Financing Higher Education and Mobility*

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Abstract

This paper analyzes how mobility of students across different countries affects the way higher education is financed. We start by examining a closed economy. If the economy is in the steady-state, we find that the optimal level of education in a fee-financed system is efficient while the level of education in a tax-financed system is sub-optimally high. The reason is that for the same level of education more individuals decide to study in a tax-financed education system than in a fee-financed one. The resulting higher financing needs lead the tax-country to choose a higher level of education as this - via general equilibrium effects - reduces the incentives to acquire education. For an imperfect credit market, the superiority of fee-financing is less clear. We, therefore, analyse the optimal choice of financing for this case allowing for a mixed system.

With mobility of skilled workers, we can replicate the steady-state result of the closed economy. If students as well as skilled workers are allowed to migrate, however, we show that for a higher level of education in the tax-financed system all individuals decide to study in this country. An inner solution for the migration equilibrium can only result if the level of education in the fee-country exceeds the one in the tax-country. Again, we are interested in the effects of an imperfect capital market on the optimal choice of financing when both countries are now linked via migration.

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1 Introduction

Mobility is a driving force in the labor market. It is especially crucial as higher education and research are concerned as it enlarges the opportunities of students and academics and affects their returns to education. In addition, mobility of students and skilled workers induces changes in governmental policies and introduces competition between educational institutions or countries.

We are here particularly interested in the impact of governmental financing of education on incentives and how this is affected by the migration behavior of those who are (about to be) educated. The aim is thus to analyze which quality levels of education can be sustained in countries open to migration and which financing (mix) is optimal.

For the analysis, we have chosen a very general setup to address these issues. We analyze a two-period model with two jurisdictions and individuals who differ in their innate abilities. 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 the closed economy case to derive results which can serve as benchmarks for the open economy setting. In a second part, we analyze open economies where migration is first restricted to skilled workers and then extended to students as well.

The first part on closed economies looks in detail at different financing instruments - namely financing via fees and via taxes. The education levels are derived for both systems and compared to the first-best. In the case of perfect capital markets we find that for the same education level more individuals choose to become educated when education is tax financed than when it is fee financed. Tax financing thus induces individuals also with lower ability levels to opt for acquiring education. Furthermore, we can show that the chosen education level in the tax-financing country is higher than in the fee-financing country with the latter corresponding to the first-best level. If capital markets are imperfect, however, the education level in the fee-financing country is lower than the first-best level, while the education level in the tax-financing country depends on the effect through the selection of abilities. We therefore analyse the optimal choice of financing for this case allowing for a mixed system. The insights from the closed economy case can then be used as a starting point for the open economy case.

The second part addresses the mobility issue by considering open economies. Questions of interest are: How does the policy of one country change taking the policy (financing system and education level) of the other country into account? Will students' (and workers') mobility lead to an increase of private funding? Or more precisely, will the (former) tax-country adopt a policy where education is fully fee-funded? And is it also possible to have the case where the (former) tax-country opts to no longer provide education - no matter how it is financed - free-riding on the other country?

First, we restrict mobility to the skilled workers. Their migration decision in the second period depends on the wages in both countries. A migration equilibrium requires that the wage in the fee-country equals the wage net of tax in the tax-country. From this it follows that for a given education level in the fee-country, the education level in the tax-country has to be higher - similar to the closed economy case.

Second, we allow for mobility both of students and of skilled workers. Young individuals thus have to decide whether and where to study in case they study. In the absence of capital market imperfections, their choice is made by comparing their lifetime income as students / skilled workers with their lifetime income as unskilled workers. It again follows that more individuals in the tax-country than in the fee-country will opt to study. We can then distinguish two cases: If the education level in the tax-country is higher than in the fee-country, all individuals who decide to study go to the tax-country. From their point of view, a better quality of education without inquiring any costs is superior to the alternative characterised by a lower education level and fees to be paid. An inner solution for the migration equilibrium can thus only be expected to realise if the education level in the fee-country exceeds the one in the tax-country. Again, we are interested in the effects of an imperfect capital market on the optimal choice of financing when both countries are now linked via migration.

[To be continued]

We proceed as follows: In the next section, we present the model. In section 3, we analyze the closed economy where migration is not possible. We then allow for migration of students and workers in section 4. Section 5 concludes.

