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Blue Cards, Blue Prospects?[1]

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Recently, the European Commission has proposed to introduce a new migration policy instrument - Blue Cards - to attract highly skilled workers from abroad by lifting labour market restrictions, offering financial and housing benefits. The excludability character of human capital suggests that what is beneficial for receiving countries might be harmful for sending countries. This article investigates if and why high-skill migration in general and Blue Card scheme in particular might be harmful for sending countries. We find that the proposed Blue Card scheme makes the developing country growth prospects indeed blue. However, compared to other forms of labour migration, the upcoming Blue Card scheme is known well in advance. Analysing alternative policy options we show that, taking advantage of this ex-ante information, targeted and timed policy interventions can minimise the adverse impacts of high-skill emigration. Thus, compared to other migration regimes Blue Cards are worse for sending countries, but they offer better opportunities for them to avoid the adverse impacts.

Keywords: High-skill migration, innovative capital, economic growth.
JEL classification: F02, F22.

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1 Introduction

In October 2007 the European Commission adopted a controversial legislative proposal in the area of economic migration. The proposal aims at establishing a Framework Directive for admitting highly qualified workers to the EU by creating a special Blue Card for third country nationals. With the EU Blue Card scheme the European Union wants to attract the best-qualified labour from the developing world, which is increasingly important to overcome labour shortages in the ageing European Union. For example, the scheme proposed by the European Commission would offer skilled candidates a fast-track procedure to obtain work permits,[2] it would be made easier for them to work in another EU country, have their family join them, receive public housing and get long-term residency status.

The proposed Card has two sides, however, and has already provoked controversial political discussions in the short period since its proposal in October 2007. On the one side, the skilled labour attracted to the EU will certainly boost European competitiveness and economic growth. This is clearly expressed by the President of European Commission *José Manuel Barroso*:

"Skilled labour migration into Europe boosts our competitiveness and therefore our economic growth. It also helps tackle demographic problems resulting from our ageing population. This is particularly the case for highly skilled labour. With today's proposal for an EU Blue Card we send a clear signal: highly skilled migrants are welcome in the EU!" (October 2007)

The other side of the Card is that it might harm the less developed sending countries (LDC), as it will increase the brain drain from developing countries and make it even more difficult for LDC to improve their innovative capital which, according to recent growth theory findings, is one of the key drivers of the long-term economic growth. Although, these and other potential impacts for the sending country competitiveness and economic

[2]In order to qualify for a Blue Card, the migrant worker would need an EU job contract of at least one year guaranteeing a salary of at least three times the minimum wage in the country concerned plus health Insurance.

growth is a largely neglected issue in the EU receiving countries, the EU Blue Card proposal has been sharply criticised in the developing world. The Moroccan international economic law professor *Tajeddine El Husseini* brings it on the point:

"This is a new form of colonisation, of discrimination, and it will be very hard to find support for it among southern countries. Developing countries spend a lot of money educating and training technical students and then in the end the northern countries will cream off the best... it is a big mistake and a criminal act of the north to drain the south of its brainpower." (October 2007)

Given that population migration is not a new phenomena - it has existed for many centuries in various forms and in one way or another has affected most regions around the world - why would the EU proposed Blue Card cause so different reactions? Indeed, people have been leaving poor countries not only to the EU member states, but also to developed countries in North America and Asia-Pacific. The proposed Blue Card scheme in the EU, however, is much more complex migration policy than simply opening 'doors' for (poor) people from the developing world. It will not only relax quantity restrictions, which is already harmful enough for the sending countries, in addition, the EU Blue Card will also distort the self selection of migrants and disturb migration incentives arising from labour market prices and migration costs.

In view of these and other controversies, the proposed Blue Card raises several questions in LDC. For example, what kind and size of socio-economic impacts of skilled worker emigration can be expected? What are the best policies to cope with these migration-induced effects? Because of the high relevance of these issues on developing country growth prospects, the present study tries to answer these questions. The main objective of this study is to systematically analyse potential impacts of the proposed Blue Card scheme on the key drivers of economic growth in the less developed sending economies and, based on the gained insights, to suggest appropriate policy instruments for dealing with externalities caused by skilled worker emigration.

The rest of the paper is structured as follows. In section 2 we graphically analyse how

skilled labour migration affects the key determinants of national innovative capital: the number of workers acquiring skills through education, long-run net migration of skilled workers, domestic knowledge creation activities, and international knowledge spillovers. Section 3 proposes and analyses policy options for dealing with adverse impacts of skilled labour emigration, and section 4 concludes.

2 The impact of high-skill migration on sending country innovative capital

In this section we investigate the impact of high-skill emigration on the key drivers of economic growth in LDC. Applying the innovative capital framework,[3] we show graphically and analyse theoretically how skilled labour migration affects LDC innovative capital: the number of workers acquiring skills through education, long-run net migration of skilled workers, domestic knowledge creation activities and international knowledge spillovers. We assume that the LDC sending country is less developed than the EU receiving country (EU) and hence wages in LDC are lower than in EU. Wage differences, $w_H^{R*} > w_H^{S*}$,[4] trigger worker migration - driven by higher expected earnings in receiving country, skilled workers migrate from LDC to EU. Migration induces adjustments in innovative capital formation, which we analyse now.

2.1 Migration impact on education

We start with long-run open-economy education equilibrium, which determines the number of workers acquiring skills through education. The departure point of the long-run education equilibrium analysis is Figure 14 in the Appendix, where the equilibrium share of workers obtaining education is given by L_H^{S*} and the equilibrium wage rate for educated labour is given by w_H^{S*}. Here we explicitly account for migration-induced adjustments in education equilibrium. More precisely, we distinguish between three sources of

[3] The underlying innovative capital framework is presented in the Appendix.

[4] The LDC sending country is denoted with superscript S and the EU receiving country with superscript R. Similarly, skilled labour is denoted with subscript H (human capital) and unskilled with subscript U (unskilled).

adjustments: changes in skilled/unskilled wage ratio at home, skill downgrading effect in EU, and education cost heterogeneity effect. A fourth source of migration-induced adjustments in education equilibrium is remittances, if liquidity constraint in LDC is binding.

First, we consider changes in relative wages in LDC. If only skilled workers migrate or, alternatively, if more skilled workers migrate than unskilled ($L_H^S/L_U^S < L_H^m/L_U^m$), then the ratio of skilled/unskilled workers will decrease in LDC. A declining supply of skilled labour compared to unskilled labour supply will exert an upward pressure on wage rate for skilled labour. Increased skilled/unskilled wage gap will induce additional unskilled workers to obtain education. Thus, home wage adjustments will increase the long run education equilibrium in LDC. The education effect of skilled/unskilled wage ratio is shown in Figure 1. Without migration the equilibrium wage of skilled labour is $w_H^{S'}$ and the equilibrium wage of unskilled labour is $w_U^{S'}$. With migration the skilled labour wage increases to w_H^m. The wedge between skilled and skilled labour wage increases.[5] Because of higher skill premium, more workers obtain education.

Second, we analyse the impact of EU destination country wage effect on worker education decision in LDC.[6] According to empirical evidence from the Western European and North American destination countries (*Salt* 1997), only a small part of highly skilled immigrants are employed in skilled jobs. The majority of skilled migrants from LDC work in sectors and jobs requiring little qualification, such as agriculture, transport or construction.[7] Skill downgrading of migrant work in EU affects the education decision of unskilled workers in LDC. Because the majority of skilled migrants are employed in unskilled jobs abroad, a international reduced skill premium creates disincentives for unskilled workers to enter education and acquire skills. As a result, less unskilled workers want to become skilled.

[5]The exact magnitude of this wage ratio effect depends on the elasticity of unskilled labour demand. In Figure 1 the elasticity of unskilled labour demand is assumed to be infinitely elastic. If the elasticity of unskilled labour demand is inelastic, then the change in skilled and unskilled labour wage is the same for both.

[6]Given that the acquired knowledge of skilled workers is largely wasted, in the migration literature this effect is often referred to as a 'brain waste'.

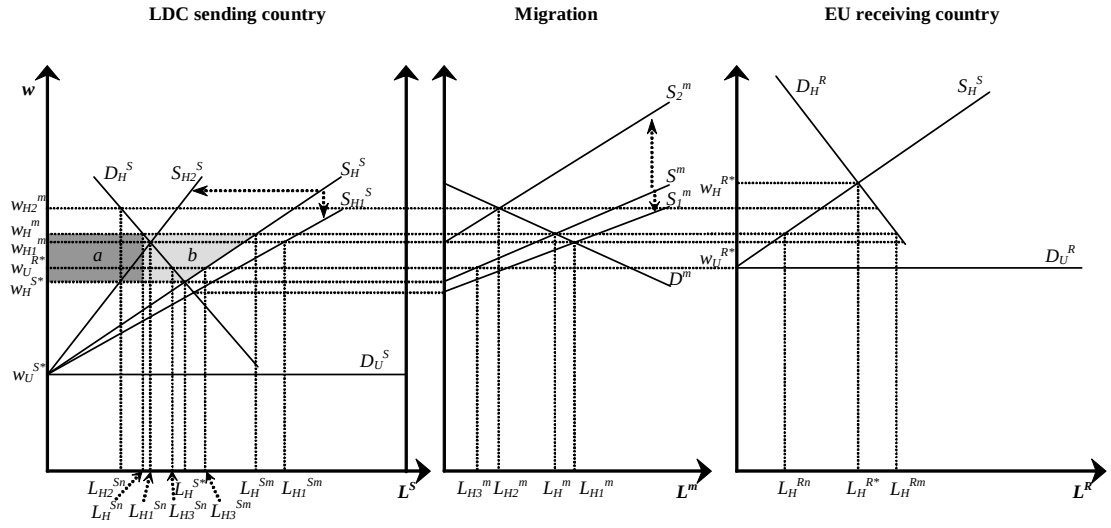
[7]Data from the US and Swiss censuses show that because of labour segmentation in destination countries only about one third of migrants from the Balkans with tertiary education have obtained skilled jobs.

Thus, foreign wage signal will decrease the equilibrium education in LDC. The skill downgrading effect is shown in Figure 1. Assuming that illegal skilled migrants qualify only for unskilled jobs in EU, the skilled labour wage in LDC is equal to the unskilled labour wage rate in EU, i.e. to $w_U^{R\uparrow}$, which is determined by intersection of skilled (illegal) migrant supply, S^m, and skilled migrant labour demand, D^m, and equilibrium migration is equal to L_{H3}^m. The stock of skilled labour in EU is not affected by migration. Given that all skills coming from LDC are wasted in EU, compared to the EU Blue Card migration, where skilled migrant workers were employed in skilled jobs, LDC gains from illegal migration (and the associated brain waste) in terms of human capital in LDC: there is less migration $\downarrow L_{H3}^m$ $(\downarrow L_H^m)$ and more skilled workers stay LDC $\uparrow L_{H3}^{Sn}$ $(\uparrow L_H^{Sn})$. However, the incentives for acquiring education in LDC also decline, because wage rate of skilled labour is lower in the case of emigration $\downarrow w_U^{R\uparrow}$ $(\downarrow w_H^m)$. As a result, less workers obtain education $\downarrow L_{H3}^{Sm}$ $(\downarrow L_H^{Sm})$.

Next, we look at the impact of worker ability heterogeneity. Workers are not equally talented; they are highly heterogeneous in their ability to acquire education. In Figure 1 worker heterogeneity is represented by the slope of the skilled labour supply curve, S_H^S. The utility maximisation of workers implies that, in the presence of positive costs of education, only the most talented obtain education. This in turn implies that, on average, those workers which were unskilled before migration started, are less talented than skilled workers who have first obtained education, suggesting that acquiring skills through education will be more costly for the remaining unskilled workers. As a result, after emigration of the most talented workers, LDC will have less skilled workers in equilibrium than before migration. Thus, in the presence of worker heterogeneity, the emigration of skilled workers has an additional negative impact on human capital creation through education. The effect of education cost heterogeneity can bee seen in Figure 1. With migration the wage rate of skilled labour increases which allows more individuals to acquire education. Before migration the stock of skilled labour is $L_H^{S\uparrow}$, whereas with migration the stock of human capital increases by $L_H^{Sm} \nwarrow L_H^{S\uparrow}$. Because the education cost

curve, S_H^S, is upward sloping, the average cost of education after migration is higher, $w_H^{S'} < w_U^{S'}$ $EC' < EC^m$ $w_H^m < w_U^{S'}$. As a result, for less workers it pays to enter education.

Figure 1: The impact of migration on education



Finally, we consider how education equilibrium in LDC is affected by worker emigration when liquidity constraint is binding. The key aspect here are rents which emigrants receive in EU and, as other groups of migrants, remit part of their income received abroad to their families in LDC. According to *Cox* (1987), skilled worker remittances differ from unskilled worker remittances in at least two respects: quality and quantity. On the one hand, highly-skilled migrants remit less than unskilled because skilled migrants are more likely to settle and to reunite with their family in EU. On the other hand, in contrast to unskilled worker remittances, which are mostly spent for consumption goods, remittances of skilled migrants are more often invested in production, fixed assets and education (*World Bank* 2000). These findings suggest that skilled worker remittances may move upward or completely remove the liquidity constraint of education. As a result, more workers, particularly those which were restrained from education by the liquidity constraint, are able to acquire skills

through education.[8] The effect of remittances is shown in Figure 1. Migration leads to an increase in worker welfare by area ab. Workers welfare increases because of remittances (area b) and because of higher skilled labour wage in LDC (area a). However, remittances can also cause apposite effects. First, more recourses alleviate credit constraint of individuals which in the long-run increases the education attainment (*Edwards* and *Ureta* 2003). The result is a shift of labour supply from S_H^S to S_{H1}^S and migration from L_H^m to L_{H1}^m, with L_H^m 🖫L_{H1}^m. In the same time, because of lower skilled labour wage the skilled labour stock in LDC increases from L_H^{Sn} to L_{H1}^{Sn}, with L_H^{Sn} 🖫L_{H1}^{Sn}. Second, the moral hazard problem may reduce education attainment (*Chami*, *Fullenkamp* and *Jahjah* 2003). In Figure 1 the supply of skilled labour decreases from S_H^S to S_{H2}^S and migration from L_H^m to L_{H2}^m. LDC's human capital stock decreases from L_H^{Sn} to L_{H2}^{Sn}, with L_H^{Sn} ☢L_{H2}^{Sn}.

Summarising findings of this section we may conclude that, when accounting for induced effects triggered by skilled worker migration, the long-run education equilibrium will likely be affected by four sources of induced adjustments in education equilibrium: changes in skilled/unskilled wage ratio in LDC, skill downgrading effect in EU, education cost heterogeneity, and the impact of remittances on liquidity constraints. Given that two effects (the first and the fourth) have a positive impact on worker education, and two negative (the second and the third), it is impossible to a priori determine sign of the relationship between skilled worker emigration and the number of workers acquiring skills through education. Moreover, for LDC a more important question is whether the newly skilled workers stay in LDC or emigrate, which we consider next.

2.2 Long-run net migration

Next, we consider induced feed-back effects of migration, which determine the long-run net migration of skilled labour. The departure point of our analysis is Figure 15 in the Appendix, according to which the equilibrium migration is determined by a trade-off between expected increase in earnings and migration cost. In the long-run migration

[8] According to the *World Bank* (2000) about 80% of remittances in Albania go to poor households.

induces adjustments in relative wages, which affect the equilibrium migration through several channels. In addition to the direct brain drain effect, in this section we also investigate the induced second-round migration effects: changes in relative wages in LDC and EU and changes in migration costs.[9]

Before considering the induced effects, we summarise the direct brain drain effect of skilled worker emigration on human capital stock in LDC. As above, because of exogenous cross-country wage differences skilled workers migrate from low wage LDC to high wage EU. The direct and most visible effect of skilled worker migration is transfer of human capital embodied in labour.[10] Assuming, that skilled migrants transfer only embodied private productive skills, the excludability character of human capital suggest that the stock of human capital in LDC is monotonically declining in skilled worker emigration. The direct brain drain effect on LDC's human capital can bee seen in Figure 2, where migration is equal to L_H^m (middle panel). In equilibrium, LDC has less skilled workers, L_H^{Sn}, with L_H^{Sn} 🖫$L_H^{S^{\circ}}$, compared to pre-migration.

In the long run, skilled worker migration affects wages in LDC and EU and migration costs, which in turn affect the migration decision itself. As pointed out in section 2.1, the emigration of skilled workers will reduce labour supply in LDC. If labour demand does not change,[11] a decreasing labour supply will exert an upward pressure on wages in LDC. This implies that changes in LDC's wages will narrow the migration-driving wage gap between LDC and EU, implying less migration in the long-run. Thus, wage flexibility has a positive impact on human capital stock in LDC.

