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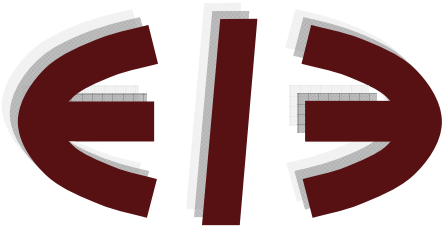
EERI Research Paper Series No 21/2011

ISSN: 2031-4892



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Modelling the Flow of Knowledge and Human Capital: A Framework of Innovative Capital[1]

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Abstract: Recently, the EU Council adopted a new labour migration policy instrument - the EU Blue Cards (BC) - for attracting the highly skilled workers to the EU. The present paper examines the potential impacts, which BC may cause on less developed sending countries (LDC). Our results suggest that the EU BC will reduce human capital in LDC. In addition, BC will also have a negative impact on knowledge capital. These findings suggest that without appropriate policy responses, BC makes developing country growth prospects rather bleak than blue. Therefore, we propose and analyse alternative migration policy instruments for LDC. We find that policies implemented on the demand side of the skilled labour market are the most efficient. In contrast, policies that address the supply side of the skilled labour market are the least efficient, though they might be less costly to implement.

Keywords: Knowledge capital, human capital, high-skill migration, innovative capital, economic growth.

JEL classification: F02, F22, J24, J61, O15.

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[1]The authors acknowledge helpful comments from Julda Kielyte and participants of the European Society for Population Economics (ESPE) conference in Seville. The authors are solely responsible for the content of the paper. The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

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1. Introduction

Recently, the Council of the European Union adopted a directive aimed at facilitating conditions of entry and residence in the EU of highly skilled migrants for the purpose of highly qualified employment (*European Commission* 2009). The directive establishes more attractive conditions for highly skilled third-country workers to take up highly qualified employment in the member states of the Union, by creating a fast-track procedure for issuing a special residence and work permit called the "EU Blue Card" to highly skilled applicants. With the EU Blue Card (BC) scheme the European Union wants to attract the best-qualified labour from the developing world, which is increasingly important to overcome the labour shortages in the ageing European Union.

The Blue Card has two sides, however, and has already provoked controversial political discussions since its adoption. On the one side, the skilled labour attracted to the EU will certainly boost European competitiveness and economic growth. 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.

More precisely, the adopted BC is both a selective and discriminatory policy instrument. BC aims neither at 'opening doors' for all poor people from LDC, nor at attracting labour from LDC in general. Instead, only the most skilled workers will be eligible for BC. In addition, the EU Blue Card can be revoked, if its holder has lost his job and was unemployed for more than three months! This mechanism implies a double-selection. At a first stage, only the most skilled workers from the total workforce in LDC will be selected and recruited to the EU. Second, only the most talented and successful of all recruited migrants will be allowed to stay and work in EU.

Second, BC is discriminatory because it targets especially young male workers from LDC. For example, those highly skilled workers which are under 30 would need to earn only twice the minimum wage to be entitled to the scheme (for the rest the requirements is at least three times the minimum wage in the country concerned plus health insurance). Moreover, EU receiving country governments could decide to waive the salary requirement altogether, if the potential migrant is young enough and skilled enough. Thus, accounting for the gender wage gap, for young males it will be considerably easier to obtain BC than for older workers and women. This implies that EU aims at diverting the net tax income flow from LDC to EU.

Third, BC will distort international labour market price signals by reducing migration costs for highly skilled and, hence, increasing the net wage difference between EU and LDC. For example, fast-track procedure to obtain work and residence permits for highly skilled and single application procedure adopted by the European Council will lower the transaction costs for skilled migrants. In addition, BC holders will be treated favourably regarding tax benefits, social assistance, payment of pensions and access to public housing in the receiving countries.

Hence, BC will 'open the doors' only to a small share of selected persons from LDC, the moral aspects of what are highly questionable from a developing policy's perspective. In view of these and related controversies, the adopted BC raises several questions for the less developed sending countries. For example, what kind and size of socio-economic impacts of skilled worker emigration can be expected in LDC? What will be the long-term impacts of BC on growth and development in LDC?

The main objective of this study is to analyse the impacts of the recently adopted Blue Card scheme on the key drivers of economic growth in the less developed sending economies and, based on the gained insights, to propose appropriate policy instruments for dealing with the negative externalities caused by skilled worker emigration.

The paper is structured as follows. Section 2 presents the underlying conceptual framework. Section 3 proposes and analyses policy options for LDC in order to address the adverse impacts of skilled labour emigration. Section 4 concludes.

2. Conceptual framework

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 models (*Solow* 1956; *Mankiw*, *Romer and Weil* 1992) and endogenous growth models (*Lucas* 1988; *Romer* 1990) stress the importance of innovative capital in economic development in one way or another. For reasons explained below, we rely on the *Romer*'s (1990) model.

2.1. Endogenous growth

The endogenous growth model of *Romer* (1990) has three sectors: a technology producing sector, an intermediate goods producing sector where capital goods are produced, and a final output producing sector. The production function is given by

$$Q = L_{H\gamma}^{\alpha} L_U^{\beta} \int_0^I x_i^{1-\alpha-\beta} di \tag{1}$$

Where L_U is share of unskilled labour and $L_{H\gamma}$ is the share of human capital employed in the production sector, which depends on the overall stock of human capital $L_{HT} = L_{H\gamma} + L_H$, with the latter denoting the share of human capital devoted to the accumulation of technology, I. The part of human capital that is not used for producing goods and services, L_H, is used for creating new technologies. The level of human capital, L_H, has thus a positive effect on the growth of technology, I, the level of which determines the number of differentiated intermediate goods, x.

The innovation sector operates according to a national innovation production function:

$$\dot{I} = \delta L_H^{\alpha_1} K^{\alpha_2} \tag{2}$$

where $\dot{I}$ is a sustainable rate of innovation. According to equation (2), the sustainable rate of innovation, $\dot{I}$, is an increasing function of the number of skilled workers, L_H, and the stock of knowledge available to these skilled workers, K. The two coefficients (α_1 and α_2) measure the relative contribution of the two innovative inputs: human capital and knowledge capital. Parameter α_1

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 α_2 determines the returns to scale with respect to the stock of existing knowledge. Coefficient δ is a productivity parameter, which captures all other factors affecting the creation of innovative capital but not captured by variables L_H and K.

Romer's (1990) model is particularly attractive for our study for two reasons. First, the rate of technological change is endogenous because the share of the economy devoted to the innovation sector is a function of the skilled workforce (determining L_H), and the allocation of resources to innovative activities depends on the R&D productivity. Second, the rate of technological change is endogenous because 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).

2.2. Determinants of growth: the innovative capital

Applying a logarithmic transformation to equation (2) and rewriting the growth rate in form of stock changes we obtain innovation production for a closed economy:

$$\ln I = \delta + \alpha_1 \ln L_H + \alpha_2 \ln K \tag{3}$$

According to equation (3), 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 both innovative inputs (L_H and K) are accumulable, their endowment is determined endogenously in the model. The size of the human capital, L_H, is determined by skilled labour wage, w_H, and the size of knowledge capital, K, depends on national R&D.

In open economies with international flows of knowledge and human capital, the national innovative capital depends not only on country's endowment with skilled workers and technology, 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 (human capital), whereas not accounting for international knowledge spillovers would underestimate the marginal revenue of national R&D expenditure (knowledge capital). Therefore, we introduce high-skill migration and international knowledge flows into equation (3), which yields:

$$\ln I^S = \ln \delta^S + \alpha_1 \ln\left(L_H^S + L_H^m\right) + \alpha_2 \ln\left(K^S + K^m\right) \tag{4}$$

According to equation (4), open economy S's innovative output, I^S, depends on the size of skilled workforce, L_H^S, net migration of skilled workers, L_H^m, domestic knowledge production through R&D,

K^S, inward knowledge spillover, K^m, and parameters of the model.[4] The relative contribution of the four components to national innovative supply, I^S, depends on the equilibrium strategies of economic actors (*Kancs* and *Ciaian* 2007).

2.3. Human capital

Assume that sending country S is endowed with $L^S\left(=L_H^S+L_U^S\right)$ units of labour, which is shown on the horizontal axis in the left panel of Figure 1. Skilled labour, L_H^S, is measured from the left to right, whereas unskilled labour, L_U^S, from the right to the left. 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 S.