2 The model

We analyze a two-stage game with two countries. The production sector in each country uses two kinds of input:[1] labor supplied by individuals with and without higher education, L_s (skilled labor) and L_u (unskilled labor) respectively, where it is assumed that only skilled labor is mobile in open economy.[2] Production takes place according to a neoclassical production function with constant returns to scale so that:

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

where $l = \frac{L_s}{L_u}$ denotes the ratio of skilled to unskilled labor. We assume competitive labor markets in each country. The optimal demand for labor implies that productivities of skilled and unskilled workers are equal to their respective wage rates w_s and w_u:

$$w_s = f_l \tag{2}$$

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

It follows that

$$\frac{\partial w_u}{\partial L_s} > 0; \quad \frac{\partial w_s}{\partial L_s} < 0; \quad \frac{\partial w_u}{\partial L_u} < 0; \quad \frac{\partial w_s}{\partial L_u} > 0. \tag{4}$$

Individuals are distinguished by an ability parameter, y, which reflects individually different benefits from higher education. The distribution of abilities is identical in each country, assumed for simplicity to be uniform in the range $[0, \overline{y}]$.

To be skilled, an individual must receive some education. Education quality or level is denoted by e. The quantity of skilled labor provided by an educated worker with education

[1] We abstain here from explicitly considering capital in the production technology. Taking the effect of education on capital into account would be interesting, but it is outside the scope of the present paper.

[2] This corresponds to empirical evidence according to which mobility increases with education. See, e.g., Ehrenberg and Smith (1993).

level e depends on her ability y: it is given by ye. For simplicity, we assume that the amount of money spent for higher education per individual only depends on the education level, given by $c(e)$. Put differently, costs in education are proportional to the number of students, given the quality.[3] The cost function c is assumed to be increasing and convex.

Throughout the paper, to avoid corner solutions, we shall assume Inada conditions, according to which marginal productivities with respect to a factor increase indefinitely as the factor becomes scarce and that marginal cost to education increases indefinitely with the level:

Assumption 1: $\lim_{L_u \to 0} F_{L_u}(L_u, L_s) = \infty$ and $\lim_{L_s \to 0} F_{L_s}(L_u, L_s) = \infty$;
$\lim_{e \to \infty} c'(e) = \infty$.

At the first stage, governments decide on the education level and the financing of higher education via taxes or fees. At the second stage, individuals make their decisions on studying and working given the governments arrangements for higher education. For this, we introduce a two-period lifecycle model. Both countries may differ with respect to the level and the financing of education. 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 when uneducated in their country of origin. Capital markets are first assumed to be perfect so that lifetime income can be shifted between both periods without constraint. Later, we investigate imperfect capital markets so that the costs of higher education cannot be fully financed by raising a loan on future labor income. If the individual chooses not to study, she works and receives the wage income of an unskilled in the first period. In the second period, individuals with higher education, if they are mobile, decide in which country to work while individuals without higher education are assumed to be immobile thus working in their home country. We solve the model by backward induction.

3 Education decision without migration

As a benchmark, this section disregards migration effects and analyzes the individual and governmental decisions within a closed country. We start by considering the individual choice of studying if higher education is financed either by fees or by taxes. We derive the first-best solution when abilities are observed and both the education levels and the students can be chosen. We then study the decision problem faced by a government which chooses the education level without observing abilities.

3.1 Individual decisions

Pure fee-financed higher education If an individual decides to study, she has to pay a fee of the amount $c(e)$ in the first period and earns no wage income. In the second period, the educated worker receives a wage income which depends on her ability y: $w_s ye$. Hence, the lifetime income of a skilled worker is

$$w_s \frac{ye}{1+r} - c(e). \tag{5}$$

[3]Education is thus considered here as a private good.

If the individual decides not to study, she works in both periods earning the wage w_u. The lifetime income of the unskilled worker is

$$w_u \frac{2+r}{1+r}. \tag{6}$$

The individual compares the lifetime incomes and chooses the option which maximizes her income. The decision whether to study or not depends on the ability of the individual. The marginal ability type who is indifferent between both options is given by

$$y^F = \frac{w_u (2+r) + (1+r)\, c(e)}{w_s e} \tag{7}$$

Pure tax-financed higher education In this case, an individual who studies earns no wage income in the first period and receives a wage income net of tax of $w_s ye (1-\tau)$ in the second period where τ is the tax rate levied to finance higher education. Thus her lifetime income is

$$(1-\tau)\, w_s \frac{ye}{1+r}. \tag{8}$$

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

$$(1-\tau)\, w_u \frac{2+r}{1+r}. \tag{9}$$

The marginal ability type who is indifferent between studying can then be characterised by

$$y^T = \frac{w_u (2+r)}{w_s e} \tag{10}$$

Mixed-financed higher education Higher education may be financed partly by fees payed by students and partly subsidized by taxes levied on labor income. A student thus pays a fraction $0 \leq f \leq 1$ of her eductaion costs as fees during the first period of studying and receives a wage income net of tax of $w_s ye (1-\tau)$ in the second period where τ is the tax rate levied to finance the remaining costs of higher education. Thus her lifetime income is

$$(1-\tau)\, w_s \frac{ye}{1+r} - f \cdot c(e). \tag{11}$$

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

$$(1-\tau)\, w_u \frac{2+r}{1+r}. \tag{12}$$

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

$$y^{FT} = \frac{w_u (2+r)}{w_s e} + \frac{(1+r)\, f\, c(e)}{(1-\tau)\, w_s e} \tag{13}$$

3.2 Equilibrium Employment

We are interested in the impact of the education level on individual decisions and the resulting impact on the labor markets. We describe here how an education level e determines a (steady state) equilibrium of the labor markets.