According to *Borjas* (1994), international labour migration affects not only wage rate in sending but also in receiving country. The immigration of workers increases labour supply in EU, which will exert a downward pressure on wages. Lower wages in EU will narrow

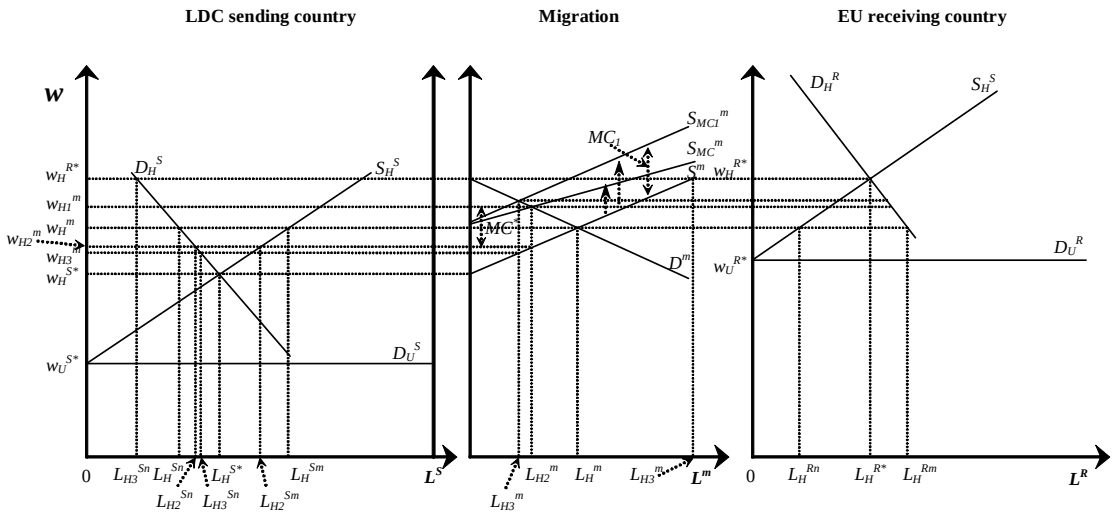
[9]In reality, there much more forces at work. For example, the economic geography and urban systems literature stress that because of agglomeration economies, firms in the larger region will be able to pay higher wages attracting in such a way even more workers. We abstract from these effects, as we think that at international scale they are less pronounced.

[10]Given that the human capital embodied in skilled workers is draining out of country, in the migration literature this effect is often referred to as a 'brain drain'.

[11]This assumption is more likely to hold for tradable goods sectors than sectors producing non-tradable goods.

the migration-driving wage gap between LDC and EU. Smaller wage differences will in turn attract fewer migrants. Less emigrating skilled workers imply higher human capital stock in LDC. Thus, we may conclude that wage flexibility in EU has a positive impact on human capital stock in LDC.

Figure 2: The long-run migration equilibrium



Both wage effects on high-skill migration are shown in Figure 2, where migration equalises the wage rate between LDC and EU. The wage effect depends on LDC's size - the larger is the sending country, the bigger is the wage effect in EU. Migration from large LDC decreases the skilled wage in EU from to $w_H^{R'}$ to w_H^m (left panel in Figure 2). In LDC the wage rate increases from $w_H^{S'}$ to w_H^m. In equilibrium the wage rate for skilled labour, w_H^m, is equal in both countries and migration equals to L_H^m. Because of LDC and EU wage effects, equilibrium migration is lower than it would be without wage effects, as in the case of a small sending country. If LDC is small then labour migration does not affect skilled labour wage in EU. In this case, skilled labour wage in EU would be equal to $w_H^{R'}$, both with and without migration, and skilled labour migration equals to L_{H3}^m. Compared to a large LDC less skilled workers stay at home, L_{H3}^{Sn}, with L_{H3}^{Sn} $L_H^{S'}$. Thus, if LDC is small, the equilibrium migration is higher than if LDC is large L_{H3}^m L_H^m.

Workers care not only about the wage they may receive in EU but also about costs related to migration (*Sjaastad* 1962). Thus, workers trade the expected income increase off these costs. Workers migrate if the expected benefits arising from migration are higher than migration costs.[12] According to *Carrington*, *Detriagiache* and *Vishwanath* (1996), migration costs are decreasing in migrant stock from LDC in EU. Declining migration costs in turn widen the net wage gap between LDC and EU attracting more migrant workers. The effect of migration cost on skilled labour migration is shown in Figure 2. Equilibrium migration with zero migration cots, MC, is L_H^m. With positive migration costs, the net wage difference between LDC and EU decreases. In Figure 2 this is reflected by the shift of skilled labour migration supply from S^m to S_{MC}^m. The difference between S_{MC}^m and S^m represents migration costs. The two curves, S^m and S_{MC}^m, are not parallel because of decreasing migration costs with increasing migration (*Carrington*, *Detriagiache* and *Vishwanath* 1996). In equilibrium the migration cost is MC^* and migrants receive the net wage equal to $w_{H2}^m = w_{H1}^m - MC^*$. The net wage with migration costs, w_{H2}^m, decreases relative to the wage without migration costs, w_H^m, with $w_H^m > w_{H2}^m$. The wage decrease is stronger the higher is the elasticity of skilled labour migration demand, D^m, i.e. the smaller is the effect of skilled labour migration from LDC on international skilled labour wage. The number of migrating workers decreases from L_H^m to L_{H2}^m, with $L_H^m > L_{H2}^m$ and skilled labour in LDC increases from L_H^{Sn} to L_{H2}^{Sn}, with $L_H^{Sn} < L_{H2}^{Sn}$.[13]

Summarising the potential impacts of skilled labour migration we find strong support to previous literature (*Beine*, *Docquier* and *Rapoport* 2001; *Lowell* and *Findlay* 2001; *Lucas* 2004; *Katseli*, *Lucas* and *Xenogiani* 2006) that brain drain is strictly negative for human

[12]Migration costs include not only the physical relocation costs but also employment uncertainty (which is higher abroad than at home), social costs of leaving family and/or friends behind, cultural adjustment costs etc.

[13]With constant migration costs MC_1 skilled labour migration supply shift from S^m to S_{MC1}^m. Because of constant migration costs, now the two curves S^m to S_{MC1}^m are parallel. The net wage is w_{H3}^m, and the number of migrants is equal to L_{H3}^m, which is less than migration with decreasing migration costs, $L_{H3}^m < L_{H2}^m$. The stock of skilled labour in LDC is equal to L_{H3}^{Sn}, which is higher than with decreasing migration costs, $L_{H3}^{Sn} > L_{H2}^{Sn}$.

capital stock in LDC. In addition we show that the long-run migration impact on the human capital stock in LDC is determined by three additional forces which are not present in the short run: LDC's wage effect, EU's wage effect, and changes in migration costs. Adjustments in LDC's wage rate and destination country's wage rate have a negative impact on migration and, hence, a positive impact on human capital stock in LDC. In contrast, declining migration costs magnify the direct brain drain effect which, as discussed above, is negative for human capital stock in LDC.

2.3 Migration impact on innovation

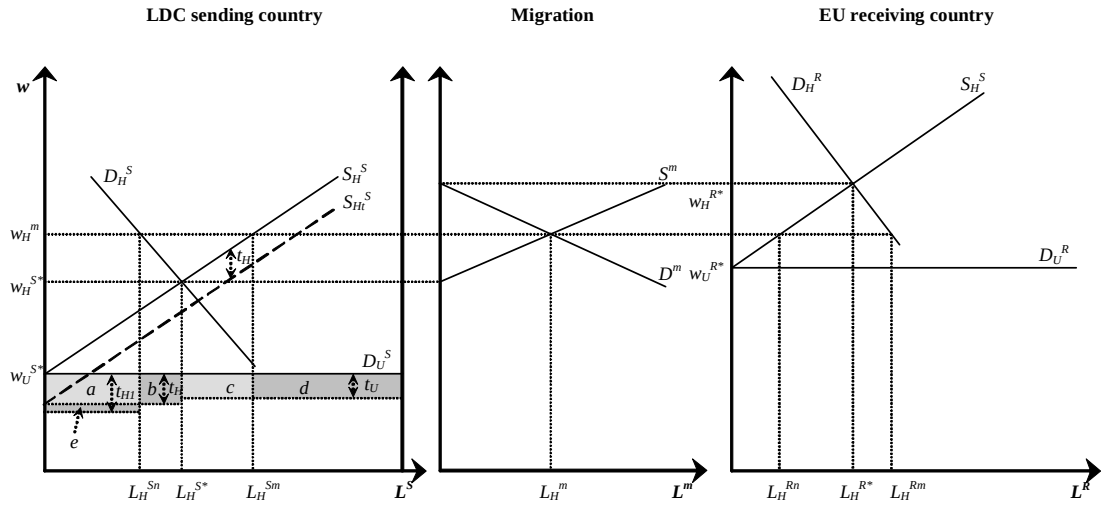
This section analyses the impact of skilled labour migration on long-run innovation equilibrium which determines the amount of domestically created knowledge. The two key determinants of national R&D activities is size of budget (government revenue) and budget share spent on R&D. We show that skilled labour migration affects both size and structure of government budget which in turn implies that the emigration of skilled workers affects the long-run innovation equilibrium. In addition, migration affects also the R&D efficiency of remaining workers.

We start with migration impact on size of government budget by considering the impact of highly skilled labour migration on government revenue. Before migration all workers contribute to government budget through tax payments. After migration less skilled workers contribute to LDC tax revenue. Given that, on average, skilled workers are higher net contributors than unskilled workers, government revenue decreases due to fewer taxpayers.[14] Lower tax revenue reduces government budget allowing for less expenditure on science, research and development, which in turn slows down the accumulation of knowledge capital. The fiscal effect of migration is shown in Figure 3. Assume that the wage which workers receive includes also taxes. The absolute value of taxes paid by skilled and unskilled workers is t_H and t_U, respectively, where $t_H \neq t_U$. If taxes are paid as a fixed rate of the gross wage then the absolute value of tax paid by skilled labour with

[14]Because on average the wage rate for skilled work is higher than for unskilled and the unemployment rate among skilled workers is lower, per capita, skilled workers contribute more to tax revenue than unskilled workers.

migration, t_{H1}, increases because of higher wage $w_H(1-t_{H1})$. Because the skilled labour wage increases with migration, the tax revenue increases by area e. The total tax revenue without migration is equal to area $abcd$, and to area ade with migration. With migration the number of individuals that pay taxes declines by $L_H^{Sm} - L_H^{Sn}$, hence the government tax revenue is reduced by area bc. If area bc is larger than area e, then tax revenue declines, otherwise it increases. The relative size of these areas depends on the size of brain drain effect, spillover effect, public technical knowledge transfer effect, unskilled labour productivity effect and remittance effect.

Figure 3: The fiscal effect of migration



Next, we show how skilled worker emigration affects the structure of government budget, i.e., the share of R&D expenditure. Because of emigration skilled worker share in the total workforce (and population) decreases whereas the share of unskilled workers increases.[15] Given that workers are also voters, the voting power of unskilled workers increases relative to that of skilled workers in the case of high-skill emigration. If political interests of the two

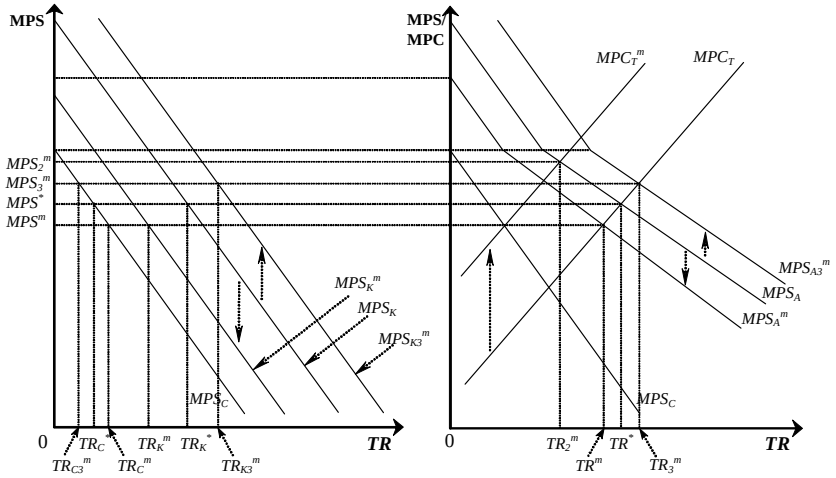
[15]The increasing share of unskilled workers results from the assumption that the ratio of skilled/unskilled migrants is higher than the ratio of skilled/unskilled domestic workforce (positive selection, *Borjas* 1987).

worker groups are different,[16] shifts in the relative voting power between the two worker groups will change the demand for specific policies which in turn may affect the structure of government expenditure in LDC. In the case of skilled worker emigration, a shift in relative voting power towards unskilled workers would result in a higher demand for social redistribution policies and less future-oriented investment (e.g. R&D expenditure). Lower government expenditure share on research and development would in turn slow down the accumulation of knowledge capital in LDC.

The migration impact on government expenditure structure is shown in Figure 4. In equilibrium without migration marginal political support is equal to marginal political costs and the total policy transfers are TR°. The equilibrium redistributive and growth related policy transfers are TR_C° and TR_K°, respectively, where $TR_C^{\circ} \leq TR_K^{\circ} \leq TR^{\circ}$. With migration the stock of skilled workers declines hence reducing the number of individuals who would benefit from growth oriented polices. This implies that public spending on knowledge will produce smaller political support with migration than without migration. In Figure 4 this effect shifts curve MPS_K down to MPS_K^m. Additional public money spent on knowledge creation will produce less additional political support. Consequently the aggregate marginal political support shifts down as well from MPS_A to MPS_A^m. The equilibrium marginal political support is MPS^m and the equilibrium total policy transfers decrease from TR° to TR^m. This implies a reallocation of public spending between transfers on knowledge creation and redistributive transfers. The equilibrium redistributive transfers increase from TR_C° to TR_C^m, while growth related transfers decrease from TR_K° to TR_K^m, because of decrease in relative political benefits from knowledge and redistribution. Migration affects also marginal political costs, MPC, because the number of individuals that pay taxes is reduced which requires higher tax rates to rise the same government budget as before migration. In Figure 4 this effect shifts the marginal political cost curve from MPC_T to MPC_T^m. Comparing to the pre-migration situation, with migration the equilibrium transfers decline from TR° to TR_2^m, because it is politically more expensive to rise taxes.

[16]Usually, the demand for social redistribution policies is higher by low-paid unskilled workers, whereas the

Figure 4: The impact of migration on political equilibrium



Finally, we consider the scale effect of national R&D activities. According to the knowledge production function of *Romer* (1990), new knowledge is produced using existing ideas and human capital resources seeking out new ideas at a point in time as inputs (equation (3) in the Appendix). The earliest discoveries are those ideas that require the least amount of scientific knowledge. Subsequent discoveries are harder and require more resources. According to *Abdih* and *Joutz* (2006), the larger the number of people searching for ideas is, the more likely it is that duplication or overlap in innovation would occur. As a result, doubling the number of researchers, the number of unique ideas or discoveries is less than double, and halving are more than half. The duplication in research or the 'fishing out' effect might be offset by the 'standing on shoulders' effect (*Caballero* and *Jaffe* 1993). The decreasing returns of innovation output with respect to the number of people seeking out new ideas suggest that the emigration of skilled workforce might increase the innovative output per researcher.[17] In Figure 4 the marginal political support of public spending on knowledge shifts from MPS_K to MPS_{K3}^m. Consequently, the aggregate marginal political support shifts up from MPS_A to MPS_{A3}^m. The equilibrium marginal

demand for government investment in research and development is higher by skilled workers.

[17]The 'fishing out' hypothesis is consistent with the observation made by *Jones* (1995) that although the number of research scientists and engineers has increased significantly over the post-war period there has been no accompanying increase in the rate of economic growth in the U.S. economy.

political support is MPS_3^m and the equilibrium total transfers increase from $TR^{\P}$ to TR_3^m. There are important reallocation effects between policy transfers on knowledge creation and redistributive transfers. Because of higher relative political benefits from investment in innovation than from redistribution policies, the equilibrium redistributive transfers decrease from $TR_C^{\P}$ to TR_{C3}^m, while growth related transfers increase from $TR_K^{\P}$ to TR_{K3}^m.

