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Abstract

This paper presents a model of two countries competing for a pool of students from the rest of the world (ROW). In equilibrium, one country offers high educational quality for high tuition fees, while the other country provides a low quality and charges low fees. The quality in the high quality country, the tuition fees, and the quality and tuition fee differential between the countries increase with the income prospects in ROW and the number of international students. Higher stay rates of foreign students lead to more ambiguous results. In particular, an increase in educational quality can be accompanied by a decline in tuition fees. Furthermore, international competition for students can give rise to a brain gain in ROW.

JEL-Code: H870, F220, I280.

Keywords: higher education, student mobility, vertical quality differentiation, return migration, brain gain.

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1 Motivation

Higher education has become increasingly internationalised over the last decades. On the demand side, talented students increasingly aim at receiving an excellent education as a sound basis for future careers, even if this requires being internationally mobile and studying abroad. In particular, many students from developing countries consider a degree from a university in a developed country as a chance to enhance their career prospects at home and abroad. On the supply side, university programmes in developed countries increasingly accommodate the needs of foreign students in order to attract international talent. As a result, the number of international students (i.e., students enrolled outside their country of citizenship) has grown considerably over the last thirty years, and this growth has been accelerated in recent years. Since 2000, the number of foreign students within OECD countries has increased by more than 50%. Asia is by far the largest sending region. Students from China and India alone constitute 15.4% and 5.4% of the students from OECD partner countries enrolled within the OECD (see OECD, 2008, chapter 3).

In the host countries, the perceived benefits from foreign students are diverse, encompassing, for instance, additional revenues from tuition fees and positive spillovers to domestic students, the university and the society as a whole.[1] Importantly, the acquisition of international students also reflects a long-term strategy to increase the future number of skilled workers in the domestic economy, as many of the foreign talent will continue to stay in their host countries after graduation (see, e.g., Dreher and Poutvaara, forthcoming; Finn, 2003; Lowell, Bump and Martin, 2007; Rosenzweig, 2006). Recent measures of several OECD countries to promote the access of international students to the domestic labour market indicates that countries are aware of this option (see, e.g., Chaloff and Lemaitre, 2009; Tremblay, 2005).

However, the supply of talent is limited, and ability varies substantially among international students. This gives rise to an intense competition between developed countries for the international pool of talent. Also, changes in the socio-economic environment will continue to transform this competition. Notably, the size of the pool of talent from developing countries will continue to grow over the next decades. At the same time, the share of international students who stay in their host country after graduation (i.e., the 'stay rate') is very likely to change too. Finally, major sending countries, such as China and India, will continue to catch up with the developed countries and provide better income prospects for graduates who return

[1]See, for example, Throsby (1991, 1998) for some cost-benefit considerations in the context of foreign student enrollment.

to these countries.

The aim of our paper is to analyse the competition between developed countries for the pool of talent from developing countries and its implications. In particular, we explore how the aforementioned changes in the socio-economic environment will alter the outcome of this international competition. This analysis will not only provide some hints about future trends in the developed countries, but also shed new light on the discussion of brain drain and brain gain.

We apply a model with duopolistic competition and vertical product differentiation.[2] Two developed countries compete for a pool of students from developing countries. These two host countries non-cooperatively choose educational quality and tuition fees. They aim at maximising their net benefit from educating foreign students, which includes future tax payments of those who continue to stay in the host country. In equilibrium, one country offers a high-quality education at high tuition fees and attracts the brightest students, while the other country provides a lower quality education at low tuition fees and receives the less talented students.

More interestingly, educational quality, tuition fees and the allocation of students responds sensitively to changes in the socio-economic environment, i.e., to an increase in the size of the talent pool, the stay rate and the income prospects for graduates who return to their home countries in the developing world. All three changes unambiguously increase the quality of education in the high-quality country and widen the quality gap between the two host countries. In contrast, the conclusions about tuition fees are less clear-cut. Both an enlarged pool of talent and enhanced income prospects for returning graduates raise the tuition fees in the two countries and the tuition fee differential. A higher stay rate of students in their host countries after graduation leads to ambiguous results. In this case, the tuition fees in both countries and the tuition fee differential can decline. Finally, a higher stay rate implies that a larger share of international students end up in the high-quality country. By contrast, in the case of rising income prospects for graduates in the developing world, and only in this case, the allocation of students can shift in favour of the low-quality country.

This paper also suggests new mechanisms that cause brain drain or brain gain. The policy responses of the developed countries to an increase in the stay rate and

[2]Models of oligopolistic competition with vertically differentiated products are frequently used in the literature on industrial organisation. Seminal papers include, for instance, Gabszewicz and Thisse (1979) and Shaked and Sutton (1982). A recent application of this type of model to public economics is Zissimos and Wooders (2008). They analyse competition for firms by means of tax policy and the provision of public goods that reduce production costs.

the size of the talent pool unambiguously yield a qualitative brain gain. That is, the average human capital of the returning graduates increases. However, a larger stay rate also leads to a quantitative brain drain, as fewer students return to the developing regions.

Our analysis contributes to the literature on higher education policy and international competition for mobile students. For instance, Del Rey (2001) analyses the impact of economic integration on public education when students are internationally mobile and foreign students return to their home country after graduation. She finds that countries tend to underinvest in public education to discourage foreign students from free-riding on the domestic education system. Demange and Fenge (2010) explore competition between two countries for students in a model with vertically differentiated educational quality levels. There is no free-riding of foreign students because universities are completely fee-financed. Nevertheless, competition for students yields inefficient equilibria as long as not all students return to their home country. The underlying reason is that attracting foreign students who at least partly continue to stay in their host country after graduation implies a negative externality for the country of origin.

Our contribution differs from these papers in two ways. Firstly, we analyse competition in both tuition fees and quality of education, while both Del Rey (2001) and Demange and Fenge (2010) consider quality competition only. Expanding the policy space allows us to show, for instance, that quality levels and tuition fees can move in opposite directions if the stay rate of foreign students after graduation increases. Secondly, we analyse how the non-cooperative quality levels and tuition fees vary with changes in the socio-economic environment, while the papers referred to above focus on exploring the welfare properties of non-cooperative equilibria. Thirdly, considering explicitly a pool of students from developing countries, we can derive some conclusions about the impact of international competition for talent on brain drain and brain gain.[3]

Kemnitz (2007a) analyses how different funding schemes and different degrees of

[3]Several further papers cover the effects of student mobility on education systems in a different but related context. For instance, Büttner and Schwager (2004), Hübner (2009), and Kemnitz (2007b) analyse the implications of student mobility for the education policy within a federation. These contributions show how different institutional arrangements and degrees of decentralisation affect the efficiency of education policy and the distribution of gains and costs. Hoyt and Jensen (2001) explains why two competing cities—each of them aiming at maximising its house prices—offer different qualities of public schooling. De Fraja and Iossa (2002) analyse under which circumstances two competing universities which are located in different cities differ in their admission standards and research budgets.

university autonomy affect the competition between educational institutions when universities care about research budgets and teaching output. He applies a model with vertical product differentiation in which tuition fees and educational quality are endogenously determined, similar to the one we use. However, he considers a closed economy, while we focus on international competition for students when education policy is used to lure students into the country. Thus, the questions we raise, such as the effect of a higher stay rate on quality levels and tuition fees, are naturally not part of his analysis, although the underlying model types are similar.[4]

Our paper also contributes to the literature on brain drain and brain gain (e.g., Beine, Docquier and Rapoport, 2008; Eggert, Krieger and Meier, 2010; Stark, Helmenstein and Prskawetz, 1997, 1998; Stark and Wang, 2002; Vidal, 1998). This literature stresses that international mobility reinforces private incentives to invest in education, and thus might increase human capital in developing countries. By contrast, we show how socio-economic changes affect the education policy in the host countries of students from developing countries, and how this might increase human capital in developing countries.

Our paper is organised as follows. In Section 2, we set up the basic model. Section 3 analyses the competition between the two host countries for the international pool of talent. It characterises the resulting subgame-perfect equilibrium. In Section 4, we explain how socio-economic changes shape education policies and student allocation in equilibrium. Section 5 discusses the implications for the stock of human capital in developing countries, and sketches the welfare effects of international competition. In Section 6, we provide some concluding remarks.

2 Governments and International Students

In this section, we set the stage for the analysis of the competition between two developed host countries for international students. We apply a duopoly model with vertical product differentiation. That is, two host countries offer different qualities of higher education and charge different tuition fees. We start by exploring student

[4]Like Kemnitz (2007), Grazzini, Luporini and Petretto (2010) explore competition between universities within a jurisdiction. In their framework, multiple equilibria exists: universities might specialise in teaching or research, and high ability students might sort themselves to a different university as their low-ability counterparts. Furthermore, Boadway, Marceau and Marchand (1996) explore the competition between private schools. They show that this competition typically leads to inefficient outcomes.

characteristics and the expected income that results from migrating to, and studying in, one of the host countries. Afterwards, we discuss the host countries' policy instruments and their objectives. Finally, we present the timing of the decisions.

