Hence, intensified product differentiation is predicted to reduce a technology-based backlog in skill accumulation in two ways: by reducing the outflow of high-talent professionals and at the same time by improving the motivation of low-talent agents to join programs of higher education. Whether, and if so, to what extent this can lead to international convergence in skill endowments when one is taking account of the likely repercussions these adjustments have on sectoral structure and skill formation within the receiving countries will be answered by the next section.

In addition, something that has not been considered so far are the potential consequences of altered wage levels for the demand side of the market for domestic varieties. Under the given assumption that the economy of concern is such small that any finite change of the size of local markets has effectively no impact on a firms' profit margin, this has been completely neglected. As a corollary of the same assumption, potential effects of migration flows on a target countries' wage structure had likewise been left aside. If the number of migrants is however high enough to bring about a significant shock to the receiving economies' skill structure, this could seriously affect competitiveness and thereby sectoral structure of foreign production as well. Then, this would imply the existence of an additional indirect effect of skill-biased migration operating through trade.

		Dependent variable (with $\frac{Q^A}{Q^B} < \frac{Q^{A;ROW}}{Q^{B;ROW}}$ )						
		$d\left(\frac{Q^A}{Q^B}\right)$	$d\left(\frac{p^A}{p^B}\right)$	$d\left(\frac{w^h}{w^l}\right)$	$da^e$	$da^m$	$d\left(\frac{H}{L}\right)$	
$\sigma^i < \infty$	$\infty \uparrow$ $c_{mig}$	$d\phi$	$> \mathbf{0}$	$< \mathbf{0}$	$< \mathbf{0}$	$\leq \mathbf{0}$	$0$	$> \mathbf{0}$
		$d\sigma^i$	$< \mathbf{0}$	$< \mathbf{0}$	$< \mathbf{0}$	$> \mathbf{0}$	$0$	$< \mathbf{0}$
	$\infty < \infty$ $c_{mig}$	$d\phi$	$> \mathbf{0}$	$< \mathbf{0}$	$< \mathbf{0}$	$\leq \mathbf{0}$	$< \mathbf{0}$	$> \mathbf{0}$
		$d\sigma^i$	$< \mathbf{0}$	$< \mathbf{0}$	$< \mathbf{0}$	$> \mathbf{0}$	$< \mathbf{0}$	$< \mathbf{0}$
		$dc_{mig}$	$\geq \mathbf{0}$	$\leq \mathbf{0}$	$\leq \mathbf{0}$	$\geq \mathbf{0}$	$\geq \mathbf{0}$	$\geq \mathbf{0}$
	$\sigma^i \rightarrow \infty$	$\infty \uparrow$ $c_{mig}$	$d\phi$	$> \mathbf{0}$	$0$	$0$	$< \mathbf{0}$	$0$
$\infty < \infty$ $c_{mig}$		$d\phi$	$> \mathbf{0}$	$0$	$0$	$< \mathbf{0}$	$0$	$> \mathbf{0}$
		$dc_{mig}$	$\geq \mathbf{0}$	$0$	$0$	$0$	$\geq \mathbf{0}$	$\geq \mathbf{0}$

Table 1: The signs of marginal long-run effects for an economy specializing in the low-skill sector

Besides endogenizing the classification into sending and receiving economy, taking our migration framework to the 2-country case will also provide us with propositions on how skilled migration can shape the pattern of comparative advantages and the resulting trade flows, and how these are again sensitive to the degree of product substitutability. This range of topics will be discussed in the next section.

## 4.5 The interplay between trade and skilled migration for 2 large economies

### 4.5.1 The 2-country framework

By imagining the countries of the world to merge to just two blocks of equal population size, each fully integrated in terms of factor mobility, the set of geographical entities effectively reduces to just 2 countries  $i = 1, 2$ . We maintain in the following the general structure of 2 sectors  $j = A, B$  producing consumption goods. However, to restrict our focus on skill intensities as explanatory factors for comparative advantage patterns, we omit physical capital as a factor of production. Instead, production is now undertaken by merely combining skilled and unskilled labour according to a nested constant returns to scale technology, which is for the purpose of numerical analysis further restricted to adopt a CES form:

$$Q_{i,t}^j = \left[ \gamma^j H_{i,t}^j \frac{\sigma^l - 1}{\sigma^l} + (1 - \gamma^j) L_{i,t}^j \frac{\sigma^l - 1}{\sigma^l} \right]^{\frac{\sigma^l}{\sigma^l - 1}}. \quad (4.51)$$

with  $\sigma^l$  representing the elasticity of substitution between skill types of labour. Share parameters  $\gamma^j$  are only chosen to be sector-, not country-specific, as we are focusing on the generation of endowment- instead of technology-based specialization patterns across countries. This analogy to the static Heckscher-Ohlin case will facilitate deriving statements on specialization tendencies of countries. The meaning of other symbols is also the same as before. In addition, we also borrow the specific overlapping generations structure and the corresponding assumptions on the technology of human capital creation from the last section.