Findings from this section suggest that skilled worker emigration affects both size and structure of government budget, as well as the efficiency of national R&D activities. This in turn implies that, at least indirectly, the emigration of skilled workers affects the long-run innovation equilibrium. If the share of skilled worker in migrant population is higher than in home population, and political preferences are different between skilled and unskilled workers, then both fiscal effects (size and structure) decrease the domestically created knowledge capital. In contrast, if the 'fishing out' effect dominates the 'standing on shoulders' effect (*Caballero* and *Jaffe* 1993), then the R&D efficiency effect has a positive impact on knowledge capital in LDC. These findings allow us to conclude that in the long-run skilled labour migration will likely reduce the total creation of knowledge capital but might increase the innovative capital output per worker in LDC.

2.4 Migration impact on knowledge spillover

This section analyses the impact of skilled labour migration on knowledge spillovers between LDC and EU, as it co-determines the amount of knowledge capital is available domestically. The equilibrium level of knowledge spillover is determined by two opposite forces: the advantage of country backwardness and country's absorptive capacity. Skilled worker migration affects the absorptive capacity through three channels: human capital capacity and 'adaptive' research capacity, and the cost of international knowledge transmission.

The availability of highly skilled workers largely determines country's capability to adopt foreign technology and to use imported ideas in own knowledge capital creation. *Eaton* and *Kortum* (1996) find that country's level of education plays a significant role in the ability to absorb foreign ideas. These results suggest that emigration of highly skilled workers

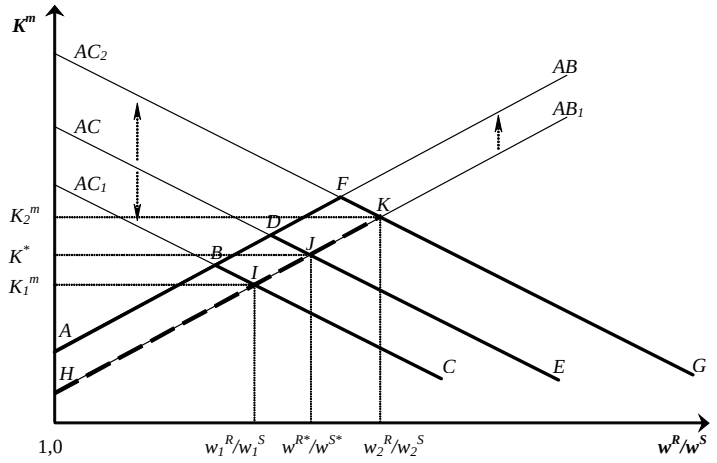
decreases country's ability to benefit from knowledge spillovers, because of less skilled and educated workers able to apple apply the incoming foreign knowledge.

In addition, country's absorptive capacity depends on investment in adoptive R&D which in turn depends on the size of domestic workforce (taxpayers).[18] According to *Geroski* (1995), the size of national R&D expenditure is important not only for own innovation production but also for 'adaptive' research activities, because in order to be able to adopt or improve the knowledge generated by other countries, a country has to invest in 'imitative' or 'adaptive' research activities. Indeed, *Geroski*'s argument has sample empirical validation. At firm level the econometric studies of *Cohen* and *Levinthal* (1989) illustrate that the firm's own R&D activity enhances its absorptive capacity of innovations generated by other firms. At country level *Guellec* and *van Pottelsberghe* (2001) tested this hypothesis by interacting foreign R&D with business R&D intensity for each country. Their results show that the impact of domestic R&D intensity on the elasticity of foreign R&D is positive and significant. These findings suggest that national absorptive capacity is increasing in 'adaptive' research activities and decreasing in skilled labour migration, which reduces tax revenue for such activities.

The effect of declining absorptive capacity is shown in Figure 5. With migration country absorptive capacity, AC, declines, because there are less skilled workers that can use the knowledge coming from EU. As a result, the AC curve shifts down from AC to AC_1. The knowledge spillover possibility frontier changes from HJE to HIC implying that there will be less knowledge exchange. Up to the relative wage w_1^R/w_1^S migration does not affect the knowledge spillover possibility frontier. Above w_1^R/w_1^S (i.e. if the country is poorer), the absorptive capacity, AC, and the knowledge spillover possibility frontier declines.

Figure 5: The impact of high-skill migration on knowledge spillover

[18]According to *Mansfield* (1981), on average imitation costs are about 65 percent of the original innovation costs.

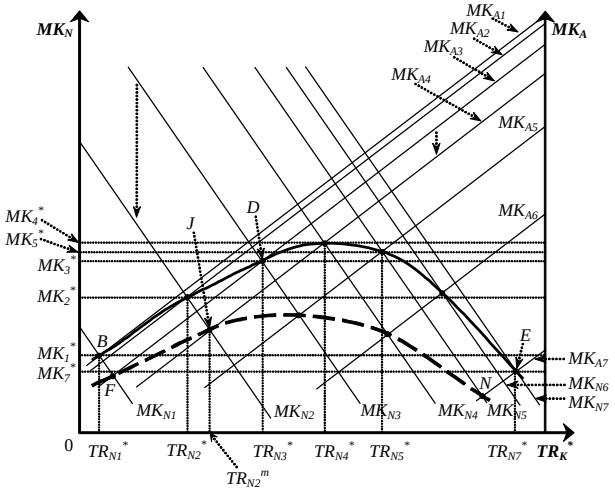


Next, we consider how skilled labour migration affects knowledge transmission costs. Among the first who employed patent citations for studying the issue of cross-border mobility of knowledge was *Jaffe et al* (1993). They find that a patent is typically 30 to 80 percent more likely to cite other patents whose inventors reside in the same country, than patents from other countries. This suggests that cross-border mobility of knowledge is limited and that knowledge spillovers are spatially localised. *Kapur* (2001) finds that skilled worker migration facilitates the spillover of knowledge through business contacts and spread of information in destination countries.[19] Based on these findings we may conclude that skilled worker migration increases knowledge spillover from migrant destination countries to their home countries. In Figure 5 lower knowledge transmission costs shift up the AB_1 curve to AB. The knowledge spillover possibility frontier shifts from HJE to ADE. The impact of decreasing knowledge transmission costs on knowledge capital can be seen in Figure 12. Assume that the initial skilled labour demand is D_{H1}^S, unskilled labour demand is D_{U1}^S and skilled labour supply is S_{H1}^S. Because of lower transfer costs more public knowledge is transferred to LDC, which increases productivity of skilled and unskilled labour. In Figure 12 the respective demand curves shift up from D_{H1}^S to D_H^S for skilled labour and from D_{U1}^S to D_U^S for unskilled labour. Because of unskilled labour wage increase, skilled labour supply shifts up from S_{H1}^S to S_H^S. As a result,

[19]In migration literature this effect is known as diaspora effect.

the wage rate for skilled labour increases from w_{H1}^{m} to w_{H}^{m} and migration decreases from L_{H1}^{m} to L_{Hm}^{m}, with L_{H}^{m} L_{H1}^{m}. Because of higher skilled labour wage, the skilled labour stock increases from L_{H1}^{Sn} to L_{H}^{Sn}, with L_{H}^{Sn} L_{H1}^{Sn}.

Figure 6: The impact of high-skill migration on knowledge expenditure allocation between knowledge creation and knowledge adoption



In addition, labour migration may also affect the ratio of national/international knowledge spillovers. Given that the number of researchers decreases in country size, the probability that the peers with whom skilled workers interact increases in worker emigration. If international ideas are more valuable than national ideas, then knowledge output per worker will increase. *Guellec* and *van Pottelsberghe* (2001) test this 'size effect' hypothesis by interacting foreign R&D with an indicator of country size and find that smaller countries do benefit more from foreign R&D than larger ones. However, the increasing international knowledge spillovers might be offset by decreasing national knowledge spillovers. Therefore, the net effect of the changed national/international knowledge flows will unlikely be significant and, in presence of positive knowledge transmission costs between countries, it might be even negative.

High-skill migration also affects government expenditure allocation between innovation

(knowledge creation) and knowledge adoption. Assume that LDC's equilibrium allocation of $TR_K^{\wedge}$ between new knowledge and absorption is at point D in Figure 6, corresponding to $TR_{N3}^{\wedge}$ and $TR_{A3}^{\wedge}$ $TR_K^{\wedge}$ $TR_{N3}^{\wedge}$, respectively. High-skill migration reduces the absorptive capacity. As a result, the marginal new knowledge gain, MK_N, and marginal absorbed knowledge gain, MK_A, decreases by shifting downward from MK_{N3} to MK_{N2} and from MK_{A3} to MK_{A4}. As a result, the equilibrium allocation of knowledge transfers is at $TR_{N3}^{\wedge}$, which is inefficient. MK_{A4} at point O is larger than MK_{N2} at point P. Allocating more transfer to absorption than to new knowledge increases total knowledge. The new allocation equilibrium of $TR_K^{\wedge}$ is at point J in Figure 6. In equilibrium more is invested in knowledge absorption technologies, TR_{A2}^m, with TR_{A2}^m $TR_K^{\wedge}$ TR_{N2}^m $TR_K^{\wedge}$ $TR_{N3}^{\wedge}$, and less is invested in new knowledge TR_{N2}^m, with TR_{N2}^m TR_{N3}. Overall, the optimal allocation of $TR_K^{\wedge}$ for different levels of country development shifts down from BDE to FJN.[20]

Summarising findings from this section we may conclude that skilled labour migration affects knowledge spillover between LDC and EU at least through three channels. Two effects might restrict international knowledge spillovers: human capital capability to adopt imported technologies and national R&D expenditure for 'adaptive' research activities in LDC. The third effect, which rather facilitates international knowledge infusion is knowledge transmission cost effect. Presence of two knowledge diffusion limiting forces and one augmenting effect does not allow us to make general predictions about sign of the relationship between skilled labour migration and international knowledge spillovers.

2.5 The impact of Blue Cards on innovative capital

In Sections 2.1 - 2.4 we have analysed long-run impacts of skilled labour migration on innovative capital in LDC. In the above analysis we have implicitly assumed that

[20]For the sake of simplicity we implicitly assume that knowledge creation transfers, $TR_K^{\wedge}$, do not change with country development. This is equivalent with the case if all variables are represented in percentage shares instead of absolute values.

quantitative migration restrictions are either evaded (e.g. illegal migration) or have been removed through migration policies, such as the EU Blue Card. The proposed EU Blue Card scheme will, however, not only relax quantity restrictions to labour markets in receiving countries, it also foresees an active recruitment policy in LDC offering highly skilled migrant workers job contracts, fast-track procedure for work permits and special financial and housing benefits in the EU receiving countries. Thus, in addition to removing quantity restrictions, which already is harmful enough for the sending countries, the EU Blue Card will also distort the natural self selection of migrant population (*Borjas* 1987) and distort migration incentives arising from labour prices and migration costs (*Straubhaar* 1986).

First, the proposed Blue Card scheme is an unprecedently selective and discriminatory policy instrument, because the EU aims at attracting not labour in general (which under certain circumstances might be even beneficial for sending countries), but only the best-qualified workers from the developing countries. In addition, according to the Commission's proposal, the EU Blue Card could be revoked if its holder lost his or her job and was unemployed for more than three months. This mechanism implies a double-selection. In a first stage, only the most skilled workers will be selected from the total workforce in LDC and recruited in the EU. In a second stage, only the most talented and successful of recruited migrants will be allowed to stay and work in the EU, the rest of migrants will have to return to their home countries after exceeding the maximum period of unemployment. The proposed Blue Card is discriminatory, because it targets especially young workers. For example, those highly skilled workers which are under 30 years old would need to earn only twice the minimum wage to be entitled to the scheme. Moreover, governments could decide to waive the salary requirement altogether, if the potential migrant is young enough and skilled enough. Thus, for highly skilled young migrants, it will be considerably easier to obtain the EU Blue Card than for older workers with average skills.

Second, the proposed Blue Card will also distort international labour market price signals. In absence of quantity restrictions for highly skilled workers (which the EU Blue Card will remove), workers base their economic migration decision on the net wage difference, which

results from the expected income increase minus migration costs. The proposed Blue Card will affect migration costs and, hence, the net wage difference and migration decision. Active recruitment policy in LDC, fast-track procedure to obtain work permits for highly skilled and single application procedure proposed by the European Commission will lower the transaction costs. In addition, the EU Blue Card holders will be treated favourably regarding tax benefits, social assistance, payment of pensions and access to public housing in the receiving countries. Thus, by reducing the transaction costs of relocating between countries, the EU Blue Card increases the net wage gap between the poor sending countries and rich EU destination countries.

Table 1 compares the impact of different migration regimes on innovative capital in LDC. The impact of high-skill emigration on worker education through the skilled/unskilled wage ratio is positive under either migration regime. The impact of brain waste on worker education (2.1) is strongly negative under illegal migration regime (IL),[21] negative under open economy migration regime (OE), and positive under the EU Blue Card scheme (BC). This difference is due to the fact that under BC skilled workers are employed in skilled jobs in the destination countries. BC has the strongest negative worker heterogeneity impact on education, as BC is more (double) selective than IL and OE. Education remittances are always good for human capital, though their size might be limited under IL due to lower earnings and missing opportunities to legally remit the earned money through bank transfers or exiting/entering the country.

Brain drain is always negative for human capital in LDC (2.2), though it is more sizeable under BC due to double selection of most skilled. Upward pressure on wages in sending country and downward in receiving is positive for LDC's human capital. The positive effect is lower under BC, as migrants are employed in higher paid skilled jobs compared to IL and OE. Declining migration costs magnify the negative impact of high-skill emigration. The negative impact is higher under BC, which reduces search, uncertainty and social costs of migrants.

Table 1: The impact of different skilled labour migration regimes on the sending country

[21]Based on the *Ethier*'s (1986) economic foundations of illegal immigration.

innovative capital

	Illegal migration	Open economies[1]	Blue Card scheme
2.1 Worker education			
Skilled/unskilled wage ratio	☾	☾	☾
Brain waste	☾	🕘	🕗
Skill/ability heterogeneity	🕘	🕘	☾
Education remittances	🕗	☾	☾
2.2 High-skill migration			
Brain drain	🕘	🕘	☾
Wage in sending country	☾	☾	☾
Wage in receiving country	🕗	🕗	☾
Migration costs	🕘	🕘	☾
2.3 Domestic innovation			
Innovation budget size	🕘	🕘	☾
Innovation share in budget	🕘	🕘	☾
R&D returns to scale	🡻	🡻	🡻
2.4 Knowledge spillover			
Stock of absorbing workers	🕘	🕘	☾
Absorptive research capacity	🕘	🕘	☾
Knowledge transmission costs	🕗	🕗	☾
Aggregate growth impact	Low	Medium	High
Migration known a priori	No	Yes	Yes

[1] Removing only quantitative highly skilled migration restrictions. ☾ strongly positive impact on sending country innovative capital, 🕗 positive, 🡻 ambiguous, 🕘 negative, ☾ strongly negative.

The emigration of highly skilled workers has a negative impact on domestic innovation (2.3) both through declining government budget and shifting expenditure structure under IL and OE, and a strongly negative under BC, which is due to higher selectivity between highly skilled and age-biased restrictions. The impact of R&D returns to scale depends on country characteristics depending on which high-skill emigration may affect knowledge capital in LDC both either positively or negatively.

The absorptive capacity of international knowledge spillovers (2.4) is decreasing under all three migration regimes. Declining absorptive capacity is negative for knowledge capital

under IL and OE, and a strongly negative under BC, because of higher fiscal and brain losses. Declining transmission costs increase LDC's knowledge capital. The effect is positive under IL and OE, and a strongly positive under BC, which is due to legal and skilled employment status and more business contacts with highly skilled natives in EU.

The results reported in Table 1 suggest that, because of supplementary (adversely selective and distortionary) measures, the EU Blue Card will harm the innovative capital and hence the long-term growth in LDC considerably more than other forms of labour migration, because of higher migration incentives adverse selection of migrants.