International Students The size of the international student population is exogenous and denoted by N. It represents the total demand from the Rest-of-the-World (ROW) for education in two ex ante identical host countries 1 and 2. Each of these ROW students studies in one of the two host countries. More precisely, this 'pool of international talent' can be considered as the student population from developing countries who enrol at universities in developed countries.

The ROW students differ in their ability, denoted by a. The ability a is uniformly distributed over the unit interval, i.e., $a \in [0, 1]$. It captures the capacity to exploit the quality of higher education, as reflected by their future gross wage. This future gross wage w consists of a 'graduate' base salary $\underline{w}$ and an educational quality premium aq_i, where $q_i \geq 0$ denotes the quality of education the individual receives in the host country i, $i = 1, 2$. That is, $w = \underline{w} + aq_i$. Ability and university quality are complementary in the production of the educational quality premium. The resulting labour income is taxed at the exogenous rate $\tau \in [0, 1]$ in each of the developed countries 1 and 2. In contrast to those who continue to stay in their host country and earn gross wage w, the individuals who return to their native ROW country earn gross wage γw, $\gamma \in [0, 1]$, which is taxed at the exogenous rate $\tau_{\text{ROW}} \in [0, 1]$.

Although labour incomes in the developed host countries usually exceed those in ROW (and we will assume that this is the case), there are usually non-economic reasons for foreign students to return to their home countries after graduation. Examples for such motives are failure of social integration in the host country, private and family ties to the country of origin, homesickness, problems with regard to the change of status from student to permanent immigrant in the host country, or labour market frictions.[5] These non-economic motives are captured by an exogenous repatriation rate $(1 - p)$. That is, with probability p individuals stay in their host country after graduation and receive a net wage $(1 - \tau)w$. With probability $(1 - p)$, they return to their native country and earn net wage $(1 - \tau_{\text{ROW}})\gamma w$.

When migrating, individuals already anticipate that they will stay on in the host country only with probability p; however, information on whether they belong to

[5] See, for example, Baruch, Budhwar and Khatri (2007) for a questionnaire survey on return/non-return determinants of foreign students in the US and the UK.

the group of repatriates is only revealed after graduation.[6] Thus, the expected net labour income of a graduate with ability a is

$$\mathrm{E}\{w_a\} = \varrho(\underline{w} + aq_i), \quad \text{where } \varrho := \varrho(p,\gamma) = p(1-\tau) + (1-p)(1-\tau_{\mathrm{ROW}})\gamma > 0. \quad (1)$$

As the two host countries represent the developed parts of the world, and as ROW stands for the developing region, the net labour income of a graduate in ROW never exceeds that in the developed countries:

Assumption 1 $(1-\tau) - (1-\tau_{ROW})\gamma \geq 0$.

This assumption implies that staying in the host country after graduation is beneficial on pure income grounds. Only non-economic motives induce graduates to return to their native country with probability p, as discussed above. This economic attractiveness of the developed host countries creates the asymmetry between sending and receiving countries which is typical for brain drain models. Furthermore, we assume that the 'graduate' base salary $\underline{w}$ is sufficient to make studying abroad beneficial for all individuals in the 'pool of talent'. That is, we consider a market for higher education that is completely covered.

Governments The government of each host country sets its tuition fees for higher education t_i and the quality of education q_i. Providing educational quality causes variable costs per student $c(q_i) = \alpha q_i$, $\alpha \in [0,1]$, and fixed costs $F(q_i)$, where $F(q_i)$ is a twice continuously differentiable function with $\partial F/\partial q_i > 0$, $\partial^2 F/\partial q_i^2 > 0$ and $F(0) = 0$. Tuition fees do not necessarily cover these costs, and need not be positive, as a country might subsidise international students.

[6] We ignore the possibility that a foreign-born graduate moves from the host country of education to the other developed country in order to work there. For several reasons, this assumption is not too restrictive. Firstly, after having studied several years in the host country, graduates are already (at least partly) integrated into their host society. They have built up social and, perhaps, family ties, and are thus attached to their host country. Secondly, during the studies in the host country, graduates are acquiring country-specific skills, such as language skills and knowledge of the institutions, regulations and laws in their host country. This component of human capital receives a higher return in the host country than in the other developed country. Thirdly, and related to the previous point, graduates usually find it easier to integrate into the labour market of the their host country than of another developed country. In addition, the host country might facilitate visa and work-permit processes if the applicant has successfully graduated from a domestic university. For instance, Germany allows foreign graduates from a German university to stay on in the country for one year in order to find a job (see Chaloff and Lemaitre, 2009, for similar regulations in other OECD countries).

Each government maximises its net benefit, or rent, from offering higher education to international students,

$$R_i = \tau W_i + N_i[t_i - c(q_i)] - F(q_i), \tag{2}$$

where N_i and W_i stand for the number of international students in country i (with $N_1 + N_2 = N$), and the expected wage sum, or tax base, generated by the international students who continue to stay and work in country i. A country gains from international students, as they pay tuition fees $N_i t_i$ and generate expected tax revenues τW_i. These benefits are diminished by the variable and fixed costs of education $c(q_i)$ and $F(q_i)$.

Timing Decisions take place in three stages. In the first stage, the two governments simultaneously choose education qualities q_1 and q_2. In the second stage, the two governments set tuition fees t_1 and t_2. In the third stage, ROW students decide whether to study in country 1 or in country 2. Each government maximises its net benefit (2), and each individual maximises their expected income net of taxes and tuition fees $\varrho(\underline{w} + aq_i) - t_i$ (i.e., expected net income minus tuition fees).

3 Quality and Tuition Fee Competition

We solve this three-stage game recursively and look for the subgame-perfect equilibrium. Hence, we begin by analysing the migration choices of the ROW students.

Migration Decisions In the third stage, each ROW student decides whether to migrate to, and study in, country 1 or country 2, given tuition fees (t_1, t_2) and educational qualities (q_1, q_2). Comparing the individual net benefit $\varrho(\underline{w} + aq_1) - t_1$ and $\varrho(\underline{w} + aq_2) - t_2$ reveals that individuals choose country 2 (country 1) if and only if their ability a is above (strictly below) the threshold value

$$\hat{a} = \frac{t_2 - t_1}{\varrho \Delta q}. \tag{3}$$

where $\Delta q := q_2 - q_1$ denotes the regional quality differential.

Without loss of generality, we may assume country 2 is the high quality provider, i.e., $\Delta q > 0$. (We exclude the case $q_2 = q_1$, since this can never be a subgame-perfect equilibrium, as we will discuss below.) Hence, all students would obviously enrol in country 2 if the tuition fee t_2 were less than or equal to tuition fee t_1 (because then

$\hat{a} \leq 0 \leq a$). For $t_2 > t_1$, only individuals with a high ability $a \geq \hat{a}$ find it beneficial to study in country 2, since their high ability allows them to exploit the higher educational quality effectively and to recoup the higher private costs of education. The other students choose the low-price study programme in country 1. Thus, the number of international students is $N_1 = \hat{a}N$ in the low quality country 1, and $N_2 = (1 - \hat{a})\, N$ in high quality country 2.

Then, the wage sums, or tax bases, of the two countries are

$$W_1 = pN \int_0^{\hat{a}} (\underline{w} + aq_1)da = p\hat{a}N \left[\underline{w} + \frac{1}{2}\hat{a}q_1\right], \tag{4}$$

$$W_2 = pN \int_{\hat{a}}^1 (\underline{w} + aq_2)da = p\,(1 - \hat{a})\, N \left[\underline{w} + \frac{1}{2}\,(1 + \hat{a})\, q_2\right], \tag{5}$$

where the threshold value $\hat{a}$ is given by (3). The sums comprise the expected number of foreign-born workers, $p\hat{a}N$ and $p\,(1 - \hat{a})\, N$, and the corresponding average labour income, $\underline{w} + \frac{1}{2}\hat{a}q_1$ and $\underline{w} + \frac{1}{2}\,(1 + \hat{a})\, q_2$. The terms $\frac{1}{2}\hat{a}q_1$ and $\frac{1}{2}\,(1 + \hat{a})\, q_2$ capture the average human capital of foreign-born workers, or educational quality premium, in country 1 and 2.

