The Provision of Higher Education in a Global World—Analysis and Policy Implications

Gabrielle Demange*, Robert Fenge[†] and Silke Uebelmesser[‡]

Abstract

Mobile students and graduates react to the institutional framework of higher education and on their turn induce changes in governmental policies. In this article, we are interested in how governmental decisions about the financial regime and the quality level of higher education interact with individual incentives to invest in higher education in closed economies and in economies open to migration. We show that mobility of (part of) the population results in a situation where the optimal instruments of the closed economy are no longer necessarily viable. The aim of the article is to derive policy implications as to the optimal financial regime and quality level of higher education in the presence of migration opportunities. (JEL codes: H77, I22, I28)

Keywords: Higher education, funding, quality competition, migration, policy implication.

1 Introduction

Mobility is a driving force in the labour market. It is especially crucial as higher education is concerned because mobility enlarges the opportunities of students and graduates or skilled workers, respectively, and affects the returns to their investment in education. Mobile students and graduates react to the institutional framework and on their turn induce changes in governmental policies as competition between educational institutions and countries becomes more intense. We are here interested in how governmental decisions about the financial regime and the quality level of higher education interact with individual incentives to invest in higher education in closed and in open economies.

The Bologna Process, which was launched in 1999, aims at removing the obstacles to mobility for students by establishing the so-called European Higher Education Area by the year 2010. Due to the common structure of

* Paris School of Economics, and CESifo, e-mail: demange@pse.ens.fr
† Ifo Institute and University of Munich, and CESifo, e-mail: fenge@ifo.de
‡ CES, University of Munich, and CESifo, e-mail: uebelmesser@lmu.de

higher education and the more comparable university systems across Europe, students should be able to choose from a wide range of high-quality programmes and both students and graduates should benefit from standardized recognition procedures as their qualifications are concerned.[1] These measures—especially those which increase transparency and comparability of different degree programmes—should lower migration costs. Acquiring a degree in a particular country should be less risky if it no longer restricts the relevant geographical area for the professional career as much as before to the boundaries of this country. A similar argument should also hold for graduates for whom more standardized educational degrees make it easier to work in countries other than the country where they received higher education.

With equal conditions for access—following the non-discrimination principle, which holds for EU-citizens—increased mobility is supposed to lead to more competition in terms of quality among different institutions of higher education.[2] But the European Higher Education Area also creates incentives for governments to free-ride on other countries and regions. Free-riding should be especially strong if students are less mobile than skilled workers and if most of those who study abroad return to their home country after graduation. This shows how important it is for an evaluation of the Bologna Process to study different mobility scenarios.[3] One may suspect that the Bologna Process—due to the fact that it aims above all at promoting the mobility of students—will also affect the policy of governments, both in terms of how higher education is financed and what quality level is chosen. Two main questions arise. What is the rationale to increase student mobility? What will be the impact on the financing of higher education and its quality level? Our aim is to address these questions, relying on a simple general equilibrium model.[4]

We look at a two-period model with two *ex ante* identical jurisdictions and individuals who differ in their innate abilities. The optimum is analysed and contrasted with the outcome in the absence of an omniscient social planner in a setting where we allow for distortions on

---

[1] See, in particular, http://www.europeunit.ac.uk/bologna_process/index.cfm and http://ec.europa.eu/education/policies/educ/bologna/bologna_en.html.

[2] For a discussion of the benefits of degree standardization and harmonization and of international mobility in creating competitive European higher education institutions see, among others, Veugelers and van der Ploeg (2008).

[3] It should be noted, however, that if governments draw some private benefits in educating students, free riding due to the public-good aspect should be softened. For an example, see Gérard and Ruiz (2006).

[4] A more extensive presentation of the model can be found in Demange, Fenge and Uebelmesser (2007).

capital markets. Depending on the degree of integration and on the specific assumptions as to mobility, in the first period, individuals decide whether and where to study and in the second period, educated workers decide where to work. In a first part, we look at a closed economy that serves as a benchmark. It turns out that the optimum in terms of the quality level of and the access restrictions to higher education can be achieved with a well chosen mix of fee- and tax-financing. In a second part, we analyse open economies. Mobility of (part of) the population results in a situation where the optimal instruments of the closed economy are no longer necessarily viable. The aim is to derive policy implications as to the optimal financial regime and quality level of higher education in the presence of migration opportunities.

Our article is related to the literature on higher education, which focuses on financing as well as on quality issues. In a closed economy set-up, one of the earlier contributions is Johnson (1984) who analyses the distributional effects of educational subsidies. He argues that even though these subsidies benefit only those who study, there is not necessarily a conflict of interest due to complementarities between skilled and unskilled labour. Creedy and Francois (1990) more directly address the underlying political-economy aspects by looking at majority voting on higher education subsidies when education generates a positive growth-enhancing externality. Both Johnson and Creedy and Francois abstract, however, from capital market distortions and uncertainties related to the education investment. The riskiness of this investment is at the core of the analysis by García-Peñalosa and Wälde (2000) who compare the efficiency and equity effects of a tax-subsidy scheme to loan schemes and graduate taxes. All these papers have in common that they abstract from an integrated labour market.

The analysis has therefore been extended to an open economy framework in newer contributions. Wildasin (2000) studies the effects of labour market integration on human capital investment in a general equilibrium model with uncertainty where education may be either publicly or privately financed. (Industry-specific) skills expose individuals to wage risks, while mobility across jurisdictions can help to eliminate these risks. The focus is thus on the decision to acquire education in an open economy setting with uncertainty where two financial regimes are compared and workers are mobile. In Del Rey (2001) students are mobile. The analysis concentrates on the ensuing fiscal competition and how this affects the governmental decision about the public provision of higher education.

A further aspect is central in Kemnitz (2005). He looks at the impact of tuition fees on the quality of higher education under decentralized and centralized decision making. Special attention is given to the question as to

what extent fees crowd out public funds under both regimes. Busch (2007) and Mechtenberg and Strausz (2008) also look at the quality level of education in an open economy. While in Busch the positive correlation between education quality and the mobility of graduates induces governments to lower the quality level to counteract the threat of a brain drain, Mechtenberg and Strausz come to similar conclusions in a setting with mobile students where governments fear free-riding.[5]

Our article contributes to this literature by systematically analysing in a general equilibrium framework how closed-economy results change in open economy with mobility of students and/or skilled workers. A special focus is on deviations from the optimal policy as the choice of the financial regime and of the quality level of education is concerned. Allowing for mobility of both groups at the same time goes beyond the analysis in the existing literature. We show in particular that mobility of students helps to alleviate the sub-optimality of both the finance-mix and the education quality, which emerge when only skilled workers are mobile. Furthermore, our model is the first one to analyse the interdependency of the (simultaneous) decisions of whether to study or not and where to study. This helps us to better understand the consequences of mobility for the provision of higher education and allows formulating policy implications.

We will proceed as follows. In the next section, we present some empirical evidence that motivate some of the basic assumptions of the model to be developed in the following sections. In Section 3, the basic set-up of the model is introduced. The individual and governmental decisions in a closed economy are discussed in Section 4 and compared to the optimum. In Section 5, the economy is opened up. The sustainability of the policies of the closed economy is analysed when students and/or skilled workers are mobile. Policy implications are derived in Section 6 and Section 7 concludes.

