Education Policy, Student Migration, and Brain Gain*

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January 2013

Abstract

In this paper, we analyse how increasing student migration from a less developed to a developed country alters education policy in the developed country, and how it affects human capital and welfare in the two countries. We argue that a higher permanent migration probability, i.e., a higher probability that international students continue to stay in their host country after graduation, incentivises the host country to improve its education quality. A higher education quality in turn raises the human capital of all students, including returning students. As long as the permanent migration probability is not too large, this positive quality effect increases human capital and welfare in both the less developed country (LDC) and the developed host country. Thus, a brain gain to the LDC occurs. A decline in the taxes on labour income in the two countries can reinforce this brain gain, although the developed country then raises the tuition fees.

Keywords: Brain gain; education; human capital; mobility; return migration.
JEL classification: F22; I28; H52.

*We thank Alessandra Casarico, Silke Uebelmesser, Marcel Gérard, Panu Poutvaara, Daniel Shilcof, and David Wildasin for very helpful comments. We have also benefited from discussions at the workshop on 'Globalization, Education and Taxation' in Konstanz, at the CESifo Venice Summer Institute workshop on 'Cross-Border Mobility of Students and Researchers', and at the Ifo Institute in Munich. Thomas Lange gratefully acknowledges financial support from the Fritz Thyssen Stiftung (Project on 'Globalization, Education and Taxation').

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1 Motivation

Advancing production technologies and the growing complexity of service industries will demand an increasingly larger share of highly qualified workers in the future labour force. At the same time, the ageing of workforce will not only depress overall labour supply but also put strains on public finances, as old age-related spending is expected to grow at a higher rate than tax revenues and social security contributions (see also the discussion in Wildasin, 2012). From the perspective of a developed country, this situation could be at least partly solved by promoting immigration of skilled workers or by attracting talented students from abroad who are allowed to continue to stay in their host country after graduation (e.g., Storesletten, 2000). These permanent immigrants could fill the gaps in the skilled labour force and generate pure and fiscal externalities in their host country.

Developed countries could, for instance, implement policies to attract skilled workers from emerging or less developed economies (for brevity, referred to 'LDCs' henceforth). However, a more promising strategy might be to attract talented students from LDCs and provide them with the necessary professional, language and cultural skills at a university in the developed country. This local education then facilitates the integration of foreign graduates into the labour market of the host country. In fact, the number of foreign students in OECD countries has substantially increased in recent years, from 2.1 million in 2000 to 3.7 million in 2009, with a particularly large share of these students coming from China (18.2%) and India (7.3%) (OECD, 2011: 320 and 327). On average, about 25% of foreign students in OECD countries stay in their host country upon graduation (OECD, 2011: 330).[1] In the US, about two-thirds of all foreign-born PhDs remain in the country (Finn, 2003), and the share of Indian and Chinese PhD students who intend to stay in the US after completing their thesis even exceeds 80% (Tremblay, 2002).

According to recent estimates by the OECD, investing in the tertiary education of international students can turn out to be very beneficial to the host countries. In the OECD, the net public return per student amounts to over USD 90,000 (55,000) for a man (woman) in present value terms (OECD, 2011: 165). These figures take into account the impact of higher education on tax revenues, social security contributions and social transfers. They also include direct and indirect public costs of higher education (OECD, 2011: 160). In addition to this net public return, other positive effects arise, such as a more balanced age structure in the host country and a culturally enriched learning environment for domestic students (e.g., NAFSA,

[1] Dreher and Poutvaara (2011) and Felbermayr and Reczkowski (2012) also find empirical evidence of a close relationship between student flows and subsequent permanent migration flows.

2006).[2] These effects constitute a positive externality from international students and graduates on the host countries.

Hence, the host countries should have strong incentives to attract foreign students by accommodating their needs through additional investments in tutors, language courses and international programmes. These investments go beyond improving the overall quality of study programs, which would also benefit domestic students, and may include specific programs aimed at foreign students only. Indeed, there is evidence that various countries have successfully launched policies to lure foreign students to their universities.[3] According to OECD (2011: 324–5), for instance, such policies are part of a broader strategy to foster socio-economic development in countries such as Australia, New Zealand, and Japan.

The OECD numbers outlined above indicate a growing mobility of students from developing countries. This increase in mobility partly results from technological developments, such as better communication and transportation technologies. These developments allow expatriates to keep in touch with family and friends left behind more easily and at lower costs, thus softening the downside of migration. Also, permanent migration may rise because of institutional and political changes, such as more liberal immigration laws, an easing of visa regulations, or measures to promote access to the labour market of the host country (e.g., Chaloff and Lemaitre, 2009). As a consequence, permanent migration may become increasingly common in the future, ultimately increasing the stay rates in the developed host countries after graduation.

However, 'one country's pleasure may be another country's pain.' From the perspective of an LDC, the increase in the probability of permanent migration implies a quantitative loss in human capital, as fewer qualified students return from abroad.[4] The present paper addresses this concern by investigating (i) the incentives for a developed country to provide tertiary education to LDC students, who may or may not stay in their host country upon graduation, and (ii) the resulting effects on human capital and welfare in the LDC. We analyse this in a model in which internationally mobile natives of an LDC can study in a rich host country. This host country can benefit from foreign students not only because they pay tuition fees, but also because if they continue to reside in their host country upon graduation, they generate a positive net public return in their host country.

[2] Throsby (1991, 1998) provides a more comprehensive analysis of the costs and benefits of foreign student enrolment.

[3] Even if the universities autonomously decide on the admission of international students, government regulations can, purposely or not, set strong incentives for universities to attract foreign students, as Murphy (2012) shows for the case of non-EU students in the UK.

[4] The traditional brain drain literature predicts that this loss of human capital reduces welfare and hampers economic development in LDCs (e.g., Bhagwati and Hamada, 1974).

Our model shows that an increase in the permanent migration probability (i.e., the stay rate upon graduation) makes it more attractive for the host country to invest in education quality, as this investment generates a larger net public return to the host country. We also show that the apparently negative impact on the human capital stock in the LDC need not occur. A higher probability of permanent migration strengthens the incentives of the host country to improve education quality. This boosts the human capital of all foreign students, including those who ultimately return to the LDC. As a consequence of this quality effect, aggregate human capital in the LDC increases with the permanent migration probability as long as this probability is not too large, implying a *qualitative* brain gain. Once the permanent migration probability exceeds a critical level, however, a further increase depresses aggregate human capital in the LDC. The relationship between the net public return that returning graduates generate in the LDC and the permanent migration probability follows the same pattern. As the permanent migration probability increases, the net public return in the LDC first rises and then declines, in line with the changes in the human capital stock in the LDC.

At first glance, the identified pattern is somewhat reminiscent of Haupt and Janeba (2009) and Stark and Wang (2002). In both papers, low levels of mobility are beneficial to LDCs, while high levels are detrimental to the welfare in LDCs. However, neither of these papers relates this outcome to the incentives for host countries to invest in the education of LDC students. In fact, our approach adds a new and complementary channel to the recent theoretical and empirical literature on 'brain gain' effects (e.g., Mountford, 1997; Stark et al., 1997, 1998; Vidal, 1998; Beine et al., 2001, 2008; Mayr and Peri, 2009; Eggert et al., 2010) by focusing specifically on *public* education investments of a developed host country. The standard explanations for beneficial emigration of talented individuals focus instead on the impact of mobility on *private* investments in higher education. As skilled wages are higher in the rich world, the prospect of emigrating to a developed country raises the expected private returns to human capital even in remote and poor corners of the world. Therefore, more natives of developing countries invest in their education. Despite the temptations of the rich world, many students from developing countries end up staying in, or returning to, their home country. Consequently, developing countries enjoy a brain gain if the private incentive effect is sufficiently strong.

In this literature, however, the quality of education and thus the private returns on investment on education are exogenously given (e.g., Stark and Wang, 2002). Our paper differs fundamentally from this approach, as we endogenise the education quality in the host country, which in turn affects the private returns on education. That is, our model proposes a mechanism that is a natural extension of the standard

argument. In addition to the *private* incentives for students from LDC to invest into their human capital, there are also *public* incentives for host countries to invest in their education. The current paper focuses on this latter incentive.