Recall that we excluded the case $q_2 = q_1$ above. The reason is that equal quality levels in the two countries can never be an equilibrium. With $q_2 = q_1$, tuition fee competition would be ruinous, as all students would simply migrate to the country that offers lower fees. But then each country would gain from choosing an educational quality that differs from its neighbour's, thereby weakening the ensuing tuition fee competition.[7] For completeness, we prove the non-existence of the symmetric solution in the Appendix (see the proof of Lemma 1).

Tuition Fee Competition Having analysed the students' migration choices, we now turn to the tuition fee competition in the second stage. Using the student demands N_1 and N_2 and the resulting wage sums W_1 and W_2, captured by (4) and (5), we rearrange the objective functions of the two governments:

$$R_1 = \underbrace{\hat{a}N \left\{\tau p \left[\underline{w} + \frac{1}{2}\hat{a}q_1\right] + t_1 - c(q_1)\right\}}_{\text{variable net rent } r_1} - F(q_1), \tag{6}$$

$$R_2 = \underbrace{(1 - \hat{a})\, N \left\{\tau p \left[\underline{w} + \frac{1}{2}\,(1 + \hat{a})\, q_2\right] + t_2 - c(q_2)\right\}}_{\text{variable net rent } r_2} - F(q_2). \tag{7}$$

[7] This argument is completely in line with standard results in the literature on vertical product differentiation, in which firms differentiate product qualities in order to relax price competition.

The terms in braces capture the countries' expected variable net benefit from each student, consisting of expected future tax payments and current tuition fees less variable education costs. The last term in each line stands for the fixed costs of education.

Each government i chooses the tuition fee t_i that maximises rent R_i, thereby taking the educational qualities (q_1, q_2), which were determined in the first stage, and the other government's tuition fee t_j as given. When raising the tuition fees, government i faces a trade-off. Obviously, the students who still migrate to country i pay more for their education. Also, as higher fees deter students, the variable public spending on education decreases. However, fewer students move to country i and pay tuition fees. Moreover, the decrease in student numbers reduces the future wage sum and thus tax revenues. Balancing these opposing effects gives country i's best response function $t_i^{br}(t_j; q_1, q_2)$, which follows from the first-order condition $dR_i/dt_i = 0$ (see the Appendix for details).

The equilibrium tuition fees (t_1^*, t_2^*) simultaneously solve $t_1^* = t_1^{br}(t_2^*; q_1, q_2)$ and $t_2^* = t_2^{br}(t_1^*; q_1, q_2)$:

$$t_1^* (q_1, q_2) = \frac{\varrho[\varrho\Delta q - p\tau q_1 + \alpha(q_2 + 2q_1)]}{p\tau + 3\varrho} - p\tau\underline{w}, \tag{8}$$

$$t_2^* (q_1, q_2) = \frac{\varrho[2\varrho\Delta q - p\tau q_1 + \alpha(q_1 + 2q_2)]}{p\tau + 3\varrho} - p\tau\underline{w}. \tag{9}$$

The resulting tuition fee differential

$$\Delta t^* (\Delta q) := t_2^* - t_1^* = \Omega (p, \varrho) \Delta q, \quad \text{where} \quad \Omega (p, \varrho) = \frac{\varrho(\alpha + \varrho)}{(p\tau + 3\varrho)} > 0, \tag{10}$$

reflects the fact that the high-quality country charges higher tuition fees for two obvious reasons. Firstly, the country that offers a higher educational quality strengthens the demand for its education system. This enables the high-quality country to raise the tuition fees above the fee level of its competitor. Secondly, the high-quality country 2 passes the higher costs on to the students.

The equilibrium tuition fees determine the equilibrium allocation of students:

$$\hat{a}^* = \frac{\alpha + \varrho}{p\tau + 3\varrho}, \tag{11}$$

which follows directly from inserting the tuition fee differential (10) into the ability threshold (3). Importantly, the equilibrium threshold level $\hat{a}^*$ does not depend on the educational quality differential Δq. That is, every change in the quality differential is offset by a proportional change in the equilibrium tuition fees so that the allocation of students to the two countries remains unaltered.

Educational Quality Competition In the first stage, government i chooses the educational quality q_i that maximises its net benefit R_i.[8] Each government takes the quality of education abroad as given and anticipates the implication of its quality decision for the tuition fee competition at the second stage. Taking the equilibrium tuition fees (t_1^*, t_2^*) and the threshold value $\hat{a}^*$ into account, the marginal effect of the educational quality $q_1 \geq 0$ on net benefit R_1 is

$$\begin{aligned} \frac{dR_1}{dq_1} &= \hat{a}N\left[\frac{p\tau}{2}\hat{a}^* + \frac{\partial t_1^*}{\partial q_1} - \frac{\partial c}{\partial q_1}\right] - \frac{\partial F}{\partial q_1} \\ &= \underbrace{-\frac{N}{2}(p\tau + 2\varrho)\hat{a}^{*2}}_{dr_1/dq_1=} - \frac{\partial F}{\partial q_1} < 0. \end{aligned} \tag{12}$$

Since the marginal impact is always negative, the optimal educational quality of country 1 is $q_1^* = 0$.[9] The intuition for this solution is straightforward. Any increase in the educational quality of the low-quality country not only drives up both fixed and variable costs, it also intensifies the tuition fee competition in the second stage because of the diminished quality differential. As a result, the benefit per student that accrues to country 1 declines. Consequently, the government of country 1 differentiates the educational quality as much as possible to relax the tuition fee competition.

The circumstances are different for country 2. Now the optimal quality of education is indeed implicitly determined by the first-order condition for an 'interior' solution[10]

$$\begin{aligned} \frac{dR_2}{dq_2} &= (1-\hat{a})\,N\left[\frac{p\tau}{2}(1+\hat{a}) + \frac{\partial t_2^*}{\partial q_2} - \frac{\partial c}{\partial q_2}\right] - \frac{\partial F}{\partial q_2} \\ &= \underbrace{\frac{N}{2}(p\tau + 2\varrho)(1-\hat{a}^*)^2}_{dr_2/dq_2=} - \frac{\partial F}{\partial q_2} = 0. \end{aligned} \tag{13}$$

[8]International students indeed shape quality decisions for several reasons. Firstly, many countries outside the English speaking world have introduced specific international programmes taught in English and geared towards the needs of foreign students. Also, many programmes in English speaking countries, particularly at the postgraduate level, are de facto set up for foreign students, as they form the overwhelming majority of participants. Furthermore, many universities specifically improve the quality of the education that foreign students receive by offering them support programmes. Universities provide, for instance, additional tutorials for students from specific countries and transition courses that enables foreign students to successfully integrate into the host country's higher education systems.

[9]A quality level $q_i = 0$ must not be interpreted as no quality at all. It rather means that the country's university just fulfils the minimum requirements for higher education.

[10]The second-order condition is fulfilled as $d^2R_2/dq_2^2 = -\partial^2 F/\partial q_2^2 < 0$.

An increase in the quality of education in the high-quality country 2 raises the human capital of future skilled workers, leading to higher wages and higher expected tax payments. It also widens the gap between the two countries' educational systems which, in turn, weakens tuition fee competition and drives up tuition fees. Higher future tax payments and current tuition fees means that country 2's variable benefit from each student increases, despite growing variable costs. This positive impact on the variable net rent r_2 has to be balanced against the rise in fixed costs.

The resulting asymmetric equilibrium is summarised in

Lemma 1 *In equilibrium, one host country of the ROW students provides a higher quality of education and charges higher tuition fees than the other host country. That is, $q_2^* > q_1^* = 0$ and $t_2^* > t_1^*$. The high-quality country attracts the brightest students from the international pool of talent, i.e., those with $a \in [\hat{a}^*, 1]$. This equilibrium is determined up to the permutation of the two countries across the two indices.*

Proof. See the Appendix. ■

4 Competition in a Changing Environment

Now we turn to the question of how a changing socio-economic environment, as highlighted in the Motivation, affects the international competition for the pool of talent. More specifically, we consider three scenarios: an increase in (i) the stay rate of foreign students, (ii) the income prospects of graduates in developing countries, and (iii) the size of the talent pool. We show how these changes affect educational quality, tuition fees, and the allocation of students. This analysis helps us to understand potential future trends in higher education. In addition, it enables us to assess possible consequences of these changes for the sending countries of talented students in Section 5.1. We begin by analysing the impact of a change in the stay rate.

4.1 Stay Rate of Foreign Students

Technological, societal or political developments can explain changes in the stay rate of foreign students in their host countries.[11] Proposition 1 summarises the impact

[11] Technological progress, for instance, has led to plummeting communication and travel costs. As a result, people who work abroad can keep in touch with their relatives and friends at home more easily and at lower costs. This reduces the psychological and financial burden of staying abroad

of an increase in the stay rate p on quality levels, tuition fees, and the allocation of students.