According to equation (4), workers decide on two issues: education and migration.[5] First, we consider the education decision in autarky, where workers choose between offering unskilled labour versus investing in education and offering skilled labour. According to *Averett* and *Burton* (1996), the education decision is determined by a trade-off between skill premium (difference between skilled wage, w_H^S, and unskilled wage, w_U^S), the cost of education, EC^S, and the stock of knowledge, K^S. Thus, in equation (5) 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).

$$L_H^S = L_H^S(w_U^S, w_H^S, EC^S, K^S) \tag{5}$$

Given that education is costly, workers invest in education only if education increases their net income.[6] Thus, net of education costs, workers must earn at least the unskilled labour wage, which in equilibrium is equal to w_U^{S*}. The vertical difference between skilled labour supply, S_H^S, and the equilibrium unskilled wage rate, w_U^{S*}, represents the cost of acquiring education (Figure 1, left panel). Its slope is increasing because workers are not equally talented, they are heterogeneous in their ability to acquire education (*Cameron* and *Heckman* 1998). In line with *Willis* and *Rosen* (1979), the last skilled worker, who enters education at L_H^{S*}, is just able to compensate the education costs, his skill premium is equal to zero. Assuming full employment, the rest of workers, $L^S - L_H^{S*}$, stay unskilled. The equilibrium wage of unskilled workers without migration, w_U^{S*}, is at the point where the demand for unskilled labour, D_U^S, intersects the vertical line at L_H^{S*}. The equilibrium stock of skilled labour is L_H^{S*} and skilled labour wage rate is w_H^{S*}. In equilibrium the education cost of the marginal worker, who enters education, is equal to EC^*.[7]

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[4] For the sake of simplicity, we assume that national knowledge spillovers are already accounted for in the domestic knowledge production function, K^S. The LDC sending country is denoted with superscript *S* and the EU receiving country with superscript *R*.

[5] We recognise that in reality there are many more decisions to make, e.g. labour-leisure, consumption, etc.

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

[7] For the sake of graphical tractability, we assume that the elasticity of unskilled labour demand is infinitely elastic. If the elasticity of unskilled labour demand would be partially elastic, then there would be additional unskilled labour wage effect, which would affect the ratio of skilled/unskilled workers in *S*. However, the obtained results with partially elastic unskilled labour demand would be qualitatively similar to those presented above.

The equilibrium for receiving country, R, is analogous. In absence of migration, the equilibrium skilled wage, unskilled wage and the stock of skilled labour are w_H^{R*}, w_U^{R*}, and L_H^{R*}, respectively (Figure 1, right panel).

Second, we consider the skilled worker decision 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 through migration versus migration costs, MC, (equation 6).[8] Workers migrate if the expected benefits arising from migration are higher than the migration costs.[9]

$$L_H^m = L_H^m(w_H^S, w_H^R, MC) \tag{6}$$

where L_H^m is skilled labour migration, w_H^R is skilled wage rate in R, and MC are migration costs.

Due to cross-country differences in knowledge capital, $K^R > K^S$, the receiving country, R, is more developed than sending country, S. Differences in country development and hence wage levels trigger migration from S to R. In the presence of positive migration costs, $MC > 0$, the net wage, which migrant workers earn, is lower than the skilled incumbent wage in R, because the net wage of migrants is equal to skilled wage in destination country, w_H^R, minus migration costs, MC.

According to migration network theory and the empirical evidence (*Carrington*, *Detriagiache* and *Vishwanath* 1996), migration costs are not constant, they decrease in the number of migrants from S residing in R. In Figure 1 (middle panel) these network effects are captured by a decreasing vertical distance between curves S_{MC}^m and S^m. Curve S^m is migrant work supply on the international labour market, which is derived by subtracting skilled labour supply, S_H^S, from skilled labour demand, D_H^S, in S. Curve S_{MC}^m is migrant supply adjusted by migration costs MC.

In equilibrium L_H^m skilled workers migrate incurring migration cost, MC^*, and receiving net wage, $w_H^m \left(= w_{Ho}^{R*} - MC^*\right)$. The equilibrium wage rate of skilled labour, w_{Ho}^{R*}, is determined by the intersection of migration supply, S_{MC}^m, and migration demand D^m (Figure 1, middle panel). Migration demand, D^m, is derived by subtracting skilled labour demand, D_H^R, from supply, S_H^R, in *R*. (right panel in Figure 1). Immigration reduces skilled wage in R from w_H^{R*} (skilled equilibrium wage without migration) to w_{Ho}^{R*} (skilled equilibrium wage with migration). The magnitude of the wage effect depends on the sending country S's relative size - the larger is S relative to R, the bigger is the wage effect in R. If S is sufficiently small, then migration does not affect the equilibrium wage rate in R at all. This would be the case if S faces perfectly elastic skilled labour demand in R, such as D_{H1}^R (Figure 1, right panel). In this case, the equilibrium skilled labour wage in R would be equal

[8] These costs include not only the direct transportation costs to the destination country, but also employment uncertainty (which is higher abroad than at home), social costs of leaving family and/or friends behind, cultural adjustment costs, language barriers, etc. (*Straubhaar* 1986).

[9] 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.

to w_{Ho}^{R*} both with and without migration and migration would be equal to L_H^m.

Workers from S migrate to R as long as $w_H^{R*} - MC^* > w_H^{S*}$. The mass of skilled workers that emigrate, $L_H^{Sm} - L_H^{Sn}$, is determined by the slope of migrant work supply curve, S_{MC}^m. Due to emigration, the stock of skilled and unskilled labour in S decreases from L_H^{S*} to L_H^{Sn}, and from $L^S - L_H^{S*}$ to $L^S - L_H^{Sm}$, respectively. Given that the stock of skilled workers decreases relatively more than that of unskilled, the return to education increases. As a result, the equilibrium mass of workers who acquire education increases from L_H^{S*} to L_H^{Sm}, with $L_H^{S*} < L_H^{Sm}$.

In Figure 1 we have assumed that only skilled workers have a migration option. Abstracting from the unskilled worker migration is motivated by two considerations: the focus of the study and the empirical evidence (*Salt* 1997). Moreover, it can be easily verified that, as long as the condition $L_H^S / L_U^S \leq L_H^m / L_U^m$ holds, the results with unskilled labour migration would be qualitatively equal to those presented here.

2.4. Knowledge capital

According to equation (4), the level of knowledge available in S is determined by domestic knowledge production and foreign knowledge spillovers. Knowledge creation involves production of new knowledge, whereas knowledge adoption is uptake of knowledge developed in other countries (both are costly). In order to increase the level of knowledge, sending country, S, can invest in knowledge production (new knowledge) or in knowledge adoption of inward spillovers (adopted knowledge).

In equation (7) the level of technology (knowledge) available in S is determined by a total (private and public) expenditure on knowledge, TR^S, and skilled workforce, L_H^S. Knowledge, K^S, increases in both R&D expenditure, TR^S, and human capital, L_H^S, which increases the productivity of knowledge.[10]

$$K^S = K^S(TR^S, L_H^S) \tag{7}$$

In absence of knowledge flows between countries (autarky), the only source of country S's knowledge improvement is innovation through investment in R&D. The autarky equilibrium knowledge in S is shown upper panel of Figure 2, where the horizontal axis measures the level of knowledge, K^S, and the vertical axes measures units of expenditure spent on knowledge accumulation, $tr^S (= TR^S / K^S)$. We assume that marginal costs of knowledge creation, MC_C^S, are increasing in technological development, and marginal productivity (benefit) of knowledge demand, MB^S, is decreasing in technological development (both new and adopted knowledge). This is represented by the upward and downward sloping marginal cost and productivity curves, MC^S, and MB^S, respectively (upper panel in Figure 2). In absence of international knowledge flows, the equilibrium domestic innovation, K_C^{S*}, is at the point where marginal costs of knowledge creation,

[10] This follows from equation (2).

MC_C^S, and marginal productivity of knowledge, MB^S are equal. The equilibrium innovation, K_C^{S*}, implies tr^{S*} units of R&D expenditure.

Analogously, knowledge for receiving country, R, is shown in bottom panel of Figure 2. The intersection between receiving country, R's, marginal cost of knowledge creation, MC_C^R, and marginal productivity of knowledge, MB^R, yields equilibrium domestic innovation and per unit expenditure K_C^{R*} and tr^{R*}, respectively. Assuming higher skilled/unskilled worker ratio in R implies higher equilibrium knowledge in R than in S, ($K_C^{R*} > K_C^{S*}$).

Next, consider the opening of borders for international knowledge flows. As shown in Figure 2, in open economy equilibrium more knowledge available in R allows S to adopt inward knowledge spillovers from the more developed R. The maximum level of spillover knowledge which can be adopted in S is equal to the R's equilibrium knowledge production, K_C^{R*}. On the other hand, in a two country model R cannot benefit from knowledge spillovers from S, because the technological development in S is lower than in R.

We assume that S 's marginal costs of knowledge adoption are constant, given along the horizontal line MC_A^S, which implies that in absence of knowledge flows between countries, the equilibrium expenditure of knowledge creation, tr^{S*}, is higher than the marginal costs of knowledge adoption, $MC_A^S < tr^{S*}$ in equilibrium.[11,12] This assures that in the presence of knowledge flows between countries, the knowledge adoption may yield positive profits. The total equilibrium knowledge in S is K_T^m, which is a sum of domestically created knowledge, K_C^m, and the adopted foreign knowledge, $K_A^m (= K_T^m - K_C^m)$. Hence, in the presence of international knowledge spillovers the equilibrium knowledge production is lower in S, $K_C^m < K_C^{S*}$ (though the total knowledge in S is higher, $K_T^m > K_C^{S*}$). Note that knowledge equilibrium in R is not affected by international spillovers, because due to country development gap, knowledge spillovers are one-directional: from the more developed receiving country, R, to the less developed sending country, S.