3 Sending country policy options

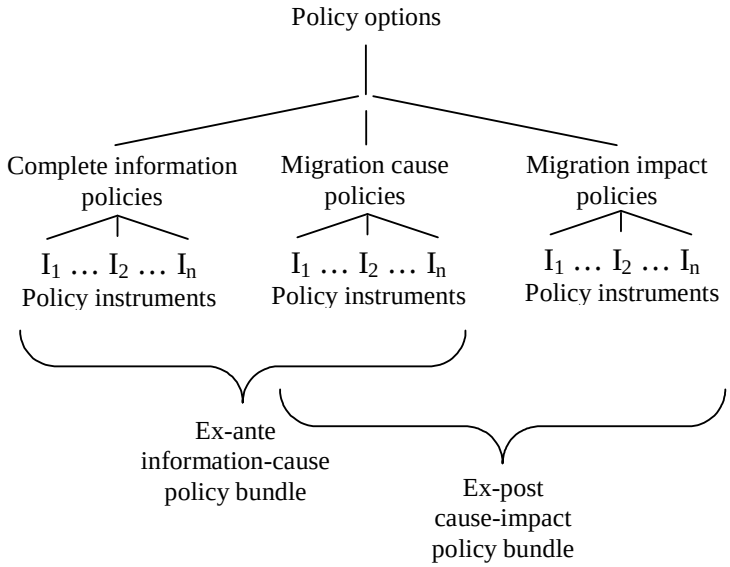
From previous sections we know that the EU Blue Card scheme has been announced (section 1) and that it will likely have negative impacts on the less developed sending country innovative capital (section 3) and hence growth (section 5). What can the potential sending countries do against the negative impacts? Are there any policy options for mitigating the adverse impacts of high-skill migration? We aim to answer these questions in the present section.

Migration policy options in LDC have been investigated in several studies (e.g. *Abella* 1992; *Lowell* and *Findlay* 2001). Usually, studies of international labour migration issue policy recommendations for sending countries such as to tax migrants (*Bhagwati* 1976), improve the economic situation (*Lowell* and *Findlay* 2001), encourage investment and trade (*IMF* 2007). Although efficient from the international labour migration theory's viewpoint, often they are of little help for LDC policymakers. There are two main reasons why the suggested migration policies are seldom implemented in praxis: either they are too general (e.g. improve the economic situation), or politically infeasible (e.g. Bhagwati tax), or both. In this study we aim to address both migration policy issues. The innovative capital framework adopted in the present study allows us to derive and assess specific migration policy measures and, in the same time, account for political feasibility constraints. Moreover, it allows us to identify potential policy impacts on innovative capital in LDC as well as its costs.

In section 2 we have shown that in the long run the emigration of skilled workforce decreases the stock of innovative capital in LDC through various channels. In light of these findings and the fact that, innovative capital is an important source for economic growth and development, LDC will likely want to reduce/eliminate the adverse effects caused by the skilled worker emigration. Therefore, in the policy analysis throughout this section we explicitly assume that the main policy objective of LDC is economic growth and development and, hence, to maintain (augment) the national innovative capital.

Generally, the set of policy options available for achieving this goal is wide. However, their implementation largely depends on policy constraints. In the context of skilled labour migration, we identify three key policy constraints: government budget constraint, political equilibrium, and country openness. For example, if there would be no restrictions to government expenditure, then LDC's government could simply increase the wage rate to EU level, and there would be no incentives for economically-driven emigration. Similarly, if staying at power was not a government objective, then it could infinitely increase the tax rate for unskilled labour, decrease for skilled, and the human capital stock in LDC would increase. Third, if country's openness would be a policy option, then government could isolate the country from the rest of the world, and there would be not international labour migration in autarky. Obviously, all three scenarios are unrealistic in a real world. Therefore, in order to account for feasibility of the proposed migration policies, which we will suggest in this section, in the following policy analysis we assume that LDC's government can neither change the budget balance (e.g. through foreign borrowing), nor depart from political equilibrium, nor change the country's openness. In light of these three policy constraints and government objective to maintain or increase the national innovative capital, we propose alternative migration policy instruments and graphically analyse their impact on innovative capital in LDC.

Figure 7: Migration policy implementation options in LDC sending countries



We regroup all policy instruments, $I_1 \ldots I_n$, of addressing high-skill migration into three groups: complete information policies, migration cause policies, and migration impact policies (see Figure 7).[22] Complete information policies enable implementation of migration cause policies in ex-ante period, migration cause policies address drivers of migration (causes), and migration impact policies compensate for human capital and/or knowledge capital losses through high-skill emigration. Government has two options when to implement these policies: (i) ex-ante - when high-skill migration has been announced; (ii) ex-post - when high-skill migration has started. If talent emigration has not started yet, but is likely in the future, then government weigh the costs of implementing complete information and migration cause policies and choose either the ex-ante information-cause policy bundle or the ex-post cause-impact policy bundle (see Figure 7). If talent emigration has already started, then government can only implement migration cause and migration impact policies in order to maintain the national innovative capital and to eliminate causes of worker migration.

Figure 7 shows a two-stage decision making of sending country government. In a first

[22]Alternatively, they might be thought of as innovative capital creation and innovative capital attraction policies.

stage, depending on policy implementation costs and ex-ante availability of information, government chooses either the ex-ante information-cause policy bundle or the ex-post cause-impact policy bundle. Implementing only complete information and/or migration impact policies would not stop the emigration. Implementing only migration cause policies is not feasible in the ex-ante period, whereas in the ex-post period they would not compensate for innovative capital losses caused by high-skill migration. In a second step government chooses between policy instruments. In the following we analyse impacts of the three types of migration policies starting with complete information policies.

3.1 Complete information policies

The main objective of complete information policies is to enable ex-ante implementation of migration cause policies. Per se, they do not affect labour migration. According to Figure 17, policy equilibrium is determined by political preferences of workers/voters subject to government budget balance. The policy equilibrium follows from a trade-off between marginal political costs and marginal political benefits. Information completeness affects political preferences of workers and, hence, the policy equilibrium. Given that workers form their political preferences on the basis of the available information about potential costs and benefits of alternative policies, the inter-temporal and inter-group completeness of information about the upcoming migration and its potential impacts is crucial for political feasibility of migration cause policies, which address a future situation. To see the role of information asymmetries, we compare two policy equilibriums: (i) workers do not have complete inter-temporal information about the upcoming high-skill migration and their potential impacts; and (ii) workers have complete information about it.

First, consider a situation when only government has complete information about the upcoming Blue Cards and their potential impacts on welfare, but not workers. If LDC is in political equilibrium, no further policy actions are feasible, because according to the available information to workers, they believe that any new taxes and policy transfers would make them worse off. As a result, government has no incentives to change the current policies, as any policy changes without voter support would distort the political equilibrium making government worse off. Thus, if workers/voters have no information

about the upcoming high-skill migration, government does not adjust policies, because it cannot improve its present welfare, even if it is informed about the upcoming migration. In other words, government is locked in a 'political feasibility trap' and cannot implement migration cause policies before the migration has started. Binding political constraints are one of the main reasons, why in most less developed sending countries migration policies cannot be implemented a priori.[23]

Second, consider a situation when workers in LDC have complete inter-temporal information about the upcoming high-skill migration and its potential impacts. Future information will change current political preferences of voters, because workers (and government) maximise not only the present but their lifetime utility. *Altonji* and *Card* (1991) identify two types of possible changes: adjustments in voter groups, and adjustments in voting behaviour within groups. First, complete information about the EU Blue Cards, migration opportunities, migration costs and wages in the destination countries will create a new voter group - potential migrants. Because of different interests, the voter group of skilled workers will split into two separate voter groups: potential migrants and non-migrants. Second, whereas the potential migrants among skilled workers have no incentives to change their voting behaviour (they are indifferent as they would benefit also from the cross-country wage differences as soon as the migration starts), the non-migrating skilled and unskilled workers will adjust their voting behaviour. Complete information about potential impacts triggered by the upcoming skilled worker emigration increases their political support for policies reducing incentives driving skilled worker emigration.[24] Increased support for immigration policies shifts the political equilibrium - the welfare maximising government will implement migration cause policies, which maximise the inter-temporal lifetime utility function of both government and non-migrating workers.

Based on these findings we may conclude that inter-temporal and inter-group completeness

[23]Similar logic applies also to the receiving countries. For example, it is well known that labour migration in general and skilled labour migration in particular increases the receiving country welfare. However, because of political constraints (e.g., right-wing party pressure), most of the old EU member states do not open their labour markets to CEE workers.

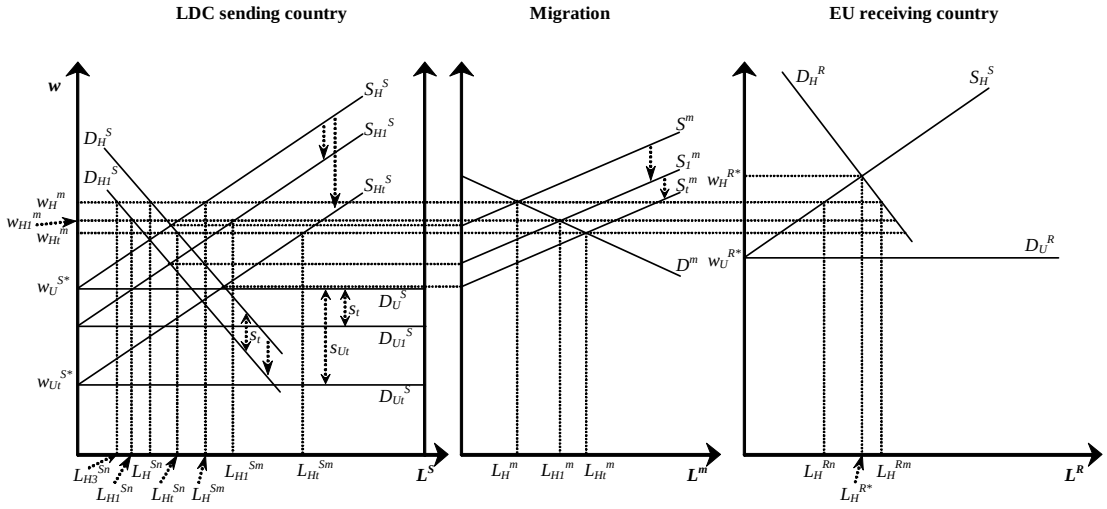
[24]Theoretically, providing information about upcoming opportunities could trigger migration. However, given that the Blue Cards scheme itself contains active recruitment measures in the sending countries, the potential migrants will be informed anyway.

of information about the upcoming high-skill migration and its potential impacts determines feasibility of migration cause policies in the ex-ante period. If government has information about the upcoming migration, as in the case of Blue Cards, then maximisation of government inter-temporal utility requires policy adjustments. However, government may be locked in a 'political feasibility trap', if workers/voters do not have this information, as they will vote against migration policies, which need to be financed through additional taxes. When both government and workers have complete information, then migration cause policies are both feasible and unavoidable, because policy adjustments will improve the inter-temporal welfare of both the non-migrating workers and government.

3.2 Migration cause policies

Second, we consider migration cause policies, the main objective of which is to reduce/avoid worker emigration. They can be implemented either ex-ante (in combination with complete information policies) or ex-post (in combination with migration impact policies). In open economies migration cannot be banned directly. Instead, it needs to be addressed indirectly, for example, by adjusting skilled worker incentives causing migration, in a way that makes migration unattractive. Given that the main driving force of skilled worker emigration is the net income difference between LDC and EU, government needs to address international wage differences (*Straubhaar* 1986). Generally, the cross-country net wage gap can be affected by changing wage rate in the sending and destination countries, by changing income tax rate, and by changing migration costs. However, from LDC perspective, among the few feasible policy options for lowering the net wage gap between the sending and receiving countries is to adjust net wage for skilled labour in LDC. This can be done, for example, imposing skill subsidies and different taxation policies.

Figure 8: The effect of income tax reduction in sending country



The impact of tax policy on the stock of skilled labour is shown in Figure 8. Before any taxes are imposed, the initial equilibrium stock of skilled labour is L_H^{Sn}, the initial migration is L_H^m and the equilibrium wage rate is w_H^m. Imposing tax rate, s_t, to both skilled and unskilled labour will reduce the stock of skilled labour and increase migration because of lower net wage. Taxing both skilled and unskilled labour with tax rate s_t shifts their demands down: skilled labour demand decreases from D_H^S to D_{H1}^S, and unskilled labour demand decreases from D_U^S to D_{U1}^S. The effect of unskilled labour tax is a shift of skilled labour supply from S_H^S to S_{H1}^S. Because taxes reduce net income in LDC, skilled labour migration increases to L_{H1}^m. In the same time more migration would lead to a further decrease in the skilled labour wage on the world labour market (middle panel in Figure 8). Skilled labour wage decreases from w_H^m to w_{H1}^m. As a result, in equilibrium there is lower stock of skilled labour in LDC L_{H1}^{Sn}, with L_H^{Sn} ☮ L_{H1}^{Sn} and higher emigration L_{H1}^m, with L_{H1}^m ☮ L_H^m.

The above analyses imply that the same tax rate imposed on both skilled and unskilled worker income is not efficient for maintaining or increasing the stock of skilled labour in LDC. Government can improve policy efficiency by imposing a differentiated tax rate for skilled and unskilled workers. In order to simplify the analysis we assume that only

unskilled labour is taxed with a tax rate equal to s_{Ut}.[25] A skill-biased tax affects only the demand for unskilled labour: in Figure 8 D_U^S shifts from to D_{Ut}^S. The corresponding shift in the skilled labour supply is from S_H^S to S_{Ht}^S. Skilled labour demand remains unaffected at D_H^S. Taxes reduce the net wage of unskilled labour. The incentives for educating increase leading to higher migration. Higher migration, in turn, decreases skilled labour wage. In equilibrium the wage rate for skilled labour decreases from w_H^m to w_{Ht}^m. Lower wage allows firms in LDC to use more skilled labour. As a result, the stock of skilled labour in LDC increases to L_{Ht}^{Sn}, with L_H^{Sn} L_{Ht}^{Sn} and emigration increases to L_{Ht}^m, with L_{Ht}^m L_H^m.

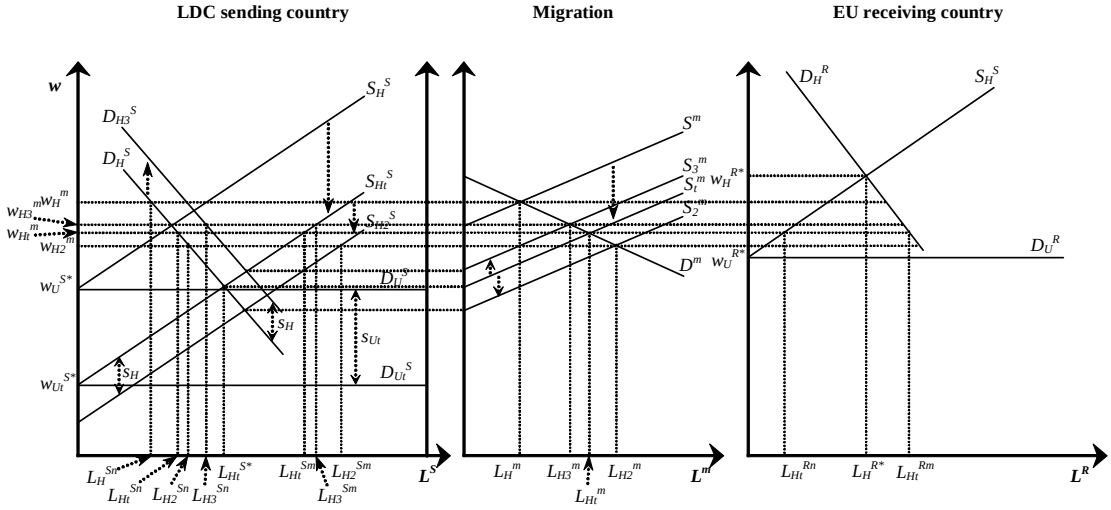
In the above analysis we assumed that LDC is large, implying that it can affect the international wage rate for skilled labour. Only this indirect effect led to expansion of skilled labour in LDC. More precisely, by introducing a skill-biased tax LDC dampens the wage for skilled labour in EU which depresses international skilled wage. If, however, LDC is small, then LDC's tax policy does not affect the international wage rate for skilled labour. If the initial skilled wage is w_H^m, migration will not affect it, if LDC is small. Hence, in both cases with and without taxation of unskilled labour, s_{Ut}, the stock of skilled labour will also stay unchanged at L_H^{Sn}. When both types of workers are taxed with the same income tax (flat tax), s_t, the stock of skilled labour decreases to L_{H3}^{Sn}, if LDC is small. Thus, the skill-biased tax is more efficient than a flat tax rate.