Proposition 1 *An increase in the stay rate of foreign students after graduation in the host countries of education*

(i) raises the educational quality q_2^* and the quality differential Δq^* (i.e., $dq_2^*/dp > 0$ and $d\Delta q^*/dp > 0$), but it does not affect the educational quality $q_1^* = 0$;

(ii) has an ambiguous effect on the tuition fees t_1^* and t_2^* and on the tuition fee differential Δt^*. In particular,

$$\frac{d\Delta t^*}{dp} \gtreqless 0 \quad \Leftrightarrow \quad \varepsilon_{\Delta q,p} + \varepsilon_{\Omega,p} + \varepsilon_{\Omega,\varrho}\varepsilon_{\varrho,p} \gtreqless 0, \tag{14}$$

where $\varepsilon_{\Delta q,p} := (d\Delta q/dp)(p/\Delta q) > 0$, $\varepsilon_{\Omega,p} := (\partial\Omega/\partial p)(p/\Omega) < 0$, $\varepsilon_{\Omega,\varrho} = (\partial\Omega/\partial\varrho)(\varrho/\Omega) > 0$ and $\varepsilon_{\varrho,p} := (\partial\varrho/\partial p)(p/\varrho) \geq 0$. (Recall that Ω is defined in (10));

(iii) raises the share of foreign students who study in the high-quality country (i.e., $d(1 - \hat{a}^*)/dp > 0$).

Proof. See the Appendix. ■

We relegate the proof to the Appendix and focus now on the economic intuition. To elucidate the impact of the stay rate p on the equilibrium outcome, we begin by considering a special case, which highlights the main mechanisms, and turn to the more general setting afterwards.

Special case: $\tau_{\text{ROW}} = \tau$ and $\gamma = 1$.

In this special case, we have $\varrho = 1 - \tau$. That is, the parameter ϱ and thus the expected net labour income of a student, $E\{w_a\}$, are independent of the stay rate p (see (1)), also implying $\varepsilon_{\varrho,p} = 0$. Consequently, the allocation of the students to the two countries, $\hat{a}^*$, only depends on the ratio of the tuition fee differential to the quality differential $\Delta t^*/\Delta p^*$. That is, there is no *direct* effect of the stay rate on the allocation of students, i.e., $(\partial\hat{a}/\partial\varrho)(\partial\varrho/\partial p) = 0$ (see (3)). Then, the stay rate affects the equilibrium allocation only via its impact on the countries' policies, which we now discuss.

after graduation, and can thus boost the stay rate of foreign students. Also, recent measures of developed countries to open up labour market access to foreign graduates contributes to higher stay rates.

Education Quality A higher stay rate p causes a *direct tax revenue effect on educational quality* q_2^*. It increases the expected future tax payment of a foreign student in country 2. More importantly, as fewer students leave their host country after graduation, the positive impact of a higher educational quality on the expected per-student contribution to the future tax revenues is reinforced (i.e., $\partial^2 W_2^* / (\partial q_2^* \partial p) > 0$). This strengthens country 2's incentive to invest in educational quality. It thus raises its quality level q_2^*.

At the same time, country 1 continues to face an incentive to differentiate its quality level from that of its opponent as much as possible in order to soften the ensuing tuition fee competition. This incentive, which is discussed in Section 3, does not wither away with increasing stay rates. Therefore, country 1 sticks to its quality level $q_1^* = 0$, and the quality differential Δq^* widens as the stay rate p increases.

Tuition Fees The impact of the stay rate on tuition fees is ambiguous. In particular, using $\Delta t^* = \Omega(p, \varrho(p)) \Delta q^*$ (see (10)) we find that

$$\frac{d\Delta t^*}{dp} = \Omega \frac{\Delta q^*}{p} \left(\varepsilon_{\Delta q,p} + \varepsilon_{\Omega,p} + \varepsilon_{\Omega,\varrho} \varepsilon_{\varrho,p} \right), \tag{15}$$

where the elasticities are defined in Proposition 1. In our special case, the third term in the brackets vanishes as $\varepsilon_{\varrho,p} = 0$. Then, the overall effect of the stay rate on tuition fees can be decomposed into two components. Firstly, there is an *educational quality effect on tuition fees*. The widening quality gap that follows from a higher stay rate weakens tuition fee competition. The two countries face an incentive to raise their tuition fees. This incentive is particularly strong for country 2, which already charges higher tuition fees. It can now exploit its enhanced market power, since it provides an even higher educational quality. Consequently, the education quality effect drives up tuition fee t_2^* by more than t_1^*, and thus widens the tuition fee differential Δt^*. Formally, $\varepsilon_{\Delta q,p} > 0$ captures this effect.

Secondly, there is a *direct tax revenue effect on tuition fees*. Students become more valuable because their expected tax payments in their host country increase with the stay rate p. In response, the two countries face an incentive to lower their tuition fees in order to attract more foreign students. This is particularly true for country 2. Its opportunity costs of losing students in terms of foregone tax revenues are particularly high because its students build up more human capital, and thus will receive higher wages and pay more taxes than those in country 1. Hence, the direct tax revenue effect induces country 2 to cut its tuition fee by more than country 1. This effect reduces the tuition fee differential. Formally, it is reflected by $\varepsilon_{\Omega,p} < 0$.

The opposing educational quality effect and direct tax revenue effect are already sufficient to conclude that the impact of a higher stay rate on tuition fees and the tuition fee differential is ambiguous. More specifically, we find that

$$\frac{d\Delta t}{dp} \gtreqless 0 \Leftrightarrow \varepsilon_{F,q} \lesseqgtr \frac{p\tau + 3\varrho}{p\tau + 2\varrho} + \frac{2\,(\alpha + \varrho)}{p\tau + 2\varrho - \alpha} =: \Gamma, \tag{16}$$

where $\varepsilon_{F,q} := (\partial^2 F/\partial q^2)q/(\partial F/\partial q)$ stands for the elasticity of marginal fixed costs. Improving the quality of education is the more expensive, the greater is the elasticity $\varepsilon_{F,q}$. Hence, a high elasticity curbs the rise of educational quality q_2^* in response to an increase of the stay rate p. This in turn weakens the educational quality effect. If the the elasticity $\varepsilon_{F,q}$ exceeds the threshold level Γ, then the educational quality effect is so weak that the direct tax revenue effect dominates. Under these circumstances, the tuition fee differential declines along with tuition fees. Otherwise, the tuition fee differential increases.

Allocation of Students In response to a higher stay rate, the high-quality country 2 raises its educational quality q_2^* further. This strengthens its market power in the tuition fee competition. Country 2 exploits its improved position by grabbing a larger share of the pool of talent whose value to the host country has gone up. The low-quality country 1 loses students. Formally, a decline in the ratio of the tuition fee differential to the quality differential causes this shift in the allocation of students in favour of country 2 and at the expense of country 1.

Further Effects in the General Case We now return to our more general setting with a parameter ϱ that varies with the stay rate p (i.e., $\varepsilon_{\varrho,p} \geq 0$). In this case, an *expected income effect* emerges in addition to the aforementioned effects. Now, the expected net labour income increases with the stay rate ($d\,\mathrm{E}\{w_a\}/dp > 0$). This positive impact of an increase in the stay rate on labour income is the greater, the higher is the educational quality. Thus, a rise in the stay rate reinforces the incentives to study in the high-quality country 2, which has three implications.

Firstly, the demand for university places shifts in favour of country 2 and at the expense of country 1 for given policies (q_1, q_2) and (t_1, t_2). Thus, the *expected income effect on demand* reinforces the decline in the ability threshold $\hat{a}^*$. Secondly, facing a growing demand, country 2 finds it even more beneficial to invest in its quality of education. Thus, the *expected income effect on educational quality* reinforces the positive impact of the stay rate on educational quality q_2^* and the quality differential Δq^*.

Thirdly, growing demand for university places in country 2 strengthens the incentives for country 2 to further raise its tuition fee for given quality levels (q_1, q_2). This relaxes the pressure on country 1, which is now more likely to increase its tuition fee, too (note that the fees t_1^* and t_2^* are strategic complements, as rivals' choices usually are in the case of price competition), albeit to a lesser extent than country 2. As the *expected income effect on tuition fees* exhibits a stronger upward pressure on t_2^* than on t_1^*, it fosters a larger regional gap in tuition fees. Formally, $\varepsilon_{\Omega,\varrho}\varepsilon_{\varrho,p} > 0$ captures this impact (see (14)). This direct effect is even reinforced, as the expected income effect drives up the quality differential, and thus strengthens the *educational quality effect on tuition fees*. Again, this mechanism raises tuition fees and the tuition fee differential. However, the overall effect of the stay rate on tuition fees and the tuition fee differential remains ambiguous.