Thus, our argument bridges a gap between the aforementioned literature on brain gain and recent papers on education policy with student mobility (e.g., Del Rey, 2001; Demange and Fenge, 2010; Demange et al., forthcoming; Gérard, 2007; Kemnitz, 2007; Lange, 2009, 2013). Both strands of the literature deal with complementary aspects of the same economic mechanism, but have—to the best of our knowledge—not yet been connected explicitly.

Our conclusions hinge crucially on the net public return that graduates generate, which in turn depends on future tax payments and social security contributions. According to many papers on tax competition, the taxes on the income of mobile, skilled workers tend to fall in the course of globalisation. Interestingly, the impact of a decline in the tax rates very much depends on the circumstances. If the permanent migration probability is low (high), a fall in tax rates will increase (decrease) human capital and welfare in the LDC and the rich host country. In an extension of our analysis, we derive and explain these contrasting outcomes.

Our basic model focuses on the incentives that foreign students set for the host country's education policy as well as on initiatives that specifically enhance the education of these students. However, many policies improve the quality of education in general, i.e., for domestic and international students, and cannot be targeted at a specific subgroup of students. To analyse how the presence of international students affects the investment in such general improvements of education quality, we extend our basic model to include domestic students and consider only policies that enhance the quality of education in general. We show that our previous conclusions are robust with respect to this extension. Moreover, a rise in the permanent migration probability now generates a further positive effect in the rich host country, since it induces an increase in the general education quality, which in turn boosts human capital and future gross income of domestic students.

The paper proceeds as follows. In Section 2, we present our model. Section 3 characterises the optimal education policy of the rich country and analyses how this optimal policy responds to an increase in the permanent migration probability. In Section 4, we explore how the permanent migration probability affects human capital and welfare. This section contains our key conclusion on brain gain and brain drain. Section 5 analyses the impact of declining income tax rates on education policy and welfare, while Section 6 examines whether including domestic students and general education quality alters our conclusions. In section 7, we discuss some policy implications of our analysis. Section 8 concludes the paper.

2 The Model

We explore our argument in a model with two countries, Poor P (the LDC) and Rich R (the developed country). Rich hosts a university, called the University of Rich (UoR). The government of Rich controls, directly or indirectly, the quality of education q, $q \geq 0$, and the tuition fee t. An improvement in education quality increases both variable costs per student $c(q) = \alpha q$ and fixed costs $F(q)$, with $F(0) = 0$, $F'(q) \geq 0$ and $F''(q) > 0$. The elasticity of marginal fixed costs with respect to quality (i.e., $\varepsilon := F''q/F'$) is constant; a case in point is a quadratic cost function.

There is no university in Poor; however, UoR is open to natives of Poor. Those individuals from Poor who enrol and study at UoR stay on and work in Rich after graduation with probability m, $m \in [0,1]$, and return to and work in Poor with probability $(1-m)$. The returning individuals are randomly drawn from the set of Poor's natives who have graduated at UoR. We refer to m as 'permanent migration probability'.

If individual k studies at UoR, this individual acquires human capital $a_k q$ and, upon graduation, earns gross wage $w_k(q) = a_k q$. That is, individual human capital $a_k q$ and wage w_k increase with k's innate ability, denoted by a_k, and the quality of the university education q. Individuals differ in their ability a_k, $a_k \in [0,1]$, and ability is uniformly distributed across Poor's population, whose size is normalised to one. If individuals do not study at UoR, they do not acquire human capital and receive only a basic wage. For convenience, we set the basic wage to zero.[5] We refer to those individuals who graduate (do not graduate) as skilled (unskilled) workers.

The investment in the tertiary education of individual k yields a public return of $\tau w_k(q)$, $\tau > 0$, in the country where, after graduation, this individual resides and works. This public return can be interpreted in at least two different ways. Firstly, it can consist of k's tax payments and contributions to the social security systems net of any social transfers to individual k. Then, the net wage is $(1-\tau)\, w_k(q)$. Secondly, we can interpret $\tau w_k(q)$ as the value of a positive human capital externality associated with higher education. Then, $w_k(q)$ stands for the overall income or benefit generated by graduate k, and $(1-\tau)\, w_k(q)$ captures the share of this overall

[5] We implicitly assume that skilled wages are the same in Poor and Rich. This simplification is justified, since we focus on the incentives for the host country to invest in education quality. These incentives are not qualitatively affected by the assumption of equal wages across countries. We acknowledge, of course, that both base wages and skill premia vary across countries (e.g., Rosenzweig 2006, 2008). Importantly, however, the price level is lower in less developed countries than in wealthy ones. This difference in price levels at least diminishes the gap in real income, which ultimately matters for the welfare of workers. For instance, Baruch et al. (2007) point out that Chinese and Indian individuals with a foreign university degree have excellent career opportunities back in their home countries, creating a very respectable living standard.

income or benefit that accrues to individual k as personal income. In the following analysis, we refer to the tax interpretation of the parameter τ. However, it is important to bear in mind that interpreting the parameter τ as a human capital externality leads to exactly the same results.

The timing of decisions is as follows: Rich chooses its education quality q in the first stage and its tuition fee t in the second stage. It maximises the net public return to Rich generated by foreign students, as detailed in objective function (3) in Section 3. In the third stage, the natives of Poor decide whether they study at UoR or whether they do not. They maximise their disposable income, i.e., wage income minus tuition fee. All other actions occur 'automatically'. Students complete their education. They continue to stay in Rich with permanent migration probability m or return to Poor with probability $(1-m)$. Graduate k earns wage $w_k(q)$ and generates public return $\tau a_k q$ in the individual's final country of residence.

As outlined in Section 1, people have become increasingly mobile over recent decades of globalisation. More and more students study abroad and seek work in their host country after graduation. In the model, a rise in the permanent migration probability captures this development, and we analyse how such a rise affects education quality, tuition fees, and welfare in Poor and Rich. In this context, the term 'permanent' should not be taken literally. It is only supposed to refer to the fact that some foreign students do not leave their host country immediately after graduation, but continue to stay and work there for at least some time.

Globalisation has, of course, further implications. For instance, it tends to depress tax rates of highly skilled and mobile workers. Therefore, in an extension we analyse how a change in the tax rate τ affects our conclusions. Also, as we ignore domestic students in our basic model, we include them in a further extension. However, it turns out that our results are very robust with respect to this extension.

3 Education Policy and Permanent Migration

In this section, we first determine the education quality, the tuition fee, and the number of students in the subgame-perfect equilibrium. Afterwards, we explore how the education policy and the number of students vary with the permanent migration probability.

Applying backward induction, we begin with analysing the optimal decisions of the potential students. In the third stage, each native of Poor decides whether she studies at UoR, which yields disposable income $DI_k = (1-\tau)\, w_k(q) - t = (1-\tau)\, a_k q - t$, or stays at home, which leads to disposable income $DI_k = 0$. Only

individuals whose ability a exceeds the threshold value

$$\hat{a} = \frac{t}{(1-\tau)\,q} \tag{1}$$

find it beneficial to study abroad and pay tuition fees. They can convert education quality q into a higher net wage $(1-\tau)\,aq$ very effectively, and thus at least recoup the initial private education costs t. As expected, the lower the tax rate τ or the tuition fee t, the more natives of Poor choose to study in Rich (i.e., the lower the threshold ability level $\hat{a}$). Similarly, a higher education quality q induces more natives of Poor to enrol at UoR.

As ability is distributed uniformly, aggregate ability of the individuals who study at UoR is

$$A = \int_{\hat{a}}^{1} a \; da = \frac{1}{2}(1-\hat{a}^2). \tag{2}$$

In the second stage, Rich chooses its tuition fee t. Taking the implication of its policy on the ensuing decisions of the potential students into account, it maximises the net public return (NPR) generated by foreign students:

$$NPR_R = \underbrace{\tau m A q}_{\text{tax revenues}} + \underbrace{(1-\hat{a})t}_{\text{tuition fees}} - \underbrace{[(1-\hat{a})\alpha q + F(q)]}_{\text{education costs}}. \tag{3}$$

The first term on the RHS captures the future tax revenues. As discussed in Section 2, an alternative interpretation is that this term captures a positive human capital externality. The tax revenues increase with aggregate human capital Aq, permanent migration probability m, and tax rate τ. The second and third term show aggregate tuition fees and education costs, respectively. The sum of these three terms captures the net public return to Rich.