The third type of tax policy is migration tax, i.e., LDC's government imposes a tax (Bhagwati tax) from emigrating skilled workers (*Bhagwati* 1976). Abstracting from feasibility issues of such a tax scheme, which obviously requires high international tax cooperation between LDC and EU, in Figure 2 we analyse how Bhagwati tax would affect the stock of human capital in LDC. We assume that a tax, t_H^m, is imposed on emigrating skilled workers (for the sake of simplicity we assume that t_H^m MC). In contrast to income tax, migration tax does not affect domestic workers in LDC and EU. Instead,

[25]If both types of labour were taxed, then s_{Ut} would represent the tax difference between skilled and unskilled work.

migration tax reduces the net skilled labour wage of migrant workers from w_H^m to w_{H2}^m. Because of smaller net wage differences between LDC and EU, the number of migrants decreases from L_H^m to L_{H2}^m, with $L_H^m \ominus L_{H2}^m$ and the stock of skilled labour in LDC increases from L_H^{Sn} to L_{H2}^{Sn}, with $L_H^{Sn} \boxminus L_{H2}^{Sn}$.[26]

Figure 9: The impact of skill subsidy



Next, we consider the impact of skill subsidies on net migration. This is shown in Figure 9. The initial equilibrium migration (without skill subsidy) is given by $L_H^m \boxminus L_H^{Sm} \boxminus L_H^{Sn}$, the initial stock of skilled labour by L_H^{Sn}, and the initial wage rate by w_H^m. In order to finance the skill subsidy, government imposes tax, s_{Ut}, on unskilled labour. Taxes decrease the demand for unskilled labour from D_U^S to D_{Ut}^S. In Figure 9 the supply of skilled labour shifts from S_H^S to S_{Ht}^S. This is the same effect as already shown in Figure 8. Unskilled labour taxes lead to an increase in the stock of skilled labour in LDC: L_H^{Sn} shifts to L_{Ht}^{Sn}, and to higher migration from L_H^m to L_{Ht}^m.

In order to reduce the cross-country wage gap which drives migration, government grants

[26]If feasible, migration quota/restriction would have a similar effect to Bhagwati tax on human capital in LDC. The only difference is that migration quota would not contribute to government budget.

skill subsidy, s_H, directly to skilled workers. First, assume that government pays the subsidy directly to skilled workers. The effect of direct skill subsidy is shown in Figure 9, where the subsidy shifts the supply of skilled labour down from S^S_{Ht} to S^S_{H2}. The demand for skilled labour is, however, not affected at D^S_H. As a result, the wage rate for skilled labour decreases from w^m_{Ht} to w^m_{H2}. The total income of skilled labour is equal to wage plus subsidy, w^m_{H2} s_H. Skilled labour in LDC increases from L^{Sn}_{Ht} to L^{Sn}_{H2}, with L^{Sn}_{Ht} L^{Sn}_{H2}. Note that the stock of skilled labour increases only because of the indirect wage effect. The skilled wage decreases from w^m_{Ht} to w^m_{H2}. As a result, firms in LDC are willing to hire more skilled workers. However, if LDC would be small, the international wage rate for skilled labour would not be affected. It would stay at w^m_{Ht} and the stock of skilled workers would be L^{Sn}_{Ht} both with and without the skill subsidy. More skilled workers have an incentive to migrate, because with the skill subsidy, s_H, it becomes easier to buy the 'skill migration ticket' such as Blue Card (it is cheaper to acquire education and then migrate). In Figure 9 the skilled labour migration increases from L^m_{Ht} to L^m_{H2}, with L^m_{Ht} L^m_{H2}.

Government can improve policy efficiency by targeting the subsidy towards skilled labour that does not migrate. Assume that the same subsidy is granted to companies in LDC to decrease skilled labour costs. The effect of indirect skill subsidy is shown in Figure 9, where the subsidy does not affect the supply of skilled labour, S^S_{Ht}, but instead shifts the demand for skilled labour up from D^S_H to D^S_{H3}. Because of higher demand, the wage rate for skilled labour increases from w^m_{Ht} to w^m_{H3}. Higher domestic wage implies that less skilled workers have an incentive to emigrate. As a result, migration decreases from L^m_{Ht} to L^m_{H3}, with L^m_{H3} L^m_{Ht}. In the same time, because of higher wage, the stock of skilled labour at home increases from L^{Sn}_{Ht} to L^{Sn}_{H3}, with L^{Sn}_{Ht} L^{Sn}_{H3}.

Comparing the two types of skill subsidies (direct and indirect) we can conclude that paying skill subsidy to firms is more efficient than paying it directly to workers. In this case: (i) there are more skilled workers in LDC, L^{Sn}_{H2} L^{Sn}_{H3}, (ii) less skilled workers emigrate, L^m_{H2} L^m_{H3}, and (iii) budgetary costs are lower, $s_H L^m_{H2}$ $s_H L^{Sn}_{H3}$. The reason for

higher efficiency is that the indirect skill subsidy is better targeted than the direct skill subsidy. The main disadvantage of the direct skill subsidy is that it also supports those workers that will emigrate. In other words, it helps them to buy the 'migration ticket' such as Blue Card, because education is a precondition for eligibility of the EU Blue Card scheme. A subsidy granted to skilled labour increases the stock of skilled labour only indirectly, through the international wage effect for skilled labour. If the country is small, then the subsidy granted to skilled labour has no effect at all on the stock of skilled labour in LDC.

3.3 Migration impact policies

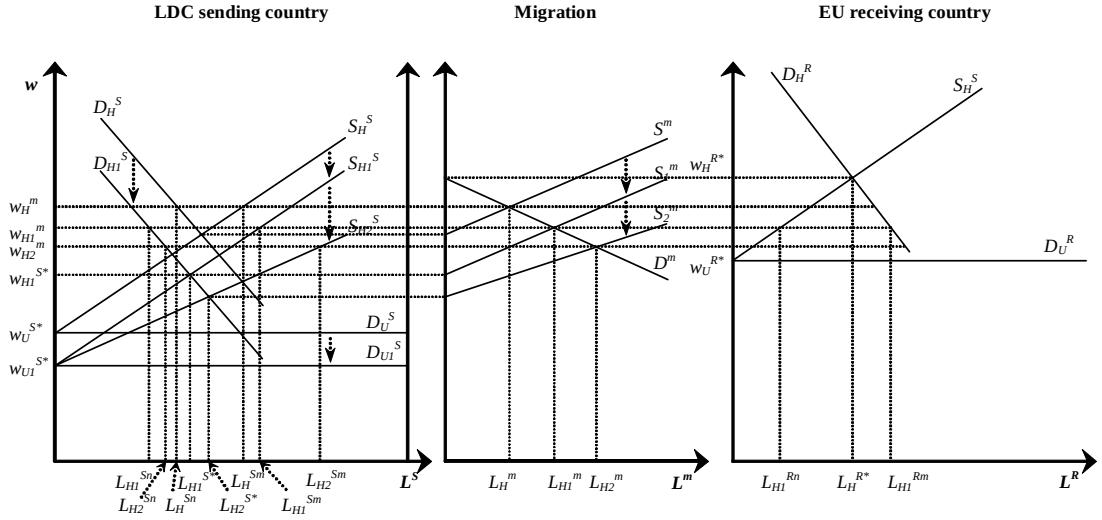
Finally, we consider migration impact policies aimed at compensating for innovative capital losses caused by high-skill emigration. If migration cause policies were not implemented a priori and emigration has already started, it has reduced the domestic stock of human and knowledge capital (see section 2). If LDC policy objective is to maintain the national innovative capital then government needs to implement migration impact policies in order to compensate for human capital losses due to migration. There are several policies for recovering the reduced innovative capital in LDC, for example, education and knowledge creation policies.

According to the underlying theoretical framework (section 5.3) worker education decision is determined by a trade-off between higher wage for skilled work (skill premium) and the cost of education. Thus, the demand for education can be increased either by increasing the skill premium or by reducing the cost of education. Government can raise skill premium in LDC, for example, through a skilled work subsidy or differentiated income tax rates for skilled and unskilled work, which we considered in section 3.2. The cost of education can be reduced, for example, by investing in public education, or by subsidising education through state scholarships. The effect of direct education subsidy, e.g. free university education, is illustrated in Figure 10. The initial equilibrium stock of skilled labour is L_H^{Sn} and the initial migration is L_H^m. In order to finance education policy, government imposes taxes on worker income, which shift skilled labour demand, D_H^S, and unskilled labour

demand, D_U^S, to D_{H1}^S and D_{U1}^S, respectively. Because of lower net income in LDC, high-skill emigration increases to L_{H1}^m and the stock of skilled labour decreases to L_{H1}^{Sn}. In order to increase skilled workforce government invests the collected tax revenue in education. Because the price of education decreases, more unskilled workers enter education. As a result, the skilled labour supply shifts from S_{H1}^S to S_{H2}^S. Because of higher supply of skilled workers in LDC, the stock of human capital increases from L_{H1}^{Sn} to L_{H2}^{Sn}, and migration increases from L_{H1}^m to L_{H2}^m. Note that the stock of skilled labour increases only because of the wage effect. Higher supply of skilled workers exerts a downward pressure on skilled labour wage, which decreases from w_{H1}^m to w_{H2}^m. If the skilled worker wage rate would not change, then the stock of skilled labour would not change either. Therefore, this policy is ineffective in terms of increasing human capital. First, the imposed taxes increase migration. Second, a direct education subsidy also increases migration. Third, the stock of skilled labour in LDC depends only on the wage effect but not on the education policy directly.

The effectiveness of education subsidies can be increased if they are coupled with migration cause policies. For example, if the state subsidised higher education is coupled with employment in the country providing education. Such policy has been implemented in several developing countries and has proven to be an efficient way of increasing the stock of human capital. Graphically this is shown in Figure 10, where the stock of skilled workers increases to $L_{H2}^{S'}$, if education subsidies are coupled with migration cause policies and skilled workers do not emigrate.

Figure 10: The effect of public investment in education



Next, consider a policy that invests in education at firm level (indirect education subsidy). The support of education at firm level will shift the demand for skilled labour up. Higher demand for skilled labour exerts an upward pressure on skilled labour wage. Because of higher skill premium, the stock of skilled labour in LDC increases. Indirect education subsidy is more effective than policy addressing education through labour market supply side for three reasons: (i) more skilled labour in LDC, (ii) lower migration, and (iii) the budgetary costs are lower. Thus, by supporting the education at firm level (addressing the demand side of skilled labour market), the policy is better targeted and hence more efficient. This policy has a similar effect to skill subsidy.

The poorness of the developing world has two striking implications for innovative capital and hence for LDC economic growth prospects: low education and high emigration. The poorer the country is, the higher are liquidity constraints of workers for obtaining formal education, and the higher is the attractiveness to emigrate. Thus, in very poor countries the limiting factor of human capital growth is not the missing financial incentives of workers to learn skills, but instead, the liquidity constraint for obtaining education. Therefore, in these very poor sending countries government objective should be to remove the liquidity constraint for obtaining education.

The education liquidity constraint could be removed by government subsidies. However,

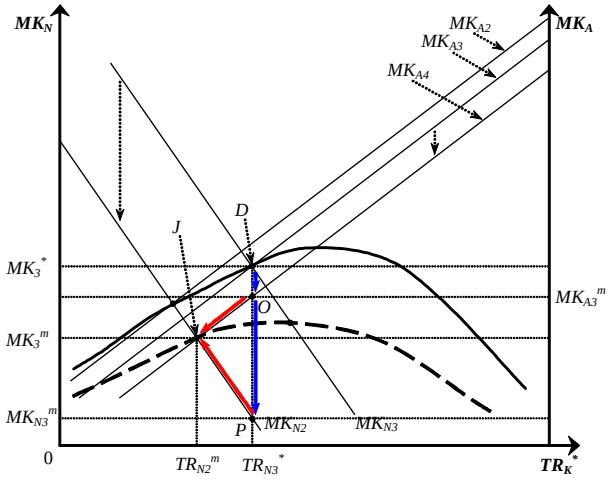
given that under government budget constraint all subsidies need to be collected by additional taxes, such policy would not substantially decrease the liquidity constraint. Alternatively, given that emigrated workers remit part of their income earned in LDC to their home country, government can affect the spending of remittance income. Because this policy does not require additional taxes, investing remittances in education may move upward or completely remove liquidity constraint of education. Remittance flows from the receiving to sending countries can be increased, for example, by introducing a tax relief for remittances or reducing remittance transfer costs.[27] Lower remittance taxes would increase the purchasing power of remittances in LDC and hence the incentives to remit. As a result, the emigrated workers would increase their remittances to LDC. The share of remittances invested in education could be increased, for example, by introducing a distortionary taxation to remittances spent for consumption goods and/or tax exemptions to remittances invested in education.[28] Because the purchasing power of remittances for consumption goods would decrease compared to education services, workers would invest more remittances in education. As a result, the stock of skilled workers would increase in LDC. This can be seen in Figure 10. Consider that government increases remittance tax rate spent for consumption goods compared to education services. This will change relative prices, which in turn will shift skilled labour supply from S_{H1}^{S} to S_{H2}^{S}. As a result, the stock of skilled labour in sending country increases from L_{H1}^{Sn} to L_{H2}^{Sn}.

The tax relief for remittances invested in education is less effective than a policy, which is targeted only at those skilled workers that remain in the country, because part of the additional workers which obtain education would emigrate (skilled labour migration increases from L_{H1}^{m} to L_{H2}^{m}). If coupled with migration cause policies, the education remittance policy would be considerably more efficient. Given that this policy changes the stock of skilled labour in sending country only through the price effect, it is equivalent to education policy, which subsidises the supply side of labour market. Because more workers migrate, skilled labour wage increases, which reduces skilled labour migration. If migration

[27] In most countries foreign remittances are subject to income tax (*Chami*, *Fullenkamp* and *Jahjah* 2003).

would not affect the skilled labour wage, then the policy that increases incentives to invest more remittances in education, would not affect the stock of skilled labour in sending country.

Figure 11: Migration-induced shifts in knowledge expenditure allocation between knowledge creation and knowledge adoption

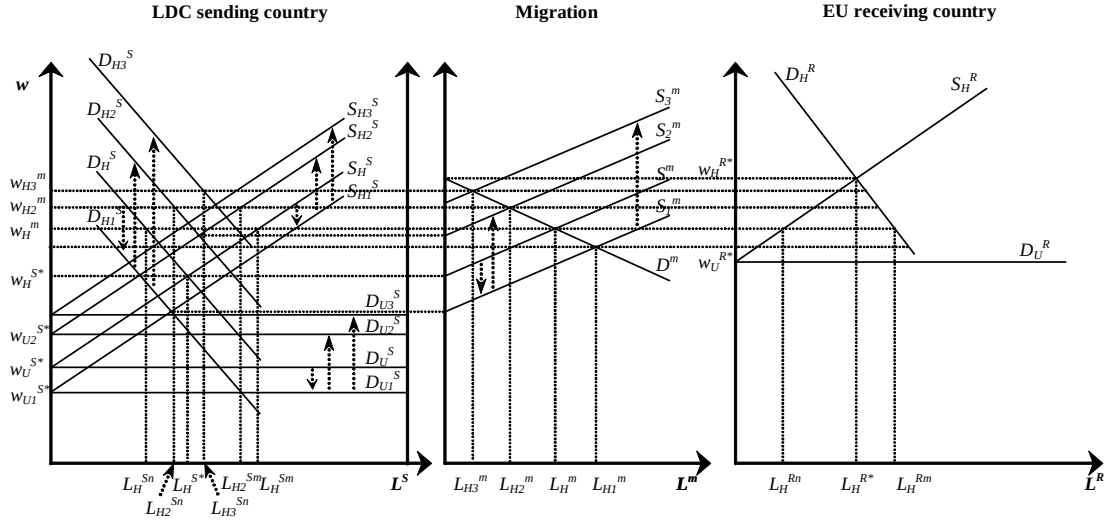


In line with the underlying innovative capital framework, a further migration impact policy option for compensating for losses in the national innovative capital caused by high-skill emigration is to increase the domestic innovation. Government has two options for allocating the R&D expenditure: investment in new knowledge or in knowledge adoption. Figure 11 shows how migration affects government choice between the two types of knowledge investment. Assume that before migration LDC's equilibrium allocation of TR_K^* between new knowledge and absorption is at point D in Figure 11, corresponding to TR_{N3}^* and TR_{A3}^* (i.e. $TR_K^* = TR_{N3}^*$), respectively. Migration reduces the absorptive capacity (see section 2.4). This reduces both marginal new knowledge gain, MK_N, and marginal absorbed knowledge gain, MK_A, by shifting downward from MK_{N3} to MK_{N2} and from MK_{A3} to MK_{A4}. For this reason the allocation of innovation transfer, TR_{N3}^*, is in

[28]None of the proposed policies would affect/worsen government revenue: lower remittance taxes would lead to more remittance, and hence compensate the lower tax rate. Lower taxes for remittances may be

disequilibrium, i.e. it is inefficient. Marginal new absorbed gain, MK_{A3}^{m}, at point O is larger than marginal new knowledge gain, MK_{N3}^{m}, at point P. Allocating more funds to knowledge absorption than to new knowledge would increase the total knowledge. The effect of investment on absorptive and on new knowledge on migration and on the stock of skilled labour is shown in Figure 12. New allocation equilibrium of $TR_K^{\uparrow}$ is at point J in Figure 11. In equilibrium relatively more is invested in absorption of knowledge, TR_{A2}^{m}, where TR_{A2}^{m} $TR_K^{\uparrow}$ TR_{N2}^{m} $TR_{A3}^{\uparrow}$ $TR_K^{\uparrow}$ $TR_{N3}^{\uparrow}$, and less is invested in new knowledge TR_{N2}^{m}, with TR_{N2}^{m} $TR_{N3}^{\uparrow}$.