All in all, the conclusions in the more general setting are qualitatively the same as in the special case. In particular, the educational quality q_2^* and the quality differential on the one hand and the tuition fees and the tuition fee differential on the other hand can move in opposite directions, as stated in the following Corollary.

Corollary 1 *If the direct tax revenue effect on tuition fees is sufficiently strong, then an increase in the stay rate of foreign students after graduation widens the educational quality gap (i.e., $d\Delta q^*/dp > 0$), while the tuition fees of the two countries converge (i.e., $d\Delta t^*/dp < 0$). Also, both tuition fees t_1^* and t_2^* fall, whereas educational quality q_2^* increases.*

In the special case, this outcome occurs if the elasticity condition $\varepsilon_{F,q} < \Gamma$ holds. For example, the quadratic cost function $F(q) = \mu q^2$, $\mu > 0$, fulfils this elasticity condition, as $\Gamma > 1$ and, in this case, $\varepsilon_{F,q} = 1$.[12] Also, if the tuition fee differential declines, then the tuition fees do so, too.[13]

4.2 Income in ROW

A feature of the present framework is that students can earn higher net wages in their host countries than in their home countries. This feature reflects the fact that the host countries represent developed countries, while ROW stands for developing

[12]Note that, in an interior solution, $\hat{a}^* < 1 \Leftrightarrow \alpha < p\tau + 2\varrho$ holds. Then, the second term of Γ is positive (see (16)). The first term is obviously greater than one (see again (16)). So $\Gamma > 1$ results.

[13]From (8) and (9) follows that $t_2^* = 2t_1^* + p\tau\underline{w}$. Then, $d\left(t_2^* - t_1^*\right)/dp = dt_1^*/dp + \tau\underline{w} = 0.5\left(dt_2^*/dp + \tau\underline{w}\right)$, and thus $d\left(t_2^* - t_1^*\right)/dp < 0$ implies both $dt_1^*/dp < 0$ and $dt_2^*/dp < 0$.

regions. In this section, we consider the impact of the ROW's catching up with the developed countries in terms of graduate income, as we observe in the case of, e.g., China or India. Analytically, we capture this narrowing wage gap between developed and less developed countries by a marginal increase in γ. The following proposition summarises the resulting comparative statics.

Proposition 2 *An increase in the graduate income in the home countries of the students*

(i) raises the educational quality q_2^* and the quality differential Δq^* (i.e., $dq_2^*/d\gamma > 0$ and $d\Delta q^*/d\gamma > 0$), but it does not affect the educational quality $q_1^* = 0$;

(ii) raises the tuition fees t_1^* and t_2^* and the tuition fee differential Δt^* (i.e., $dt_i^*/d\gamma > 0$ and $d\Delta t^*/d\gamma > 0$);

(iii) has an ambiguous effect on the share of foreign students who study in the high-quality country:

$$\frac{d(1-\hat{a}^*)}{d\gamma} \gtreqless 0 \quad \Leftrightarrow \quad 3\alpha - p\tau \gtreqless 0. \tag{17}$$

Proof. See the Appendix. ■

A growing graduate income in ROW increases the expected net labour income. Again, this positive impact on wages is the larger, the higher is the educational quality. Thus, a rise in the wage parameter γ reinforces individual incentives to study in the high-quality country 2. This *expected income effect* is the very same in qualitative terms as the one discussed in the general scenario of Section 4.1, and so are the implications.

Firstly, the demand for university places in the high-quality country rises for given policies (q_1, q_2) and (t_1, t_2). Secondly, as students become more inclined to study in the high-quality country, the government of country 2 benefits even more from investing in its educational quality (i.e., $[\partial^2 W_2^* / (\partial q_2^* \partial \varrho)] \, \partial \varrho / \partial \gamma > 0$). Again, the educational quality q_2^* and the quality differential Δq^* increase. (Needless to say, the quality $q_1^* = 0$ is again not affected, for reasons already explained above.) Thirdly, the expected income effect directly pushes up tuition fees and the tuition fee differential, as discussed in Section 4.1. This effect is again reinforced by the *educational quality effect on tuition fees*, as the quality differential widens.

Note that the ambiguity about the changes in tuition fees in Proposition 1 is caused by the *direct tax revenue effect on tuition fees*, which works in favour of lower and converging fees. But exactly this effect does not have a counterpart in the current context. Therefore, Proposition 2 provides an unambiguous result about tuition fees.

By contrast, the conclusion about the share of students in the high-quality country is no longer clear-cut. Without the direct tax revenue effect on tuition fees, there is no force that counteracts the rise in tuition fees and the tuition fee differential in response to a larger value of γ. Hence, the surge in the tuition fee differential, which drives students to the low-quality country, can be so drastic that it more than compensates for the rise in γ and the induced increase in the quality differential, which pushes students to the high-quality country. Then, the share of students in the high-quality country falls in equilibrium. Otherwise, this share rises.

4.3 Size of the Pool of Talents

In the light of increasing international student mobility, we finally analyse how an enlarged pool of international talent affects the subgame-perfect policies and the allocation of students.

Proposition 3 *An increase in the size of the international pool of talent*

(i) raises the educational quality q_2^* and the quality differential Δq^* (i.e., $dq_2^*/dN > 0$ and $d\Delta q^*/dN > 0$), but does not affect the quality $q_1^* = 0$;

(ii) raises the tuition fees t_1^* and t_2^* and the tuition fee differential Δt^* (i.e., $dt_i^*/dN > 0$ and $d\Delta t^*/dN > 0$);

(iii) has no impact on the share of students who study in the high-quality country (i.e., $d(1 - \hat{a}^*)/dN = 0$).

Proof. See the Appendix. ■

Firstly, there is a *direct demand effect on the educational quality.* A larger international student population raises the marginal variable rent of a quality increase in the high-quality country 2. That is, $d^2 r_2/dq_2 dN > 0$ (see (13)). As the fixed costs of quality improvements remain the same and are now divided over a greater number of students, investing in educational quality becomes more beneficial in country 2. Consequently, country 2 increases its educational quality q_2^*. Its opponent again leaves its quality level at $q_1^* = 0$, for the same reasons as discussed above. Thus the quality differential between the two countries increases.

Secondly, there is the *educational quality effect on tuition fees*. Again, a widening quality gap weakens tuition fee competition and enables both countries to charge higher fees, and leads to a larger tuition fee differential, as discussed above. Finally, as there is neither the *direct tax revenue effect* nor the *expected income effect* at work in the present scenario, each country's share of the international talent pool remains unchanged. Without the expected income effect, an increase in the size of the talent pool affects the allocation of students only indirectly through changes in policies. However, without the direct tax revenue effect, the ratio of the tuition fee differential to the educational quality differential (i.e., Ω) remains unaltered, and thus the allocation of students, see (10).

4.4 Comparison

Table 1 summarises the impact of the socio-economic changes analysed in this section. In all three scenarios, the demand for university places and the number of future tax payers increase in the high-quality country for given policies (q_1, q_2) and (t_1, t_2). Consequently, country 2 finds it more beneficial to invest in educational quality. As a result, educational quality q_2^* and, along with it, the quality differential, increase in all three scenarios.

In contrast to this unambiguous result, the trend of tuition fees is less clear-cut. Both an increase in the income prospects in developing countries γ and the size of the talent pool N drives up the tuition fees and the tuition fee differential. But the overall effect on tuition fees of a rise in the stay rate p is ambiguous. In particular, tuition fees and the tuition fee differential can diminish. The reason for this outcome is that an increasing stay rate makes foreign students more valuable particularly in the long run, i.e., as future tax payers. This restrains the countries' appetites for charging high tuition fees, which would deter students. There is no similarly restraining motive at work in the other two scenarios.

An increase in the stay rate definitely shifts the equilibrium allocation of students in favour of the high-quality country 2. This conclusion stems from the fact that, while the quality gap clearly widens, the tuition fee differential increases only moderately, if at all. Thus, the high-quality country becomes more attractive. In the other two scenarios, particularly the high-quality country faces a stronger incentive to raise tuition, and the tuition fee differential tends to widen more drastically. As a result, the share of students in the high-quality country remains constant (if the size of the talent pool increases) or might even fall (if earnings prospects in ROW improve).