The only difference lies in the fact that schooling decisions in 2 countries are now analyzed simultaneously. As consumers in both economies exert significant influence on aggregate demand for certain varieties, there exists even in the absence of cross-border labour flows a lot of room for interactions with regards to the development of school enrollment in the 2 economies, established by links between factor and commodity prices. The threshold is then easily obtained as:

$$a_{i,t}^e = z \left( \frac{E_t w_{i,t+1}^l + (1 + r_t)(\epsilon w_{i,t}^l)}{E_t w_{i,t+1}^h \phi_i} - \frac{1}{\phi_i} \right). \quad (4.52)$$

In comparison to the last section, what is just added here besides country index  $i$  is a time index for the interest rate. The lack of a ROW entity taking the simultaneous role of a producer of the capital good  $K$  and a lender to domestic firms implies that the rate at which households can borrow at a certain point in time can no longer reasonably assumed to be exogenous. Outside any stable long-run situations, this rate should thus be expected



to fluctuate over time alongside correspondent variations in other prices. Taking account of these variations in the model outcome requires us to explicitly model savings decisions. The nature of the agents intertemporal preferences, which in this chapter had been of no significance so far thanks to the assumption of perfect capital markets, thus gains in importance.

Given the absence of firm demand for capital in this variant, lending and borrowing on credit markets is assumed to take place on a pure interhousehold basis. There are no costs associated with transferring capital across countries, a common market for the allocation of credit thus emerges. As a consequence, supply and demand on this market are matched by a common interest rate  $r_t$ . Since there exists no outside world that would allow individuals in the 2 regions as a whole to take a net borrower or net lender position, the corresponding equilibrium condition is that total wealth aggregated over agents and regions has to be equal to zero at each point in time. For consistency, we denote the stock of wealth owned by a member of generation  $g$  at time  $t$  that is born in  $i$  with  $k_{i,t}^g$ .

$$\sum_g \sum_i \left( \int_0^1 k_{i,t}^g(a) da \right) = 0 \quad (4.53)$$

Wealth as such is then measured in terms of the numeraire.

In the following, we choose unskilled labour in region 2 to represent our numeraire. The amount a certain individual is indebted in is thus measured in the number of periods the individual would have to spent working as an unskilled worker in 2 in order to accumulate an equivalent amount of labour income.

As a next step, in order to determine how much of the value of aggregate skill that has been accumulated in the past will be spent on wealth accumulation today, consumption and savings levels need to be determined. For consistency with the notion of rational agents, these levels need to be derived as explicit solutions to the problem of lifetime maximization of intertemporal utility as formulated in (4.17)-(4.19), subject to the familiar lifetime budget constraint. For our representative agent summarizing all members of the generation born in the 2 countries in  $t$ , it can be stated as:

$$\max. \quad U_t = \sum_{b=0}^2 \beta^b \frac{C_{t+b}^{1-\eta} - 1}{1-\eta} \quad (4.54)$$

$$s.t. \quad P_t C_t^y + P_{t+1} \frac{C_{t+1}^m}{1+r_{t+1}} + P_{t+2} \frac{C_{t+2}^o}{(1+r_{t+1})(1+r_{t+2}^n)} = PVI_t. \quad (4.55)$$

with  $P_t$  symbolizing the aggregate price index for consumption goods in general. It results from the problem of minimizing the expenditures required to generate one unit of the aggregate bundle  $C$  whose Cobb-Douglas composition is given by (4.18). Accordingly, it turns out to be a function of the sectoral price indices, which were already derived above:

$$P_t = P_t^{A\alpha} P_t^{B^{1-\alpha}} \left[ \left( \frac{1-\alpha}{\alpha} \right)^{\alpha-1} + \left( \frac{1-\alpha}{\alpha} \right)^{\alpha} \right]. \quad (4.56)$$

Finally,  $PVI_t$  marks the aggregate lifetime income of the generation born in  $t$  expressed in present value terms. From this, it is already evident that skill accumulation does not

merely influence wages through its impact on labour supply, but also by shaping the consumption pattern of domestic agents. The corresponding optimality conditions are:

$$C_t^{y-\eta} = \frac{\beta}{(1+r_{t+1}^n)} \frac{P_t}{P_{t+1}} C_{t+1}^{m-\eta} \quad C_{t+1}^{m-\eta} = \frac{\beta}{(1+r_{t+2}^n)} \frac{P_{t+1}}{P_{t+2}} C_{t+2}^{o-\eta}. \quad (4.57)$$

Plugging this term into the intertemporal budget constraint yields consumption levels for different stages of life as functions of factor prices. Summing these over generations eventually delivers total consumption volumes and hence also total savings.