Figure 12: The effect of public investment in knowledge creation



The effect of increased public spending on knowledge is shown in Figure 12. The initial equilibrium migration is L_H^m. First, government imposes taxes to be able to finance the expenditure necessary for knowledge transfers. If government taxes labour demand, skilled and unskilled labour demand decreases. In Figure 12 the labour demand curve D_H^S shifts to D_{H1}^S and D_U^S to D_{U1}^S, respectively. As above, migration increases from L_H^m to L_{H1}^m. Government can invest either (i) in producing new knowledge or (ii) in absorptive capacity

compensated by higher taxes for consumption goods.

of knowledge from EU. Because, as shown in Figure 11, at knowledge transfer allocation $TR_{N3}^{\clubsuit}$ and $TR_{A3}^{\clubsuit}$, the knowledge gain is higher from adoptive than new technologies (see section 2.4), the impacts of the two types of policies will be different too. First, consider government investment in new knowledge creation. More knowledge capital increases productivity of both skilled and unskilled labour. In Figure 12 the demand shifts up from D_{H1}^{S} to D_{H2}^{S} for skilled labour and from D_{U1}^{S} to D_{U2}^{S} for unskilled labour. The effect of unskilled labour wage increase is an increase in skilled labour supply from S_{H1}^{S} to S_{H2}^{S}. Because of smaller wage gap between the receiving and sending countries, the stock of skilled labour in LDC increases from L_{H}^{Sn} to L_{H2}^{Sn}, with $L_{H}^{Sn} \square L_{H2}^{Sn}$, and migration of skilled workers decreases to L_{H2}^{m}, with $L_{H1}^{m} \clubsuit L_{H}^{m} \clubsuit L_{H2}^{m}$.

Next, we consider government investment in adoptive research. Given that it is more efficient to transfer technology, which is already developed, than to develop new technology, government can increase the efficiency of public spending. In Figure 12 higher knowledge creation efficiency will shift the labour demand stronger upwards. Demand for skilled labour shifts up from D_{H1}^{S} to D_{H3}^{S} and demand for unskilled labour from D_{U1}^{S} to D_{U3}^{S}. The skilled labour supply shifts up from S_{H1}^{S} to S_{H3}^{S}. Migration decreases to L_{H3}^{m}, with $L_{H1}^{m} \clubsuit L_{H}^{m} \clubsuit L_{H2}^{m} \clubsuit L_{H3}^{m}$. The stock of skilled labour in sending country increases to L_{H3}^{Sn}, with $L_{H3}^{Sn} \clubsuit L_{H2}^{Sn} \clubsuit L_{H}^{Sn}$.

3.4 Policy recommendations

Government has two types of decisions to make: the inter-temporal policy implementation strategy and policy instrument choice. The inter-temporal policy implementation choice is fully determined by policy implementation costs and ex-ante completeness of information. We can only note that, in addition to comparing the direct policy implementation costs, in the long-run the *ex-ante* implementation of migration policies might be less costly than *ex-post*, because with repeated migration threat complete information policies are less expensive (they need to be implemented only once) than migration impact policies (which need to be implemented every time when high-skill migration occurs). Migration cause

policies are required in either scenario and their implementation costs are similar between ex-ante and ex-post implementation strategies. Therefore, where the upcoming migration is known a priori, as in the case of Blue Cards, and information transaction costs are not prohibitive,[29] the ex-ante migration mitigation policies should be preferred over ex-post impact-cause policies.

In addition to choosing between the ex-ante information-cause policy bundle or the ex-post cause-impact policy bundle, government also has to select appropriate instruments from each policy bundle. Policies that address the *supply side* of the skilled labour market (e.g., direct education subsidy, direct skill subsidy) are the least efficient. This is especially the case when LDC is small relative to receiving country. Such policies enhance migration, they do not have a direct impact on skilled labour stock in LDC. In fact, this policy facilitates migration. Only, if LDC is large, supply side policies may increase the stock of skilled labour in LDC. Policy-induced migration decreases the international wage rate for skilled labour. Only this indirect wage effect will increase the stock of skilled labour in LDC. Because of lower wage rate, less skilled workers will have an incentive to migrate. If, however, LDC is small, there will be no wage effect and the stock of skilled labour will not be affected by the policy at all.

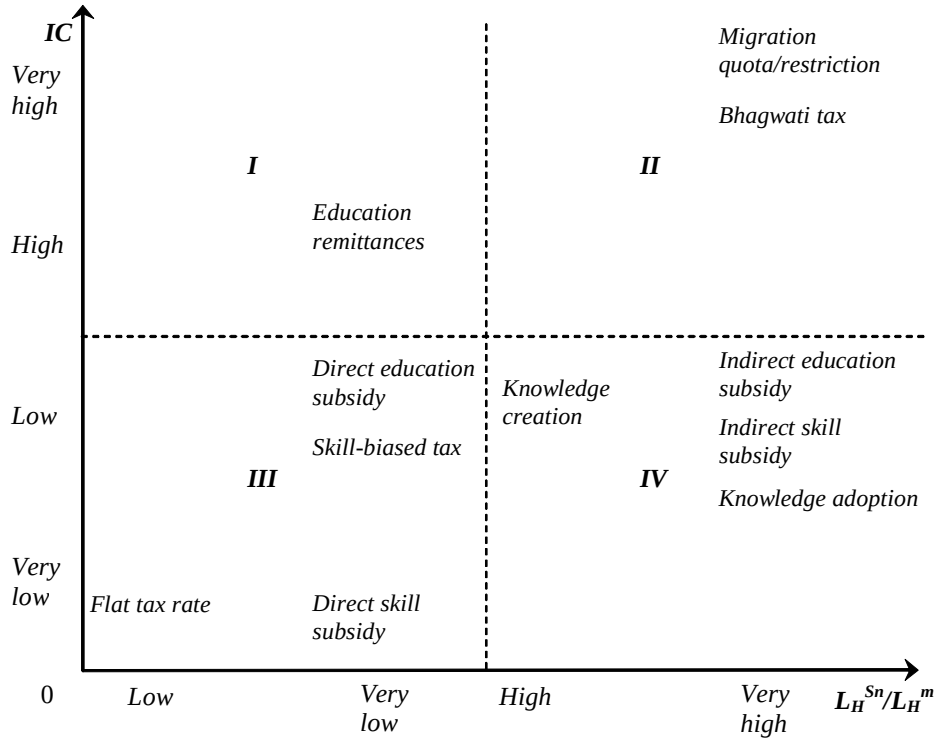
In general, the weakest point of policies that address the supply side of skilled labour market is that these policies do not distinguish between skilled labour that migrates and skilled labour that stays. Given that they target both potential migrants and non-migrants, they help the potential migrants to buy the 'skill migration ticket' such as the EU Blue Card. The efficiency of government policy can be improved by a better targeting: (i) directly on the *demand side* of the skilled labour market in LDC (e.g. through skill subsidy granted to firms, or subsidisation of education at firm level); or (ii) directly on *migrants only* (e.g. through Bhagwati tax, migration quota, etc.). The first policy changes incentives only of those that stay. The second policy does the reverse - it changes the incentives of those that migrate. In terms of implementation feasibility, the policy that addresses the demand side of the skilled labour market appears to be less costly. The enforcement costs of policy

[29]In densely populated less developed African economies with poor infrastructure they may indeed be

which addresses only migrants is more costly and may require cooperation with the receiving country which may not be desired by EU.

Figure 13 classifies policies according to two parameters. The vertical axes shows the political implementation costs, IC, which capture administrative implementation cost and political support, which decreases in taxes. The horizontal axes shows policy efficiency in increasing the stock of skilled labour, L_H^{Sn}, and of decreasing skilled labour migration, L_H^m.[30]

Figure 13: Assessment of migration policies



The most efficient policies are represented in quadrant IV. Indirect education subsidy, indirect skill subsidy to firms and investment in knowledge adoption are the most efficient

prohibitive.

[30]The horizontal axes shows the ratio of the skilled labour stock to migration, L_H^{Sn}/L_H^m.

policies in terms of political implementation costs and in terms of increasing the L_H^{Sn}/L_H^m ratio in LDC. This is because they have relatively low costs of implementation and lead to an increase in the stock of skilled labour while they decrease migration. However, these policies do not have the highest political support after migration, i.e. they are not at the bottom of quadrant IV. With migration the political support increases for redistributive policies. Investment in new knowledge has the same political implementation costs as the other two policies in the quadrant IV, but is less efficient in increasing the L_H^{Sn}/L_H^m ratio than investment in knowledge adoption.

Quadrant I shows the least efficient policies - they have low efficiency in increasing the L_H^{Sn}/L_H^m ratio and they are politically infeasible. The policy that targets remittances spent on education is costly in terms of implementation, as it requires cooperation with EU which may be rather limited. In the same time it increases migration because it will become less expensive for workers to acquire education and to emigrate (it will be easer to 'buy' the EU Blue Card). It increases the stock of skilled labour only indirectly through wage effect if LDC is large. If LDC is small, then this policy will not have an impact on the stock of skilled labour at all.

Quadrant III shows policies which are politically feasible but inefficient in reducing skilled migration. These policies include: direct skill subsidy paid to workers, direct education subsidy, and skill-biased income tax. They all have the same effect on the L_H^{Sn}/L_H^m ratio, as a policy that targets remittances to be spent on education. The flat tax rate policy is even worse than the education remittance policy because it decreases the stock of skilled labour and, in the same time, it increases emigration. However, the flat tax rate and the direct skill subsidy are politically more feasible than the direct education subsidy, and the skill-biased tax, because after migration there is less political support for polices that target growth related issues as well as the share of unskilled labour in voting population increases, which will make it difficult to introduce higher tax rate for unskilled labour.

Quadrant II shows policies which are politically not feasible but efficient in increasing the L_H^{Sn}/L_H^m ratio. There are two policies in this quadrant: Bhagwati tax and migration

quota/restriction. Both the Bhagwati tax and migration quota/restriction efficiently increase the stock of skilled labour and decreases migration. However, they are is costly in terms of implementation, because they require cooperation with EU and expensive border control measures.

4 Conclusions

According to the endogenous growth theory (*Romer* 1990), innovative capital is one of the key drivers of economic growth. Given the extraordinary importance of innovative capital in the developing country growth prospects, we use the endogenous growth theory to derive a theoretical framework for studying the impact of high-skill migration. The innovative capital framework, which we adopt in the present study, differs from other approaches in that it combines insights from different theories: skill premium from investment in education stressed by labour economics, brain drain, brain waste, brain gain, stressed by different migration theories, R&D and innovation role and knowledge capital, and knowledge spillover literature.

We apply the innovative capital framework for potential impact analysis of high skill labour migration in general and the proposed Blue Card scheme in particular on innovative capital in LDC. In line with previous studies (e.g. *Beine*, *Docquier* and *Rapoport* 2001; *Lowell* and *Findlay* 2001; *Lucas* 2004; *Katseli*, *Lucas* and *Xenogiani* 2006), we find that high-skill migration decreases national innovative capital and hence long-run growth. Moreover, we find that because of supplementary non-market measures, the EU Blue Card may harm the innovative capital and hence growth prospects in LDC considerably more than other forms of labour migration. All these findings about the EU Blue Card are new and represent the main empirical contribution of the present study.

Based on the gained insights about potential impacts of skilled worker emigration on innovative capital in LDC, we identify three types of policies, which could help the sending countries to damp down or even to avoid the adverse growth effects arising from emigration of skilled workforce: complete information policies, migration cause policies, and migration impact policies. We also propose different policy instruments for achieving

the identified policy goals and graphically analyse their impacts on innovative capital stock in LDC. Providing policy recommendations for coping with the adverse effects arising from high-skill emigration is our main policy contribution.

Turning to limitations of our study we recognise that, although accounting for all key effects of skilled labour migration on innovative capital in LDC, the performed graphical analysis cannot provide us with numerical answers about migration impacts and cannot quantitatively compare different policy instruments. However, our study offers a blueprint for deriving a formal general equilibrium model of linking labour migration to economic growth, which is required for quantifying all those effects which we discussed positively in the present study. Our findings suggest that this is a promising area for future research.

Summarising our findings we may conclude that high skill migration in general and the EU Blue Card in particular make developing country growth prospects indeed blue. However, compared to other forms of labour migration (e.g. illegal migration) the EU Blue Cards are known well in advance. We show that, using this information advantage, targeted and timed policy interventions can minimise the adverse impacts of high-skill emigration. Thus, compared to other migration regimes Blue Cards are worse, but they offer better opportunities for sending countries to mitigate migration.

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5 Appendix: Theoretical framework

Economic growth is one of the key policy priorities for most of the (democratic) developing countries. In this section we review the most recent growth theories with respect to driving forces of economic development. From the endogenous growth theory we derive innovation production function for a closed economy. Next, drawing on findings from international labour migration and knowledge spillover literature, we augment the closed economy innovation production function to open economy model. Finally, we decompose the open economy innovative capital function into four key components: worker education, international labour migration, national knowledge creation through research and development and international knowledge spillovers, and analyse their behaviour in the short run.

The main reason for choosing the innovative capital framework for our study is that at present there is no single, coherent theory of international labour migration fully capturing high-skill migration impacts on economic growth. Only a fragmented set of theories exist that have developed largely in isolation from one another segmented by disciplinary boundaries (*Lucas* 2004). The international growth trends and patterns in labour migration suggest, however, that a full understanding of the relationship between high-skill migration and economic growth will not be achieved by relying on the tools of one model alone, or by focusing on selected aspects such as brain drain stressed by the neoclassical theory, brain gain/waste emphasised by the 'new migration theory', diaspora's role in knowledge spillovers stressed by migration network theory. Rather, its complex, multifaceted nature requires an integrated approach that incorporates all these effects, forces, and assumptions. By adopting the innovative capital framework we attempt to integrate all key effects and forces triggered by high-skill migration on economic development in one unified framework.[31]

5.1 Closed economy growth determinants

[31]The innovative capital framework adopted here is similar to the innovative capacity approach of *Furman, Porter* and *Stern* (2002).

Innovative capital in general and human capital in particular takes a central role in most theories of economic growth and development. Both the augmented neo-classical growth model and most endogenous growth models stress the importance of innovative capital in economic development in one way or another. However, different schools of economic theory propose different functional relationships between the growth rate of national income and innovative capital. With respect to the role of innovative capital, growth models can be regrouped into two strands of theoretical views. According to the first view, the accumulation of human capital as a factor of production drives economic growth, implying that differences in levels of human capital are related to differences in output levels across countries (*Solow* 1956, *Mankiw*, *Romer* and *Weil* 1992). Worker skills acquired through education and experience are important for economic growth. However, because worker skills are rival and excludable, each type of labour is rewarded for its effort fully in wages. There are no positive knowledge externalities of human capital implying that skilled workers have no positive impact on other skilled and unskilled worker output.