In each period, employment consists of young and old unskilled workers and old skilled workers. Given an education level e and a threshold ability level of skilled workers y^*, the employment of unskilled labor is given by

$$L_u = 2\int_0^{y^*} 1\ dy = 2y^* = 2N_u \tag{14}$$

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

$$\begin{aligned} L_s &= \int_{y^*}^{\overline{y}} yedy = e\left(\frac{\overline{y}^2-(y^*)^2}{2}\right) = (\overline{y}-y^*)\,e\left(\frac{\overline{y}+y^*}{2}\right) \\ &= N_s e\left(\frac{\overline{y}+y^*}{2}\right) \end{aligned} \tag{15}$$

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

The above expressions determine the labor forces and hence the wages of skilled and unskilled labor thanks to (2) and (3) as a function of the threshold y^*. These wages in turn determine the incentives to be skilled. In a fee-financed country for example they determine y^F as given by (7). At an equilibrium of the labor markets, the obtained value y^F must be equal to the initial one y^*.

Let us show that there is a unique equilibrium. Consider the mapping just described that associates to a threshold value y^* the wages and the associated threshold y^F. An interior equilibrium is a fixed point of this mapping. The mapping is decreasing: as y^* increases, skilled labor decreases: w_s increases and w_u decreases and as a result y^F decreases. Furthermore for small y^*, unskilled labor is negligible so that w_u is very large compared to w_s: y^F is larger than y^*. Similarly if y^* is large, w_s is very large compared to w_u: y^F is smaller than y^*. This gives the result.

3.3 Government decisions

We first derive a first-best allocation in the absence of any informational constraints. Then, we compare it to the optimal decisions of governments for cases where higher education is financed either via fees or via taxes and individuals freely choose to study.

3.3.1 First-best allocation

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 criterion is aggregate production net of education cost at a steady state, given by $F(L_s, L_u) - N_s c(e)$. This is the criterion that obtains in a fully fledged overlapping generations economy in which the planner treats all generations equally. 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 (see Gale, 1973).

The choice of the level of education and of the minimum ability of those who study, e and y respectively, fully determines skilled and unskilled labor from (14) and (15). Hence defining

$$W(y, e) = F(L_s, L_u) - N_s c(e) \tag{16}$$

where L_s, L_u are functions of e and y and N_s is a function of y alone, the objective is to maximize $\underset{e,y}{Max}\ W(y, e)$.

The objective is concave, and thanks to Assumption 1, there must be both skilled and unskilled workers at an optimum, and the education level is bounded.[4] Hence the optimum is interior. The impact of a marginal increase in e keeping the set of students fixed is given by

$$\begin{aligned} \frac{\partial W}{\partial e} &= F_{L_s}\frac{\partial L_s}{\partial e} + F_{L_u}\frac{\partial L_u}{\partial e} - N_s c'(e) \\ &= (\overline{y} - y)\left[w_s \frac{\overline{y} + y}{2} - c'(e)\right] \end{aligned} \tag{17}$$

It is equal to the effect on the production of the skilled minus the increase in cost.

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

$$\begin{aligned} \frac{\partial W}{\partial y} &= F_{L_s}\frac{\partial L_s}{\partial y} + F_{L_u}\frac{\partial L_u}{\partial y} - c(e)\frac{\partial N_s}{\partial y} \\ &= -w_s e y + 2w_u + c(e) \end{aligned} \tag{18}$$

It is equal to the net impact on the productivity of a student of ability just equal to y from becoming skilled compared to remaining unskilled where the impact is measured at the steady state situation.

At the optimum, the level of education and the threshold ability level are given by the following first-order conditions

$$(\overline{y} - y)\left[w_s \frac{\overline{y} + y}{2} - c'(e)\right] = 0 \tag{19}$$

$$-w_s e y + 2w_u + c(e) = 0 \tag{20}$$

that is, the marginal gain from a change in education on the average student, $w_s \frac{\overline{y}+y}{2}$ is equal to the marginal cost, and the net gain of education for the marginal student is null.

[4] If the cost is linear, one has to assume that education levels are bounded: from (17) with $c'(e) = 1$, if the return to education is positive for y, then education should be as large as possible: the optimal level is at the upper bound.

3.3.2 Education level with pure fee-financing

We now introduce two differences with respect to the previous setting.