Having described the evolution of consumption patterns in total, its sectoral composition is then again determined by the level of relative prices. We stick with our previous assumptions on the structure of preferences also in this regard. Of special importance is in this context the symmetry assumption, i.e. the absence of any fundamental bias in the desirability of the single varieties' properties, which excludes the possibility of taste-based differences in national production patterns. The only deviation from the small economy case lies in the fact that consumers allocate their constant expenditure shares just among two instead of infinitely many varieties in both sectors, each variety originating from one of the two countries.

$$C_t^j = \left( c_{1,t}^j \frac{\sigma^{j-1}}{\sigma^j} + c_{2,t}^j \frac{\sigma^{j-1}}{\sigma^j} \right)^{\frac{\sigma^j}{\sigma^j-1}} \quad (4.58)$$

By applying the same procedure of expenditure minimization as above, demand functions being symmetric across countries of origin arise:

$$c_{i,t}^A = \left( \frac{p_{i,t}^A}{P_t^{A^{1-\sigma^j}}} \right) \alpha P_t C_t \quad c_{i,t}^B = \left( \frac{p_{i,t}^B}{P_t^{B^{1-\sigma^j}}} \right) (1-\alpha) P_t C_t \quad (4.59)$$

$$C_t = \sum_g C_t^g. \quad (4.60)$$

One should note that the sectoral price indices now represent variables that are no longer insensitive to isolated shocks to a single country's production structure. Instead, cost-induced price changes in one country's variety do effectively exert an indirect effect on the demand pattern of the other country's variety, with the sign of this cross-price elasticity being determined by the degree of substitutability.

The gradual long-run shift to more knowledge-intensive production as a result of enhanced learning efficiency is thus likely to exercise the reverse impact on the foreign countries pattern of sectoral specialization. In this regard, the dynamic implications seem to mimic the predictions made in the context of exogenous changes of factor endowments in a static Heckscher-Ohlin world. The existence of national product differentiation coupled with preferences expressing "love of variety" does, however, set limits to the emergence of a direct linkage between efficiency aspects of education in one country and the international division of labour. The preference of consumers for consumption bundles that are balanced with respect to the origin of goods reduces opportunities to transform cost advantages into higher market shares, as it makes consumers reluctant to allocate asymmetrically large parts of their budget to the cheaper variety alone.

To fully capture the general equilibrium dimension of this reasoning, we first need to set up explicit market clearance conditions for the trade in the 2X2 types of commodities and the 2 classes of labour as we already did for the investment good:

$$Q_{i,t}^j = c_{i,t}^j \quad H_{i,t} = \sum_j H_{i,t}^j \quad L_{i,t} = \sum_j L_{i,t}^j. \quad (4.61)$$

This finally determines the real rewards to workers at each point in time and hence the correspondence between the time paths of the evolution of labour supply and the evolution of prices. A link between goods and factor prices is then once again set by the zero-profit-condition required to hold for firms in each sector and both countries:

$$\begin{aligned} W_{i,t}^j &= w_{i,t}^h \tilde{H}_{i,t}^j + w_{i,t}^l \tilde{L}_{i,t}^j \\ &= w_{i,t}^h \left[ \gamma^j + (1 - \gamma^j) \left( \frac{w_{i,t}^l}{w_{i,t}^h} \right)^{1-\sigma^l} \right]^{\frac{\sigma^l}{1-\sigma^l}} + w_{i,t}^l \left[ (1 - \gamma^j) + \gamma^j \left( \frac{w_{i,t}^h}{w_{i,t}^l} \right)^{1-\sigma^l} \right]^{\frac{\sigma^l}{1-\sigma^l}}. \end{aligned} \quad (4.62)$$

$$(4.63)$$

where unit demand for each factor is again obtained by minimizing the costs of the firms associated with producing one unit of output in each sector.<sup>12</sup>

Then, in order to introduce endogenous migration into this 2-country framework in a consistent way, conditions based on microeconomic optimization need to be formulated that in principle allow for the generation of labor flows in both directions. Maintaining our simplifying assumptions that emigrating is conditional on the completion of the schooling program, the condition under which a skilled worker born in country  $i$  is willing to emigrate to the other country  $\bar{i}$  can be formulated as follows:

$$(1 + a\phi_i) w_{i,t}^h - c_{mig} \geq (1 + a\phi_i) w_{i,t}^h. \quad (4.64)$$

Note that choosing unskilled labour in country 1 to represent the numeraire implies  $c_{mig}$  to measure the number of the stages of life a potential migrant would have to spent working in the low-skill segment of country 1's labour market in order to fully compensate the loss of wealth associated with moving.

With this help, one can determine country-specific migration thresholds, each representing the minimal ability level above which migration to the other country becomes worthwhile. Thereby, they also indicate together with efficiency parameter  $\phi_i$  how migrants differ from the native population in a sending country in terms of their average productivity.

$$a_{i,t}^m = z \left( \frac{\bar{p}_t^K c_{mig}}{\phi (w_{i,t}^h - w_{i,t}^l)} - \frac{1}{\phi} \right) \quad (4.65)$$

---

<sup>12</sup>Note that the imperfect substitutability of national varieties restrains international competition between same-sector firms and thereby involves the introduction of a country index for  $p$  despite the absence of trade frictions.

implying the following country-specific labour stocks:

$$H_{i,t} = \int_{a_{i,t-1}^e}^1 (1 + a\phi_i) da = (1 - a_{i,t-1}^e) + 0.5\phi_i (1 - a_{i,t-1}^e)^2 \quad (4.66)$$

$$L_{i,t} = \left( \int_0^1 l_{i,t}^1 da + \int_0^1 l_{i,t}^2 da \right) = (a_{i,t}^e + (1 - \epsilon) \cdot (1 - a_{i,t}^e) + a_{i,t-1}^e). \quad (4.67)$$

To gain insight into the implications of an increase of labour mobility within this setup, the complexity of the model structure forces us to rely on the means of numerical simulation.