2.5. The impact of BC on LDC

BC affects the innovative capital equilibrium, by reducing migration costs and improving access to skilled jobs in EU, which leads to a positive skilled wage gap between EU and LDC.[13] Positive net of migration cost wage differences trigger migration of skilled workers from LDC to EU. In addition to these direct labour market effects, migration also induces adjustments in the stock and accumulation of

[11] Note that we assume differences in marginal costs between knowledge creation and knowledge adoption. This is consistent with the finding in the literature. According to *Mansfield* (1981), on average imitation costs are about 65 percent of the original innovation costs. Further, we assume that both new and adopted knowledge are homogenous in production, i.e. they do not differ with respect to marginal productivities.

[12] In reality the marginal costs of knowledge adoption may increase with the additional knowledge adopted. However, the slope of the marginal costs of knowledge adoption should be lower than the marginal costs of knowledge creation (*Mansfield* 1981). To simply the figures we assume constant marginal costs of knowledge adoption, but the results hold in general.

[13] In line with the empirical evidence, we assume that the LDC sending country, S, is less developed than the EU receiving country, R, (i.e. $K_T^{Sm} < K_C^{R^*}$) and hence skilled wage in LDC is lower than in EU, $w_H^{R^*} > w_H^{S^*}$.

innovative capital (knowledge and human capital) (see *Kancs* and *Ciaian* 2010 for a detailed analysis).

The BC effect is shown in Figure 1. In the absence of BC the equilibrium stock and wage of skilled labour is L_H^{Sn} and w_H^m, respectively, the equilibrium migration is L_H^m, and the equilibrium stock and wage of unskilled labour is $L^S - L_H^{Sm}$ and w_U^{S*}, respectively, in LDC (Figure 1, left panel). BC reduces migration costs. To simplify the graphical exposition we assume that BC reduces migration costs, MC, to zero. As a result, the excess supply of skilled labour increases from S_{MC}^m to S^m and the equilibrium skilled labour wage in LDC increases to w_{HB}^m, implying that the wedge between skilled and unskilled labour wage in LDC increases.[14] Because of higher skill premium, more workers obtain education under BC. The mass of LDC workers who acquire education increases from L_H^{Sm} to L_{HB}^{Sm}. However, BC increases skilled labour migration from L_H^m to L_{HB}^m (middle panel). In the BC equilibrium LDC has less skilled workers L_{HB}^{Sn}, with $L_{HB}^{Sn} < L_H^{Sn}$ (left panel). Thus, because of brain drain, BC has a strictly negative impact on the human capital in LDC.[15]

Second, *knowledge productivity in LDC decreases,* because after the introduction of BC part of the skilled labour from LDC migrates to EU, implying that fewer skilled workers are available in LDC. As a result, the absorptive capacity decreases (*Cohen* and *Levinthal* 1990). In Figure 6 (upper panel) this implies that the marginal productivity curve shifts downward from MB^S to MB_B^S and the equilibrium knowledge decreases from K_T^m to K_{TB1}^m. On the other hand, BC increases knowledge productivity in EU, because immigration increases skilled labour supply. In Figure 6 (lower panel) higher stock of skilled labour increases EU's marginal productivity of knowledge from MB^R to MB_B^R and the equilibrium knowledge increases from K_C^{R*} to K_{CB}^{R*}. More knowledge in EU does not affect the knowledge level in LDC, because the LDC's absorptive capacity is constraining absorption of more foreign knowledge - both with and without BC not all knowledge produced in EU is absorbed by LDC, $K_T^m < K_C^{R*}$ and $K_{TB1}^m < K_{CB}^{R*}$, respectively.

Kapur (2001) argues that skilled worker migration facilitates the spillover of knowledge, technology and business contacts from destination countries, by interacting as a carrier between knowledge producing country and knowledge absorbing country. In migration literature this effect is known as the diaspora effect. This in turn suggests that skilled worker migration induced by BC will reduce the barriers of EU's knowledge flows to LDC and increase the absorptive capacity. In Figure 6 (upper panel) the marginal costs of knowledge adoption decreases from MC_A^S to MC_{AB}^S and the equilibrium total knowledge shifts from K_{TB1}^m to K_{TB}^m. Thus, through the reduced knowledge transmission barriers, BC will increase the productive inward knowledge spillovers.

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[14] 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 implying no unskilled wage effect.

[15] In the case of small LDC country the skilled labour demand in the EU is perfectly elastic D_{H1}^R (Figure 3). In this case the equilibrium skilled labour wage in EU would be equal to w_{Ho}^{R*}, both with BC and without BC. The equilibrium skilled labour migration would equal to L_H^m without BC and L_{Ho}^m with BC. Compared to migration from a large LDC, more skilled workers emigrate, $L_{Ho}^m > L_{HB}^m$, implying less human capital in LDC. Thus, the losses of human capital induced by BC are lower if LDC is large compared to a small LDC.

3. Migration policy options for LDC

Often migration policy studies propose either (i) infeasible policy recommendations, such as to restrict emigration (*Abella* 1992); (ii) rather general policy recommendations, such as to improve the economic situation in LDC (*Lowell* and *Findlay* 2001); (iii) or both infeasible and general, such as to increase investment and trade with developed countries (*OECD* 2009). Although, efficient from migration theory's perspective, they are of little help for policymakers in LDC.[16]

Recognising these insufficiencies, in this section we propose and examine specific migration policy instruments, while accounting for their political implementation feasibility. In the context of international labour migration policies, there are three important policy implementation constraints: (i) government budget constraint, (ii) political support constraint, and (iii) country openness, all of which we account for.[17]

3.1. Migration taxes

First, in order to compensate for BC-induced losses in innovative capital and to reduce the migration-driving international net wage differences, LDC government can imposes a migration tax (*Bhagwati tax*) to emigrating skilled workers (*Bhagwati* 1976). The impact of Bhagwati tax on human capital in LDC is shown in Figure 1. We assume that tax, t_H^m, is imposed on emigrating skilled workers (for the sake of simplicity we assume that $t_H^m = MC^*$). The migration tax does not affect domestic workers in LDC and EU. Instead, migration tax reduces the net skilled labour wage of migrant workers from w_{HB}^m to w_H^m. Because of smaller net wage differences between LDC and EU, the number of migrants decreases from L_{HB}^m to L_H^m, with $L_{HB}^m > L_H^m$ and the mass of skilled workers in LDC increases from L_{HB}^{Sn} to L_H^{Sn}, with $L_{HB}^{Sn} < L_H^{Sn}$.[18] Note that the emigration and the size of skilled labour force are reduced to their pre-BC levels, because we assumed that the tax is equal to the migration costs, $t_H^m = MC^*$.

Second, given that Bhagwati tax requires high international cooperation between LDC and EU, the skilled worker incentives for making use of BC can be reduced by increasing the skilled wage in LDC, for example, by imposing a differentiated tax rate for skilled and unskilled workers. In order to simplify the following analysis we assume that only unskilled labour is taxed with a tax rate equal to

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[16]According to *Lucas* (2004), the two main reasons why the suggested migration policies are seldom implemented in praxis: (i) either they are too general (e.g. improve the economic situation); (ii) or politically infeasible (e.g. Bhagwati tax), or both.

[17]First, if there would be no restrictions to government expenditure, then through wage subsidies LDC's government could straightforwardly increase the wage rate up to the EU level, and there would be no economically-driven emigration either with or without BC. Second, if maintaining political power would not be a government objective, then it could infinitely increase the tax rate for unskilled labour, decrease for skilled and achieve similar results. Third, if restricting outward migration would be a feasible policy option for LDC, then government could isolate the country from the rest of the world, and there would be no international labour migration in autarky. Obviously, all three policy scenarios are unrealistic and hence infeasible.

[18]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.

t_U.[19] A *skill-biased tax* affects only the demand for unskilled labour, which in Figure 3 shifts from D_U^S 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 education increases leading to higher migration. Higher migration, in turn, decreases skilled labour wage. In equilibrium the wage rate for skilled labour decreases from w_{HB}^m with BC to w_{Ht}^m with skill-biased tax. Lower wage allows firms in LDC to hire more skilled workers. As a result, the size of skilled labour force in LDC increases from L_{HB}^{Sn} to L_{Ht}^{Sn}, with $L_{HB}^{Sn} < L_{Ht}^{Sn}$ and emigration increases to L_{Ht}^m, with $L_{Ht}^m > L_{HB}^m$.