A higher tuition fee per student has ambiguous effects on aggregate tuition fees, as the payment per student goes up while the number of students falls. Moreover, the decline in the number of students in response to a higher fee reduces tax revenues and aggregate education costs. Balancing the positive and negative effects gives the optimal tuition fee t° and the resulting threshold level $\hat{a}^\circ$:

$$t^\circ = \frac{(1-\tau+\alpha)\,(1-\tau)}{2\,(1-\tau)+m\tau} q \qquad \text{and} \qquad \hat{a}^\circ = \frac{1-\tau+\alpha}{2\,(1-\tau)+m\tau}, \tag{4}$$

which follow directly from the first-order condition $\partial NPR_R/\partial t = 0$ in combination with threshold value (1) and aggregate ability (2).[6] To avoid tedious discussions of

[6] In this paper, all second-order conditions are fulfilled.

boundary solutions, we assume that for the marginal cost parameter $\alpha \in [0, 1-\tau)$ is satisfied. Then, an interior solution $\hat{a}^\circ \in (0,1)$ is guaranteed for all $m \in [0,1]$ (see Eq. (4)). Otherwise, Rich would prefer to relinquish educating any foreign students for a sufficiently low permanent migration probability m, since it would not be able to charge a tuition fee such that higher education for students from Poor were economically beneficial to Rich.

In the first stage, Rich chooses the optimal education quality q°. Inserting tuition fee (4) into objective function (3) and maximising the resulting expression with respect to q yields the first-order condition

$$\frac{\partial NPR_R}{\partial q} = \tau m A + (1-\hat{a}^\circ)\frac{\partial t^\circ}{\partial q} - (1-\hat{a}^\circ)\alpha - \frac{\partial F}{\partial q} = 0. \tag{5}$$

An improvement in education quality increases aggregate human capital and gross wages in Rich. It thus boosts tax revenues in Rich (see first term of the derivative). Moreover, a higher education quality enables Rich to raise tuition fees, as it makes studying at UoR more beneficial to the natives of Poor (see second term). On the downside, a higher education quality increases both variable and fixed costs (see third and fourth term). In the optimum, Rich balances the marginal benefits and marginal costs of enhancing the quality of education.

We are interested in how education quality, tuition fees and enrolment depend on the permanent migration probability. Our conclusions on these relationships are summarised in Proposition 1.

Proposition 1 *Permanent Migration Probability and Higher Education*
(i) The quality of education at UoR and the number of Poor natives who study at UoR increase with the permanent migration probability. Formally, $dq^\circ/dm > 0$ *and* $d\hat{a}^\circ/dm < 0$.
(ii) The quality-adjusted tuition fee, defined as tuition fee per quality unit (i.e., t°/q°*), declines with the permanent migration probability. Formally,* $d\left(t^\circ/q^\circ\right)/dm < 0$.
(iii) The tuition fee increases (decreases) with the permanent migration probability if and only if the elasticity of marginal fixed costs is below (above) the threshold level $\widehat{\varepsilon} = (1+\hat{a}^\circ)/(1-\hat{a}^\circ)$. *Formally,* $dt^\circ/dm \gtreqless 0 \Leftrightarrow \varepsilon \lesseqgtr \widehat{\varepsilon}$.

All proofs are relegated to the Appendix to focus on the economic intuition in the main text. The explanation for parts (i) and (ii) of Proposition 1 is straightforward. As discussed above, foreign students who continue to stay in Rich after graduation generate tax revenues in Rich. An increase in the probability of permanent migration makes it more likely that this gain does indeed arise in Rich. Consequently, Rich

finds it beneficial to invest more in students from Poor. It further increases the human capital of foreign students, through raising the education quality, and attracts more of them, through lowering the *quality-adjusted* tuition fee. In response to these policy changes, more natives of Poor migrate to Rich to study there.[7]

Whether the tuition fee itself falls or rises depends on the additional fixed costs caused by increasing education quality. If enhancing education quality is not too expensive (i.e., if the elasticity of marginal fixed costs falls short of the threshold $\widehat{\varepsilon}$), Rich will significantly increase its education quality. The improved attractiveness of UoR will then be used to raise the tuition fee as well. By contrast, if enhancing education quality is rather expensive (i.e., if the elasticity of marginal fixed costs exceeds the threshold $\widehat{\varepsilon}$), Rich will only moderately increase the education quality. It will then attract further foreign students mainly by cutting its tuition fees.

4 Welfare, Brain Drain, and Migration

We can now analyse how a rise in the permanent migration probability affects welfare in Poor and Rich, and whether it causes a brain gain or brain drain from the perspective of Poor. In this context, we define brain gain (brain drain) as an increase (decrease) in the aggregate human capital in Poor after return migration has taken place. Recall that only those Poor citizens who study at UoR build up human capital. Thus, the aggregate human capital in Poor is given by

$$HC_P = (1-m)Aq^{\circ}. \tag{6}$$

The net public return that returning graduates generate in Poor is simply proportional to their aggregate human capital:[8]

$$NPR_P = \tau(1-m)Aq^{\circ} = \tau HC_P. \tag{7}$$

Then, the impact of a marginal increase in the permanent migration probability

[7] Note that allowing for a University of Poor (UoP) in the LDC would not qualitatively change these conclusions as long as there is a sufficiently strong 'pull factor' which induces talented students from Poor to move to Rich to study. In terms of our model, a positive differential in education quality between UoR and UoP would be a pull factor. Such a differential appears to be a reasonable assumption, since most universities of high quality are located in the developed world. Then, even if Poor also hosts a university, migration of talented individuals to Rich will still take place and generate public incentives in the host country to invest into the education of Poor's students.

[8] We implicitly assume that the net public return accrues in a way which does not distort the initial education decisions. Following the tax interpretation of the net public return, this can mean, for instance, that the revenues are used to finance spending on the post-eduction generations, and not spending on the generation whose education decision is considered.

m on human capital HC_P and net public return NPR_P is

$$\frac{dHC_P}{dm} = -Aq^\circ + (1-m)\underbrace{\frac{dA}{d\hat{a}}\frac{d\hat{a}^\circ}{dm}}_{(+)}q^\circ + (1-m)A\underbrace{\frac{dq^\circ}{dm}}_{(+)}, \tag{8}$$

$$\frac{dNPR_P}{dm} = \tau\frac{dHP_P}{dm}. \tag{9}$$

Derivative (8) shows three different effects of a higher permanent migration probability m on aggregate human capital, and thus net public return, in Poor. The first term captures that a higher probability m means less return migration, and thus a lower human capital stock in Poor. The second term reflects that, in response to the changes in education policy, more individuals from Poor study at UoR. This effect increases human capital in Poor, as some student migrants return. Finally, the third term captures the positive effect of the permanent migration probability on the quality of education in Rich, and thus on the human capital of return migrants.

These three effects lead to our key result, which is stated in the Proposition 2.

Proposition 2 *Human Capital in Poor after Return Migration*
Suppose that the tax rate τ is sufficiently large. Then, human capital HC_P and net public return NPR_P increase (decrease) with permanent migration probability m if and only if probability m is below (strictly above) a unique threshold level $\widetilde{m} \in (0,1)$. That is,

$$\frac{dHC_P}{dm} \gtreqless 0 \quad \Leftrightarrow \quad \frac{dNPR_P}{dm} \gtreqless 0 \quad \Leftrightarrow \quad m \lesseqgtr \widetilde{m}. \tag{10}$$

This proposition establishes a non-monotonic relationship between the human capital stock and the net public return in Poor on the one hand and the permanent migration probability on the other hand. A rise in the permanent migration probability does indeed cause a brain gain and an increase in the net public return, but only if this probability is not too large. Once the permanent migration probability exceeds a critical level, a further rise in permanent migration has the opposite effect and leads to a brain drain and a fall in the net public return to Poor (see Figure 1). Let us explore the intuition for this conclusion.