#### 4.5.2 The transitional impact of skilled migration

In order to generate any migration incentives at all, we choose an asymmetric specification and set  $\phi_1 = 2$  and  $\phi_2 = 1$ , implicating that the difference between most and least talented individuals with respect to their expected post-graduate levels of income turns out to be twice as high in 1 than in 2. This indicates the superiority of country 1's schooling system in transforming talent into practical skill.

Concerning the agents' rate of time preference, we assume one model period to comprise 20 years and choose an annual discount rate of 1%. This translates into a discount factor of  $\beta \approx 0.81957$ . In line with our discussion in the section before, we continue to assume *A*-sector production to be more skill-intensive, enabling us to create a link between skill accumulation and sectoral production patterns, here reflected in our choice for the share parameter  $\gamma^j$  ( $\gamma^A = 0.6$ ,  $\gamma^B = 0.4$ ). Finally, with regards to the elasticity of substitution between national varieties in consumption, we do not set just one specific value for  $\sigma^j$ , but run simulations for some range of values to support our intuition on the parameters' impact. Other parameter values are chosen in accordance with the previous chapters:  $\alpha = 0.6$ ,  $\sigma^l = 1.4$ ,  $\epsilon = 0.76$ ,  $\eta = 0.8$ .

The parameter to be shocked in this context is obviously  $c_{mig}$ . We decide to calibrate its initial pre-shock value in such a way that for the given set of other parameter values the country 1 worker with the highest degree of talent within the countries' young generation is in the initial steady-state exactly indifferent between earning her income at home or abroad. This means we focus on a situation in which obstacles to the mobility of skilled workers have just been fallen to a level at which going abroad does at least for the elite within the labour force no longer represent an inconceivable option.

With this as a starting point in period  $t = 0$ , we witness the adjustment process following a sudden, unanticipated drop in migration costs one period after (e.g. taking the form of a reduction in the administrative costs of job search for migrants as a consequence of an international treaty). This is modelled by letting  $c_{mig}$  decrease by 20% in  $t = 1$ . We can expect this to implicate that, all of a sudden, emigration becomes worthwhile for some share of top-talented workers in country 1, which had thought differently in their period of youth in  $t = 0$ .

First Figure 4.1 shows how labour markets respond in the aftermath of this shock.

As an immediate response taking place in  $t = 1$ , we can observe a small group of highly talented country 1 professionals to make use of the improved migration opportunities and

