Essays on Systems Competition with Human Capital Mobility

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Contents

Summary

This thesis is composed of results from my work as an economist at the Ifo Institute for Economic Research in Munich and as a doctoral student at the Chair of Public Economics at the University of Konstanz. It is a collection of four stand-alone essays on international competition for human capital, together with a general introduction and some concluding remarks.

The first essay was published in *FinanzArchiv/Public Finance Analysis* (2009), vol. 65 (2), pp. 178-199. It deals with decentralized public education and human capital mobility. The international mobility of highly-skilled workers may result in an underinvestment in local public higher education when national entities independently decide on educational expenditures to maximize local output. This well-established result due to a positive interregional spillover of national educational policy when some individuals emigrate after graduating, can reverse if student mobility is taken into account. When local educational policy attracts foreign students, a negative spillover takes place, and the actual discrepancy between decentralized policy and the global-output-maximizing solution depends on the relative sizes of the two spillovers. The paper also presents a variant of this model in which local governmental objectives rest exclusively upon the native population.

The second essay is a joint work with Tim Krieger and is forthcoming in *International Tax and Public Finance* (2010). The paper analyzes the effect of increasing human-capital mobility – i.e., student and labor mobility – on net tax revenues when revenue-maximizing governments compete for human capital by means of income tax rates as well as amenities offered to students (positive expenditure) or by tuition fees (negative expenditure). An increase in labor mobility results neither in an intensified tax competition nor an erosion of revenues. In fact, the equilibrium tax rate even increases with labor mobility. Amenities offered to students are non-monotonically related to labor mobility; overall, net revenues increase with labor mobility. An increase in student mobility, however, erodes revenues,

mainly due to intensified tax competition. A concurrent cutback in expenditures mitigates this erosion but cannot fully prevent it.

The third essay is a revision of *Ifo Working Paper* No. 74 (2009) and presents a model of student migration in order to determine the optimal level of non-resident tuition fees in a host country of higher education. Students with rational expectations consider a potential return migration in their first-round decision of whether to study abroad, so that demand for the higher-educational system in the host country and optimal non-resident tuition fees depend on the stay rates of foreign-born graduates. A decline in stay rates of foreign students is demonstrated to lead to a *cutback* in optimal tuition fees if the cost of education per student is not too high. The fact that students take into account the possibility of return migration after graduation in their first-stage location decision, in combination with rational expectations, finally produces this result.

The fourth essay is a joint work with Alexander Haupt and Tim Krieger and is a revised version of *Hitotsubashi University CCES Discussion Paper* No. 31 (2010). It presents a model of two countries competing for the international pool of talented students from the rest of the world. To relax tuition-fee competition, countries differentiate their educational systems in equilibrium. While one country offers high educational quality at high rates for students – the most talented choose to study in this country – the other provides lower quality and charges lower tuition fees. The regional quality-differentiation increases with the size of the international talent pool, with the stay rate of foreign students in the host countries after graduating, and with the degree of development of the home countries of the foreign students. In comparison to the welfare-maximizing educational policy, the decentralized solution is likely to result in an inefficient allocation of foreign students to the two host countries, as well as an inefficient quality differentiation.

Zusammenfassung

Die vorliegende Dissertation ist in meiner Zeit als wissenschaftlicher Mitarbeiter am Ifo Institut für Wirtschaftsforschung in München und Doktorand am Lehrstuhl für Finanzwissenschaft an der Universität Konstanz entstanden. Sie enthält vier eigenständige Forschungsartikel zum internationalen Wettbewerb um Humankapital, sowie ein allgemeines Einleitungskapitel und abschließende Bemerkungen.

Der erste Artikel wurde in *FinanzArchiv/Public Finance Analysis* vol. 65 (2), S. 178-199, veröffentlicht. Er handelt von dezentral organisierter Bildungspolitik und Humankapitalmobilität. Die internationale Mobilität hochqualifizierter Arbeitskräfte kann zu einer Unterinvestition in öffentliche Hochschulbildung führen, wenn die Nationalstaaten unabhängig von einander über die Höhe der Bildungsausgaben zur Maximierung des nationalen Outputs entscheiden. Dieses bekannte Ergebnis, das auf positive regionale Externalitäten lokaler Bildungspolitik zurückzuführen ist wenn einige Absolventen nach Abschluss ihrer Universitätsausbildung ins Ausland abwandern, kann sich ins Gegenteil kehren, wenn zusätzlich zur Absolventenmobilität auch die Mobilität von Studenten berücksichtigt wird. Wenn das nationale Bildungsangebot ausländische Studenten anlockt, entsteht eine negative regionale Externalität, so dass die tatsächliche Abweichung der nationalen Politik von der globalen wohlfahrtsmaximierenden Lösung von der relativen Größe der beiden Externalitäten abhängt. Der Artikel führt außerdem eine Modellvariante an, in der sich die nationalen Regierungen ausschließlich an den Interessen ihrer eigenen Staatsbürger orientieren.

Der zweite Artikel wurde gemeinsam mit Tim Krieger verfasst und erscheint in *International Tax and Public Finance* (2010). Das Papier analysiert die Auswirkung steigender Humankapitalmobilität (d.h. Studenten- und Absolventenmobilität) auf nationalstaatliche Nettosteueraufkommen, wenn aufkommensmaximierende Regierungen mittels Einkommensteuersätzen und Studiensubventionen (bzw. Studiengebühren) um Humankapital konkurrieren. Ein Anstieg der Absolventenmo-

bilität führt dabei weder zu einer Intensivierung des Steuerwettbewerbs, noch zu einer Erosion des Staatsaufkommens. Im Gegenteil, die gleichgewichtigen Einkommensteuersätze steigen sogar in der Absolventenmobilität an. Der Zusammenhang zwischen Studiensubventionen und Absolventenmobilität ist nicht-monoton; insgesamt steigt das Staatsaufkommen in der Absolventenmobilität. Ein Anstieg der Studentenmobilität führt jedoch zu einer Erosion des Staatsaufkommens, hauptsächlich da es zu einer Intensivierung des Steuerwettbewerbs kommt. Eine gleichzeitige Reduktion der Studiensubventionen kann diese Erosion abschwächen, aber nicht vollständig kompensieren.

Der dritte Artikel ist einer Überarbeitung des *Ifo Working Paper* No.74 (2009) und stellt zunächst ein Modell der Studentenmigration vor, um die optimale Wahl von Studiengebühren für ausländische Studenten in einem Gastland universitärer Ausbildung zu bestimmen. Studenten mit rationalen Erwartungen berücksichtigen bei ihrer Entscheidung ob sie im Ausland studieren wollen die potentielle Rückkehr in ihr Heimatland, so dass die (ausländische) Nachfrage nach der Hochschulbildung im Gastland und damit auch die optimale Studiengebühr für ausländische Studenten von der Rückkehrwahrscheinlichkeit der im Ausland geborenen Absolventen abhängt. Die Modellanalyse zeigt, dass ein Anstieg dieser Rückkehrwahrscheinlichkeit ausländischer Studenten zu einer *Senkung* der optimalen Studiengebühren führt, wenn die Kosten der Ausbildung je Student für das Gastland nicht zu hoch sind. Die Tatsache dass die Studenten die Möglichkeit der Rückkehr in ihr Heimatland nach Abschluss des Studiums bereits in ihrer ersten Migrationsentscheidung berücksichtigen, erklärt zusammen mit den rationalen Erwartungen der Studenten schlussendlich dieses Ergebnis.

Der vierte Artikel wurde zusammen mit Alexander Haupt und Tim Krieger verfasst und ist eine Überarbeitung des *Hitotsubashi University CCES Discussion Paper* No. 31 (2010). Das Papier stellt ein Modell vor, in dem zwei Länder um talentierte Studenten aus dem Rest der Welt konkurrieren. Um den Wettbewerb mittels Studiengebühren abzumildern, differenzieren die Länder im Gleichgewicht ihr Bildungsangebot. Während ein Land eine hohe Hochschulqualität anbietet und dafür hohe Studiengebühren verlangt – die talentiertesten Studenten studieren in diesem Land – bietet das andere Land eine geringere Qualität an und verlangt niedrigere Studiengebühren. Diese regionale Qualitätsdifferenzierung nimmt mit steigender Zahl internationaler Studenten ebenso zu, wie mit steigender Ver-

bleibsquote der ausländischen Studenten im Gastland nach Abschluss des Studiums und mit steigendem Grad der Entwicklung der Herkunftsregion der internationalen Studenten. Im Vergleich zur wohlfahrtsmaximierenden Bildungspolitik ist die dezentrale (nationale) Lösung mit hoher Wahrscheinlichkeit durch eine ineffiziente Allokation von Studenten in die zwei Gastländer und eine ineffiziente Differenzierung der Bildungspolitik gekennzeichnet.

1 Motivation and General Introduction

1.1 Globalization and systems competition

International labor migration and global competition for highly-skilled human capital (especially in science and technology) have finally made it onto the political agenda in many OECD countries. Rising demand for skilled labor in knowledge-based societies and the ongoing globalization of the world economy expose these countries to an international competition for talent, bringing about the need to examine not only national immigration policy, but also fiscal and educational policy.

1.1.1 Human capital migration

The economic globalization of the late 19$^{\text{th}}$and early 20$^{\text{th}}$century has been characterized by considerable increase in the international flow of capital, as well as the flow of migrants (Age of Mass Migration). Decreasing costs of transportation and communication encouraged the migration of low-skilled workers to the industrial centers of that time in North America and Northwestern Europe. Beginning in the late 20$^{\text{th}}$century, with rapid technological change and massive state intervention to reduce international trade barriers and obstacles to the flow of investments, globalization took on a whole new dimension. Most notably, the computer revolution and the international specialization of production created an increased relative demand for highly-skilled workers in developed countries.[1]

Based on an international employer survey, Winkelmann (2002) found that firms recruit internationally in order to acquire international competence and to offset a national shortage of skilled labor. In 'demand-driven' (i.e., employer-driven) immigration systems (e.g., Europe, Japan, and Korea), foreign workers need a

[1] See Bhagwati (2004, pp. 10-12) and Chiswick (2005).

concrete job offer to be eligible for work and residence permits, while 'supply-driven' systems (e.g., Canada, Australia, New Zealand, and the UK) allow some highly-skilled immigration without job offers (Chaloff and Lemaitre, 2009, pp. 19-23). The latter usually use point-based systems to select immigrants; for example, points can be awarded based on (academic) qualifications, work experience, language ability and age. Within the European Union, EU citizens can generally take up employment in any member state without further restrictions (Freedom of Movement for Workers).

This thesis focuses on highly-skilled human capital migration. Data on the educational attainment of migrants in OECD countries suggest that emigration rates are highest among individuals with tertiary education (Docquier and Marfouk, 2006, p. 164), and that top research scientists are especially mobile (e.g., Hunter, Oswald and Charlton, 2009). Today's immigration regulations in OECD countries usually feature a skill bias, in that they favor highly-skilled immigration over low-skilled immigration. Definitions of 'highly-skilled' can be based on a worker's education (e.g., university degree), their current occupation, and the wage level of their current job (Chaloff and Lemaitre, 2009, pp.10-12). For example, according to the Canberra Manual, the OECD and Eurostat define 'human resources in science and technology' as people who have either completed tertiary education in a science and technology field of study or – in case they do not have this formal qualification – who occupy a job in the field which usually would require such a qualification (see Auriol and Sexton, 2002).

Highly-skilled labor is perceived as a main instigator of innovation, invention, and therefore economic growth (e.g., Lucas, 1988; Romer, 1990; Aghion and Howitt, 1992).[2] As has been demonstrated in the American biotechnology industry, the most qualified workers ('super stars' or star scientists) can be particularly critical for innovation and growth in high-tech industries (e.g., Zucker, Darby and Brewer, 1998; Zucker and Darby, 2007). Furthermore, against the background of demographic change and the aging of western societies, highly-skilled immigration not only mitigates skilled-labor shortages but could also be a remedy to

[2] The new growth theory stresses the importance of human capital for growth. The new economic geography involves agglomeration benefits (for example from increasing the stock of human capital). Acs (2006) compiles a collection of seminal contributions to these issues from economic theory and regional science.

sustain fiscal stability and social security systems (e.g., Storesletten, 2000; Fehr, Jokisch and Kotlikoff, 2004; Rowthorn, 2008). Storesletten (2000, pp. 315-318) calculates a theoretical marginal (discounted) net government gain of $177,000 for an additional 40- to 44-year old highly-skilled immigrant to the U.S.; given the current age structure of immigrants to the U.S., he calculates a net present value of *representative* high-, medium-, and low-skilled immigrants of $96,000, -$2,000, and -$36,000, respectively. Holzner, Munz and Übelmesser (2009) compute a fiscal externality of 639,200 €[3] for an exemplary physician who emigrates from Germany.[4]

1.1.2 The New Systems Competition

Ongoing globalization leads to a New Systems Competition (Sinn, 2002a,b, 2004): while the historic systems competition between communist and capitalist states has been characterized by competition for economic, cultural and military dominance with *closed* borders, the New Systems Competition is a competition for advantage of location. Nations align themselves with the integrated world economy and adjust their institutions (e.g., tax system, social security, provision of public goods, regulations, and legal system) to compete for internationally mobile highly-skilled workers, for capital, and for new corporate investments. Only under ideal conditions (perfect mobility of resources and rational location choice, full knowledge of regional policy differentials, and absence of external effects of public services between regions) might the competitive pressure on governments – in some way analogous to private competition – induce efficient public-good provision (Tiebout, 1956). The analogy of private and public competition is, however, far from perfect (e.g., Sinn, 1994, 1998). The primary problem is that

[3] Absolute values for the U.S. and Germany from these studies cannot be compared due to different methodology of calculating externalities. For instance, Storesletten also includes the cost of future children in his analysis.

[4] While highly-skilled immigration is generally perceived as desirable, theoretically, natives to a country need not always benefit from highly-skilled immigration. If immigration of highly-skilled net fiscal contributors to the host country goes along with an inflow of (complementary) low-skilled immigrants who are net fiscal beneficiaries, the overall welfare effect on the natives can be negative (Michael, 2006). Kemnitz (2009) shows that highly-skilled immigration may raise unemployment of low-skilled labor in the host country (if high- and low-skilled labor are closed substitutes) and reduce aggregate native gross income.

the state usually intervenes in cases of private market failure. According to Sinn's (1997) Selection Principle, the reintroduction of the market through competition between nations cannot eliminate the primary market failure:

> It is more likely that the failings that led the state to act will reappear on the higher level of competition between states. [...] Drawing analogies between competition in the private sphere and competition between states is completely inadmissable because the states administer the exceptions in the competitive allocation process. Precisely because competition functions well in the private sphere it must be feared that it will fail in the public sphere. (Sinn, 2004, p. 30)

The fiscal-competition literature argues that horizontal competition for a mobile tax base brings about inefficiently low tax rates and inefficient local public-good provision (e.g., Zodrow and Mieszkowski, 1986; Wildasin, 1988; Bucovetsky and Wilson, 1991; Wilson, 1999). The underlying reason is that individually rational local governments ignore externalities of their fiscal policy on other states. Furthermore, the competitive pressure on fiscal policy hampers income redistribution and the sustainment of social security systems (e.g., Sinn, 1994, 1998; Cremer et al., 1996; Krieger, 2001; Wildasin, 2000a, 2006).[5]

[5] In this context, especially large social welfare states face an important tradeoff. On one hand, as already argued, welfare states appreciate highly-skilled immigration, as redistribution systems rely on above-average income earners who are net contributors to the system. On the other hand, the existence of redistribution systems implies a disincentive for potential skilled immigrants, while low-skilled individuals (who are net beneficiaries) have an incentive to immigrate. The latter aspect could explain the puzzle that some European countries end up with mainly low-skilled immigration, even though they would prefer highly-skilled immigration: only 11.3% of foreign-born individuals aged 25-64 in Italy have a tertiary education, 18.9% in Germany and 21.1% in France, while Canada (46.1%) and the U.S. (35%) are much more successful at attracting highly-skilled individuals (see OECD, 2007, Table II.1, p. 133). Hans-Werner Sinn made this point in his concluding remarks at the 7$^{\text{th}}$Munich Economic Summit (June 5-6, 2008) on "Europe in the Global Competition for Talent."

1.2 Competition for highly-skilled human capital

Against the background of the New Systems Competition, countries realign institutions to create a favorable environment for highly-skilled workers and highly-skilled immigration.

1.2.1 Various strategies

As already mentioned, immigration policies in OECD countries favor highly-skilled over low-skilled human capital. However, Chaloff and Lemaitre (2009) report from a review of immigration policies in ten OECD countries that

> [...] most of these policies are not so much designed to attract workers as to reduce the obstacles to their immigration. [...] What is surprising [...] is that 'active' policy is generally defined as simply creating exemptions from the restrictions on labour migration applied across-the-board. As shortages increase, truly 'active' policies for the high skilled may start to be adopted, especially outside the benchmark high-wage and English-speaking countries. (Chaloff and Lemaitre, 2009, p. 30)

Special job fairs (already utilized by Australia and the UK), multilingual job-offer portals (as in the Czech Republic), and assistance in administrative procedures during and after immigration are examples of truly *active* measures (Chaloff and Lemaitre, 2009, p. 30).

In addition to immigration policy, fiscal policy can serve as an effective strategic instrument in the competition for highly-skilled human capital. Efforts to reduce top income tax rates and to cut down on income redistribution aim to improve general competitiveness. In addition, many OECD countries have introduced specific incentives for highly-skilled immigrants in their tax systems. Japan, for example, offers tax-free relocation and regular home-leave allowances. In Sweden, certain experts and scientists with skills in high demand can benefit from a 25% income tax deduction for up to ten years. Similar deductions are offered in Norway (15%), the Netherlands (30%), Austria (35%), and Korea (40%). The

province of Québec in Canada even offers a 75% tax exemption on personal income for five years for researchers who work for an R&D firm in the province.[6]

A further strategy to attract highly-skilled human capital currently utilized by most OECD countries (and the focus of this thesis), is based on the recruitment of foreign students. The following section elaborates on this strategy in more detail.

1.2.2 Recruitment of foreign students

Foreign students who stay on in the host country of higher education after graduating add to the stock of highly-skilled human capital in the country. This recruitment channel is already of some importance for Australia, Canada, and New Zealand, among other countries. About 20% of highly-skilled immigrants to Australia changed their immigration status from foreign student to skilled worker (Chaloff and Lemaitre, 2009, p. 25). A two-tiered governmental strategy would aim to (i) attract foreign students and (ii) retain them as graduates.

1.2.2.1 Student mobility

The international migration of students has become more and more important over the last few decades. The OECD (2009, ch. C2) reports that in 2007, more than three million tertiary students studied outside their country of citizenship (more than 80% of these in an OECD country). In 1975, the number was no more than 0.8 million. Between the years 2000 and 2007, growth in the number of students enrolled abroad was about 58%. In some countries, the number of foreign students in tertiary education more than doubled over this period (e.g., Australia, New Zealand, Korea, Ireland, the Netherlands). International students make up a considerable share of total tertiary enrollments in some OECD countries, such as Australia (19.5% in 2007), the UK (14.9%), Switzerland (14.0%), New Zealand (13.6%) and Austria (12.4%). The OECD (EU 19) average is 7.1% (6.2%). The proportion of international students in advanced research programs can actually be much higher (e.g., 45.0% in Switzerland, 42.1% in the UK; the OECD average

[6] See CESifo (2005) for an overview of fiscal incentives for highly-skilled immigrants.

is 16.3%, the EU 19 average is 12.3%). The largest host countries of foreign students (in absolute terms) are the U.S. (with a 'market share' of 19.7% in 2007), the UK (11.6%), Germany (8.6%), and France (8.2%). These four countries host nearly 50% of all international students. Adding Australia, Canada, Japan, New Zealand, and Russia, this group serves more than two thirds of the global market. Asia is the most important regional source of foreign students: nearly 50% of international students are Asian. The largest OECD countries of origin are France, Germany, Japan, and Korea; China and India are the largest countries of origin among OECD *partner* countries.[7] Taking both in- and outflows of students into account, Australia, the UK, Austria, Germany, France, and the U.S. are clearly net receiving countries, while Finland, Korea, and Ireland are examples of net producing OECD countries of foreign students (OECD, 2001, p. 102).

Dreher and Poutvaara (2005) find empirical support for a close relationship between student migration and subsequent migration of labor. In their study of the U.S., this relationship could be explained by students staying on in the host country of education as well as networks built up by students and then used by other labor migrants. However, even though clear international evidence is scarce, primarily due to lack of data, there is a general consensus that at least some foreign students (especially from less-developed countries) stay on in their host countries of higher education upon graduation (Tremblay, 2002, p. 43; OECD, 2008, pp. 83-84). Estimated stay rates of foreign students in the U.S. range from one fifth (Rosenzweig, 2006, p. 24) to one third (Lowell, Bump and Martin, 2007, p. 45). For foreign citizens who earned a doctorate in the U.S., the estimated stay rate is two thirds (Finn, 2003, p. 3; Lowell, Bump and Martin, 2007, p. 45). The percentage of students who actually *intend* to stay on in the host country can be even higher. The intended stay rate is therefore an indicator of the *potential* of highly-skilled labor immigration through the student migration channel. The proportion of Chinese and Indian PhD students in the U.S. who intend to stay on in the country after graduation exceeds 80%, and ranges from 50% to 75% for students from the UK, Germany, Canada, New Zealand, and France (Tremblay, 2002, p. 44).

[7] The data in this paragraph are all taken from OECD (2009, pp. 308-334).

1.2.2.2 Targeted educational policy

Immigration regulations for foreign students are usually quite liberal in OECD countries. The European Union holds a special position as a marketplace for international students, since for EU citizens there are basically no restrictions to immigration into other member states. While the immigration policy for students ensures only that foreign students are *allowed* to immigrate, countries may also want to take active measures to encourage students' *desire* to study in their country. Therefore, in the New Systems Competition, public higher-educational policy becomes a strategic instrument to attract human capital. Good institutional reputations, the existence of centers of excellence in certain fields, the quality of education, and the general conditions at universities, as well as the availability of courses taught in English foster the international competitiveness of national higher-educational systems. Efforts to preserve competencies in a field with traditional expertise (e.g., science and engineering in Germany and Finland), which can be a major draw for foreign-student immigration (OECD, 2009, p. 322), certainly adds to the list of promising strategies. Subsidies (including scholarships, housing support, travel tickets, medical benefits, and book grants) and other 'amenities' like special student loans, hospitality services, leisure and sports facilities, child care, housing offices, and health centers are additional potential instruments to attract foreign students.[8] Measures especially designed for foreigners include international housing offices, language training and welcome desks to support students struggling with administrative and personal difficulties. The city of Paris and the Cité Internationale Universitaire de Paris, as an example, provide a central information desk for foreign students, where several public service units (an immigration office, police headquarters, a department for child and family services, a department for employment issues, and a regional public transportation office) are represented (Gros, 2009).

In addition to the quality of education and the provision of subsidies and amenities, tuition fees also play an important role in competition for foreign students. If countries perceive student immigration as a source of higher-education funding through non-resident tuition fees, they face a tradeoff between raising revenues

[8] Public subsidies can make up a considerable share of total public expenditures in tertiary education (e.g., in 2006, 42.3% in New Zealand, 41.7% in Norway, 31.0% in Australia, 30.9% in the U.S., and 19.5% in Germany; see OECD, 2009, p. 260).

and avoiding the adverse effects of deterring foreign students from immigration. Survey data of foreign students who decided *not* to study in the U.S. suggest that the high cost of tuition was the overriding motive for their decision (Lowell, Bump and Martin, 2007, p. 37). The third essay of this thesis deals in particular with this tradeoff and analyzes the effect of the stay rate of foreign students in the host country upon graduation on the optimal non-resident tuition fee.

The absolute level of tuition fees charged to foreign students as well as the relative level compared to domestic students varies greatly among host countries. While Finland, Sweden, and Norway charge neither domestic nor international students any tuition fees, Australia, Canada, and New Zealand charge considerably higher fees for international than for domestic students. In American public universities, overseas students are treated like domestic out-of-state students (who pay higher fees than in-state students) and in the UK, Austria, Ireland, and the Netherlands, students from non-EU countries have to pay higher fees than domestic and EU students. France, Germany, Italy, Japan, Korea, and Spain charge the same tuition fees for domestic and foreign students.[9]

In regard to the relevance of non-resident tuition fees in the UK, the Economist recently noted that

> [students] from outside the EU are vital to British universities' finances. Neither their numbers nor their fees are capped by government (UEA's foreign-student fees, around £10,000 a year for most courses, are pretty standard; nationally, fees paid by overseas students in higher education total some £2.5 billion). They keep open departments in some subjects – science, engineering – that are shunned by locals. And the more of them a university attracts, the higher it rises in the ever-more-important international league tables. (*The Economist*, "International students - Build it, and they will come," January 15, 2009.)

The same article argues that Britain has to make sure to offer value for money (in terms of service and quality) in order to remain an attractive host country for overseas students because other countries such as Germany and Japan now also

[9] See OECD (2009, Box C2.3, p. 317).

offer programs taught in English, increasing the competition.

The fact that Australia, the UK, and the U.S. charge the highest tuition fees but are still among the largest host countries, reflects to a large extent a greater 'market power' in the higher-education market, due to issues of language and the outstanding quality of the top institutions in these countries. Furthermore, they also offer large public subsides to students (OECD, 2009, p. 249).

At this point, it is necessary to emphasize that this thesis focuses on the role of *government* in competition for human capital, and not on private universities. The reason I am restricting my analysis to public higher education and fiscal policy is that I am especially interested in the relationship between student migration and subsequent labor migration, which is recognized (or rather should be recognized) by rational forward-looking governments, but less so by the administration of private institutions.[10] Additionally, even in the U.S., where private universities play a much more important role in the higher-education sector than in many European countries, the government still has a role in international competition for foreign students. First of all, two thirds of foreign students in the U.S. are currently studying at a public university (Lowell, Bump and Martin, 2007, p. 49). And further, some academics are already calling for federal government intervention to sustain the country's leading position in the education of international talent.

> National debate is needed on the role of the federal government in fostering the competitiveness of the United States in attracting and retaining foreign students. Some questions to address: Should the federal government provide subsidies to offset high tuition and living costs, and, if so, at what level of education (graduate and/or undergraduate level)? Also, should the Federal government play a greater role in marketing to international students? (Lowell, Bump and Martin, 2007, Executive Summary)

[10] Perhaps one reason why private universities might also consider the relationship between student and graduate mobility is that institutions could have an incentive to attract the best students from all over the world in order either to retain them as faculty upon graduation or at least to retain them in local academia as potential collaborators for their former supervisors. Eric Weese pointed out this issue to me, which could be relevant to American universities. In fact, the fourth essay in this thesis could be reinterpreted in light of this.

It should also be mentioned that student immigration is usually perceived as beneficial not only because of subsequent labor migration. Foreign students can help overcome national bottlenecks in finding talented students in some fields and help utilize economies of scale; they may contribute to R&D as graduate students, generate positive spillovers to domestic students and domestic society as a whole, promote diversity and creativity on campus, and work as cheap labor in educational institutions. Like all other types of immigrants, they also contribute to domestic demand in the host country.[11]

While some of the measures described so far primarily target foreign students, efforts to improve general conditions or a competitive subsidy tuition-fee package attempt simultaneously to attract foreign human capital and to retain domestic human capital. In many of the economic models to be discussed in the literature overview, attracting and retaining human capital are simply two sides of the same coin.

1.2.2.3 Immigration regulations

Alongside efforts to ensure a general attractiveness for highly-skilled workers, countries apply liberal immigration regulations to retain foreign students upon graduation. Foreign graduates are by definition highly-skilled and therefore belong to the target group of modern immigration policies. Furthermore, in comparison to first-time immigrants, they are already provided with some country-specific education, have built up social and maybe even professional networks (e.g., at university, during internships or other off-campus employment), usually have some language proficiency, and are familiar with the host country culture and way of life, so that they can easily be integrated. Immigration rules might therefore ease the status change for foreign students to become permanent residents. Canada's Post-Graduation Work Permit Program, for example, grants foreign students a three-year work permit allowing graduates to gain some 'Canada Experience', which is a prerequisite for permanent residency. In Germany, foreign students (from non-EU countries) are allowed to stay on in the country upon graduation for one year in order to find a job, and they are exempted from the

[11] See e.g., Throsby (1991, 1998) and Tremblay (2002) for some general cost-benefit considerations in student immigration.

labor-market test. As highly-skilled workers and after five years of residence, they are entitled to a permanent residence permit. The UK International Graduate Scheme works in a similar way.[12] Many countries also allow foreign students to work during their studies. This type of employment can provide students with a first contact to the host country's labor market, where they can gain certain country- and market-specific experiences which should help them find a job in the host country after graduation, and thereby increasing the probability to their staying on (see Chaloff and Lemaitre, 2009, pp. 24-25). The fact that many OECD countries take all these measures to promote foreign students' access to the national labor market clearly indicates that countries value student immigration as a channel of highly-skilled human capital recruitment.

Survey data suggests that the adjustment process of foreign students (that is, their successful integration into the host country society) is an important determinant of foreign students' propensity to stay on after graduation (Baruch, Budhwar and Khatri, 2007). Fostering social support of foreign students therefore complements immigration policies and strengthens the student-labor migration channel.

It is worth noting that flexible immigration regulations are also an indirect tool to attract students. Given students' potential intention to stay on in the host country, the perception of the opportunity to become a permanent resident in the host country after graduation might influence their initial choice of location.

1.3 Literature overview

This thesis is primarily inspired by the public-finance literature on regional income tax and educational-policy competition, as well as on local funding of public higher education in the presence of human capital mobility. This section briefly summarizes some selected contributions in the field.

[12] See Tremblay (2005) and Chaloff and Lemaitre (2009, pp. 43-51) for an overview of highly-skilled immigration policies and pathways from student to labor immigration in OECD countries.

1.3.1 Educational and tax policy with highly-skilled labor mobility

The following section focuses on the effect of international highly-skilled labor mobility on national educational and fiscal policies. Student mobility will not be considered until section 1.3.2.

1.3.1.1 Brain drain and the cost of education

Raymond (1973) presents an early analysis of public education with regard to labor mobility, which is very much rooted in the brain-drain discussion at that time and the question of the cost of emigration to the source country of migrants. He challenges the notion that the true cost of public education is the cost of a brain drain and starts from the very fact that human capital created by education (HC) involves individual as well as social gains. First, education raises individual disposable income (ΔDI) and consumption of public services (ΔPS). Second, the community benefits from excess taxation (ET) if the educated are net payers to the national budget and from production externalities (PE) due to higher labor productivity. Thus,

$$HC = \Delta DI + \Delta PS + ET + PE. \tag{1.1}$$

Raymond (1973) then argues that, with $ET = PE = 0$, an outflow of graduates does not result in any real loss to the source country, because it is the working generation who finance their descendants' education, and altruistic parents would willingly do so independent of their children's future residence. Hence, $ET + PE$ is the true cost of the brain drain, so that even if students were paying back education costs to their country of origin, any repayment ignoring ET and PE would fall short of compensating the source country. Without full compensation, it may then partly shift resources away from public higher-education funding.

1.3.1.2 Income taxation and education subsidies

In most OECD countries, tertiary education is to a large extent publicly funded.[13] Therefore, these countries rely primarily on income tax revenue to finance higher education. If highly-skilled workers can elude high income taxation through emigration, however, national tax revenues and thus education budgets might come under pressure. Furthermore, Poutvaara (2001) shows that income tax rates can be inefficiently low if countries which only act in the best interest of their *own* citizens compete for human capital and ignore the negative fiscal externality of lowering tax rates to attract foreign workers. In his model, tax revenue is needed to provide a lump-sum transfer to immobile students in order to insure them against uncertain returns on their education and to boost individual incentives to invest in human capital. He proposes a nationality-based taxation (i.e., graduates would always pay taxes to the country in which they were educated) to eliminate tax competition and thereby use increased revenues to encourage individual education investments. Because the option to emigrate also represents an insurance against country-specific shocks (see also Wildasin, 2000b), in a closely related analysis, Poutvaara (2000) advises against jumping to the conclusion that labor mobility (and therefore the risk of some erosion of tax revenues) necessarily threatens national welfare.

Wildasin (2000b) and Andersson and Konrad (2003a), however, point out that tax competition can lead to a shift of the entire financial burden of educational expenditures onto low-skilled, internationally immobile workers and therefore result in increasing income inequality. The extreme result of a *full* shift of the tax burden in both studies stems from the assumption that highly-skilled workers can emigrate with zero migration costs; i.e., that they are perfectly mobile.

A direct link between tax and educational policy exists in the context of the hold-up problem with time-consistent income taxation. If governments cannot commit to a certain tax policy in the future at the time when individuals are

[13] The share of public funding is exceedingly high in European countries (e.g., 97.0% in Norway, 96.4% in Denmark, 95.5% in Finland, 89.1% in Sweden, 85.0% in Germany, and 83.7% in France). Korea (23.1%), Japan (32.2%), the U.S. (34.0%), and Australia (47.6%) are the only countries with a considerable contribution from private sources. The OECD (EU 19) average is 72.6% (81.1%). See OECD (2009, p. 233).

making their decision about education, educated individuals run the risk of ultimately losing part of their educational rent, because governments may want to increase taxes to redistribute income once individuals have irrevocably made their decisions and graduated from university. Individuals with rational expectations, however, will anticipate a time-consistent tax policy and underinvest in human capital. Governments can then provide educational subsidies to restore the individual incentive to invest in education (see Boadway, Marceau and Marchand, 1996a). The hold-up problem is mitigated by human-capital mobility because individuals can simply avoid an unfavorable income taxation by emigrating. In addition, when fiscal competition keeps tax rates low, it serves as a commitment device and the hold-up problem becomes less severe. This general point has been made by Kehoe (1989) in the context of capital taxation and by Andersson and Konrad (2003a) in the context of income taxation with benevolent governments. Building on this idea, Thum and Übelmesser (2003) show that providing students with internationally applicable education, which potentially raises labor mobility, can also be a commitment device. The reasoning is as follows: in a gerontocracy, where the older generation benefits from taxing the younger, imperfectly mobile generation, the government might have an incentive to raise the mobility costs of graduates by providing students primarily with country-specific education, in order to gain greater latitude to increase income tax rates. Students, however, would anticipate the excessive time-consistent taxation in the future and therefore reduce their individual human capital investment. The older generation is demonstrated to benefit from mitigating the hold-up problem by providing students with at least some internationally applicable education to raise graduates' mobility and thereby credibly commit to lower taxes in the future.

An interesting case arises if graduates are perfectly mobile (i.e., migration costs are zero) and governments are extortionary (Leviathans) instead of benevolent. Andersson and Konrad (2003b) show that Leviathans may also have an incentive to subsidize private educational expenditures to overcome the hold-up problem arising from time-consistent (extortionary) income taxation. But this is only the case for closed economies. With perfectly mobile high-income earners, Leviathans realize that a positive tax rate on those individuals' incomes cannot be sustainable in international tax competition – specifically, Andersson and Konrad analyze a standard Nash game in a two-country model – so that the entire fiscal burden will be borne by low-income individuals who are internationally immo-

bile. The individual incentive to invest in higher education is then higher than in the closed economy, where the Leviathan fully confiscates returns on education. The Leviathan, however, knowing that skilled individuals will not pay any taxes, discourages private education investments (e.g., by taxing or even prohibiting education) to prevent individuals from becoming skilled and therefore also internationally mobile. In the extreme case with no prohibition costs, all individuals end up unskilled and utility is lower than in the closed economy, where at least some individuals obtain higher education; with an extortionary government, skilled individuals do not earn higher net incomes than unskilled individuals, but they do benefit from a consumption value of education. Thus,

> [if] the Leviathan can discourage education effectively [...], the constraints introduced by mobility may reduce the equilibrium utility for Leviathans *and* for individuals. These results corroborate a more general conclusion, viz. that the competition among extortionary governments induced by increased mobility of factors is likely not only to bring beneficial tax competition, but also additional distortions that may be socially costly. (Andersson and Konrad, 2003b, p. 1552)

With *imperfect* labor mobility, welfare effects are less clear. If some individuals have positive migration costs (e.g., they have some home attachment), the Nash equilibrium of the tax-competition game exhibits strictly positive tax rates for high-income earners. An increase in highly-skilled labor mobility, unsurprisingly, reduces equilibrium tax rates and thus encourages individual educational investments. While the effect on the optimal educational subsidy is ambiguous, Andersson and Konrad (2003b) find that, for given private educational investments, an increase in mobility erodes Leviathans' tax revenues.