	Education quality	Tuition fees	Student allocation
Increase of ...			
... stay rate ($p \uparrow$)	$q_2 \uparrow$, $q_1 = 0$, $\Delta q^* \uparrow$	change of Δt^* ambiguous	$\hat{a}^* \downarrow$
... ROW income ($\gamma \uparrow$)	$q_2 \uparrow$, $q_1 = 0$, $\Delta q^* \uparrow$	$t_i \uparrow$, $\Delta t^* \uparrow$	change of $\hat{a}^*$ ambiguous
... size of talent pool ($N \uparrow$)	$q_2 \uparrow$, $q_1 = 0$, $\Delta q^* \uparrow$	$t_i \uparrow$ $\Delta t^* \uparrow$	$\hat{a}^*$ unchanged

Table 1: Summary of comparative statics effects.

5 Implications

Having explored how a changing environment affects educational quality, tuition fees, and the allocation of students, we now discuss some implications of our analysis. We begin by exploring how our analysis contributes to the discussion about brain drain and brain gain. Afterwards, we briefly sketch how the non-cooperative equilibrium diverges from the efficient outcome, and why it does.

5.1 Brain Drain and Brain Gain

From the perspective of the developing countries, a prime question is whether the socio-ecomonic changes analysed in Section 4 yield a brain drain or a brain gain. That is, the question is whether these changes increase or decrease the human capital in developing countries after returning graduates are taken into account. The findings in the previous sections shed some light on this question and imply novel mechanisms that generate brain drain or brain gain. In the following, we focus on only two scenarios, a rise in the stay rate and in the size of the talent pool.

Stay Rate First of all, an increase in the stay rate p reduces the number of internationally educated graduates who return to ROW, which constitutes a *quantitative brain drain*. At the same time, an increase in the stay rate alters the competition between the host countries for foreign students (see Section 4.1). Firstly, a larger share of the talent pool is educated in the high-quality country 2 (i.e., $d(1 - \hat{a}^*)/dp > 0$). Secondly, the educational quality in country 2 increases, while the quality in country

1 remains unchanged. Both effects push up the average human capital of graduates who return to ROW, which constitutes a *qualitative brain gain*. Overall, ROW suffers from a *quantitative brain drain*, but it benefits from a *qualitative brain gain*.[14]

Size of the Talent Pool For a given return rate $(1-p)$, the number of internationally educated graduates in ROW apparently increases with the number of students sent abroad, N. This increase constitutes a *quantitative brain gain*. (Of course, this is only a per-capita brain gain if the increase in the number of international students N results from a rising student share of the population in ROW, and not merely from population growth.)

In addition, an increase in the number of international students N alters the competition between the host countries for ROW-born students (see Section 4.3). Country 2 now offers a higher educational quality q_2, while the educational quality in country 1 remains unchanged at $q_1^* = 0$. The allocation of students within the host regions remains unchanged as well. Consequently, the average human capital of the returning graduates increases, implying a *qualitative brain gain*. Overall, ROW benefits from both a quantitative and qualitative brain gain.

The novelty of these brain gain and brain drain effects is that they are driven by policy changes in the developed countries. By contrast, the 'standard' economic literature on brain drain and brain gain stresses how migration shapes private incentives to invest in education (e.g., Stark et al. 1997, 1998). In this sense, our model complements the existing literature on brain drain and brain gain by explicitly considering the host countries' competition for talent from developing countries.

5.2 International Competition and Efficiency

In the present paper, we focus on the positive analysis of the international competition for talent and the effects of socio-economic changes on the subgame-perfect equilibrium. From a normative perspective, an interesting question is whether the competition for international talent is efficient. That is, in the current context, the question is whether non-cooperative decisions on education qualities and tuition fees

[14] Haupt, Krieger and Lange (2010a) analyse qualitative brain gain and quantitative brain drain effects in a framework with only one developed country that hosts students from a developing country. As in the current framework, these students stay in their host country with a certain probability. Haupt, Krieger and Lange (2010a) show that aggregate and per-capita human capital in the developing country increases with the stay rate of students in the developed host country as long as this stay rate is not too large.

in developed countries maximise the aggregate surplus of educating international talent. Not surprisingly, the answer is, in general, no.

While host countries in the decentralised setting maximise their net benefit from educating foreign students, a benevolent social planner would choose an allocation of students to the two host countries and educational qualities so that the graduates' aggregate gross income net of educational costs is maximised. An earlier version of this paper provided a welfare comparison between the first-best solution of the social planner and the subgame-perfect equilibrium (see Haupt, Krieger and Lange, 2010b). In the following, we will only summarise the quintessence of this analysis.

First of all, the student allocation in the decentralised equilibrium is, in general, inefficient. In the non-cooperative equilibrium, the allocation follows from government choices that balance each country's trade-off between additional fee and tax revenues on the one hand and higher education costs on the other hand. The efficient allocation, instead, results from balancing the trade-off between a higher aggregate wage sum on the one hand and higher aggregate education costs on the other hand.

To see the implications of these different trade-offs, suppose that the quality of education does not affect its variable costs (which is the case if $\alpha = 0$). Then, in the first-best solution, all students are apparently allocated to the high-quality country 2. This allocation maximises aggregate gross wages and avoids any fixed costs in country 1. It is thus certainly welfare-superior to a solution that allocates any students to region 1. In the decentralised equilibrium, however, demand for the low-quality country 1 is strictly positive. Imperfect competition implies some market power for each host country, which allows country 1 to successfully attract some international students, although this is actually inefficient.

If the quality of education affects the variable costs (which is the case if α is sufficiently large), then allocating the less talented students to country 1 becomes worthwhile for the benevolent planner. Thereby, overall education costs can be reduced because a lower quality leads to lower costs per student. The welfare comparison is then ambiguous. The allocation of students in the decentralised equilibrium can, in principle, deviate from the first-best solution in both directions. That is, in the non-cooperative equilibrium, too many as well as too few students might end up in the high-quality country 2.

The educational quality that results from the competition for the international pool of talent is, in general, inefficient as well. While the first-best solution for the low quality level q_1^o coincides with the corresponding level in the decentralised equilibrium (i.e., $q_1^o = q_1^* = 0$), the first-best solution for the high quality level q_2^o

does not, for two reasons. Firstly, even for identical allocations of students in the decentralised setting and the first-best solution, the objectives of the competing countries are not aligned with the objective of the benevolent planner, as explored above. Secondly, the allocation of students in the decentralised equilibrium is likely to deviate from the first-best solution, as argued above. This adds another distortion to the incentives for the host countries to invest in quality. Hence, depending on the parameters in the model (particularly the stay rate of students, the income-tax rate in the host countries and the variable costs of education), educational quality q_2 can deviate from the first-best solution in both directions. That is, in the non-cooperative equilibrium, the high-quality country 2 may invest too much or too little in the quality of education.

The subgame-perfect equilibrium is, in general, inefficient, irrespective of the stay rate. In contrast, Demange and Fenge (2010) show that, in their model, two non-cooperative countries choose efficient educational quality levels if all foreign students return to their home countries after graduation. Their model differs from our approach in three major respects. Firstly, all students are native to one of the two competing countries. That is, there is no 'ROW'. Secondly, there is no tuition fee competition because tuition fees are such that education costs are fully covered. Third, there are no fixed costs of providing educational quality. As a result, if all students return to their home country, there are no educational externalities and thus no opportunities to free-ride, and the two countries have no incentive to compete for foreign students.

In our setting, by contrast, inefficiency prevails, no matter whether students return to their home country or not. In any case, the governments do not take the students' benefit into account and, even if all students leave after graduation, still compete for foreign students as tuition fee payers. However, the different conclusions are not surprising. After all, we analyse quality and tuition-fee competition for students from outside of two competing countries, whereas Demange and Fenge (2010) consider quality competition only, and only for students who are native to one of the competing countries. The results are therefore not perfectly comparable; in fact, the two papers are complementary.

6 Conclusion

In this paper, we have analysed the competition between developed countries for the pool of students from the developing world. Developed countries try to attract foreign students not only because these students pay tuition fees, but also because they provide long-term benefits to the societies of the developed world if they continue to stay in their host countries. In our model, these long-term benefits were captured by additional tax revenues. However, modelling these benefits as human capital spillovers would have led to the same qualitative results.

In equilibrium, the two countries provide different quality levels of higher education to relax the ensuing tuition fee competition. That is, one country charges high tuition fees for a high quality education, while the other country charges low tuition fees for a low quality education.

To analyse potential trends in developed and developing countries, we explored three scenarios: an increase in (i) the stay rate of foreign students after graduation, (ii) the income prospects in developing countries, and (iii) the size of the talent pool. In all three scenarios, the quality differential and quality of education in the high-quality country increase. Only in the second and third scenario do tuition fees and the tuition fee differential rise, too. In these scenarios, higher education becomes unambiguously more differentiated in terms of both quality and tuition fees. By contrast, tuition fees and the tuition fee differential may decline as the stay rate increases.