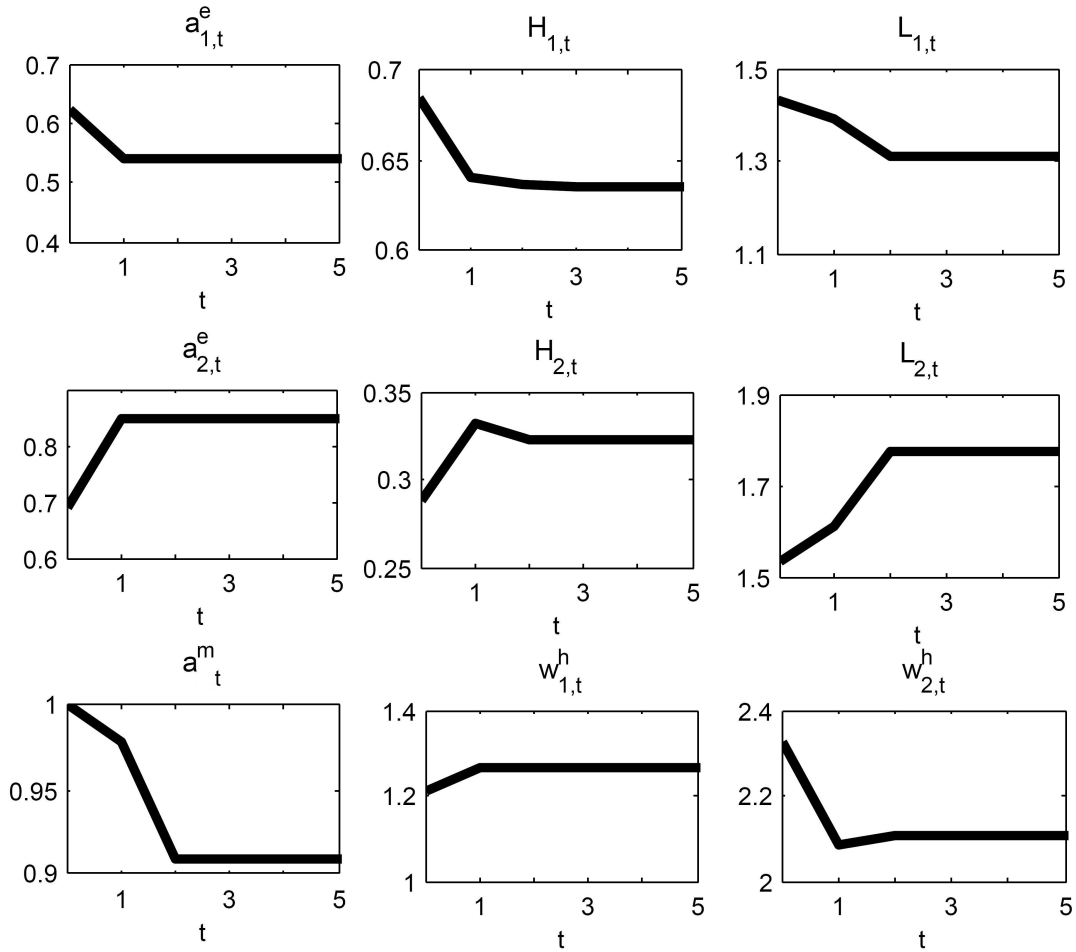


Figure 4.3: Effect of lifting migration barriers

enter the high-skill segment of the labour market in country 2 in order to benefit from local shortages. This results in contrary effects on both countries' endowments with qualified labour. The subsequent generation of workers, which was born in the period shocked, does then already take the existence of migration incentives into account when making decisions on their educational career. For those born in country 1, it is clear that, as a consequence of opened emigration perspectives for the productive elite, chances of getting access to well-paid jobs are raised for less-talented individuals. This does encourage some of those to invest in education that would have lacked a sufficient level of talent to do so in the pre-shock scenario.

The situation for those born in country 2 is diametrically opposed to this: The young generation is here confronted with the prospect of an inflow of the best-trained individuals of the foreign labour force. The remuneration they can expect to receive as a skilled worker is thus on the decline. For this reason, schooling remains attractive for merely a smaller range of highly-talented individuals. The local stocks of unskilled labour therefore move in parallel with those of human capital, illustrating the dominant impact of the migratory pattern on local educational incentives.

Then, in  $t = 2$ , skilled migration does not only persist as a phenomenon, but is even further amplified to an extent that exceeds the volume of the initial outflows. This can

be traced back to the repercussions enrollment rates again have on migration flows: To the degree to which young individuals in country 2 become aware of the existence of an immigration potential, the corresponding deterioration of their expected returns from schooling would further intensify future scarcity of skill in the absence of emigration. This creates an even larger pre-migration wage gap between the countries that is stimulating inflows into 2.

At the same time, this is additionally supported by developments in the sending country. The increasing student numbers in country 1 imply an increase in competitive intensity on the local market for skilled labour, imposing emigration pressure on skilled workers in 1.

However, there is also another force at work, which is responsible for the fact that the partial convergence in efficiency-equivalent stocks of skilled labour to be observed in  $t = 1$  loses momentum in later periods. In particular, an ongoing rise of emigration rates is prevented by the selection mechanism itself: Given that the rising student numbers are attributable to the enrollment of individuals which are on average less productive than the emigrants and thus can not replace them in efficiency terms, the positive response of the skill premium in country 1 to this fact dampens future outflows. This, in turn, contributes to the stabilization of a long-term migration rate. Moreover, the existence of a similar productivity differential between immigrants and natives in country 2 simultaneously limits absorption capacities on the other side of the border.

We can thus conclude that the sending country is still predicted to face a net loss of skilled labour from opening its borders in the short- as well as in the long-term perspective when considering endogenous responses by agents in the destination country. Conversely, the destination country can experience a permanent appreciation of its aggregate stock of human capital, even though the number of people graduating from the domestic schooling program is falling.

In this regard, local trends in skill accumulation can turn out to oppose the development of the actual levels of local knowledge.

Besides, a main feature is that, in contrast to models with homogeneous workers, labour flows are persistent in the sense that their volumes do not gradually recede when the system reaches a new long-run equilibrium after the occurrence of a shock to the strength of migration barriers. Instead, the fact that international wage differentials net of migration costs remain positive in the course of the transition renders it possible to attain permanently higher emigration levels as a result of such a shock.

The reason why full wage convergence can not be achieved here is due the fact that migration barriers are lifted only partially. The fact that going abroad remains to some extent costly implies that the existence of negative net returns from migration for some country 1-workers can be consistent with the existence of a positive wage differential. This prevents a complete withdrawal of skilled labour from 1 that could have been guaranteed to eliminate this differential. Worker heterogeneity then assures that, for individuals above a certain level of talent, the personal differential is sufficiently high to imply these net returns to remain positive. In this respect, our model is easier to reconcile with the empirical fact of strong historical continuities in bilateral migration rates between many countries (e.g. between the Mexico and the US (Hanson (2006))) than representative agent setups.