2 Empirical evidence

We present empirical evidence on the relative mobility of different groups (unskilled versus skilled individuals, students versus graduates) and on the dominant funding regimes of higher education (public versus private) in developed countries, especially EU countries.

---

[5] The incentives for a government or an old generation to invest in internationally applicable education are studied in Thum and Uebelmesser (2003) and Poutvaara (2004). These questions will, however, not be included in the analysis here.

2.1 Mobility

When comparing mobility of unskilled and skilled workers, there is evidence that migrants tend to be high-skilled. This has been shown for inner-country migration, e.g. by Ehrenberg and Smith (1994) for the United States, by Mauro and Spilimbergo (1999) for Spain, by Coniglio and Prota (2003) for Italy and by Hunt (2006) for Germany.[6] Migration within a country is certainly of interest here—at least for countries where the education policy and the funding regimes are decided in a decentralized way on a sub-national level. Migration across countries is, however, also relevant as far as it affects the provision of higher education on a national level. In general, whether low- or high-skilled individuals are more likely to migrate depends on the dispersion in returns to education, i.e. the inequalities of (net) earnings, as emphasized by Borjas (1987) on the basis of the model by Roy (1951). Given that we focus here on migration of EU citizens within the European Union, the cross-country differences in inequality can be expected to be not very pronounced even though redistributive activities are in general more important in continental Europe and less so in the Anglo-Saxon world. When the inequality is comparable in both countries—and even when the inequality in the sending country exceeds the one in the receiving country, it is possible to identify mechanisms which lead to positive self-selection. Brücker and Defoort (2006) extend Roy's model by including migration costs. This suffices to render the theoretical impact of the inequality of earnings on the selection of the migrant population ambiguous. Their empirical analysis shows that the majority of migrants are in fact favourably selected.

Even more interesting for our analysis of the impact of mobility on the provision of higher education is the question whether students, i.e. those who are in the process of becoming skilled, show a smaller or higher propensity to migrate than graduates, i.e. those who have already acquired the necessary qualifications, which allow them to be employed as skilled workers. More precisely, the relevant (potential) difference concerns the degree of mobility of students at the beginning of their studies and of graduates at the beginning of their professional career.[7] In general, mobility decreases with age. This might be due to emotional ties to a specific region, which grow stronger the longer one stays there. But this might also stem from job-related aspects if firm-specific (and thus also

---

[6] Based on data about migration intensions from Germany, this is also confirmed by Uebelmesser (2006).

[7] We thus abstract from migration during the period of higher education as well as later during the working life.

country-specific) human capital becomes important soon after entering the labour market.

Students seem to have a strong preference for studying close to home (Kelchtermans and Verboven 2008); those who study abroad, however, are more likely to stay abroad (Oosterbeek and Webbink 2006; Parey and Waldinger 2007, among others). If the general migration propensity of graduates indeed is largely determined by previous migration for educational purposes, one might be tempted to conclude that student mobility is a precondition for graduate mobility and thus plays a more important role—even though empirical evidence is difficult to get hold of.

Apart from the difficulties to find migration data that allow differentiating between the different groups, it is also important to note that data on migration flows are only helpful as far as they allow to draw conclusions about the (actual and potential) relative mobility of students and graduates. The absolute magnitude of the migration flow is of minor relevance as it is likely that the financing decision of higher education is not so much affected by it as by the general propensity to leave the home country, i.e. by the threat of migration (cf. Andersson and Konrad 2005).

What can be observed, though, is the steady increase in foreign enrolment. Over the past three decades, the number of students in a foreign country has more than quadruplicated rising from 0.6 millions in 1975 to 2.7 millions in 2004 (OECD 2006). This process has accelerated over the last 10 years, where the number of foreign students has doubled. This can be seen as reflecting the general globalization trend. It can be expected that the internationalization of tertiary education will be further boosted by the Bologna process, which we will discuss in some detail subsequently.

2.2 Financial regimes

Total expenditure on higher educational institutions is non-negligible in most countries. As a percentage of gross domestic product (GDP) it ranges from 0.9 percent to 1.8 percent in the EU-25 countries for which data are available with Denmark, Finland and Sweden leading the list and Italy and the Slovak Republic spending the least (cf. Figure 1, all data for 2003). For comparison, the United States exceeds all EU-25 countries with 2.9 percent. Between 1995 and 2003, total expenditure slightly increased in most countries.

The two main financial regimes of higher education are a system where education is publicly financed via taxes and a system where financing of education is private, i.e. where it is based on fees. In all EU-25 countries, some combination of these two systems can be observed, but public financing clearly dominates. Only in Poland, private financing plays a

	1995	2003		
	Total	Public	Private	Total
Austria	1.2	1.1	0.1	1.1
Belgium	–	1.2	0.1	1.3
Czech Republic	1.0	0.9	0.2	1.1
Denmark	1.6	1.7	0.1	1.8
Finland	1.9	1.7	0.1	1.8
France	–	1.1	0.2	1.4
Germany	1.1	1.0	0.1	1.1
Greece	0.8	1.2	–	1.3
Hungary	1.0	1.0	0.3	1.3
Ireland	1.3	1.0	0.1	1.2
Italy	0.8	0.7	0.2	0.9
Netherlands	1.4	1.1	0.3	1.3
Poland	0.8	1.0	0.5	1.5
Portugal	0.9	1.0	0.1	1.1
Slovak Republic	0.8	0.8	0.1	0.9
Spain	1.0	0.9	0.3	1.2
Sweden	1.6	1.6	0.2	1.8
United Kingdom	1.2	0.8	0.3	1.1
United States	2.7	1.2	1.6	2.9

Source: OECD (2006) – tables B2.1b

Figure 1 Expenditure on higher education as a percentage of GDP—EU25 and United States

significant role. Private sources are more important than public ones, however, in the United States.

3 The model

As already mentioned, we focus here on a two-period, two-stage game with two countries.[8] The production sector in each country uses two kinds of input: skilled and unskilled labour. Production takes place according to a neoclassical production function with constant returns to scale and complementarity between skilled and unskilled labour. Labour markets in each country are competitive and wages correspond to the respective productivities per skill-unit.

In accordance with the empirical evidence cited earlier, we assume that unskilled individuals are immobile and analyse the impact of mobile

---

[8] See the Appendix for a more technical presentation of the basic ingredients of the model.

students and/or mobile graduates on the provision of higher education.[9] We also choose a general setting with a mixed financial regime with pure tax-financing and pure fee-financing as special cases.

Individuals differ with respect to their innate ability where we assume a uniform distribution of abilities. For unskilled jobs, the ability level is not relevant. Only if individuals receive some education, their ability becomes important as the returns of higher education depend on the quality level of education as well as on the innate ability. Both together generate the skill-units an individual is endowed with after having acquired education.

For simplicity, we assume that the amount of money spent for higher education per individual only depends on the level of education quality. Costs of education are thus proportional to the number of students, given the quality; they increase in a convex way. This reflects that education is considered here to be a private good.