According to the second view, a greater human capital stock affects economic growth mainly by facilitating innovation and adoption of new technologies, implying that differences in levels of human capital cause differences in output growth across countries (*Lucas* 1988, *Romer* 1990). *Lucas* (1988) models human capital in a firm's production function in a manner analogous to the augmented *Solow* model (private margin of innovative capital). However, in addition, he introduces an 'external' (social margin of innovative capital), whereby the average level of human capital in the economy affects individual firms' output but is not taken account of in their profit-maximisation decisions. In the growth model of *Lucas* individual workers decide between acquiring education and offering labour to firms on the basis of standard inter-temporal utility maximisation. The model has two sectors. In one sector human capital and physical capital is used to produce output according to the usual Cobb-Douglas production function:

$$Q = KZ^{\alpha} L_H L_U^{\beta} L_H^{\gamma} \tag{1}$$

where Z is physical capital, K is technology level (knowledge) L_U is labour, u is the share

of time devoted to production, $L_{\bar{H}}$ is the average human capital in the economy, and ε captures the spillover effects of human capital. The other sector uses human capital (the share that is not used in production activities) to produce human capital. Equation (1) implies constant returns to the two reproducible factors (Z and L_H) and, for the interval $\varepsilon + \eta > 0$, increasing returns to all factors. Because of constant returns to the two types of capital, the model suggests an important role for worker skills and knowledge capital both in the short-run and in the long-run. In the context of our study an important feature of *Lucas* (1988) model is that even if there is no positive knowledge spillover effect, long run growth is determined by investment in both physical and human capital.

The other major strand of endogenous growth theories was pioneered by *Romer* (1990). The growth model of *Romer* has three sectors: a technology producing sector, an intermediate goods producing sector where capital goods are produced, and a final output producing sector. In his model the steady state growth additionally depends on the human capital stock. The part of human capital that is not used for producing goods and services is used for creating new technologies. The level of human capital, L_H, has thus a positive effect on the growth of knowledge, K, the stock of which determines the number of differentiated intermediate goods, x. According to the *Romer*'s (1990) model, firm production function is given by

$$Q = L_{H_Y}^{a} L_U^{\beta} \int_0^K x_i^{1-\alpha-\beta} di \tag{2}$$

where L_{H_Y} is the share of human capital employed in the production sector, which depends on the overall stock of human capital L_H $= L_{H_Y} + L_{Ha}$, with the latter denoting the share of human capital devoted to the accumulation of technology, K. The innovation sector operates according to a national innovation production function:

$$\dot{I} = \delta L_{Ha}^{\eta_1} K^{\eta_2} \tag{3}$$

where $\dot{I}$ is a sustainable rate of innovation and δ is a productivity parameter. According to equation (3), the sustainable rate of innovation, $\dot{I}$, is an increasing function of the number of skilled workers, L_{Ha}, and the stock of knowledge available to these skilled workers, K. Thus, in the *Romer*'s (1990) model the rate of technological change endogenous in two distinct ways. First, the share of the economy devoted to the innovation sector is a function of the skilled workforce (determining L_{Ha}), and the allocation of resources to innovative activities depends on the R&D productivity. Second, the productivity of innovation creation is sensitive to the stock of knowledge capital, K, created by past innovations. Although, there is neither a general agreement on the precise values of these parameters nor on the functional form linking innovations to economy-wide long-term productivity growth, there is a relatively broad agreement that these factors are, indeed, crucial in explaining the realised level of economy-wide innovation (*Furman*, *Porter* and *Stern* 2002).

5.2 Structure of open economy innovative capital

Given the detailed treatment of human capital and knowledge capital in endogenous growth theory, we base the theoretical framework of our study on the endogenous model à la *Romer* (1990). The starting point of the conceptual framework is equation (3), according to which the innovation production function takes the Cobb-Douglas form. Applying a logarithmic transformation to equation (3) and rewriting the growth rate in form of stock changes we obtain the following innovation production for a closed economy:

$$\ln I = \delta + \lambda_1 \ln L_H + \lambda_2 \ln K \qquad (4)$$

According to equation (4), the national innovative output, I, is an increasing function of the size of skilled workforce, L_H, and the stock of knowledge available to workers, K. Given that the two innovative inputs are accumulable, their endowment is determined endogenously through equilibrium strategies of economic actors. The size of the human capital in the country is determined by the number of educated workers, L_H. The stock of country knowledge capital depends on national research and development activities, K.

The two coefficients (and) measure the relative contribution of the two innovative inputs: human capital and knowledge capital. Parameter determines whether the marginal product of an additional invention is increasing (the so-called 'standing on shoulders' effect, *Caballero* and *Jaffe* 1993) or decreasing (the so-called 'fishing out' hypothesis) in the stock of human capital, and parameter determines the returns to scale with respect to the stock of existing knowledge. is a productivity parameter, which captures all other factors affecting the creation of innovative capital but not captured by variables L_H and K.

Next, we consider the innovative capital supply in an open economy. Empirical evidence and previous studies suggest that in an open economy, when international flows of human capital and knowledge capital are possible, the national innovative capital depends not only on country's endowment with skilled workers and the level of technological knowledge, but also on the net migration of skilled labour (*Sjaastad* 1962; *Bhagwati* and *Rodriguez* 1975) and international knowledge spillovers (*Krugman* 1979). Not accounting for skilled labour emigration would underestimate the return to education, whereas not accounting for international knowledge spillovers would overestimate the marginal revenue of national R&D expenditure. Therefore, we explicitly account for the net high-skill migration which, depending on the sign, might augment or shrink locally educated workforce; and for international knowledge spillovers, which magnify the locally produced knowledge, by including them in the innovative capital supply function.

In order to account for international movements of innovative inputs, we introduce two new variables in equation (4): L_H^m denotes the net migration of skilled workers, and K^m denotes stock changes in technological knowledge due to cross-country knowledge spillovers. According to the underlying endogenous growth theory of *Romer* (1990), at least part of the technological knowledge is a public good (i.e. non-excludable and non-rival). This implies that cross-country spillovers of technological knowledge can only increase the national innovative capital creating a no-loose situation for both sending and receiving countries ($\partial K^R \geq 0$, $\partial K^S \geq 0$). In contrast, skilled labour is a rival input implying that international migration of skilled workers decreases its stock in LDC and increases the stock of human

capital in the receiving countries creating a win-lose situation for the receiving and sending countries, respectively ($\partial H^R / \partial \cdot > 0$, $\partial H^S / \partial \cdot < 0$). Substituting the two new variables - skilled labour migration and international knowledge spillovers - into equation (4) we obtain the aggregate supply of innovative capital, I^S, in open economy S:

$$\ln I^S = \ln \alpha^S + \underbrace{\gamma_1 \ln\left(L_H^S + L_H^m\right)}_{\text{worker education, high-skill migration}} + \underbrace{\gamma_2 \ln\left(K^S + K^m\right)}_{\text{domestic innovation, knowledge spillover}} \tag{5}$$

According to equation (5), open economy S 's innovative output, I^S, depends on the number of workers who acquired skills through education, L_H^S, net migration of skilled workers, L_H^m, domestic knowledge creation through R&D, K^S, national and international knowledge spillovers, K^m, and parameters of the model.[32] The relative contribution of the four components to national innovative supply, I^S, depends on equilibrium strategies of economic actors. In the following sections we analyse how education and migration decisions of workers determine size of the private margin of innovative capital, and how the public fund allocation decision of government determines size of the social margin of innovative capital.

5.3 Worker education

We start with worker education decision in the short run, where the only decision which workers face is to offer unskilled work versus to invest in education and to offer skilled work.[33] According to *Freeman* (1986), the education decision is determined by a trade-off between skilled, w_H^S, and unskilled, w_U^S, wage differences (skill premium), and the cost of

[32]For the sake of simplicity, we assume that national knowledge spillovers, K^{SS}, are already accounted for in the domestic knowledge production function, K^S.

[33]We recognise that in reality there are many more decisions to make, e.g. labour-leisure, consumption, etc, and that workers may make the education and migration decisions simultaneously. However, for the sake of graphical tractability, we analyse them separately.

education, EC^S, (see equation 6). Thus, we explicitly assume that education is costly for workers. These costs capture both direct costs of education, such as tuition fees, as well as indirect costs, such as worker opportunity costs and education effort (which is different across individuals).

$$L_H^S = L_H^S(w_U^S, w_H^S, EC) \tag{6}$$

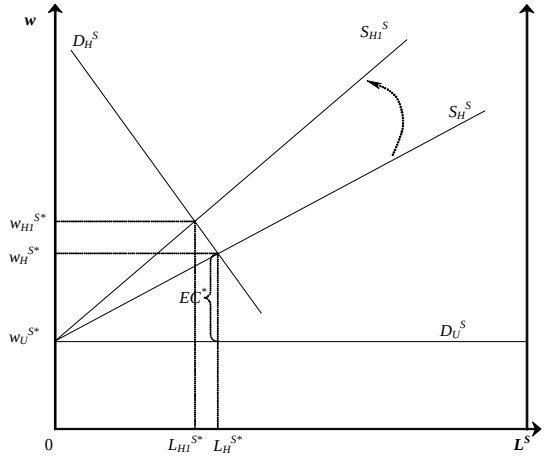
In line with the underlying endogenous growth model presented in section 5.1, we assume that country S is endowed with L^S units of labour. This is shown on the horizontal axis in Figure 14. Skilled labour, L_H^S, is measured from the left to right, whereas unskilled labour, L_U^S, is measured from the right to the left on the horizontal axis in Figure 14. The total labour endowment, L^S, is equal to $L_H^S + L_U^S$. Curves D_H^S and D_U^S represent the demand for skilled and unskilled labour, respectively, and S_H^S is the supply of skilled labour in country S.

Given that education is costly, individuals invest in education only if education increases their income.[34] Thus, net of education costs, workers must earn at least the unskilled labour wage, which is equal to w_U^{S*}. The vertical difference between skilled labour supply, S_H^S, and the unskilled wage rate, w_U^{S*}, represents the cost of acquiring education. It is increasing because workers are not equally talented, they are heterogeneous in their ability to acquire education. The skilled individual on the margin is just able to compensate the education costs. Assuming full employment, the rest of the workers, $L^S - L_H^{S*}$, are unskilled. The equilibrium wage of unskilled labour, w_U^{S*}, is at the point where the demand for unskilled labour, D_U^S, intersects vertical line at L_H^{S*}. The equilibrium stock of skilled labour is L_H^{S*} and the equilibrium skilled wage rate is w_H^{S*}. In equilibrium the education cost of the marginal worker for whom it pays to obtain education is equal to EC^*.[35]

[34] We implicitly assume that all workers, for whom it pays off to become skilled, invest in education.

[35] For the sake of graphical tractability in the above analysis we assumed that the elasticity of unskilled labour demand is infinitely elastic. If the elasticity of unskilled labour demand would be partially elastic, then there

Figure 14: Education equilibrium in closed economy



Next, we determine education equilibrium with liquidity constraint, because it is an important issue in many poor developing and transition economies (*World Bank* 2000). In the presence of a binding liquidity constraint workers either acquire less education or some able individuals may have no access to education at all. As a result, the skilled labour supply is lower. In Figure 14 the skilled labour supply rotates up from S_H^S to S_{H1}^S, implying that in equilibrium there is a lower stock of skilled labour, L_{H1}^S L_H^S, and higher wage rate, w_{H1}^S.

5.4 High-skill migration

Second, we consider the decision of skilled workers where to offer their work, at home or abroad, which determines the short-run equilibrium migration. According to *Sjaastad* (1962), the trade-off which workers face here is given by the expected income increase (w_H^R w_H^S) through migration versus migration costs, MC, (see equation 7). These costs include not only the direct transportation costs to EU but also employment uncertainty (which is higher abroad than at home), social costs of leaving family and/or friends behind,

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would be additional unskilled labour wage effect, which would affect the ratio of skilled/unskilled workers in the sending country. However, the obtained results with partially elastic unskilled labour demand would be qualitatively similar to those presented above.

cultural adjustment costs, language barriers etc (*Straubhaar* 1986). Workers migrate if the expected benefits arising from migration are higher than migration costs.[36]

$$L_H^m = L_H^m(w_H^S, w_H^R, MC) \tag{7}$$

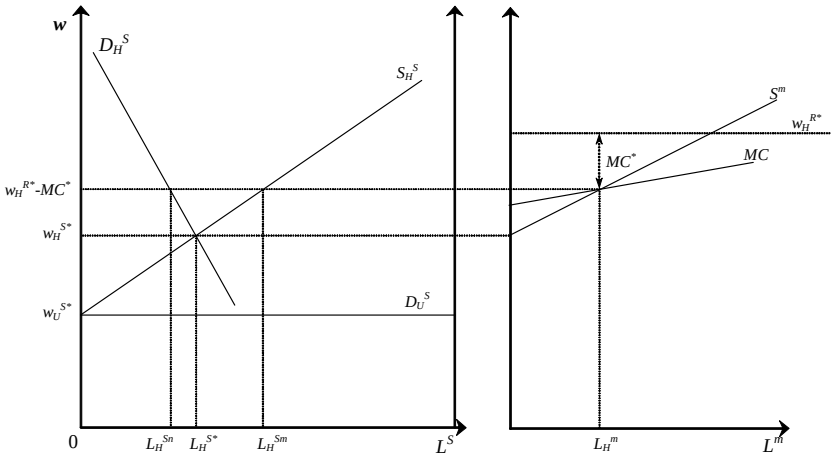
Migration decision arises from exogenous differences in technological development between LDC and EU. More precisely, we assume that origin country S is less developed and hence has lower wages for both skilled and unskilled labour than destination country R. Wage differences trigger worker migration - driven by higher expected earnings in EU skilled workers migrate from S to R. However, the net wage, which migrant workers earn in EU, is lower than the wage rate in R, because migrants face positive migration costs, MC. Therefore, the net wage of migrants is wage in destination country, w_H^R, minus migration costs, MC. According to migration network theory and empirical evidence (*Carrington, Detriagiache* and *Vishwanath* 1996), migration costs are not constant, they decrease in the number of workers migrating from S to R. In Figure 15 these network effects are captured by the upward slope of the MC curve. S^m is migrant worker supply on international labour market, which is derived by subtracting skilled labour supply, S_H^S, from demand, D_H^S.

In equilibrium, L_H^m migrants incur cost MC^* and receive the net wage $w_H^{R^*} - MC^*$.[37] Workers migrate if and only if $w_H^{R^*} - MC^* > w_H^{S^*}$. Because of the gap in technological development and net wages between the two countries, at least for some workers the migration condition is satisfied, and part of skilled workforce leaves country S. As a result, the domestic labour supply decreases in LDC. In equilibrium L_H^{Sn} workers are skilled and do not migrate. The total migration is given by $L_H^{Sm} - L_H^{Sn}$. With migration the domestic

[36]We recognise that in reality the migration decision of workers is driven not only by wage differences but also by non-economic considerations. However, in the present study we abstract from all other determinants of migration and consider cross-country wages differences as the only force driving labour migration.
[37]The results for unskilled labour migration are analogous. Therefore, they are not spelled out explicitly.

skilled labour stock decreases from L_H^{S*} to L_H^{Sn}, and the unskilled labour stock in LDC decreases from $L^S - L_H^{S*}$ to $L^S - L_H^{Sm}$. Because of higher return to education, migration increases the number of workers who acquire education from L_H^{S*} to L_H^{Sm}, with $L_H^{S*} > L_H^{Sm}$.

Figure 15: Short-run migration equilibrium



In Figure 15 we assumed that only skilled workers have a migration option. Abstracting from unskilled labour migration is motivated by two considerations: focus of the study and empirical evidence (*Salt* 1997). Moreover, it can be easily verified that, as long as the condition $L_H^S/L_U^S \approx L_H^m/L_U^m$ holds, the results with unskilled labour migration would be qualitatively equal to those presented here. A further simplification, which will be introduced in the following sections, concerns migration costs. For the sake of graphical tractability, we will not model migration costs explicitly but, instead, assume that the wage difference between the receiving and sending countries is already net of migration cost.