We had shown above that in the context of trade liberalization with Armington-type goods the strength of the countries tendencies to specialize in activities with distinct

skill content is crucially dependent on the question if a sufficient degree of competition between domestic and foreign firms can be initiated. The main result in this regard was that a higher complementarity of national varieties is able to dampen the emergence of a production pattern according to comparative advantage. The dynamic aspect of this sensitivity reveals itself in the evolution of the local rates of skill accumulation. Lower substitutability implies a less severe divergence in accumulation rates, given that it implies a weaker trade-induced pressure on national wages of skilled workers to equalize. In comparison, the less skill-abundant country can hence maintain a substantially higher wage offer for employees offering a certain level of performance. This allows this country still to partially compensate its efficiency lag with regards to schooling.

Concerning the analysis of migration incentives, it is obviously important to tell in how far a similar impact of intrasectoral specialization on convergence can be verified after taking the effect of this wage gap sensitivity on migration opportunities into account. In this light, figure 4.2 documents responses to the same shock as before, but this time for different values of  $\sigma^j$ .

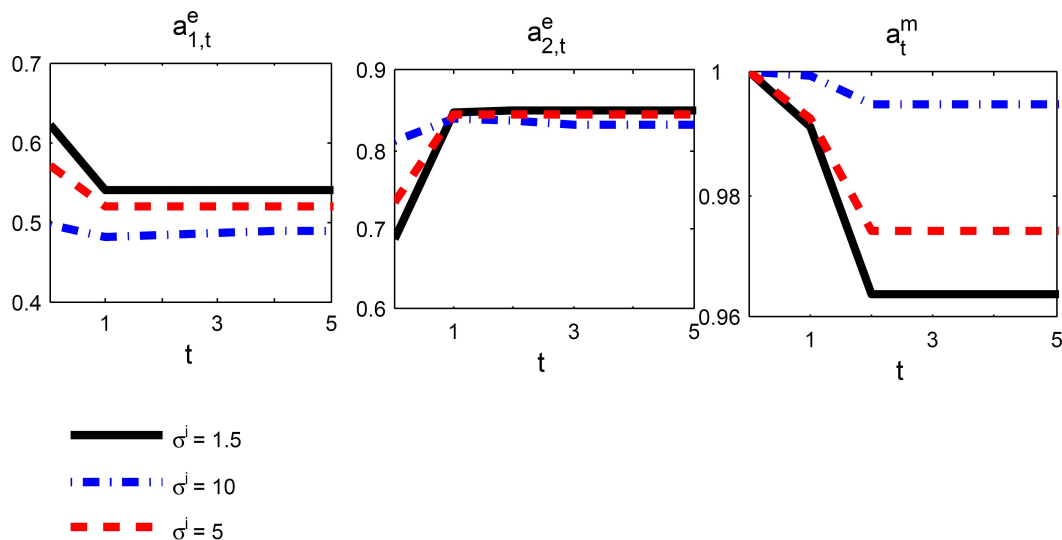


Figure 4.4: The impact of reducing migration barriers for different degrees of product differentiation

It is evident that the effects of a reciprocal opening of labour markets correlate with the extent of national product differentiation in a way contrary to what has been ascertained in the context of integrating commodity markets. If consumers perceive goods of distinct origin to differ in significant aspects here, the market-opening is revealed to have particularly strong implications for the measures under consideration.

With respect to migration, this manifests itself in a comparatively extensive decline of the minimal talent requirements and hence in a very strong migration wave. Consistent with this, adjustments of educational incentives are also of more significant scale for lower  $\sigma^j$ , as these are again made against the background of shifts in competitive pressure on national labour markets resulting from selective migration. Here, the strength of these shifts is positively related to the ability of firms to enforce international within-sector price differences. Since worker heterogeneity ensures the dominance of the migration-related effects over schooling choices, this produces the picture of a convergence process whose

magnitude is positively related to the extent of national product differentiation.

As stressed above, the cause underlying this observation is here again to be found in the growth of the price differential across national varieties that can be witnessed when these varieties address increasingly distinct needs. As this in turn implies the existence of more room for wage rates to differ, a higher price differential creates a higher potential for cross-border flows of skilled labour. The process of within-sector specialization hence does also in this respect exhibit effects contrary to those of sector-wide specialization. If the elimination of barriers to trade is indeed likely to deepen the extent of intraindustry as opposed to interindustry trade, as been suggested by empirical evidence (Greenaway (1991), Egger et al. (2008)), this hence reduces the burden associated with trade integration in even two ways. Adverse specialization, which slows down skill accumulation, is curbed and at the same time immigration of badly needed professionals promoted.

Having demonstrated how trade-related restructuring affects migration incentives, it remains to be clarified how it impacts on factor allocation within countries. For this purpose, we investigate how the long-run evolution of sectoral production patterns is related to the permeability of borders with respect to qualified labour. Figure 4.3 reports the corresponding results for country 1's sectoral shares in worldwide production expressed in market value for the given sectors.