In a companion paper, Andersson and Konrad (2003a) show that benevolent governments, unlike Leviathans, may still want to subsidize private education, even if highly-skilled workers are perfectly mobile upon graduation. The reason is that, in an open economy, subsidies have not only a direct effect on human capital investment by reducing the cost of education, but also an indirect positive incentive effect through a shift of the entire financial burden of educational expenditures onto unskilled workers, as skilled workers do not pay any income taxes because of the fierce tax competition for human capital. But overall, the welfare effects

of globalization are ambiguous.

Haupt and Janeba (2009) analyze how the threat of a highly-skilled brain drain affects unilateral time-consistent income taxation with a redistributive objective and educational policy in a small source-country of migration. In their model, the government chooses income tax rates and educational subsidies to maximize transfer payments to unskilled individuals who are internationally immobile. Subsidies are used to partially overcome liquidity constraints to finance private education[14] and tax rates are not determined until students have invested in higher education, which implies a hold-up problem. Graduates can, however, avoid excessive taxation through costly emigration. The mobility of graduates constrains income taxation. The higher the migration costs, however, the higher the maximum tax rate, which is consistent with no emigration. The rising tax rate then accompanies an increased incentive to subsidize education in order to broaden the tax base (only the skilled individuals pay income taxes, while the unskilled receive transfer payments). With high migration costs, the government has an additional incentive to raise subsidies to overcome the hold-up problem, which becomes more severe when graduates are less mobile.

Haupt and Janeba (2009) also analyze the non-monotonic welfare effect of increased highly-skilled mobility, i.e., decreasing migration costs. Starting from fully immobile graduates, a small decrease in migration costs mitigates the severe hold-up problem, and the government can cut down on both tax rates and subsidies. As the subsidy is decreased by more than the tax bill, the income transfer to unskilled workers can be increased, so that they actually gain from a rising graduate mobility. The skilled workers are demonstrated to gain as well, due to a reduction of individual tax-avoidance costs (the total tax cost includes the tax rate and avoidance costs) which, together with the declining tax rate, overcompensates the subsidy cutback. With migration costs falling further, the threat of brain drain becomes more important and subsidies are reduced more drastically. Thus demand for education falls, which creates a worsening ratio of the number of net contributors to beneficiaries of the fiscal budget and therefore

[14] With credit market imperfections, individuals need a sufficiently high initial endowment to afford private education. Individuals differ in their initial endowment in Haupt and Janeba's (2009) model. Subsidies effectively reduce the individual costs of education and thereby boost overall demand for education.

a need to cut down on transfer payments, leaving unskilled individuals worse off. Skilled workers suffer from a net income loss as well, as tax costs decline to a lesser extent than educational subsidies. With already low migration costs, a further decline limits redistribution and thereby unskilled welfare to a minimum, while the few remaining skilled individuals benefit from low taxation. In summary, Haupt and Janeba (2009) show that increasing highly-skilled labor mobility benefits both skilled *and* unskilled workers only if the economy is not yet very open. With medium mobility, both groups suffer from ongoing globalization. Only with already high mobility do skilled workers tend to benefit from a further fall in migration costs – this time at the expense of unskilled workers.

1.3.1.3 Public provision of higher education with graduate mobility

The international mobility of graduates can have considerable impact on the provision of national higher education. A public funding of the educational system might lack political support if older citizens prefer the provision of *immobile* public goods (e.g., infrastructure) because they cannot benefit from higher human-capital investments if highly-skilled workers emigrate (Konrad, 1995). Furthermore, a social contract on public education between high- and low-ability agents can become unsustainable if highly-skilled university graduates are internationally mobile while unskilled workers are immobile. Poutvaara and Kanniainen (2000) show that, in a closed economy, low-ability individuals (who do not themselves take up higher education) would have an incentive to subsidize the education of high-ability individuals if high- and low-skilled labor are complements in production, and the education exhibits some positive externalities. With skilled labor mobility, however, this social contract breaks down, as unskilled workers anticipate the skilled workers' incentive to emigrate upon graduation and therefore the risk of being left with the entire burden of financing higher education. In addition, if the low-skilled expect highly-skilled immigration from abroad, they will free-ride on the human capital of these immigrants and refuse to contribute to domestic higher education.

Apart from these political-economic considerations, the mobility of highly-skilled individuals – or to be more precise, the mobility of university graduates – can fundamentally affect a country's readiness to invest in public higher education.

With a fully income tax-funded educational system, a graduate can avoid paying for their education by emigrating. The host country of education then bears the full cost of a student's education but does not earn its full return, because it loses the graduate's human capital and related income tax revenue. Justman and Thisse (1997) present a simple case in point, which serves as a basic reference for the recent literature on educational policy with human capital mobility and also for the first essay of this thesis. They analyze a two-country model with mobile highly-skilled labor as an input in the country's national product. A country i determines domestic human capital s_i to maximize the rent from human-capital employment $\pi(h_i)$, $\pi' > 0$, $\pi'' \leq 0$, net of the cost of providing public education, cs_i. The total human-capital measure consists of domestic and foreign human capital. People stay on in their home country with some exogenous probability $q \in]0,1[$, so that total human capital in country i is

$$h_i = qs_i + (1-q)s_{-i}. \tag{1.2}$$

The countries engage in a static Nash-competition with perfect information. The symmetric equilibrium for an interior solution $s_i = s_{-i} = s$ is then characterized by

$$q\pi'(h) = c \quad \Leftrightarrow \quad \pi'(h) = c/q; \tag{1.3}$$

i.e., each country chooses domestic human capital such that its marginal return when employed domestically ($q\pi'$) equals its marginal cost c. In a closed economy or with joint maximization of both countries' net rents (*first best*), the optimal investment in domestic human capital is determined by

$$\pi'(h) = c; \tag{1.4}$$

i.e., the *total* marginal return on human capital equals its marginal cost. Comparing (1.3) and (1.4), the concavity of π implies an underinvestment in local human capital when human capital is partially mobile and countries choose their investment in an uncoordinated fashion. The reasoning is straight-forward: in the decentralized setting, each country only obtains a fraction q of the marginal return on human capital (i.e., the marginal return from the domestically educated human capital which is also domestically employed), while it bears the entire marginal cost. In other words, each country ignores the positive external effect

of domestic human capital investment on the other country through migration, so that a decentralized equilibrium implies an underinvestment in human capital. A decentralized *first best* would require countries to pay only a fraction q of their costs and an international lump-sum transfer scheme to cover remaining costs.

Justman and Thisse (2000) present a more sophisticated model and extend Justman and Thisse (1997) by including endogenous labor mobility. Among moving costs and individual-specific migration motives, graduates consider regional wage-rate differences when deciding in which country to work after graduating. With imperfectly-mobile human capital used in local output production and endogenous wage rates from a competitive factor-market equilibrium, local educational policy in the form of human capital investment alters local wage rates and therefore international migration flows. With local output-maximizing governments, the decentralized Nash equilibrium implies a local underinvestment in public education compared to the global output-maximizing level. The logic is fully analogous to Justman and Thisse (1997): with emigration of some graduates in equilibrium, the local human capital investment results in a positive external effect on the other region which is ignored by local governments. The relationship between the results arises from the governments' exclusive preference for the welfare of ultimate *residents* (or rather, the factor rewards of locally employed human capital and an immobile factor of production), who can be either natives or foreigners. In an important extension, Justman and Thisse (2000) show that the underinvestment in public education turns into an overinvestment if the objective functions of local governments solely consider the factor rewards to *natives*, either living at home or abroad. Politicians then ignore the external effects of the human capital investment (through endogenous wage rates) on the earnings of locally employed foreign highly-skilled workers and the reward of the immobile factor of production abroad.

The first essay of this thesis extends the model in Justman and Thisse (2000) by adding student mobility. National educational investment can attract foreign students. For given objective functions of local governments, the welfare evaluations of the decentralized educational-policy equilibrium are no longer unambiguous. With graduate *and* student mobility, decentralization can in principle lead to underinvestment as well as overinvestment, no matter whether governments maximize the welfare of residents or natives.

If only graduates who have obtained internationally applicable education are mobile, Poutvaara (2004, 2008) shows – somewhat in relation to Justman and Thisse (1997) – that national governments in a two-country model with publicly funded education tend to provide an inefficiently low number of students with internationally applicable education in favor of more country-specific education, which creates immobile graduates. In light of a rising applicability of internationally-oriented education abroad and therefore a rising mobility of graduates,[15] benevolent governments face a tradeoff with respect to the optimal composition of higher education. On one hand, the threat of a brain drain reduces the basic incentive to invest in emigration-enhancing education. On the other hand, if governments also take the utility of emigrants into account – emigrants who might earn higher wages abroad than in their home country (e.g., due to some beneficial 'brain exchange') – they could have an incentive to promote emigration through the provision of internationally applicable education. In addition, the rising applicability of education abroad increases private returns on education and therefore raises the individual human capital investment of students with an international education (Poutvaara, 2008, considers endogenous individual effort choice), which in turn represents an incentive for government to invest in international education. This tradeoff is reminiscent of Raymond (1973), who pointed out that

> [there] appears to be good reasons for concluding that localities contemplating lower educational expenditures to combat a brain drain are damned if they do and damned if they don't. The dilemma results from two separate considerations. First, the propensity to migrate is positively related to educational level. Second, the losses associated with the migration of educated individuals can be avoided by discouraging migration only if the discouraged migrants are in fact educated. [...] Thus, while the local area may reduce out-migration by lowering the education of its young people, it cannot in this way retain the externalities, consumer surplus, and excess taxation that would have been generated by these young people after they had achieved

[15] The applicability issue takes center stage in the Bologna Process, which aims to create a European Higher Education Area by making academic degrees comparable throughout Europe and thereby encouraging labor mobility.

educated status. (Raymond, 1973, p. 31)

If emigrants are ignored in national welfare considerations, governments' readiness to provide internationally applicable education is demonstrated to diminish unambiguously with increasing applicability. A graduate tax which ensures that emigrants also contribute to education funding in their home country – provided it is enforceable when a graduate has already emigrated – mitigates the national underprovision of internationally applicable education. Replacing part of domicile-based wage taxes by graduate taxes then increases social welfare in the decentralized equilibrium (Poutvaara, 2004, 2008). Income-contingent loans have the same positive effect if repayment is independent of a graduate's country of residence (Poutvaara, 2004).

1.3.2 Educational policy with graduate and student mobility

The contributions discussed in the section above focused on the role of *graduate* mobility for national educational policy. But naturally, *student* mobility plays an important role as well.

1.3.2.1 Public provision of higher education and student mobility

Del Rey (2001)'s two-country model of public provision of higher education shows that international student mobility brings about underinvestment in national education if host countries cannot charge differentiated non-resident tuition fees (as with EU countries, who are not allowed to charge foreign but EU-citizen students higher fees, as this would violate the non-discrimination principle) and if foreign students pay taxes only in their countries of origin upon graduation. Although public education can in principle be welfare-improving (public provision of education is a second-best policy in her model), countries fear that high investments in education could attract foreign students who would free-ride on the national educational system without contributing to its financing. Therefore, in comparison to the optimal policy in a closed economy or an internationally coordinated policy, these countries underinvest in their national educational system. Two important qualifications must be made regarding this result. First, the implied return rate of 100% of international students to their countries of origin upon

graduation is extreme and inconsistent with empirical evidence (see Section 1.2); and second, any further benefits of student immigration to the host country are ignored. These limitations weaken Del Rey's (2001) underinvestment result.

Büttner and Schwager (2004) analyze a two-country fiscal-competition model with imperfect student mobility and local decisions on individual productivity-enhancing higher-education quality. Students are assumed to stay on in the country of education upon graduation. If local governments exclusively act upon the interest of native students, the decentralized equilibrium implies an underinvestment in the local quality of education. The explanation for this is that local policy makers ignore the positive external effect of raising educational quality on foreign students' productivity (and therefore incomes). As in Del Rey (2001), the model ignores any positive effects of student immigration on host countries, which brings about the unambiguous result. If foreign students contributed to the financing of their host country's education, local underinvestment could diminish. Therefore, Büttner and Schwager (2004) suggest a uniform tuition fee at the federal level to boost local governments' incentive to invest in quality of education (the additional tuition-fee revenue from attracted foreign students adds to the marginal revenue of a country's investments in quality), thereby mitigating the adverse effect of the fiscal externality.

1.3.2.2 Tuition fees as strategic instruments

If uniform tuition fees cannot be set on a supranational level but are determined independently by national governments, they become strategic instruments in fiscal competition.[16] Boadway, Marceau and Marchand (1996b) analyze the competition of two private (i.e., profit-maximizing) institutions by means of quality investments and tuition fees in a two-stage game (quality levels are simultaneously chosen in the first stage and tuition fees are set in the second stage). The focus on private schools implies that migration of *graduates* has no effect on educational 'policy', as decision makers ignore any local benefits from employing them (e.g., tax revenue, external effects, etc.). Nevertheless, the decentralized educational policy is likely to generate an inefficient allocation of resources. In

[16] A decentralized educational policy is often preferred by politicians who fear that a uniform policy would threaten the cultural identity of a country.

the first stage of the game, a marginal quality increase alters price competition in the next stage. If an increase in quality of school 1 raises the tuition fees of school 2, school 1 benefits from an additional inflow of students, which leads to relatively higher marginal profits of raising quality compared to a centralized solution where price competition is absent.[17] As a consequence, decentralized institutions tend to overinvest in quality. Providing students with vouchers which have to be accepted by both schools effectively eliminates price competition if schools are not allowed to charge any extra fees on top of the voucher. When schools cannot affect prices by raising the quality of education, the efficient use of resources can be implemented in a decentralized equilibrium.

Hübner (2009) demonstrates not only that local expenditure levels might be inefficient, but also that tuition fees can distort students' migration decisions, such that decentralized educational policy suffers from welfare losses in comparison to a centralized solution. In his two-country model with student and graduate mobility, governments choose educational quality and tuition fees to maximize the welfare of natives. Public higher-education funding draws both on income tax revenue and tuition fees. The symmetric Nash equilibrium results in local underinvestment in educational quality, as countries ignore its positive external effect on incomes of non-resident students and tax revenue abroad. More interestingly, countries discriminate prices in equilibrium; i.e., they charge relatively higher tuition fees for foreign students in order to partially shift the financial burden of public education from natives to foreigners.[18] From a welfare perspective, the problem arises that higher non-resident tuition fees distort students' migration decisions. For given qualities of education in the two countries, students with a certain propensity to study abroad (i.e., individuals with negative migration costs) are deterred from emigration by relatively higher non-resident fees abroad,

[17] The centralized planner determines the allocation of students and quality investments to maximize incomes net of resource costs in schools and individual mobility costs.

[18] While raising both resident and non-resident tuition fees has a revenue effect, raising resident tuition fees also has a (negative) welfare effect. The fact that local governments are only concerned about *natives'* disposable incomes explains why non-resident tuition fees exceed resident fees. In other words, countries use price discrimination to redistribute wealth from foreign students to domestic students. With *revenue*-maximizing governments, the elasticities of tax bases would determine tax-rate differentials (see Hübner, 2009, pp.20-21, for a discussion of how to relate his results to the literature on preferential tax regimes).

in contrast to a situation with undifferentiated tuition fees. In addition, overall demand for higher education is demonstrated to be lower in an equilibrium with discrimination. At the least, Hübner's (2009) results call for a ban on discriminatory tuition fees in federal systems in which the educational policy is actually under member states' authority. Without mentioning this explicitly, they also justify the EU's anti-discrimination legislation (which applies to tuition fees) on the grounds of efficiency.

1.3.2.3 Vertical quality differentiation

Demange and Fenge (2010) analyze how international student mobility affects educational quality in a two-country model with fully fee-financed higher-education systems. Individuals are heterogeneous with respect to their ability to use educational quality in human capital production. As students fully bear education costs (in the form of tuition fees), only individuals with a high enough ability to make efficient use of educational quality and earn a sufficiently high education rent decide to study. The ablest students would then study in the country with the higher educational quality, while all other students would opt for education in the country with lower quality. Students are assumed to be perfectly mobile; i.e., there are no migration costs. An efficient solution, which maximizes aggregate output (produced by skilled and unskilled workers) net of education costs, requires a differentiation in educational quality between the two (ex ante identical) countries to match students' abilities to the quality of education.[19]

The welfare evaluation of a decentralized Nash equilibrium (both countries simultaneously choose educational qualities to maximize the net wage sum of ultimate residents in the country) is then demonstrated to depend on the exogenous return rate of foreign students to their home countries. If all foreign students return home after graduation, local education policies and the allocation of students are efficient; this implies that the equilibrium is asymmetric. In such a situation, there is no point in competing for foreign students. (By assumption, there is no incentive to free-ride the other country either, as higher education is fully fee-financed.)

[19] As students differ in their marginal returns to education, an optimal educational policy would have to balance each individual's marginal returns and marginal costs. With a uniform education-quality level in each country, offering at least two different quality levels is optimal.

Yet each country deliberately specializes in the education of either high- or low-ability students to maximize total returns from education, because ultimately, both countries will end up with exactly the same labor force and distribution of skill-types. However, if *all* students stayed on in the country of education after graduation, countries would engage in competition for students. Starting from the optimal degree of differentiation, the country with a higher-quality educational system has an incentive to reduce quality (and therefore tuition fees) to attract some students who would otherwise study in the lower-quality country, and the lower-quality has an incentive to raise the quality of education to attract some abler students from the higher-quality country. As a result, differentiation will be less than optimal. Under certain circumstances (e.g., when the cost-of-education function is quadratic), countries do not differentiate at all in the decentralized equilibrium. Quality levels are then inefficiently high and demand for higher education is lower than in closed economies. Demange and Fenge (2010) conjecture that for intermediate return rates of foreign students and asymmetric equilibria, any decrease in the return rate would reduce the degree of quality differentiation, such that the lower-quality country would overinvest in education while the higher-quality country would underinvest.

The fourth essay of this thesis also deals with quality differentiation, but in a somewhat different setting, that of two developed host countries competing for students from a less-developed region. In contrast to Demange and Fenge (2010), tuition fees are also direct control variables of the host country governments. The rationale for quality differentiation in the decentralized equilibrium thus differs: host countries differentiate qualities to relax tuition-fee competition. A symmetric Nash equilibrium does not exist. The equilibrium degree of quality differentiation depends negatively on the return rate of foreign students to the country of origin and can be either too small or too large from an overall-welfare perspective.

1.3.2.4 The financing regime of higher education

In a companion paper of Demange and Fenge (2010), Demange, Fenge and Übelmesser (2010) analyze uncoordinated decisions on the optimal financing of higher education in a two-country model with endogenous student and graduate mobility and undifferentiated levels of educational quality. The public educa-

tional systems can use (i) public funds (i.e., tax revenue), (ii) private funds (i.e., tuition-fee revenue), or (iii) mixed public and private funds to finance investments in educational quality. Individual education decisions are again endogenous; i.e., only the ablest individuals will obtain higher education. In comparison to a closed economy and for given uniform quality levels in the two countries, each country has an incentive to raise tuition fees and free-ride on the other country's educational system. (Attracting foreign students and retaining domestic students by low tuition fees is not an effective means of attracting highly-skilled human capital in the model, since graduates are assumed not to have any attachment to their location of education, but rather locate where they can earn the highest net income.) In addition, a higher share of fee-funding allows countries to cut down on taxes to finance higher education, thereby attracting more highly-skilled workers, who are required to produce local output. The authors show that a Nash equilibrium exists with zero taxes and therefore exclusively fee-financed higher education. In the benchmark case of a closed economy, credit market imperfections would call for education subsidies in the form of partial tax-funding of public education to mitigate individual underinvestment in education. The open-economy equilibrium is thus characterized by inefficiently low demand for higher education.

If graduates were not assumed to be perfectly mobile, tuition fees would become a strategic instrument in the open economy to attract students, and the extreme result of a fully fee-financed educational system might evolve into a mixture of public and private funding. Demange, Fenge and Übelmesser (2010) themselves present another possible rationale for mixed funding of higher education with student and graduate mobility. If a country assumes that the other country will always match any change in its financing scheme ('matching conjecture'), it lacks the incentive to raise tuition fees when the economy opens up. Any attempt to free-ride on the educational system in the other country would immediately be thwarted by this country and, finally, with identical qualities of education and tuition fees, both countries would end up with the same number of students. In comparison to a situation in which neither country alters tuition fees in the first place, both countries would suffer from an inefficiently low demand for higher education due to excessively high tuition fees. Therefore, countries abstain from tuition-fee competition and the (symmetric) 'conjectural equilibrium' is characterized by the optimal financing scheme drawing both on taxes and tuition fees.

1.3.2.5 Educational policy and endogenous openness

While this thesis treats the mobility of individuals exogenously and considers migration to be affected only indirectly by tax and educational policy, an interesting new branch of the literature deals with both educational policy and mobility as control variables of governments. Some recent contributions deserve special attention.

Mechtenberg and Strausz (2008) present a two-country model in which the quality of higher education is determined locally, and a supranational has to decide on the optimal level of international student mobility. This situation reflects a main characteristic of the European Higher Education Area: while educational policy is under member states' authority, the supranational level encourages student mobility via the Bologna Process to foster international competition between universities and provide students with productivity-enhancing multicultural skills. In this model, foreign students stay on in their host country with some exogenous probability. When graduates' individual human capital exhibits a positive externality to the country of residence, countries then have an incentive to attract foreign students and retain native students by means of high-quality education. In this sense, student mobility would be predicted to raise educational quality, as a 'competition effect'. But countries may also have an incentive to save costs by keeping quality low and encouraging students to be educated abroad (the 'free-rider effect').

As decentralized decision-making implies that countries ignore the spillover effects of national educational policy on the other countries, the level of educational quality will be inefficient in equilibrium. Whether countries spend too many or too few resources on education depends on the relative sizes of the competition effect and the free-rider effect.[20] The supranational level could then restore efficient quality levels by fully preventing student mobility (and thereby eliminating international competition through educational policy). However, the result of full immobility is that students cannot acquire any multicultural skills, which is also inefficient. A similar dilemma arises for perfect student mobility. While all students who would actually benefit from studying abroad could indeed emigrate

[20] When the free-rider effect dominates the competition effect, countries tend to underinvest in educational quality.

and develop their multicultural skills, full mobility also implies fierce international competition for students and inefficient national quality levels. Therefore, Mechtenberg and Strausz's (2008, p. 123) primary result is that "optimal mobility levels will have to trade inefficiencies in university quality off against inefficiencies in multi-cultural skills."

Gérard (2007) takes up the idea that studying abroad allows students to obtain some productivity-enhancing multicultural skills, and analyzes whether the country of origin or the host country of foreign students should pay for their education in order to ensure an efficient level of international education. In a symmetric two-country model, governments decide on the amount of education (credits) supplied to a representative foreign student. Universities are assumed to be fully publicly funded.[21] With the 'production principle' (or 'host country principle' as it is called in Gérard, 2010), it is the host country which bears the cost of educating foreign students. Foreign students are assumed to return to their country of origin with some exogenous probability. Countries then decide on the supply of credits which maximizes the contribution of final residents in the country (educated either at home or abroad) to local production, net of education costs. If the stay rate of foreign students upon graduation is fairly low, countries have an incentive to free-ride on the foreign educational system. Furthermore, each country ignores the positive externality of educating foreign students on the other country; i.e., compared to the joint-welfare maximizing solution, the uncoordinated educational policy implies an underinvestment in international education.

By the 'origin principle', it is the country of origin which has to pay the educational costs of its citizens studying abroad. The government provides domestic students with portable vouchers which they can redeem abroad to obtain credits. With this financing rule, a country willingly accepts any number of foreign students, as there are no crowding costs in the model and the vouchers (handed out by the foreign country) fully cover the costs of educating them. However, each country now directly controls the number of domestic students sent abroad. As local governments ignore the positive external effect of sending students abroad if some of them stay on in the host country after graduation, the level of inter-

[21] The model does not a priori exclude tuition fees, which are meant to equalize individual demand and public supply of credits. However, the central welfare comparison of the different funding principles draws on fully tax-financed educational systems.

national education is still inefficiently low. Yet the incentive to free-ride on the foreign country's educational system is reduced, because encouraging students to be educated abroad now comes at the cost of issuing vouchers. Overall, Gérard (2007) concludes that if the return probability of foreign students is not too low, the origin principle boosts international education more successfully than the production principle:

> From a policy point of view, it turns out that charging the country of origin of students to be responsible for organizing the payment of their studies abroad [...] is a second-best solution, being the less inefficient between the two solutions [...]. Nevertheless it is less efficient than the centralized outcome, the difference being the price to pay for the respect of subsidiarity principle at the root of, for example, the EU. (Gérard, 2007, p. 452)

One qualification has to be made with respect to this conclusion. The origin principle is only Pareto superior if the return rate of foreign students is sufficiently high. The lower the return rate (i.e., the higher the stay rate of foreign students), the larger a country's incentive to supply credits to foreign students under the host country principle, which implies a negative externality to the foreign country due to the human capital outflow. If the stay rate exceeds some critical value, countries may actually overinvest in international education. By the origin principle, the amount of education obtained abroad is inefficiently low for *any* (strictly positive) stay rate. Thus, for medium stay rates, the host country principle can very well be more efficient than the origin principle. For high stay rates, the welfare evaluation depends on the relative sizes of the negative externality under the host country principle and the positive externality under the origin principle.[22]

Haupt and Übelmesser (2009) analyze a sequential voting on the openness of the economy and national educational policy in a less-developed country which is threatened by a brain drain. At an institutional stage, voters first decide on whether the country's labor market should be 'globalized'; i.e., whether workers should be allowed to emigrate to a developed neighboring country. At a second

[22] This issue, which becomes more apparent in a slightly modified presentation of the model in Gérard (2010), was raised by Robert Fenge in a discussion.

stage, voters decide on (lump-sum tax-financed) public provision of higher education. Individuals are assumed to differ in their abilities to transform education into effective human capital and in their attachment to their home country (i.e., their international mobility). For a given openness of the country to migration, only voters with a high enough ability level would prefer public investment in higher education. The return on education for low-ability individuals falls short of the education tax, so they would oppose public higher education. When it comes to the decision on the openness to migration for a given educational policy, sufficiently mobile individuals would always prefer openness as they could benefit from emigration and earn higher wages in the developed country. Relatively immobile individuals would oppose openness, as a brain drain reduces individual productivity (and therefore wages) of those left behind, due to a reduction in domestic aggregate human capital.

Haupt and Übelmesser (2009) then demonstrate that a *joint* analysis of the decisions on openness and educational policy can reverse the outcome of an isolated analysis of voting on these issues, as the decisions are linked. First, the degree of the country's openness affects individual returns on education and therefore the willingness to support public education investments ('forward linkage'). Second, voters aware of this forward linkage have an incentive to support a degree of openness, which at the next stage brings about a majority in favor of the preferred educational policy ('backward linkage'). That is,

> [under] some circumstances, labor-market integration does not gain a majority at the polls for any exogenously given education policy. Yet under the very same circumstances integration wins if the education policy is also endogenously determined. The reason is that some citizens now strategically vote for labor-market integration, since their favored education policy gains a majority only with this institutional arrangement. [...] The interaction between the two decisions makes all the difference. (Haupt and Übelmesser, 2009, p. 362)

1.4 Contents of the thesis

The four essays in this thesis contribute to the analysis of the international systems competition for highly-skilled human capital with student and graduate mobility. Against the background of the insights from the general introduction and the literature review, the essays deal with the following issues:

(i) Extending Justman and Thisse's (2000) analysis of publicly funded higher education with labor mobility by including international student mobility, how is the outcome of an uncoordinated international educational-policy competition to be assessed with respect to efficiency of the allocation of resources?

(ii) What is the effect of an increase in international human capital mobility (i.e., student mobility and highly-skilled labor mobility) on the fiscal budget of revenue-maximizing governments exposed to systems competition, which compete for human capital by means of income tax policy and educational policy?

(iii) How does the optimal non-resident tuition fee in a host country of foreign students depend on the expected stay rate of students in the country upon graduation?

(iv) What characterizes the educational policy of developed host countries of foreign students competing for talent from less-developed countries, and how is the uncoordinated equilibrium to be evaluated from an overall-welfare perspective?

A common feature shared by all four essays is the consideration of student immigration as a channel of subsequent highly-skilled human capital immigration. This relationship implies that the expected future benefits from retaining foreign-born graduates or the risk of emigration of students upon graduation have to be taken into account by policy-makers with rational expectations when deciding on higher-educational policy with human capital mobility. While all of the essays deal with systems competition and human capital mobility, they each represent stand-alone papers.

The following section briefly outlines the contents of the four essays of the thesis.

Public Funding of Higher Education when Students and Skilled Workers are Mobile

Published in *FinanzArchiv/Public Finance Analysis* (2009), vol. 65(2), 177-199.

The first essay extends Justman and Thisse's (2000) model by adding imperfect student mobility and analyzes the welfare effects of decentralized provision of public higher education. In a symmetric two-country model, aggregate output is produced by means of internationally mobile highly-skilled human capital, and an immobile fixed factor. Factor rewards are determined endogenously in competitive factor markets. The two countries play a Nash game with respect to national educational policy. Governments first simultaneously determine public expenditures on higher education. Next, students, who differ in their international mobility, decide on their location of education. They take individual productivity-enhancing educational expenditures in the two countries into account, as well as expected wage rates and expected migration costs at the next stage of the game. After graduating from university, they choose their ultimate residence and supply highly-skilled labor. Graduates are heterogenous with respect to migration costs; i.e., while some graduates have a strong attachment to their location of education, others have a high propensity to emigrate or return to their home country. Regional wage-rate differences are also considered in the migration decision.

Local governments choose educational expenditures to maximize local output (equivalent to maximizing the wage sum of final residents in the country), net of education costs. As in Justman and Thisse (2000), local education investments cause a positive spillover to the other country if some students emigrate upon graduation and take their human capital with them. Ceteris paribus, this positive spillover would result in local underinvestment in higher education compared to the global-output-maximizing allocation of resources. However, an increase in educational expenditures attracts foreign students. This effect, absent in Justman and Thisse (2000), creates a negative spillover, as some of the foreign students will stay on in the host country upon graduation, thereby reducing human capital available for production in the other country. The overall welfare assessment thus depends on the relative sizes of the two spillover effects. If the equilibrium stay rates of graduates in their countries of education are sufficiently high and wage rates are rather inelastic with respect to changes in human capital, the decen-

tralized equilibrium is characterized by an overinvestment in higher education; i.e., countries waste resources in the competition for human capital. This result would turn Justman and Thisse's (2000) conclusion upside down.

The essay also discusses a version of the model with alternative preferences of local governments, in which educational expenditures are chosen to maximize only the welfare of *natives* to the country, irrespective of their ultimate residence. Again, different spillovers can be identified. Finally, while countries overinvest in public education if the stay rate of students in their home country in equilibrium is fairly high, they tend to underinvest if students have a high propensity to study abroad.

The results call for very careful analysis of both student and labor migration before proposing specific kinds of interventions at a supranational level (e.g., in the EU) in national educational policy. Furthermore, federal efforts to enhance student and/or graduate mobility (such as the Bologna Process and the Lisbon Strategy in Europe) can have the potential to push decentralized spending on higher education towards efficient (globally-optimal) levels. But they can also corrupt already detrimental welfare effects of systems competition. The analysis provides an informative basis for when to expect the respective outcomes.

Education Policy and Tax Competition with Imperfect Student and Labor Mobility

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online-first version available: doi: 10.1007/s10797-010-9129-9.

The second essay analyzes how an increase in student mobility and graduate mobility affects equilibrium net tax revenues of countries which are competing for human capital. In a symmetric two-country setting, governments play a Nash game by simultaneously choosing income tax rates and educational subsidies to maximize net fiscal revenues. Then students decide on their location of education, taking into account the international subsidy differential, migration costs at the student-migration stage, expected migration costs at the graduate-migration stage, and the international tax rate differential. Students consider expected labor-migration costs and tax rates in their first-round location decision because

their attachment to the location of education is not revealed until the end of the education period; i.e., there is some uncertainty with respect to the risk of being 'locked-in' within the country of education upon graduation (perhaps due to family or social ties built up during the years of study) and thereby of exposure to local income tax rates. As a consequence, a unilateral rise in income tax rates in one country would – all other things being equal – persuade some students from this country to study abroad and simultaneously deter some foreign students from studying in the country. The lower the risk of being locked-in within the country of education, however, the less pressing the 'evasion' of taxes becomes at the student-migration stage. Once labor-migration costs are revealed, graduates choose their ultimate residence, taking tax rate differentials into account as well.

The model is first solved for tax rates, educational subsidies and net revenues in a symmetric decentralized equilibrium. The results are then derived by means of a comparative-static analysis. First, we consider a symmetric rise in graduate mobility due to a reduction of labor-migration costs. While the equilibrium tax rate is demonstrated to *increase*, the subsidy may either increase or decrease, depending on the initial degree of labor mobility. Overall, the rising tax revenue would always overcompensate a potential rise in expenditures on subsidies, such that net revenues actually increase. The result with respect to tax rate seems counterintuitive at first glance. It is mainly due to a reduction in the net wage elasticity of the number of students in a country (which ultimately also affects the size of the tax base). With higher labor mobility, the risk of being locked-in within the country of education upon graduation is reduced and the students' location choice is thus less sensitive to marginal increases in the tax rate. This effect also translates into the tax base, as graduates are still only imperfectly mobile; i.e., some graduates will always stay on in the country of education. The reduced net wage elasticity of students therefore allows governments to increase income tax rates.

A symmetric increase in student mobility has less favorable effects on net fiscal revenues in the two countries. The comparative-static analysis reveals that a rise in student mobility implies fiercer tax competition and therefore a reduction in equilibrium tax rates. Even though governments cut down on educational subsidies as well, the tax-competition effect dominates, so that net revenues diminish.

The results suggest that regulations like the Freedom of Movement for Workers in the EU or initiatives to foster highly-skilled labor mobility (such as the Bologna Process) need not result in a race-to-the-bottom in tax rates and an erosion of national fiscal budgets, even when countries use tax and educational policy as strategic instruments to compete for internationally-mobile human capital. Student migration, however, in combination with the potential for foreign students to stay on in the host country of education upon graduation, might increase the competitive pressure in systems competition.

Return Migration of Foreign Students and the Choice of Non-resident Tuition Fees

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Revise and Resubmit *Journal of Population Economics*.

The third essay deals with a fairly practical question in the context of the education of foreign students. It asks how tuition fees for foreign students should be adjusted if their return rate upon graduation increases, taking the perspective of a host country which chooses non-resident tuition fees to maximize the rent from educating foreign students. Students are assumed to stay on in the host country with some exogenous probability and to bring about a positive externality in case they actually do so; i.e., the host country benefits from retaining a foreign student as a highly-skilled worker upon their graduation. The optimal choice of tuition fees takes into account that an increase in fees deters students from immigration and therefore not only reduces demand for higher education (or rather, for the country's international study program) but also the total size of the externality. On the other hand, raising tuition fees has a positive revenue effect per student.

