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Public Education in an Integrated Europe: Studying to Migrate and Teaching to Stay?

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Abstract

An increasing international applicability of a given type of education encourages students to invest more effort when studying. Governments, on the other hand, face an incentive to divert the provision of public education away from internationally applicable education toward country-specific skills. This would mean educating too few engineers, economists and doctors, and too many lawyers. If the total tax rate is kept constant, then replacing part of existing wage taxes with graduate taxes or income-contingent loans, collected also from migrants, would improve efficiency. It could even allow for a Pareto-improvement.
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1. Introduction

There is wide political consensus within the European Union that decisions on public education should be left to individual member states. Benefits, however, accrue partly to other member states through migration. By providing skilled immigrants, investments in internationally applicable education generate positive externalities to other member states. As individual member states have no incentives to internalize these externalities, decentralized decision-making tends to lead into inefficiently low investments in internationally applicable degrees. Increased mobility of the highly educated generates incentives to scale back public financing, recently exemplified in the introduction of top-up fees in England. Before that Sweden replaced a system of income-contingent loans, in effect between 1989 and 2001, by ordinary annuity loans. (CSN 2002). Sweden abandoning its income-contingent loan system may reflect the pressures of increased labor mobility. Of all of those who graduate from Swedish universities, 15 percent emigrate. (Eklund 1998). Unlike income-contingent loans, annuity loans do not require cooperation from foreign tax authorities. Migration also tends to be concentrated in certain fields. For example, 5.8 percent of Finnish working-age doctors and 5.0 percent of nurses lived abroad in 2001. (Vaalgamaa and Ohtonen 2002) The share of the members of the Finnish Association of Graduates in Economics and Business Administration (SEFE) living abroad is 4 percent. (Oksanen 2002)

Even though the possibility of migration reduces the incentives of individual governments to provide internationally applicable education, it also encourages students to study more intensively, by increasing the expected returns to human capital. Private effort and public provision are complements in the formation of human capital. Increased complementary investments by students may also encourage more public

investments.

This paper examines the effects of migration on the provision of country-specific and internationally applicable public education when public and private investments in human capital are complements. Including these two aspects of human capital formation allows evaluation of whether the brain gain effect would swamp the brain drain effect in the public provision of education, so that an increased mobility would result in higher public investment. The framework used allows the member states of the common labor market, from now on referred to as federation, to differ in general productivity. The analysis considers both the case in which member states levy only wage taxes on their residents, and also a case in which member states levy also graduate taxes or income-contingent loans which are paid to the country which provided education independently of future domicile. Graduate tax is used to denote a tax which is collected from university graduates, without a requirement that tax revenue collected from them would have to equal the costs of providing education. Such graduate taxes give the country which educated migrants a stake also in their productivity gains earned elsewhere. Income-contingent loans, on the other hand, are collected as a share of future income, until the education is fully repaid. This study focuses on education targeted to young adults.[1]

Income-contingent loans would allow reducing the wage tax burden, at the same time allowing students to purchase insurance against the risk of low income. In the absence of uncertainty, they could effectively reproduce the same outcome as private investment in education. The analysis of this paper focuses on graduate taxes, as the

[1]In the spirit of Tiebout (1956), parents valuing education may buy better education for their children by paying higher taxes. Such a mechanism is much weaker in higher education, as young adults may go to a university in a different city, or even country, than in which their parents pay taxes.

framework does not include uncertainty. The advantages of income-contingent loans as a policy recommendation, as opposed to graduate taxes, are discussed in conclusion. The main advantage is that voluntary income-contingent loans would better protect citizens against a possibility of government exploitation, allowing students to opt out of contracts they consider unattractive.