Apart from the technology-related interpersonal links, which are reflected in the complementarity between skilled and unskilled workers, we do not consider any additional externalities—in particular, we abstract from positive spill-over effects among students and skilled workers. We follow here the interpretation of the empirical literature by Jacobs and van der Ploeg (2006) according to which the empirical evidence in favour of human capital externalities is not very strong. The social (macroeconomic) returns to education are approximately equal to the private (micro-economic) returns.[10] It is important to note that this implies that in our framework public funding of higher education needs to be justified on other grounds than externalities.

The set-up we have in mind is the following: at the first stage, governments choose the quality level of education and how higher education is financed, i.e. via taxes and/or via fees. Both countries may differ with respect to both dimensions. At the second stage, individuals make their education and migration decisions given the governmental arrangements for higher education. We introduce a two-period life-cycle model. In the first period, individuals decide whether (and where) to study. For this, they compare the maximal lifetime income with higher education to the lifetime income they receive when uneducated. Individuals without higher education are assumed to be immobile.

---

9   The framework is thus more general than in most of the papers cited below—with the exception of Kemnitz (2005)—which focus on either the possibility of migration before studying (cf. Mechtenberg and Strausz 2008) or on possible migration of graduates or skilled workers respectively (cf. Wildasin 2000; Thum and Uebelmesser 2003; Poutvaara 2006; Busch 2007).

10   For more details, see the empirical literature cited there.

Thus, individuals who choose not to study work and earn the wage income of an unskilled in their home country in both periods of their life. As for those who choose to acquire education, in the first period, they receive no wage income. In the second period, if they are mobile, they decide in which country to work and earn the wage income of a skilled there. Taxes and/or fees are paid according to the financial regime in place. We investigate the impact of distortions on credit markets by which we understand an interest rate that exceeds the population growth rate. Young individuals have to bear an extra cost for borrowing. In particular, those who choose to study bear the cost because they have no earnings in the first period and must borrow to finance the fees (if any) and their consumption.

4 Education decision in closed economies

As a benchmark, we start with the non-migration case and analyse the individual and governmental decisions within a closed country. In particular, we contrast the individual choice of studying with the decision problem of the government to choose the quality level without observing abilities. We allow for different financial regimes. With this we are able to capture the fact that the importance of fee- and tax-financing varies across countries (cf. Figure 1).

It is important to note that we assume here a uniform level of education quality in the sense that—once decided by the government—it applies to all students. This implies in particular that it cannot be topped up privately. This assumption is approximately satisfied in most EU-countries since higher education is predominantly publicly financed (cf. Figure 1).

4.1 Individual decisions

When individuals face the decision whether to acquire higher education or not, they compare their lifetime incomes with and without education and choose the option which maximizes their income.

If higher education is purely tax-financed, students do not have to contribute at all to the costs of higher education while studying. The necessary taxes are levied from the unskilled in both of their working periods and from the skilled after having completed their studies. With pure fee-financing of higher education, on the contrary, students have to fully cover the costs of higher education while studying, whereas there are no taxes to be paid by skilled or unskilled workers.

The focus here is on a mixed system where higher education is financed partly by fees paid by students and partly by taxes levied on labour income. This represents the most general case.

In all cases, the decision whether to study or not depends on the ability of the individual. The periodic net wages—appropriately discounted—allow us to determine the marginal ability type who is just indifferent between studying or not. In general, we find that—quite intuitively—the higher the share of education costs financed by taxes, the more attractive it is to become skilled: this allows escaping the tax duties during the first period when studying and above all this implies a reduced total financial burden as part of the costs are co-financed by the unskilled via their tax payments. In fact, an important difference between both systems is that with a tax-regime—but not with a fee-regime—students partially free-ride on the unskilled who contribute to the financing of higher education via tax payments in both of their working periods.

We focus here on an equilibrium under rational expectations. This means that the individual decisions to be skilled or unskilled are based on "expected" wages. These decisions or more precisely the ability threshold of the marginal individual determines the supply of skilled and unskilled labour, which in turn determines the wages that clear the markets. At an equilibrium, these realized wages must be equal to the initial expected wages.[11]

For the following analysis, it is important to get a more precise idea of how the level of education quality affects the ability threshold, which is implicitly given by the employment equilibrium. The quality level has two direct effects: one is beneficial because the total wage of a skilled worker is proportional to the quality level of education; the other one is harmful because the individually relevant costs increase with the quality level. The total impact of these direct effects depends on the financing of the system. More precisely, the cost effect for the individual decision to acquire higher education is the less important the larger the share of the costs financed by taxes.

In our general equilibrium modelling framework, there is an additional indirect effect on wages that always lowers the benefits: increasing the level of education quality is akin to an increase of the amount of skilled labour. Hence skilled wages decrease and unskilled wages increase. The more elastic wages are, the stronger the indirect impact is. In particular, with full complementarity between skilled and unskilled labour, increasing the quality level of education always discourages some individuals to acquire education.

---

[11]   In our companion paper, Demange, Fenge and Uebelmesser (2007), we have established that for the given modelling framework the equilibrium is unique. The intuition is that as there are fewer skilled individuals, the incentives to become skilled are enhanced through the impact on wages, which gives an equilibrating force. In other words, increasing the threshold ability means that fewer workers acquire skills, which raises the wage rate for skilled and decreases the wage rate for unskilled.

The total effect can therefore not be determined unambiguously: it is well possible that a higher quality level induces more individuals to become skilled, which would lower the ability threshold. It is, however, also possible that a higher quality level discourages some individuals from acquiring higher education if the negative relative wage effect as well as the cost effect dominate. This would then lead to a higher ability threshold.

To get a better idea of which of the two cases is more likely, we look at some (indirect) evidence taking both sides of the market, i.e. the supply and the demand of skilled workers, into account, as both sides are important as relative wage changes are concerned.

In fact, when studying the college graduate wage relative to the high school wage in the United States, we see a clear upward trend of the college wage premium since the 1950s—interrupted only by a decrease between 1970 and 1980 (Goldin and Katz 2007).[12] During this period, demand of college "equivalents" relative to high school "equivalents" has increased—most strongly in the period 1980–90.[13] At the same time, supply of college "equivalents" has also increased—especially between 1970 and 1980 and to a lesser extent after 1990. The slowdown of the growth of relative supply for the last 15–25 years could be interpreted as a reaction to expected lower relative wage growth by individuals who have consequently abstained from higher education. Indeed, Goldin and Katz state that the observed rise in the college wage premium after 1980 has been mainly due to the strong decrease of the growth of the skilled labour supply. This would point towards a negative correlation between the quality level of education and the number of students if indeed changes of the quality level could be identified as the driving factor.

It is evident, however, that if changes of the supply of skilled workers coincide with changes of the demand, it is not easy to isolate the effect of an increase in the education quality on the number of students, i.e. on the ability threshold. This shows that a more general framework, which allows that the correlation can be negative or positive, has some benefits.

4.2 Government decisions

We first look at the optimum as implemented by a social planner and then derive the decisions of a government as the provision of higher education is concerned.

---

[12] This can also be observed in the UK and to a lesser extent in continental Europe (Davis, 1992).

[13] College "equivalents" comprise college graduates plus one half of those with some college education, while high school "equivalents" refer to those with 12 or fewer years of schooling and the other half of those with some college education.

Under complete information about individual abilities, a social planner can decide on the level of education and on the ability of those who study, i.e. on the ability threshold. The objective function of the social planner is aggregate production net of education cost at a steady state.[14] In other words, we are at the golden rule with an implicit interest rate equal to the population growth rate, which is here equal to zero.