The expected stay rate of students affects the optimal tuition fee in several ways. A lower stay rate leads to a reduced externality in the future per educated student, which makes raising tuition fees and thereby deterring foreign students less 'costly' for the host country. This effect provides an incentive to increase non-resident tuition fees when the stay rate of foreign students after graduation declines (what I call a 'direct effect'). However, and more interestingly, total demand for higher education can also depend on the expected stay rate (what

I call a 'behavioral effect'). Students with rational expectations take not only tuition fees in the host country into account when deciding on the location of education, but also the expected value of having the opportunity to stay on in the country of education. In particular, if the host country is a developed country and the country of origin is less developed, a student could benefit in terms of a higher income or a better way of life in the host country as compared to the home country. Therefore, the lower the expected stay rate, the lower the return on education abroad and thus the lower the incentive to immigrate. While a specific student-migration model presented in the essay elaborates on this issue, it is sufficient for now to note that demand for education in the host country could actually diminish if the expected stay rate of foreign students upon graduation declines. Fewer foreign students, however, means lower marginal revenue from raising tuition fees, which provides an incentive to *cut back* non-resident tuition fees if the stay rate of students declines.

Using the migration model developed in the essay, it can be shown that the behavioral effect (through the shift in demand for higher education in the host country) could dominate the more direct effect of a decline in the stay rate of students on the benefits of the host country. A sufficient condition is that the cost of educating foreign students is not too high. The optimal non-resident tuition fee would then need to be cut back.

This result challenges the conventional wisdom that promotes raising non-resident tuition fees if foreign students become more likely to return to their home countries upon graduation, in order to recover foregone benefits from educating them.

Competition for the International Pool of Talents: Education Policy with Student Mobility

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Hitotsubashi University CCES Discussion Paper No. 31 (2010).

The fourth essay starts from the observation that only a small number of top destinations (all of them OECD countries) host a majority of the international student population. Students from OECD partner countries China and India represent an important share of the international student body. The essay therefore

presents a model of oligopolistic competition under quality differentiation with two ex ante identical rich host countries of higher education that compete for the international pool of talented students from less-developed countries.

In a two-stage Nash game, the host countries simultaneously choose quality of education at the first stage and tuition fees at the second stage. Students from the less-developed countries, who differ in learning ability, then move to their preferred location of higher education. While highly-talented students would opt for education in the country offering higher quality (which also charges higher tuition fees), less-talented students would choose the lower-quality educational system in the other country. With identical educational systems in the host countries, students would allocate themselves randomly. When students do not return to their home countries upon graduation, the host country benefits from the tax revenue generated by these graduates. Host countries choose their educational policy to maximize the net rent from offering an international study program; i.e., tuition-fee revenue plus income tax revenue from foreign students when they stay on in the country after graduating, net of the cost of providing educational quality.

In equilibrium, countries differentiate their educational systems to relax tuition-fee competition. While one country offers high educational quality at high charges for students – the most talented ones study in this country – the other one provides lower quality and charges lower tuition fees. The higher the stay rate of foreign students in the host countries upon graduation, the larger the degree of quality differentiation. To follow this reasoning, it is helpful to regard a rise in educational quality as an investment in the domestic tax base, as some foreign students will always stay on in the country as graduates, and as it not only boosts each graduate's productivity (and therefore income) but also attracts additional foreign students. The higher the stay rate, the higher the return on this investment. For the higher-quality country, the incentive to raise educational quality is finally higher than for the lower-quality country, as it hosts the most talented students who are able to process educational quality more efficiently and therefore have higher returns on education. This mechanism primarily explains the rise in the degree of quality differentiation. In addition, the equilibrium allocation of students shifts towards the higher-quality country if the stay rate of students increases. The comparative-static analysis furthermore reveals that the equilibrium degree of quality differentiation depends positively on the size of the talent

pool in the less-developed countries as well as the degree of development of the countries of origin.

In comparison to the welfare-maximizing educational policy, the decentralized solution results in an inefficient degree of quality differentiation (which can be either too large or too small) and finally also an inefficient allocation of foreign students to the two host countries. Apart from externalities caused by local quality investments, this is because an efficient solution requires an allocation of students which represents an optimal match of abilities and quality levels, for given costs of providing educational quality. In the systems competition, however, countries will try to attract as many students as possible to generate tax and tuition-fee revenues.

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2 Public Funding of Higher Education when Students and Skilled Workers are Mobile

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2.1 Introduction

Public funds make up a major part of higher education expenditures in all OECD countries. This is especially true for several countries within the European Union, where tertiary education is to a large extent publicly provided (e.g., Germany or France). But also in the U.S., where private universities play a much more important role, the states are subsidizing higher education. When there are no (or only low) tuition fees, public education budgets mainly rely on income tax revenues. The interregional mobility of the highly skilled individuals (who are therefore an important part of the tax base), however, might put a downward pressure on local income tax rates and therefore funds, which are not only needed for education institutions directly, but also, for example, to finance subsidies/transfers to induce (risky) individual human capital investment (Poutvaara, 2000, 2001). To some extent, the tax burden may be shifted to a more immobile factor like unskilled labor, implying increasing inequality (Wildasin, 2000). The political support for public higher education expenditures by low-ability individuals not participating in the education system and older people basically preferring immobile public infrastructure investments to public education provision is potentially reduced by the presence of high-skilled labor mobility (Poutvaara and Kanniainen, 2000; Konrad, 1995). Furthermore, countries might generally underinvest in public

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education due to regional spillovers from migration (Justman and Thisse, 1997, 2000) or provide an inefficiently low level of internationally applicable education relative to country-specific education (Poutvaara, 2004, 2008). This underinvestment could either justify coordinated policies or interventions at a federal level, or call for the availability of adequate fiscal instruments like graduate taxes (provided that host countries can collect them also from foreign students) or tuition fees.

However, focusing on the mobility of high-skilled university graduates alone provides an incomplete picture of human capital mobility, since student mobility is also becoming more and more relevant: the number of students enrolled outside their home country increased by about 50% from 2000 to 2005 and has more than quadrupled over the last 30 years (OECD, 2007, p. 302). Recognizing the empirical evidence on the relationship between student migration and subsequent (high-skilled) labor migration (e.g., Baruch, Budhwar, and Khatri, 2007; Hein and Plesch, 2008; Dreher and Poutvaara, 2005; Finn, 2003), countries can have an incentive to attract students as future human capital by means of education policy. The OECD (2007, p. 303) supports this notion: "[in] the past few years, the rise of the knowledge economy and global competition for skills provided a new driver for the internationalisation of education systems in many OECD countries, whereby the recruitment of foreign students is part of a broader strategy to recruit highly skilled immigrants." Krieger and Lange (2008) demonstrate that considering student and labor mobility at the same time in a model with education policy and income tax competition between two countries produces some interesting new insights: increasing labor mobility allows for *higher* income taxation and therefore revenues. The increased scope for taxation mainly comes from a reduction in the income elasticity of the number of students in a region, meaning that the propensity to migrate as a student (who considers future tax rates and potential locked-in effects within the country of education) in order to evade unfavorable taxation is reduced. An increasing student mobility, however, induces countries to engage in intensified tax competition, resulting in decreasing revenues. A simultaneous cut in expenditures only partially offsets the erosion.

The present paper contributes to the literature on education policy with interregionally mobile human capital in that it provides a more complete view on decentralized resource spending by considering two types of academic mobility

simultaneously. It reconsiders the well-known underinvestment issue in this context and extends Justman and Thisse's (2000) two-country one-sector analysis with (imperfect) high-skilled labor mobility to student mobility. I find that in a setting of local-output-maximizing governments, with a high enough incentive to attract students by means of productivity-enhancing education expenditures, countries might even engage in excessive education funding. Results mainly depend on the stay rate of graduates in their country of education and the sensitivity of wage rates in both regions to changes in the human capital measure. Furthermore, I consider the case of local governments only maximizing natives' utility. Depending on the stay rates of graduates *and* students now, regions may either overinvest or underinvest in public education. The results call for federal interventions, which must anticipate local policy adjustments very carefully. The optimal intervention would largely depend on student and labor migration propensities. Federal initiatives to foster human capital mobility, like for example the Bologna process and the Lisbon strategy in Europe, have to be assessed with respect to potentially undesirable reactions by means of education policy at the national level.

The remaining sections of the paper are organized as follows. Section 2.2 introduces the main ingredients of the model, develops student and labor migration probabilities, and derives the effect of a country's education policy on local human capital. Section 2.3 presents the globally optimal education policy, which is compared with the local policy in a decentralized equilibrium for two different government objective functions analyzed in section 2.4. Section 2.5 concludes.

2.2 The model

The model presented in this paper is closely related to Justman and Thisse's (2000) model in order to make results as comparable as possible. One main difference – besides the consideration of student mobility, of course – is in the modeling of migration flows. Here, I make use of a modified version of the approach recently presented by Krieger and Lange (2008), where interregional net-income differentials and individual mobility costs determine migration behavior of students and graduates.

2.2.1 Production and time structure

In each of two regions (i and j), the number of identical and perfectly competitive firms is normalized to one. They produce an aggregate output good by means of native and foreign-born human capital (denoted by h), an internationally immobile factor l, which might be interpreted as unskilled labor and is in fixed supply, and a constant-returns-to-scale production function

$$y_x = f(h_x, l_x) = A h_x^{\alpha} l_x^{1-\alpha}, \qquad x = i, j, \quad \alpha \in (0, 1), \tag{2.1}$$

where $A \geq 1$ is some technology parameter. The production function satisfies the Inada conditions. The specific form of the production function is used for a numerical exercise when it comes to the evaluation of locally optimal policy. A competitive factor market equilibrium implies that each efficiency unit of human capital and each unit of unskilled labor supply is rewarded according to its marginal product (goods prices are normalized to one):

$$f_1 = \partial f / \partial h_x = w_x, \qquad x = i, j, \tag{2.2}$$

$$f_2 = \partial f / \partial l_x = w_x^u, \qquad x = i, j. \tag{2.3}$$

The regions are assumed to be identical with respect to production technology, the endowment with the immobile factor, and the size of the population going for higher education, which is normalized to one. The human capital measure includes the number of skilled workers within a region (natives and foreigners), where each worker is weighted with the public expenditure on education (denoted by s) of the region where he graduated from university. This way of modeling allows s to be interpreted as quality of education, or rather effective labor supply.[1] Following Justman and Thisse (2000), the expenditure is assumed to be financed by a lump-sum tax in order to focus on education policy. Büttner and Schwager (2004) and Mechtenberg and Strausz (2008) implicitly make the same assumption in a comparable context. The simultaneous consideration of both tax- and education-policy competition is provided, for example, by Haupt and

[1] While Justman and Thisse (2000, p. 249) focus on the "amount of education (number of school places)" as policy instrument, the quality approach appears more appropriate in the present model, given the interregional mobility of students. The comparability of results, however, does not really suffer from the slightly diverging approaches.

Janeba (2009), Andersson and Konrad (2003), and Krieger and Lange (2008). The determination of a region's h requires an analysis of the migration decisions of students and workers, which are presented in section 2.2.2.

The time structure of the model is as follows: (i) both regions simultaneously choose the public expenditure on higher education; (ii) students decide on the location of their education (they are assumed to pass the entire duration of study at the chosen location); (iii) after graduating from university, individuals decide whether to stay at the location of education in order to supply labor or to migrate to the other region (nature does not reveal the corresponding migration costs until the individual graduates from university); (iv) the firms in both regions produce output using human capital and the immobile factor.

2.2.2 Individual migration decisions

An individual's lifetime utility is described by the following utility function:

$$U = s_x w_x - \delta m_0 - \theta m, \qquad x = i, j, \tag{2.4}$$

where the first term represents labor income (which is the product of the effective labor supply s_x and the wage rate per unit of effective labor, w_x). Note that the formulation of the utility function in (2.4) captures four different types of careers (let us take the perspective of an individual born in i): the individual can study in i and work in i (the corresponding labor income is $s_i w_i$), study in i and work in j ($s_i w_j$), study in j and work in j ($s_j w_j$), or study in j and work in the country of origin i ($s_j w_i$). An implicit assumption here is that education is perfectly internationally applicable. The parameters δ and θ take the value of one if an individual migrates at the student migration stage ($\delta = 1$), at cost m_0, and/or the labor migration stage ($\theta = 1$), at cost m, and zero otherwise. Migration costs $m_0 \in [\underline{m}_0, \overline{m}_0]$ and $m \in [\underline{m}, \overline{m}]$ are uniformly distributed among individuals. The corresponding density functions are $f(m_0) = 1/\Delta m_0$ and $f(m) = 1/\Delta m$ with $\Delta m_0 = \overline{m}_0 - \underline{m}_0$ and $\Delta m = \overline{m} - \underline{m}$. I do not restrict migration costs to be nonnegative: in fact, I assume $\underline{m}_0, \underline{m} \leq 0$. Negative migration costs imply a strong individual migration propensity. While positive costs m_0 represent some kind of home attachment, positive costs m imply an attachment to the location of education (both of domestic and foreign students) reflecting social ties or networks in general, built up during the education period. In what follows, I assume

$\overline{m} > |\underline{m}|$, implying that the expected (average) mobility cost is positive ($\mathrm{E}\{m\} = \int_{\underline{m}}^{\overline{m}} mf(m)dm = \frac{1}{2}(\overline{m} + \underline{m}) > 0$). This is analogously assumed for m_0. The fact that there is no discounting between periods in this model does not change the results qualitatively.

The individual migration decisions can be determined from the utility function and by means of backward induction. After graduating from a university in i (j), an individual stays in i (j) if his

$$m > s_i(w_j - w_i) \qquad (m > s_j(w_i - w_j)), \tag{2.5}$$

i.e., if migration costs exceed the labor income differential between regions, given that the individual obtained a university degree in region i (j). At the student-migration stage, an individual takes into account not only migration costs m_0, but also expectations about the migration costs m, which are not revealed until the individual finishes his studies and which occur if the individual wants to leave the location of education.[2] An individual born in region i compares his expected lifetime utility $\mathrm{E}\{U_i^i\}$ when studying in the home region with the expected utility $\mathrm{E}\{U_j^i\}$ from studying in the other region. Note that

$$\begin{aligned} \mathrm{E}\{U_i^i\} &= \Pr\{m > s_i(w_j - w_i)\}s_i w_i \\ &\quad + \Pr\{m < s_i(w_j - w_i)\}[s_i w_j - \mathrm{E}\{m | m < s_i(w_j - w_i)\}]. \end{aligned} \tag{2.6}$$

With probability $\Pr\{m > s_i(w_j - w_i)\}$, the individual stays in region i after graduating from university and earns labor income $s_i w_i$. With probability $\Pr\{m < s_i(w_j - w_i)\}$, however, the individual decides to work in j and to earn $s_i w_j$. The expected migration costs are $\mathrm{E}\{m | m < s_i(w_j - w_i)\}$. Alternatively, the individual born in i can also decide to study in j. The corresponding expected

[2] The uncertainty at this stage comes in because students cannot be sure about the kind and strength of social ties and networks in the future, built up during the education period. For example, getting together with a partner or spouse during this period, founding a family, and having an extended circle of friends are to a large extent unpredictable events, which will, however, crucially determine the attachment to the location of education. The unpredictability applies to domestic as well as foreign students, while the latter also face some very general uncertainty with respect to their success at social integration abroad.

utility then is

$$\begin{aligned} \mathrm{E}\{U_j^i\} &= \Pr\{m > s_j(w_i - w_j)\}s_j w_j \\ &\quad + \Pr\{m < s_j(w_i - w_j)\}[s_j w_i - \mathrm{E}\{m | m < s_j(w_i - w_j)\}] \\ &\quad - m_0. \end{aligned} \tag{2.7}$$

The main difference from the case of studying in i is that now, the individual has to bear the cost m_0 at the first stage. Then, an individual from region i decides to stay in i at the first stage if $\mathrm{E}\{U_i^i\} > \mathrm{E}\{U_j^i\}$. Using (2.6) and (2.7) yields after some manipulations the following student-migration decision: an individual from region i stays in i in order to attend university only if his

$$\begin{aligned} m_0 &> (1/\Delta m)\{s_i(\underline{m} w_j - \overline{m} w_i) + s_j(\overline{m} w_j - \underline{m} w_i) \\ &\quad - (1/2)[s_i^2(w_j - w_i)^2 - s_j^2(w_i - w_j)^2]\}. \end{aligned} \tag{2.8}$$

From this condition and the assumption of uniformly distributed migration costs, we can derive the number of students within region i. It consists of the number of those individuals who are born in i and stay there at stage 1 (denoted by Γ_i) and of individuals born in j who have decided not to study in their home region, but in i $(1 - \Gamma_j)$. The number of students in i then is

$$\begin{aligned} \Psi_i &= \Gamma_i + (1 - \Gamma_j) \\ &= (1/\Delta m_0)\{\Delta m_0 + (1/\Delta m)[2s_i(\overline{m} w_i - \underline{m} w_j) - 2s_j(\overline{m} w_j - \underline{m} w_i) \\ &\qquad + s_i^2(w_j - w_i)^2 - s_j^2(w_i - w_j)^2]\}, \end{aligned} \tag{2.9}$$

which depends on the education policy in both countries. Calculating $d\Psi_i/ds_i$, evaluating this derivative at a symmetric equilibrium (implying $s_i = s_j = s$, $\Psi_i = \Psi_j = 1$, $h_i = h_j = h = s$, and $w_i = w_j = w$), and collecting terms yields

$$\left(\frac{d\Psi_i}{ds_i}\right)_{\text{equ.}} = 2\left[\frac{w}{\Delta m_0} + \frac{(\overline{m} + \underline{m})s}{\Delta m \Delta m_0}\left(\frac{dw_i}{ds_i} - \frac{dw_j}{ds_i}\right)_{\text{equ.}}\right]. \tag{2.10}$$

Increasing education expenditures attract additional students from abroad who expect to benefit from higher expenditures through a higher labor income in the future. This effect is represented by the first term in the brackets in (2.10). The second term captures the effect of a change in the wage differential between countries that is influenced by labor migration flows subsequent to student flows. The

more student immigration translates into subsequent residence (i.e., the larger $(\overline{m} + \underline{m})/\Delta m$), the more relevant this wage effect becomes. Since education policy also affects the number of native students (*attracting* additional students from abroad always goes along with *retaining* additional domestic students), the overall effect of a marginal policy change on the number of students is twice the quantity in brackets.[3]

2.2.3 Human capital

Using the individual migration decisions and the distributions of migration costs, finally, the human capital in region i can be written as

$$h_i = \frac{\overline{m} - s_i(w_j - w_i)}{\Delta m}\Psi_i s_i + \frac{s_j(w_i - w_j) - \underline{m}}{\Delta m}\Psi_j s_j, \tag{2.11}$$

where the first term represents the number of students in i staying in i after graduating from university (weighted with the public education expenditure in i) and the second term represents the number of individuals educated in region j and working in i (weighted with the education expenditure in region j).

Obviously, h_i (as well as h_j, of course) depends on the education policy in both regions. When it comes to the analysis of i's optimal (local) education policy, the effect of a marginal expenditure increase on the size of the human capital measure within both regions plays a decisive role. It is therefore necessary to determine dh_i/ds_i and dh_j/ds_i. Note that

$$\begin{aligned}\frac{dh_i}{ds_i} &= \frac{\overline{m} - s_i(w_j - w_i)}{\Delta m}\left(\frac{d\Psi_i}{ds_i}s_i + \Psi_i\right) - \frac{w_j - w_i}{\Delta m}\Psi_i s_i \\ &\quad + \frac{\frac{dw_i}{ds_i} - \frac{dw_j}{ds_i}}{\Delta m}\left(\Psi_i s_i^2 + \Psi_j s_j^2\right) + \frac{s_j(w_i - w_j) - \underline{m}}{\Delta m}\frac{d\Psi_j}{ds_i}s_j. \end{aligned}\tag{2.12}$$

The human capital measure is affected not only directly by an increase in the education expenditure, but also indirectly, via its effect on the number of students and therefore – with a certain probability of students staying in the country of their education – on the number of workers in the country, and via the change in the

[3] This can also be verified by recognizing that $(d\Psi_i/ds_i)|_{\text{equ.}} = (d\Gamma_i/ds_i)|_{\text{equ.}} + [d(1 - \Gamma_j)/ds_i]|_{\text{equ.}} = 2(d\Gamma_i/ds_i)|_{\text{equ.}}$.

wage differential between countries. Using the fact that $d\Psi_j/ds_i = -(d\Psi_i/ds_i)$, in a symmetric equilibrium

$$\left(\frac{dh_i}{ds_i}\right)_{\text{equ.}} = \frac{\overline{m}}{\Delta m} + \frac{(\overline{m}+\underline{m})s}{\Delta m}\left(\frac{d\Psi_i}{ds_i}\right)_{\text{equ.}} + \frac{2}{\Delta m}\left(\frac{dw_i}{ds_i} - \frac{dw_j}{ds_i}\right)_{\text{equ.}} s^2. \quad (2.13)$$

The effect of an increase in the education expenditure on the wage rate differential depends on the effect of the expenditure increase on human capital. Evaluated at a symmetric equilibrium and using $(dh_j/ds_i)_{\text{equ.}} = 1 - (dh_i/ds_i)_{\text{equ.}}$, we have

$$\left(\frac{dw_i}{ds_i} - \frac{dw_j}{ds_i}\right)_{\text{equ.}} = f_{11}\left[2\left(\frac{dh_i}{ds_i}\right)_{\text{equ.}} - 1\right]. \quad (2.14)$$

With this expression and the effect of a marginal expenditure increase on the number of students according to (2.10) in (2.13), solving the equation for $(dh_i/ds_i)_{\text{equ.}}$ then finally yields

$$\left(\frac{dh_i}{ds_i}\right)_{\text{equ.}} = \frac{\frac{\overline{m}}{\Delta m} + \frac{2(\overline{m}+\underline{m})sf_1}{\Delta m \Delta m_0} - \frac{2s^2 f_{11}}{\Delta m}\left[\frac{(\overline{m}+\underline{m})^2}{\Delta m \Delta m_0} + 1\right]}{1 - \frac{4s^2 f_{11}}{\Delta m}\left[\frac{(\overline{m}+\underline{m})^2}{\Delta m \Delta m_0} + 1\right]}. \quad (2.15)$$

Recognizing that $\overline{m}/\Delta m$ represents the stay rate of graduates in the country of education in equilibrium (denoted by $p > 1/2$ in what follows) and with $(-\underline{m})/\Delta m = 1 - p$ and therefore $(\overline{m} + \underline{m})/\Delta m = 2p - 1$, we have

$$\left(\frac{dh_i}{ds_i}\right)_{\text{equ.}} = \frac{p + \frac{2(2p-1)}{\Delta m_0} sf_1 - 2s^2 f_{11}\left[\frac{(2p-1)^2}{\Delta m_0} + \frac{1}{\Delta m}\right]}{1 - 4s^2 f_{11}\left[\frac{(2p-1)^2}{\Delta m_0} + \frac{1}{\Delta m}\right]}. \quad (2.16)$$

Stay rates smaller than one capture the fact that there are further (nonmonetary) migration determinants besides income differentials. In order to illustrate the new insights from considering student mobility and as a benchmark, it seems useful to present $(dh_i/ds_i)_{\text{equ.}}$ from a simpler version of the model with immobile students (implying $d\Psi_i/ds_i = d\Psi_j/ds_i = 0$ and $\Psi_i = \Psi_j = 1$), which I indicate with a circle as superscript:

$$\left(\frac{dh_i}{ds_i}\right)^{\circ}_{\text{equ.}} = \frac{p - 2s^2 f_{11}/\Delta m}{1 - 4s^2 f_{11}/\Delta m} < 1. \quad (2.17)$$

This expression is the analogue to the one presented by Justman and Thisse (2000, p. 252). The main difference comes from their explicit consideration of

a worker's responsiveness to interregional income differentials. Implicitly, the individual responsiveness in the present model is one and therefore has the same weight as migration costs capturing nonwage migration determinants. The overall relevance of the wage effect due to migration is therefore solely determined by the characteristics of the production function.

The consideration of student mobility is first of all reflected in the marginal benefit from attracting/retaining students by increased education expenditures (as represented by $(2(2p-1)/\Delta m_0)sf_1$ in (2.16)). The higher the stay rate of graduates, the more an increase in the number of students translates into an increase of human capital, and therefore the larger $(dh_i/ds_i)_{\text{equ.}}$. Secondly, the additional wage effect that can be traced back to student migration has to be considered (the first term in brackets within the last term of the numerator and that of the denominator). Again, the higher the stay rate, the more relevant this effect becomes.

2.3 Globally optimal education policy

The centralized solution with respect to education policy serves as a benchmark when it comes to an evaluation of the decentralized outcome. A federal institution would maximize global output, which is equivalent to the wage sum of skilled and unskilled workers (due to firms' zero net profitability conditions in a competitive market equilibrium) net of public expenditures on higher education in both regions on choosing an education policy that equates the human capital's marginal product and the marginal cost of spending resources on higher education in each region. I assume resource costs following the cost function $c_i(s_i) = cs_i$ here. As in the model of Justman and Thisse (2000, p. 252), the first-order condition for the global output maximizing expenditure then is

$$f_1(h_x, l_x) = c, \qquad x = i, j, \tag{2.18}$$

and therefore

$$f_1(s^*, l) = c \tag{2.19}$$

in a symmetric solution (i.e., $h_i = h_j = s_i = s_j = s^*$). For further reference, the centralized solution is indicated by an asterisk.

2.4 Decentralized education policy

Strategic interaction in decentralized policymaking in the context of competition by means of public education expenditure can generally occur, for example, on a state level or a national level. In any case, the relative weight of foreigners in the decision-making of local authorities can vary. Therefore, following especially Justman and Thisse (2000), I will deal with two cases: in section 2.4.1 local governments are assumed to care only about residents (skilled and unskilled workers, independently of their origin), while in section 2.4.2 they only consider natives' interests (independently of their residence).

2.4.1 Maximizing residents' wage sum

Decentralized policymaking in a setting of local governments maximizing the wage sum of local workers (natives and foreigners) implies competition for human capital. Let the regions maximize local output (which is equal to the local wage sum) net of education expenditures; thus region i faces the following optimization problem, in which it takes region j's policy as given:

$$\max_{s_i} \quad \Phi^{LO} = f(h_i, l_i) - cs_i. \tag{2.20}$$

The corresponding first-order condition in a symmetric equilibrium then is

$$f_1(s, l) \times \left(\frac{dh_i}{ds_i}\right)_{\text{equ.}} = c. \tag{2.21}$$

Comparing the centralized and the decentralized solution, with $(dh_i/ds_i)^{\circ}_{\text{equ.}} < 1$ and $f_{11} < 0$, the well-known underinvestment result (as presented in Justman and Thisse, 2000, p. 253) emerges unambiguously: as a country's marginal increase of education expenditure does not completely translate into an increase of human capital, there is a reduced local incentive to provide public education compared to the centralized solution. This result, however, needs no longer hold if there is an additional benefit from increasing expenditures that is due to the attractiveness of students as future human capital.

2.4.1.1 Spillover effects and inefficient local policy

The condition (2.21) indicates that, compared to the centralized solution, local jurisdictions underinvest in education if the equilibrium implies $(dh_i/ds_i)_{\text{equ.}} < 1$ and overinvest if it implies $(dh_i/ds_i)_{\text{equ.}} > 1$, i.e.,

$$s \left\{ \begin{array}{c} > \\ = \\ < \end{array} \right\} s^* \quad \text{if} \quad \left(\frac{dh_i}{ds_i}\right)_{\text{equ.}} \left\{ \begin{array}{c} > \\ = \\ < \end{array} \right\} 1.$$

A marginal increase in local education investment in country i causes both a positive and a negative spillover to country j. On the one hand, a certain percentage of individuals being educated in country i emigrate after graduation and contribute to production in country j (positive spillover). On the other hand, higher education quality in i attracts students from j, thereby – *ceteris paribus* and given a certain fraction of students staying in the host country of education – reducing human capital in j (negative spillover). While the positive spillover dominates for $(dh_i/ds_i)_{\text{equ.}} < 1$ (as is of course also the case in Justman and Thisse, 2000, where the negative spillover does not exist), the negative one dominates for $(dh_i/ds_i)_{\text{equ.}} > 1$. For $(dh_i/ds_i)_{\text{equ.}} = 1$, the two spillovers balance and the local levels of public funding match the efficient level s^*, which would be chosen by a federal entity.

The second part of the conditions above can be rewritten as

$$\chi = \underbrace{-(1-p) + 2\left(\frac{\partial p_i}{\partial w_i}\right)_{\text{equ.}} \epsilon_{wh} f_1}_{\chi^+} + \underbrace{2(2p-1)\left[\frac{s}{\Delta m_0} + \left(\frac{\partial p_i}{\partial w_i}\right)_{\text{equ.}} \epsilon_{wh} \frac{(2p-1)\Delta m}{\Delta m_0}\right] f_1}_{\chi^-} \left\{ \begin{array}{c} > \\ = \\ < \end{array} \right\} 0, \quad (2.22)$$

where $\epsilon_{wh} = f_{11}s/f_1 < 0$ is the wage elasticity with respect to human capital in equilibrium, and $p_i = [\overline{m} - s_i(w_j - w_i)]/\Delta m$ is the stay rate of graduates in i. The quantity $\chi^+ = -(1-p) + 2\left(\partial p_i/\partial w_i\right)_{\text{equ.}} \epsilon_{wh} f_1$ is related to the positive spillover. While the first term within it captures the direct positive spillover from the quality investment as explained above, the second captures the corresponding

wage effect. The more elastic the wage rate per unit of effective labor with respect to an increase in human capital, the more the emigration of graduates from this region triggered by the decreasing wage rate, and therefore the greater the spillover. The spillover also increases in the sensitivity of graduates' migration behavior to a wage rate change (represented by $\partial p_i/\partial w_i \overset{(\text{equ.})}{=} s/\Delta m$). Note that $\chi^+ < 0$, as it reflects the perspective of the country considering investment in education. From the other country's point of view this is the positive spill-in. The quantity $\chi^- = 2(2p-1)\left[s/\Delta m_0 + (\partial p_i/\partial w_i)_{\text{equ.}}\, \epsilon_{wh}(2p-1)\Delta m/\Delta m_0\right] f_1$ captures the negative spillover. While $2p-1$ reflects the degree to which an increase in the number of students translates into future human capital,[4] the first term in brackets relates to the direct negative spillover and the second term is again the wage effect. The direct effect – i.e., the benefit from attracting/retaining students for the investing country, implying the loss of human capital in the other region – is positive. The wage effect is again negative, due to the decreasing wage rate. The wage elasticity, the degree to which the additional number of students translates into human capital, and the sensitivity of graduates' migration behavior to a wage rate change strengthen the wage effect. Overall, $\chi^- > 0$, as can be verified by recognizing that I have assumed $p > 1/2$ and noting that the specification of the production function implies $\epsilon_{wh} = \alpha - 1$ and therefore $|\epsilon_{wh}| < 1$.[5]

[4] The skilled workforce, say in country i, is in principle composed of two types of individuals: (i) (native and foreign-born) graduates from the higher education system in i and (ii) graduates from the foreign system j. While a marginal increase in education expenditures in i would generally increase the number of graduates (Ψ_i) from a university in i (given that the negative wage effect is not dominating), the number of graduates from a university in j (Ψ_i) would decrease by the same amount, given the exogenously fixed size of the population (student body). If both types of graduates were finally represented equally in the actual workforce in i, its size would remain unchanged. This would be the case if the fraction of graduates staying in their country of education (p) equaled the fraction of graduates leaving it ($1-p$), i.e., if $p = 1/2$. If, however, more than half of the graduates do not leave the country of education in equilibrium (i.e., $p > 1/2$, implying $2p - 1 > 0$), the marginal increase in the overall number of retained (native and foreign-born) graduates overcompensates the decrease in the number of graduates immigrating/repatriating from the foreign system. Hence, the higher the equilibrium stay rate p, the more an increase in the number of students in a country translates into an increase of human capital.

[5] Note that $\text{sgn}(\chi^-) = \text{sgn}\{(2p-1)[1+(2p-1)\epsilon_{wh}]\} = 1$.

2.4.1.2 A numerical example

Although the model's setup is kept as simple as possible, it is hard to say whether, overall, the negative or the positive spillover dominates. Furthermore, an analytical solution for s unfortunately cannot be derived. Therefore I present a numerical example allowing us to compare the outcomes of centralized versus decentralized education policy. Given the simplicity of the model economy presented above, I should emphasize that this example is first and foremost considered to serve an illustrative purpose and to show that in principle three different outcomes might show up as a result of the efficiency valuation: (i) local underinvestment, (ii) local overinvestment, or (iii) globally optimal local investment in education.

Especially two parameters are driving the (likely) deviation of local from globally optimal policy: p, the stay rate of graduates in equilibrium, and α in the production function, which is the income share of high-skilled labor or the output elasticity of skilled labor ($\sigma = f_1 h/y$) and which determines – amongst other things – the sensitivity of wages to changes in the human capital measure and therefore also to migration flows, as represented by ϵ_{wh}. Using the functional form of the production function as presented in (2.1) in the local first-order condition (2.21) allows us to find optimal values for the local education expenditure depending on p and α.[6]

One example is presented in figure 1 as a dark-colored surface.

The diagram, which also includes the globally optimal expenditure s^* (only depending on α and represented by the light-shaded surface), indicates that in general, locally chosen education levels could deviate from s^* in both directions, i.e., depending on the size of the two types of spillovers discussed in section 2.4.1.1, the decentralized equilibrium could imply either under- or overinvestment. Oc-

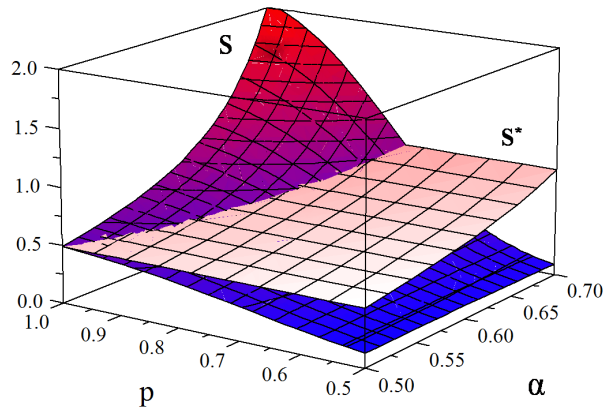
[6] The local optimality condition for the education expenditure is

$$A\alpha \left(\frac{l}{s}\right)^{1-\alpha} \times \left(\frac{dh_i}{ds_i}\right)_{\text{equ.}} = c.$$

Using (2.16) and rewriting the equation yields

$$A\alpha p l^{1-\alpha} + 4A\alpha(\alpha-1)\eta c s l^{1-\alpha} - c s^{1-\alpha} + 2A^2\alpha^2 \left[\frac{2p-1}{\Delta m_0} + (1-\alpha)\eta\right] s^{\alpha} l^{2(1-\alpha)} = 0,$$

where $\eta := (2p-1)^2/\Delta m_0 + 1/\Delta m$.



Note: Specification: $A = 1.4$, $l = 1$, $c = 1$, $\Delta m = 1$, $\Delta m_0 = 1$

Figure 2.1: Local education investment with output-maximizing governments

casionally, local and central expenditure levels coincide. These combinations of the stay rate p and α at the intersection of the two surfaces in figure 1 can also be presented in the two-dimensional space.