The main results are the following. If there are no graduate taxes (or income-contingent loans) and governments care only about the citizens who stay, then governments tend to reduce investment in internationally applicable education when its applicability increases. If a government attaches a sufficiently high positive weight also on the utility of emigrants, then it might increase investment in internationally applicable education when it becomes more mobile. Independently of the weight attached to emigrants and of the productivity differential between the two countries, replacing part of the current wage taxes by a graduate tax (or income-contingent loan) always leads to higher welfare and more efficient investment in internationally applicable education than the current system, provided that the aggregate tax rate does not increase. In addition, this study finds that the welfare effects of labor mobility may be non-monotonic. For the sake of argument, consider rich and poor member states of the European Union. Increasing international applicability of human capital benefits rich member states by allowing them to attract skilled workers from poor member states. However, if migrating to a rich member state becomes very attractive, this may discourage the government of the poor member state to provide citizens internationally applicable education. The rich member state would also be hurt by losing a base of potential immigrants.

This paper is organized as follows. Section 2 reviews literature. Section 3 develops the model. Section 4 presents the results, and section 5 concludes.

2. Literature review

A key question in fiscal federalism literature is whether decentralized outcomes are efficient or not, and whether centralization would increase or decrease welfare. Justman and Thisse (1997) show that a government that maximizes the utility of immobile residents reduces investment in public education when the educated become mobile. Their model includes only one type of education. Another inefficiency is identified by Wildasin (2000). When the highly-skilled become mobile, tax competition tends to erode any taxes they have to pay. This shifts the burden of financing public education to immobile tax bases. If taxation relies heavily on less mobile and less educated workers, then public education would imply regressive redistribution. It seems unlikely outcome, in that governments must gain political support from the citizens staying.[2]

Brain drain literature, pioneered by Grubel and Scott (1966) and Bhagwati and Hamada (1974), highlights the losses that emigration imposes on source countries. This view has been questioned by recent literature, suggesting that emigration may benefit the source country. Stark et al. (1997) show that when students invest privately in their human capital, some migration from developing countries to developed countries may actually benefit the country of origin. The mechanism is as follows. A possibility to migrate to a richer country increases the expected return to human capital investment in a poor country, thus encouraging private investment. Even with a part of high-skilled workers migrating, this initial brain gain may dominate, so that the less developed country can end up with a higher average level of human capital per worker with migration than without it. The empirical analysis by Beine et al. (2001) shows that

[2] A different view on tax competition may arise if governments cannot commit to taxation, either explicitly or implicitly. Andersson and Konrad (2003) and Thum and Uebelmesser (2003) suggest that labor mobility could increase investment in education as it serves as a commitment device to low taxation. Recently, also Haupt and Janeba (2004) have studied the effect of migration on education and redistribution in the absence of commitment.

such a beneficial brain drain cannot be ruled out. Finally, Stark and Wang (2002) show that a possibility of migration to a richer country may serve as a substitute for subsidies for human capital formation, thus potentially benefiting also the country of emigration. These contributions focus on private investment in human capital, and they study the use of migration quotas by less developed countries. This study focuses on public provision of education, in the presence of complementary private investment. It assumes that there are no legal restrictions to migration, consistent with the EU principles of free mobility.

Also Poutvaara (2004) studies public and private provision of different types of education with different tax rules. This paper differs in three respects. First, Poutvaara (2004) assumes that human capital depends only on individual ability and public investment in education, while this paper allows human capital to depend also on private investment in effort. Including simultaneously complementary public and private investments in human capital allows analysis of whether the brain drain effect could be swamped by the brain gain effect in the public provision of education. This study considers both the extensive margin of how many students are educated, and the intensive margin of how much they invest in their effort, and how much human capital is generated. Second, Poutvaara (2004) models only a federation of symmetric member states, while this paper allows member states to differ. Allowing for different productivities is important to allow comparisons with the brain gain literature, which has focused on unilateral migration from poor to rich countries. Third, Poutvaara (2004) allows for externalities, while this paper derives its results in the absence of externalities.

3. The model

3.1. Game structure

A federation consists of two member states, labeled A and B. Both member states are populated by overlapping generations of heterogeneous citizens who become educated and work, and by recipients of government transfers who neither participate in production nor migrate. Each citizen lives for two periods, becoming educated in his or her member state of birth in the first period, and choosing where to live, work and pay taxes in the second period. There are two types of education, labeled i and s. These subscripts refer to whether the education is internationally applicable (i) or country-specific (s). Only those with internationally applicable education may migrate. Students with ability-intensive internationally applicable education may also invest privately effort in their education. Such investment cannot be verified by the government.