We have also shown that the induced policy adaptations to these socio-economic changes lead to brain drain and brain gain effects. For instance, an increase in the stay rate of foreign students causes a quantitative brain drain and a qualitative brain gain to the sending countries.

Our model could be generalised in various ways. For instance, students from developing countries might prefer one host country over the other for private or cultural reasons, resulting in imperfect mobility with respect to the potential destinations.[15] Then competition would be less fierce, and quality differentiation would be less extreme. However, the fundamental characteristics of the equilibrium and the comparative statics would not change qualitatively.

Furthermore, we have assumed that the stay rate is not affected by other variables, such as the quality of education or expected income. For instance, the stay

[15]'Pure' two-country models with student migration usually feature imperfect student mobility (e.g., Boadway, Marceau and Marchand, 1996; Büttner and Schwager, 2004; Gérard, 2007; Krieger and Lange, 2010; Lange, 2009). However, in this case, countries try to attract students from each other, and these students might be strongly attached to their home country. By contrast, we consider students who leave their home country anyway. These students are then more likely to be indifferent between different destination countries with respect to their private or cultural preferences.

rates could positively depend on educational quality. Students who attend an elite university and have high potential earnings in the host country might have a higher propensity to stay than graduates from a low-quality university. With differentiated educational systems, the stay rates would then differ between host countries. Again, this should not affect international competition and its implications fundamentally. When making their decisions, governments would just take into account that raising educational quality causes a further marginal benefit, as it increases the stay rate. But they would still differentiate the qualities of education to relax tuition fee competition. Only the equilibrium degree of differentiation is likely to change. The comparative-static analysis should not be affected qualitatively.

Our analysis points to some interesting avenues for future research. For instance, instead of the countries deciding simultaneously, they could make their quality, or market entry, choices sequentially (e.g., by launching international study programmes). Countries would then have an incentive to spend resources to lead the way and obtain a first-mover advantage by choosing the more profitable quality level. Furthermore, it would be worthwhile considering an endogenous immigration policy which determines the stay rates of graduates. Countries could implement some measures to foster social integration and to facilitate the labour market access of graduates (e.g., by promoting permanent residency). More and more OECD countries already make use of this option, and it would be interesting to elaborate the link between immigration policy and the competition for students in more detail. Adding admission standards to the choice set of countries, as, for example, in De Fraja and Iossa (2002), may also enrich further research.

Appendix

Tuition Fee Competition (Section 3)

Country 1 chooses t_1 to maximise R_1 according to (6), taking t_2 and quality levels (q_1, q_2) as given. The corresponding first order condition for given $\Delta q > 0$ is

$$t_1 \left(\frac{p\tau q_1}{\varrho \Delta q} - 2 \right) - t_2 \left(\frac{p\tau q_1}{\varrho \Delta q} - 1 \right) - p\tau \underline{w} + c(q_1) = 0, \tag{18}$$

from which the best-response function $t_1 = t_1^{br}(t_2; q_1, q_2)$ can be directly derived:

$$t_1 = \theta_1 t_2 + \frac{p\tau \underline{w} - c(q_1)}{\frac{p\tau q_1}{\varrho \Delta q} - 2}; \quad \theta_1 := \frac{\frac{p\tau q_1}{\varrho \Delta q} - 1}{\frac{p\tau q_1}{\varrho \Delta q} - 2}. \tag{19}$$

Following from (7), the first order condition for tuition fees chosen by country 2 and the best-response function $t_2 = t_2^{br}(t_1; q_1, q_2)$ can analogously be determined as

$$t_1 \left(\frac{p\tau q_2}{\varrho \Delta q} + 1 \right) - t_2 \left(\frac{p\tau q_2}{\varrho \Delta q} + 2 \right) - p\tau \underline{w} + c(q_2) + \varrho \Delta q = 0 \tag{20}$$

and

$$t_2 = \theta_2 t_1 + \frac{\varrho \Delta q + c(q_2) - p\tau \underline{w}}{\frac{p\tau q_2}{\varrho \Delta q} + 2}; \quad \theta_2 := \frac{\frac{p\tau q_2}{\varrho \Delta q} + 1}{\frac{p\tau q_2}{\varrho \Delta q} + 2}. \tag{21}$$

Combining (19) and (21) yields equilibrium tuition fees

$$t_1^*(q_1, q_2) = \frac{1}{1 - \theta_1 \theta_2} \left[\frac{p\tau \underline{w} - c(q_1)}{\frac{p\tau q_1}{\varrho \Delta q} - 2} + \theta_1 \frac{\varrho \Delta q + c(q_2) - p\tau \underline{w}}{\frac{p\tau q_2}{\varrho \Delta q} + 2} \right], \tag{22}$$

$$t_2^*(q_1, q_2) = \frac{1}{1 - \theta_1 \theta_2} \left[\theta_2 \frac{p\tau \underline{w} - c(q_1)}{\frac{p\tau q_1}{\varrho \Delta q} - 2} + \frac{\varrho \Delta q + c(q_2) - p\tau \underline{w}}{\frac{p\tau q_2}{\varrho \Delta q} + 2} \right], \tag{23}$$

which finally can be reduced to (8) and (9). Note that the second order conditions for optimal tuition fees in the two countries are given by $p\tau q_1 - 2\varrho \Delta q < 0$ and $-p\tau q_2 - 2\varrho \Delta q < 0$.

Proof of Lemma 1 and Non-existence of Symmetric Equilibrium

To show that a symmetric solution cannot exist, we first analyse tuition fee competition, assuming that the two countries had chosen identical educational qualities $q_1 = q_2 =: q$ in the first stage. Further assume that students who are indifferent between the two countries study in each of the two countries with probability 0.5. For undifferentiated quality levels, the variable net rent then amounts to

$$r_i|_{\Delta q = 0} = \begin{cases} \tau W + N(t_i - c(q)) & \text{if} \quad t_i < t_j, \\ \frac{1}{2}[\tau W + N(t_i - c(q))] & \text{if} \quad t_i = t_j, \\ 0 & \text{if} \quad t_i > t_j, \end{cases} \tag{24}$$

where $W = pN \int_0^1 (\underline{w} + aq) da = pN(\underline{w} + q/2)$. The fixed costs of providing quality are already sunk and therefore irrelevant for tuition fee competition. Countries have an incentive to undercut their competitor in order to attract all foreign students as long as r_i is positive, thereby engaging in a race-to-the-bottom leading to tuition fees $t_1 = t_2 = \alpha q - p\tau(\underline{w} + q/2)$ and $r_i = 0$.

This result of the second stage affects, in turn, the overall rent R_i after taking quality competition into account. If the variable net rent in (6) and (7) is zero, only the fixed costs remain, i.e., $R_i = -F(q)$, $i = 1, 2$. Then educational qualities $q_1 = q_2 > 0$ cannot constitute an equilibrium. One country could unilaterally deviate and choose a slightly lower educational quality, thereby increasing its net benefit R_i because fixed costs $F(q)$ decline and tuition fees can always be set such that the variable net rent r_i is at least zero.

Next we show that $q_1 = q_2 = 0$, implying $R_1 = R_2 = 0$, cannot be an equilibrium either. The reason is that one country, say country 2, can then gain from unilaterally raising its quality to q_2^*, while the other country sticks to $q_1^* = 0$, the optimal response to q_2^*. That is, $R_2 > 0$ for $q_2^* > q_1^* = 0$. Moreover, $R_1 > 0$, too, for $q_2^* > q_1^* = 0$. First we show that net variable rents are strictly positive for an interior solution of the allocation of foreign students $\hat{a}^*$. That is, we prove that $r_i(q_1, q_2) \equiv \tau W_i + N_i[t_i - c(q_i)] > 0$, $i \in \{1, 2\}$. Variable net rents are

$$r_1(q_1, q_2) = N\hat{a}^* \left\{ \frac{p\tau}{2}\hat{a}^* q_1 + t_1^* - \alpha q_1 \right\}, \tag{25}$$

$$r_2(q_1, q_2) = N(1-\hat{a}^*) \left\{ \frac{p\tau}{2}(1+\hat{a}^*) q_2 + t_2^* - \alpha q_2 \right\}. \tag{26}$$

Using equilibrium values t_1^*, t_2^* and $\hat{a}^*$, which are defined in (8), (9) and (11), and imply $t_2^* > t_1^*$, we find that

$$r_1(q_1, q_2) > 0 \quad \text{if} \quad p\tau q_1 - 2\varrho\Delta q < 0, \tag{27}$$

$$r_2(q_1, q_2) > 0 \quad \text{if} \quad \left(\frac{p\tau}{2} q_2 + \varrho\Delta q\right)(p\tau + 2\varrho - \alpha) > 0. \tag{28}$$

While the second order condition for the optimal t_1^* guarantees $r_1(q_1, q_2) > 0$, a strictly positive demand for education in country 2 (i.e., $(1 - \hat{a}^*) = (p\tau + 2\varrho - \alpha)/(p\tau + 3\varrho) > 0$) implies $r_2(q_1, q_2) > 0$. With $q_2^* > q_1^* = 0$, country 1 generates a strictly positive rent $R_1 > 0$ (see (6)) because $F(0) = 0$ and $r_1(q_1^*, q_2^*) > 0$.