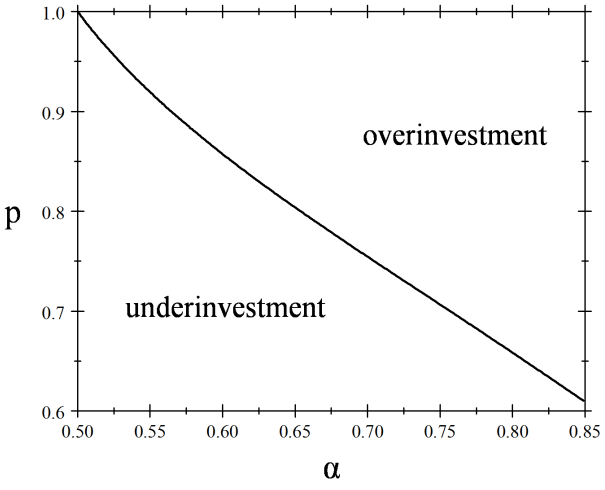


Figure 2.2: The efficiency line of coinciding local and central levels of education investment

The declining curve in figure 2 represents coinciding $s = s^*$ levels and might be referred to as the *efficiency line*. The functional form of this curve is implicitly

given by

$$\frac{p + 2A\alpha s^{\alpha} l^{1-\alpha}\{\frac{(2p-1)}{\Delta m_0} - (\alpha-1)[\frac{(2p-1)^2}{\Delta m_0} + \frac{1}{\Delta m}]\}}{1 - 4A\alpha(\alpha-1)s^{\alpha} l^{1-\alpha}[\frac{(2p-1)^2}{\Delta m_0} + \frac{1}{\Delta m}]} = 1, \qquad (2.23)$$

which means $(dh_i/ds_i)_{\text{equ.}} = 1$ according to (2.16) and the specification of the production function. The equilibrium s is of course equal to $s^* = (A\alpha/c)^{1/(1-\alpha)} l$. In the example, the higher the stay rate p of graduates and the higher α (i.e., the smaller $|\epsilon_{wh}|$), the larger the regions' tendency to overinvest in local education. While combinations located to the northeast of the efficiency line imply local overinvestment, combinations to the southwest mean underinvestment.[7]

2.4.1.3 The cost of providing public education

At this stage it seems indicated to briefly reconsider the cost function $c_i(s_i) = cs_i$, which simply implies a constant marginal cost of using resources. One might argue, however, that there are costs $c_i = c(\Psi_i)s_i$ depending on the number of students enrolled. In that case – provided that overall $d\Psi_i/ds_i > 0$ and $c' > 0$ – from the point of view of a local entity there is an additional cost of attracting students by means of increasing resources, namely $c'(d\Psi_i/ds_i)s_i$. If there were nothing to gain from the attraction of foreign students, countries would clearly underinvest in education compared to the centralized solution. Del Rey (2001) makes this point in a model where foreign students always pay taxes in their home countries and contribute neither to the host country's welfare nor to the financing of its education system. Mechtenberg and Strausz (2008) refer to the *free-rider*

[7] The results presented in the numerical example are *prima facie* plausible, in view of the more direct effects of parameter changes on the spillovers. *Ceteris paribus*, i.e., for a given level of s, the absolute value of χ^+ decreases in p (implying an increase in χ), while the effect of p on the negative spillover is ambiguous. As long as the absolute value of the elasticity ϵ_{wh} is not too high, the overall effect on χ is positive, implying a local overinvestment tendency. The indirect effect of an increase in p on χ via s would also have been to be considered in an analytical treatment, which, however, no longer produces interpretable results. A similar problem arises in an analytical treatment of a change in the parameter α. An increase in α is equivalent to a decrease in the absolute value of the elasticity ϵ_{wh}, which – ceteris paribus – would imply an (unambiguous) increase in χ and therefore an overinvestment tendency. An increase in α, however, has also an effect on s and f_1, which again makes it impossible to finally come up with an appropriately interpretable analytical solution.

effect when countries have an incentive to provide a low-quality education to induce students to study abroad in order to save variable costs. The size of the free-rider effect compared to the incentive to attract students by means of higher quality then determines whether the decentralized equilibrium results in a local over- or underinvestment.[8] In the context of the model presented in this section, the stronger the additional marginal cost effect from attracting students, the more likely it is that underinvestment will result.

The way the cost of providing quality is modeled in this paper implies that education quality is *nonrival*, i.e., incoming foreign students do not increase the cost of quality provision. In a certain range of mobility this assumption appears to be plausible. De Villé, Martou, and Vandenberghe (1996, p. 210), for example, argue that due to the high level of institutions' fixed costs, the marginal cost of some additional students is negligible, especially because the admission of those students usually does not restrict other students' access. However, they also make clear that this is only true if certain thresholds are not reached and local capacity constraints do not become binding.

Furthermore, the model ignores economies of scale in university and college education and the efficient size of institutions or systems. In the context of the analysis presented above, this could imply that countries try to attract foreign students in order to enhance the efficiency of domestic institutions. Larger institutions or systems, however, may also incur higher management costs, so that the overall effect is not that clear.[9]

The present paper abstracts from these cost-related issues, given its focus on spillover effects related to human capital as input in the production process, in

[8] In Mechtenberg and Strausz's (2008) model, foreign students stay in the host country with some exogenous probability and contribute to social welfare as graduates. Since graduates who studied in their home country are assumed to be perfectly immobile, there is no positive spillover of local education policy as in Justman and Thisse (2000, ch. 4.1) or as represented by χ^+ in the present paper.

[9] There could also be negative spillovers from quality investments in that the sending country may not only suffer from increasing costs per student due to the existence of fixed costs, but also from *sticky costs*, i.e., from retardation of the total cost savings when enrollment declines, due to ongoing salary payment for tenured faculty or building maintenance. See for example Dickmeyer (1982), discussing economies of scale and further aspects related to the size of educational institutions.

order to make the results as comparable as possible to Justman and Thisse (2000). A similar approach is for example also chosen by Büttner and Schwager (2004, p. 254, fn. 1).

2.4.2 Maximizing the natives' wage sum

Justman and Thisse's (2000) suggestion of a potential source of underinvestment in public education, namely high-skilled labor mobility, is not the only lesson to learn from their analysis. The demonstration that assumptions about local government objectives drive the results is just as important. In their model, "[decentralization] leads to under-investment in education when political interests are predominantly defined in geographic terms and local governments act to maximize regional output, but may lead to over-investment when the political interests of native-born highly educated are well represented" (Justman and Thisse, 2000, p. 255). Reassessing this issue in the context of the extended model in the present paper as well seems worthwhile.

Think of an objective function that considers only the native-born skilled population – which studies and works either in the home country or abroad – and the locally used immobile factor (or rather respective factor incomes). The optimization problem then becomes

$$\begin{aligned} \max_{s_i} \quad \Phi^N &= P_i^{ii} s_i f_1(h_i, l_i) + P_i^{ij} s_i f_1(h_j, l_j) + P_i^{ji} s_j f_1(h_i, l_i) \\ &\quad + P_i^{jj} s_j f_1(h_j, l_j) + l_i f_2(h_i, l_i) - c s_i. \end{aligned} \tag{2.24}$$

The P's represent the numbers of workers who are born in i (subscript) and who have studied either in i or j (first superscript) and work either in i or j (second superscript). Note that

$$P_i^{ii} = \frac{\overline{m} - s_i(w_j - w_i)}{\Delta m}\Gamma_i \ , \qquad P_i^{ij} = \frac{(w_j - w_i)s_i - \underline{m}}{\Delta m}\Gamma_i \ ,$$

$$P_i^{ji} = \frac{(w_i - w_j)s_j - \underline{m}}{\Delta m}(1 - \Gamma_i) \ , \qquad P_i^{jj} = \frac{\overline{m} - s_j(w_i - w_j)}{\Delta m}(1 - \Gamma_i).$$

The first-order condition for the maximization reads

$$\begin{aligned}\frac{d\Phi^N}{ds_i} &= \frac{dP_i^{ii}}{ds_i}s_i f_1(h_i,l_i) + P_i^{ii} f_1(h_i,l_i) + P_i^{ii} s_i f_{11}(h_i,l_i)\frac{dh_i}{ds_i} \\ &+ \frac{dP_i^{ij}}{ds_i}s_i f_1(h_j,l_j) + P_i^{ij} f_1(h_j,l_j) + P_i^{ij} s_i f_{11}(h_j,l_j)\frac{dh_j}{ds_i} \\ &+ \frac{dP_i^{ji}}{ds_i}s_j f_1(h_i,l_i) + P_i^{ji} s_j f_{11}(h_i,l_i)\frac{dh_i}{ds_i} \\ &+ \frac{dP_i^{jj}}{ds_i}s_j f_1(h_j,l_j) + P_i^{jj} s_j f_{11}(h_j,l_j)\frac{dh_j}{ds_i} \\ &+ l_i f_{21}(h_i,l_i)\frac{dh_i}{ds_i} - c \quad = \quad 0. \end{aligned} \tag{2.25}$$

Calculating the derivatives of the P's with respect to education policy (refer to the Appendix), evaluating the whole condition at a symmetric equilibrium, and using $(dh_i/ds_i)_{\text{equ.}}$ and $(dh_j/ds_i)_{\text{equ.}}$ from section 2.2 and the properties of the production function (especially $f_{21} = f_{12}$ and $hf_{11}(h,l) + lf_{12}(h,l) = 0 \Leftrightarrow lf_{12}(s,l) \overset{\text{(equ.)}}{=} -sf_{11}(s,l)$), we finally end up with

$$f_1 p_0 + s f_{11} \underbrace{(2pp_0 - p - p_0)}_{(-)} \left[2\left(dh_i/ds_i\right)_{\text{equ.}} - 1\right] = c, \tag{2.26}$$

where $p_0 = \Gamma_{\text{equ.}} = \overline{m}_0/\Delta m_0$ reflects students' propensity to stay in their home country, and $1 - p_0 = 1 - \Gamma_{\text{equ.}} = -\underline{m}_0/\Delta m_0$ refers to students' preference to study abroad in equilibrium.

Different spillover effects are again likely to cause a deviation of decentralized from globally optimal policy. Note that now, the migration behavior of students, as mainly represented by p_0, also plays a decisive role. Two different types of spillovers can be distinguished. The first one can be illustrated by inspecting especially the first term on the left-hand side of (2.26) and ignoring the wage-rate-related effects (second term) for a moment: if the wage differential between countries were not affected by a change in education policy, the local first-order condition would be

$$f_1 p_0 = c. \tag{2.27}$$

Since only those natives benefit from the increased expenditure in their home region who stay there as students, a stay rate p_0 smaller than one implies that

regions (exclusively interested in natives' incomes) only receive part of the investment's total marginal benefit from a global point of view, while bearing the entire marginal cost. Compared to the centralized solution, this exclusive focus on natives generates the local underinvestment that technically follows from (2.27) due to $f_1 > c$ and the assumptions on the production function. In other words, local governments ignore the spillover effect of education expenditures on foreign students who benefit from increased incomes in the future due to better education. This result is basically in line with the one presented by Büttner and Schwager (2004) in a model with interregionally mobile students in a federation (graduates are assumed to stay in the region where they were educated) and a comparable local objective function. Tuition fees at the federal level would in their model mitigate this underinvestment, as local governments had an increased incentive to attract students by quality in order to raise revenue from fees.

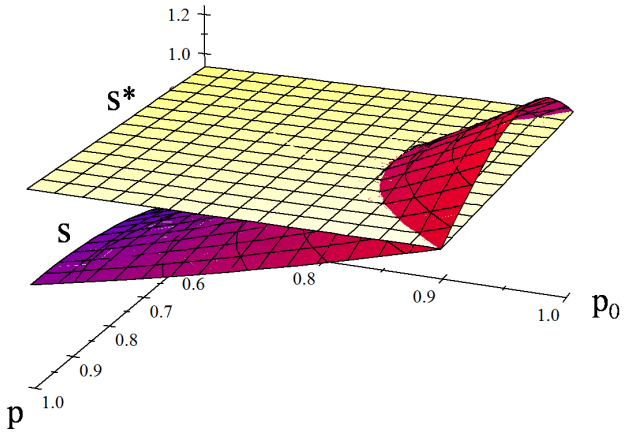
The second type of spillover is related to the fact that local governments ignore the effect of a marginal policy change on the earnings of nonnative skilled workers and the immobile factor abroad: the second term on the left-hand side of (2.26), which is unambiguously nonnegative for the assumed parameter range $1/2 \leq p_0, p \leq 1$, reflects a local incentive to overinvest in education. Overall, taking both kinds of spillovers into account, it is *a priori* – again – not clear in which direction local policy might deviate from the efficient solution, as the signs of the spillovers are opposing. For $p_0 = 1$ (i.e., no student migration in equilibrium), the result is unambiguous, as the Büttner–Schwager type of spillover described earlier vanishes. The local optimality condition then looks like the one presented by Justman and Thisse (2000, p. 256), implying local overinvestment:

$$f_1 - \underbrace{s f_{11} \left\{ (1-p) \left[2 \left(dh_i / ds_i \right)_{\text{equ.}} - 1 \right] \right\}}_{(-)} = c. \tag{2.28}$$

Note that $p_0 = 1$ does not mean there cannot be any student migration at all. It only says that with equalized education qualities among regions, no student wants to study abroad. There can be migration in out-of-equilibrium situations. Effectively $p_0 = 1$ also means that students do not have any other migration motives than income-related ones.

Finally, I present a numerical example illustrating the results for different parameter values p_0 and p. As can be seen in figure 3, where the light-colored plane

indicates the globally optimal expenditure level s^* which is independent of both parameters, and the dark-colored surface represents the local equilibrium expenditure s for different (p_0, p) combinations, again, in principle three scenarios – overinvestment, underinvestment, and globally optimal investment – may result from decentralized education policy.



Note: Specification: $A = 1.4$, $\alpha = 0.7$, l=1, $\Delta m_0 = 1$, $\Delta m = 1$, c=1

Figure 2.3: Local education investment with governments maximizing natives' wage sum

As proved analytically by means of the condition (2.28), for $p_0 = 1$, local governments overinvest for all given levels of p in the interval $(1/2, 1)$. The lower the stay rate p_0 of students in equilibrium, however, the more likely there will be local underinvestment. This result can be traced back to the first type of spillover as discussed above (the one that also drives the result in Büttner and Schwager, 2004), which is enforced by a lower student stay rate.[10]

[10] In order to really observe the illustrated effect, the absolute value of the wage elasticity must not be too high, because otherwise the opposing effect of p_0 on the wage-rate-related spillover dominates:

$$\operatorname{sgn}(ds/dp_0) = \operatorname{sgn}\{f_1 + sf_{11}[(2p-1)[2\,(dh_i/ds_i)_{\text{equ.}} - 1]]\} = 1$$

only if

$$-\epsilon_{wh} < \{(2p-1)[2\,(dh_i/ds_i)_{\text{equ.}} - 1]\}^{-1}.$$

The curvature of the local expenditure surface along the p-dimension can hardly be explained intuitively any more. The wage-rate-related effect of a marginal policy change (second term on the left-hand side in (2.26)) is affected by the graduates' stay rate through the actual residency of natives (as finally reflected in the factor $2pp_0 - p - p_0$) and through its effect on the international wage differential's sensitivity to the policy change (as represented by $f_{11}[2\,(dh_i/ds_i)_{\text{equ.}} - 1] = (\frac{\partial w_i}{\partial s_i} - \frac{\partial w_j}{\partial s_i})_{\text{equ.}}$).

The important message to take away from the illustration is that the unambiguous local overinvestment in Justman and Thisse (2000, ch. 4.2) is reversed into underinvestment once student mobility exceeds some critical threshold.

2.5 Conclusion

The present analysis is inspired by the increasing relevance of student mobility and the potential interest of countries in attracting foreign students as future human capital. Increasing efforts of OECD countries to facilitate foreign students' transition from university to the domestic labor market after graduation (see, e.g., Tremblay, 2005, and Chaloff and Lemaitre, 2009) support the view that countries are aware of this option. When public resources spent on higher education attract foreign students due to their productivity-enhancing effect, the well-known underinvestment result from models exclusively focusing on labor mobility does not necessarily carry over to settings in which something is to be gained from attracting students. I find that local-output-maximizing countries tend to overinvest in higher education if equilibrium stay rates of graduates are sufficiently high and the wage effect from an increase in human capital is only modest.

In a two-stage game of two competing private schools maximizing profits by choosing both education quality (stage 1) and tuition fees (stage 2) with a pool of imperfectly mobile students, Boadway, Marceau, and Marchand (1996) find that institutions overinvest in quality in a symmetric Nash equilibrium if one institution's equilibrium fees at the second stage of the game increase in resources spent on quality by the other institution. Whereas in their framework it is universities that benefit from attracting students via increasing revenue from tuition fees, I have supposed countries benefiting from student immigration via subse-

quent human capital immigration and at the same time being threatened by a graduate brain drain. A similar approach is chosen by Kemnitz (2007), who shows that a sufficiently low "fiscal leakage" of the local education investment in a federation (which is due not only to graduate emigration but also to fiscal equalization) could induce excessive local spending.

In the light of Justman and Thisse's (2000) insight that local objective functions – or rather the relative weight of foreigners residing in the country and the weight of natives living abroad in the objective function – crucially determine education policy, I consider not only residents' but also natives' utility maximization at the local level. When policy is only driven by natives' interests, students' migration propensity comes into play: basically, the lower the student stay rates in equilibrium, the lower a country's marginal benefit from resource spending, and therefore the larger the tendency to underinvest in education. *A priori*, results are ambiguous again.

These results – and especially their ambiguity – advise against hasty calls for specific forms of federal intervention in education policy. Depending on government objectives and human capital migration propensities, the use of federal subsidies for local education systems or tuition fees could cause undesirable outcomes. Federal interventions or international cooperation need of course not be limited to the use of fiscal instruments. Europe could serve as an example here: while the design of public education policy is under national authority, there are joint initiatives like the Bologna process and the Lisbon strategy, intended to enhance (academic) mobility. Against the background of the analysis presented above, these efforts could lead to a convergence of decentralized education policy to a common optimum – but they need not. Mechtenberg and Strausz (2008) interpret the Bologna process as a second-best policy (at the federal level) determining optimal student mobility, which trades off the mobility's effect on quality competition between countries against its effect on the development of students' (productivity-enhancing) multicultural skills. In the end, any targeted federal intervention always premises first of all a thorough understanding of local entities' strategic interaction via policies within their sphere of authority and of the actual discrepancy between locally and globally optimal policies (i.e., over- versus underinvestment).

Appendix

Calculating the derivatives of the P's with respect to s_i and then using the equilibrium conditions yields

$$\begin{aligned}
\left(\frac{\partial P_i^{ii}}{\partial s_i}\right)_{\text{equ.}} &= \frac{f_{11}}{\Delta m}\left[2\left(\frac{dh_i}{ds_i}\right)_{\text{equ.}} - 1\right] s\frac{\overline{m}_0}{\Delta m_0} + \frac{\overline{m}}{\Delta m}\left(\frac{\partial \Gamma_i}{\partial s_i}\right)_{\text{equ.}}, \\
\left(\frac{\partial P_i^{ij}}{\partial s_i}\right)_{\text{equ.}} &= -\frac{f_{11}}{\Delta m}\left[2\left(\frac{dh_i}{ds_i}\right)_{\text{equ.}} - 1\right] s\frac{\overline{m}_0}{\Delta m_0} - \frac{\underline{m}}{\Delta m}\left(\frac{\partial \Gamma_i}{\partial s_i}\right)_{\text{equ.}}, \\
\left(\frac{\partial P_i^{ji}}{\partial s_i}\right)_{\text{equ.}} &= \frac{f_{11}}{\Delta m}\left[2\left(\frac{dh_i}{ds_i}\right)_{\text{equ.}} - 1\right] s\left(\frac{-\underline{m}_0}{\Delta m_0}\right) - \frac{\underline{m}}{\Delta m}\left(\frac{\partial (1-\Gamma_i)}{\partial s_i}\right)_{\text{equ.}}, \\
\left(\frac{\partial P_i^{jj}}{\partial s_i}\right)_{\text{equ.}} &= \frac{f_{11}}{\Delta m}\left[2\left(\frac{dh_i}{ds_i}\right)_{\text{equ.}} - 1\right] s\frac{\underline{m}_0}{\Delta m_0} + \frac{\overline{m}}{\Delta m}\left(\frac{\partial (1-\Gamma_i)}{\partial s_i}\right)_{\text{equ.}}.
\end{aligned}$$

Furthermore, note that

$$\begin{aligned}
\left(\frac{\partial \Gamma_i}{\partial s_i}\right)_{\text{equ.}} &= \frac{1}{\Delta m_0}\left\{f_1 + \frac{(\overline{m}+\underline{m})}{\Delta m} s f_{11}\left[2\left(\frac{dh_i}{ds_i}\right)_{\text{equ.}} - 1\right]\right\} \\
&= -\left(\frac{\partial (1-\Gamma_i)}{\partial s_i}\right)_{\text{equ.}},
\end{aligned}$$

which cancels out, however, in the first-order condition.

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3 Education Policy and Tax Competition with Imperfect Student and Labor Mobility

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3.1 Introduction

In all OECD countries, tertiary education is to a large extent publicly funded. Except for Japan and the U.S., the share of public funding in higher education exceeds 50%, rising to over 90% in many European countries. In times of increasing high-skilled labor mobility, there is a problem in that some of those who benefit from a predominantly publicly funded tertiary education may not pay for their education in terms of income taxes after graduation if they leave the country in order to work abroad. Not only may the international competition for human capital cause an erosion of local taxation or at least inefficiently low tax rates (Poutvaara, 2000, 2001); graduates' mobility and related spillovers from migration may also provide an incentive to underinvest in public education (Justman and Thisse, 1997, 2000) or favor country-specific over internationally applicable

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education (Poutvaara, 2004, 2008).[1]

The picture becomes even more interesting and relevant when students' international mobility, too, is considered. When foreign students can benefit unrestrictedly (via 'free-riding') from national education systems and the imposition of discriminating fees is not an option (Del Rey, 2001), or if host countries ignore the positive external effect of education policy on foreign students and instead only maximize natives' welfare (Büttner and Schwager, 2004), there might be local underinvestment in public higher education. Lange (2009) then shows that, generally, both types of human-capital mobility, i.e. student and high-skilled labor mobility, should be considered together when analyzing education-policy competition. He extends Justman and Thisse's (2000) model to include student mobility and argues that countries might even make excessive use of higher education resources when they have an incentive to attract students as human capital in the future. The degree of student and graduate mobility and the assumptions concerning political interests (or rather objective functions) on the local level are crucial to the results.

Three recent publications further stress the relevance of student mobility and analyze optimal mobility levels in the context of the Bologna Process, a European policy to establish a common 'European Higher Education Area'. Mechtenberg and Strausz (2008) consider foreign students who acquire productivity-enhancing multi-cultural skills and find that an optimal level of student mobility trades off inefficiencies in education quality due to international competition for the best students and inefficiencies in the development of their multi-cultural skills. Demange, Fenge and Übelmesser (2008a,b) analyze the rationale behind increasing international student mobility and its impact on the optimal mix of private and public funding and the quality of higher education.

The fact that student mobility (represented by the number of foreign students enrolled in tertiary education outside their country of origin) in the OECD coun-

[1] The mobility of highly educated individuals can also reduce political support for public higher education funding. Konrad (1995) shows that older citizens prefer to finance immobile public goods such as infrastructure rather than education which is embodied in mobile individuals who avoid taxation by emigrating. Poutvaara and Kanniainen (2000) demonstrate that a social contract on education subsidies between low and high skilled individuals may not be feasible.

tries increased by more than 50% between 2000 and 2006 alone (OECD, 2008, p. 353) illustrates the increasing relevance of these aspects. While countries like Australia, the UK, Austria, Germany and France observe a considerable net inflow of foreign students, Norway and Ireland for example are typical net sending countries (OECD, 2001, p. 102).

Against the background of these stylized facts, our paper presents a model of student and labor migration in a two-country setting, allowing us to analyze strategic competition in two policy instruments of two net revenue maximizing governments: (i) education expenditures in the form of an 'amenity'/subsidy provided to students (we also allow for negative expenditures which we can interpret as tuition fees to be paid by students) and (ii) income tax rates.

Students have an attachment to their location of education, which can be either their country of origin or the foreign country. With respect to foreign students, Dreher and Poutvaara (2005) for example find empirical evidence of a close relationship between student flows and subsequent permanent migration flows. The attachment can be explained e.g. by social networks and family ties (e.g., Baruch, Budhwar and Khatri, 2007).[2] Our model captures the attachment in the shape of the migration costs incurred when leaving the location of education, which differ between individuals. In other words, we allow for the possibility that foreign-born graduates with relatively high migration costs may not be able to leave their host country and therefore cannot free-ride on that country's publicly funded education system. Similarly, domestic students differ in their preferences for leaving their home country upon graduation.

In such a setting, countries potentially want to attract foreign students in order to increase their future tax base. Alternatively, they may want to charge tuition fees in order to guarantee that those who benefited from the education system also pay for it. The purpose of this paper is to analyze the use of fiscal instruments in the context of strategically interacting governments that maximize their net revenues and evaluate the consequences of globalization in the sense of increasing student and labor mobility on regional budgets. Given this intention, the differentiated view of human-capital mobility as student and high-skilled labor mobility suggests

[2] Our focus here is on foreign students who graduate from the university in the host country rather than spending only one semester abroad.

that education and tax policy should be considered together, not separately.

Unlike the intuition presented in most of the literature, in our two-country, two-instrument competition model with heterogeneous students and graduates[3] we find that a government's net revenue does not decrease with a higher degree of labor mobility. This is due to an equilibrium tax rate increasing effect caused by a reduction in the wage elasticity of the number of students in the country. An increase in student mobility, however, erodes net revenues due to intensified tax competition.

Our model presents some new insights that extend the literature on higher education policy in the international context. First, we allow for a combined student and labor migration decision, implying that students, when they decide where to gain an education, may already consider tax policy and expected migration costs, information that will determine their labor-migration decision at the next stage. Kemnitz (2007), who analyzes quality effects of tuition fees in a federation and thereby considers both student and graduate mobility, rules out this effect by assuming that governments only compete by means of education policy but not tax policy. Second, we consider the migration cost advantages of repatriates who leave the country where they were educated to work in their home country compared to migrants who leave their country of origin for the first time. Both features influence the results. Third, we consider simultaneous competition in two fiscal instruments, including income tax rates, which are often kept fixed in the literature. Exceptions are for example Haupt and Janeba (2009) and Andersson and Konrad (2003a), where education subsidies can be used to mitigate the potential hold-up problem of time-consistent income taxation. Furthermore, in contrast to Wildasin (2000) and Andersson and Konrad (2003b), we assume that there is no further immobile factor such as unskilled labor to which the burden of taxation could be (perfectly) shifted.

The structure of the paper is as follows. The model is set up and students' and graduates' migration decisions are derived in section 5.2. Section 3.3 introduces the tax and education policy competition (section 3.3.1), characterizes equilibrium policies (3.3.2) and analyzes the effect of increasing student and labor

[3] Within the group of students and within the group of graduates, individuals differ with respect to migration costs or rather mobility.

mobility on policy instruments and net revenues in equilibrium (3.3.3). Section 5.5 concludes.

3.2 Model

The time structure of the model is as follows. First, the governments of two countries i and j, which are identical in all respects, simultaneously set tax rates t_x and an education policy represented by expenditure s_x per student, $x \in \{i, j\}$. The education expenditure can either be positive, in which case we refer to it as an amenity, or negative, in which case it can be interpreted as tuition fees per student. The term 'amenity' captures governmental expenditures that potentially attract students.[4] As these expenditures and tuition fees are basically two sides of the same coin within the present model, most of the time we only refer to amenities when considering education policy. Lange (2009) presents a comparable migration model with endogenous wage rates and education expenditures which increase individual wages. If the (negative) wage-rate effect of immigration is not too large, the effect of education policy on the number of students in a country is, as in the present model, clearly positive (Lange, 2009, equ. (10), p. 184). Investments in education quality, however, imply additional regional spillovers from migration which complicate the analysis and are not central to the main argument in the present paper, so we prefer to maintain the amenity approach.

Students who are aware of their migration costs m_0 when leaving their country of origin then decide on the location of education. 'Migration costs' in our model not only capture monetary costs (such as moving expenses) but also non-monetary costs or benefits that are related to the psychological, social and cultural aspects of migration and therefore also describe a student's country-specific preferences.[5]

[4] These could include subsidies (scholarships, housing support, travel tickets, medical benefits, book grants etc.), special student loans, hospitality services, leisure and sports facilities, child care, housing offices and health centers. In many OECD countries, subsidies for tertiary education as a percentage of total public expenditure on education are considerable (e.g., Germany 19.1%, U.S. 23.5%, UK 25.8%, Australia 32.3%, New Zealand 41.5%, Norway 42.6%; data from 2005; source: OECD, 2008, p. 290).

[5] See e.g. Beckmann and Papageorgiou (1989), Mansoorian and Myers (1993) and Haupt and Peters (2003) who use the concept of 'home attachment', or Boneva and Frieze (2001) as an

After graduation, nature reveals the individual migration costs m of leaving one's location of education, if the individual studied in their home country, and $(1-\alpha)m$ with $\alpha \in [0,1[$ if the individual graduated from a foreign university before returning to their place of origin. A non-zero α captures the migration cost advantage of a repatriate compared to a graduate who leaves their home country for the first time. This cost advantage can for example be due to linguistic proficiency, existing social networks in the home country, faster (re)familiarization etc.

Finally, university graduates decide on the location of labor supply. It seems reasonable to assume that individuals as students are not aware of the migration costs they will face upon graduation. There is some uncertainty with respect to the social networks and ties they built and/or maintained while at college, which are included in non-economic costs and represent a crucial migration/return determinant. In addition, foreign students can barely judge whether they will be able to successfully integrate in their host country. Therefore students can only form expectations about future migration costs.

If tax rates were set after the student-migration and before the labor-migration decision, the government could attract students by announcing low tax rates for the future, but later deviate from this policy after students find themselves unable to leave the country due to high individual migration costs ('lock-in'). Following Poutvaara's (2001) argument, we abstain from this hold-up problem, since in a repeated game or rather OLG setting future generations would adjust their behavior in response to deviations from announced policy.[6]

Mobility costs $m_0 \in [\underline{m}_0, \overline{m}_0]$ and $m \in [\underline{m}, \overline{m}]$ are assumed to be uniformly distributed among students and graduates, respectively. We assume that the upper limit of each distribution is positive, implying that there are always individuals with positive migration costs. Furthermore, it seems reasonable to believe that there are at least some individuals (students and graduates) with negative

example of the socio-psychological approach.

[6] Our assumption that *all* individuals decide to obtain an education (and exert an identical and exogenously fixed level of effort) directly implies that we disregarded the hold-up problem, which arises in settings with time-consistent taxation and which may be mitigated by interregional competition for human capital (see, e.g., Boadway, Marceau and Marchand, 1996; Andersson and Konrad, 2003a; and Haupt and Janeba, 2009).

migration costs, implying a strong desire for migration; i.e. $\underline{m}, \underline{m}_0 < 0$.[7] The corresponding density functions are $f(m_0) = 1/\Delta m_0$ and $f(m) = 1/\Delta m$ with $\Delta m_0 = (\overline{m}_0 - \underline{m}_0)$ and $\Delta m = (\overline{m} - \underline{m})$. In what follows, we also assume that $\overline{m} > |\underline{m}|$, implying that the expected value of m or rather the average mobility cost is positive:

$$\mathrm{E}\{m\} = \int_{\underline{m}}^{\overline{m}} m f(m) dm = \frac{1}{2}(\overline{m} + \underline{m}) > 0.$$

Hence, a student expects to face positive migration costs when they want to leave their location of education (the home or the foreign country) upon graduation. A positive m representing an individual's attachment with respect to their location of education can be due for example to social ties – especially family ties – and the acquisition of country-specific human capital during the course of their studies.[8]

The individual decision-making process consisting of (i) a student-migration decision and (ii) a migration decision upon graduation (labor-migration decision), is solved recursively.

Labor migration At the labor-migration stage, a student who was born and educated in country i, decides to stay in i (leave i) upon graduation if

$$m > (t_i - t_j)w \qquad (m < (t_i - t_j)w)\,, \tag{3.1}$$

i.e. if mobility costs exceed (fall short of) the tax differential between the two countries. The gross-wage income for inelastically supplied labor, which could be interpreted as the return to education, is exogenously given and denoted by w.[9]

[7] A repatriate's negative cost could for example be interpreted as homesickness, while a first-time migrant's negative cost reflects a sense of adventure, which not only captures risk-loving behavior but also aspects such as career concerns or intercultural interests.

[8] Baruch, Budhwar and Khatri (2007) and Henseler and Plesch (2009) present empirical analyses of return/non-return determinants of foreign students. Tremblay (2005) provides a more general overview with respect to the relationship between student and high-skilled labor mobility. Finn (2003) reports high stay rates for foreign doctorate recipients from U.S. universities (about 2/3). Estimated stay rates for foreign students in the U.S. range from 1/5 (Rosenzweig, 2006) to 1/3 (Lowell, Bump and Martin, 2007).

[9] The assumption of exogenous wage rates is not too restrictive. If the magnitude of migration-induced wage-rate effects is only secondary, they have a quantitative but no qualitative effect on migration flows (see Lange, 2009).

A graduate in i, if born in j, stays in i (repatriates) if

$$(1-\alpha)m > (t_i - t_j)w \qquad ((1-\alpha)m < (t_i - t_j)w)\,. \tag{3.2}$$

The labor-migration decision has two basic dimensions. First, individuals consider net income differentials as a migration motive. Second, non-economic migration incentives or disincentives are incorporated in the m's that vary across individuals. Individuals with negative migration costs, having a strong desire to emigrate, do so even if there is nothing to gain in terms of net income. This two-dimensional approach applies by analogy to the student migration decision. While most of the time we refer to migration costs when describing individuals' migration behavior (which is quite illustrative as we use money equivalents for migration preferences in individuals' decision making), m and m_0 can in fact also represent individuals' country-specific preferences, i.e. preferences concerning where to live.

Student migration Whether a student born in country i also attends university in country i depends on the international education expenditure and net income differential, individual migration costs m_0 and expectations about migration costs m that are revealed at the next stage. Here, we assume risk-neutral individuals. An individual in country i compares the expected net payoff from studying in i (π_i^i) with the expected payoff if they study abroad (π_j^i). Studying in i yields the following expected net payoff:[10]

$$\begin{aligned} \mathrm{E}\{\pi_i^i\} \;=\; & \Pr\{m > (t_i - t_j)w\}(1-t_i)w \\ & + \Pr\{m < (t_i - t_j)w\}\left[(1-t_j)w - \mathrm{E}\{m | m < (t_i - t_j)w\}\right] \\ & + s_i. \end{aligned} \tag{3.3}$$

With probability $\Pr\{m > (t_i - t_j)w\}$, the individual works in country i upon graduation and earns net labor income $(1-t_i)w$. With probability $\Pr\{m < (t_i - t_j)w\}$, the individual leaves i to work in j where they earn net labor income $(1-t_j)w$. The corresponding expected migration costs are $\mathrm{E}\{m | m < (t_i - t_j)w\}$.

[10] To simplify matters we assume that there is no discounting between periods. This assumption has no qualitative impact on our results.

When studying in i, the individual benefits from education expenditure $s_i > 0$ (or has to pay tuition fees $|s_i|$ when $s_i < 0$).