The ability threshold is then chosen such that for the marginal student the net gain of education is null, i.e. the skilled wage in the second period net of the costs of education in the first period just equals the opportunity costs in form of unskilled wages in both periods. As concerns the education quality, the optimal level is determined by the social planner such that the marginal gain from a change in education for the average student is equal to the marginal cost.

For the following analysis, we enlarge the setting in two ways:

First, individual abilities are no longer observable (or contractible). Due to these informational asymmetries, the set of students can no longer be directly chosen but it depends on the decisions by the individuals. The best the government can do is to determine the level of education taking account of these decisions.

Second, the interest rate faced by the individuals is no longer necessarily at the golden rule level. A positive interest rate can be interpreted as a risk premium charged by credit markets due to the risky investment in human capital and moral hazard problems leading to distortions, which we want to capture (von Weizsäcker and Wigger 2001; Jacobs and van der Ploeg 2006).

We look at the general case where the costs of higher education are mixed-financed. The specific financing regime affects the budget constraint and thus the optimization problem of the government. The government maximizes again aggregate production net of education costs by choosing simultaneously the quality level of education and the share of costs financed by fees where the tax rate is endogenously determined by the budget constraint.

As the government now disposes of two instruments, it is well possible that the optimal policy of the social planner can be mimicked. In fact, if the interest rate is at the golden rule level, the optimum is reached with pure fee-financing. This is intuitive as in the absence of any distortions, there is no reason for governmental intervention in the form of tax-financing of higher education. If, however, the interest rate exceeds the golden rule level due to distortions on credit markets, these distortions justify a (partial) intervention of the government via tax-financing.

---

[14] This is the criterion that obtains in a fully fledged overlapping generations economy in which the social planner treats all generations equally.

The optimal policy can be reached with a mixed-financing regime. The reason for the optimality of mixed-financing with distortions on the credit markets is that with pure fee-financing too few individuals decide to study. The welfare can thus be increased by subsidizing higher education via taxes as this encourages more individuals to study. It should, however, be noted that if the distortions on the credit markets are high, the fee level has to be negative, meaning that students then are even directly subsidized for acquiring education.

In a framework with skill complementarities, but in the absence of any externalities, we have thus established the optimality of partial tax-financing, which rests entirely on efficiency (and not on equity) considerations. We have argued that the optimal share of taxes and fees depends on the degree of distortions on capital markets. As it is likely that capital market institutions vary across countries, the implemented financial regimes should differ as well. We are thus able to give a rationale for why different countries resort to different systems as the relative importance of fees and taxes for financing higher education is concerned as long as borders are closed.

5 Education and migration decisions in open economies

With open borders, the relative importance of taxes and fees and the quality of education can be expected to be affected. We take the closed economy as a starting point for the following analysis where we allow for mobility—first only of skilled workers and then of both students and skilled worker.[15]

We consider two identical countries A and B. The number of students depends on the decisions of the different ability types to take up a university education in one of the two countries, which in turn depends on the institutional framework and expected wages. This determines the labour force of skilled and unskilled workers in the whole economy. We focus here again on the case where capital markets are distorted. As we know from the previous analysis, in a closed economy setting, at least, an appropriately chosen mixed-financing regime would achieve the optimum. The question is then how the financing of education, the level of education quality and also the number of students and skilled workers change if the governments take mobility into account.

---

[15] The focus is here on two political entities—countries or regions—with the competence to determine the education policy and to raise the necessary financial resources. We comment on other settings in the conclusion.

5.1 Only skilled workers are mobile

First, only skilled workers are mobile, while students and unskilled workers are immobile. Skilled workers will migrate between both countries as long as the net-of-tax wage income is different. Thus, the migration equilibrium requires that skilled workers receive the same net wage income in both countries (arbitrage condition).[16]

Let us consider the mixed system that implements the optimal policy in a closed economy. Starting from this situation, we want to determine how welfare of one country, say country A, changes, when this country modifies its financial regime. We are thus interested in seeing whether the optimal policy is a Nash equilibrium, and if not, in which direction a country is incited to change the fee level.

To be more precise, we first consider the welfare of a country at the new equilibrium induced by the new fee level but keeping the level of education quality fixed. The equilibrium is again determined by the ability thresholds, the taxes and the migration levels that satisfy the budget constraints in the two countries as well as by the arbitrage condition. We assume that the migration equilibrium is stable. The stability condition needed to ensure this is that the net skilled wage in the country which receives migrants decreases with migration. This simply implies that if the net skilled wage in one country, say A, exceeds the net skilled wage in the other country, say B, migration from B to A reduces the gap between the skilled net wage in the two countries accounting for equilibrium effects, i.e. for the decisions to acquire education and the impact on wages and taxes. If we can establish that the stability condition holds, it can be shown that both countries will increase fee-financing above the level necessary to achieve the optimum.

Let us provide some intuition for this: if country A increases its fee without changing the quality level of education, there will be fewer individuals who decide to study, i.e. the ability threshold will increase. The higher share of fees as well as the smaller number of students enable country A to lower its tax rate. In addition, since the number of skilled individuals decreases the wage rate of the skilled relative to the unskilled increases. The higher net wage attracts skilled workers from country B who have received higher education there: country A free-rides on country B.[17] So far, we have assumed that country B does not react to the outflow of (part of) its skilled labour force. Country B has, however, the same incentives to increase its fee as country A has. It follows that the

---

16 We rule out corner solutions where all skilled individuals move to the same country by assuming that the Inada condition holds for the production function.

17 There is, however, a countervailing equilibrium effect: the higher skilled net wage incites more people to study. But this (second-order) effect does not dominate here.

closed-economy level of the fee is not a Nash equilibrium when skilled workers are mobile. In the new equilibrium, the fee level in both countries will be higher than the level that achieves the optimum as both countries aim at attracting foreign skilled workers as tax-payers, while free-riding on the other country's provision of higher education.

For the question of how the chosen level of education quality changes in an open-economy setting with mobility of skilled workers, it is again necessary to consider what happens to the net wages of the skilled when a closed economy modifies its quality level. It is reasonable to conjecture that when the level is decreased fewer individuals decide to study. This increases skilled wages and decreases the total costs of education which triggers a decrease in taxes. This leads to higher skilled net wages. Under a stability condition, skilled workers are again attracted from the other country when economies are open. Thus, if the conjecture is true, both countries have an incentive to decrease the quality level of education below the optimal one.

To sum up, when students are assumed to be immobile, the rationale for countries to adjust their education policies is to attract skilled workers. This is achieved by increasing the net-skilled wage rate, i.e. by decreasing the tax rate or by increasing the skilled wage rate (or by both). It has been shown that under some technical conditions (specifically an arbitrage and a stability condition) and given that the quality level of education and the number of students are positively correlated, countries can reduce education costs borne by the public via taxes by increasing fees or by lowering the quality level of education. In both cases, the number of students is reduced thereby making the skilled labour force scarcer.

The deviation from the optimal policies results from the exclusive focus on skilled workers as the only mobile group. One possibility to counteract this is to increase the mobility of other groups as well. We investigate this rationale for promoting the mobility of students in the following.