First, individuals' abilities are no longer assumed to be observable (or contractible). Due to these informational asymmetries, the set of students cannot be chosen as an omniscient social planner does. The government chooses the optimal level of education taking account of the individual decisions which are determined by the threshold level of ability y^F.

Second, the interest rate faced by the individuals is not necessarily at the golden rule level. There are various reasons to take it as positive, for instance because of moral hazard problems (see von Weizsäcker and Wigger, ...). The positive interest rate can be interpreted as a risk premium charged by credit markets due to the risky investment in human capital.

The welfare criterion of the government is still the aggregate production net of education cost at a steady state. Given an education level, the equilibrium ability threshold which determines who decides to study is denoted by $y^F(e)$. Thus, the government objective is

$$\underset{e}{Max}\, W(y^F(e), e) = F(L_s, L_u) - N_s c(e) \tag{21}$$

in which skilled and unskilled labor levels are those determined by the equilibrium threshold ability level:

$$N_s = \overline{y} - y^F(e), L_u = 2y^F(e), L_s = N_s e \left(\frac{\overline{y} + y^F(e)}{2} \right) \tag{22}$$

The impact on welfare due to a marginal change of education is

$$\frac{\partial W}{\partial y} \frac{dy^F}{de} + \frac{\partial W}{\partial e} \tag{23}$$

where $\frac{dy^F}{de}$ denotes the equilibrium change in the threshold ability level - and thus in the selection of abilities - that results from an increase in the education level. The impact on welfare due to a marginal change of education is thus composed of two terms: an indirect one through the selection of abilities and a direct one.

For $r = 0$, the optimal ability associated to a given education level coincides with that chosen by individuals, that is $\frac{\partial W}{\partial y}(y^F(e), e)$ is identically null as can be seen from (7) and (18). An immediate consequence is that the optimal level of education coincides with the first best level as given by (20).

Consider now the more plausible situation in which, due to distortions on the credit market, r is positive. With (7) and (18), we have

$$\frac{\partial W}{\partial y}(y^F(e), e) = -r(w_u + c(e)) \tag{24}$$

This reflects the interest on the effective cost of education to an individual, i.e. the fee plus the forgone wage in the first period. Since this is negative, the impact of credit constraints is to lower the marginal benefit of eduction on welfare if $\frac{dy^F}{de}$ is positive and conversely if it is negative. It remains to determine the sign of $\frac{dy^F}{de}$. Recall that the equilibrium on the labor markets changes with the threshold ability level. Therefore the behavior of y^F cannot be directly seen from equation (7) due to the impact on wages. Under an additional assumption, we show in Appendix A that y^F is increasing with e.

Assumption 2: $\dfrac{w_U(e)}{w_S(e) \cdot e}$ is increasing in e (given y^F).

Under Assumption 2, $y^F(e)$ increases with e. With a higher education level e fewer individuals decide to study because the negative effects of 1) higher wages for unskilled, 2) lower wages for skilled, and 3) higher cost of education dominate the positive effect of higher returns to education.

We can therefore state

Proposition 1 *Consider an economy with purely fee-financed education.*
With a perfect credit market, $r = 0$, the optimal level of education leads to the first-best allocation.
With an imperfect credit market, $r > 0$, and under Assumption 2, the optimal level of education is lower than the first-best level.

3.3.3 Education level with pure tax-financing

We consider the same setting except that now the government levies a tax on all workers in a given period to finance education. We assume that there is no distortionary impact of taxes on the labour-leisure choice nor any redistributive considerations outside the educational system. The decision problem for the optimal level of education is then given by

$$\underset{e}{Max}\, W(y^T(e), e) = F(L_s, L_u) - N_s c(e) \tag{25}$$

subject to the budget constraint:

$$\tau \left(w_s L_s + 2 w_u N_u\right) = N_s c(e)$$

in which skilled and unskilled labor levels are those determined by the threshold ability level $y^T(e)$, as in (22) replacing $y^F(e)$ by $y^T(e)$.

Since the level $y^T(e)$ is independent of τ, the government can choose the education level and then set the tax rate so as to finance the costs, provided this gives a value for τ smaller than 1.

Maximization with respect to the education level e yields

$$\frac{\partial W}{\partial y}\frac{dy^T}{de} + \frac{\partial W}{\partial e} = 0 \tag{26}$$

For the indirect impact through the threshold, we have with (10) and (18)

$$\frac{\partial W}{\partial y}(y^T(e), e) = -r w_u + c(e). \tag{27}$$

If r is null, the derivative is positive: increasing the ability threshold above that chosen by individuals is welfare improving. In other words, the absence of costs for becoming skilled gives to some individuals too much incentive to study, contrary to the fee setting. Under imperfect credit markets, that is with a positive r, there is a counterbalancing effect due to the interest on the forgone wage.