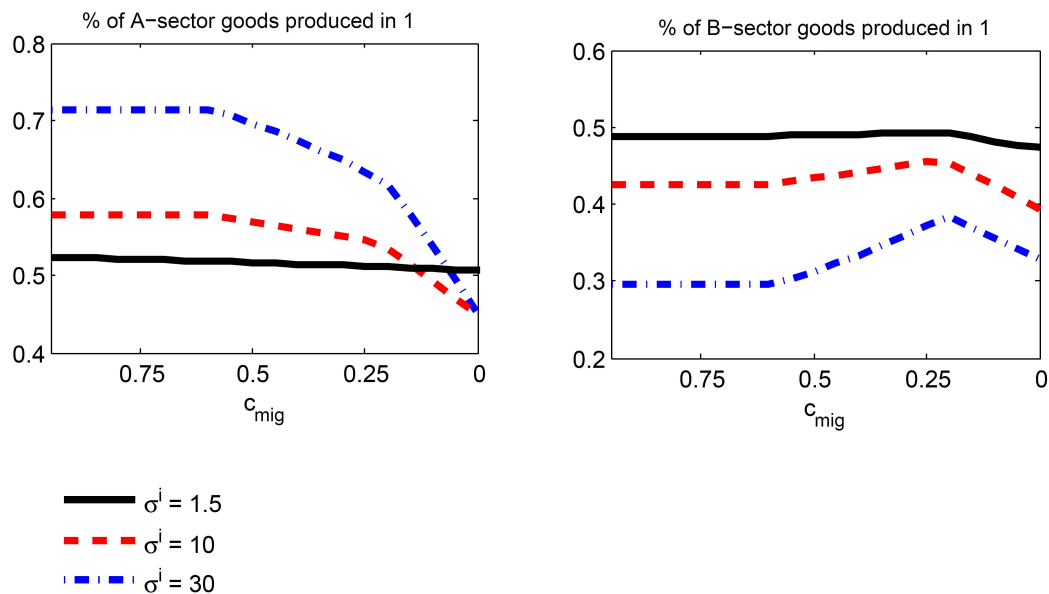


Figure 4.5: Long-run effects of facilitating migration on the sectoral structure

It turns out that skilled migration contributes to an erosion of the schooling-based cross-country distribution of comparative advantage. With shrinking migration costs, the value of *A*-sector varieties produced in country 1 makes up a decreasing share of the worldwide production value of skill-intensive goods in steady state. Instead, resources in 1 are increasingly shifted to the less skill-intensive *B*-sector in response to the outflow, up to a point at which the loss of skilled labour is strong enough to reduce country 1's production share in both sector. In this regard, migration also tends to partly neutralize the production patterns resulting from trade. This implies for the sending country that, in addition to a direct loss of professionals, also indirect adverse effects in terms of foregone positive externalities associated with knowledge-intensive production could arise.



If national varieties are highly substitutable, this effect is particularly pronounced, as under these conditions sectoral specialization is especially intense. In response to an increase in the salaries of skilled workers resulting from migration-induced scarcity, the price increase for country 1 varieties has in this situation an especially strong detrimental impact on demand as a result of tough price competition. Accordingly, one can also witness more serious shifts in production than for the case of highly complementary varieties, where wage increases can to a larger extent be passed on to consumers without suffering from a significant drop in market share.

Finally, the evolution of regional income differentials at the individual level deserves some separate comments. In the preceding elaborations, wage convergence was always referred to in terms of an equalization of payments received by employees for offering an equivalent skill bundle to their employers. In an approach adopting the simplistic view of homogeneous skilled workers, this would essentially tell the whole story. The way our model is constructed, however, points to the fact that neither a trend towards equalization of actual average wages paid to skilled workers in different regions nor towards convergence of the regional distribution of labour income as a whole necessarily has to follow. Since emigrants represent a positive selection of the sending countries reservoir of skilled labour, amplified outflows are capable of raising comparable wage rates and at the same time lowering the average income of schooling graduates in the economy. Applying the same thought to wage fluctuations in an immigration country yields the reverse constellation: The inflow of the foreign elite may cause a downward shift in the local skill premium which would hurt native workers. However, if immigrants are more productive, this may outweigh this fact and average wages might actually rise in response to immigration.

## 4.6 Conclusion

Our contribution primarily consisted of adding two essential features to a dynamic Heckscher-Ohlin trade model with skill accumulation: First, imperfect substitutability in commodities at a national level, allowing us to assess the impacts of intra- relative to intersectoral trade. An additional merit of this feature was that it set the stage for the introduction of the second one: international migration of high-skilled labour.

As a first important result, we had demonstrated that trade integration as such maintains in the presence of product differentiation its adverse impact on school participation for countries with a relatively low level of educational productivity within the integration area. This further amplifies their tendency to specialize in low-tech goods with potentially little prospect of upgrading the economies general technology standards through learning externalities. In this respect, constant improvements in the quality of knowledge generation should represent from the perspective of both small and large developing economies important steps in limiting the risk of entering a development trap after market integration.