5.5 Domestic innovation

In this section we determine the short-run domestic knowledge creation. Abstracting from efficiency issues of public research activities, the level of domestic innovation is determined by interaction of three forces. The political costs of raising taxes, t, from worker income need to offset by political benefits arising from redistributing tax revenue to

workers in form of different policies, (pro-growth R&D policies, TR_K, and consumption transfers, TR_C), (see equation 8). Given that skilled and unskilled workers have different political preferences, in equilibrium, marginal benefits arising from those policies favoured by unskilled workers must be equal to marginal benefits arising from those policies favoured by skilled workers.

$$K^S = K^S(TR_K, TR_c, t) \tag{8}$$

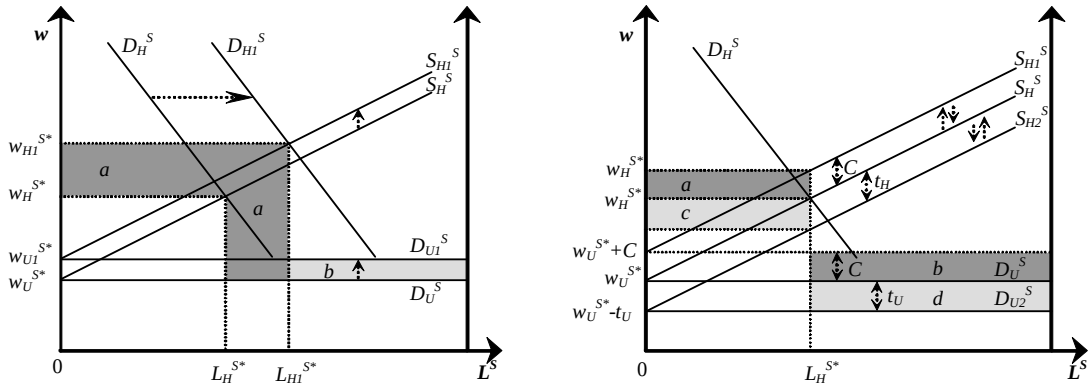
In order to graphically analyse the innovation equilibrium, we make several simplifying assumptions. We recognise that in reality government budget revenue is determined by the tax revenue collected from all economic actors and by the net lending/borrowing position of the economy. However, the graphical tractability and our intention to keep the study focused on skilled worker migration requires to reduce the sources government revenue. Therefore, we assume that the only source of government revenue is income tax contributions of workers, all other sources of government tax revenue are neglected. In addition, we make two further assumptions concerning R&D expenditure. First, we assume that the optimal strategy of government is only to decide between two types of policies: investment in growth related policies (R&D) and consumption expenditure. Thus, in the present study we abstract from all other government policies. Second, for the sake of simplicity, we assume that government R&D decisions are also representative for firm R&D activities. Thus, we implicitly assume that the research activities undertaken by private firms are proportional to government R&D expenditure.[38]

We assume that politicians provide policy transfers, TR, in return for political support. Policy transfers are financed from income tax revenue, which decrease political support from voters, as taxes reduce worker income. Voter groups increase their political support if they are net (of taxes) gainers from government policies, while voters reduce support if they are net losers from government policies. Political support, S_i, of individual i is

[38]Governments which invest in knowledge creation are also likely to support policies that increase incentives for private spending in R&D expenditure, for example, through enforcement of patents. In absence of public policy support to private innovation, markets would fail because of the public good character of knowledge.

assumed to be strictly concave and increasing in (utility) income. There are two groups of voters (skilled and unskilled workers) and two types of policies matching interests of the two voter groups. Skilled workers demand relatively more growth related policies (investment in knowledge creation) whereas unskilled workers more redistributive consumption policies.

Figure 16: Public investment in innovation, redistribution and income taxation

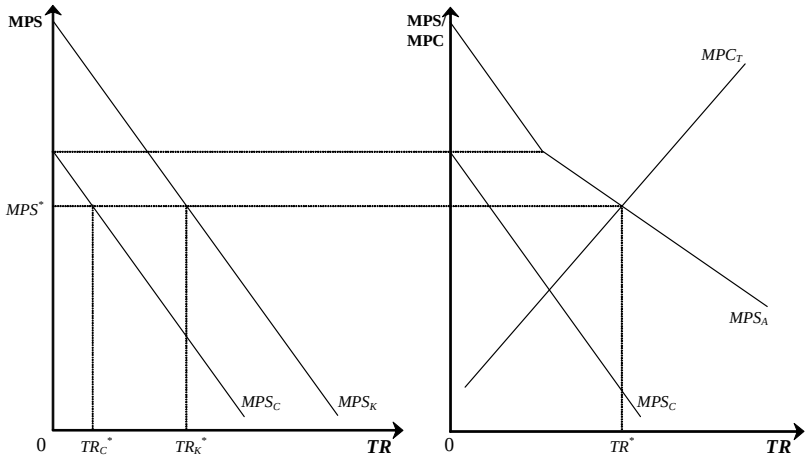


First, we consider growth oriented policies, TR_K. If politicians invest in knowledge creation, then the productivity, and hence the effective stock of skilled labour, increases. This is shown in Figure 16 (left panel). The effect of public investment in knowledge creation is a shift in skilled labour demand from D_H^S to D_{H1}^S. Because more skilled labour is used in the production, the productivity of unskilled labour increases as well. In Figure 16 unskilled labour demand shifts from D_U^S to D_{U1}^S. Higher demand for unskilled labour affects the supply of skilled labour, which shifts from S_H^S to S_{H1}^S. As a result, the equilibrium stock of skilled labour increases from L_H^{S*} to L_{H1}^{S*}. Public investment in knowledge creation increases income of skilled and unskilled labour by the shaded areas a and b, respectively. Because of higher income of workers, the political support increases. Figure 17 (left panel) shows the marginal political support of investment in knowledge creation, MPS_K. Given decreasing marginal returns of government policies, the MPS_K curve is downward sloping.

Next, we consider income redistribution oriented policies, TR_C. The effect of consumption transfer, C, to skilled and unskilled workers is shown in Figure 16 (right panel). Redistributive transfer policy increases the income of unskilled workers income from $w_U^{S'}$ to $w_U^{S'} + C$. Higher unskilled labour income has a corresponding impact on the supply of skilled labour which shifts from S_H^S to S_{H1}^S. However, because also skilled workers receive the policy transfer, C, the skilled labour supply shifts back to S_H^S. As a result the equilibrium stock of skilled labour, $L_H^{S'}$, is not affected by income redistribution policies. However, redistribution policies affect equilibrium income, and hence the political support, of both skilled and unskilled labour. More precisely, they increase the income of skilled and unskilled labour by areas a and b, respectively. This is shown in the left panel in Figure 17, where the marginal political support of redistributive transfer is represented by the MPS_C curve. The marginal political support of redistributive transfer, MPS_C, decreases in redistributive transfers - the higher they are, the lower is marginal political support. The right panel in Figure 17 shows the aggregate marginal political support, MPS_A, which represents marginal political support for total transfers (for redistribution policies, MPS_C, and for investment in knowledge creation policies, MPS_K).

Figure 16 (right panel) shows the effect of taxes on income and hence on political support. Taxes on unskilled labour paid by employers, t_U, shift the unskilled labour demand from D_U^S to D_{U2}^S. Because of lower unskilled labour demand the supply of skilled labour decreases. In Figure 16 the skilled labour supply curve shifts from S_H^S to S_{H2}^S. However, because also skilled workers pay the same tax, $t_U = t_H$, the skilled labour supply shifts back to S_H^S. As a result the equilibrium stock of skilled labour, $L_H^{S'}$, is not affected. Taxes decrease income of skilled and unskilled labour respectively, by area c and area d, respectively. As a result, politicians get less support. Because of lower net income, the political support decreases. In Figure 16 the imposed taxes decrease the net income of skilled and unskilled workers by areas c and d, respectively. In Figure 17 the marginal political cost, MPC_T, increases in policy interventions, TR, (taxes-transfers).

Figure 17: Innovation equilibrium



Politicians weigh political costs of taxation, MPC, and political benefits, MPS, from redistributive and growth related transfers. In equilibrium all types of transfers have to yield the same marginal political support and, in the same time, have to be equal to marginal political costs. In Figure 17 (right panel) the policy equilibrium is given by the point where the marginal political cost curve, MPC_T, intersects the aggregate marginal political support curve, MPS_A. Thus, according to Figure 17, the equilibrium policy interventions (taxes-transfers) are TR^*. From the total equilibrium policy interventions we can derive the equilibrium redistributive policy, TR_C^*, and growth oriented knowledge creation policy, TR_K^*, where $TR_K^* \square TR_C^* \square TR^*$.[39]

Thus, according to Figure 17, the domestic innovation equilibrium, TR_K^*, depends on the income tax revenue and government budget share spent on redistributive policies and growth oriented knowledge creation policies. The relative political support of the two voter groups depends on their share in the total population (labour force) and net income changes through government policies.

[39]Although, in the present study we implicitly assume that only the innovation investment is determined endogenously, the underlying political decision making mechanism is more general and similarly applies to other decisions of politicians and voters.

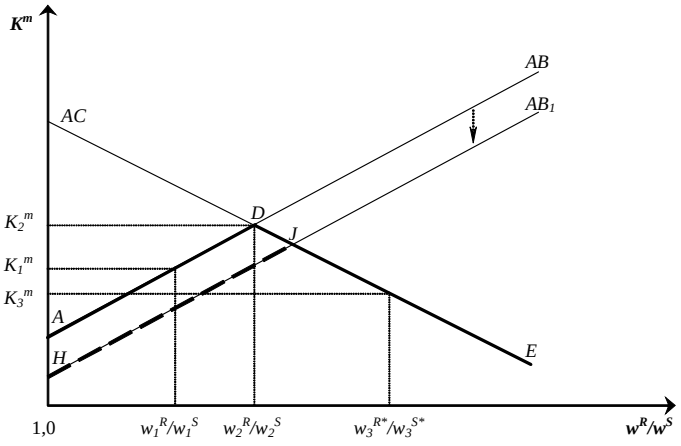
5.6 Knowledge spillovers

The fourth and last determinant of national innovative capital in is knowledge spillover from other countries. According to *Eaton* and *Kortum* (1996), the equilibrium level of knowledge spillover is determined by two opposite forces: the advantage of country backwardness, AB, and the absorptive capacity, AC, (see equation 9). On the one hand, the further behind a country is, the greater is the backlog of technology and knowledge available for spillover, and therefore the larger are the potential spillovers. In the literature this knowledge spillover effect is often referred to as the advantage of backwardness (*Cohen* and *Levinthal* 1990). On the other hand, the size of the technological gap alone does not determine the magnitude of knowledge infusion. In order to take the advantage of knowledge spillover, a country needs to have appropriate capacities, such as skilled workers who use the new technologies, in place. In the literature these factors have often been labelled as social capability or absorptive capacity (*Cohen* and *Levinthal* 1990).

$$K^m = K_H^m(AB, AC) \tag{9}$$

Figure 18 shows the advantage of backwardness, AB, and the constraint of absorptive capacity, AC. The advantage of backwardness is higher, the less developed LDC is, i.e. the larger is the wage gap, w^R/w^S, between the receiving and sending countries (*Cohen* and *Levinthal* 1990). When both countries are equally developed ($w^R/w^S = 1$), LDC's knowledge gains from international spillovers are lower, than when the development gap between countries is sizeable. However, according to *Cohen* and *Levinthal* 1990), a country can benefit from international knowledge spillovers only as much as its absorptive capacity allows. In Figure 18 the second curve, AC, shows country S 's absorptive capacity. According to *Cohen* and *Levinthal* (1990), the adoption of foreign knowledge requires certain know-how. Therefore, the less developed a country is, the less know-how is available in the country, the lower is its absorptive capacity. In Figure 18 this is captured by the downward slope of curve AC - it decreases in the development gap between the countries, w^R/w^S.

Figure 18: Equilibrium knowledge spillover

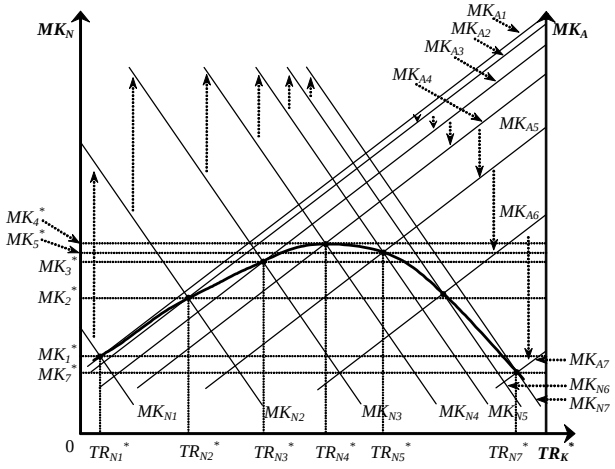


Depending on the development gap between countries (captured by w^S/w^R), the equilibrium knowledge spillover is determined by one of the two curves in Figure 18. The advantage of backwardness, AB, determines how much knowledge, K^m, spills over from other countries, it is increasing in the technological development gap between countries, w^R/w^S. Country's absorptive capacity, AC, determines how much knowledge can be absorbed from receiving country. For example, for relative income equal to w_1^R/w_1^S, only K_1^m units of knowledge can be absorbed, which is below the AC curve. For w_3^R/w_3^S, only K_3^m units of knowledge can be absorbed, which is less than available knowledge, AB, from EU. It follows that, when LDC is relatively rich (w^R/w^S 🖫w_2^R/w_2^S), then constraining is the AB curve, not AC. The opposite holds if LDC is relatively poor (w^R/w^S ☮w_2^R/w_2^S). Both curves together determine the *knowledge spillover possibility frontier*, which is showed by the kinked line ADE in Figure 18. However, the transfer of knowledge is costly, because knowledge transmission requires certain infrastructure. These costs shift the AB curve to AB_1, which changes the knowledge spillover possibility frontier from ADE to HJE.

In Figure 17 (section 5.5) we have derived the political equilibrium transfer on knowledge without migration, $TR_K^{\text{🖻}}$. Government can allocate this total knowledge transfer either for development of new knowledge, N, or invest in knowledge absorption technologies, A,

where TR_K TR_N TR_A. Government will weight the marginal new knowledge obtained from additional transfer, MK_N, with the marginal absorbed knowledge from additional transfer, MK_A. This is shown in Figure 19, where horizontal axes shows knowledge transfer allocation: from the left to the right are transfers on new knowledge, TR_N, and from the right to the left are transfers on knowledge absorption, TR_A TR_K TR_N. Vertical axis shows marginal knowledge benefit per additional unit of public expenditure: on the left vertical axis is marginal new knowledge gain, MK_N, and on the right vertical axis is marginal absorbed knowledge gain, MK_A. Both MK_N and MK_A decrease in knowledge transfers TR.[40]

Figure 19: Allocation of knowledge expenditure between knowledge creation and knowledge adoption



When the country is relatively poor (w^R/w^S w_2^R/w_2^S in Figure 18), the absorptive capacity is constraining knowledge diffusion. In this case there is high increase in knowledge if growth expenditure is invested in absorption technology. This is because there is a lot of possibility to absorb knowledge from EU (AB curve in Figure 18 is

[40]Note that TR_K may change with the country development level. To simplify the analysis we abstract from this effect. This is equivalent with the case if all variables are represented in percentage shares instead of absolute values.

increasing in country poorness). The marginal absorbed knowledge gain is MK_{A1} in Figure 19. On the other hand, the absorptive capacity, AC, is low and reduces the efficiency of new knowledge development. Hence, the marginal new knowledge gain from transfer, MK_{N1}, is low when country is poor. The equilibrium is were MK_{A1} and MK_{N1} are equal. i.e. where marginal gains of all types of knowledge investment are equal. At this point knowledge gains from total transfers TR_K^* are maximised. The equilibrium transfer on new knowledge is TR_{N1}^* and the equilibrium transfer for knowledge absorption is $TR_{A1}^* = TR_K^* - TR_{N1}^*$. If the country is richer (w^R/w^S is closer to w_2^R/w_2^S from the right hand side in Figure 18), then the gain from investment in new knowledge is higher - in Figure 19 it shifts up from MK_{N1} to MK_{N2}. However, the richer the country is, the smaller is the shift in MK_N, because the more knowledge is found the less there is possibility to find new knowledge ('fishing-out' effect). Further upward shifts in MK_N to MK_{N3}, MK_{N4}, etc. decrease with country development. The opposite holds for MK_A, which decreases in country development, because there is less and less possibility to absorb knowledge from elsewhere (in Figure 18 the downward sloping AB curve declines in country technological development). The downward shift in MK_A from MK_{A1} to MK_{A2}, MK_{A3}, etc. is larger and larger, the more developed the country is. The points where MK_A and MK_N are equal, at MK_{A1} and MK_{N1}; MK_{A2} and MK_{N2}; MK_{A3} and MK_{N3}, etc. determine the optimal allocation of knowledge transfer between new knowledge development and absorption of knowledge for different country development levels. This curve is shown by the bold line in Figure 19. The highest marginal knowledge gain from transfer is MK_4^* and the corresponding equilibrium transfer on new knowledge is MK_{N4}^* and the equilibrium transfer on knowledge absorption is $MK_{A4}^* = MK^* - MK_{N4}^*$. This coincides with the development level measured by the wage ratio w_2^R/w_2^S in Figure 18). At this point the relative marginal gain from investment in new knowledge and the marginal gain from absorbed knowledge investment is highest and in equilibrium results in the highest marginal gain in knowledge. At this point neither AB nor AC is constraining as shown in Figure 18.