5.2 Skilled workers and students are mobile

We next consider the case where students are mobile and have access to the education system of a foreign country at the same conditions as natives in line with EU non-discrimination rules. Graduates are assumed to be (partially) mobile as well. We thus allow for some non-perfect link between student and graduate mobility following, e.g. the evidence provided by Parey and Waldinger (2007). Now, young individuals not only have to decide whether to study but also where to study. In both countries, in the first period, individuals then compare their net lifetime incomes for all possible education and migration choices. This gives the

marginal ability types of the young individuals who are indifferent between studying or not and migrating or not.

Let us start again from the symmetric mixed-financed system which is optimal in closed economy. As before, we want to distinguish two cases in the following.

We assume first that the quality level is kept unchanged in both countries. Let a country, say *A*, contemplate increasing its fee. Only fees matter as by the arbitrage condition the net skilled wages are equalized if a sufficiently large part of the skilled workers is mobile. It follows that for any ability level the net lifetime income of a skilled would be larger by studying in country *B*: all individuals will study in *B* if they decide to study. As a result of the large inflow of students, country *B* would then have to increase fees up to the same level as in *A*. This would lead to the same financing policy with the same number of students in both countries. Higher education, however, would now be financed by a sub-optimal mixture of fees and taxes. If *A* anticipates the reaction of *B*, it is plausible to expect country *A* to abstain from increasing the level of fees in the first place. A symmetric equilibrium would then result where the optimal finance mix of the closed economy could be sustained.

Next, we consider the case where the quality level can be adjusted as well. From the previous argument it follows that a migration equilibrium with different levels of fees and taxes in the two countries can only realize if the quality level of education in a country, say *A*, which increases its fees exceeds the one in country *B*. Then *A* specializes in attracting high-ability students while *B* focuses on low-ability ones. Whether this constitutes an equilibrium when general equilibrium effects are taken into account, depends on the specific functional forms. The relative importance of student and graduate mobility will be essential for the financial regime and the quality level of education. Note, however, that, in general, this differentiation could present one possibility to alleviate a sub-optimality inherent in our model. By assuming a uniform level of education quality which applies to all students in a country, we have ruled out that education can be topped up individually to better correspond to individual ability. If migration and the ensuing competition between countries result in differentiated quality levels across countries, the uniformity of education quality on a country-level is no longer as detrimental from a welfare point of view.

In fact, even though it is difficult to identify clear instances of intentional differentiation strategies across countries, within countries, examples can be found. In the United Kingdom, for example, the Russell Group, an association of 20 major research-intensive universities, strives at maintaining the highest standards of research, education and knowledge transfer. By doing so, the universities which belong to this

group clearly want to differentiate themselves with respect to other British and possibly European and North American universities. This can, however, be only partially translated into a correspondingly large differentiation of fees as British students are concerned given the maximum of £3000 which universities are allowed to charge per year for full-time undergraduates. This upper bound also applies to students from the European Union due to the non-discrimination rules, but there is no limit for fees for students coming from outside the European Union.

Summarizing, with mobile students in addition to (partially) mobile skilled workers, the suboptimality of the finance structure of higher education, which was the case when only skilled workers were mobile, can be expected to vanish. If, in addition, the requirements that the quality levels of education have to be the same in both countries are relaxed, differentiated quality levels could result. This would then alleviate the inherent inefficiency that stems from the imposition of a uniform level of education quality within a country.

6 Policy implications

The analysis has shown that with integrated labour markets where students and/or skilled workers are mobile, the financing decision and the chosen quality level of education are affected. This conclusion points to relevant policy issues (cf. Del Rey 2001). We will first elaborate on policy conclusions which can be directly derived from the model and then discuss related issues.

6.1 Conclusions from the model

In the context of the European Union, the principle of non-discrimination on the basis of nationality prevents the differential treatment of native and foreign students and thus restricts the set of possible financial instruments.[18] It is thus necessary to be clear about how higher education should be financed.

As long as no full-cost fees are charged and as long as no transnational compensation mechanisms exist, it is likely that foreign students pay only part of the costs with the rest being subsidized by the tax-payers of the country that provides higher education. There are some complaints, in particular by Austria and Belgium because of the many students from

---

[18] This has been challenged—albeit unsuccessfully—by Belgium, Denmark and the UK. They were taken to court in 1985 as they insisted that according to the subsidiarity principle every Member State should have responsibilities towards its natives, but not towards the citizens of other countries (Gravier judgement, European Court of Justice, 1985 – cf. also Del Rey 2001).
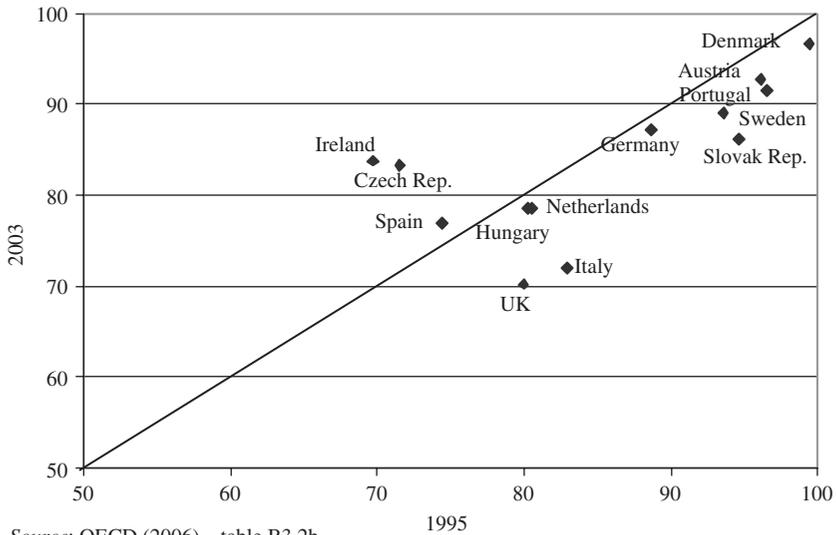
Figure 2 Share of public expenditure for higher education as a percentage of total expenditure – EU25

Germany and France, respectively, who go there to pursue their studies before returning back home in order to get around the access restrictions, which exist in their home countries. As has been shown in the model when skilled workers, i.e. graduates, are mobile, countries give a more important role to fees. This tendency towards more fee-financing can also be seen in the data.

Figure 2 displays the share of public expenditures for higher education of the EU-25 countries in 1995 and 2003. In countries which are above the diagonal line, the relative proportion of public expenditure has increased between 1995 and 2003, while taxes have become relatively less important in countries below the diagonal line. With the exception of Ireland, Spain and the Czech Republic, we find for all countries for which data are available that the share of public expenditures decreased implying that the share of private expenditures increased for the period under consideration.

There are different possible explanations for this trend towards relatively more fee-financing (cf. Jacobs and van der Ploeg 2006): On the one hand, the growth of public funds has decreased and can be expected to continue to do so due to ageing and due to restricted borrowing possibilities for members of the European Union for which the Maastricht criteria apply. On the other hand, as the analysis here has shown generating public funds has also become more costly because of the increased mobility of the tax-payers. The interplay of the financing regime

of higher education and the mobility of students and/or graduates is of particular relevance. This is also what can be observed when following the recent discussions and reforms in some European countries.