Analogously, studying in j yields

$$\begin{aligned} \mathrm{E}\{\pi_j^i\} &= \Pr\{(1-\alpha)m > (t_j - t_i)w\}(1-t_j)w \\ &\quad + \Pr\{(1-\alpha)m < (t_j - t_i)w\} \\ &\quad \times [(1-t_i)w - \mathrm{E}\{(1-\alpha)m | (1-\alpha)m < (t_j - t_i)w\}] \\ &\quad + s_j - m_0. \end{aligned} \tag{3.4}$$

With probability $\Pr\{(1-\alpha)m > (t_j - t_i)w\}$, the individual stays in j after studying there. With probability $\Pr\{(1-\alpha)m < (t_j - t_i)w\}$ they return to their country of origin. The student incurs migration costs m_0 at the student-migration stage.

A student born in i attends university in country i if $\mathrm{E}\{\pi_i^i\} > \mathrm{E}\{\pi_j^i\}$. Using the probabilities and expected migration costs[11] in (3.3) and (3.4) and solving for m_0 yields the following condition:

$$m_0 > (s_j - s_i) + \frac{(\overline{m} + \underline{m})w}{\Delta m}(t_i - t_j) - r(\alpha), \tag{3.5}$$

where

$$r(\alpha) := \frac{\alpha\left[\underline{m}^2 - \frac{(t_i - t_j)^2 w^2}{1-\alpha}\right]}{2\Delta m}, \quad r(0) = 0. \tag{3.6}$$

The less generous the amenities in the country of origin relative to those abroad, the more students leave the country (first term on the RHS in (3.5)). The second term represents the fact that the higher the tax rate in the country of origin relative to the foreign tax rate, the higher the rate of student emigration. This holds for the assumed positive expected value of migration costs m. This is because students anticipate that they may not be able to escape unfavorable

[11] The expected migration costs are

$$\begin{aligned} \mathrm{E}\{m | m < (t_i - t_j)w\} &= \frac{1}{2}[(t_i - t_j)w + \underline{m}], \\ \mathrm{E}\{m(1-\alpha) | m(1-\alpha) < (t_j - t_i)w\} &= \frac{1-\alpha}{2}\left[\frac{(t_j - t_i)w}{1-\alpha} + \underline{m}\right]. \end{aligned}$$

taxation at the next stage, so they will tend to do so already at the first stage. Furthermore, the lower expected labor-mobility costs at the second stage, i.e. the higher expected labor mobility, the weaker the impact on the student migration decision, implying lower student mobility. The third term $r(\alpha)$ relates to the difference in graduate migration between a repatriate and a first-time migrant for $\alpha > 0$.

3.3 Tax and education policy competition

After presenting the basic setup of the fiscal competition model, this section derives equilibrium policy and analyzes comparative static effects with respect to human capital mobility.

3.3.1 Basic setup

The government in each country maximizes local net revenues, i.e. tax revenue minus education amenities (plus tuition fees, respectively), minus variable cost of education depending on the number of students in country i. The parameter c denotes variable costs per student which do not necessarily have to be non-negative.[12] Normalizing the size of the population in each country to one, country i's net revenue can be written as

$$R_i := t_i w \underbrace{(P_i^{ii} + P_j^{ii} + P_i^{ji} + P_j^{ji})}_{=L_i} - (s_i + c) \underbrace{[D_i + (1 - D_j)]}_{=S_i} \tag{3.7}$$

with P_a^{bi}, $a, b \in \{i, j\}$, denoting the probability of an individual born in a and educated in b working in i. Therefore

$$L_i := P_i^{ii} + P_j^{ii} + P_i^{ji} + P_j^{ji} \tag{3.8}$$

represents the labor force in country i (constituting i's tax base when multiplied with wage per worker). D_i represents the number of domestic students attending

[12] In principle there could be certain benefits per student. The parameter c then can be interpreted as a net figure, being negative if benefits per student exceed costs.

university in i. Hence, $(1 - D_i)$ is the number of students leaving country i to study abroad while

$$S_i := D_i + (1 - D_j) \tag{3.9}$$

represents the total number of domestic and foreign students in country i. With migration decisions as represented by (3.1) and (3.2) and uniformly distributed migration costs m, we can determine the size of each of the four different groups constituting the total labor force in i[13]:

$$P_i^{ii} = \frac{[\overline{m} - (t_i - t_j)w]}{\Delta m} D_i \ , \qquad P_j^{ii} = \frac{[\overline{m} - \frac{(t_i - t_j)w}{1-\alpha}]}{\Delta m}(1 - D_j) \ ,$$

$$P_i^{ji} = \frac{[\frac{(t_j - t_i)w}{1-\alpha} - \underline{m}]}{\Delta m}(1 - D_i) \ , \qquad P_j^{ji} = \frac{[(t_j - t_i)w - \underline{m}]}{\Delta m} D_j.$$

With the student-migration decision as represented by (3.5) and uniformly distributed migration costs m_0, the allocation of students born in i can be calculated as

$$\begin{aligned} D_i &= \frac{1}{\Delta m_0}\left[\overline{m}_0 - (s_j - s_i) - \frac{(\overline{m} + \underline{m})(t_i - t_j)w}{\Delta m} + r(\alpha)\right], \\ 1 - D_i &= \frac{1}{\Delta m_0}\left[(s_j - s_i) + \frac{(\overline{m} + \underline{m})(t_i - t_j)w}{\Delta m} - r(\alpha) - \underline{m}_0\right]. \end{aligned}$$

The allocation of students born in j, i.e. D_j and $(1 - D_j)$, can be expressed analogously. Neither taxes nor amenities discriminate against foreigners.

Similarly to Andersson and Konrad (2003a), governments maximize local net revenues treating the other country's policy as given. Lemma 3.1 in Section 3.3.2 will prove that net revenues are always positive in equilibrium, implying that future tax revenue can always finance education policy.[14] The first order conditions of government i's optimization problem

$$\max_{t_i, s_i} R_i = R_i(t_i, s_i; t_j, s_j)$$

[13] An implicit assumption we maintain throughout the entire paper is that the parameters associated with migration costs guarantee that (student and graduate) stay rates as presented here are always strictly between zero and one.

[14] The surplus could be used to finance lump-sum transfers, for example.

are

$$\frac{\partial R_i}{\partial t_i} = wL_i + t_i w\frac{\partial L_i}{\partial t_i} - (s_i + c)\frac{\partial S_i}{\partial t_i} = 0, \tag{3.10}$$

$$\frac{\partial R_i}{\partial s_i} = t_i w\frac{\partial L_i}{\partial s_i} - S_i - (s_i + c)\frac{\partial S_i}{\partial s_i} = 0. \tag{3.11}$$

The optimal tax rate equalizes the marginal costs and benefits of taxation. An increase in t_i reduces the tax base by (i) reducing the number of (domestic and foreign) students in country i and (ii) reducing the number of individuals staying in i upon graduation and reducing the number of immigrants and repatriates with a foreign university qualification. The second term in (3.10) represents this effect, which is the marginal cost of taxation. The marginal benefits can be broken down into a simple tax-rate effect (first term), a cost-reducing (if $c > 0$) and an amenities-reducing effect (third term), which is due to the reduced number of students in i. If, however, s_i is negative and therefore has to be interpreted as tuition fees, this latter effect belongs to the marginal cost component.

The optimal amenity equalizes the marginal costs and benefits of providing the amenities. An increase in amenities broadens the tax base by attracting students and thereby – ceteris paribus – increasing the number of individuals working and paying taxes in i. This effect, represented by the first term in (3.11), is the marginal benefit of providing the amenities. However, an increase in amenities also increases governmental expenditures through a simple direct effect and an indirect effect through the increased number of students. The second and third term in (3.11) represent the marginal costs of providing the amenities.

The reaction of country i's number of students and size of the labor force to a policy change, i.e. $\partial S_i/\partial y$ and $\partial L_i/\partial y$, $y \in \{t_i, s_i\}$, can be calculated as follows. Consider the number of students first.

$$\frac{\partial S_i}{\partial s_i} = \frac{\partial}{\partial s_i}[D_i + (1 - D_j)] = \frac{2}{\Delta m_0} > 0 \quad \text{and} \quad \frac{\partial S_i}{\partial t_i} = -\frac{2(\overline{m} + \underline{m})w}{\Delta m \Delta m_0} < 0, \tag{3.12}$$

i.e. the number of students increases with the amenity and decreases with the tax rate. The latter effect reflects the fact that students anticipate a potential lock-in effect upon graduation which could make it difficult for them to avoid unfavorable income taxes. A marginal increase in the tax rate therefore implies that the student at the margin decides to avoid the tax increase already at the

student-migration stage. The size of the labor force reacts as follows:

$$\frac{\partial L_i}{\partial s_i} = \frac{2(\overline{m}+\underline{m})}{\Delta m \Delta m_0} = \theta\left(\frac{\partial S_i}{\partial s_i}\right) > 0, \tag{3.13}$$

$$\frac{\partial L_i}{\partial t_i} = -\frac{w}{\Delta m}\left[D_i + D_j + \frac{(1-D_i)+(1-D_j)}{1-\alpha}\right] - \theta^2\frac{2w}{\Delta m_0} - \frac{2(t_i-t_j)^2 w^3\left(-\frac{\alpha}{1-\alpha}\right)^2}{\Delta m^2 \Delta m_0} < 0. \tag{3.14}$$

The number of workers (i.e. taxpayers) in country i increases with the amenity offered to students. This effect consists of the student attracting effect of $\partial S_i/\partial s_i$ and

$$\theta := \frac{\overline{m}+\underline{m}}{\Delta m} > 0 \tag{3.15}$$

which can be interpreted as the degree to which the change in the number of students finally translates into a change in the number of workers who stay in the country upon graduation. The higher expected migration costs $\mathrm{E}\{m\}$ (implying lower graduate mobility), the higher θ. Furthermore, the size of the labor force in a country decreases with its tax rate.

3.3.2 Political equilibrium

This section derives the tax rate, the amenity and the net revenue in a symmetric equilibrium.[15] Equilibrium values are indicated by asterisks. Considering first the effect of tax changes on revenues R in equilibrium (denoted by R^{t^*}), we state the first-order condition for t^*, which amounts to

$$R^{t^*} = w - t^* w\left(\theta^2\frac{2w}{\Delta m_0} + \frac{2w\Delta\widetilde{m_0}}{\Delta m \Delta m_0}\right) + (s^*+c)\theta\frac{2w}{\Delta m_0} = 0, \tag{3.16}$$

where $\Delta\widetilde{m_0} := \overline{m}_0 - \underline{m}_0/(1-\alpha) - (\underline{m}^2/2\Delta m)[\alpha^2/(1-\alpha)]$ is used as a shortcut for clarity. Furthermore, in equilibrium, the first order condition with respect to the amenity, i.e. $R^{s^*} = 0$, reads

$$R^{s^*} = \theta\frac{2}{\Delta m_0}t^* w - 1 - (s^*+c)\frac{2}{\Delta m_0} = 0. \tag{3.17}$$

[15] Please refer to the Appendix for a proof that the symmetric solution is an equilibrium, and for some characteristics of the best-response functions.

The assumption of uniformly distributed migration costs allows us to derive the equilibrium values explicitly, only depending on exogenous parameters. From (3.17) the equilibrium amenity can be derived as a function of the tax rate:

$$s^* \quad = \quad \theta t^* w - \frac{\Delta m_0}{2} - c. \tag{3.18}$$

For positive expected migration costs at the labor migration stage, the amenity increases with the tax rate. Furthermore, it increases with the expected migration costs m and the sensitivity of the number of students to education policy (remember that $\partial S/\partial s = 2/\Delta m_0$). The amenity decreases with the marginal cost of an additional student studying in a country. Using (3.18) in (3.16) yields the equilibrium tax rate

$$t^* \quad = \quad \frac{1-\theta}{\frac{2w\Delta\widetilde{m_0}}{\Delta m \Delta m_0}}. \tag{3.19}$$

With the equilibrium amenity and tax rate from (3.18) and (3.19) we can also determine the governmental equilibrium net revenue as

$$R^* \quad = \quad t^* w - (s^* + c) = (1-\theta) t^* w + \frac{\Delta m_0}{2}. \tag{3.20}$$

From (3.19) and (3.20), one can directly verify the following Lemma on the sign of the equilibrium tax rate and net revenue:

Lemma 3.1 *The assumptions $\underline{m} < 0$ and $\Delta\widetilde{m_0} > 0$ are sufficient conditions for the equilibrium tax rate t^* to be positive. Furthermore, even with a positive amenity s^*, net revenue R^* is also always strictly positive in equilibrium.*

The education amenity can in principle be negative in equilibrium, in which case one can refer to $|s^*|$ as per-student tuition fees. As of equation (3.18), the amenity tends to become negative especially if the cost per student c is very high, and/or the number of students within a country is rather insensitive to changes in education expenditures (i.e., $\partial S/\partial s$ is very small). The absence of a race to the bottom (i.e., $R^* > 0$) is finally due to the individuals' imperfect mobility, which implies some market power for the two countries when choosing tax rates and education policy.

The equilibrium tax rate can also be expressed implicitly as a function of the wage elasticity of the tax base given a fixed number of students $\overline{S}$ ($\epsilon_{L\omega} := (\partial L(\overline{S})/\partial\omega)(\omega/L) > 0$) and the wage elasticity of the number of students ($\epsilon_{S\omega} := (\partial S/\partial\omega)(\omega/S) > 0$) in equilibrium (please refer to the Appendix for the derivation):

$$t^* = \frac{1 - \epsilon_{S\omega}\left(w\frac{\partial S}{\partial s}\right)^{-1}}{1 + \epsilon_{L\omega}}, \tag{3.21}$$

where $\omega := (1-t)w$ represents the net wage. The elasticity notation presents a clearer picture of the driving force behind the equilibrium result and facilitates the intuition of the comparative statics result presented in the following section 3.3.3. As expected, the more elastically students and graduates react to interregional net income differentials, the more intense the tax competition and the lower the equilibrium tax rate (ceteris paribus):

Proposition 3.1 *The equilibrium tax rate decreases with the wage elasticity of the labor force $\epsilon_{L\omega}$ and the wage elasticity of the number of students $\epsilon_{S\omega}$. Furthermore, the tax rate increases with the sensitivity of the number of students to education policy (as represented by $\partial S/\partial s$), which is mainly due to increased expenditures.*

3.3.3 Comparative statics

It appears that the mobility of individuals is a major determinant of equilibrium policies and the resulting net revenues. This section analyzes how a symmetric (i.e., not a country-specific) increase in student mobility and in graduate mobility affects the political equilibrium. The increase in mobility is modeled as a decrease in migration costs which is identical for all individuals. For instance, suppose the total migration costs $m_k \sim U(\underline{m}, \overline{m})$ of some individual k as presented in the section above can be broken down into an individual-specific component $m_k^{indiv} \sim U(\underline{m}^{indiv}, \overline{m}^{indiv})$ reflecting country-specific preferences and the attachment to a region, and a component ϑ representing general conditions of international migration, which is identical for all individuals, such that $m_k = m_k^{indiv} - \vartheta$. An increase in ϑ represents changes in the general conditions of international migration which reduces all individuals' migration costs. These changes include

lower general or institutional barriers to migration (e.g., transport and moving costs, restricted labor-market access for foreigners, visa and work-permit issues) and greater international applicability of higher education. The common European Higher Education Area, the ultimate objective of the Bologna Process, is a case in point. For example, by making academic degrees more comparable and compatible, the Bologna Process is supposed to promote student and graduate mobility within Europe. Technically, an increase in labor mobility as represented by an increase in ϑ marginally shifts the support of the labor migration cost's distribution to the left, such that $d\underline{m}/d\vartheta = d\overline{m}/d\vartheta = -1$ and $d\Delta m = 0$. The analysis of an increase in student mobility is performed by analogy.

Alternatively, a shift of the support $[\underline{m}, \overline{m}]$ ($[\underline{m}_0, \overline{m}_0]$) may be interpreted as a global change in country-specific preferences in the sense of more individuals preferring to leave the country of education (the home country in order to study abroad).

Labor mobility Consider a change in the mobility of graduates due to a reduction in labor migration costs first. We state the following proposition.

Proposition 3.2 *An increase in labor mobility decreases the wage elasticity of students $\epsilon_{S\omega}$. This decrease causes the income tax rate t^* to increase with labor mobility. There is a non-monotonic relation between the amenity s^* and labor mobility: for low degrees of labor mobility, an increase in mobility increases the amenity, while for higher degrees of mobility a further increase leads to a decrease in the amenity. Overall, net revenues R^* increase with labor mobility.*

An increase in ϑ reduces expected migration costs $\mathrm{E}\{m\}$, and effectively also implies an increased number of graduates who can realize their preference for leaving their country of education. The effect on the equilibrium tax rate is unambiguous:

$$\frac{\partial t^*}{\partial \vartheta} = \frac{2\Delta\widetilde{m_0} - (1-\theta)\frac{\alpha^2 \underline{m}}{1-\alpha}}{2w\Delta\widetilde{m_0}^2}\Delta m_0 > 0. \tag{3.22}$$

Here and in what follows, $\underline{m} < 0$ and $\Delta\widetilde{m_0} > 0$ are sufficient conditions to determine the comparative statics' effects unambiguously.

A marginal increase in labor mobility increases the equilibrium tax rate. This result may seem counterintuitive at first sight. The elasticity notation of the combined first order condition (3.21) and the related discussion helps to develop an economic intuition. The main insight from the present analysis is that an increase in labor mobility decreases students' wage elasticity, i.e.,

$$\left.\frac{\partial \epsilon_{S\omega}}{\partial \vartheta}\right|_{dt^*=0} = -\frac{4\omega}{\Delta m \Delta m_0} < 0.$$

The reason is that higher mobility at the second stage of the game makes it less costly to avoid potentially high income taxes through emigration. Students, when making their first-round migration decision, account for this reduction in expected future migration costs, which implies a lower risk of having to remain in the country of education upon graduation. The perceived risk of having to stay plays an important role in the student-migration decision because it may induce students to avoid an anticipated unfavorable taxation at the second stage even before the actual lock-in effect takes hold. A reduced lock-in risk therefore makes students less sensitive to marginal tax rate increases. Ceteris paribus, as of (3.21), the reduced elasticity drives up the tax rate.

In addition, for $\alpha > 0$, $\epsilon_{L\omega}$ also decreases with labor mobility, thereby reinforcing the tax-rate increasing effect:

$$\left.\frac{\partial \epsilon_{L\omega}}{\partial \vartheta}\right|_{dt^*=0} = \frac{2\omega\alpha^2 \underline{m}}{(1-\alpha)\Delta m^2 \Delta m_0} < 0.$$

An increase in labor mobility shifts the composition of the student body (and therefore ceteris paribus also the labor force at the second stage) towards more domestic and fewer foreign individuals in equilibrium; as domestic graduates react less sensitively to a change in income tax rates compared to foreign-born graduates if $\alpha > 0$, overall, the wage elasticity of students decreases.

The equilibrium amenity also changes with increasing labor mobility:

$$\frac{\partial s^*}{\partial \vartheta} = \theta \frac{\partial t^*}{\partial \vartheta} w - \frac{2w}{\Delta m} t^*. \tag{3.23}$$

The direction of this change depends on the relative size of two effects. One effect goes along with the effect on the tax rate (first summand) while the second (second summand) countervails this effect: ceteris paribus, the higher the tax rate,

the higher the benefit of attracting a student as potential tax payer in the future and therefore the higher the incentive to increase the amenity. However, for a given tax policy, an increase in labor mobility reduces a jurisdiction's incentive to offer an amenity to attract students, because their higher propensity towards emigrating upon graduation implies that attracting students becomes a less effective means of attracting future tax payers. In order to highlight the main insight, the derivative is presented at $\alpha = 0$:

$$\left.\frac{\partial s^*}{\partial \vartheta}\right|_{\alpha=0} = \frac{2(\mathrm{E}\{m\} + \underline{m})}{\Delta m} \begin{cases} > 0 & \text{if} \quad \mathrm{E}\{m\} > |\underline{m}| \\ \leq 0 & \text{if} \quad \mathrm{E}\{m\} \leq |\underline{m}| \end{cases} . \tag{3.24}$$

For high average migration costs, i.e. for low degrees of labor mobility, an increase in mobility increases the equilibrium amenity, while for higher degrees of mobility, a further increase leads to a decrease in amenities.

Putting the effects on both the tax rate and the amenity together shows how the equilibrium net revenue evolves with increasing labor mobility[16]:

$$\frac{\partial R^*}{\partial \vartheta} = \frac{\partial t^*}{\partial \vartheta} w - \frac{\partial s^*}{\partial \vartheta} = (1-\theta)\frac{\partial t^*}{\partial \vartheta} w + \frac{2w}{\Delta m} t^* > 0. \tag{3.25}$$

An increase in labor mobility increases equilibrium net revenues. This increase is mainly due to the increased revenue from income taxation. Even if expenditures in form of the amenity were also increased, the higher tax revenue would overcompensate the expenditure increase.

[16] R^* also represents the overall net fiscal burden imposed on individuals studying *and* working in a country.

Student mobility An increase in student mobility is analyzed in full analogy to the labor mobility case, i.e. the support of the migration costs' distribution is marginally shifted to the left by $\Delta\vartheta_0$. We state the following proposition:

Proposition 3.3 *With foreign-born graduates reacting more sensitively to marginal tax policy changes (i.e., with $\alpha > 0$), the equilibrium tax rate t^* and the equilibrium amenity s^* decrease (or rather tuition fees increase) with student mobility. The effect of intensified tax competition dominates the effect of the expenditure cutback and therefore, overall, net revenues R^* decrease with student mobility.*

Using again the explicit solution for the equilibrium tax rate (3.19), the effect of an increase in student mobility as represented by an increase in ϑ_0 has an unambiguous effect:

$$\frac{\partial t^*}{\partial \vartheta_0} = -\frac{\alpha t^*}{(1-\alpha)\Delta\widetilde{m}_0} \leq 0. \tag{3.26}$$

For a non-zero α, t^* decreases with student mobility. This result can be traced back to the effect of student mobility on wage elasticity with respect to the size of the labor force. As

$$\left.\frac{\partial \epsilon_{L\omega}}{\partial \vartheta_0}\right|_{dt^*=0} = \frac{2\omega\alpha}{(1-\alpha)\Delta m \Delta m_0} > 0,$$

there is downward pressure on the tax rate, as demonstrated in section 3.3.2. More students preferring to study abroad implies that the composition of the student body within a country shifts towards more foreign students (relative to domestic students) and therefore also foreign-born graduates. As those foreign-born graduates react more sensitively to marginal changes in tax rates than domestic graduates if $\alpha > 0$ (see migration decisions represented by (3.1) and (3.2)), the higher elasticity reduces the scope for income taxation.

An increase in student mobility also has an unambiguously negative effect on the equilibrium education amenity:

$$\frac{\partial s^*}{\partial \vartheta_0} = \theta \frac{\partial t^*}{\partial \vartheta_0} w \leq 0. \tag{3.27}$$

Then, for the net revenue to decrease with student mobility, the tax-revenue decreasing effect of an increase in student mobility has to overcompensate the

cutback in amenities. In fact, the net revenue decreases unambiguously:

$$\frac{\partial R^*}{\partial \vartheta_0} = (1-\theta)\frac{\partial t^*}{\partial \vartheta_0} w \leq 0. \tag{3.28}$$

Our results in this section indicate that a differentiated view is advisable when evaluating the effects of increasing human-capital mobility on fiscal policy and national net tax revenues in a competitive setting. While higher labor mobility in the sense of more graduates having a preference for leaving the country of education allows for higher income taxation – thereby preventing an erosion of net revenues – a shift of students' preferences towards studying abroad induces an intensified tax competition threatening national budgets even if education expenditures are also reduced.

3.4 Conclusion

The paper presented a two-country, two-instrument fiscal competition model with two types of human capital mobility: student and labor mobility. The national governments can choose income tax rates and higher education policy to maximize net revenues. The countries' tax and education policies affect international migration flows. Assuming some attachment to the location of education upon graduation, students will take not only amenities/tuition fees but also income tax policy into account when deciding whether to study in their country of origin or to study abroad. The reason is that, ex ante, a student cannot be sure that they can leave the location of education upon graduation (in order to escape from an unfavorable income taxation) due to social networks and/or family ties established during their years of study. Therefore, both income taxes and education expenditures should be considered when dealing with internationally mobile students and skilled workers in a fiscal competition context. The model allows us to consider those aspects simultaneously and lays open the mechanisms at work in this competition and the effect of increasing human capital mobility on governmental net revenues.

While for increasing student mobility we find higher pressure on the public budget, there is no erosion of net revenues due to ongoing globalization in the form of increasing labor mobility. In fact, net revenues even increase. The latter result is

mainly due to a tax-revenue increasing effect caused by a reduction in the wage elasticity of the number of students in a country.

The results with respect to mobility's effect on net revenues hold in a version of the model with students who are 'myopic' in the sense that they ignore future taxation and the migration costs incurred should they choose to leave the location of education already when they choose where to obtain education.[17] The equilibrium net revenues then increase with labor mobility due to a cutback in equilibrium amenities. Also, the qualitative effects of an increase in student mobility still hold, i.e. the negative effect of an intensified tax competition dominates a cutback in amenities and therefore reduces equilibrium net revenues.

In the light of the paper's insights, the regulations on the free movement of workers within the European Union and the efforts of the Bologna Process to promote graduate mobility will not necessarily lead to an undesirable competition over income tax policy, a matter still subject to Member States' authority, or even a race to the bottom in tax rates. Measures to increase student migration (which are also part of the Bologna Process), however, can expose countries to intensified competition for human capital.

[17] Please refer to the working paper version (Krieger and Lange, 2009) for the details and a related discussion of Haupt and Krieger (2009) who analyze the effects of decreasing relocation costs of firms on net tax revenues when two jurisdictions compete for those mobile firms with preferential subsidy and tax regimes.

Appendix

Equilibrium concept and slope of best-response functions

The following proves that a country has no incentive to deviate unilaterally from the symmetric solution. The two first order conditions for the optimal policies of country i, given the policies of country j, can more generally be written as

$$R^t(t_i, s_i; t_j, s_j) = 0, \tag{3.29}$$
$$R^s(t_i, s_i; t_j, s_j) = 0. \tag{3.30}$$

The Jacobian of the system of equations (3.29) and (3.30) which is the Hessian matrix of the net revenue function R_i is

$$\mathbf{H} = \begin{bmatrix} \frac{\partial R^t}{\partial t_i} & \frac{\partial R^t}{\partial s_i} \\ \frac{\partial R^s}{\partial t_i} & \frac{\partial R^s}{\partial s_i} \end{bmatrix}. \tag{3.31}$$

Evaluated at the symmetric solution, the Hessian determinant amounts to

$$\det(\mathbf{H}) = \frac{\partial R^t}{\partial t_i}\frac{\partial R^s}{\partial s_i} - \frac{\partial R^s}{\partial t_i}\frac{\partial R^t}{\partial s_i} = \frac{16w^2\Delta\widetilde{m_0}}{\Delta m \Delta m_0^2}. \tag{3.32}$$

For $\alpha = 0$, $\Delta\widetilde{m_0} := \overline{m}_0 - \underline{m}_0/(1-\alpha) - (\underline{m}^2/2\Delta m)[\alpha^2/(1-\alpha)]$ coincides with $\Delta m_0 > 0$. For $\alpha > 0$, without further assumptions on α or $\underline{m}$, the overall sign of $\Delta\widetilde{m_0}$ and therefore $\det(\mathbf{H})$ is ambiguous. In order to ensure that $\det(\mathbf{H}) > 0$, we assume $\Delta\widetilde{m_0} > 0$, which is for example guaranteed by an α which is not too large, meaning that repatriates' migration cost advantage is in some sense moderate. With this assumption, the signs of the Hessian's leading principal minors, i.e. $\operatorname{sgn}(M_{11} = \partial R^t/\partial t_i) = -1$ and $\operatorname{sgn}(M_{22} = \det(\mathbf{H})) = 1$, guarantee that $\mathbf{H}$ is negative definite and therefore R_i and R_j attain a local maximum at (t^*, s^*). In other words, the symmetric solution is an equilibrium of the fiscal competition game.

The equilibrium is basically a second-order locally consistent equilibrium (2-LCE), i.e. each country's equilibrium policy ensures a local net revenue maximum given the foreign country's equilibrium strategy, implying that no country has an incentive to deviate unilaterally from (t^*, s^*) by some small adjustment to its tax

or education policy. This concept is somewhat weaker than the Nash equilibrium which requires that each country maximizes net revenues over the whole strategy set. See for example Bayindir-Upmann and Ziad (2005), who apply the 2-LCE concept to tax competition.

The complexity of the best-response functions makes it difficult to gain a clear insight into their slopes for all possible combinations of tax rates and amenities. However, one can calculate the slopes *at the equilibrium*: suppose (i) the two countries are in an equilibrium (t^*, s^*) and (ii) for some exogenous reason, country j marginally increases its tax rate t_j (ceteris paribus, i.e. s_j remains unchanged). Applying the implicit function theorem and Cramer's rule, we can calculate

$$\left.\frac{\partial t_i}{\partial t_j}\right|_{(t^*,s^*)} = \frac{\det(\mathbf{H}_1^t)}{\det(\mathbf{H})} = \frac{1}{2} \quad , \quad \left.\frac{\partial s_i}{\partial t_j}\right|_{(t^*,s^*)} = \frac{\det(\mathbf{H}_2^t)}{\det(\mathbf{H})} = 0,$$

and in full analogy,

$$\left.\frac{\partial s_i}{\partial s_j}\right|_{(t^*,s^*)} = \frac{\det(\mathbf{H}_2^s)}{\det(\mathbf{H})} = \frac{1}{2} \quad , \quad \left.\frac{\partial t_i}{\partial s_j}\right|_{(t^*,s^*)} = \frac{\det(\mathbf{H}_1^s)}{\det(\mathbf{H})} = 0,$$

where

$$\mathbf{H}_1^s := \left[\begin{array}{cc} -\frac{\partial R^t}{\partial s_j} & \frac{\partial R^t}{\partial s_i} \\ -\frac{\partial R^s}{\partial s_j} & \frac{\partial R^s}{\partial s_i} \end{array}\right]_{(t^*,s^*)} \quad , \quad \mathbf{H}_2^s := \left[\begin{array}{cc} \frac{\partial R^t}{\partial t_i} & -\frac{\partial R^t}{\partial s_j} \\ \frac{\partial R^s}{\partial t_i} & -\frac{\partial R^s}{\partial s_j} \end{array}\right]_{(t^*,s^*)}$$

$$\mathbf{H}_1^t := \left[\begin{array}{cc} -\frac{\partial R^t}{\partial t_j} & \frac{\partial R^t}{\partial s_i} \\ -\frac{\partial R^s}{\partial t_j} & \frac{\partial R^s}{\partial s_i} \end{array}\right]_{(t^*,s^*)} \quad , \quad \mathbf{H}_2^t := \left[\begin{array}{cc} \frac{\partial R^t}{\partial t_i} & -\frac{\partial R^t}{\partial t_j} \\ \frac{\partial R^s}{\partial t_i} & -\frac{\partial R^s}{\partial t_j} \end{array}\right]_{(t^*,s^*)}.$$

Elasticity notation of the equilibrium tax rate

The combined first-order condition for the equilibrium tax rate reads

$$w - t^* w \left[\frac{2\theta^2 w}{\Delta m_0} + \frac{2w\Delta\widetilde{m_0}}{\Delta m \Delta m_0}\right] + \frac{2\theta w}{\Delta m_0}\left[\theta t^* w - \frac{\Delta m_0}{2}\right] = 0. \tag{3.33}$$

More generally, (3.33) can be expressed as

$$w + t^* w \left.\frac{\partial L_i}{\partial t_i}\right|_{(\text{equ.})} - \left.\frac{\partial S_i}{\partial t_i}\right|_{(\text{equ.})} \left[\theta t^* w - \left(\frac{\partial S_i}{\partial s_i}\right)^{-1}\Bigg|_{(\text{equ.})}\right] = 0. \tag{3.34}$$

Indices and equilibrium indications will be suppressed in order to keep the following expressions clear. First of all, the tax base effect of a marginal tax policy can be broken down into two components:

$$\frac{\partial L}{\partial t} = \frac{\partial L(\overline{S})}{\partial t} + \theta \frac{\partial S(t)}{\partial t},$$

where $\partial L(\overline{S})/\partial t = -2w\Delta\widetilde{m_0}/\Delta m\Delta m_0$ captures the direct effect on the size of the labor force for a given number of students, while $\theta(\partial S/\partial t) = -2\theta^2 w/\Delta m_0$ reflects the effect which can be traced back to the reduced number of students. θ is again the degree to which the change in the number of students is reflected in the change in tax base. With $\underline{m} = 0$, in equilibrium (implying equalized net incomes) there are basically no migration incentives for graduates and therefore a change in the number of students translates directly into the change in labor force size ($\theta = 1$). This is no longer the case for $\underline{m} < 0$, where at least some individuals emigrate even in the absence of a regional net income differential, implying $\theta < 1$. In the combined first-order condition, however, this effect cancels out and we are left with

$$w + t^* w \frac{\partial L(\overline{S})}{\partial t} + \frac{\partial S}{\partial t}\left(\frac{\partial S}{\partial s}\right)^{-1} = 0.$$

Referring to $\omega := (1-t)w$ as net labor income, this condition may be reformulated as

$$w + t^* w \frac{\partial L(\overline{S})}{\partial \omega}\frac{\partial \omega}{\partial t} + \frac{\partial S}{\partial \omega}\frac{\partial \omega}{\partial t}\left(\frac{\partial S}{\partial s}\right)^{-1} = 0.$$

Multiplying the equation by $(1-t)$, using $S^* = L^* = 1$ and solving for t^* yields the implicit solution for the equilibrium tax rate as represented by (3.21).

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4 Return Migration of Foreign Students and the Choice of Non-resident Tuition Fees

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4.1 Introduction

4.1.1 Background

The economic globalization rooted in the late 19th, early 20th century, brought about a considerable integration of the world economy, not only in the sense of international flows of traded goods, services and capital, but also international migration flows. Back in the mid 1960s and 70s, the first contributions analyzing the economic effects of labor migration on the host countries and countries of origin of human capital flows emerged (e.g., Grubel and Scott, 1966, 1968; Aitken, 1968; Raymond, 1973; Bhagwati and Dellalfar, 1973; Bhagwati and Hamada, 1974, Bhagwati, 1976). These early papers constituted a branch of the literature often referred to as the 'brain-drain literature', highlighting various issues related to the question of which regions benefit and which regions lose from these human capital flows (often in asymmetric settings with a developing and a rich country, e.g., Stark, Helmenstein and Prskawetz, 1997, 1998; Beine, Docquier and Rapoport, 2001; Stark, 2004; Docquier and Rapoport, 2007) and trying to measure the actual brain brain (e.g., Carrington and Detragiache, 1998, 1999;

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Straubhaar, 2000; EEAG, 2003; Becker, Ichino and Peri, 2004).

Countries are predicted to gain from the immigration of highly-skilled workers, so that they apply various strategies to attract those workers, for example by means of fiscal incentives (see CESifo, 2005), active immigration policies (such as special job fairs, multilingual employment-offer portals and assistance in administrative procedures during and after entry; see Chaloff and Lemaitre, 2009) and 'liberal' immigration regulations. Another way to recruit highly-skilled human capital, which this paper focuses upon, is to attract foreign students and retain them in the country after they have graduated from university. Leaving the domestic higher-educational system, they are highly skilled, and they can be easily integrated as they are also provided with some country-specific education, usually have some language proficiency and are familiar with the culture of the host country. The international mobility of students increased considerably over the last few decades (OECD, 2008a) and "[students], especially from developing countries, often stay on in OECD countries for further research or employment and contribute to innovation in these countries" (OECD, 2008b, pp. 83-84). Estimates of stay rates of foreign students within the U.S. are between one fifth (Rosenzweig, 2006, p. 24) and one third (Lowell, Bump and Martin, 2007, p. 45), or even about two thirds of foreign citizens who received a science or engineering doctorate in the U.S. (Finn, 2003, p. 5). For Germany, Hein and Plesch (2008, p. 11) report a stay rate of 35% of foreign students who participated in a special scholarship program. The host countries of foreign students (the U.S., the UK, Germany, and France are the most important ones, together hosting about 50% of all international students worldwide) seem to be quite aware of the education of foreign students being a channel of recruiting highly-skilled human capital, given their efforts to promote access of foreign students to the labor market, once they are graduated (see e.g. Tremblay, 2005; OECD, 2008b, Ch. 4; Chaloff and Lemaitre, 2009).