In the above analysis we implicitly assumed that LDC is large enough to affect the international wage rate for skilled labour. Only this indirect wage effect increased 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 sufficiently small, then LDC's tax policy does not affect the international wage rate for skilled labour. This would be the case, for example, if the EU's skilled labour demand is perfectly elastic, such as D_{H1}^R in Figure 3. The skilled wage with BC is w_{Ho}^{R*}, both with and without the skill-biased tax, and will not be affected by LDC's tax policy. As a result, in both cases with and without taxation of unskilled labour, the stock of skilled labour in small LDC will stay unchanged at L_{Ho}^{Sn}. However, in the presence of BC, a skill-biased tax will increase migration from L_{Ho}^m to L_{H2}^m, which is due to reduced after-tax wages in LDC.

3.2. Skill subsidies

In order to reduce/compensate for BC-induced losses in human capital, LDC government can top up skilled wage by a subsidy (*Heckman* 2000, *Carneiro* and *Heckman* 2003). This is shown in Figure 4. The initial equilibrium emigration with BC (share of workers which would emigrate without skill subsidy) is given by $L_{HB}^m \left(= L_{HB}^{Sm} - L_{HB}^{Sn}\right)$, the initial stock of skilled labour by L_{HB}^{Sn}, and the initial wage rate by w_{HB}^m. In order to reduce the cross-country wage gap, which drives migration, LDC grants skill subsidy, s_H. First, assume that LDC pays the subsidy directly to skilled workers.

The effect of *direct skill subsidy* is shown in Figure 4, where the skill subsidy shifts the supply of skilled labour down from S_H^S to S_{HS}^S. The demand for skilled labour is, however, not affected at D_H^S. As a result, the wage rate for skilled labour decreases from w_{HB}^m to w_{Hs}^m. The total income of skilled labour is equal to wage plus subsidy, $w_{Hs}^m + s_H$. The size of skilled work force in LDC increases from L_{HB}^{Sn} to L_{Hs}^{Sn}, with $L_{HB}^{Sn} < L_{Hs}^{Sn}$. Note that the stock of skilled labour increases only because of the indirect wage effect - the skilled wage decreases from w_{HB}^m to w_{Hs}^m. As a result, firms in LDC hire more skilled workers. However, if LDC is small enough, the international wage rate for skilled labour is not affected. With perfectly elastic skilled labour demand, D_{H1}^R, the wage rate and LDC's skilled labour stock stays at w_{Ho}^{R*} and L_{Ho}^{Sn}, respectively, both with and without skill subsidy. More skilled workers have incentives to migrate, because with skill subsidy, s_H, it becomes easier to buy the

[19] If both types of labour were taxed, then t_U would represent the tax difference between skilled and unskilled work.

'migration ticket' - BC, as it is cheaper to acquire education and then migrate. In Figure 4 skilled labour migration increases from L^m_{HB} to L^m_{Hs}, with $L^m_{HB} < L^m_{Hs}$ (in the case of a big LDC) and from L^m_{Ho} to L^m_{H2}, with $L^m_{Ho} < L^m_{H2}$ (in the case of a small LDC).

LDC government can improve the efficiency of skill subsidy by targeting the subsidy toward those skilled workers, e.g. through employer, which do 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 4, where the subsidy does not affect the supply of skilled labour, S^S_H, but instead shifts the demand for skilled labour up from D^S_H to D^S_{Hd}. Because of higher demand, the wage rate for skilled labour increases from w^m_{HB} to w^m_{Hd}. Higher domestic wage implies that less skilled workers have incentives to emigrate. As a result, migration decreases from L^m_{HB} to L^m_{Hd}, with $L^m_{Hd} < L^m_{HB}$. In the same time, because of higher wage, the stock of skilled labour at home increases from L^{Sn}_{HB} to L^{Sn}_{Hd}, with $L^{Sn}_{HB} < L^{Sn}_{Hd}$.

Comparing the two types of skill subsidies (direct and indirect) suggests that skill subsidy to firms is more efficient policy than paying it directly to skilled workers: (i) there are more skilled workers in LDC, $L^{Sn}_{Hs} < L^{Sn}_{Hd}$, (ii) less skilled workers emigrate, $L^m_{Hs} > L^m_{Hd}$, and (iii) budgetary costs are lower, $s_H L^{Sm}_{Hs} > s_H L^{Sn}_{Hd}$. The indirect skill subsidy is more efficient, because it 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' - BC.[20] A subsidy granted to skilled labour increases the stock of skilled labour only indirectly, through the international wage effect for skilled labour. If LDC is sufficiently small, then the skill subsidy has no effect at all on the stock of skilled labour in LDC.

3.3. Education subsidies

According to the underlying innovative capital framework, worker education decision is determined by a trade-off between the wage increase for skilled work (skill premium) and the cost of education. Thus, in addition to increasing the skill premium, the demand for education can be also increased by reducing the cost of education, for example, by investing in public education, or by subsidising education through government scholarships (*Heckman* 2000, *Carneiro* and *Heckman* 2003, *Fender* and *Wang* 2003).

The effect of *direct education subsidy* is similar to direct skill subsidy. As above, the stock of skilled labour increases only because of indirect wage effect. Higher supply of skilled workers exerts a downward pressure on skilled labour wage, which decreases. If skilled wage rate would not change, then the stock of skilled labour would stay the same. Therefore, this policy is ineffective in terms of increasing human capital. In addition, the direct education subsidy also increases migration. The stock of skilled labour in LDC depends only on the skilled wage effect in EU, but not on the education policy directly.

[20]Note that high-level skills obtained through the education is a precondition for eligibility of the EU Blue Card.

The effectiveness of education subsidy can be increased by conditioning the education subsidy on post-education employment in the LDC providing education. *Conditional education subsidy* has been implemented in several LDC and has proven to be an efficient way of increasing the stock of human capital (*Lowell* and *Findlay* 2001). Graphically the effect of conditional education subsidy is shown in Figure 4, where the stock of skilled workers increases from L_{HB}^{Sn} with BC to $L_{H}^{S^*}$ with conditional education subsidy. As a result, all skilled workers stay in LDC and there is no migration.

Alternatively, LDC government can implement the education subsidy through employer (similarly to skill subsidy). The support for education at firm level (*indirect education subsidy*) will shift the demand for skilled labour up. Higher demand for skilled labour exerts upward pressure on skilled labour wage. Because of higher skill premium, the stock of skilled labour in LDC will increase. Hence, the indirect education subsidy is more efficient than policy addressing education through labour market supply side (direct education subsidy) for three reasons: (i) the stock of skilled labour is higher in LDC, (ii) lower migration, and (iii) lower budgetary costs. 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 indirect skill subsidy.

If invested in education, the remittances from EU increase equilibrium education in LDC. Hence, by *increasing incentives for investing remittances into education*, e.g. by introducing a tax relief for remittances or reducing remittance transfer costs, LDC government could increase education.[21] A tax relief for remittances would increase the purchasing power of remittances in LDC and hence the incentives to remit. The share of remittances invested in education can be increased, for example, by introducing a distorting taxation to remittances spent for consumption goods and/or tax exemptions to remittances invested in education.[22] Because the purchasing power of remittances for consumption goods would decrease compared to education services, more remittances would be invested in education. As a result, the stock of skilled workers would increase in LDC. This can be seen in Figure 5. Increases a remittance tax rate for consumption goods changes the relative prices of remittances spent on consumption and education, which in turn shifts skilled labour supply from S_H^S to S_{Hr}^S. As a result, the stock of skilled labour in LDC increases from L_{HB}^{Sn} to L_{Hr}^{Sn}.[23]

As above, the efficiency of education remittance tax relief can be improved by granting the tax relief only for those skilled workers that remain in LDC, because part of the additional workers which obtain education would emigrate (in Figure 5 skilled labour migration increases from L_{HB}^{m} to L_{Hr}^{m}).

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

[22]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. However, lower remittance taxes can be compensated by higher taxes on consumption goods.

[23]Note that the stock of skilled labour increases only because of the indirect wage effect. In the case of a small LDC country, the tax relief for remittances invested in education will not affect the LDC skilled labour. With perfectly elastic skilled labour demand D_{H1}^R the wage rate and LDC skilled labour stock stays at w_{Ho}^{R*} and L_{Ho}^{Sn}, respectively, both with and without the tax relief for remittances.

3.4. R&D policies

As shown in section 3, high skill migration affects not only human capital but also knowledge capital in LDC. Hence, in addition to coping with BC-caused losses in human capital, LDC government also has to cope with decreasing knowledge capital (which not only reduces growth, but also co-determines skilled labour migration). The two main options for increasing knowledge capital are investing in R&D for generating new ideas (subsidising the innovation of new knowledge), or in adoption of foreign knowledge (subsidising the adoption of foreign knowledge). Figure 6 shows the effects of both types of polices.

Knowledge adoption subsidy can be implemented in two ways: co-financing the cost of knowledge adoption or subsidising the demand for knowledge, MB_B^S. Figure 6 (upper panel) shows the effect of a policy, which co-finances the cost of knowledge adoption. We assume that LDC government pays knowledge subsidy, s_K, per unit of adopted knowledge. Knowledge adoption subsidy reduces marginal costs of knowledge adoption from MC_{AB}^S to MC_{As}^S, which increases LDC's equilibrium knowledge from K_{TB}^m with BC to K_{Ts}^m with s_K.