From the perspective of Poor, there is a quantity-quality trade-off. If the permanent migration probability is low (i.e., $m < \widetilde{m}$), many students return from Rich to Poor upon graduation, but their human capital is rather low. In this situation, Poor can benefit from stronger incentives for Rich to improve the quality of education, and an increase in the permanent migration probability makes it more attractive for Rich to invest in its education quality. The resulting increase in the human capital of returning students more than compensates Poor for the loss of skilled workers due to

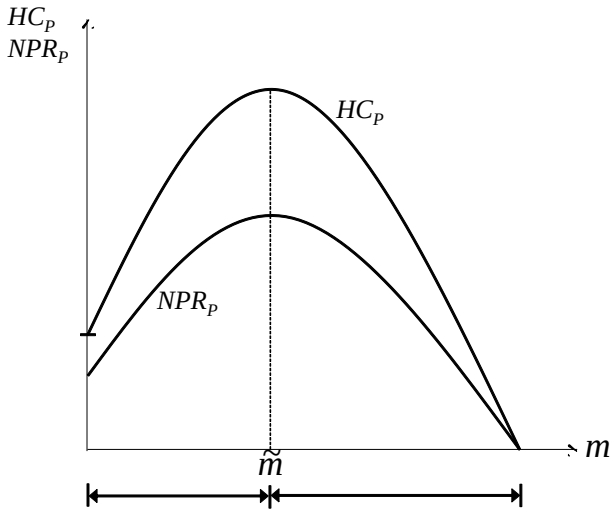

Figure 1: Human Capital, Net Public Return, and Permanent Migration Probability

less return migration. Overall, an increase in the permanent migration probability m leads to a brain gain and a rise in net public return.

By contrast, if the permanent migration probability is high (i.e., $m \geq \widetilde{m}$), the host country already provides a high education quality. Thus, the acquired human capital of the students who return from Rich is also already large, and Poor cannot benefit that much from a further increase in the education quality abroad. Instead, the human capital stock in Poor will suffer substantially if even fewer students return. Under these circumstances, a further increase in the permanent migration probability m causes a brain drain and a drop in net public return.

To understand the novelty of this result, recall that a change in probability m has no *direct* effect on the decisions of the students. For a given education policy (t, q), variations in m have no impact on the students' incentives to acquire education and study abroad, and thus leave threshold (1) unaltered. The probability of permanent migration affects human capital and the resulting net public return in Poor only via its impact on the education policy of Rich. As pointed out above, this mechanism distinguishes our paper from the previous literature on potential brain gains.

There is one qualification to be made. A brain gain and a rise in net public return to Poor can only arise if the tax rate τ is sufficiently high. Otherwise, Rich cannot significantly benefit from permanent migration, and has no incentive to sufficiently

enhance its education quality, as probability m increases. Consequently, Poor cannot sufficiently benefit from better educated students who return from Rich. Formally, $\widetilde{m} = 0$ results in this case.[9]

A change in the permanent migration probability has an unambiguous impact on the disposable income of graduate k, i.e., on

$$DI_k = (1-\tau)\, a_k q^o - t^o = (1-\tau)\,(a_k - \hat{a}^\circ)\, q^o, \tag{11}$$

where we made use of the optimal tuition fee (4).

Proposition 3 *Disposable Income of Graduates*
The disposable income DI_k of graduate k increases with the permanent migration probability m. Formally, $dDI_k/dm > 0$.

Proposition 3 follows from the fact that, as the permanent migration probability rises, the quality of education increases, too, while the quality-adjusted tuition fee declines. Consequently, higher education becomes more beneficial to each graduate and the number of graduates grows.

Finally, let us consider welfare in Rich. We can immediately conclude:

Proposition 4 *Welfare in Rich*
The net public return NPR_R increases with the permanent migration probability. Formally, $dNPR_R/dm > 0$.

Rich can only gain from a rise in permanent migration and, thus, aggregate human capital. The net public return automatically surges even without any policy changes. By adjusting education quality and tuition fees to a higher permanent migration probability, the net public return to Rich further increases.

To summarise, an increase in the permanent migration probability is certainly to the benefit of the graduates from Poor who benefit from a higher education quality and a lower quality-adjusted tuition fee. Similarly, Rich also gains from a higher permanent migration, since it drives up the net public return generated by international students. Regarding the net public return that arises in Poor, the picture is mixed. For a sufficiently low permanent migration probability, a marginal increase in permanent migration raises aggregate human capital in Poor and the net public return to Poor. However, once permanent migration exceeds the threshold level $\widetilde{m}$, both human capital and the net public return in Poor drop, as the permanent migration probability increases further.

[9] A sufficient, but not necessary, condition for $\widetilde{m} > 0$ is $\tau/(1-\tau) > 6/(2+9\varepsilon)$ (see proof in the Appendix). The minimum tax rate τ that is required for Proposition 2 to hold depends on the cost parameter α. For instance, if α is sufficiently close to $1-\tau$, a brain gain and an increase in the net public return to Poor occur for all $\tau \in [0,1)$.

5 Declining Tax Rates

In the era of globalisation, people have become more internationally mobile. A larger share of individuals do not only study abroad, but continue to stay abroad after graduation. In the last two sections, we have analysed the implications of such a rise in permanent migration.

However, globalisation has wider implications. For instance, a large body of literature on international tax competition suggests that globalisation curbs the governments' ability to tax increasingly mobile production factors such as capital and highly skilled workers (see, e.g., Genschel and Schwarz, 2011; Keen and Konrad, 2012, for extensive recent surveys). More specifically, since income tax rates of competing jurisdictions are strategic complements (e.g., Brueckner, 2003; Revelli, 2005), the observed locational choices of workers (e.g., Liebig and Sousa-Poza, 2005; Schmidtheiny, 2006, for Switzerland; Hsieh and Wang, 2011, for the US) provide indirect evidence for the existence of local and international income tax competition between districts and countries for high-skilled workers. These effects can be expected to become even stronger in the future, as international economic integration and globalisation intensify.

We have so far ignored this aspect by assuming that tax rates are constant. While a fully-fledged incorporation of tax competition is beyond the scope of this paper, we will at least sketch to what extent falling tax rates reinforce or qualify our previous results. To this end, we first explore how a uniform decline in tax rates in the two countries, which might result from intensified tax competition, affects education quality, quality-adjusted tuition fees, and enrolment.

Proposition 5 *Tax Rates and Higher Education*
(i) For a sufficiently low (high) permanent migration probability, a decline in the tax rate τ leads to a rise (fall) in education quality q and the number of foreign students enrolled at UoR $(1-\hat{a}^{\circ})$.
(ii) The quality-adjusted tuition fee t°/q° increases, as the tax rate τ declines.

To understand Proposition 5, consider first the case of a low permanent migration probability. In this case, a decline in the tax rate has no significant impact on the net public return to Rich, since the vast majority of foreign students return to their home country anyway. However, the increase in future net income of graduates fosters demand for higher education in Rich, which becomes less price-elastic. In response, Rich increases its tuition fees. As foreign students become more attractive tuition fee payers, Rich also raises education quality to further enhance the appeal of UoR. But as the increase in education quality does not keep up with the rise in

tuition fees, the quality-adjusted tuition fee goes up, which curbs the rise in student numbers.

Now, consider the case of a high permanent migration probability. If a large share of foreign students continue to stay in Rich after graduation, a drop in the tax rate significantly reduces net public return that accrues to Rich, since it causes a substantial drop in tax revenues. As foreign students become less attractive, Rich lowers its education quality, and the quality-adjusted tuition fee again increases. These policy changes lead to a fall in enrolment.

Having explored the implications of lower tax rates on education policy and enrolment, we can now analyse how welfare in Poor and Rich is affected.