Alongside high-skilled labor recruitment, also the following issues play a role when evaluating the effect of educating foreign students on the host country: the compensation of potentially lacking demand for the higher educational system from domestic students, economies of scale in the educational system, a promotion of diversity and creativity on campus, increased R&D activities, cheap foreign labor for the institutions (in labs, as TA's or as support of research activities) and the reliance on tuition-fee revenues from foreign students. Especially the

latter aspect is fairly interesting, because host countries face a trade-off here between raising revenues and charging reasonable fees in order to attract foreign students, or at least not to deter them from immigration.

4.1.2 Purpose of the paper

This paper analyzes a very specific aspect in light of the ongoing internationalization of higher education, namely how optimal non-resident tuition fees change with declining stay rates of foreign students in the host country after graduation. The first intuition that fees would have to rise is usually based on a fixed-budget argument: the lower the proportion of foreign students staying on in the host country after graduation as highly-skilled human capital, the lower the benefit for the host country of educating foreign students. As a consequence, tuition fees have to rise in order to cover costs per student. This view, however, appears too narrow: (i) a more appropriate way to describe the host country's behavior is to think of tuition fees which are set to maximize some net benefit from educating foreign students, instead of balancing a fixed budget; (ii) the optimal tuition policy has to consider that the number of foreign students depends negatively on the level of fees; (iii) the demand of foreign students could depend on the expected probability of staying on in the host country after graduation. In particular the third point plays an important role in this paper; it is usually ignored in migration theory although it is crucial for the question with respect to the choice of non-resident tuition fees. Depending on what exactly causes the return migration of foreign students after graduation, a higher probability of return should have an impact on rational students' first-stage decision whether to study abroad or not. A change in demand for the educational system in the host country, in turn, should also influence the optimal choice of tuition fees. The theoretical migration literature usually treats migration decisions at various stages separately and analyzes either determinants of (first-time) emigration or determinants of return migration, ignoring that the perception of chances and preferences to stay on abroad can affect the first-round emigration decision.

The student-migration model derived in the main part of the paper shows that an increased return probability of foreign students reduces demand for education abroad and raises the sensitivity of demand to marginal changes in tuition fees.

The higher return rates can either be due to some exogenous event (either in the host country or the country of origin, forcing the student to return no matter whether he would actually like to stay on) or by a higher probability that a student ex ante overstates the positive value of the way of life abroad, causing return migration due to unmet expectations. In both cases, an increase in the return probability leads to a reduction in the expected individual benefit from staying on in the host country after graduation and therefore reduces the demand for education abroad. As a consequence, when adjusting non-resident tuition fees as a response to the declining stay rate of foreign students, the host country has to tradeoff a behavioral effect (i.e., the effect caused by the changing student migration behavior), which provides an incentive to cut back tuition fees, against the incentive to raise them due to the reduced loss of a marginal increase in fees from deterring foreign students from immigration. When the cost of education per student in the host country is not too large, the behavioral effect becomes particularly important and the host country *cuts down* on non-resident tuition fees when students' stay rates decline.

The migration model and the choice of non-resident tuition fees is analyzed in a two-country setting: a developed country ('DC', such as the UK) hosts foreign students from a less-developed country ('LDC', such as China or India). As already stated earlier, only a small number of OECD countries hosts a majority of international students. While Asia is the leading region of origin of international students, France, Germany, Japan, and Korea are the largest countries of origin. Chinese and Indian students represent by far the largest group of foreign students in OECD countries from non-OECD countries (OECD, 2008b, Ch. 3).

The structure of the paper is as follows: section 4.2 presents a first look on the problem of choosing optimal non-resident tuition fees and highlights the influence of foresighted student-migration behavior. Section 4.3 derives the student-migration and return-migration model (4.3.1) and analyzes the optimal adjustment of tuition fees when the stay rates of foreign students in the host country decline (4.3.2). A special case of 'irrational' students, who believe that they can stay on in the host country for sure and that their positive expectations about foreign lifestyle will certainly come true, is presented in 4.3.3, in order to highlight the relevance of the consideration of the behavioral effect in the student migration decision when return probabilities change. Section 4.4 briefly discusses

the monopoly assumption with respect to the supply of higher education (4.4.1) and presents an extension taking into account the composition of the pool of international students (4.4.2). Section 4.5 concludes.

4.2 Choice of non-resident tuition fees: a first look

Suppose the host country faces demand $S = S(f, p)$ (in terms of the number of foreign students), where f denotes tuition fees and p the probability that a foreign student stays on in the host country after graduating from university. The term 'tuition fees' is used in a very conceptional way in this paper and is not necessarily to be taken literally. While it appears justifiable to assume the government to be in charge of setting tuition fees in public higher educational systems (like in some European countries), a more differentiated view would be needed for countries where also private institutions play an important role in the higher-educational sector (for instance, in the U.S. tuition fees are set in a highly decentralized way in a mixed public/private setting). It could be argued, however, that the government at the state/province level could still influence the price charged to students, by providing scholarships or certain subsidies in cash or kind. In the model, the host country determines a net price for education, meaning tuition fees net of various subsidies and grants. Furthermore, foreigners can only work in the DC after graduation with a domestic university degree; i.e., immigration of workers who earned a degree in their home country (LDC) is ignored. The host country maximizes the net benefit from educating foreign students over tuition fee policy:

$$\max_f \Pi = (\pi^c + f + \delta_G p \pi^g) S(f, p), \tag{4.1}$$

where π^c denotes a net measure of costs and benefits per student to the host country during the education period (π^c could in principle be positive or negative; the cost side first and foremost includes resource costs, while the benefit side could include peer effects, cultural spillovers or economies of scale within institutions) and $\pi^g > 0$ denotes the benefit from retaining foreign students as highly-skilled human capital after graduation (this could again include some positive externalities, positive net contributions to the host country's social security system or above-average tax payments when graduates are high-income earners).

The government discounts expected future benefits by some factor $\delta_G < 1$. The first order condition for the optimal tuition fee is

$$\frac{\partial \Pi}{\partial f} = S + (\pi^c + f + \delta_G p \pi^g) \frac{\partial S}{\partial f} = 0. \tag{4.2}$$

The effect of a marginal increase of tuition fees on the number of students is predicted to be negative ($\partial S / \partial f < 0$). Survey data suggests that the high cost of U.S. tuition is the main reason why international students abstain from studying in the U.S. (Lowell et al., 2007, pp. 37-38). The optimal fee can be expressed by using the price elasticity of demand for the educational system:

$$f = -\frac{(\pi^c + \delta_G p \pi^g)}{1 + 1/\epsilon}, \tag{4.3}$$

where $\epsilon = \frac{\partial S}{\partial f} \frac{f}{S} < 0$. Ignoring expected benefits accruing to the host country from retaining foreign students after graduation, the optimal tuition-fee policy actually comes up to a standard monopoly price setting, in which $\pi^c < 0$: the host country charges a price in excess of the marginal cost of providing education and the higher the country's monopoly power (as represented by the absolute value of $1/\epsilon$, which at $f = \arg\max \Pi(f)$ equals the well-known 'Lerner index' of monopoly power), the higher tuition fees. Taking into account expected future benefits $p\pi^g$ per foreign student educated in the host country, a higher price elasticity of demand for the educational system also provides an incentive to cut back tuition fees in order to attract foreign students and realize those benefits. The overall effect depends on the relative sizes of the costs and discounted benefits per student:

$$\frac{\partial f}{\partial |\epsilon|} = \frac{\pi^c + \delta_G p \pi^g}{(1 + \epsilon)^2}. \tag{4.4}$$

The primary focus of the paper is however not on optimal tuition fees per se, but rather the effect of a decline in the stay rate of foreign students in the host country after graduation on optimal non-resident fees. From the first order condition (4.2), the effect of the students' stay rate p on the optimal level of tuition fees can be derived:

$$\frac{df}{dp} = -\frac{1}{\Sigma} \left\{ \left[\frac{\partial S}{\partial p} + (\pi^c + f + \delta_G p \pi^g) \frac{\partial^2 S}{\partial f \partial p} \right] + \delta_G \pi^g \frac{\partial S}{\partial f} \right\} \gtreqless 0, \tag{4.5}$$

where $\Sigma := 2(\partial S/\partial f) + (\pi^c + f + \delta_G p\pi^g)(\partial^2 S/\partial f^2)$ has to be negative from the second order condition. A priori, the sign of df/dp is ambiguous. The underlying reason is that the number of students is assumed to depend on the stay rate p. If S were only depending on the level of tuition fees f, i.e., $S = S(f)$, then $df/dp = -[\delta_G \pi^g(\partial S/\partial f)]/\Sigma < 0$. The lower the stay rate p, the lower the marginal loss from raising tuition fees due to the reduced number of students and therefore the higher optimal tuition fees. However, this view seems to be too narrow. Students who think of whether to study abroad or in their home country should consider (and probably do consider) the possibility of return to their home country after having studied abroad.

4.3 Student migration and the choice of non-resident tuition fees

A more thorough analysis of the question of how the host country should adjust non-resident tuition fees when a higher proportion of foreign students tends to return to their home countries should consider *why* students return and *how* this affects students' decision whether to study abroad. Furthermore, the *composition* of the group of students who potentially end up studying in the DC can play an important role, as will be demonstrated in section 4.4.2.

4.3.1 Student immigration and return

The following section presents a student-migration model to predict the sign of (4.5) from the very conceptional model above.

Various factors can influence an individual's decision in the LDC whether to study abroad. First of all, suppose that the return on education realized after graduation is higher when the student studied abroad: while a student obtains a return on education $\underline{v}$ when he studies in his home country and works there afterwards, he obtains $v^H > \underline{v}$ when working in his home country after having graduated from the foreign university. This means that, in principle, all students potentially want to study abroad. However, while education is assumed to be for free in the home country, students have to pay fees f abroad. The 'pure' return

on education in the DC is assumed to be the same in the host country and the home country of students. This assumption is mainly made for convenience and is not crucial for the main results. The more classical *brain drain* literature usually simply assumes a wage differential between the DC and the LDC. However, not only wage rates matter, but also the general price level. Furthermore, given that Chinese and Indian students, for example, have excellent career chances within their home countries with a foreign university degree and some international experience (Baruch, Budhwar and Khatri, 2007), which should allow them a good standard of living, this assumption also appears reasonable. Alongside the pure living standard in terms of earnings and career chances, a further motive for emigration is the preference for the *way of life* in the DC. While the way of life in the DC is a 'pull-factor' of migration, some characteristics of the LDC can be 'push-factors':

> [...] migration is not necessarily induced by economic reasons of self-advancement to which one may attach low weight; [...] in fact, a substantial part of migration may be induced by 'non-economic' reasons, including political difficulties and personal problems arising from the inevitable tension between traditional societal laws and institutions in LDC's and the aspirations and needs of the 'modernized' professional classes. (Bhagwati and Dellalfar, 1973, p. 95).

To some extent, push- and pull-factors are two sides of the same coin here. Therefore, I assume some difference of the quality-of-life between the host and the home country, denoted by $\Delta v = v^F - v^H > 0$, which is subjectively valued by individuals who are heterogenous with respect to the weight $\theta \in [0, \overline{\theta}]$ they attach to this quality-of-life difference.

The country-specific preference, which is represented by $\theta \Delta v$, plays an important role in the student-migration decision, primarily with regard to individual evaluations of the costs and benefits of returning to the home country after graduation. This section considers two reasons why foreign students might return: (i) they *have* to return for some exogenous reason; perhaps they do not get a work permit, they fail to find a job at the foreign labor market, or they have to take care for sick relatives at home; (ii) they *want* to return because they realize a mistake with respect to expectations about the foreign way-of-life advantage Δv. Figure

4.2 illustrates the return-migration pattern in the model.

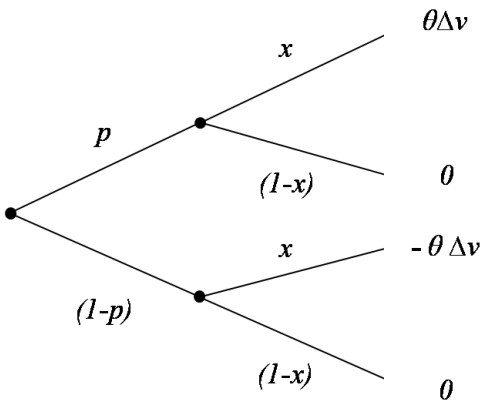

Figure 4.1: Consumption of the western way of life: stay versus return

Only after graduating, foreign students learn whether they are allowed/able to stay on in the host country; the corresponding probability is denoted by p. With some probability x, a student's ex ante valuation of the quality-of-life-difference $\theta\Delta v$ turns out to be correct. Thus, they stay on in the host country and 'consume' the extra utility $\theta\Delta v$. With probability $(1-x)$, their expectations do not come true (the country-specific preference for the host country vanishes in that case), and they return to their home country and earn v^H there. With probability $(1-p)$, an individual must return to his home country for some exogenous reason. If they belong to the group of graduates who changed their mind about the foreign way of life anyway (the probability of belonging to this group is $(1-x)$) and therefore want to return, they do not incur any utility loss but simply earn v^H in the home country. Things are different, however, for individuals who still have a preference for the foreign way of life (with probability x their expectations come true) and who are forced to return to the poor region. These individuals incur a utility loss $\theta\Delta v$ which mainly reflects the psychic cost related to involuntary migration (e.g., in the form of a reverse culture-shock).

When deciding whether to study abroad, students cannot be sure to which of the groups (i.e., those who are allowed to stay on versus those who have to return, and those who find their positive expectations about the foreign lifestyle coming true versus those who realize that they ex ante overstated the way of life abroad), so that they have to build expectations based on probabilities p and x.

Their expected extra benefit from having the option to stay on in the DC after studying abroad is $\theta x(2p-1)\Delta v$. In what follows, $p \in (1/2, 1]$ and $x \in (0, 1]$ will be assumed, so that the expected benefit is strictly positive. Please note that the stay rate of students finally is px. The assumption that $p \geq 1/2$ is therefore not too restrictive, because *overall*, stay rates could still fall short of 50%. Therefore the migration model is very well consistent with stay rates smaller than 1/2 as for example reported by Rosenzweig (2006) and Lowell, Bump and Martin (2007) for the U.S. or Hein and Plesch (2008) for Germany. In order to keep things simple in the analysis, graduates who stay on in the host country after graduation do so for the rest of their life. Although this assumption is not fully realistic because some people may want to return to their home countries once they have accumulated a certain amount of wealth, the model abstains from introducing an endogenous timing of return migration at some point in time during the working life of a highly-skilled worker (as in Dustmann, 2003; Dustmann and Weiss, 2007), because the present paper focusses on the effects of (either enforced or voluntary) return migration immediately after graduation. The main reasoning for the results should not change qualitatively in the presence of an additional return-migration decision at a later date.

The student-migration behavior can be depicted by the following indifference condition:

$$\delta_I[v^H + \hat{\theta}x(2p-1)\Delta v] - f = \delta_I \underline{v}. \tag{4.6}$$

A student is exactly indifferent between studying at home and studying abroad when the discounted net benefit from studying abroad (i.e., the return on foreign studies plus the expected extra benefit from consumption of the foreign way of life net of tuition fees) equals the discounted reservation utility $\delta_I \underline{v}$ which they obtain from studying and working in their home country. An implicit assumption with respect to the migration model as presented by indifference condition (4.6) is that foreign students can always afford non-resident tuition fees in the DC. That means that either their initial endowment is already sufficiently high or that there are no credit constraints and the direct return on education (i.e., $v^H - \underline{v}$) always exceeds individual expenses for the tuition fee. Furthermore, differences in the consumption value of education or the value of 'college life' between the two regions are ignored. The individual discount factor applied to benefits accruing in the working period is $\delta_I < 1$, for all students. All students with a valuation of

the foreign lifestyle $\theta \geq \hat{\theta}$ will study abroad, while those with a lower valuation stay on in their home country. With the overall size of the student body which is eligible for education in the DC being normalized to one, the number of students opting for education abroad is

$$S = \int_{\hat{\theta}}^{\overline{\theta}} dF(\theta) = 1 - F(\hat{\theta}),$$

where $F(\theta)$ is the cumulative distribution function of θ; the cut-off valuation of the western way of life is

$$\hat{\theta} = \frac{\underline{v} - v^H + f/\delta_I}{x(2p-1)\Delta v} \tag{4.7}$$

by indifference condition (4.6). In order to be able to derive the optimal tuition fee explicitly in the next step, θ is assumed to be uniformly distributed among foreign students over the interval $[0, \overline{\theta}]$, so that

$$S = 1 - \frac{[\underline{v} - v^H + f/\delta_I]}{\overline{\theta}x(2p-1)\Delta v}. \tag{4.8}$$

The demand of students for the educational system in the DC depends negatively on tuition fees, positively on the probability of being allowed to staying on in the host country after graduation and positively on the probability of finding one's positive expectations about foreign way of life fulfilled:

$$\begin{aligned}
\frac{\partial S}{\partial f} &= \frac{-1}{\delta_I \overline{\theta} x(2p-1)\Delta v} < 0, \\
\frac{\partial S}{\partial p} &= \frac{2(\underline{v} - v^H + f/\delta_I)}{\overline{\theta}x(2p-1)^2\Delta v} > 0, \\
\frac{\partial S}{\partial x} &= \frac{\underline{v} - v^H + f/\delta_I}{\overline{\theta}x^2(2p-1)\Delta v} > 0.
\end{aligned}$$

Technically, the positive signs for $\partial S/\partial p$ and $\partial S/\partial x$ follow from the constraint $S < 1$, which requires $[\underline{v} - v^H + f/\delta_I] > 0$. The intuition is moreover straightforward: since the expected consumption value of the western lifestyle increases with a student's possibility to stay on in the host country and with the probability that the positive expectations about the foreign way of life come true, demand for education in the rich country increases with p and x.

4.3.2 Choice of tuition fees

The government of the host country maximizes the net benefit from educating foreign students:

$$\max_f \Pi = (\pi^c + f + \delta_G p x \pi^g) S(f, p, x) \quad \text{s.t.} \quad S(f, p, x) \in (0, 1). \tag{4.9}$$

The first order condition for the optimal non-resident tuition fee, using the education demand function as represented by (4.8), which was derived from the migration model, reads:

$$\frac{\partial \Pi}{\partial f} = 1 - \frac{[\underline{v} - v^H + f/\delta_I]}{\overline{\theta} x (2p-1)\Delta v} - \frac{(\pi^c + f + \delta_G p x \pi^g)}{\delta_I \overline{\theta} x (2p-1)\Delta v} = 0, \tag{4.10}$$

from which the optimal fee can be determined as

$$f = \frac{1}{2}\left[\delta_I \overline{\theta} x (2p-1)\Delta v + \delta_I (v^H - \underline{v}) - (\pi^c + \delta_G p x \pi^g)\right]. \tag{4.11}$$

The restriction on the parameter range for the stay rate, $p \in (1/2, 1]$, ensures the second order condition for a maximum to hold. A decline in the percentage of foreign students staying on in the host country can be due to a decline in p or in x. Tuition fees are adjusted accordingly:

$$\frac{df}{dp} = x\left(\delta_I \overline{\theta} \Delta v - \delta_G \frac{\pi^g}{2}\right), \tag{4.12}$$

$$\frac{df}{dx} = \frac{1}{2}\left[\delta_I \overline{\theta} (2p-1)\Delta v - \delta_G p \pi^g\right]. \tag{4.13}$$

The direction of both adjustments is a priori ambiguous. As already argued based on the more conceptional version of the model in section 4.2, different return-migration patterns of graduates affect not only the benefits of the host country from educating foreign students, but also the students' migration behavior. Both aspects must be taken into account by the optimal tuition fee. On one hand, the lower the stay rate of graduates (i.e., the lower px), the lower the marginal cost of raising tuition fees due to the fee's deterrent effect on the number of foreign students and therefore the higher the non-resident fee. This effect is in each case represented by the second term in brackets in equations (4.12) and (4.13). On the other hand, the expected stay rate affects the student-migration pattern: (i) the

lower the expected stay rate, the lower total demand S and therefore, the lower the marginal benefit from raising tuition fees (the idea is analogous to the argument that a smaller tax base implies a smaller marginal benefit from increasing the tax rate); (ii) the lower the expected stay rate, the higher the absolute value of the sensitivity of demand to tuition fees, i.e., $\partial(|\partial S/\partial f|)/\partial\rho < 0$, $\rho \in \{p, x\}$, and therefore the higher the marginal cost of rasing tuition fees. The corresponding (combined) effect which implies an incentive to cut back tuition fees is represented in both cases by the first term in brackets in (4.12) and (4.13). I refer to the latter effects as the 'behavioral effects', which are directly opposed to the more direct 'revenue effects'. The behavioral effects become more relevant the larger the difference in the quality of life for highly-skilled individuals between the host and the country of origin (as represented by Δv) and the larger students' average ex ante valuation of the western way of life ($\overline{\theta}/2$). The difference in the validation of expected benefits in the future from the individual perspective and the host-country perspective also plays a role: the greater the importance of future payoffs for individuals' utility relative to the importance to governments' objectives (i.e., the larger δ_I relative to δ_G), the larger the behavioral effects relative to the revenue effects in both (4.12) and (4.13) and therefore the more likely a decline in tuition fees when stay rates of foreign students diminish.

The overall signs of df/dp and df/dx finally depend on the relative size of the parameter values in the model. Taking into account that the set of parameters has to ensure that the constraint $S(f, p, x) \in (0, 1)$ is met given the optimal choice of tuition fees, however, one can at least come up with the following insight: if the cost of education per student in the host country is not too large or if the host country's educational system even observes a net benefit ($\pi^c > 0$) from educating foreign students, the effect of a declining stay rate of students in the host country on non-resident tuition fees can be unambiguously signed:

Proposition 4.1 *$\delta_I(v^H - \underline{v}) > -\pi^c$ is a sufficient condition for the optimal non-resident tuition fee to be cut back if the stay rate of foreign students (from an LDC) in the host country (DC) after graduation declines; i.e., $df/dp > 0$ and $df/dx > 0$.*

Proof. Please refer to the Appendix. ■

Verbally, $\delta_I(v^H - \underline{v}) > -\pi^c$ means that the individual discounted direct return to education in the foreign country has to exceed the cost of education per student. This also includes cases where $\pi^c \geq 0$, meaning that the host country actually already benefits from the education of foreign students during the education period and not only when they stay on as highly-skilled workers.

The analysis in this section highlights that the consideration of the adjustment of students' migration behavior when the return-migration pattern after graduation changes is crucial for the optimal adjustment of non-resident tuition fees. Given that the condition in Proposition 4.1 holds, the behavioral effects will dominate the revenue effects, and therefore a decline in the stay rate of foreign students induces a decline in tuition fees. For all other cases, the overall signs of df/dp and df/dx depend on the relative sizes of the other parameters in the model, as explained above. The condition $\delta_I(v^H - \underline{v}) > -\pi^c$ is a sufficient but not a necessary condition for $df/dp > 0$ and $df/dx > 0$.

4.3.3 Special case: irrational expectations

A special case of the analysis presented above arises if students have irrational expectations in the sense that they believe that (i) they are allowed to stay in the host country for sure and (ii) they will not change their mind with respect to the valuation of the foreign way of life to be enjoyed when staying on in the host country. In other words, in their first-round (student-) migration decision, they mistake probabilities p and x (i.e., they take $p = x = 1$ for granted). In that case, the demand for education in the rich country is

$$S^{IR} = 1 - \frac{[\underline{v} - v^H + f/\delta_I]}{\overline{\theta}\Delta v} \geq S \tag{4.14}$$

and the optimal tuition fee can be calculated as

$$f^{IR} = \frac{1}{2}\left[\delta_I \overline{\theta}\Delta v + \delta_I(v^H - \underline{v}) - (\pi^c + \delta_G p x \pi^g)\right] \geq f. \tag{4.15}$$

Since irrationality of students effectively result in higher country-specific preferences for the DC (from an ex ante perspective) and therefore also a lower sensitivity of the number of foreign students to a marginal increase in tuition fees, unsurprisingly f^{IR} exceeds the tuition fee f from the main section above if

the *actual* stay rate px is smaller than one. The comparative-static effects with respect to the stay rate of foreign students are unambiguous:

Proposition 4.2 *With students having irrational expectations in the sense that they wrongly believe that they can stay on in the foreign host country of education (DC) for sure and that their positive perception of the western way of life will not change once they really became acquainted with living abroad, non-resident tuition fees in the DC will unambiguously increase with a declining stay rate of foreign students.*

This can be directly seen from

$$\frac{df^{IR}}{dp} = -\delta_G \frac{x\pi^g}{2} < 0, \tag{4.16}$$

$$\frac{df^{IR}}{dx} = -\delta_G \frac{p\pi^g}{2} < 0. \tag{4.17}$$

Non-resident tuition fees increase with a declining stay rate of foreign students. The reason is that a behavioral effect as presented in section 4.3.2 does not exist due to the irrationality of students. The remaining revenue effect then explains the increase in tuition fees.

This special case of irrational students serves as a benchmark vis-à-vis the model with students who have realistic expectations about the chances and the preferences for life spent in the DC after being educated there. Depending on the perception of students' decision making, in light of these two (polar) cases a change in student return-migration might affect non-resident tuition fees raised in the host country in a directly opposed way.

Given the case of students having irrational expectations, the comparative-statics in the rational-expectations setting in section 4.3.2 can actually be written as

$$\frac{df}{dp} = \underbrace{\frac{df^{IR}}{dp}}_{(<0)} + \underbrace{x\delta_I\overline{\theta}\Delta v}_{(>0)}, \tag{4.18}$$

$$\frac{df}{dx} = \underbrace{\frac{df^{IR}}{dx}}_{(<0)} + \underbrace{\frac{1}{2}\delta_I\overline{\theta}(2p-1)\Delta v}_{(>0)}. \tag{4.19}$$

4.4 Discussion and extension

This section briefly discusses the monopoly assumption in the main part of the paper and analyzes whether results still hold for alternative market forms (4.4.1) and takes into account a further group of international students, namely those who want to study abroad but intend to return to their home country immediately after graduation (4.4.2).

4.4.1 Competition for students in an oligopoly

The two-country setting which is used in sections 4.2 and 4.3 in order to illustrate how non-resident tuition fees in a DC, which is a monopolist in higher education, depend on the return-migration behavior of foreign students from LDC's is of course highly stylized. Given the fact that a handful of DC's actually host a majority of international students, it can be argued that an oligopoly should be the object of investigation capturing the fact that some large players are competing for the pool of potentially international students. Thus, this section briefly discusses tuition-fee competition in a duopoly setting. When it comes to the evaluation of a change in the return-migration behavior of foreign students after graduation on equilibrium tuition fees, the players' market power is shown to determine whether a behavioral effect as described earlier exists and therefore how tuition fees are finally adjusted.

Suppose first of all two identical countries (denoted by 1 and 2) which compete in a classical *Bertrand* set-up: both countries offer identical higher-educational systems and maximize net benefits from educating foreign students over non-resident tuition fees, which are chosen in both countries simultaneously. Students from the LDC do not have any country-specific preferences with respect to DC 1 or 2, so that demand for education in DC i is

$$S_i^B(f_i, f_{-i}, p, x) = \begin{cases} S^B(f_i, p, x) & \text{if } f_i < f_{-i} \\ \frac{1}{2} S^B(f_i, p, x) & \text{if } f_i = f_{-i} \\ 0 & \text{if } f_i > f_{-i}. \end{cases} \tag{4.20}$$

In the (unique) Nash equilibrium (f_1^*, f_2^*), both countries set their tuition fees

equal to costs net of non-tuition benefits accruing in the future; i.e.,

$$f_1^* = f_2^* = f^* = -(\pi^c + \delta_G p x \pi^g). \tag{4.21}$$

Each country faces an infinitely elastic demand curve given the tuition fees charged by the other country, and therefore, the game results in the perfectly competitive outcome. In the pure Bertrand case with fierce price competition, the behavioral effect of a change in foreign students' return-migration behavior on the first-round demand for education abroad does not play any role for the adjustment of equilibrium fees: a decrease in stay rates, either caused by a decline in p or x, raises equilibrium tuition fees unambiguously; i.e., $df^*/dp, df^*/dx < 0$. The more students return to their home countries after graduation, the less fierce becomes competition in DC's for these students and therefore the higher equilibrium tuition fees.

The story changes, however, if students are assumed to perceive some difference among the higher-educational systems in the two countries. In contrast to the standard Bertrand game, the two host countries of foreign students now have some market power due to *product differentiation*. I will not specify the product differentiation any further because my focus is finally on the effect of stay rates of foreign students on equilibrium tuition fees. Beside differences within the higher-educational system itself, one could for example also think of spatial models of education differentiation in which LDC-students differ in their relative distance (e.g., in the sense of geographic and/or cultural distance) to one of the two DC's.

Country i then faces a demand of foreign students represented by a continuous function $S_i^{PD}(f_i, f_{-i}, p, x)$ (note that the demand function $S_i^B(f_i, f_{-i})$ was *dis*continuous at $f_i = f_{-i}$) with $\partial S_i^{PD}/\partial f_i < 0$ and $\partial S_i^{PD}/\partial f_{-i} > 0$. Each country i chooses tuition fees f_i given tuition fees $\overline{f}_{-i}$ in the other country in order to solve

$$\max_{f_i} \Pi_i = (\pi^c + f_i + \delta_G p x \pi^g) S_i^{PD}(f_i, \overline{f}_{-i}, p, x).$$

Country i's best-response function $b(f_{-i})$ is implicitly determined by

$$S_i^{PD}(f_i, \overline{f}_{-i}, p, x) + (\pi^c + f_i + \delta_G p x \pi^g) \frac{\partial S_i^{PD}(f_i, \overline{f}_{-i}, p, x)}{\partial f_i} = 0. \tag{4.22}$$

Analogous to the monopoly setting, the behavioral effect now comes again into play when analyzing a decline in students' stay rates. I will focus here on a decline in p. The analysis of a decreasing x is in full analogy. For given $\overline{f}_{-i}$, the optimal tuition fee f_i either increases or decreases with p, depending on the strength of the behavioral effect:

$$\begin{aligned} \left.\frac{df_i}{dp}\right|_{b(f_{-i})} &= -\frac{1}{\Gamma}\left[\frac{\partial S_i^{PD}}{\partial p} + (\pi^c + f_i + \delta_G p x \pi^g)\,\frac{\partial^2 S_i^{PD}}{\partial f_i \partial p}\right] \\ &\quad - \frac{1}{\Gamma}\delta_G x \pi^g \frac{\partial S_i^{PD}}{\partial f_i} \quad \gtreqless 0, \end{aligned} \tag{4.23}$$

where $\Gamma := 2(\partial S_i^{PD}/\partial f_i) + (\pi^c + f_i + \delta_G p x \pi^g)(\partial^2 S_i^{PD}/\partial f_i^2)$ has to be negative from the second order condition. For $\partial S_i^{PD}/\partial p, \partial^2 S_i^{PD}/(\partial f \partial p) > 0$, as in the main section of the paper, the behavioral effect (term in squared brackets) opposes the more standard effect through the reduced marginal cost of deterring students from immigration by rising tuition fees when p decreases. Thus, the equilibrium fee f^* either decreases when p decreases (that is the case when the behavioral effect is dominant; see the stylized diagram (a) in figure 4.2) or increases (that is the case when the behavioral effect is offset; see diagram (b) in figure 4.2).

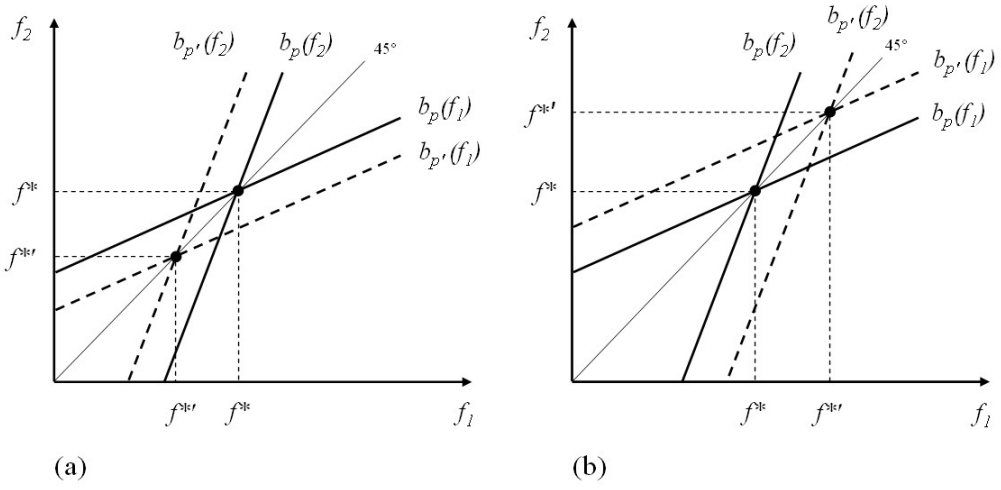

Figure 4.2: Bertrand competition with differentiated education; $p' < p$

Therefore the main result in section 4.3 derived from a monopoly setting still holds if countries are assumed to offer some differentiated higher education and therefore effectively have some market power.

4.4.2 Composition of the pool of international students

The analysis so far focused on a special sub-group of real-life foreign students, namely those who ex ante *intend to stay* in the host country after graduation (given that their expectations about foreign lifestyle are fulfilled). One might call this group IS-students (for 'intend to stay'). Another group that can be of interest is students who want to study abroad in order to increase career chances and the individual living standard within their home country upon return and actually never intended to stay on in the host country (one might call them MA-students for 'mission-accomplished' because they intend to return immediately after graduation).

Taking this latter group into account, a decline in the stay rates of foreign students can also be caused by a shift in the composition of foreign students from less IS-students to more MA-students. The MA-students are assumed to return for sure in case they decide to study abroad. The number of MA-students going for education in the DC depends negatively on tuition fees. In order to study the composition effect, suppose a fraction $n \in (0,1)$ of the whole foreign student body who potentially studies in the DC is of the MA-type and the fraction $(1-n)$ of the IS-type. The DC has no information on the individual types, but only knows the composition of the student body, i.e., n. The total demand for the foreign educational system is

$$S(f) = nS^{MA}(f) + (1-n)S^{IS}(f), \tag{4.24}$$

where S^{MA} and S^{IS} are the numbers of students from each group actually studying abroad.