Other option at disposal of LDC is to subsidise the creation of new knowledge. Assume that LDC's government pays the same subsidy, s_K, to reduce the cost of new knowledge creation. In Figure 6 (upper panel) this implies that the marginal cost curve of knowledge creation shifts from MC_C^S to MC_{Cs}^S. In this case *knowledge production subsidy*, s_K, does not affects the equilibrium level of knowledge in LDC. Hence, in the presence of BC knowledge capital stays unchanged at K_{TB}^m both with and without s_K. The knowledge production subsidy, s_K, only changes the equilibrium distribution between new knowledge and adopted knowledge: it increases the innovation of new knowledge from K_{CB}^m to K_{Cs}^m, and decreases the adopted knowledge from $K_{TB}^m - K_{CB}^m$ to $K_{TB}^m - K_{Cs}^m$.

These results suggest that, as long as the knowledge gap is positive, subsidising the creation of new knowledge is less efficient than subsidising the adoption of foreign knowledge. For LDC it is cheaper to adopt foreign knowledge than to produce new knowledge. As a result, subsidising the creation of new knowledge only offsets the cost disadvantage of new knowledge production compared to knowledge adoption and leads to zero (or smaller) increase in the total knowledge capital.[24]

On the other hand, the reallocation of subsidies between adopting foreign knowledge and producing new knowledge affects also skilled migration, at least in the long run. Investing in R&D increases the productivity of both skilled and unskilled labour. However, because the efficiency of subsidies invested in new knowledge creation is lower than the efficiency of subsidies invested in knowledge adoption, the increase in productivity of labour is higher with latter than with former policy. These

[24] Note that if marginal costs of knowledge adoption, MC_{AB}^S, is not constant but increasing in knowledge adoption, then subsidising the creation of new knowledge will result in higher knowledge capital in equilibrium. However, because creation of knowledge is more expensive than adoption of foreign knowledge (i.e. in terms of Figure 2 the slope of MC_C^S is higher than the slope of MC_{AB}^S), the result that subsidising the creation of new knowledge is less efficient than subsidising the adoption of knowledge holds in general.

effects are shown in Figure 7. Investing in production of new knowledge increases skilled labour demand from D_H^S to D_{H1}^S and unskilled labour demand from D_U^S to D_{U1}^S (Figure 7, left panel).[25] Due to increase in unskilled labour wage, skilled labour supply increases from S_H^S to S_{H1}^S. Because of smaller wage gap between EU and LDC, the stock of skilled labour in LDC increases from L_{HB}^{Sn} to L_{H1}^{Sn}, with $L_{HB}^{Sn} < L_{H1}^{Sn}$, and migration of skilled workers decreases to L_{H1}^m, with $L_{HB}^m > L_{H1}^m$.

As shown in Figure 6, reallocating subsidies from new knowledge production to foreign knowledge adoption, the knowledge capital increases stronger and hence labour productivity in LDC increases more. In Figure 7 higher productivity shifts labour demand more upwards: from D_H^S to D_{H2}^S for skilled labour and from D_U^S to D_{U2}^S for unskilled labour. The skilled labour supply shifts up from S_H^S to S_{H2}^S. Migration decreases to L_{H2}^m, with $L_{HB}^m > L_{H1}^m > L_{H2}^m$. The stock of skilled labour in LDC increases to L_{H2}^{Sn}, with $L_{H2}^{Sn} > L_{H1}^{Sn} > L_{HB}^{Sn}$.

In summary, the efficiency of knowledge the adoption subsidy is higher than of the knowledge production subsidy. The latter increases more knowledge capital and hence labour productivity. Higher productivity increases skilled labour in LDC and reduces skilled migration more efficiently than the knowledge production subsidy.

3.5. Policy recommendations

Findings from the previous sections suggest that policies that address the *supply side* of skilled labour market (e.g., direct education subsidy, direct skill subsidy) are the least efficient. This is especially the case when the LDC is small relative to EU, as such policies enhance migration, but they do not have a direct impact on skilled labour stock in LDC. Only if the LDC is large enough compared to EU, supply side policies may increase the stock of skilled labour in LDC, as skilled migration decreases the international wage rate for the 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 direct subsidies at all. The key issue 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. Being targeted at both potential migrants and non-migrants, they help also the potential migrants to buy the 'skill migration ticket' - BC.

The efficiency of migration policies in LDC can be improved through a better targeting: (i) directly on the *demand side* of skilled labour market (e.g. through skill subsidy granted to firms, or subsidising education at firm level); or (ii) directly on *migrants only* (e.g. through Bhagwati tax, conditional education subsidy). Whereas the former changes incentives only of those that stay, the latter does the reverse - it changes the incentives of those that migrate. In terms of the implementation feasibility, the policy that addresses the demand side of skilled labour market appears to be less costly. The

[25]Here we assume that subsidies invested in new knowledge creation increase knowledge capital in LDC. This holds when marginal costs of knowledge adoption, MC_{AB}^S, are increasing in knowledge adoption.

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

Figure 8 classifies LDC policy options according to two criteria. 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.[26]

The most efficient policies are located in quadrant IV. Indirect education subsidy, indirect skill subsidy to firms and investment in knowledge adoption are the most efficient policies in terms of political implementation costs and in terms of increasing the distribution of skilled labour between LDC and EU, L_H^{Sn} / L_H^m. They have relatively low costs of implementation and lead to a high increase in the stock of skilled labour by decreasing brain drain. However, these policies do not have the highest political support after migration, i.e. they are not at the bottom of quadrant IV. With skilled worker emigration, the political support for redistributive policies increases (*Kancs* and *Ciaian* 2010). Investment in new knowledge has the same political implementation costs as the other two policies in 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 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 encourages to acquire education and to emigrate (it will be easer to 'buy' BC). 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 any impact on the stock of skilled labour in LDC.

Quadrant III shows policies that are politically feasible but inefficient in maintaining the innovative capital. 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. According to *Kancs* and *Ciaian* (2010), the direct skill subsidy is 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 efficient in increasing the L_H^{Sn} / L_H^m ratio but are politically infeasible. There are two policies in this quadrant: Bhagwati tax and migration quota/restriction. Both the Bhagwati tax and the migration quota/restriction efficiently increase the stock of skilled labour and decreases migration. However, their implementation is very costly, because they both require cooperation with EU and expensive border control measures. The EU cooperation is questionable

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

since it would contradict the objectives of BC.

3.6. Discussion and limitations

Despite the holistic framework, as all models, our analysis is subject to several limitations, which should be kept in mind when interpreting the model results. First, the innovative capital model we propose is throughout static. This implies that the potentially reciprocal effects of migration on both receiving and sending countries are not considered in the analysis. In order to analyse the causal effects of migration on economic growth and knowledge exchange, a dynamic and longitudinal model is called for, which is a promising avenue for future research. Second, the proposed model is partial equilibrium in sense that the two main effects (human capital and knowledge capital) are analysed separately. In reality, however, they are interlinked and affect each other. Hence, in future the underlying innovative capital model should be extended by incorporating an interaction term between human and knowledge capital. Third, due to data limitations, the present paper is largely theoretical. In future the analysis could be considerably strengthened, if empirical evidence could be presented.

4. Conclusions

In May 2009 the EU adopted a Blue Card directive, which will facilitate the entry, highly qualified employment, and residence of highly skilled LDC workers in EU. The present paper examines the potential impacts, which BC may cause on knowledge and human capital in the least developed migrant sending countries.

The conceptual framework we adopt in the present study is based on the theory of innovative capital (*Furman, Porter and Stern* 2002), which combines insights from several theories, which in our view are important for LDC growth prospects: investment in education and skill premium stressed by labour economics, brain drain, brain waste and brain gain, stressed by different migration theories, R&D and innovation role and knowledge capital, and knowledge spillovers literature.

In line with previous studies (*Beine, Docquier and Rapoport* 2001; *Lowell and Findlay* 2001; *Lucas* 2004; *Katseli, Lucas and Xenogiani* 2006), we found that BC will reduce human capital in LDC. In addition, BC will also have a negative impact on knowledge capital. Although important for LDC growth and development, the link between skill migration and knowledge capital has been studied to a much lesser extent. In addition, through mutual interaction of the two components of innovative capital (knowledge and human capital), the long-run equilibrium will likely be different from a partial equilibrium short run perspective.

Based on the identified impacts on selected growth drivers, we propose and examine alternative policy instruments for LDC. Our findings suggest that policies implemented on the demand side of skilled labour market (e.g. through skill subsidy granted to firms, or subsidising education at firm level) are the most efficient, followed by policies targeted only to migrants (e.g. through Bhagwati tax, conditional education subsidy). Policies that address the supply side of skilled labour market (e.g., direct education subsidy, direct skill subsidy) are the least efficient, although their implementation

feasibility is higher.