Proposition 6 *Tax Rates and Welfare*
(i) Suppose the tax rate τ is sufficiently large initially. Then, for a sufficiently low (high) permanent migration probability, a marginal decline in the tax rate τ increases (decreases) the net public return in Poor and Rich, NPR_P and NPR_R.
(ii) For a sufficiently high permanent migration probability, some potential graduates are worse off in terms of disposable income DI_k, as the tax rate τ declines.

In the case of a high permanent migration probability, the welfare effects of a falling tax rate are straightforward. Education quality and the number of graduates decline, which reduces the gross wage sum. Both the fall in the wage sum and the drop in the tax rate depress tax revenues in Poor and Rich. Consequently, the net public return certainly plummets in both Poor and Rich.

Also, not only are there fewer graduates, but some of them must be worse off. Just consider the marginal students after the decline in the tax rate; that is, the students who are now indifferent between studying and not studying, and whose disposable incomes are thus zero. As they were non-marginal students before the tax change, their disposable incomes were positive, and they lose out for sure.

With low permanent migration probability, the situation is more complicated, as both the quality of education and the number of students go up when the tax rate falls. The policy changes promote human capital formation and increase the gross wage sum. These positive effects are particularly important when the permanent migration probability is low, since the incentive for Rich to invest in education quality is rather low in this case. Then, the boost in the wage sum more than compensates Poor for a lower tax rate, and the net public return to Poor increases. In Rich, a higher wage sum and higher tuition fees outweigh the decline in the tax rate and the rise in public education costs. Consequently, the net public return increases in both Poor and Rich.

Summarising the Effects of Globalisation Let us now combine the conclusions in Sections 3, 4, and 5. If the process of globalisation causes a decline in tax rates in combination with a rise in the share of foreign graduates who continue to stay in their host country, then the following picture emerges. Globalisation tends to increase education quality, the number of students, the net public return in Poor and Rich, and the disposable income of graduates as long as the permanent migration probability remains fairly low. In this case, the effects of falling tax rates and rising permanent migration reinforce each other.

With a fairly high permanent migration probability, the situation is more complicated. Then, the net public return that accrues to Poor certainly drops. However, regarding all the other variables of the system, the conclusions are now ambiguous. Whilst an increase in permanent migration reduces the quality-adjusted tuition fee and drives up education quality and the net public return in Rich, a decline in the tax rate has exactly the opposite effect. Even the disposable income of some graduates will decline if the tax rate falls.

The interplay between tuition fees and tax rates is particularly interesting, as they serve, at least partially, as substitutes. A high tax rate reduces the demand for education in Rich and makes this demand more price-elastic, thus curbing the ability of Rich to charge high tuition fees. By contrast, declining tax rates enable Rich to charge higher tuition fees, thus effectively replacing tax revenues with fee payments. For a sufficiently low permanent migration probability, this replacement is beneficial from the perspective of Rich, since all foreign students pay tuition fees, but only those who continue to stay in Rich will pay taxes. As tuition fees are only imperfect substitutes for taxes, Rich cannot benefit any more from falling tax rates once the permanent migration probability is fairly high and a large share of foreign students do continue to stay in their host country.

Tuition fees frequently have an advantage over taxes. While it is often legally difficult to levy higher taxes on foreigners than on natives, doing so with tuition fees is accepted practice in many countries.[10] In the EU, the non-discrimination principle limits this practice; that is, EU member states are not permitted to treat non-domestic EU students differently than domestic students. However, these countries are still allowed to charge higher tuition fees for non-EU students than for domestic

[10]Empirically, we observe a general tendency for tuition fees to rise in the OECD countries (cf. OECD, 2012: 272), where substantial increases of annual average tuition fees charged by public tertiary-type A educational institutions (e.g., institutions which offer second-degree programmes, such as master's degrees) have been reported for 1995–2009. Countries with strong fee increases include Australia, Belgium, Japan, New Zealand, the Netherlands, and the US (for the US, see also College Board, 2012). At the same time, however, some countries, particularly in Scandinavia, decided to keep higher education free of charge. Austria is the only OECD country in which tuition fees had fallen slightly during the reported time period.

students. The possibility of differentiating tuition fees becomes important once we include domestic students in our analysis, which leads us to the next section.

6 Domestic Students

In the previous sections, we have ignored the existence of domestic students. We now include them in our analysis. Even with domestic students, many university initiatives aim at enhancing, specifically or predominantly, the education quality that foreign students experience. In many programmes in English speaking countries, particularly at the postgraduate level, foreign students constitute the overwhelming majority of participants. Furthermore, universities specifically invest in the quality of the education that foreign students receive by setting up support programmes. Measures include, for instance, tutorials for students from specific countries and transition courses to bridge the gap between the education system of the students' home country and of their host country. Many countries, particularly those outside the English speaking world, have set up specific international programmes in English geared towards the needs of foreign students.

Nevertheless, a large share of spending equally enhances the education quality of domestic and foreign students. Therefore, we have to differentiate between spending on general education quality, which benefits both domestic and foreign students, and on specific education quality, which benefits foreign students only. As far as spending on specific education quality is concerned, the conclusions in Propositions 1 to 4 in Sections 3 and 4 remain valid even if we include domestic students. The question arises whether taking general education quality into account alters the previous results.

To give an answer to this question, we extend our simple model: domestic students now join foreign students at UoR. We ignore specific education quality, as it has already been analysed above, and assume that all students face the same education quality q_g, where the subscript g stands for 'general'. An improvement in education quality increases the costs of education as described in Section 2. Importantly, Rich can differentiate tuition fees. It charges domestic students tuition fee t_R and foreign students t_P.[11]

The potential domestic graduates have the same characteristics as the foreign ones. In particular, the innate ability of natives a_k, $a_k \in [0,1]$, is also uniformly distributed across the population of Rich, whose size is also equal to one. (The

[11] Many countries apply discriminatory tuition fee systems. According to OECD (2011: 324), 14 out of 25 member countries under investigation demand higher tuition fees from international students than from domestic students.

assumption that the foreign and domestic populations are identical does not drive our conclusions qualitatively.) Native k who studies at UoR acquires human capital $a_k q_g$ and, upon graduation, earns wage $w_k(q) = a_k q_g$, as the foreign counterpart does. Natives who do not study receive a basic wage as unskilled workers. This basic wage is still set to zero. All income in Rich is taxed at rate τ, since the government is not allowed to differentiate taxes on the basis of citizenship.

Repeating our previous line of reasoning yields the threshold values for domestic and foreign students

$$\hat{a}_R = \frac{t_R}{(1-\tau)\, q_g} \qquad \text{and} \qquad \hat{a}_P = \frac{t_P}{(1-\tau)\, q_g} \tag{12}$$

and the aggregate ability of domestic and foreign individuals who study at UoR

$$A_R = \frac{1}{2}(1-\hat{a}_R^2) \qquad \text{and} \qquad A_P = \frac{1}{2}(1-\hat{a}_P^2), \tag{13}$$

which are in line with their counterparts (1) and (2) in Section 3.

The government of Rich only considers the welfare of its citizens. As we now take into account domestic students, the objective function of Rich now includes the aggregate income of natives net of their education costs in addition to the net public return generated by international students:

$$W_R = A_R q_g - (1-\hat{a}_R)\alpha q_g + \tau m A q_g + (1-\hat{a}_P)t_P - (1-\hat{a}_P)\alpha q_g - F(q_g). \tag{14}$$

The first two terms on the RHS capture the new components, the gross wage sum of natives and their variable education costs. The other four terms on the RHS show the net public return as defined in Eq. (3). Note that the tax payments of natives and their tuition fees do not explicitly show up in welfare (14). As they reduce private spending by the same amount by which they increase public and university revenues, they cancel each other out exactly.