I will not present a specific migration model here, but derive an implicit solution for f and df/dn. The rich country's optimization problem reads

$$\begin{aligned} \max_f \Pi \quad &= \quad (\pi^c + f)S(f) + \delta_G p x \pi^g (1-n) S^{IS}(f) \\ &\text{s.t.} \quad S(f) = nS^{MA}(f) + (1-n)S^{IS}(f). \end{aligned} \tag{4.25}$$

The first order condition for the optimal tuition fee f is

$$\frac{\partial \Pi}{\partial f} = (\pi^c + f)\frac{\partial S}{\partial f} + S + \delta_G p x \pi^g (1-n)\frac{\partial S^{IS}}{\partial f} = 0. \tag{4.26}$$

See that an increase in n implies a decline in the stay rate of foreign students due to the shift towards MA-students. The effect on the optimal tuition fee can be calculated as

$$\frac{df}{dn} = -\frac{1}{\Omega}\left[(\pi^c + f)\left(\frac{\partial S^{MA}}{\partial f} - \frac{\partial S^{IS}}{\partial f}\right) + (S^{MA} - S^{IS}) - \delta_G p x \pi^g \frac{\partial S^{IS}}{\partial f}\right], \quad (4.27)$$

where $\Omega := 2(\partial S/\partial f) + (\pi^c + f)(\partial^2 S/\partial f^2) + \delta_G p x \pi^g (\partial^2 S^{IS}/\partial f^2)$ has to be negative from the second order condition.

According to (4.27), the overall effect can be decomposed in three components. First of all, the differences in sensitivities of demand for education abroad to a marginal increase in tuition fees between the two subgroups matters. If the demand from the MA-group, for example, reacts less strongly on a change in tuition fee policy than the demand from the IS-group (i.e., $|\partial S^{MA}/\partial f| < |\partial S^{IS}/\partial f|$) and if tuition fees fall short of education costs per students (i.e., $\pi^c + f < 0$ so that the host country incurs a loss per student from training international students during the education period), a shift in the overall demand from IS-students to MA-students – ceteris paribus – represents an incentive to cut back tuition fees. If, however, the demand from the IS-group is less sensitive, or tuition fees per student exceed costs per student, there is an incentive to raise tuition fees. This effect is represented by the first term within squared brackets.

Second, demand for education abroad within the two subgroups plays a role. If for example more individuals from within the IS-group opt for education in the DC than individuals from within the MA-group, a shift towards a larger MA-group and therefore a smaller IS-group (i.e., a higher n, implying a higher overall return rate of foreign students) means a reduced marginal revenue from raising tuition fees, so that there is an incentive to cut back fees. This effect is represented by the second term within squared brackets.

Finally, the third term within squared brackets represents an incentive to raise tuition fees if the stay rate of graduates (caused by an increase in n) declines. The reason is that a shift in the composition of foreign students towards MA-types effectively reduces the marginal cost of raising fees caused by the fees' negative effect on the demand from the IS-group and the related loss of post-education benefits to the host country.

Overall, without any further specifications of the migration behavior of students,

the sign of df/dn is ambiguous. The development of a model which explicitly derives the migration decision of MA-students and relates that to the migration behavior of IS-students is left for further research.

4.5 Conclusion

This paper started from the observed increasing relevance of international student mobility and the fact that some international students intend to stay on in the host country of education after graduation, which is probably especially true for students from LDC's who opt for higher education in an OECD country (DC). Host countries can thus benefit from educating foreign students beyond the pure period of education. When the choice of tuition fees for international students in the host country takes into account these benefits, the optimal fees will also depend on the stay rate of students after graduation. The paper argues that for changing stay rates, the host country has not only to consider the direct effect on the expected benefits from retaining foreign students as highly-skilled human capital, but also a behavioral effect which reflects the adjustment of student-migration behavior. Rational students are aware of the fact that they might return to their home countries after being educated abroad, even if they initially intended to stay on in the host country in order to be employed there, for further research or for launching a business. While the reasons for return can be manifold, the main part of the paper focusses on scenarios where (i) students return as graduates because they are 'forced' to do so (no matter what their actual preferences are) or (ii) because once staying abroad, they realize that their positive expectations about the foreign way of life did not come true. At the time when deciding whether to study abroad, students can only build expectations about whether they might return for one of these reasons, although they ex ante intend to stay on in the host country. If students' perception of these events to occur in the future changes, their expected benefits from studying abroad and therefore their first-round location decision is altered. The optimal adjustment of tuition fees in the host country, finally, has to consider both the direct effect of a change in the stay rate of foreign students and the behavioral effect, which alters demand for its educational system and which is directly opposed to the direct effect. If the cost of education per student is not too high, the behavioral

effect is dominant, so that a decline in stay rates of students in the host country induces a cutback in non-resident tuition fees.

According to Gmelch (1980), return migrants can be assigned to one of three broader categories: (i) those who intended to stay but are *forced* to return, (ii) those who intended to stay but *choose* to return and (iii) those who only intended temporary migration and return when they have achieved their objectives abroad. The migration model in the main part of the paper captured the first two categories. The extension in section 4.4.2 considered returning graduates from the third category, and analyzed a scenario where a decline in stay rates is caused by a shift in the composition of the group of potential foreign students from those who intend to stay abroad after graduation to those who intend to return promptly after having 'accomplished their mission'.

There are several aspects which are closely related to the issues analyzed in the present paper and which deserve more attention in future research. While the model treated the cause of return migration exogenously, the host country could also try to actively influence the stay rates of foreign students after graduation. This can include immigration legislation, efforts to integrate foreign students into the domestic society and to reduce their risk of failure to adapt, the provision of country-specific human capital and measures to facilitate national labor market access. The predicted positive impact on stay rates, from which the host country hopes to benefit, then has to be contrasted with the cost of introducing and extending these policies, which includes resource costs and political costs.

Further issues arise when also taking into account the source countries' perspective and recognizing that DC's might not only maximize 'profits' from educating foreign students, but could also be committed to foreign-aid aspects of training international students, thereby considering explicitly the utility of students as well as the source countries' welfare. Furthermore, the present analysis also ignores the source country as an active 'player' in the competition for highly-skilled human capital: LDC's can in fact apply various policies to retain students or rather to promote their repatriation as graduates in case they went for education abroad (see for example Gribble (2008) for an overview of policy options employed by countries experiencing some significant student outflow) so that DC's and LDC's actually could interact strategically, both using quite different policies.

Appendix

The proof of Proposition 4.1 uses the constraint that the optimal tuition fee f is supposed to imply an interior solution with respect to the foreign demand for the educational system in the DC. The constraint that the exogenous parameters in the model have to ensure that $S(f = \arg\max \Pi(f))$ is strictly smaller than one (i.e., not the entire pool of potential international students ends up in the DC) can be written as

$$\delta_I \overline{\theta} x(2p-1)\Delta v - \delta_G p x \pi^g > \delta_I(v^H - \underline{v}) + \pi^c, \tag{4.28}$$

where I used the optimal tuition fee as of (4.11) in the demand function $S(f, \cdot)$ as given by (4.8). This constraint directly shows that if the right hand side of the inequality is positive, the left hand side has to be positive as well, i.e., $\delta_I(v^H - \underline{v}) + \pi^c > 0$ implies $\delta_I \overline{\theta} x(2p-1)\Delta v - \delta_G p x \pi^g > 0$, the latter finally implying $df/dx > 0$ as can be seen from (4.13). This proves the first part of the proposition. The second part, namely $df/dp > 0$, can be proved as follows: see that $\delta_I \overline{\theta} x(2p-1)\Delta v - \delta_G p x \pi^g > 0$ can be written as

$$\frac{\delta_I}{\delta_G} > \frac{p\pi^G}{\overline{\theta}(2p-1)\Delta v}. \tag{4.29}$$

See that from (4.12), df/dp is positive if

$$\frac{\delta_I}{\delta_G} > \frac{\pi^G}{2\overline{\theta}\Delta v}. \tag{4.30}$$

The fact that $\frac{p\pi^G}{\overline{\theta}(2p-1)\Delta v} > \frac{\pi^G}{2\overline{\theta}\Delta v}$ from the assumed range of p (namely $p > 1/2$), ensures that (4.30) also automatically holds when (4.29) is fulfilled, thereby proving that $df/dp > 0$.

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5 Competition for the International Pool of Talents: Education Policy with Student Mobility

Joint work with Alexander Haupt and Tim Krieger.
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5.1 Introduction

The ongoing internationalization of higher education creates a significant challenge for national educational policies within the OECD area. The number of international students (i.e., students enrolled outside their country of citizenship) has grown considerably over the last thirty years and growth has been accelerated especially over the last couple of years. Since the year 2000, the number of foreign students within OECD countries has increased by more than 50%. The four top destinations, namely the U.S., the UK, Germany, and France host about half of the entire international student body. Besides Korea and Japan, France, and Germany are also the largest sending countries. Overall, Asia is by far the largest sending *region* of origin of foreign students. Apart from students from OECD members Korea and Japan, especially students from China and India largely contribute to the group of international students. With 15.4% (China) and 5.4% percent (India), they represent the largest group of students from OECD partner countries enrolled within the OECD.[1]

This paper analyzes an oligopolistic competition under quality differentiation

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[1] See OECD (2008, ch. C3).

with two developed countries competing for a pool of students from 'the rest of the world (ROW)', by which we especially mean less developed non-OECD countries. The two host countries can choose educational quality and tuition fees to maximize the rent from educating foreign students. In equilibrium, they are demonstrated to differentiate educational qualities in order to relax tuition-fee competition. The regional quality differentiation increases with the size of the international pool of talents, with the stay rate of foreign students in the host countries after graduation and with the degree of development of the sending region of foreign students. A brief welfare analysis shows that the allocation of students to the two host countries and the regional quality differentiation are likely inefficient. The cost of providing educational quality plays an important role for the welfare analysis.

In principle, a country might be interested in attracting students from abroad in order to overcome national bottlenecks in finding qualified students, raise additional tuition-fee revenue, benefit from research output by foreign graduate students or positive spillovers from foreign to domestic students, to the university or to society as a whole.[2] Furthermore, given that part of foreign students stay on in their host country as graduates (see e.g., Lowell, Bump and Martin, 2007; Rosenzweig, 2006; Dreher and Poutvaara; 2005; Finn, 2003), the acquisition of students represents a strategy to attract highly-skilled human capital. The fact that several OECD countries take measures to promote foreign students' national labor-market access after graduation (see e.g., Tremblay, 2005; Chaloff and Lemaitre, 2009), indicates that countries are aware of this option. Within the model, the positive effect of students staying on in the host country as graduates is represented by income tax revenue. Income tax rates and immigration policy are exogenous.

The analysis contributes to the literature on local public-educational policy with student mobility. In a fiscal-competition setting, Del Rey (2001) finds that countries tend to underinvest in public education if foreign students can free-ride the local educational system, especially as they are all assumed to return to their country of origin after graduation and therefore do not pay any income taxes in the host country. Büttner and Schwager (2004) state that positive external

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

effects on non-resident students may cause local underprovision if policy makers only consider the welfare of native students when deciding on educational quality. This underinvestment justifies a tuition fee which is set on the federal level and which effectively raises the incentive to provide quality in order to attract students who pay these fees. A contribution coming closer to our model is presented by Boadway, Marceau and Marchand (1996). They analyze the competition of two private schools with quality investments and tuition fees. In a symmetric equilibrium, these institutions may spend an inefficiently large amount of resources in order to attract students. While we also consider competition both in prices (i.e., tuition fees) and quality, our focus is on public higher education, implying that decision makers (i.e., politicians, governments) also account, for example, for expected benefits in the form of income tax revenue from graduates staying on in the host country after graduation.

An important difference between the present approach and the studies mentioned so far, is that the two countries in our model compete for students from a *third* country (ROW). If ROW students do not have any ex ante country-specific preferences for one of the potential host countries and if both countries are exactly identical, students must be regarded as perfectly mobile when it comes to their decision on the location of education. They will thus only consider regional quality differences and tuition-fee differences. As a consequence, a symmetric equilibrium will ultimately not exist. One country provides higher quality and charges higher tuition fees than the other country, thereby also attracting the most talented students. The quality differentiation effectively prevents fierce tuition-fee competition for the perfectly mobile pool of international students. This result is in some way analogous to Kemnitz's (2007) finding of differentiated teaching qualities and tuition fees in the context of competition between autonomous universities.

The paper is organized as follows. Section 5.2 sets up the basic model and analyzes the competition of host countries in an oligopolistic model under quality differentiation. This section also presents the comparative statics. Section 5.3 presents the welfare-maximizing solution and evaluates the decentralized equilibrium accordingly. Section 5.4 relates the differentiation result to the literature and discusses some implications of the comparative statics for the sending countries of foreign students. Section 5.5 concludes.

5.2 The model

5.2.1 Basic setting

This section sets the stage for the analysis of the competition of two host countries for foreign students in a duopoly model with vertical product differentiation (i.e., differentiation in the quality of education). On the demand side it presents foreign students' preferences and migration decisions, and on the supply side it presents host countries' objectives.

The market size, that is total demand from ROW for one of two ex ante identical developed host countries of education is exogenous and denoted by N. Students from this 'pool of international talents' are heterogenous with respect to ability, denoted by a, which is uniformly distributed over the unit interval and which captures an individual's capacity to exploit educational quality. Students allocate themselves to the host countries, such that their expected net benefit from studying abroad is maximized. Thereby, they consider expected net incomes in the future and tuition fees for higher education. Net income equals returns on education abroad net of income taxes. The return on education in one of the developed countries consists of some base salary $\underline{w}$ and an educational premium $aq_i \geq 0$, where $q_i \geq 0$ is quality of education in country i and $a \in [0,1]$ is individual talent to acquire human capital. Talent and university quality are complementary in the production of the educational premium. Labor income is taxed at rate $\tau \in [0,1]$ in countries 1 and 2, and at rate $\tau_{\text{ROW}} \in [0,1]$ in ROW.

Although labor incomes in the western countries possibly exceed those in ROW, there are usually non-economic reasons for foreign students to return to their home countries as graduates. These are represented by an exogenous repatriation rate $(1-p)$, with $p \in [0,1]$ as a graduate's stay rate in the host country (which is the probability that a foreign student stays on after graduation). Examples for repatriation motives are failure of social integration in the host country, private (e.g., family) issues in the country of origin, homesickness, problems with regard to the change of status from student to permanent immigrant in the host country, or labor market frictions.[3] Repatriates earn a fraction $\gamma \in [0,1]$ of western labor

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

income in their home countries. At the student migration stage, individuals already anticipate that they will stay on in the host country only with probability p; however, information on whether they belong to the group of repatriates is only revealed after graduation.[4]

Expected net labor-income of a graduate with ability a is

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

As ROW is supposed to be a developing region, the ROW net income of a graduate from a university in one of the host countries never exceeds this graduate's net income when staying on in one of the developed countries:

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

A student's choice of the location of education is determined by expected income, given the quality levels of the educational systems in both countries and tuition fees, which are denoted by t_i. We do not restrict tuition fees to be positive, but perceive t_i as a net measure of tuition fees and subsidies per student. The student who is exactly indifferent between studying in one of the host countries has ability $\hat{a}$, which is determined by

$$\varrho(\underline{w} + \hat{a}q_1) - t_1 = \varrho(\underline{w} + \hat{a}q_2) - t_2 \quad \Leftrightarrow \quad \hat{a} = \frac{t_2 - t_1}{\varrho \Delta q}, \tag{5.1}$$

[4] We ignore the possibility that a foreign-born graduate leaves the host country of education in order to work in the other developed country. There are good reasons to believe that this assumption is not too restrictive: (i) spending several years within the host country usually means that people have built up some social- (maybe even family-) ties and therefore have some attachment to the country; furthermore, foreign students are usually (at least to some extent) integrated in the local society of the host country, while they would have to start the integration process anew in the other country (which can be quite demanding, especially the larger the cultural difference between the host country and the new location of residence); (ii) the graduate can be integrated in the host country's labor market much more easily, because he is familiar with the country's culture (including its language) and has acquired some country-specific human capital; in addition, the host country might facilitate visas and work-permits if the applicant has successfully graduated from a domestic university (e.g., Germany allows foreign graduates from a German university to stay on in the country for one year in order to find a job and exempts applicants from the labor-market test; see Chaloff and Lemaitre, 2009, for similar procedures in other OECD countries).

where $\Delta q = q_2 - q_1 \geq 0$ denotes the regional quality differential. Whenever we consider differentiated higher-educational systems, we refer to country 2 as the higher-quality country. Highly-talented students (i.e., those with $a \geq \hat{a}$) opt for higher-quality education in country 2, while all others allocate to region 1.[5]

The number of students in the lower-quality country 1 then is

$$N_1 = N \times \begin{cases} \hat{a} & \text{if} \quad \hat{a} \in [0,1], \\ 1 & \text{if} \quad \hat{a} > 1, \\ 0 & \text{if} \quad \hat{a} < 0, \end{cases} \tag{5.2}$$

where N is the total size of the talent pool. The number of students in country 2 is $N_2 = N - N_1$.

For identical quality levels in both countries (i.e., $\Delta q = 0$), the size of the foreign student population in each country can no longer be determined by indifference condition (5.1). As students do not have any country-specific preferences, for equal qualities, all students would study in the country with lower tuition fees. If both countries offer identical educational qualities *and* tuition fees, students allocate themselves randomly such that both countries end up with an overall number of foreign students of $N/2$ and face equal demand from all ability types in the distribution of talents; i.e. for $\Delta q = 0$,

$$N_i|_{\Delta q=0} = \begin{cases} 0 & \text{if} \quad t_i > t_j, \\ N/2 & \text{if} \quad t_i = t_j, \\ N & \text{if} \quad t_i < t_j. \end{cases} \tag{5.3}$$

Host country governments are maximizing net benefits or rather rents from offering an international study program. On the benefit side, foreign students pay tuition fees and students who stay on in the country of education as graduates generate tax revenue (income is proportionally taxed at rate τ). On the cost side,

[5] The migration model relies on some implicit assumptions: (i) ex ante, foreign students do not have any 'attachment' to one of the two regions (in the sense of country-specific preferences, existing social networks, language and geographical/cultural distance); (ii) all students in the pool of talents can afford paying tuition fees when studying abroad (either because there are no credit constraints or because their initial endowment is sufficiently large); (iii) studying abroad is always preferred to studying/working in the country of origin.

there are variable costs (i.e., costs of providing quality per student) $c(q_i) = \alpha q_i$, $\alpha \in [0, 1]$, and fix costs, which are represented by a continuous function $F(q_i)$ with $\partial F/\partial q_i > 0$, $\partial^2 F/\partial q_i^2 > 0$ and $F(0) = 0$.

If educational systems are differentiated, the objective function of government 1 reads[6]

$$R_1 = \tau W_1 + N_1[t_1 - c(q_1)] - F(q_1), \tag{5.4}$$

where the wage sum or rather the foreign-born tax base is

$$W_1 = pN \int_0^{\hat{a}} (\underline{w} + aq_1)da = pN_1 \left[\underline{w} + \frac{1}{2}\frac{(t_2 - t_1)}{\varrho \Delta q} q_1\right].$$

Tax revenue from foreign students who stay on in the host country after graduation can be used, for example, to finance transfers to domestic low-skilled/low-income workers (who are not explicitly considered in the model). The rent from educating foreign students can be decomposed into a variable part, which depends on the number of students, and into fix costs:

$$R_1 = N_1 \left\{p\tau \underline{w} + \frac{p\tau}{2}\frac{(t_2 - t_1)}{\varrho \Delta q} q_1 + t_1 - c(q_1)\right\} - F(q_1). \tag{5.5}$$

The product $p\tau$ basically represents a country's effective rate of return to a marginal increase in foreign students' incomes. Analogously, the objective function in country 2 is

$$R_2 = N_2 \left\{p\tau \underline{w} + \frac{p\tau}{2}\left(1 + \frac{t_2 - t_1}{\varrho \Delta q}\right) q_2 + t_2 - c(q_2)\right\} - F(q_2), \tag{5.6}$$

where we used

$$W_2 = pN \int_{\hat{a}}^1 (\underline{w} + aq_2)da = pN_2 \left[\underline{w} + \frac{1}{2}\left(1 + \frac{t_2 - t_1}{\varrho \Delta q}\right) q_2\right].$$

[6] The analysis does not include domestic students, as the focus of the paper is on the competition for foreign students. The government determines the educational quality of an international study program and the corresponding price charged to foreign students. With this interpretation, domestic students are irrelevant for the analysis.

5.2.2 Quality and tuition fee competition

The two host countries engage in a two-stage Nash-type competition. At the first stage, both regions simultaneously choose quality levels q_i, while tuition fees t_i are determined at a second stage. The timing is analogous to Boadway, Marceau and Marchand (1996) and Kemnitz (2007). Students then allocate to host countries and either stay on or leave their host country after graduation. The game is solved recursively.

Stage 2 competition: tuition fees When competing over tuition fees, the outcome of the first stage is already known. In principle, two situations have to be considered: (i) countries have chosen different quality levels at the first stage ($\Delta q > 0$); (ii) countries have chosen identical quality levels ($\Delta q = 0$). The respective outcomes at the second stage of the game are presented one after another.

Each country i chooses tuition fees t_i to maximize rents R_i, taking the other country's policy and quality levels (q_1, q_2), which were already determined at the first stage, as given. The corresponding optimization captures the tradeoff between the marginal costs and benefits of charging tuition fees, taking into account the direct revenue effect and the effect on the number of students and thereby the number of graduates, who are potential tax payers in the host country. The equilibrium tuition fees (t_1^*, t_2^*) simultaneously solve $t_1^* = t_1^{\text{br}}(t_2^*; q_1, q_2)$ and $t_2^* = t_2^{\text{br}}(t_1^*; q_1, q_2)$, where $t_i^{\text{br}}(t_j; q_1, q_2)$ represents country i's best-response function (please refer to the Appendix for the derivation):

$$t_1^* = \frac{\varrho[\varrho\Delta q - p\tau q_1 + \alpha(q_2 + 2q_1)]}{p\tau + 3\varrho} - p\tau\underline{w}, \tag{5.7}$$

$$t_2^* = \frac{\varrho[2\varrho\Delta q - p\tau q_1 + \alpha(q_1 + 2q_2)]}{p\tau + 3\varrho} - p\tau\underline{w}. \tag{5.8}$$

The tuition fee differential

$$\Delta t^* := t_2^* - t_1^* = \frac{\varrho[c(q_2) - c(q_1) + \varrho\Delta q]}{(p\tau + 3\varrho)} = \frac{\varrho\Delta q(\alpha + \varrho)}{(p\tau + 3\varrho)} > 0, \tag{5.9}$$

reflects the fact that the higher-quality country charges higher tuition fees. First of all, that is because the country with the higher quality has greater market

power, which allows to charge higher fees, since for given tuition fees, the demand for an educational system increases with its quality. Second, the higher fees in country 2 reflect the higher costs per student which are partially passed on to students. The larger α, the more relevant becomes this effect and the larger the tuition fee differential.

The second order conditions for optimal tuition fees in the two countries are

$$p\tau q_1 - 2\varrho\Delta q < 0, \quad -p\tau q_2 - 2\varrho\Delta q < 0. \tag{5.10}$$

The equilibrium tuition fees determine the equilibrium allocation of students

$$\hat{a}^* := \hat{a}(t_1^*, t_2^*) = \frac{\alpha + \varrho}{p\tau + 3\varrho}, \tag{5.11}$$

which follows directly from using the tuition fee differential (5.9) in indifference condition (5.1).

If the two countries had chosen identical educational qualities $q_2 = q_1 = q$ at the first stage, they would face fierce tuition-fee competition for the entire pool of international students. For undifferentiated quality levels, the variable rent (i.e., the part of the rent depending on the number of foreign students) amounts to

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

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

Stage 1 competition: educational quality At the first stage, each country i decides on quality investments to maximize R_i for given quality investments abroad and subject to the non-negativity constraint $q_i \geq 0$. Thereby, countries

anticipate the outcome of tuition-fee competition at the second stage. Given the equilibrium on stage 2, countries' objective functions are

$$R_i(q_1, q_2) = \begin{cases} r_i(q_1, q_2; t_1^*, t_2^*) - F(q_i) & \text{if} \quad q_i \neq q_j \\ -F(q_i) & \text{if} \quad q_i = q_j, \quad i, j \in \{1, 2\} \end{cases} \tag{5.12}$$

where $r_i(q_1, q_2; t_1^*, t_2^*)$ denotes the variable part of country i's rent from educating foreign students, given t_1^* and t_2^* as of (5.7) and (5.8). With $q_1 = q_2$, this part of the rent is zero due to fierce tuition-fee competition.

As can be directly inferred from (5.12), a situation with undifferentiated educational quality would result in local quality choices $q_1 = q_2 = 0$ and would leave both countries with a zero-rent ($R = 0$) from educating foreign students.

When choosing quality levels in a scenario with differentiated educational qualities, decision makers consider not only direct quality effects, but also the consequences of an increased number of students and therefore graduates on the benefit side as well as on the cost side (cet. par. higher tax revenue and tuition-fee revenue vs. higher variable costs of tuition) and the effect on tuition fees $t_i^*(q_i)$ that can be charged in price competition at the subsequent stage of the game. The Kuhn-Tucker conditions for the optimal quality level in lower-quality country 1 are

$$\frac{\partial R_1}{\partial q_1} = N_1(t_1^*, t_2^*) \left[\frac{p\tau}{2} \hat{a}(t_1^*, t_2^*) + \frac{\partial t_1^*}{\partial q_1} - \frac{\partial c}{\partial q_1} \right] - \frac{\partial F}{\partial q_1} \leq 0$$
$$q_1 \geq 0 \quad \text{and} \quad q_1 \frac{\partial R_1}{\partial q_1} = 0. \tag{5.13}$$

Rent R_1 is downward-sloping and convex in q_1:

$$\frac{\partial R_1}{\partial q_1} = -\frac{N}{2}(p\tau + 2\varrho)\hat{a}^{*2} - \frac{\partial F}{\partial q_1} < 0 \quad , \quad \frac{\partial^2 R_1}{\partial q_1^2} = -\frac{\partial^2 F}{\partial q_1^2} < 0. \tag{5.14}$$

Therefore, $q_1^* = 0$ maximizes R_1 for $0 \leq q_1 < q_2$.[7]

[7] A quality level $q = 0$ need not necessarily be interpreted as no quality at all. It could, for example, mean that the host country does not set up an elite study program but rather integrates foreign students into existing regular study programs. Another interpretation is that the host country does not exert any extra effort to educate foreign students (for instance, in the form of language training or additional TA's who are fluent in the native language of foreign students).

The Kuhn-Tucker conditions for optimal quality of education in country 2 are

$$\frac{\partial R_2}{\partial q_2} = N_2(t_1^*, t_2^*) \left\{ \frac{p\tau}{2}[1 + \hat{a}(t_1^*, t_2^*)] + \frac{\partial t_2^*}{\partial q_2} - \frac{\partial c}{\partial q_2} \right\} - \frac{\partial F}{\partial q_2} \leq 0$$
$$q_2 \geq 0 \quad \text{and} \quad q_2 \frac{\partial R_2}{\partial q_2} = 0. \tag{5.15}$$

An interior solution for the quality level in country 2 ($q_2^* > q_1^*$) is then implicitly determined by

$$\frac{\partial R_2}{\partial q_2} = \frac{N}{2}(p\tau + 2\varrho)(1 - \hat{a}^*)^2 - \frac{\partial F}{\partial q_2} = 0. \tag{5.16}$$

The second order condition for a maximum holds due to $\partial^2 F / \partial q_2^2 > 0$.

The following Lemma states that the equilibrium of the game is asymmetric.

Lemma 5.1 *In equilibrium, host countries of foreign students differentiate their educational quality ($q_1^* = 0, q_2^* > 0$) to relax tuition-fee competition. One country (country 2) provides higher educational quality and charges higher tuition fees. The higher-quality country attracts the brightest students from the international talent pool.*[8]

Proof. Please refer to the Appendix. ■

The intuition for this result is analogous to the rationale for vertical product-differentiation in oligopolistic competition, known from the IO-literature (Shaked and Sutton, 1982, is one of the standard references; Tirole, 1998, ch. 7.5.1, provides a plain textbook model): firms differentiate product qualities in order to relax price competition. Kemnitz (2007) presents a similar result in the context of competition among autonomous universities.

[8] In principle, there are two asymmetric equilibria: one in which country 2 provides the high quality education and one in which country 1 provides the higher quality.

5.2.3 Comparative statics

5.2.3.1 Size of the pool of international students

In the light of the increasing trend of international student mobility (as reported for example by the OECD, 2008, ch. C3), the question arises how an enlarged pool of international talents affects the degree of international differentiation in educational systems. We state the following proposition.

Proposition 5.1 *An increase in the size of the international talent pool raises the regional differentiation in higher education.*

Proof. Follows directly from (5.14) and (5.16). ■

A marginal quality increase reduces the variable rent in country 1,[9] while it raises the variable rent in country 2. As the marginal rents' *absolute value* increases with the size of the pool of talents, this implies that the degree of quality differentiation between both countries increases with N; i.e., $\partial \Delta q^* / \partial N > 0$. While a marginal increase in educational quality always produces the same fix costs which are independent of the number of students, a rising demand implies higher variable rents for each quality level in country 2, which finally creates an incentive to raise q_2. As of (5.9), the increased quality differentiation is accompanied by more differentiated tuition fees; i.e., $\partial \Delta t^* / \partial N > 0$.

5.2.3.2 Stay rate of foreign students

The stay rate of foreign students in their host countries affects the equilibrium allocation of foreign students, the quality differentiation between the host countries and the tuition fee differential. We analyze a symmetric marginal increase

[9] The negative marginal rent of an increase in q_1 is finally due to a relatively small latitude to increase tuition fees in the competitive environment and the lower average abilities of country 1 graduates (implying a lower marginal effect of educational quality on the wage sum and therefore tax revenue in country 1) in comparison with the marginal cost of the quality investment.

in the stay rate p.[10] The following Proposition summarizes the results.

Proposition 5.2 *An increase in the stay rate of foreign students after graduation in the host countries of education*

(i) raises the share of foreign students who study in the higher-quality country (i.e., $\partial(1-\hat{a}^*)/\partial p \geq 0$),

(ii) raises the quality differential (i.e., $\partial \Delta q^*/\partial p \geq 0$), and

(iii) has an ambiguous effect on the tuition fee differential:

$$\frac{\partial \Delta t^*}{\partial p} \gtreqless 0 \quad \Leftrightarrow \quad \epsilon_{\Delta q p} + \epsilon_{\varrho p} \gtreqless |\epsilon_{\hat{a}^* p}|,$$

where $\epsilon_{\Delta q p} := (\partial \Delta q/\partial p)(p/\Delta q) > 0$, $\epsilon_{\varrho p} := (\partial \varrho/\partial p)(p/\varrho) \geq 0$ and $\epsilon_{\hat{a}^* p} := (\partial \hat{a}^*/\partial p)(p/\hat{a}^*) \leq 0$.

Proof. Please refer to the Appendix. ■

The allocation of students Utilizing Assumption 1, an increase in the stay rate p raises a student's expected benefit from studying abroad. Therefore, for given $\Delta t/\Delta q$, the allocation of students shifts unambiguously towards country 2 (see indifference condition (5.1)). This effect primarily explains part (i) of the Proposition.

The quality differential Given the equilibrium derived in the section above (especially $q_1^* = 0$), the effect of a rising p on quality differentiation Δq is equivalent to the effect on q_2^*. The stay rate of foreign students affects both marginal revenues and marginal costs of providing educational quality in the higher-quality country 2. Overall, however, $\partial q_2^*/\partial p \geq 0$ (and therefore $\partial \Delta q^*/\partial p \geq 0$). One main driving

[10] For instance, technological change could explain a symmetric rise in the stay rate. If communication becomes cheaper and travel costs diminish, students and graduates in the host countries can keep in touch with their relatives and friends at home more easily. Homesickness becomes a less severe problem and the willingness to stay on in the host country could increase.

force is the higher total tax revenue which can be generated from a marginal quality investment when the number of tax payers increases and which provides – ceteris paribus – a higher incentive to invest in quality ($\partial[\partial\tau W_2^*/\partial q_2]/\partial p] = \tau N[(1-\hat{a}^{*2})/2 - p\hat{a}^*(\partial\hat{a}^*/\partial p)] > 0$).

The tuition fee differential The effect of a rising stay rate p on the tuition fee differential is ambiguous. Given the identity $\hat{a}^*(p) \equiv \frac{1}{\varrho(p)}\frac{\Delta t^*(p)}{\Delta q(p)}$ (see (5.1)) and parts (i) and (ii) of Proposition 5.2, the intuition for the inequality in part (iii) is straightforward as an equilibrium result. The inequality does, however, not really elucidate *why* countries alter tuition fees in a way that finally implies a change in the tuition fee differential. As the effect of the stay rate p on actual choices of tuition fees is quite complex, we make use of some simplifications to highlight the main mechanisms.

Suppose $\tau_{\text{ROW}} = \tau$ and $\gamma = 1$, such that $\varrho = 1 - \tau$. The parameter ϱ is thus independent of p (and therefore also $\epsilon_{\varrho p} = 0$); i.e., the *direct* effect of the stay rate on the allocation of students ($1/\varrho$ is the proportionality constant of the relation $\hat{a} \propto \Delta t/\Delta p$ as of equation (5.1)) is eliminated, so that the focus is exclusively on the stay rate's effect on equilibrium policies and its indirect effect on student allocation through a policy change.[11] Then, using (5.9),

$$\left.\frac{\partial\Delta t^*}{\partial p}\right|_{\tau_{\text{ROW}}=\tau,\gamma=1} = \frac{\varrho(\alpha+\varrho)}{(p\tau+3\varrho)}\frac{\partial\Delta q}{\partial p} - \frac{\varrho(\alpha+\varrho)}{(p\tau+3\varrho)^2}\tau\Delta q. \tag{5.17}$$

The overall effect can be decomposed into two components. First of all, the tuition fee differential accompanies to some extent the rising quality differential; i.e., a higher differentiation in qualities allows for higher differentiation in tuition fees. This very intuitive effect is represented by the first term in (5.17).

[11] The auxiliary assumption $\gamma = 1$ in this section also implies that a foreign-born graduate from a university in one of the two developed host countries earns the same labor income when staying on in the host country as when returning to his less-developed home country. This specification can be justified by recognizing that also the relative prize-level (which is usually lower in less-developed countries) and therefore the *real* income finally matters for the welfare of workers. Furthermore, Baruch, Budhwar and Khatri (2007) point out that Chinese and Indian students, for example, have excellent career opportunities back in their home countries when they have a foreign university degree, creating a respective living standard.

The second term reflects the more direct effects of a change in the stay rate on the incentives to raise tuition fees in the two regions and thereby also considers the relevance of income tax policy. Two effects can be identified. First, the marginal cost of raising tuition fees due to deterring students from immigration (in terms of foregone tax revenue in the future) is higher in the country in which the marginal student earns higher income as a graduate, which is the higher-quality country 2. An increase in the stay rate p means that the difference in these marginal costs between the two countries increases, resulting in a relatively reduced incentive to raise tuition fees in country 2. The tuition fee differential would decrease. The second effect is directly opposed. An increase in tuition fees in country 2 raises the average income of foreign-born graduates and thereby average tax-revenues in this country. The reason is that a marginal increase in t_2 only deters away the *least* productive students in the group of ROW-students in country 2. The average income of the remaining students in the future is therefore higher. In country 1, however, an increase in t_1 deters away the students with the *highest* productivity within the group of foreign students in this country, so that the average income of graduates in country 1 decreases. As a rising stay rate of graduates implies an increase in the relevance of this tax-revenue related aspect within the governments' objective functions, the incentive to raise tuition fees in the higher-quality country increases, while it decreases in the lower-quality country. The tuition fee differential would increase. This last effect via the composition of the student body and therefore average wage incomes is a second-order effect compared to the first-mentioned effect through the marginal cost of raising tuition fees. Therefore, the second term in (5.17) is finally negative. The higher the relevance of tax revenue for local governments, the more important becomes this effect.

A priori, the overall effect of the stay rate on the tuition fee differential is ambiguous. When the tax revenue argument becomes sufficiently strong, the following interesting scenario could emerge: while an increase in the stay rate of foreign students after graduation raises differentiation in educational quality ($\partial \Delta q / \partial p > 0$), tuition fees in the two countries actually converge ($\partial \Delta t^* / \partial p < 0$).