For illustration, we briefly summarize the debate in Germany. There, student tuition fees were banned until January 2005 when the Federal Constitutional Court abolished this ban. Since then, 8 of the 16 German States have passed laws to introduce fees in the range of €300–€500 per semester. Those which have abstracted from charging fees—mostly states in East Germany—hope to attract more students to their universities. This change of policy has been accompanied by intensive discussions of advocates and opponents. Those in favour of student fees claim that these fees will provide universities with the additional funds needed, in order to overcome the international disadvantages of German universities. Fees are intended to improve teaching and learning conditions and thus the quality of higher education in a significant way (cf. HRK 2005). Given the federal structure in Germany with the states being responsible for all educational issues, it will be interesting to observe whether the initially chosen fee policies can be sustained and whether there will be any impact of the different funding structures on the quality levels of education.

Even though it is too early for first conclusions, critical voices point out two possible drawbacks. First, as total expenditure for higher education is concerned there is fear that public funding is reduced in reaction to the increased private sources. Partial crowding-out of tax-financed contributions would not help the catching-up process (Kemnitz 2005). Second, in the presence of distorted capital markets, this shift towards more fee-financing might distort the optimal financing-mix. But as we have seen, this last problem is mitigated if not only skilled workers, but also students are mobile. This provides, of course, a rationale for the Bologna process.

In addition, those who are against fees worry that equality of chances is endangered concerning access to higher education.[19] This makes it necessary to think about loan facilities and grants (Jacobs and van der Ploeg 2006) and more generally, to discuss how to best allocate the competence for higher education across the different political entities—something which we will do in the following.

---

[19] Note that even before the introduction of fees, higher education tended to be regressive reinforcing economic inequalities. This was due to the relatively strong selection of children from a high-income background into universities compared to the economically disadvantaged (see Frick, Grabka and Groh-Samberg 2007, for Germany and Chapman 2006, for Australia).

6.2 Further considerations

The questions about how to best fund higher education are closely related to the questions of which country should be hold responsible for (the organization of) the financing of studies pursued abroad. Gérard (2007) distinguishes between the home country of the student and the country that provides higher education—or correspondingly the origin principle and the production principle.

As long as financing is based on a mix of fees and taxes where the taxes are levied from those working in the country which provides higher education, the production principle applies—at least as the share of tax-financing is concerned. One possible remedy could be to move closer to the origin principle.

We distinguish here between a larger financial responsibility for education acquired abroad, which is borne by the foreign students or their home country. With the tax liability shifted to the home country of the students, an appropriate system of compensatory transfers—similar to what exists in Switzerland on an inter-cantonal level—could be installed in order to internalize the externalities generated by student and/or graduate mobility. This could be seen as a ''natural'' consequence of the Bologna process, which shifted some functions such as standardization of degrees and transparency of contents to the European level without realizing that this half-heartedly approach is responsible for the distortions that can be observed today.

Alternatively, the students could be more strongly involved financially by moving more towards fee-financing—a tendency which can be observed in most countries (cf. Figure 2). To alleviate distortions related to imperfect capital markets, the specific design of the financial regime would then be of importance.

Income-contingent loans present one possible instrument. First introduced in Australia in 1989, they have been adopted since then in New Zealand, South Africa, the UK and Thailand, and are planned for 2008 in Israel (see Chapman 2006, for an analysis of the Australian case). They provide students with the sources necessary to finance their education while repayment is conditioned on their income after graduation. Income-contingent loans can thus be seen as a mixture of loan and insurance.[20]

---

[20] Means-tested subsidies present another option. In contrast to income-contingent loans, they are targeted at poor students or students with low-income parents in order to remove the particularly adverse conditions faced by this group. In the absence of distortions on the credit market, equality of chances can already be achieved by income-contingent loans, which have the additional advantage of avoiding any negative repercussions on the saving-incentives of students and their parents.

Graduate taxes constitute an alternative policy to provide students with the necessary financial means to pursue their studies. Repayment constitutes, however, a certain fraction of future income. This implies that the payments of some graduates with high incomes will exceed the costs of education, while they will fall short of them for other graduates with low incomes. Only on an average is there a correspondence between per student costs and per graduate contributions. Exit taxes or ''brain taxes'' as first proposed by Bhagwati (1972) in the context of the brain drain from developing to developed countries can be considered as a special version of graduate taxes.

Compared to a traditional tax-subsidy scheme similar to the one in our model, income-contingent loans and graduate taxes are superior in terms of efficiency and/or equity (cf. Poutvaara 2004; García-Peñelosa and Wälde 2000; Jacobs and van der Ploeg 2006). While García-Peñalosa and Wälde (2000) find that when education outcomes are uncertain, graduate taxes are to be preferred because they provide more insurance, Jacobs and van der Ploeg (2006) argue in favour of income-contingent loans because in their view they are more flexible and better able to avoid moral hazard problems.

Given the increasing mobility of students and skilled workers, repayments of the costs of higher education are not always guaranteed if they are moved to periods after graduation. This problem equally concerns financing via loans and graduate taxes. In fact, by moving from fees, which have to be paid up-front, to income-contingent loans or graduate taxes, which are both due after graduation, an enforcement problem as in a tax-financing system is reintroduced.

A central, supra-national institution would then be needed. This could mean to assign a more active role to the European Union. One could think about establishing a monitoring system to guarantee the compliance of the financial obligations—either by foreign students or by their home countries. As the individual repayment behaviour of students is concerned, this would very probably only help to partially alleviate the problem given the number of students and graduates of whom it would be necessary to keep track. It would be probably more promising—and also more in line with the subsidiarity principle—if the European Union coordinated the compensatory transfers across countries, while the countries remained responsible for generating the necessary resources from their citizens. With full-cost compensations, the incentives to free-riding on other countries' provision of higher education would then vanish.

A more pronounced involvement of the European Union as the financial side is concerned—in addition to its involvement with the standardization and transparency of degrees—is a pre-condition for the further development of the European Higher Education Area including policies which

further stimulate the mobility of students. This brings us, however, to the question of the preferred allocation of competance for higher education. There is some evidence that transferring more financial competence to the European level might face some resistance. Given the general under-standing of most governments—and their citizens (cf. Cerniglia and Pagani 2007)—that education should remain a national area of compe-tence, a stronger involvement of the European level might be considered to be wishful thinking at the moment. Instruments which would allow achieving the optimum might not be feasible. It is thus necessary to consider the best policies given these constraints and to think about further reforms necessary to minimize the distortions stemming from an integrated economy.

7 Concluding remarks

We are now able to answer the two questions which we have asked at the beginning. With mobility of skilled workers only, governments have an incentive to decrease education spending—either by increasing fees or by decreasing quality to sub optimal levels as compared to the closed economy. This allows increasing net skilled wages and attracting skilled labour. As we have seen, promoting mobility of students helps to counteract this exclusive focus on skilled workers and can alleviate the sub-optimality of both the finance-mix and the quality level of education. This may provide a justification for the Bologna process.

We have restricted our analysis to symmetric countries, which have the competence to determine the education policy and to raise the necessary financial resources. Both assumptions deserve some discussion.