The education is provided publicly. To focus on government decisions on what type of education to provide, it is assumed that the tax rates are exogenous and the same in the two member states.[3] The government budget constraint is balanced by adjusting transfers to the rest of the population. The governments have two different tax instruments: A general wage tax rate $\tau_{w,t}$ is levied on all wage income generated domestically in period t, while there may also be a graduate tax rate $\tau_{g,t}$, paid by graduates to the member state which initially provided their education. In other words, also migrants pay their graduate taxes to their member state of origin. The total tax rate is then $\tau_t = \tau_{w,t} + \tau_{g,t}$, satisfying $\tau_{w,t} \geq 0, \tau_{g,t} \geq 0, \tau_t < 1$. Governments are

[3]Keen and Marchand (1997) use the same assumption when they study the effect of fiscal competition on the composition of public expenditure in the presence of mobile capital. They find that in a non-cooperative equilibrium, public expenditures are biased toward the provision of public inputs at the expense of local public goods benefiting immobile residents.

benevolent, choosing the education that maximizes the after-tax consumption of their remaining citizens, and possibly attaching a positive weight also on their migrating citizens. The values of all exogenous parameters with time index are known at least one period ahead, allowing for both a steady-state and a transition path.

The timing of actions in each period is as follows. First, those entering their second period of life with internationally applicable education learn what would be their wage in the other member state, then deciding whether to migrate or not. Second, governments decide on the provision of public education. Third, the educated supply labor and pay taxes, and the government collects wage taxes and finances education. Fourth, those becoming educated decide on their investment in effort.[4]

3.2. Production

The production function is linear in the two types of human capital. Aggregate production in member state A in period t is given by $Y_t^A = H_{i,t}^A + H_{s,t}^A$, in which $H_{k,t}^A$, $k \in \{i, s\}$, is the post-migration stock of effective human capital of type k, as defined in the following subsection. Labor markets are competitive, so that gross rates of return to human capital of both types are equal to unity. Income differences then follow from different amounts of human capital. Aggregate production in member state B in period t is given by $Y_t^B = x_t H_{i,t}^B + x_t H_{s,t}^B$, in which $H_{k,t}^B$, $k \in \{i, s\}$, is the post-migration stock of effective human capital of type k. Without loss of generality, it is assumed that $0 < x_t \leq 1$. This formulation allows for both a symmetric and an asymmetric federation.

Citizens differ in their productivity if they would complete education i, while they

[4]The results would remain the same with an alternative ordering of events, as long as migration decisions are made after potential migrants know their productivity elsewhere, and migration takes place before supplying labor.

have identical productivity if they would complete education s. Human capital of type i is a joint product of teaching and studying.[5] For a citizen with ability a and individual effort e_{t-1} in period $t-1$, the individual human capital stock is before eventual migration in period t

$$h_{i,t}(a, e_{t-1}) = a + e_{t-1}. \tag{1}$$

Human capital with education of type s is for all individuals normalized to unity: $h_{s,t}(a) = 1$.

The monetarized cost of effort e_t is βe_t^2. This formulation of an increasing marginal cost guarantees a bounded investment in e. The resource cost for universities of education $k, k \in \{i, s\}$, is $c_{k,t}$ in member state A and $x_t c_{k,t}$ in member state B. The assumption that the government's costs of providing education in member state B are a multiplicative x_t of those in state A captures the stylized fact that as a significant part of the costs of providing education are wage costs, an increase in the general level of productivity also causes an increase in the cost of providing education.

Ability a follows, in both member states, a continuous distribution between 0 and $\overline{a}$, with density function $f(a)$. It is assumed that $\overline{a} > 1$ and that parameter values are such that at least the government of member state A always invests in both types of human capital. The utility of the educated is linear in their consumption, net of the monetarized effort cost of investment in education, and all consumption takes place in the second period.

[5] All results would hold if also human capital of type s would be a joint product of teaching and studying.