5.2.3.3 Degree of development of the sending region

A basic feature of the present analysis is the asymmetry of host countries and countries of origin of foreign students. While host countries are developed countries, ROW is a less-developed region. This section briefly considers the ROW reaching a higher degree of development and therefore catching up with the developed countries. Analytically, we can analyze the effect of a marginal increase in γ, implying a narrowing wage gap between ROW and the developed countries. The following Proposition summarizes.

Proposition 5.3 *An increase in the degree of development of the region of origin of foreign students raises the host countries' differentiation in educational quality (i.e., $\partial \Delta q^*/\partial \gamma > 0$). The effect on the allocation of students and tuition fees is ambiguous.*

Proof. Please refer to the Appendix. ■

Ceteris paribus, the degree of development of the sending region raises a student's expected return on education abroad. For given tuition fees and quality levels in the host countries (more precisely, for given $\Delta t/\Delta q$), this increase in returns results in an increase in the share of students who decide to study in the higher-quality country 2 (see equation (5.1)). In other words, country 2 enhances market power relative to the lower-quality country 1. For some given allocation of students, a marginal increase in educational quality q_2 thus implies increased latitude to raise tuition fees at the price-competition stage.[12]

Country 2 has an incentive to increase quality. This effect largely explains the increased regional quality differentiation if the degree of development of the sending region increases.

The increase in the quality differential is likely be accompanied by a rising tuition fee differential. A sufficient condition is that the number of students in the

[12] This can bee see from (5.8):

$$\left[\frac{\partial}{\partial \gamma}\left(\frac{\partial t_2^*}{\partial q_2}\right)\right]\Bigg|_{d\hat{a}^*=0} = 2\hat{a}^*(1-p)(1-\tau_{\mathrm{ROW}}) \geq 0.$$

higher-quality country increases in equilibrium, as can be seen from the proof of Proposition 5.3.

5.3 Welfare considerations

This section analyzes whether the outcome of competitive/decentralized educational policy deviates from a welfare maximum. The allocation of students and the quality levels in the two host countries are *first best* if the talent pool's aggregate gross income net of educational costs is maximized. Graduates earn wage income either in the host countries of education or in the home region ROW. The aggregate welfare function is

$$\begin{aligned} W^\circ &= N[p+(1-p)\gamma]\left[\int_0^{\hat{a}^\circ}(\underline{w}+aq_1^\circ)da+\int_{\hat{a}^\circ}^1(\underline{w}+aq_2^\circ)da\right] \\ &\quad - N\alpha[q_2^\circ-\hat{a}^\circ(q_2^\circ-q_1^\circ)]-\sum_{i\in\{1,2\}}F(q_i^\circ), \end{aligned} \tag{5.18}$$

where the first line is aggregate gross income and the second line comprises variable and fixed costs of providing eduction quality in the two host countries. By maximizing aggregate gross income net of educational costs, the efficient solution actually maximizes the total surplus of the educational system. This total surplus includes the rents from educating foreign students accruing in the two host countries, wage incomes of foreign students net of taxes and tuition fees, and tax revenues in the sending region.[13] Taxes and tuition fees do not turn up in (5.18), because they are just transfers from students to governments.

The first order condition for an interior/boundary solution of $\hat{a}^\circ$ is

$$\frac{\partial W^\circ}{\partial \hat{a}^\circ}=N\{\alpha-[p+(1-p)\gamma]\hat{a}^\circ\}(q_2^\circ-q_1^\circ)=0, \tag{5.19}$$

[13] It can be easily verified that (5.18) is equivalent to

$$\begin{aligned} \Pi &= R_1+R_2+N\varrho\left[\int_0^{\hat{a}}(\underline{w}+aq_1)da+\int_{\hat{a}}^1(\underline{w}+aq_2)da\right]-N\hat{a}t_1-N(1-\hat{a})t_2 \\ &\quad + N(1-p)\tau_{\mathrm{ROW}}\gamma\left[\int_0^{\hat{a}}(\underline{w}+aq_1)da+\int_{\hat{a}}^1(\underline{w}+aq_2)da\right], \end{aligned}$$

which is the total surplus of the educational system.

such that the *first best* allocation of students is characterized by

$$\hat{a}^\circ = \frac{\alpha}{p + (1-p)\gamma}. \tag{5.20}$$

If there are no variable costs of providing educational quality (i.e., $\alpha = 0$), the *first best* is characterized by an allocation of the entire pool of international students to the higher-quality country 2 (boundary solution $\hat{a}^\circ = 0$). The reason is that incomes increase with quality, which is higher in country 2. Allocating students to region 1 would therefore reduce welfare. With strictly positive variable costs (i.e., $\alpha > 0$), however, allocating some students to country 1 becomes worthwhile, because a lower quality also implies lower costs per student.[14] The interior solution (5.20) balances both effects at the margin.

The Kuhn-Tucker conditions for educational qualities q_1° and q_2° are

$$\frac{\partial W^\circ}{\partial q_1^\circ} = N\hat{a}^\circ \left\{ [p + (1-p)\gamma]\frac{\hat{a}^\circ}{2} - \alpha \right\} - \frac{\partial F}{\partial q_1^\circ} \leq 0$$
$$q_1^\circ \geq 0 \quad \text{and} \quad q_1^\circ \frac{\partial W^\circ}{\partial q_1^\circ} = 0, \tag{5.21}$$

$$\frac{\partial W^\circ}{\partial q_2^\circ} = N(1-\hat{a}^\circ) \left\{ [p + (1-p)\gamma]\frac{1+\hat{a}^\circ}{2} - \alpha \right\} - \frac{\partial F}{\partial q_2^\circ} \leq 0$$
$$q_2^\circ \geq 0 \quad \text{and} \quad q_2^\circ \frac{\partial W^\circ}{\partial q_2^\circ} = 0. \tag{5.22}$$

Using (5.20) in (5.21) and (5.22) yields *first best* quality levels: $q_1^\circ = 0$ and $q_2^\circ > 0$, the latter being implicitly determined by

$$\frac{N}{2}[p + (1-p)\gamma](1-\hat{a}^\circ)^2 - \frac{\partial F}{\partial q_2^\circ} = 0. \tag{5.23}$$

With (5.20), the Hessian matrix of $W^\circ = W(\hat{a}^\circ, q_1^\circ, q_2^\circ)$ is negative-definite; i.e., the solution *maximizes* aggregate welfare.

[14] As can bee seen from (5.18) and $\int_0^{\hat{a}^\circ}(\underline{w} + aq_1^\circ)da + \int_{\hat{a}^\circ}^1(\underline{w} + aq_2^\circ)da = \underline{w} + q_2^\circ/2 - \hat{a}^{\circ 2}(q_2^\circ - q_1^\circ)/2$, the welfare loss of allocating students to country 1 if $\alpha = 0$, is captured by $N[p + (1-p)\gamma]\hat{a}^{\circ 2}(q_2^\circ - q_1^\circ)/2$. The cost saving of allocating students to country 1 if $\alpha > 0$, is captured by $N\alpha\hat{a}^\circ(q_2^\circ - q_1^\circ)$.

The equilibrium allocation of students and the differentiation in educational qualities in the competition for the international pool of talents as of Section 5.2.2 are likely to deviate from the *first best*.

Proposition 5.4 *Comparing the equilibrium of the competition for the international pool of talents to the first best, one can distinguish two cases:*

(i) If $p\tau + 2\varrho > p + (1-p)\gamma$,

(a) $(1-\hat{a}^*) \gtreqless (1-\hat{a}^\circ) \quad \Leftrightarrow \quad \alpha \gtreqless \frac{\varrho[p+(1-p)\gamma]}{p\tau+3\varrho-[p+(1-p)\gamma]}$,

(b) $(1-\hat{a}^*) \geq (1-\hat{a}^\circ)$ *involves* $q_2^* > q_2^\circ$ *(*$\Delta q^* > \Delta q^\circ$*),*

(c) $(1-\hat{a}^*) < (1-\hat{a}^\circ)$ *can in principle involve* $q_2^* \geq q_2^\circ$ *(*$\Delta q^* \geq \Delta q^\circ$*) as well as* $q_2^* < q_2^\circ$ *(*$\Delta q^* < \Delta q^\circ$*). If* $\exists \tilde{\alpha} \in [0, \frac{\varrho[p+(1-p)\gamma]}{p\tau+3\varrho-[p+(1-p)\gamma]}[$ *such that* $q_2^* = q_2^\circ$,

$$q_2^\circ \gtreqless q_2^* \quad (\Delta q^\circ \gtreqless \Delta q^*) \quad \Leftrightarrow \quad \alpha \lesseqgtr \tilde{\alpha}.$$

(ii) If $p\tau + 2\varrho \leq p + (1-p)\gamma$,

(a) $(1-\hat{a}^*) \ngtreqless (1-\hat{a}^\circ)$,

(b) $(1-\hat{a}^\circ) > (1-\hat{a}^*)$ *involves* $q_2^\circ > q_2^*$ *(*$\Delta q^\circ > \Delta q^*$*).*

Proof. Please refer to the Appendix ■

The allocation of students in the decentralized equilibrium can in principle deviate from the welfare-maximizing allocation in both directions (part (i)-(a) of Proposition 5.4). The variable costs of providing educational quality plays an important role. If there are no variable costs of educating students ($\alpha = 0$), the number of students in the higher-quality country 2 in the decentralized equilibrium falls short of the *first best* level. The welfare maximum would require an allocation of *all* students to the higher-quality country. In the decentralized solution, however, there is also demand for the lower-quality country 1. Quality differentiation leads to imperfect competition and some market power for host countries, which allows country 1 to attract some students from abroad, although this is actually inefficient. With a rising α (i.e., with rising marginal variable costs of providing educational quality), the allocation of students shifts towards the lower-quality

country both in the decentralized and the *first best* solution. The fall in demand for the higher-quality country 2 is larger in the *first best*, however, than in the decentralized equilibrium, such that for a high enough α (i.e., $\alpha > \frac{\varrho[p+(1-p)\gamma]}{p\tau+3\varrho-[p+(1-p)\gamma]}$) the number of students in the higher-quality country is larger in the decentralized solution than in the *first best*.

While the equilibrium educational quality in country 1 is welfare-maximizing (i.e., $q_1^* = q_1^\circ = 0$), educational quality in country 2 (and therefore also the quality differential Δq) is likely to deviate from the *first best*. Case (i) in Proposition 5.4 includes all cases in which for given and identical allocations of students in the decentralized solution and the *first best* (i.e., $\hat{a}^* = \hat{a}^\circ$), the marginal benefit of investing in educational quality would be higher from the rent-maximizing perspective of country 2 in the competitive setting than from the welfare-maximizing perspective (see (5.16) and (5.23)). While country 2 in the decentralized setting considers the effect of educational quality on the local tax base and tuition-fee revenue, the aggregate welfare-maximizing solution considers the effect of educational quality on aggregate income. With more students studying in country 2 in the decentralized solution compared to the *first best*, quality level q_2^* unambiguously exceeds the *first best* level q_2° (part (i)-(b) of Proposition 5.4). In other words, the competition for the pool of talents wastes resources compared to aggregate welfare. With the number of country-2 students in the decentralized equilibrium falling short of the *first best*, q_2^* can either be smaller, larger or equal to the welfare maximizing level. The higher the variable cost-parameter α, the smaller the number of country-2 students in the *first best* relative to the decentralized setting (i.e., the smaller the ratio $(1-\hat{a}^\circ)/(1-\hat{a}^*)$) and the more likely the competition for the pool of talents implies local underinvestment in educational quality ($q_2^* < q_2^\circ$).

Part (ii) of Proposition 5.4 deals with the case where, for given and identical allocations of students in the decentralized solution and the *first best*, the marginal benefit of investing in educational quality would be smaller from the rent-maximizing perspective of country 2 in the competitive setting than from the welfare maximizing perspective. This scenario is only consistent with a larger number of country-2 students in the *first best* compared to the decentralized equilibrium (part (ii)-(a)). Competition for the pool of talents then implies an underinvestment in educational quality (part (ii)-(b)).

5.4 Discussion

This section relates the differentiation result to the literature and discusses some implications of the comparative statics for the countries of origin of foreign students.

5.4.1 Public policy and vertical product-differentiation

An application of vertical product-differentiation to public finance, which is partially comparable to the present approach, was recently presented by Zissimos and Wooders (2008). In a two-country model, they analyze a two-stage Nash competition for firm settlements by means of production-cost reducing public-good provision and tax policy. If firms only differ in technology but do not have any ex ante country-specific location preferences, the decentralized equilibrium is characterized by differentiated public-good policy and tax policy. An undifferentiated public-good provision would lead to fierce tax competition leaving both countries worse off. There are further related contributions in the educational literature. In a model with imperfectly mobile households and capital mobility, Hoyt and Jensen (2001) provide a rationale for two cities to offer differentiated public-school quality which is financed by property-tax revenue: the quality differentiation raises individuals' attachment to their residence and reduces competition between cities, making both of them better off. De Fraja and Iossa (2002) analyze the competition of two ex ante identical universities within a country, which receive a fixed budget by the central government and try to maximize their institution's 'prestige' by setting student admission standards. A symmetric solution exists only with low student mobility. For high student mobility, if there is an equilibrium at all, it is asymmetric implying one university becoming an elite institution, setting higher standards and attracting only the best students.

Demange and Fenge (2010) show that, in principle, both symmetric and asymmetric equilibria could arise if two countries compete for foreign students from the other country (i.e., there is no third sending region as in our model). In their model, however, there is no tuition-fee competition. They find that educational quality is differentiated optimally if all foreign students are expected to return

to their home countries after graduation. (The ultimate reason is that there is no incentive to free-ride the other country in their model and countries have no incentive to compete for foreign students if they return to their home country.) This would not be the case in our setting, as governments would still have an incentive to compete for foreign students as tuition-fee payers. Apart from that, the return of a foreign student to his home country always means they leave the system after graduation (from the host countries' perspective), which is not the case in Demange and Fenge's (2010) model. Our results are therefore not perfectly comparable.

5.4.2 Some implications for countries of origin of foreign students

The positive effect of the size of the pool of talents on quality differentiation (5.2.3.1) has an implication for the brain-drain/brain-gain discussion, which usually takes the perspective of a less-developed source region (ROW in our case) and analyzes the consequences of (highly-skilled) emigration. Especially if domestic educational prospects are rather poor, ROW probably has a vital interest in obtaining the higher skills of native students who have been educated in a developed country.[15] Thus, for a given stay rate p, the share of highly-skilled graduates in ROW who have been educated abroad increases with N (the share of return migrants within the ROW workforce is $\psi := (1-p)N/(\overline{N}-pN)$, where $\overline{N} > N$ is the total number of ROW-born individuals; $d\psi/dN = (1-p)\overline{N}/(\overline{N}-pN)^2 > 0$). This increase is what we might call a *quantitative* brain-gain effect. In addition, an increase in N alters the competition of the host countries of ROW-born foreign students: country 2 now offers higher educational quality q_2, while educational quality in country 1 remains unchanged ($q_1 = 0$); the allocation of students to the host regions remains unchanged as well, because it is independent of N and Δq (see (5.11)). Therefore, return migrants from the higher-quality country 2 are more productive now, resulting in what we might call a *qualitative* brain-gain effect.

A qualitative brain-gain effect also plays an important role when looking at the

[15] The idea here is that human capital not only has a quantitative but also a qualitative component. The endogenous-growth theory identifies skilled human capital as a crucial determinant of economic growth (e.g., Lucas, 1988; Romer, 1990).

stay rate of foreign students in their host countries. First of all, an increase in the stay rate p reduces the share of internationally educated graduates in ROW ($d\psi/dp = N(N - \overline{N})/(\overline{N} - pN)^2 < 0$), which can be called a quantitative brain drain. At the same time, an increase in p alters competition between host countries of foreign students (5.2.3.2). The allocation of ROW-born students to host countries changes: the share of the pool of talents educated in the higher-quality country 2 increases ($d(1 - \hat{a}^*)/dp > 0$). In addition, educational quality in country 2 increases, while $q_1 = 0$ remains unchanged. Therefore, with a rising stay rate of foreign students in the host regions, ROW suffers from a *quantitative* brain *drain* effect, but benefits from a *qualitative* brain *gain* effect in terms of (i) a larger share of return migrants who have been educated in the higher-quality country 2, and (ii) a better education (and therefore higher productivity) of graduates who return from the higher-quality country. As the focus of the present paper is on host countries of foreign students and not on the regions of origin, we do not carry on this brain-gain idea in more detail.

Haupt, Krieger and Lange (2010) take up the basic idea and show that the qualitative brain-gain effect creates an increase in aggregate and per-capita human capital in the country of origin of foreign students, as long as the stay rate of students in the host country of education is not too large. So far, the recent literature on a 'beneficial brain drain' has mainly emphasized the role of additional incentives to acquire skills in a less-developed country when there is an option to migrate to a developed country after graduation in order to earn higher wages (e.g., Mountford, 1997; Stark, Helmenstein and Prskawetz, 1997, 1998; Vidal, 1998; Beine, Docquier and Rapoport, 2001, 2008; Stark and Wang, 2002; Mayr and Peri, 2009; Eggert, Krieger and Meier, 2010).

5.5 Conclusion

The present paper starts from the observation that a relatively small number of top destinations for international students hosts a considerable share of students from countries like China and India opting for higher education in one of the western developed countries. The model reduces this observation to the competition of two developed countries for the international pool of talents from a third region (ROW). There are good reasons for host countries to attract those students by

means of their educational system. Especially the prospect of thereby attracting future highly-skilled workers if some of the international students stay on in their host countries deserves special attention. The equilibrium in our model is characterized by differentiated educational policy in the sense of one country offering a higher-quality-high-price education for the most talented students, while the other country charges lower tuition fees for a lower-quality education, thereby attracting less talented students. The regional differentiation actually follows from the competitive situation and is not due to an ex ante asymmetry of countries: countries relax tuition-fee competition by quality differentiation. The differentiation in educational quality between host countries increases with the size of the international talent pool, with the stay rate of foreign students in the host countries after graduation and with the degree of development of the sending region of foreign students. The allocation of students to the two host countries as well as the degree of regional quality differentiation are likely to deviate from the aggregate welfare-maximizing solution.

It should be mentioned that the assumption of perfect student mobility might not hold in reality. If students in the international talent pool had some country-specific preferences resulting in imperfect mobility, competition would be less fierce and the quality differentiation could be less extreme. However, compared to a two-country setting in which each country tries to attract students from the other country, students from a third country (developing country), as in our model, going for education in Europe, North America or Australia, should have much weaker country-specific preferences in location choice. 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; Lange, 2009; Krieger and Lange, 2010).

In order to keep the presentation of the model clear, the stay rate of students in their host country after graduation is simply a constant. One could also think of stay rates which depend positively 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 on than graduates from a lower-quality university. With differentiated educational systems, the stay rates would then differ between host countries. The differentiation result should not be affected by considering stay rates which depend on educational quality. Governments would

just take into account an additional marginal benefit from raising educational quality when choosing optimal quality levels. But they still want to differentiate qualities to relax tuition-fee competition. Only the equilibrium degree of quality differentiation is likely to change. The comparative-static analysis should not be qualitatively affected either, as we just analyze a marginal and symmetric increase in the stay rate.

The analysis points to some issues for future research. While we assumed simultaneous moves, for example, there could also be a sequential choice of quality levels or rather entrance in the competition for international students (e.g., by launching international study programs). 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 targets the stay rates of graduates. Countries could try to support the success of social integration and exert some effort to facilitate graduates' labor-market access (e.g., by promoting permanent residency). More and more OECD countries already make use of this option and it could be interesting to elaborate more on the strategic aspects of immigration policy in the context of the competition for the international pool of talents. Adding admission standards to the choice set of countries, like for example in De Fraja and Iossa (2002), may also enrich further research.

Appendix

Tuition-fee competition (Section 5.2.2)

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

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

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

$$t_1 = \theta_1 t_2 + \frac{p\tau \underline{w} - c(q_1)}{\frac{p\tau q_1}{\varrho \Delta q} - 2}; \quad \theta_1 := \frac{\frac{p\tau q_1}{\varrho \Delta q} - 1}{\frac{p\tau q_1}{\varrho \Delta q} - 2}. \tag{5.24}$$

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

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

and

$$t_2 = \theta_2 t_1 + \frac{\varrho \Delta q + c(q_2) - p\tau \underline{w}}{\frac{p\tau q_2}{\varrho \Delta q} + 2}; \quad \theta_2 := \frac{\frac{p\tau q_2}{\varrho \Delta q} + 1}{\frac{p\tau q_2}{\varrho \Delta q} + 2}. \tag{5.25}$$

Combining (5.24) and (5.25) yields equilibrium tuition fees

$$\begin{aligned} t_1^* &= \frac{1}{1 - \theta_1 \theta_2} \left[\frac{p\tau \underline{w} - c(q_1)}{\frac{p\tau q_1}{\varrho \Delta q} - 2} + \theta_1 \frac{\varrho \Delta q + c(q_2) - p\tau \underline{w}}{\frac{p\tau q_2}{\varrho \Delta q} + 2} \right], \\ t_2^* &= \frac{1}{1 - \theta_1 \theta_2} \left[\theta_2 \frac{p\tau \underline{w} - c(q_1)}{\frac{p\tau q_1}{\varrho \Delta q} - 2} + \frac{\varrho \Delta q + c(q_2) - p\tau \underline{w}}{\frac{p\tau q_2}{\varrho \Delta q} + 2} \right], \end{aligned}$$

which finally can be reduced to (5.7) and (5.8).

Proof Lemma 5.1

With undifferentiated educational quality, both countries were demonstrated to generate a zero-rent from educating the international pool of talents (i.e., $R_1 =$

$R_2 = 0$). The fact that both countries can earn strictly positive rents ($R_1, R_2 > 0$) with differentiated qualities finally proves the Lemma.

To this end, we first of all prove that variable rents are strictly positive for an interior solution of the allocation of foreign students $\hat{a}^*$, i.e. 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 rents are

$$\begin{aligned} r_1(q_1, q_2) &= N\hat{a}^* \left\{ \frac{p\tau}{2} \hat{a}^* q_1 + t_1^* - \alpha q_1 \right\}, \\ r_2(q_1, q_2) &= N(1 - \hat{a}^*) \left\{ \frac{p\tau}{2} (1 + \hat{a}^*) q_2 + t_2^* - \alpha q_2 \right\}. \end{aligned}$$

Using equilibrium values t_1^*, t_2^* and $\hat{a}^*$ as of (5.7), (5.8) and (5.11), and for strictly positive demand for both educational systems (i.e., $0 < \hat{a}^* < 1$), we find

$$\begin{aligned} r_1(q_1, q_2) &> 0 \quad \text{if} \quad p\tau q_1 - 2\varrho\Delta q < 0, \\ r_2(q_1, q_2) &> 0 \quad \text{if} \quad \left(\frac{p\tau}{2} q_2 + \varrho\Delta q \right) (p\tau + 2\varrho - \alpha) > 0. \end{aligned}$$

While the second order condition for the optimal t_1^* guarantees $r_1(q_1, q_2) > 0$, the strictly positive demand for education in country 2 (see that $(1 - \hat{a}^*) = (p\tau + 2\varrho - \alpha)/(p\tau + 3\varrho)$) ensures $r_2(q_1, q_2) > 0$. With undifferentiated educational quality, a race-to-the-bottom in tuition fees would drive this rent down to zero.

With $q_1^* = 0$ and $r_1(q_1, q_2) > 0$, as can be seen from (5.12), country 1 generates a strictly positive rent $R_1 > 0$ from educating foreign students. The reason is that country 1 does not incur any costs from educating foreign students but nevertheless generates some (tax/tuition-fee) revenue from those students who cannot afford to study in country 2.

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

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

The equilibrium allocation of students is $\hat{a}^*$. As of (5.1), 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 Proposition 5.2

First of all,

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

can be signed unambiguously by Assumption 1. Furthermore,

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

and therefore $\partial(1-\hat{a}^*)/\partial p \geq 0$, which proves part (i) of the proposition.

Part (ii) follows from

$$\frac{\partial \Delta q^*}{\partial p} \gtreqless 0 \quad \overset{(q_1^*=0)}{\Leftrightarrow} \quad \frac{\partial q_2^*}{\partial p} \gtreqless 0 \quad \overset{(5.16)}{\Leftrightarrow} \quad \frac{\partial}{\partial p}\left[\frac{N}{2}(p\tau + 2\varrho)(1-\hat{a}^*)^2\right] \gtreqless 0$$

and

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

Considering the tuition fee differential (5.9) and the equilibrium allocation of students (5.11),

$$\begin{aligned} \frac{\partial \Delta t^*}{\partial p} = \frac{\partial[\varrho(p)\Delta q(p)\hat{a}^*(p)]}{\partial p} &\gtreqless 0 \\ \Leftrightarrow \quad \varrho\hat{a}^*\frac{\partial \Delta q}{\partial p} + \Delta q\left(\frac{\partial \varrho}{\partial p}\hat{a}^* + \varrho\frac{\partial \hat{a}^*}{\partial p}\right) &\gtreqless 0 \\ \Leftrightarrow \quad \frac{\partial \Delta q}{\partial p}\frac{p}{\Delta q} + \frac{\partial \varrho}{\partial p}\frac{p}{\varrho} + \frac{\partial \hat{a}^*}{\partial p}\frac{p}{\hat{a}^*} &\gtreqless 0, \end{aligned}$$

which proves part (iii) of the proposition.

Proof Proposition 5.3

The first part follows from

$$\frac{\partial \Delta q^*}{\partial \gamma} \gtreqless 0 \quad \overset{(q_1^*=0)}{\Leftrightarrow} \quad \frac{\partial q_2^*}{\partial \gamma} \gtreqless 0 \quad \overset{(5.16)}{\Leftrightarrow} \quad \frac{\partial}{\partial \gamma}\left[\frac{N}{2}(p\tau + 2\varrho)(1-\hat{a}^*)^2\right] \gtreqless 0 \quad (5.26)$$

and

$$\frac{\partial}{\partial\gamma}\left[\frac{N}{2}(p\tau+2\varrho)(1-\hat{a}^*)^2\right]>0 \quad \Leftrightarrow \quad 3\varrho p\tau+6\varrho^2+2\alpha p\tau+3\alpha\varrho>0,$$

which always holds. Second, with $\partial\varrho/\partial\gamma>0\ \forall\tau_{\text{ROW}}, p\in[0,1[$,

$$\frac{\partial(1-\hat{a}^*)}{\partial\gamma}\gtreqless 0 \quad \Leftrightarrow \quad \frac{3\alpha-p\tau}{(p\tau+3\varrho)^2}\gtreqless 0.$$

Third,

$$\frac{\partial\Delta t^*}{\partial\gamma}\gtreqless 0 \quad \Leftrightarrow \quad \epsilon_{\Delta q\gamma}+\epsilon_{\varrho\gamma}+\epsilon_{\hat{a}^*\gamma}\gtreqless 0,$$

where $\epsilon_{\Delta q\gamma}:=(\partial\Delta q/\partial\gamma)(\gamma/\Delta q)>0$, $\epsilon_{\varrho\gamma}:=(\partial\varrho/\partial\gamma)(\gamma/\varrho)\geq 0$ and $\epsilon_{\hat{a}^*\gamma}:=(\partial\hat{a}^*/\partial\gamma)(\gamma/\hat{a}^*)\gtreqless 0$.

Proof Proposition 5.4

Part (i)-(a) of the Proposition follows from comparing (5.11) and (5.20).

Comparing (5.16) and (5.23),

$$q_2^\circ\gtreqless q_2^* \quad \Leftrightarrow \quad \frac{1-\hat{a}^\circ}{1-\hat{a}^*}\gtreqless\sqrt{\frac{p\tau+2\varrho}{p+(1-p)\gamma}}. \tag{5.27}$$

Part (i)-(b) follows immediately.

Part (i)-(c) takes on (5.27) and uses the fact that $(1-\hat{a}^\circ)/(1-\hat{a}^*)$ decreases monotonically in α if $p\tau+2\varrho>p+(1-p)\gamma$:

$$\frac{\partial}{\partial\alpha}\left(\frac{1-\hat{a}^\circ}{1-\hat{a}^*}\right) = \frac{p\tau+3\varrho}{[p+(1-p)\gamma](p\tau+2\varrho-\alpha)}\left(\frac{p+(1-p)\gamma-\alpha}{p\tau+2\varrho-\alpha}-1\right)<0$$

$$\Leftrightarrow \quad p+(1-p)\gamma-p\tau-2\varrho<0.$$

Therefore, if there exists an $\tilde{\alpha}\in]0,\frac{\varrho[p+(1-p)\gamma]}{p\tau+3\varrho-[p+(1-p)\gamma]}[$ for which $q_2^\circ=q_2^*(\Leftrightarrow\frac{1-\hat{a}^\circ}{1-\hat{a}^*}=\sqrt{\frac{p\tau+2\varrho}{p+(1-p)\gamma}})$, it follows that

$$q_2^\circ\gtreqless q_2^* \quad \Leftrightarrow \quad \alpha\lesseqgtr\tilde{\alpha}.$$

Simplifying the analysis for example by assuming $\tau = \tau_{\text{ROW}}$, using (5.27) one finds that $q_2^\circ > q_2^*$ if $\alpha = 0$. Then, with part (i)-(b) and $(1-\hat{a}^\circ)/(1-\hat{a}^*)$ decreasing in α, there will always exist a unique $\tilde{\alpha} \in]0, \frac{\varrho[p+(1-p)\gamma]}{p\tau+3\varrho-[p+(1-p)\gamma]}[$.

Part (ii)-(a) follows from the fact that $p\tau + 2\varrho > p + (1-p)\gamma$ is a necessary condition for $(1-\hat{a}^*) \geq (1-\hat{a}^\circ)$ if $\varrho \neq 0$: with $p\tau + 3\varrho > p + (1-p)\gamma$ (which is a necessary condition for $\hat{a}^\circ \geq \hat{a}^*$), $(1-\hat{a}^*) \ngeq (1-\hat{a}^\circ)$ if $p\tau + 2\varrho < p + (1-p)\gamma$.

Part (ii)-(b) finally follows immediately from (5.27).

See that $q_2^\circ \gtreqless q_2^*$ always implies $\Delta q^\circ \gtreqless \Delta q^*$, as $q_1^* = q_1^\circ = 0$.

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6 Concluding Remarks and Perspectives

6.1 Systems competition with human capital mobility

The essays of this thesis analyzed selected issues in the context of the New Systems Competition with human capital mobility and focused in particular on public higher-educational policy.

First, I have considered public higher-education provision in a framework of international competition for highly-skilled human capital. Depending on international mobility characteristics of students and highly-skilled workers, countries either underinvest in higher education or make excessive use of public funds and spend too much on education.

Second, a rise in student mobility (in combination with foreign students potentially staying on in the host country of education after graduating) intensifies systems competition and threatens fiscal budgets when countries compete for human capital by means of income tax rates and educational policy. A rise in graduates' mobility, however, allows to extend the net fiscal budget.

Third, I have challenged the conventional wisdom that promotes raising non-resident tuition fees if foreign students become more likely to return to their home countries after graduating. If a higher expected return rate goes along with a diminishing number of foreign students in the host country and if the cost of public education is not too large, optimal non-resident tuition fees have actually to be cut back.

Fourth, host countries may want to vertically differentiate their educational systems when they compete for students from less-developed countries, in order to relax price competition. The higher the stay rates of foreign students in their host countries after graduation and the larger the international talent pool, the larger will be regional differences in educational qualities and in tuition fees. The

degree of differentiation and the allocation of students to the host countries are inefficient with uncoordinated educational policies.

6.2 Asymmetric countries

In all four essays, I have taken the perspective of developed countries and analyzed competition between those. The third and the fourth essay introduced less-developed countries as regions of origin of human capital. Yet in the models, these countries have been completely passive and welfare effects of the competition between the developed countries on the less-developed countries have been disregarded.

The early brain-drain literature first of all discussed whether (or under which conditions) countries of origin would have to suffer from a welfare loss when they experience an outflow of human capital (e.g., Grubel and Scott, 1966, 1968; Aitken, 1968; Bhagwati and Dellalfar, 1973; Bhagwati and Hamada, 1974, Bhagwati, 1976). The more recent literature points out that a brain *drain* could also go along with a brain *gain*. If people from a less-developed country have an option to emigrate to a developed country in order to earn higher wages than in their home countries, their private returns on education exceed those in a closed economy. Therefore, they would invest more in education. As there are always some graduates who finally do not emigrate after graduation but stay on in the home country or there are some workers who return to their home countries after they have spent some years abroad, the sending region ultimately sees higher per-capita human capital of those left behind. This argument is actually put forth in several more recent articles (e.g., Mountford, 1997; Stark, Helmenstein and Prskawetz, 1997, 1998; Vidal, 1998; Beine, Docquier and Rapoport, 2001, 2008; Stark and Wang, 2002; Mayr and Peri, 2009; Eggert, Krieger and Meier, 2010). The fourth essay in this thesis is already suggestive of another source of a brain gain with a brain drain. While a higher stay rate of students from a less-developed country in a developed host country of education after graduation creates a brain drain in the first place, this change in migration behavior alters the competition between host countries. With a rise in educational quality in the host countries, the countries of origin of international students see their *quantitative* brain drain being compensated by a *qualitative* brain gain through increased human capital

of return migrants. Haupt, Krieger and Lange (2010) then show that the region of origin could even benefit from a rise in the *aggregate* human capital stock. A necessary condition is, however, that the initial stay rate of students abroad is not too high.

Further research could find other examples where a systems competition of developed countries affects the welfare of less-developed countries. In the style of Haupt, Krieger and Lange (2010), a natural candidate would be immigration policy. Suppose host countries of students from a less-developed country try to actively raise students' stay rate after graduation. While this would again create a quantitative brain drain for the country of origin, the improved prospect of residence in a developed country could raise students' incentive to obtain high-quality education aborad. In other words, while the share of students abroad who return to their home country is reduced, the total number of students who study abroad would rise. With still some return migration, the country of origin might actually experience an overall increase in human capital.

Immigration policy in developed countries can of course also target graduates from less-developed countries. A more effective use of active immigration policies and the expansion of liberal immigration regulations could raises human capital mobility from the less-developed countries and reinforce the threat of a brain drain. The countries of origin are thus likely to adjust their institutions. In an asymmetric two-country setting, Webb (1985) shows that an increase in mobility (migration occurs from a poor to a rich country) induces the rich country to cutdown on educational subsidies, while the poor country might actually raise subsidies. That is, the burden of financing education is shifted from the rich to the poor country. Haupt and Janeba (2009) show that an increase in skilled mobility may benefit both low- and highly-skilled workers in a relatively rich country of origin of migrants, but could reduce welfare in a poorer country.

In any case, like Webb (1985) and Haupt and Janeba (2009), further research should also consider a reaction of countries of origin to direct changes in mobility or indirect changes through policy changes in host countries. In the context of student migration, the less-developed countries could employ various counter measures to prevent a massive brain drain. Gribble (2008) summarizes three main policy options. First, countries may try to retain students from obtaining higher education only abroad. Second, they can encourage return migration of students

who have studied abroad. And third, if students do actually stay on in the host country of education, sending countries should try to find a way to establish and maintain a link with expatriates to encourage remittances, knowledge and technology flows, and foreign investments (that is the 'diaspora approach'). Taking into account these policies as strategic instruments in the analysis of asymmetric competition for human capital would enrich future research.

Furthermore, the analysis of the New Systems Competition with human capital mobility should generally strive for a more comprehensive approach which explicitly takes into account both migration policy and fiscal policy.

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