It is, first of all, evident that countries in the European Union differ as their attractivity for foreign students and/or foreign graduates is concerned. We have seen above that, e.g. the small countries Austria and Belgium complain about the significant net inflow of students—mostly from their big neighbours Germany and France. The question is whether these asymmetric flows of migrants constitute an equilibrium or whether they must be interpreted as a transitional phase from one (closed economy) equilibrium to one (open economy) equilibrium. As long as it is not the case that some countries possess a more efficient production technology for education or other inherent advantages in relevant areas, there is no strong case to believe that these observed asymmetries will persist permanently.

It is also evident that not all political entities—especially on a sub-national level—have the competence to decide about education and tax policy. If, e.g. only the education policy is decentralized, but not the

tax policy, it depends on the financial compensation scheme in place how the decision about the quality of higher education is affected by the mobility of students and/or skilled workers. If there is a full-cost compensation, the incentives are certainly larger to implement a high quality level than if there is a lump-sum compensation—perhaps based on some average cost or quality level. For certain compensation schemes, it might thus be worthwhile to try to attract students, while inducing more skilled workers to move to a certain region does not seem to be very profitable when taxes are collected centrally anyway.

We have found in our analysis that the policy is always targeted at the mobile group of individuals. This is intuitive and has also been shown in other papers with different modelling set-ups (Andersson and Konrad 2005). It is therefore worthwhile to stress again what we consider to be the advantage of our approach. Due to the general-equilibrium effects present in our analysis and the explicitly considered education and migration decisions, the results are often ambiguous. It has become clear indeed that the results rely on some technical conditions—in particular, the arbitrage and the stability condition—as well as on several assumptions—above all the assumed positive correlation of the quality level of education and the number of students. It is therefore ultimately an empirical question whether, in a specific context, the assumptions are fulfilled and the conditions hold. It is well possible that this is not always the case. The chosen general-equilibrium approach allows modelling the complete picture including all relevant effects and is thus flexible enough to be applied to different institutional environments.

References

Andersson, F. and K.A. Konrad (2005), ''Bildung, Besteuerung und Internationale Mobilität'', in Ulrich Becker und Wolfgang Schön, eds., *Steuer- und Sozialstaat im Europäischen Systemwettbewerb*, Mohr Siebeck, Tübingen, 75–92.

Bhagwati, J.N. (1972), ''The United States in the Nixon Era: The End of Innocence'', Daedalus, 25–47.

Borjas, G.J. (1987), ''Self-selection and the Earnings of Immigrants'', *The American Economic Review* **77**, 531–33.

Brücker, H. and C. Defoort (2006), ''The (Self-)Selection of International Migrants Reconsidered: Theory New Evidence'', IZA Discussion Paper No. 2052, Bonn.

Busch, O. (2007), *A Bird in the Land is Worth Two Abroad*, University of Frankfurt, Mimeo.

Cerniglia, F. and L. Pagani (2007), ''The European Union and the Member States: Which Level of Government Should Do What? An Empirical Analysis of Europeans' Preferences'', CESifo Working Paper No. 2067, Munich.

Chapman, B. (2006), *Government Managing Risk: Income Contingent Loans for Social and Economic Progress*, Routledge, London.

Coniglio, N.D. and F. Prota (2003), ''Human Capital Accumulation and Migration in a Peripheral EU Region: The Case of Basilicata'', SNF Working Paper No. 43/2003, Bergen.

Creedy, J. and P. Francois (1990), ''Financing Higher Education and Majority Voting'', *Journal of Public Economics* **24**, 181–200.

Davis, S.J. (1992), ''Cross-Country Patterns of Changes in Relative Wages'', in O. J. Blanchard and S. Fisher eds., *NBER Macroeconomic Annual 7*, MIT Press, Cambridge MA, 239–400.

Del Rey, E. (2001), ''Economic Integration and Public Provision of Education'', *Empirica* **28**, 203–18.

Demange, G., R.Fenge and S. Uebelmesser (2007), ''Financing Higher Education and Mobility'', University of Munich, Mimeo.

Ehrenberg, R.G. and R.S. Smith (1994), *Modern Labor Economics: Theory and Public Policy*, Harper Collins, New York.

Frick, J.R., M.M. Grabka and O. Groh-Samberg (2007), ''Economic Gains from Publicly Provided Education in Germany'', IZA Discussion Paper No. 2911, Bonn.

García-Peñalosa, C. and K. Wälde (2000), ''Efficiency and Equity Effects of Subsidies to Higher Education'', *Oxford Economic Papers* **52**, 702–22.

Gérard, M. (2007), ''Financing Bologna: Which Country will Pay for Foreign Students?'', *Education Economics* **15**, 441–54.

Gérard, M. and F. Ruiz (2006), ''Interjurisdictional Competition for Higher Education and Firms'', CESifo Working Paper No. 1719, Munich.

Goldin, C. and L.F. Katz (2007), ''The Race Between Education and Technology: The Evolution of U.S. Educational Wage Differentials, 1890 to 2005'', NBER Working Paper No. 12984, Cambridge, MA.

HRK (2005), HRK-President Welcomes Today's Federal Constitutional Court Ruling on Tuition Fees and Calls for Universities to be Able to Freely Structure their Tuition Charges, Press Release – 26 January 2005 http://www.hrk.de/eng/presse/95_1599.php (last accessed 1 May 2008).

Hunt, J. (2006), "Staunching Emigration from East Germany: Age and the Determinants of Migration", *Journal of the European Economic Association* **4**, 1014–37.

Jacobs, B. and F. van der Ploeg (2006), "Guide to Reform of Higher Education: a European Perspective", *Economic Policy* **21**, 535–92.

Johnson, G.E. (1984), "Subsidies for Higher Education", *Journal of Labor Economics* **2**, 303–18.

Kelchtermans, S. and F. Verboven (2008), "Regulation of Program Supply in Higher Education. Lessons from Funding System Reform in Flanders", *CESifo Economic Studies* **54**, doi:10.1093/cesifo/ifn016.

Kemnitz, A. (2005), "Educational Federalism and the Quality Effects of Tuition Fees", TU Dresden, Mimeo.

Mauro, P. and A. Spilimbergo (1999), "How do the Skilled and the Unskilled Respond to Regional Shocks? The Case of Spain", IMF Staff Papers 46, 1–17.

Mechtenberg, L. and R. Strausz (2008), "The Bologna Process: How Student Mobility Affects Multi-Cultural Skills and Educational Quality", *International Tax and Public Finance* **15**, 109–130.

OECD (2006), *Education at a Glance*, OECD, Paris.

Oosterbeek, H. and D. Webbink (2006), "Assessing the Returns to Studying Abroad", CPB Discussion Paper No. 64, University of Amsterdam.

Parey, M. and F. Waldinger (2007), "Studying Abroad and the Effect on International Labor Market Mobility", presentation at the CESifo Workshop on "Innovation and Higher Education Reform", CESifo Venice Summer Institute.

Poutvaara, P. (2004), "Educating Europe: Should Public Education be Financed with Graduate Taxes or Income-Contingent Loans?", *CESifo Economic Studies* **50**, 663–84.

Roy, A.D. (1951), "Some Thoughts on the Distribution of Earnings", *Oxford Economic Papers* **3**, 135–46.

Thum, C. and S. Uebelmesser (2003), "Mobility and the Role of Education as a Commitment Device", *International Tax and Public Finance* **10**, 549–64.