3.3. Migration

A share γ_t of internationally applicable education in one member state is applicable in the other member state in case of migration, satisfying $0 < \gamma_t \leq 1$. Each individual faces an individual-specific random component related to productivity abroad, unknown to the government and the individual before investing in education but known to the individual before migration. The random component takes a multiplicative form $1+\varepsilon$, so that ε is uniformly distributed between -0.5 and 0.5. Some individuals would then lose an individual-specific share of their productivity in case they emigrate, while others would benefit from a boost in their productivity abroad. This allows for a possibility of mutually beneficial brain exchange between countries, helping to capture the stylized fact that there is often migration of people with same education in both directions.

A productivity differential between the member states if $x_t < 1$ would further motivate migration from member state B to member state A. At the same time, it would increase the threshold value of the positive random term needed to induce migration from member state A to member state B. An individual with internationally applicable education would then emigrate from member state A to member state B if and only if

$$\gamma_t(1+\varepsilon)x_t > 1, \tag{2}$$

and from member state B to member state A if and only if $\gamma_t(1+\varepsilon) > x_t$. Parameter values x_t and γ_t are assumed to satisfy $x_t > \gamma_t/2, \gamma_t > 2/3$. The first assumption guarantees that not everyone with internationally applicable education emigrates from member state B. The second assumption guarantees that there is at least some migration between symmetric member states, that is with $x_t = 1$. With these assumptions,

(2) defines the cutoff level of $\varepsilon_t^A = \min(1/(\gamma_t x_t) - 1, \frac{1}{2})$ below which citizens with internationally applicable education remain in member state A in period t. Therefore, there is no migration from member state A if $\gamma_t x_t \leq 2/3$. Correspondingly, the cutoff level below which citizens remain in member state B is given by $\varepsilon_t^B = x_t/\gamma_t - 1$. For simplicity, ε is assumed to not be correlated with individual ability a. By this assumption and the properties of a uniform distribution, the share of remaining internationally applicable human capital is given by $F(\varepsilon_t^j)$.

When there is also some migration from member state A, $F(\varepsilon_t^j) = 1/(x_t\gamma_t) - 1/2$ is the share of those with education i who do not migrate. The probability that an individual with education i would emigrate is then

$$p_t^A = \frac{3}{2} - \frac{1}{x_t\gamma_t}. \tag{3}$$

As long as $x_t\gamma_t > 2/3$, there is emigration from member state A. The probability of emigration reaches its peak of 0.5 when $\gamma_t = 1$ and $x_t = 1$. The probability of emigration from member state B is

$$p_t^B = \frac{3}{2} - \frac{x_t}{\gamma_t}. \tag{4}$$

As migration occurs only when the productivity of migrants is higher in the other member state, brain exchange increases the aggregate production. Note that the productivity of all migrants with education i is higher in their new member state of residence, as otherwise they would not migrate in the first place. The average productivity

multiplier of migrants from member state A is[6]

$$b_t^A = \frac{3}{4}x_t\gamma_t + \frac{1}{2}, \text{ if } \gamma_t x_t > \frac{2}{3}. \tag{5}$$

If $\gamma_t x_x \leq 2/3$, there is no migration as $p_t^A = 0$, and thus b_t^A is not determined in the model. To simplify future notation, $b_t^A = 1$ if $p_t^A = 0$. The average productivity multiplier of the human capital of migrants from member state B is

$$b_t^B = \frac{3\gamma_t}{4} + \frac{x_t}{2}. \tag{6}$$

If the member states are identical, that is, $x_t = 1$, the average productivity multiplier is the same for migrants from both member states. The productivity multiplier reports the average post-migration productivity of the pre-migration human capital of migrants. The average productivity of migrants from member state A is b_t^A times as high in member state B as it would have been in member state A. The average productivity of migrants from member state B is b_t^B/x_t times as high in member state A as it would have been in member state B.