The timing of the decisions is the same as before. In the second stage, Rich chooses the tuition fees. The optimal tuition fees for domestic and foreign students are given by

$$t_R^\circ = (1-\tau)\,\alpha q_g \qquad \text{and} \qquad t_P^\circ = \frac{(1-\tau+\alpha)\,(1-\tau)}{2\,(1-\tau)+m\tau} q_g, \tag{15}$$

yielding the equilibrium thresholds

$$\hat{a}_R^\circ = \alpha \qquad \text{and} \qquad \hat{a}_P^\circ = \frac{1-\tau+\alpha}{2\,(1-\tau)+m\tau}. \tag{16}$$

The number of students from Poor and, for given education quality, the tuition fee for Poor's natives are the same as in the scenario in Sections 2 and 3 (see Eq. (4)), and so are the explanations for this outcome. Consequently, the effect of an increase in permanent migration on the enrolment of foreign students and the direct impact of permanent migration on the tuition fee for foreign students remain unaltered.

The tuition fee imposed on domestic students is equal to the 'tax-corrected' variable education costs. This fee level ensures that only the individuals whose gross incomes after graduation exceed the variable education costs will study; that is, all natives whose innate ability is above the cost parameter α. The education decisions of the natives are thus efficient. Importantly, tuition fees for, and enrolment of, natives are independent of the permanent migration probability. Moreover, the tuition fee for domestic students is lower than the tuition fee for foreign ones. This result simply reflects the fact that Rich extracts as much surplus as possible from Poor's students.

In the first stage, Rich decides on the education quality q_g°. The optimal quality level is implicitly determined by the first-order condition

$$\frac{\partial W_R}{\partial q_g} = A_R - (1-\hat{a}_R^\circ)\alpha + \tau m A_P + (1-\hat{a}_P^\circ)\frac{\partial t^\circ}{\partial q_g} - (1-\hat{a}_P^\circ)\alpha - \frac{\partial F}{\partial q_g} = 0. \qquad (17)$$

The first two terms of the derivative (17) reflect the impact of an improvement in education quality on the gross wage sum of natives and the variable costs of educating native students. The magnitudes of these two effects do not hinge on the permanent migration probability. The other four terms of the derivative (17) and the economic explanations for them are well-known from the first-order condition (5) and the discussion in Section 3.

The two new terms obviously change the optimal level of the education quality compared to the solution in Section 3. However, as the first two terms of derivative (17) do not depend on the permanent migration probability, and as the other terms are identical to the expressions in the first-order condition (5), the impact of a change in the permanent migration probability on education quality is qualitatively the same as in the case without domestic students.

As we have explored, explicitly considering domestic students does not change the effects of a rise in the permanent migration probability on education quality, tuition fees for foreign students, and their enrolment. Therefore, the impacts of a higher permanent migration probability on the net public return in Poor, the disposable income of graduates from Poor, and the net public return in Rich generated by international students are also unaffected by the inclusion of domestic students. Thus, Propositions 1 to 4 are still valid.

7 Political Implications

In this paper, we argue that a higher permanent migration probability incentivises the host country to improve its education quality, since it increases the expected public return to education investments. A higher education quality, in turn, raises the human capital of foreign graduates. As long as the permanent migration probability is not too large, the positive quality effect increases both human capital and net public return in the LDC, despite the fact that a smaller share of graduates return to the LDC.

From the perspective of the host country, an increasing permanent migration probability is beneficial. It increases the net public return generated by foreign graduates and, as the rich host country is induced to invest more in general education quality, also boosts the human capital and thus aggregate income of domestic graduates. Consequently, the interests of the rich host country are aligned with those of the LDC as long as the permanent migration probability is sufficiently low. However, a conflict of interest will arise if permanent migration exceeds some critical level. As explained in the previous sections, the brain gain to the LDC turns into a brain drain once the permanent migration probability exceeds a critical level, while the developed country still benefits from a further rise in the permanent migration probability. (Discussing the political implications of our analysis, we again use the terms developed and less developed countries instead of the abbreviations Rich and Poor.)

Education Policy An obvious political implication of our analysis is that a developed country can benefit from adjusting its education policy to changes in the permanent migration behaviour. The incentive to do so is likely to be particularly strong in host countries for which student migration is, and has always been, an important channel for recruiting high-skilled workers. A case in point is Australia, where international students make up nearly 20% of total tertiary enrolments in 2007 (OECD, 2009: 308), and where about 20% of all high-skilled immigrants in 2005–2006 had initially come to Australia as foreign students and then continued to stay there as skilled workers after their graduation (Chaloff and Lemaitre, 2009: 25). In contrast, countries with a high domestic supply of talented students might experience a smaller net public return to investments in foreign students. Thus, the incentives to align education policy to a growing student mobility can be expected to differ across countries.

Similarly, we expect that countries deal differently with the task of adjusting education quality, since the national education systems vary widely across key target countries of international student migration (e.g., Australia, France, Germany, the

UK, and the US). In countries with a predominantly public university sector, such as many continental European countries, governments can intervene more directly and allocate resources, for instance, to providing additional tutors, language courses, and international programs. By contrast, countries with a strong private university sector may resort to indirect measures to influence education quality for, and the inflow of, international students.

Measures may include, for example, funding public academic exchange services. Such services may not only provide scholarships, but also initiate programmes to promote the integration of foreign students into the host country. For instance, consider the German Academic Exchange Service (DAAD). The DAAD offered scholarships for foreigners worth €86 million and support for the internationalisation of German universities totalling €68 million in 2011 (DAAD, 2011: 14). Measures included financial support for 39 international doctoral programmes at German universities and for the STIBET initiative.[12] STIBET is a combined scholarship and guidance counselling programme which finances improved supervision of foreign students and doctoral candidates at German universities, and is supposed to "make Germany more attractive and more competitive as a place of study" (DAAD, 2011: 29).

Our model implies that a developed country not only benefits from improving its education quality, as international student migration increases, but it might also benefit from reducing the tuition fees for foreign students. New Zealand serves as an potential example. As mentioned in Section 1, educating foreign students is an explicit part of a socio-economic development strategy in some Asian Pacific countries. In this context, New Zealand has not only increased its education quality in the last decades, but also lowered tuition fees for international students in 2005 to the same level as those paid by domestic students (OECD, 2011: 325). This policy change has made New Zealand a much more appealing destination for international students. In particular, it has significantly improved its competitive edge relative to other English speaking destinations, which offer similar programs at higher costs. According to OECD (2011), new competitors such as New Zealand may explain the comparatively small rise in foreign enrolments in the UK and the US in the last decade.

International competition between potential host countries may cause a 'race-to-the-top' in terms of education subsidies or, equivalently, a 'race-to-the-bottom' in terms of tuition fees.[13] Another outcome of intensified competition for students

[12] In fact, the funds of €9.1 million for STIBET are provided by Germany's Federal Foreign Office.

[13] However, empirical evidence is scarce, despite the fact the New Zealand cut its tuition fees for foreign students, as discussed above. The case of the German *Bundesländer* provides another example, which is, however, not directly related to attracting students from LDC. Some of the German states introduced modest tuition fees of about € 500 per semester a few years ago, but

can be an increasing quality differentiation between countries and institutions of higher education (Haupt et al., 2011; Kemnitz, 2007). That is, while some countries predominantly offer high quality education and charge high tuition fees, other countries tend to offer average quality programmes at a lower price. Students self-select into these different education systems, depending on their individual ability. This product differentiation weakens the tuition fee competition between countries and institutions. Moreover, those countries traditionally offering excellent education quality might have a first-mover advantage, as they are already attracting the best students. The investment necessary to close the gap in education quality might not pay off for potential competitors, which perpetuates the advantage of the leading countries.

Immigration Policy Our conclusions also have implications for immigration policy, as a rich host country faces incentives to promote permanent migration of graduates. Several countries have indeed initiated policies to simplify the access to their labour markets, by introducing special visas and permits enabling international students to stay for several months or years to find a job after graduation. For instance, Germany introduced a temporary residence permit valid for one year; the UK allows foreign graduates to stay for a further year under the 'International Graduate Scheme'; the US has reserved 20,000 H1-B visas for graduates; and Canada enables foreign graduates to stay for up to three years under the 'Post-Graduation Work Permit Program' (Lange 2010). In some countries, this new kind of approach to international students constitutes a fundamental break with the past in which foreign graduates often had to leave their host countries within days after their last exam because their visa only allowed them to study there.