Uebelmesser, S. (2006), "To Go or not to Go: Emigration from Germany", *German Economic Review* **7**, 211–31.

Veugelers, R. and F. van der Ploeg (2008), "Higher Education Reform and the Renewed Lisbon Strategy: Role of Member States and the European Commission", in G. Gelauff, I. Grilo and A. Lejour,

eds., *Subsidiarity and Economic Reform in Europe*, Kluwer, Dordrecht, 65–96.

von Weizsäcker, R.K. and B.U. Wigger (2001), "Risk, Resources and Education", IMF Staff Papers 48, 547–60.

Wildasin, D. (2000), "Labor Market Integration, Investment in Risky Human Capital, and Fiscal Competition", *American Economic Review* **90**, 73–95.

Appendix

Basic ingredients of the model

We sketch here the model for the closed economy presented in Demange, Fenge and Uebelmesser (2007).

Production in each country takes place according to a neoclassical production function with constant returns to scale

$$F(L_u, L_s) = L_u f\left(\frac{L_s}{L_u}\right) = L_u f(l) \tag{1}$$

with $l = L_s/L_u$ where L_s and L_u denote skilled labour and unskilled labour, respectively. With competitive labour markets in each country productivities of skilled and unskilled workers are equal to their respective wage rates w_s and w_u:

$$w_s = f_l \tag{2}$$
$$w_u = f - l f_l \tag{3}$$

Individuals are distinguished by an ability parameter, y, uniformly distributed in the range $[0, \bar{y}]$. To be skilled, an individual must receive some education denoted by e. The quantity of skilled labour provided by an educated worker is then given by ye. We assume that the amount of money spent for higher education per individual only depends on the education level, i.e. $c(e)$. The cost function c is assumed to be increasing and convex.

Throughout the article, to avoid corner solutions, we assume Inada conditions: $\lim_{L_u \to 0} F_{L_u}(L_u, L_s) = \infty$ and $\lim_{L_s \to 0} F_{L_s}(L_u, L_s) = \infty$ as well as $\lim_{e \to \infty} c'(e) = \infty$.

Individual decisions

Higher education may be financed by fees paid by students and by taxes levied on labour income. A student with ability y then pays a fraction $0 \leq f \leq 1$ of her education costs as fees during the first period of studying

and receives a wage income net of tax of $w_s y e (1 - \tau)$ in the second period, where τ is the tax rate levied to finance the remaining costs of higher education. Thus, her lifetime income—appropriately discounted by r—is

$$(1 - \tau) w_s \frac{ye}{1 + r} - f \cdot c(e). \tag{4}$$

If the individual decides not to study, she receives a wage income net of tax of $(1 - \tau) w_u$ in both periods. Hence, her lifetime income is

$$(1 - \tau) w_u \frac{2 + r}{1 + r}. \tag{5}$$

The marginal ability type who is indifferent between studying or not can then be characterized by

$$y^{FT} = \frac{w_u(2 + r)}{w_s e} + \frac{(1 + r) f \, c(e)}{(1 - \tau) w_s e} \tag{6}$$

The pure fee and pure tax financing systems can be obtained as special cases.

The education level e and the financing parameters f, τ and r determine a (steady state) equilibrium of the labour markets. Given e and y, the employment of unskilled labour is given by

$$L_u = 2 \int_0^y 1 \mathrm{d}z = 2y = 2N_u \tag{7}$$

where N_u is the number of unskilled workers and where the population growth rate is assumed to be zero. The effective skilled labour is

$$L_s = \int_y^{\bar{y}} z e \, \mathrm{d}z = e\left(\frac{\bar{y}^2 - (y)^2}{2}\right) = (\bar{y} - y)e\left(\frac{\bar{y} + y}{2}\right) = N_s e\left(\frac{\bar{y} + y}{2}\right) \tag{8}$$

where N_s is the number of skilled workers and $\frac{\bar{y}+y}{2}$ is the average ability of those workers.

The above expressions determine the labour forces and hence the wages of skilled and unskilled labour thanks to Equations (2) and (3) as a function of the threshold y. These wages in turn determine the incentives to be skilled, i.e. y^{FT} as given by Equation (6). At an equilibrium of the labour markets, the obtained value y^{FT} must be equal to the initial value y.

Government decisions

Under complete information on individuals' abilities, a social planner can decide on the level of education and on the ability of those who study. The objective is to maximize aggregate production net of education cost at

a steady state, $W(y, e) = F(L_s, L_u) - N_s c(e)$, by choosing e and y, where L_s, L_u are functions of e and y from Equations (7) and (8) and N_s is a function of y alone,

The impact of a marginal increase in e keeping the set of students fixed is given by

$$\frac{\partial W}{\partial e} = F_{L_s}\frac{\partial L_s}{\partial e} + F_{L_u}\frac{\partial L_u}{\partial e} - N_s c'(e) = (\bar{y} - y)\left[w_s\frac{\bar{y} + y}{2} - c'(e)\right] \quad (9)$$

The impact of a marginal increase in the minimum ability level y, keeping the education level fixed is given by

$$\frac{\partial W}{\partial y} = F_{L_s}\frac{\partial L_s}{\partial y} + F_{L_u}\frac{\partial L_u}{\partial y} - c(e)\frac{\partial N_s}{\partial y} = -w_s ey + 2w_u + c(e) \quad (10)$$

At the optimum, the level of education and the threshold ability level are given by Equations (9) and (10) set equal to zero.

Now individuals' abilities are no longer observable. The cost of higher education is partly financed by fees paid by the students and partly by taxes levied on wage income. The budget of the government is given by

$$\tau(w_s L_s + 2w_u N_u) = (1 - f)c(e)N_s, \quad f \in [0, 1] \quad (11)$$

The government maximizes aggregate production net of education costs by choosing e and f

$$\underset{e,f}{Max}\ W(y^{FT}(e), e) = F(L_s, L_u) - N_s c(e) \quad (12)$$

where the tax rate is endogenously determined by the budget constraint in Equation (11). The threshold ability for studying is now given by Equation (6).

To check whether the optimum can be achieved, let us consider the optimal levels e^* and $y^* = y^{FB}(e^*)$. To be implemented, one must find f and τ for which individuals have incentives such that the threshold equilibrium value y^{FT} is given by y^* and the budget constraint in Equation (11) is satisfied.

Given e^* and y^* the budget constraint determines the ratio $\rho = \tau/(1 - f)$. Now consider the expression of y^{FT} as given by Equation (6) where the right hand side is computed at the optimal levels (including the wages) and $\tau = \rho(1 - f)$. Using $y^* = y^{FB}(e^*) = \frac{1}{w_s^* e^*}[2w_u^* + c(e^*)]$, we have

$$y^{FT} = y^* + \frac{1}{w_s^* e^*}[rw_u^* - c(e^*) + c(e^*)\frac{(1 + r)f}{1 - \rho(1 - f)}]$$

The optimum is implemented for f such that $y^{FT} = y^*$, or equivalently for f for which the term in square brackets is null. As expected, for $r = 0$, the optimum is reached with pure fee-financing, i.e. $f = 1$. For $r > 0$, the optimum can be reached with mixed-financing if $rw_u^* - c(e^*) < 0$, i.e. if the distortion on the credit market is not too high.