Turning to limitations of our study, we recognise that, although accounting for most important aspects of skilled labour migration on innovative capital in LDC, the performed graphical analysis cannot provide us with a quantitative assessment of BC impacts on LDC growth prospects. Nevertheless, by pointing to the adverse growth issues arising from BC in LDC, our study offers a blueprint for deriving a formal general equilibrium framework with endogenous growth and location engines by linking innovative capital to technological development and economic growth in LDC for assessing the impact of BC. This is a promising area for future research.

Summarising our findings we conclude that without appropriate policy responses, the adopted EU Blue Card makes developing country growth prospects rather bleak than blue.

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Figure 1. Human capital model

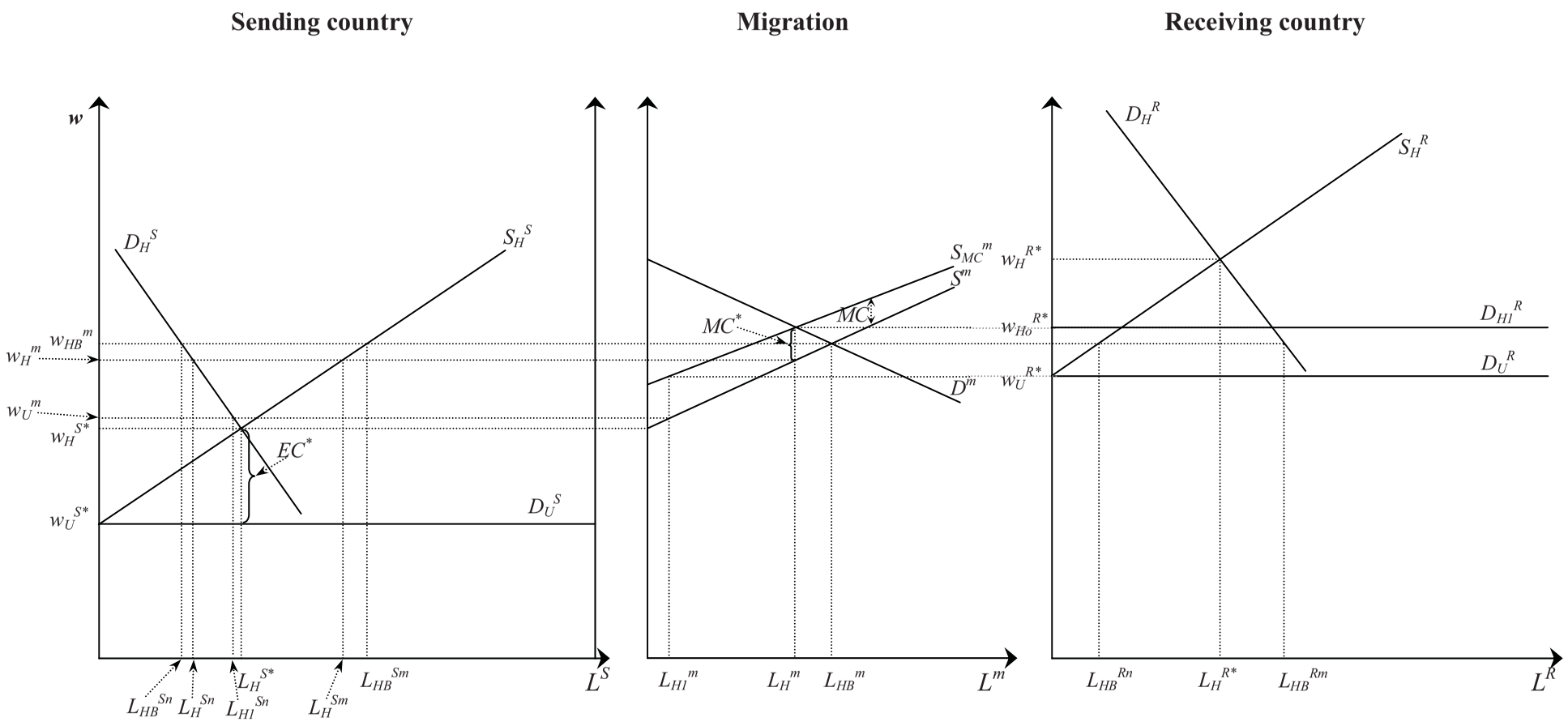

Figure 2. Knowledge model

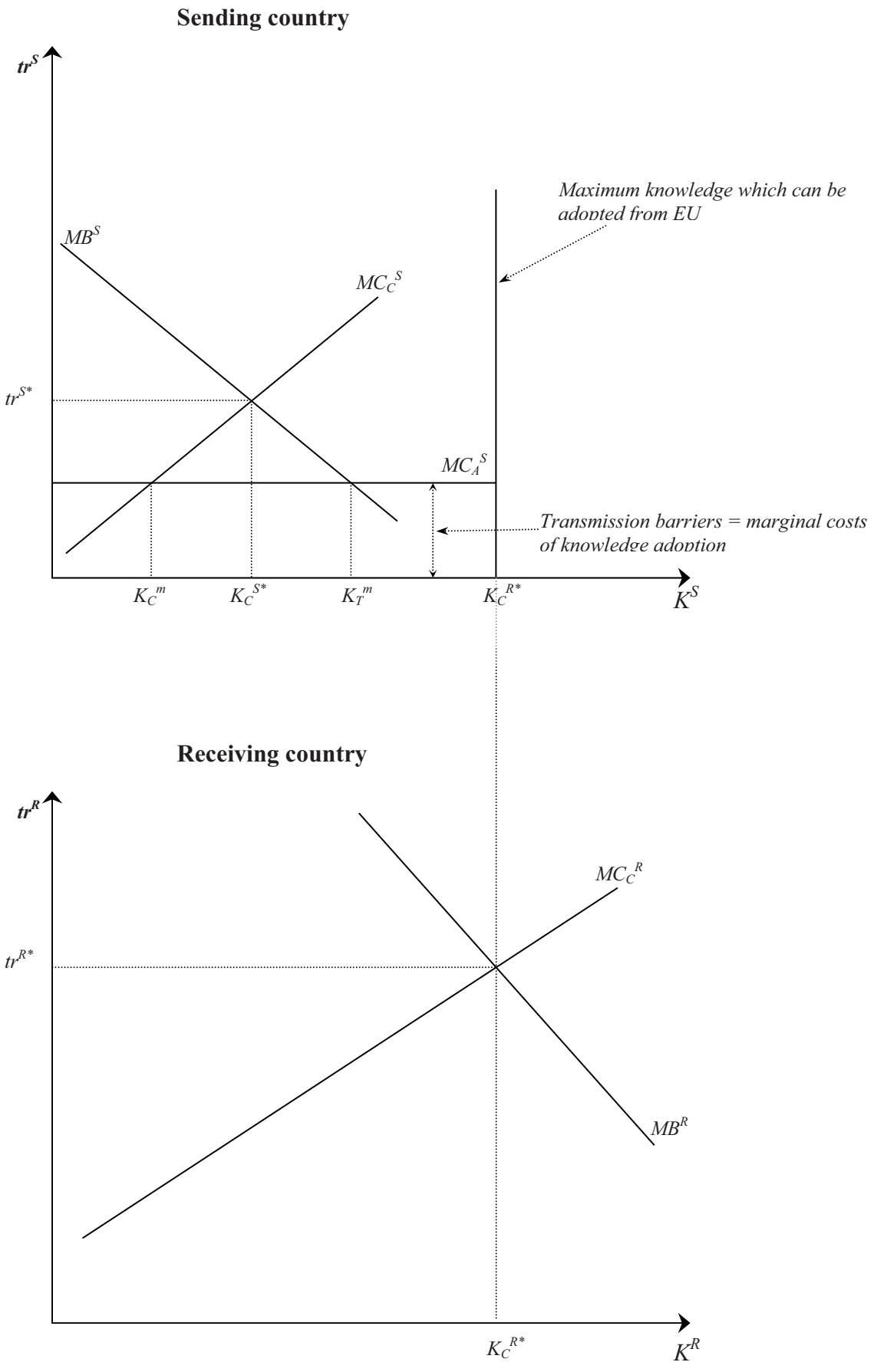

Figure 3. The effect of skilled biased tax