Country 2 also generates a strictly positive rent R_2, as $\lim_{q_2 \to 0} R(q_2) = 0$ implies

$$q_2^* = \arg\max R_2(q_2) > 0 \quad \Leftrightarrow \quad R_2(q_2^*) > 0. \tag{29}$$

The equilibrium allocation of students is $\hat{a}^*$. From (3) follows that all individuals with ability $a \geq \hat{a}^*$ study in the higher-quality country 2, while all students with $a < \hat{a}^*$ study in country 1.

Proof of Proposition 1

First of all, note that

$$\frac{\partial \varrho(p)}{\partial p} = (1-\tau) - (1-\tau_{ROW})\gamma \geq 0 \tag{30}$$

can be signed unambiguously by Assumption 1. This finding can be used to get, from (1) and (11),

$$\frac{d\hat{a}^*}{dp} = -\frac{\tau[(1-\tau_{\mathrm{ROW}})\gamma+\alpha]+3\alpha\frac{\partial\varrho}{\partial p}}{(p\tau+3\varrho)^2} \leq 0, \tag{31}$$

and thus $\partial(1-\hat{a}^*)/\partial p \geq 0$. This proves part (iii) of Proposition 1.

Now, part (i) follows from

$$\frac{d\Delta q^*}{dp} \gtreqqless 0 \quad \overset{(q_1^*=0)}{\Leftrightarrow} \quad \frac{dq_2^*}{dp} = -\frac{d^2R_2/\left(dqdp\right)}{d^2R_2/dq_2^2} \gtreqqless 0 \tag{32}$$

$$\overset{(13)}{\Leftrightarrow} \quad \frac{d^2R_2}{dqdp} = \frac{d\left[\frac{N}{2}(p\tau+2\varrho)(1-\hat{a}^*)^2\right]}{dp} \gtreqqless 0 \tag{33}$$

and

$$\frac{d^2R_2}{dqdp} = \frac{N(1-\hat{a}^*)}{2}\left[(\tau+2\frac{\partial\varrho}{\partial p})(1-\hat{a}^*)-2(p\tau+2\varrho)\frac{\partial\hat{a}^*}{\partial p}\right] \geq 0, \tag{34}$$

where the last inequality results from $\partial\varrho/\partial p \geq 0$ (see (30)), $\partial\hat{a}^*/\partial p \leq 0$ (see (31)) and $1-\hat{a}^* \geq 0$.

Considering the tuition fee differential (10), we get

$$\frac{d\Delta t^*}{dp} = \Omega\frac{d\Delta q^*}{dp} + \Delta q^*\left\{\frac{d\Omega}{dp}+\frac{\partial\Omega}{\partial\varrho}\frac{\partial\varrho}{\partial p}\right\} \tag{35}$$

$$= \Omega\frac{\Delta q^*}{p}\left\{\underbrace{\frac{d\Delta q^*}{dp}\frac{p}{\Delta q^*}}_{:=\varepsilon_{\Delta q,p}>0} + \underbrace{\frac{\partial\Omega}{\partial p}\frac{p}{\Omega}}_{:=\varepsilon_{\Omega,p}<0} + \underbrace{\frac{\partial\Omega}{\partial\varrho}\frac{\varrho}{\Omega}}_{:=\varepsilon_{\Omega,\varrho}>0} \cdot \underbrace{\frac{\partial\varrho}{\partial p}\frac{p}{\varrho}}_{:=\varepsilon_{\varrho,p}\geq 0}\right\}, \tag{36}$$

where $\varepsilon_{\Delta q,p} := (d\Delta q/dp)(p/\Delta q) > 0$, $\varepsilon_{\Omega,p} := (\partial\Omega/\partial p)(p/\Omega) < 0$, and $\varepsilon_{\varrho,p} := (\partial\varrho/\partial p)(p/\varrho) \geq 0$ follows directly from (32)-(34), (10), and (30). Furthermore, $\varepsilon_{\Omega,\varrho} = (\partial\Omega/\partial\varrho)(\varrho/\Omega) > 0$ results from

$$\frac{\partial\Omega}{\partial\varrho} = \frac{p\tau\left(\alpha+2\varrho\right)+3\varrho^2}{\left(p\tau+3\varrho\right)^2} > 0. \tag{37}$$

The derivative (36) directly implies (14), which proves part (ii) of Proposition 1.

Proof of Proposition 2

Part (i) of Proposition 2 follows from

$$\frac{d\Delta q^*}{d\gamma} \gtreqqless 0 \quad \overset{(q_1^*=0)}{\Leftrightarrow} \quad \frac{dq_2^*}{d\gamma} = -\frac{d^2R_2/\left(dqd\gamma\right)}{d^2R_2/dq_2^2} \gtreqqless 0 \tag{38}$$

$$\overset{(13)}{\Leftrightarrow} \quad \frac{d^2 R_2}{dq d\gamma} = \frac{d\left[\frac{N}{2}(p\tau + 2\varrho)(1-\hat{a}^*)^2\right]}{d\varrho}\frac{d\varrho}{d\gamma} \gtreqless 0 \tag{39}$$

and, using (11) and the fact that $d\varrho/d\gamma = (1-p)\,(1-\tau_{ROW}) \geq 0$ (see (1)),

$$\frac{d^2 R_2}{dq d\gamma} > 0 \quad \Leftrightarrow \quad 3\varrho p\tau + 6\varrho^2 + 2\alpha p\tau + 3\alpha\varrho > 0, \tag{40}$$

where the last inequality always holds.

Using (10), part (ii) of Proposition 2 follows from

$$\frac{d\Delta t^*}{d\gamma} = \frac{\partial \Delta t^*}{\partial \varrho}\cdot\frac{\partial\varrho}{\partial\gamma} + \frac{\partial\Delta t^*}{\partial\Delta q^*}\cdot\frac{d\Delta q^*}{d\gamma} > 0, \tag{41}$$

where $\partial\Delta t^*/\partial\Delta q^* = \Omega(p,\varrho) > 0$ (see (10)), $d\Delta q^*/d\gamma > 0$ (see (38)-(40)), $\partial\varrho/\partial\gamma = (1-p)(1-\tau_{ROW}) \geq 0$ (see (1)), and

$$\frac{\partial\Delta t^*}{\partial\varrho} = \frac{p\tau(\alpha + 2\varrho) + 3\varrho^2}{(p\tau + 3\varrho)^2}\Delta q^* > 0 \tag{42}$$

(see (10) and (37)). Furthermore, using (1) and (11) yields

$$\frac{d(1-\hat{a}^*)}{d\gamma} \gtreqless 0 \quad \Leftrightarrow \quad -\frac{\partial\hat{a}^*}{d\varrho}\frac{\partial\varrho}{\partial\gamma} \gtreqless 0 \quad \Leftrightarrow \quad 3\alpha - p\tau \gtreqless 0, \tag{43}$$

which proves part (iii) of Proposition 2.

Proof Proposition 3

Applying comparative statics again yields

$$\frac{\partial\Delta q^*}{\partial N} \gtreqless 0 \quad \overset{(q_1^*=0)}{\Leftrightarrow} \quad \frac{\partial q_2^*}{\partial N} \gtreqless 0 \quad \overset{(13)}{\Leftrightarrow} \quad \frac{\partial}{\partial N}\left[\frac{N}{2}(p\tau + 2\varrho)(1-\hat{a}^*)^2\right] \gtreqless 0 \tag{44}$$

and

$$\frac{\partial}{\partial N}\left[\frac{N}{2}(p\tau + 2\varrho)(1-\hat{a}^*)^2\right] = \frac{1}{2}(p\tau + 2\varrho)(1-\hat{a}^*)^2 > 0, \tag{45}$$

which proves part (i) of Propostion 3.

Part (ii) follows from

$$\frac{\partial\Delta t^*}{\partial N} = \frac{\partial\Delta t^*}{\partial\Delta q^*}\cdot\frac{\partial\Delta q^*}{\partial N} > 0, \tag{46}$$

where $\partial\Delta t^*/\partial\Delta q^* = \Omega(p,\varrho) > 0$ (see (10)) and $\partial\Delta q^*/\partial N > 0$ (see (44) and (45)).

Part (iii) follows directly from (10), as Δt^* is independent of N.

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