The US serves as an interesting example that shows how strongly changes in visa policy can affect student migration flows. After the terrorist attacks on September 11, 2001, US immigration regulations became much more restrictive. As a result, studying in the US became increasingly difficult for prospective foreign students in general and for those from Muslim countries in particular (e.g., Ewers and Lewis, 2008). In the first years after the new regulations had been introduced, the number of foreign students in the US dropped (IIE, 2011), indicating a deterioration of the competitive edge of the US.[14]

The implications can be substantial. For instance, Chellaraj et al. (2008) suggest

most of them have abandoned them now, arguably because enrolment of mobile students shifted to those states without tuition fees (e.g., Dwenger et al., 2012; Hübner, 2009). See Lange (2010) for a comprehensive discussion.

[14] As a result of the post-9/11 immigration legislation, the US additionally suffered from the reluctance of foreign researchers to come to the US (e.g., Urias and Camp Yeakey, 2009).

that a 10% rise in the number of foreign graduate students would increase patent applications in the US by 4.5%.[15] Visa restrictions tend to work in the opposite direction and could thus significantly impede innovative activities in the US. This example also shows that there is not always a positive relationship between globalisation and permanent migration. Moreover, restrictive immigration regulation can seriously undermine a country's competitiveness in the long run.

Taxation and Tuition Fees A drop in tax rates will, at least partly, be compensated by an increase in tuition fees. Replacing income taxes with tuition fees even reinforces the benefits from foreign students and the incentives to invest in their education quality if permanent migration is sufficiently low. In this case, a decline in income tax rates increases human capital and welfare in the LDC and the rich host country.

By contrast, decreasing tax rates are detrimental to the formation of human capital and to welfare in the LDC and the rich host country if the permanent migration probability is high. This conclusion reinforces the worry that fierce tax competition damages economic development, as it undermines public support for higher education (see Lange, 2010, for a discussion of this issue). However, a more thorough analysis that explains tax rates, education quality and tuition fees endogenously is needed to assess this issue more comprehensively.

Limits to the ability to tax income of mobile sources may have downsides which are not covered in the current model. Most importantly, such limits restrict a government's ability to defer the contributions of individuals to the costs of higher education. Traditionally, many countries have charged rather low tuition fees, but then levied rather high taxes on high incomes. This approach has insured people against income risks and helped them to overcome credit constraints, which would otherwise have deterred them from undertaking higher education. In the future, however, such a combination of low tuition fees and high taxes might neither be possible nor optimal.

Alternatively, governments could implement income-contingent loans for higher education as a means to tackle the inefficiencies resulting from credit constraints and risk aversion. These loan schemes are discussed in-depth in Barr (2012) and, from a politico-economic perspective, Del Rey and Racionero (2012). Enforcing repayments of income-contingent loans from internationally mobile graduates might, however, be a tricky issue and requires some form of cooperation and exchange of information between countries. Thus, an increase in mobility tends to raise the

[15] Similarly, Gagliardi (2012) finds a link between the immigration of highly skilled individuals and the local share of innovative firms in the UK.

administrative costs of such schemes, which limits their advantages over tax-financed higher education.

Policies of the LDC Finally, let us turn to the political implications for the LDC. As long as the permanent migration probability is sufficiently low, the LDC benefits from sending its talented individuals to the developed country for study. Consequently, the government of the LDC may find it beneficial to promote studying abroad by providing scholarships. The induced increase in the number of international students would incentivise the host country to improve its education quality further. Scholarship programmes might therefore raise the number and quality of returning graduates. However, there are two severe limitations to the success of scholarships. Firstly, scholarships drive up tuition fees in the host country, since they increase demand for university places. Secondly, scholarships also tend to increase the time natives of the LDC spend studying abroad, which could make it even more likely that the foreign students continue to stay in their host country after graduation (Oosterbeek and Webbink, 2011).

If the permanent migration probability is too high, the LDC will benefit from more return migration. To achieve this, the government of the LDC could provide financial incentives for graduates to return. This issue was already discussed in the classical literature on brain drain (e.g., Bhagwati and Hamada 1974). Traditional recommendations include a brain drain tax levied on graduates staying abroad and tax subsidies for returning graduates. The more recent debate on brain drain taxes advocates a combination of these two elements. For instance, Wilson (2008) proposes that the governments of LDCs reduce the income tax of returning graduates who previously paid a 'voluntary' brain drain tax, whilst charging those who evaded the brain drain tax the full income tax. However, analysing this issue requires a model with an endogenous permanent migration probability, which is beyond the scope of our paper.

8 Concluding Remarks

In this paper, we present a novel channel for brain gain. Considering individuals from an LDC who study in a rich host country, we argue that a higher permanent migration probability induces the host country to improve its education quality. A higher education quality raises the human capital of the students returning to the LDC. As long as the permanent migration probability is not too large, this positive quality effect increases human capital and welfare in both the LDC and the developed country. This mechanism is novel because the brain gain is not driven by

private incentives for Poor's population to acquire human capital (as in the standard literature), but by *public* incentives for the rich host country to change its education policy. Moreover, a decline in tax rates will reinforce the brain gain if the permanent migration probability is sufficiently low. Including domestic students in our analysis has no qualitative impact on the conclusions derived in the model with international students only.

This paper also indicates some promising areas for further research. For instance, the interaction between international competition in taxes, tuition fees and education quality is complex and deserves more attention. Previous papers have only analysed international competition in tuition fees and taxes (e.g., Krieger and Lange, 2010) or international competition in tuition fees and education quality (e.g., Haupt et al., 2011). Another interesting research question is how the rise of high quality institutions in developing and emerging economies will shake up the competition for international students. Institutions in emerging countries such as China are increasingly reaching out to foreign students. They will become increasingly competitive in the future, by being more able to offer good quality education at a very reasonable price.

Appendix

Proof of Proposition 1

(i) Using Eqs. (2) and (4) to rearrange the first-order condition (5) yields

$$\frac{\partial NPR_R}{\partial q} = (1-\tau+\alpha)\frac{(1-\hat{a}^\circ)^2}{2\hat{a}^\circ} - \frac{\partial F}{\partial q} = 0. \tag{18}$$

The reformulated derivative (18) helps us to calculate the second derivatives

$$\frac{\partial^2 NPR_R}{\partial q \partial m} = \frac{\tau}{1-\tau+\alpha}\frac{1+\hat{a}^\circ}{1-\hat{a}^\circ}\hat{a}^\circ\frac{\partial F}{\partial q} > 0 \quad \text{and} \quad \frac{\partial^2 NPR_R}{\partial q^2} = -\frac{\partial^2 F}{\partial q^2} < 0, \tag{19}$$

where we used the first-order condition (5) to evaluate $\partial^2 NPR_R/\left(\partial q \partial m\right)$ at the optimal quality level q°. Using Eqs. (18) and (19), we apply comparative statics, which yields

$$\frac{dq^\circ}{dm} = -\left(\frac{\partial^2 NPR_R}{\partial q \partial m}\right) \Big/ \left(\frac{\partial^2 NPR_R}{\partial q^2}\right) = \frac{\tau}{1-\tau+\alpha}\frac{1+\hat{a}^\circ}{1-\hat{a}^\circ}\hat{a}^\circ\frac{\partial F/\partial q}{\partial^2 F/\partial q^2} > 0. \tag{20}$$

Finally, $d\hat{a}^\circ/dm < 0$ follows directly from Eq. (4); that is, $d\left(1-\hat{a}^\circ\right)/dm > 0$.

(ii) Eq. (4) implies $d\left(t^\circ/q^\circ\right)/dm = (1-\tau)\, d\hat{a}^\circ/dm < 0$.

(iii) Using Eqs. (20) and (4), we find that

$$\frac{dt^{\circ}}{dm} = \frac{(1-\tau)\,\tau}{1-\tau+\alpha}\left(\hat{a}^{\circ}\right)^{2} q\left(\frac{1+\hat{a}^{\circ}}{\varepsilon\left(1-\hat{a}^{\circ}\right)}-1\right) \gtreqless 0 \Leftrightarrow \varepsilon \lesseqgtr \frac{1+\hat{a}^{\circ}}{1-\hat{a}^{\circ}} =: \widehat{\varepsilon}. \tag{21}$$

Proof of Proposition 2

First, we evaluate derivative (8) at the maximum permanent migration probability $m = 1$, which yields $dHC_P/dm|_{m=1} = -Aq^{\circ} < 0$.