The behavior of y^T can be determined using similar arguments as for the fee-country. Thus, under Assumption 2, y^T increases with e. This means that assuming $r = 0$, increasing the level of education has a positive impact on welfare, that is $\frac{\partial W}{\partial y}\frac{dy^T}{de}$ is positive. The reason is that increasing e discourages some individuals to be educated, which is good in a tax-country. Hence, the education level will be chosen above the first-best level. If r is positive the level of education decreases approaching the first-best level from above and falling below for high values of r.

We can therefore state

Proposition 2 *Consider a country with tax-financing.*
With a perfect credit market, $r = 0$, the level of education is higher than the first best (or that in a country with fee-financing). The larger the selection effect, the more the level of education in the tax-country exceeds the first best (or that in the fee-country).
With an imperfect credit market, $r > 0$, the level of education may be higher, equal to or lower than the first-best.
Both cases can be summarized as follows:

$$\frac{\partial W\left(y^T(e), e\right)}{\partial e}\left\{\begin{array}{c} > \\ = \\ < \end{array}\right\}0, \quad i.e. \quad e^T\left\{\begin{array}{c} < \\ = \\ > \end{array}\right\}e^*, \quad iff \quad r\left\{\begin{array}{c} > \\ = \\ < \end{array}\right\}\frac{c(e)}{w_u}$$

3.3.4 Comparison of the education level for both financing systems

The preceding analysis enables us to compare the efficiency of both financing systems in a straightforward way for the case where capital markets are perfect. We have seen that fee-financing is the superior system leading to the first-best education level while this is not the case for tax-financing which induces the government to choose a sub-optimally high level of education: $e^T > e^* = e^F$.

It is useful to note that these results can also be derived differently. In Appendix B we show that an identical level of education e implies that in a fee-financed country relatively fewer people choose higher education than in a tax-financed country, $y^F(e) > y^T(e)$ leading to a higher wage rate of skilled workers in the fee-financed country. This implies that the marginal impact on welfare in a tax-financed country where the education level is the same as in a fee-financed country can be improved by reducing the level of education:

$$\frac{\partial W\left(y^T(e), e\right)}{\partial e} < \frac{\partial W\left(y^F(e), e\right)}{\partial e} = 0 \tag{28}$$

If capital markets are not perfect, we know that the education level in the fee-financed country is sub-optimally low, while it may be higher, equal to or lower than the first best in the tax-financed country. The extent of the imperfection in fact is responsible for the (sub-)optimality of fee-financing and tax-financing.

We analyse therefore the choice of the financing system allowing for a mixed system. We are in particular interested in the factors which determine the superiority of one system or the other.

3.3.5 Education level and financing if both taxes and fees are available

Now we assume that the costs of higher education are partly financed by fees paid by the students and taxes levied on wage income. The budget of the government is given by:

$$\tau\left(w_s L_s + 2 w_u N_u\right) = \left(1 - f\right) c(e) N_s, \qquad f \in [0,1] \tag{29}$$

where f is the share of education costs which is financed by fees. The government maximizes aggregate production net of education costs by choosing simultaneously the education level e and the share of costs financed by fees, f:

$$\underset{e,f}{Max}\, W(y^{FT}(e), e) = F(L_s, L_u) - N_s c(e) \tag{30}$$

where the tax rate $\tau \in [0, 1)$ is endogenously determined by the budget constraint (29). The threshold ability for studying is now given by (13).

The first-order condition for the education level is

$$\frac{\partial W}{\partial y}\frac{dy^{FT}}{de} + \frac{\partial W}{\partial e} = 0 \tag{31}$$

Using (13) the welfare impact of the threshold ability is

$$\frac{\partial W}{\partial y}(y^{FT}(e), e) = -r w_u + c(e) - \frac{(1+r)\, f\; c\,(e)}{1-\tau}. \tag{32}$$

Note that we are back in the pure fee-financing case for $f = 1$ $(\tau = 0)$ and in the pure tax case for $f = 0$ $(\tau > 0)$. Under Assumption 2, y^{FT} increases with e since $c\,(e)$ increases and $w_s\,(e)$ decreases with e.

First we consider the financing decisions. The higher the share f the less individuals decide to study:

$$\frac{dy^{FT}}{df} = \frac{(1+r)\, c\,(e)}{(1-\tau)\, w_s e} > 0 \tag{33}$$

It is optimal for the government to finance some costs by fees if the indirect impact of the theshold ability on welfare is positive:

$$\left.\frac{\partial W}{\partial y}\frac{dy^{FT}}{df}\right|_{f=0} > 0 \Leftrightarrow r < \frac{c(e)}{w_u} \tag{34}$$

Hence, with perfect capital markets $(r = 0)$ fees should always be used. Furthermore, with perfect capital markets a pure fee-financing of higher education is optimal:

$$\left.\frac{\partial W}{\partial y}\frac{dy^{FT}}{df}\right|_{f=1} = 0 \Leftrightarrow r = 0 \tag{35}$$