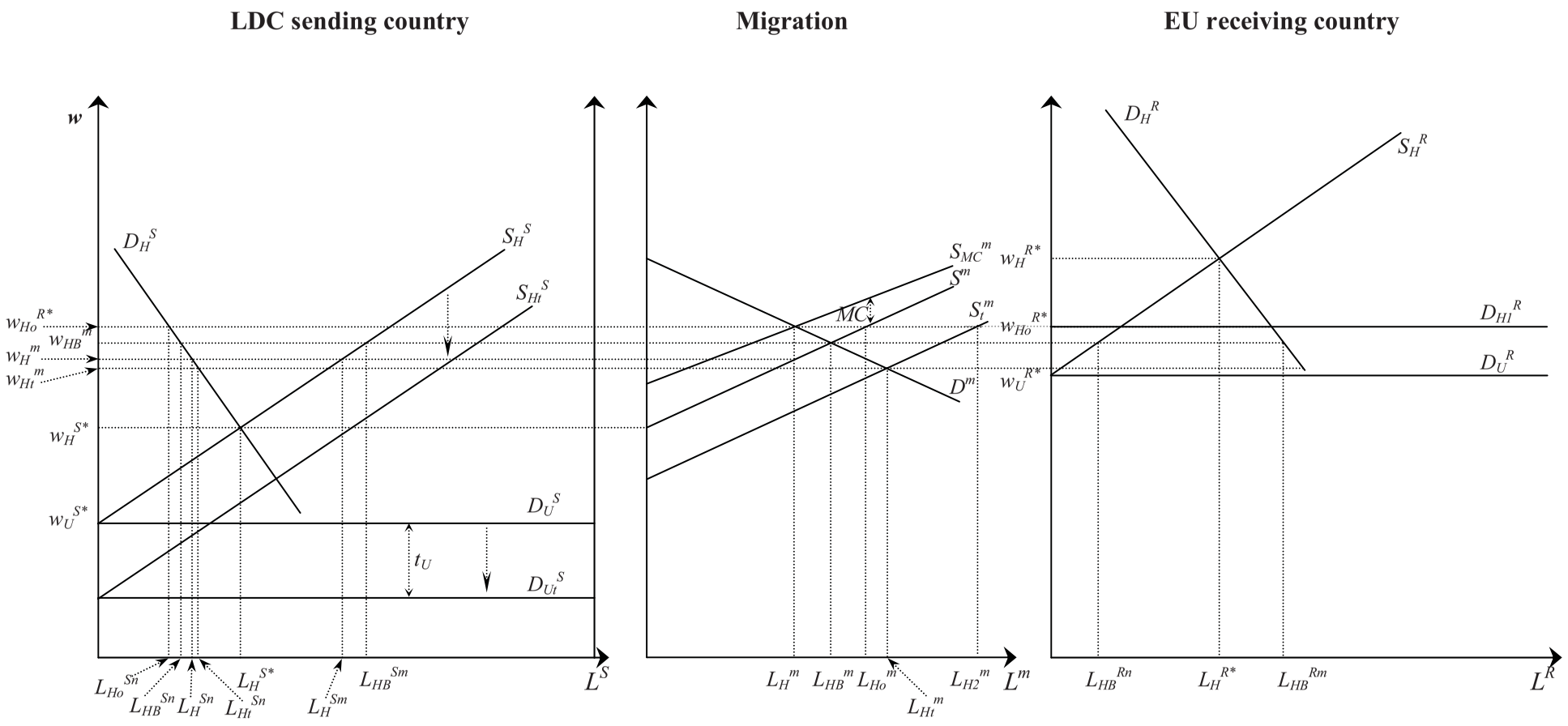

Figure 4. The impact of skill subsidy on human capital in LDC

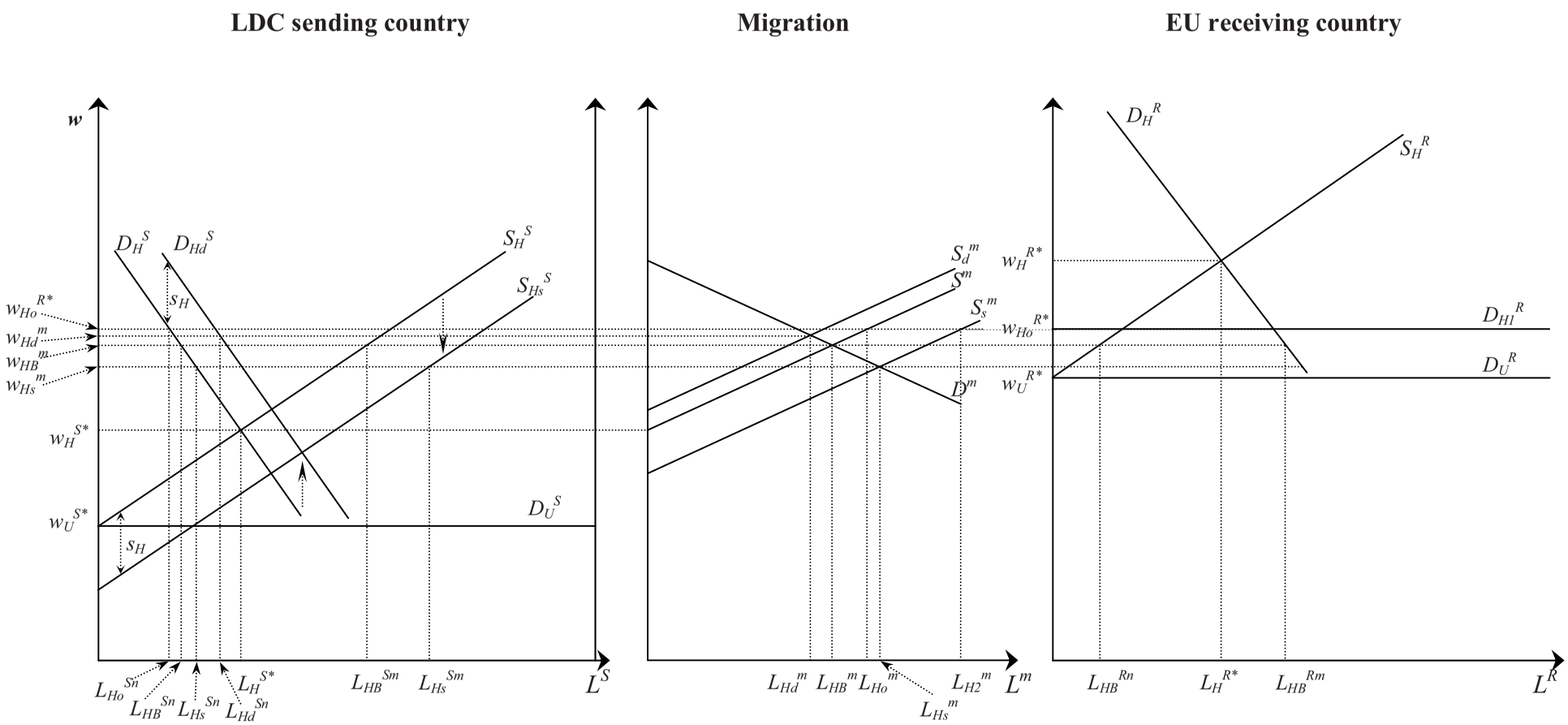

Figure 5. The impact of remittances on human capital in LDC

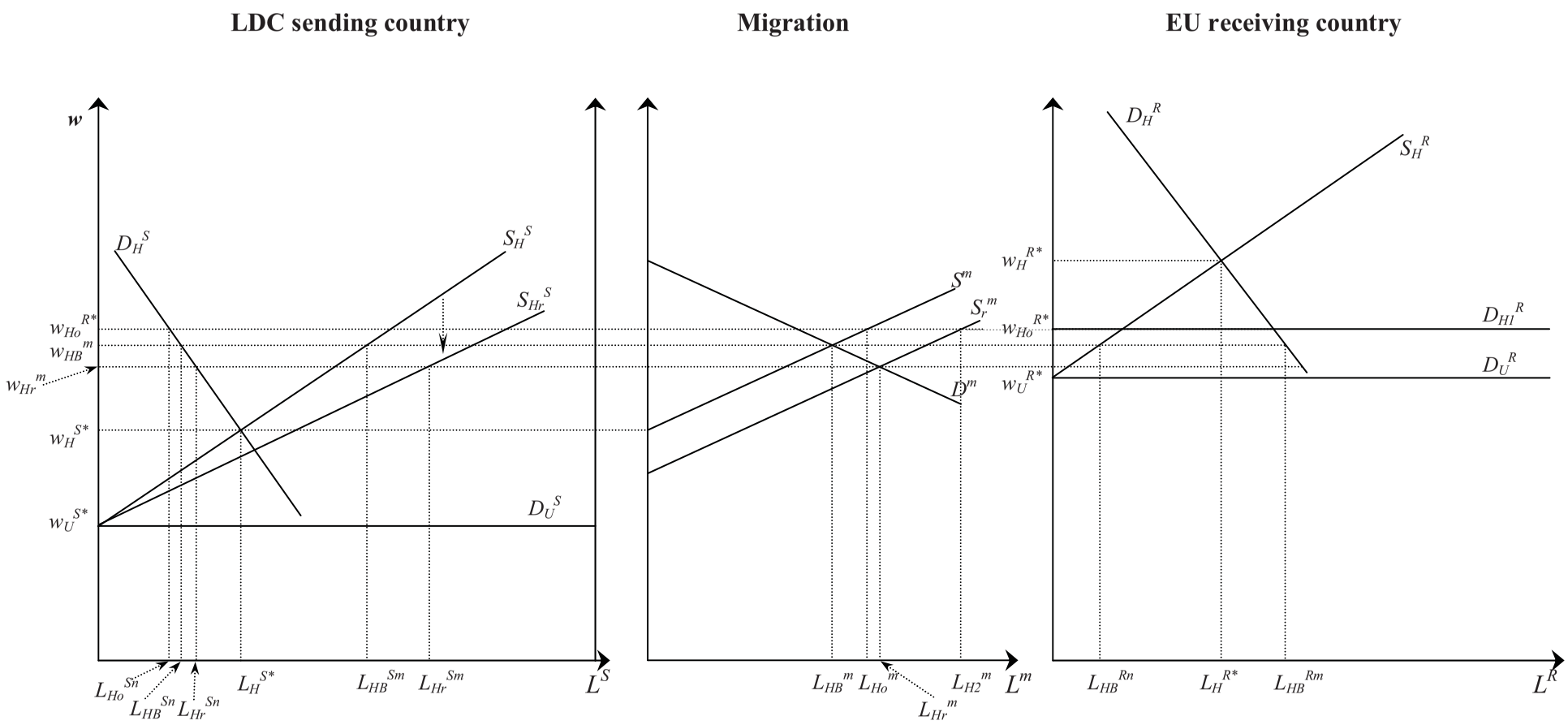

Figure 6. The impact of knowledge creation and knowledge adoption subsidies on LDC knowledge capital

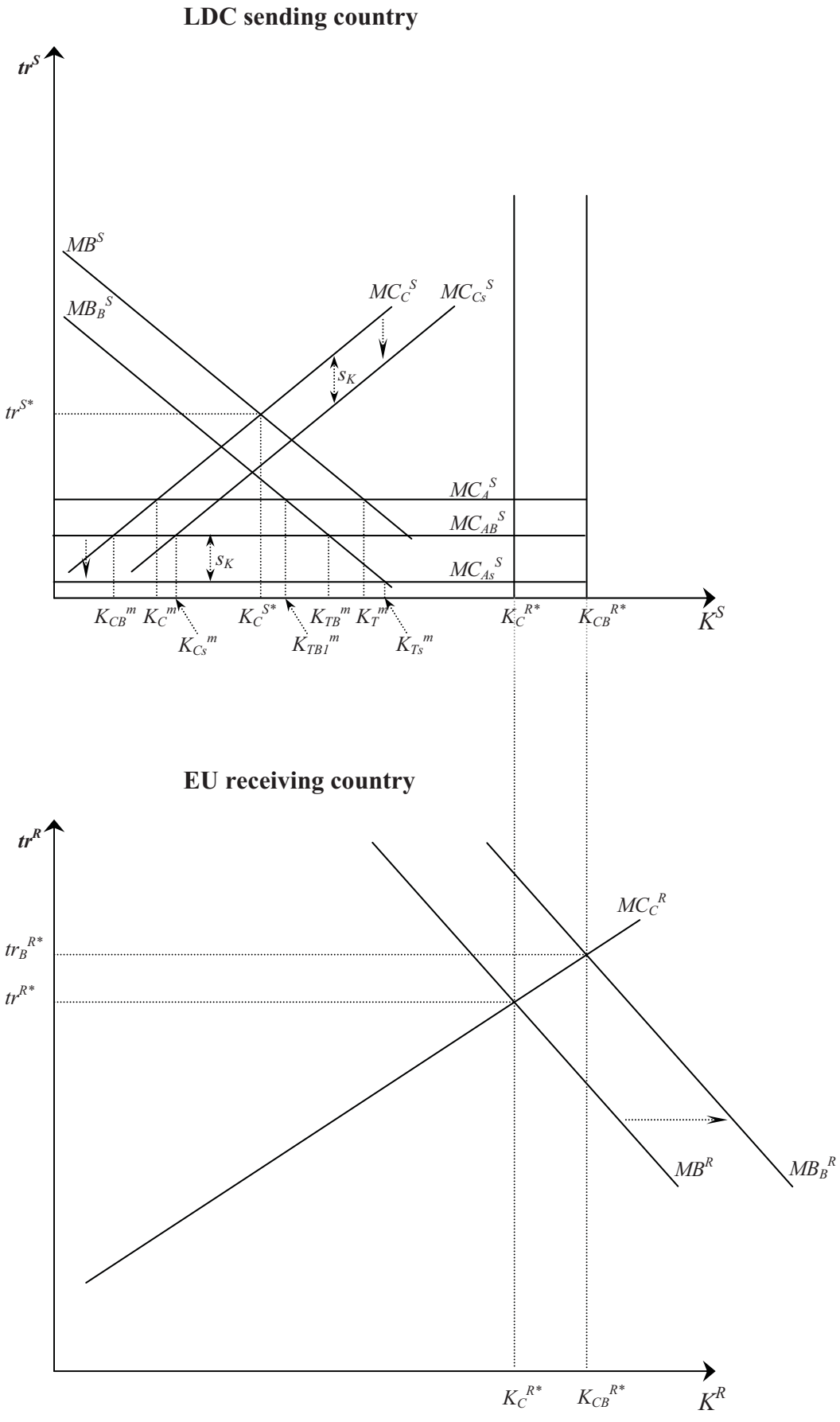

Figure 7. The effect of public investment in knowledge creation

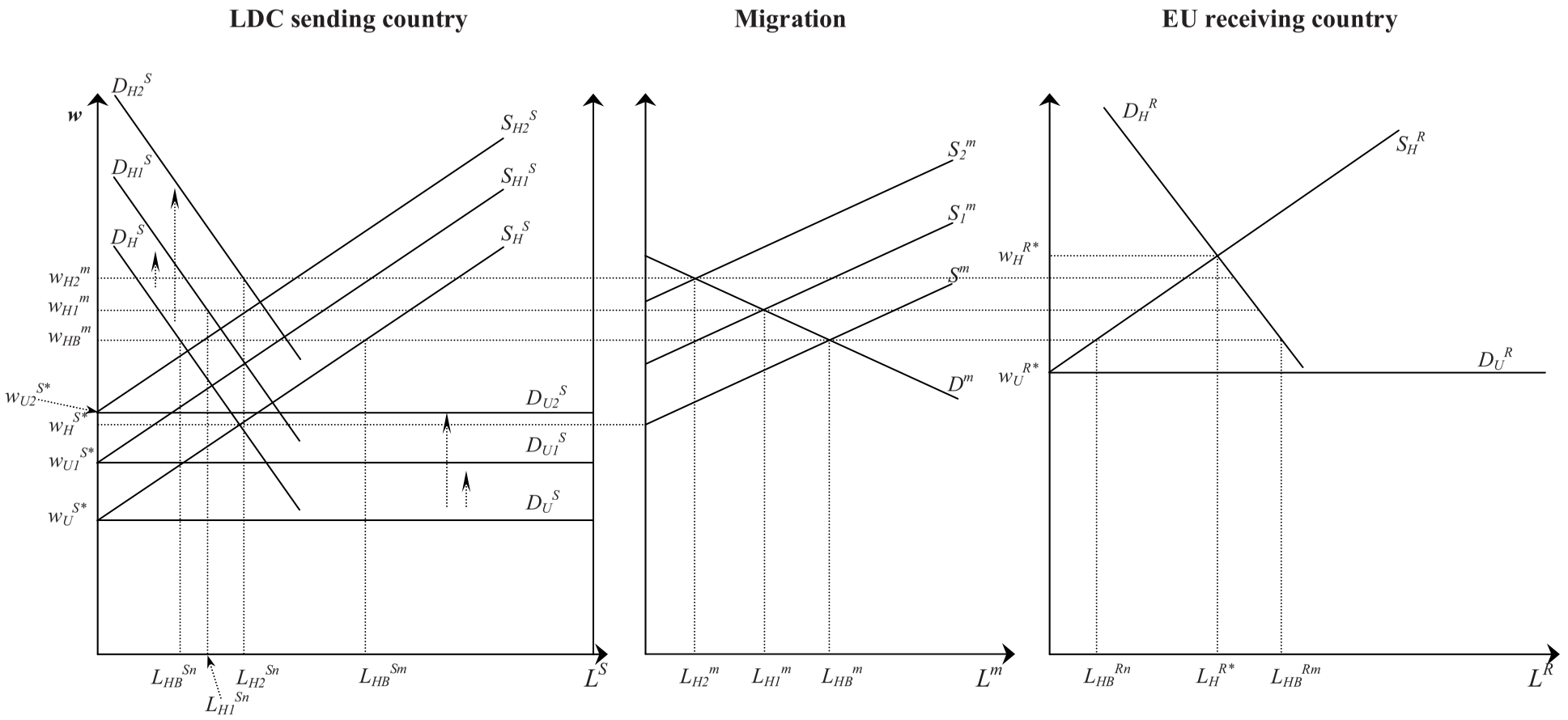

Figure 8. Policy classification