Second, we evaluate derivative (8) at the minimum permanent migration probability $m = 0$. Using Eqs. (2), (4) and (20), we start by reformulating Eq. (8):

$$\frac{dHC_P}{dm} = q^{\circ}\underbrace{\left[-\frac{1-\hat{a}^{\circ 2}}{2}+(1-m)\frac{\tau}{1-\tau+\alpha}\hat{a}^{\circ}\left(\left(\hat{a}^{\circ}\right)^{2}+\frac{1}{2\varepsilon}(1+\hat{a}^{\circ})^{2}\right)\right]}_{G(m;\alpha,\tau):=}. \tag{22}$$

Further note that $\hat{a}^{\circ}|_{m=0} = (1-\tau+\alpha)/2$ and thus

$$G(0;\alpha,\tau) = -\frac{1}{2}+\frac{(1-\tau+\alpha)^{2}}{8(1-\tau)^{2}}+\frac{\tau}{2(1-\tau)}\left[\frac{(1-\tau+\alpha)^{2}}{4(1-\tau)^{2}}+\frac{\left[3(1-\tau)+\alpha\right]^{2}}{8\varepsilon(1-\tau)^{2}}\right]. \tag{23}$$

Since $\partial G(0;\alpha,\tau)/\partial\alpha > 0$, $G(0;\alpha,\tau)$ reaches its minimum for $\alpha = 0$ (recall that $\alpha \in [0, 1-\tau)$), with

$$G(0;0,\tau) = -\frac{3}{8}+\frac{\tau}{2(1-\tau)}\left(\frac{1}{4}+\frac{9}{8\varepsilon}\right) \gtreqless 0 \quad \Leftrightarrow \quad \frac{\tau}{1-\tau} \gtreqless \frac{6}{2+9\varepsilon}. \tag{24}$$

That is, if $\tau/(1-\tau) > 6/(2+9\varepsilon)$, then $G(0;\alpha,\tau) > 0$, and thus $dHC_P/dm|_{m=0} > 0$, for all α.

Third, HC_P is strictly concave in m, since $d^2HC_P/dm^2 < 0$ (which follows from Eqs. (4) and (22)).

Since $d^2HC_P/dm^2 < 0$, $dHC_P/dm|_{m=1} < 0$ and, for $\tau/(1-\tau) > 6/(2+9\varepsilon)$, $dHC_P/dm|_{m=0} > 0$ for all α, the intermediate value theorem implies that, for $\tau/(1-\tau) > 6/(2+9\varepsilon)$, there exists a unique $\widetilde{m} \in (0,1) : dHC_P/dm \gtreqless 0 \Leftrightarrow m \lesseqgtr \widetilde{m}$ for all α.

As $NPR_P = \tau HC_P$, repeating the previous line of reasoning leads to $dNPR_P/dm \gtreqless 0 \Leftrightarrow m \lesseqgtr \widetilde{m}$ for all α.

Proof of Proposition 3

Rearranging Eq. (11) yields

$$DI_k = (1-\tau)\left[a_k - \frac{1-\tau+\alpha}{2(1-\tau)+m\tau}\right]q^{o}, \tag{25}$$

where we used Eq. (4). Eq. (25) implies that $dDI_k/dm = \partial DI_k/\partial m + (\partial DI_k/\partial q)\,(dq^o/dm) > 0$, since $\partial DI_k/\partial m > 0$, $\partial DI_k/\partial q > 0$, and $dq^o/dm > 0$.

Proof of Proposition 4

This conclusion follows from $dNPR_R/dm = \partial NPR_R/\partial m = \tau A q > 0$.

Proof of Proposition 5

(i) Differentiating equilibrium threshold $\hat{a}^\circ$ (see Eq. (4)) gives

$$\frac{\partial \hat{a}^\circ}{\partial \tau} = \frac{2\alpha - m\,(1+\alpha)}{[2\,(1-\tau)+m\tau]^2} \gtreqless 0 \quad \Leftrightarrow \quad m \lesseqgtr \frac{2\alpha}{1+\alpha}. \tag{26}$$

That is, for $m < 2\alpha/\,(1+\alpha)$ ($m > 2\alpha/\,(1+\alpha)$), the number of students $(1-\hat{a}^\circ)$ increases (decreases), as the tax rate τ declines.

Furthermore, comparative statics yields

$$\frac{dq^o}{d\tau} \gtreqless 0 \quad \Leftrightarrow \quad \frac{\partial^2 NPR_R}{\partial q \partial \tau} = -\frac{1-\hat{a}^\circ}{2\hat{a}^\circ}\left[(1-\hat{a}^\circ) + (1-\tau+\alpha)\frac{1+\hat{a}^\circ}{\hat{a}^\circ}\frac{\partial \hat{a}^\circ}{\partial \tau}\right] \gtreqless 0 \tag{27}$$

$$\Leftrightarrow \quad \frac{1-\tau+m\tau-\alpha}{3\,(1-\tau)+m\tau+\alpha} + \frac{2\alpha - m\,(1+\alpha)}{[2\,(1-\tau)+m\tau]^2} \lesseqgtr 0 \tag{28}$$

where we used Eqs. (18) and (4). The first term on the left-hand side is positive. The second term is non-negative if $m \leq 2\alpha/\,(1+\alpha)$. Thus, $dq^o/d\tau < 0$ if m is sufficiently small.

By contrast, the second term is clearly negative for $m = 1$ and, as the second term is a continuous function in m, also for m sufficiently close to one. Thus, $dq^o/d\tau > 0$ if m is sufficiently large.

(ii) Eq. (4) implies that $t^o/q = (1-\tau+\alpha)\,/\,[2+m\tau/\,(1-\tau)]$ and thus $\partial\,(t^o/q)\,/\partial\tau < 0$.

Proof of Proposition 6

After some rearrangement, we can show that

$$\frac{dNPR_R}{d\tau} \lesseqgtr 0 \quad \Leftrightarrow \quad m \lesseqgtr \frac{2\hat{a}^\circ}{1+\hat{a}^\circ}. \tag{29}$$

Recall that $m \in [0,1]$ and, as our assumptions guarantee an interior solution (i.e., $\hat{a}^\circ \in (0,1)$), $2\hat{a}^\circ/\,(1+\hat{a}^\circ) \in (0,1)$. Thus, $dNPR_R/d\tau < 0$ ($dNPR_R/d\tau > 0$) results for $m = 0$ ($m = 1$). As both m and $2\hat{a}^\circ/\,(1+\hat{a}^\circ)$ are continuous in m, $dNPR_R/d\tau < 0$ ($dNPR_R/d\tau > 0$) also holds if m is sufficiently small (large), i.e., if m is sufficiently close to zero (one).

Differentiating (7) yields

$$\frac{dNPR_P}{d\tau} = (1-m)\left[Aq^{\circ} + \tau\frac{dA}{d\hat{a}}\frac{d\hat{a}^{\circ}}{d\tau}q^{\circ} + \tau A\frac{dq^{\circ}}{d\tau}\right]. \tag{30}$$

If m is sufficiently large, then the three terms in the square bracket will be positive (see proof of Proposition 5 with respect to the second and third term). Consequently, $dNPR_P/d\tau > 0$ results. By contrast, the second and third term in the square bracket will be negative if m is sufficiently small (see again proof of Proposition 5). Moreover, for $m = 0$, $\lim_{\tau \to 1-\alpha} A|_{m=0} = 0$ results. Thus, the positive effect disappears, and $dNPR_P/d\tau < 0$ for $m = 0$. As $dNPR_P/d\tau$ is continuous in m, $dNPR_P/d\tau < 0$ will also hold if m is sufficiently close to zero, i.e., if m is sufficiently small.

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