However, if capital markets are imperfect $(r > 0)$ the optimal financing mix includes some tax-financing:

$$\left.\frac{\partial W}{\partial y}\frac{dy^{FT}}{df}\right|_{f=1} < 0 \Leftrightarrow r > 0 \tag{36}$$

The reason for this result is that with pure fee-financing and credit constraints too few individuals decide to study. The welfare could be increased by encouraging more students to study. This can be achieved by subsidizing higher education via taxes. Furthermore, simple rearrangement of (32) shows that a sufficiently high interest rate implies that pure tax-financing is optimal:

$$\frac{\partial W}{\partial y}\frac{dy^{FT}}{df} < 0 \Leftrightarrow r > \frac{c(e)(1-\tau-f)}{(1-\tau)w_u + fc(e)} \tag{37}$$

Especially, if $r > \frac{c(e)}{w_u}$ a pure tax-financing is chosen.

Now we turn to the decisions with respect to the educational level, i.e.(31). With a perfect capital market it is optimal to finance higher education purely by fees ($f = 1$, $\tau = 0$). Hence, the chosen education level is first-best. In this case, taxation does not distort the educational decisions of the individuals. With an imperfect capital market some tax-financing of higher eduaction is always optimal ($f < 1$, $\tau > 0$). And if $f \geq 1-\tau$, the education level is lower than the first-best, i.e. $\frac{\partial W}{\partial e} > 0$. In the reverse case, $f < 1-\tau$, the education level may be too high, too low or optimal.

We can therefore state

Proposition 3 *Consider an economy where taxes and tuition fees are available to finance higher education.*
With a perfect credit market, $r = 0$, pure fee-financing is optimal and the educational level is first-best.
With an imperfect credit market, $r > 0$, it is optimal to have some share of educational costs financed by taxes. If r is sufficiently high it is optimal to completely finance higher education by taxes. The educational level is suboptimal if $f \geq 1-\tau$ and under Assumption 2.

Having shown under which conditions the government of a country opts for a system which is closer to fee-financing or tax-financing, we are able to give a rationale for the simultaneous existence of different ways of financing higher education as long as borders are closed. This will serve 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 workers. With two countries with different financing systems, the question will then be how the policy of one country changes taking the policy (financing system and education level) of the other country into account.

4 Opening up economies

In the following we assume that in one country F the capital market is perfect ($r = 0$) and students can shift their lifetime income between periods without distortions. This may be the case in countries where income contingent loans for students are easily accessible. In the other country FT, the capital market is imperfect ($r > 0$) and the positive interest rate reflects a risk premium paid by students. Hence, country F finances higher education only by fees whereas in country FT at least part of the education costs are financed via taxes and the remainder via fees.

4.1 Only migration of workers (second period)

As only skilled workers are mobile, a migration equilibrium requires that skilled workers receive the same wage income (net of tax) in both countries yielding as the arbitrage condition

$$w_s^F = w_s^{FT}(1-\tau) \tag{38}$$

assuming that not all skilled individuals move to the same country (which surely holds true under an Inada condition on the production function).

Students are immobile and their choice follows the same rationale as in the closed economy where the expected net wage at the second period is now identical in both countries from the arbitrage condition. As a result, for a given education level e there are more students in the mixed financed country than in the fee-country. Since unskilled workers are immobile, $L_u^{FT} < L_u^F$. This implies that if education levels were identical and skilled workers remained in their countries one would have

$$\frac{L_s^{FT}}{L_u^{FT}} > \frac{L_s^F}{L_u^F} \Longrightarrow w_s^F > w_s^{FT} > w_s^{FT}(1-\tau) \tag{39}$$

In other words, the lack of unskilled workers in the mixed-financed country pushes the skilled wage downward. Accounting furthermore for the tax, condition (38) is surely not satisfied: skilled workers thus move to the fee-country. To avoid large migration of skilled workers to the fee-country for a given level of education in this country, e^F, the level of education in the mixed-financed country, e^{FT}, has to be higher similar to the reasoning above for the closed economy.