A qualitative change to the results of the standard model with homogeneous goods then follows from introducing skill-biased labour mobility: Due to the incomplete convergence in national wage rates paid to professionals, trade does not eliminate migration incentives as long as the costs of border-crossing are limited, these two faces of globalization hence do not represent perfect substitutes in this extended framework.

Moreover, cross-border flows of skilled workers do not only represent temporary dise-

equilibrium phenomena in our approach, but instead take the form of persistent long-run patterns. The consequences of this fact for the development perspectives of an economy are then crucially dependent on the initial technological level of this economy in relation to the rest of the trading world. We were able to show that a small, technologically inferior developing country facing a reduction of entry barriers for its high-skilled graduates to foreign labour markets is predicted to suffer from an unambiguous decline of the skill intensity of the domestic workforce, despite a simultaneous surge of educational participation, a mismatch that can again be traced back to the dominance of the effect of positive migrant selection. What is being added by switching to a multisector perspective is the opportunity to show that such a “brain drain” is predicted to have additional and probably likewise harmful implications for the structure of trade and production, as the withdrawal of embodied skill further drags the country into unbalanced specialization in (and exporting of) unskilled labour-intensive goods.

In contrast, with respect to the effects of reducing migration barriers between trading countries of similar size and technological level, our approach assigns to skilled labour mobility the role of a source of convergence. Professionals move from the country with the more to the country with the less efficient educational system in order to avoid domestic competition. This is the case even though country-wide differences in educational participation rates are further amplified in return.

Concerning the role of diversity among the varieties traded, increasing complementarity in combination with fostered intraindustry trade was revealed to promote convergence in even two ways: First, by allowing firms in lagging countries operating in the less competitive high-skill sector to charge higher equilibrium prices and hence to offer a higher remuneration to their skilled staff. This, in turn, encourages skill acquisition and leads to some degree of sectoral despecialization, raising the skill content of domestic production. Second, by affecting the volumes of migratory flows of skilled labour, enhanced investments into product differentiation are additionally supporting the emergence of a less skewed international distribution of skill. Interestingly, this holds for both setups under consideration, albeit in a notably distinct manner: From the perspective of a small developing economy lagging behind in educational productivity, intrasectoral trade has a beneficial impact on its aggregate skill reservoir, as the improved market position of domestic firms in the skill-intensive sector creates better employment opportunities for the domestic elite.

In the 2-country setup, on the contrary, it is the reverse effect on migration incentives that contributes to a partial erosion of the gap in national skill endowments. Here, skilled migration from the more to the less skill-abundant country is fostered, as the contraction of skill-intensive production in the skill-abundant country further sharpens domestic competition between graduates. This raises the international wage gap in favour of professional in the skill-scarce country, which mitigates the impact of persistent differences in educational productivity.

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## 5 Final summary

The central aim of this work was to demonstrate in how far the optimistic view of parts of the 'brain drain' literature on emigration incentives is challenged when some of the most rigid common assumptions within the structure of their models are relaxed. As a first important result, it turned out that the claim of a possible long-run net increase of a sending country's intellectual resources as a consequence of raising school participation can no longer be maintained when emigration is the result of a self-selection process. Besides, by dropping the assumption of perfect substitutability between workers of different skill, we revealed the existence of a second channel through which an increased outflow of professionals exerts a positive impact on school participation: It reduces the productivity of unskilled workers and thus the opportunity costs of education faced by young workers. In this way, the extent of the loss of skilled manpower is closely related to the degree of skill complementarity.

Concerning the welfare impact of this loss at the individual level, combining wage flexibility with heterogeneity in talent was shown to result into a welfare pattern richer than the ones obtained in models with homogeneous workers. Most importantly, we had seen that not all agents self-selecting into schooling as a consequence of a decline in migration costs are necessarily better-off than before the shock. The reason is that the increase in skilled worker remuneration is met by a drop of the wage rate received by manual labour, which depresses the first-period income of skilled workers.

As a policy remedy, we discussed the imposition of a proportional income tax used to finance a lump-sum subsidy to education. Within our policy experiment, results at both the aggregate and the individual level were shown to be quite sensitive to the question whether this subsidy is complemented by a repayment obligation in case of outmigration. First, assuming the ability to enforce such a repayment scheme turned out to lead to a more favourable outcome with respect to aggregate domestic supply of human capital in efficiency terms. Second, it attenuates the increase in individual inequality associated with the introduction of this tax scheme, as it forces the most skilled of all graduates to make a contribution to the next generation's educational support as well.

Finally, in the last chapter we had seen that the adverse net impact of skilled worker emigration on human capital is maintained in a world with product differentiation. There is also a close interrelation with the degree of sectoral specialization in the sense that increased outmigration amplifies the specialization in low-skilled products and vice versa. For the future, this opens up new avenues for empirical research by linking trade data with migration data.