4.2 Migration of skilled workers and students

Students are now mobile as well. Furthermore, in line with EU rules, they have access to the education system of a foreign country at the same conditions as the natives. Therefore, a young born in country x, $x = F, FT$, now not only has to decide whether to study but also where to study. Using the arbitrage condition (38), $w_s^F = w_s^T(1-\tau)$, allows us to write the maximum lifetime income for a y-young individual who decides to become skilled as

$$\begin{aligned} V_s(y) &= \max[w_s^F y e^F - c\left(e^F\right), \frac{w_s^{FT} y e^{FT}(1-\tau)}{1+r} - fc\left(e^{FT}\right)] \\ &= \max[w_s^F y e^F - c\left(e^F\right), \frac{w_s^F y e^{FT}}{1+r} - fc\left(e^{FT}\right)]. \end{aligned} \tag{40}$$

A young with ability y born in country x studies if

$$V_s(y) \geq (1-\tau_x) w_u^x \frac{2+r}{1+r} \tag{41}$$

where $\tau_F = 0$ and $\tau_{FT} = \tau$. This gives the marginal ability type y^x of the young individual born in country x who is indifferent between studying or not. The exact expression of y^x depends on whether the individual will study in F or in FT, that is whether the maximum in (40) is reached at F or at FT. Whatever the situation, since $w_u^F > (1-\tau)w_u^{FT}$ for a given y and V_s increasing in y, it always holds that $y^{FT} \leq y^F$.

First we analyze the case where the interest rate in the mixed-financed country is sufficiently high so that only taxes are used to finance higher education. We distinguish two cases:

Case 1: $e^T \geq e^F$ - corner solution. All individuals study in the tax-country if they decide to study because for any ability level y

$$V_s(y) = \frac{w_s^F y e^T}{1+r} \tag{42}$$

The intuition for this result is straightforward: If the education level in the tax-country is higher than in the fee-country, the tax-country is very attractive for all individuals who decide to study. A higher education level without inquiring any costs is superior to the alternative characterised by a lower education level and fees to be paid. This becomes obvious when looking separately at an individual born in T and in F.

A T-born decides whether to study by comparing his lifetime income as a skilled and as an unskilled: $\frac{w_s^T y e^T}{1+r}$ and $w_u^T \frac{2+r}{1+r}$. The threshold ability level is then

$$y_T^T = \frac{w_u^T (2+r)}{w_s^T e^T} \tag{43}$$

where the upper index of y denotes the country for studying and the lower index denotes the country of origin.

A F-born also compares both lifetime incomes: $\frac{w_s^F y e^T}{1+r}$ and $w_u^F \frac{2+r}{1+r}$. The threshold ability level is given by

$$y_F^T = \frac{w_u^F (2+r)}{w_s^F e^T}. \tag{44}$$

Since $w_s^F < w_s^T$ and $w_u^F > w_u^T$, it follows that $y_F^T > y_T^T$. Hence, more T-born individuals decide to study in T than F-born individuals because the unskilled lifetime income in their home country is higher for the latter.

An inner solution for the migration equilibrium can thus only be expected to realise if the education level in the fee-country exceeds the one in the tax-country.

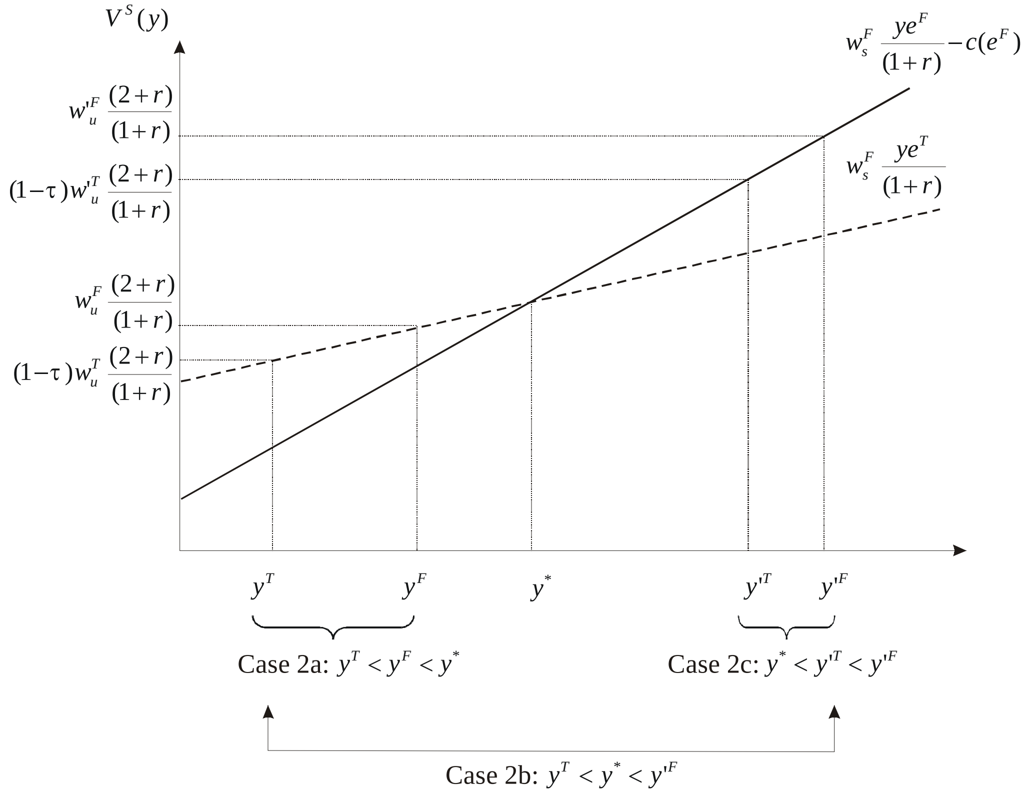
Case 2: $e^F > e^T$- inner solution for the migration equilibrium. If the individuals decide to study the migration equilibrium of students is

$$\frac{w_s^F y e^F}{1+r} - e^F = \frac{w_s^F y e^T}{1+r} \tag{45}$$

The lifetime income of a F-student increases more with y than that of a T-student. Hence a y-individual - *if* she studies (she does not necessarily do so) - studies in F iff $y \geq y^*$ where

$$y^* = \frac{(1+r)\, e^F}{w_s^F \left(e^F - e^T\right)} \tag{46}$$

Figure 1: Education thresholds in open economies: $e^F > e^T$



This yields a priori three possible cases:

$$\begin{aligned} 2a.\ y^T &< y^F < y^* \\ 2b.\ y^T &< y^* < y^F \\ 2c.\ y^* &< y^T < y^F \end{aligned}$$

The threshold y^* diminishes with the difference $e^F - e^T$; for an increase in the difference $e^F - e^T$, we thus go from case 2a to case 2c. Only in case 2a are there students in both countries originating from both countries. In cases 2b and 2c, F- born individuals who study always study in F and in case 2c, all students choose country F yielding a corner solution. Figure 1 illustrates the various cases where it should be remembered that $V_s(y) = \max[\frac{w_s^F ye^F}{1+r} - c(e^F), \frac{w_s^F ye^T}{1+r}]$.

In the following we concentrate on cases 2a and 2b where some students choose to study in country T. Now we assume that in one country higher education is fee-financed. How will the other country choose between the possibilities to finance higher education via fees or taxes if students are mobile? With perfect capital markets, the superiority of fee-financing will again hold. In the presence of capital market imperfections, however, tax-financing allows to attenuate the existing credit constraints while still distorting the decision to acquire education and to migrate. A more detailed analysis is thus needed.

[To be continued]

5 Conclusion

To be completed...

6 Appendix A

Under Assumption 1, $\frac{w_U(e)}{w_S(e)\cdot e}$ is increasing in e (possibly only at y^F) and thus $\frac{\partial y^F}{\partial e}>0$.

Given e, define for y in $]0,\overline{y}[$

$$\Delta(y,e)=\frac{w_U(y,e)\,(2+r)+(1+r)\,c(e)-w_S(y,e)}{w_S(y,e)e} \tag{47}$$

where $w_U(y,e)$ and $w_S(y,e)$ are the equilibrium wages if labor quantities are given by (14) and (15). By definition, the threshold y^F given e satisfies $y^F=\Delta(y^F,e)$. We first prove existence and uniqueness.

(a) For each e, there is a unique threshold $y^F(e)$.

First note that Δ decreases with y: Since $y\uparrow\Longrightarrow L_S/L_U\downarrow$ one has $y\uparrow\Longrightarrow w_U(y,e)\downarrow$ and $w_S(y,e)\uparrow$.

Thanks to the Inada conditions on productivities $\lim_{y\to 0}\Delta(y,e)>0$ and $\lim_{y\to\overline{y}}\Delta(y,e)<0$. Since the function $y\to y-\Delta(y,e)$ increases in y (because $\Delta_y<0$), it follows that there is a unique y^F for which $y^F-\Delta(y^F,e)=0$

(b) $y^F(e)$ increases with e under Assumption 1.

Since $y^F(e)$ is defined by the implicit equation $y^F-\Delta(y^F,e)=0$ where the left hand side is increasing in y^F, it suffices to show that Δ increases with e. The term $\frac{(1+r)c(e)-w_S(y,e)}{w_S(y,e)e}$ is surely increasing because $w_S(y,e)$ decreases with e. The first term $\frac{w_U(y,e)\,(2+r)}{w_S(y,e)e}$ is increasing by assumption. ∎

7 Appendix B

According to (7), the threshold y^F is implicitly defined by

$$yw_se-w_u\,(2+r)-(1+r)\,c\,(e)\equiv 0 \tag{48}$$

or

$$w_se\left(y-\frac{w_u\,(2+r)}{w_se}\right)\equiv(1+r)\,c\,(e) \tag{49}$$

The left-hand side of (49) increases with y since w_s increases and w_u decreases with y. According to (10), the threshold y^T is implicitly defined by setting the term in brackets equal to zero

$$y-\frac{w_u\,(2+r)}{w_se}\equiv 0 \tag{50}$$

At a given education level this implies that $y^F\,(e)>y^T\,(e)$ for all $e>0$. ∎

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