3.4. Private investment in education

By (1), (3) and (5), a student in internationally applicable education in member state A chooses private effort e_{t-1}^A to maximize

$$\rho(1-p_t^A)(1-\tau_t)(a+e_{t-1}^A) + \rho p_t^A(1-\tau_t)b_t^A(a+e_{t-1}^A) - \beta(e_{t-1}^A)^2,$$

provided that there is a positive probability of migration, that is $p_t^A > 0$. The first two

[6]With ε being uniformly distributed between -0.5 and 0.5, the highest value of $1+\varepsilon$ is $\frac{3}{2}$, while the lowest value with migration is $1+\varepsilon_t^1 = \frac{1}{x_t\gamma_t}$.

terms are the discounted value of expected future after-tax income, with an individual discount factor ρ, $0 < \rho \leq 1$. The third term is the immediate effort cost. This formulation results in the optimal effort choice

$$e_{t-1}^A = \frac{(1-\tau_t)\rho(1-p_t^A+p_t^A b_t^A)}{2\beta} = \frac{(1-\tau_t)\rho(\frac{9}{8}x_t\gamma_t + \frac{1}{2x_t\gamma_t} - \frac{1}{2})}{2\beta}. \tag{7}$$

If $p_t^A = 0$, then the optimal effort choice is $e_{t-1}^A = (1-\tau_t)\rho/(2\beta)$.

A student receiving education i in member state B would then choose effort e_{t-1}^B to maximize

$$\rho(1-p_t^B)(1-\tau_t)x_t(a+e_{t-1}^B) + \rho p_t^B(1-\tau_t)b_t^B(a+e_{t-1}^B) - \beta(e_{t-1}^B)^2,$$

resulting in the optimal effort choice in member state B (after inserting (4) and (6))

$$e_{t-1}^B = \frac{\rho(1-\tau_t)(\frac{9\gamma_t}{8} - \frac{x_t}{2} + \frac{x_t^2}{2\gamma_t})}{2\beta}. \tag{8}$$

The equations (7) and (8) imply that the investment in effort by students receiving education i is increasing in x_t and in γ_t in both member states.

3.5. Public education and aggregate production

The government has access to entrance examinations which allow it to screen applicants to the ability-intensive education. While not used in all countries, entrance examinations or results from end-of-school tests are commonly used to select those who are admitted. The cutoff level of ability chosen by the government j, $j \in \{A, B\}$, is denoted in period t by a_t^j, below which citizens are educated in field s and above which in field i. Thus, the stock of human capital s in member state j is in period t

$H^j_{s,t} = F(a^j_{t-1})$, and the pre-migration stock of human capital i is in member state j

$$\widetilde{H}^j_{i,t} = \int_{a^j_{t-1}}^{1} f(a)ada + \left[1 - F(a^j_{t-1})\right] e^j_{t-1}.$$

The first term on the right-hand side reports that part of education i which depends on individual ability, and the second term the part determined by individual effort. Post-migration internationally applicable human capital in member state j consists of share $(1 - p^j_t)$ of domestically created human capital and human capital of those who have immigrated from member state k, $k \neq j$:

$$H^j_{i,t} = (1 - p^j_t)\widetilde{H}^j_{i,t} + p^k_t b^k_t \widetilde{H}^k_{i,t}.$$

The government in each member state collects wage taxes at rate $\tau_{w,t}$ and graduate taxes at rate $\tau_{g,t}$ from the educated to finance exogenous public consumption G^j_t and public education, and returns the rest of the tax revenue to citizens not participating in production, like the elderly. The transfer in member state j is T^j. The government budget constraint reads in member state A as

$$\begin{aligned} & \tau_{w,t}(H^A_{s,t} + H^A_{i,t}) + \tau_{g,t}[H^A_{s,t} + (1 - p^A_t + p^A_t b^A_t)\widetilde{H}^A_{i,t}] \\ = \;& G^A_t + c_s F(\widehat{a}^A_t) + c_i(1 - F(\widehat{a}^A_t)) + T^A_t \end{aligned}$$

and in member state B as

$$\begin{aligned} & \tau_{w,t}(xH^B_{s,t} + xH^B_{i,t}) + \tau_{g,t}[x_t H^B_{s,t} + ((1 - p^B_t)x_t + p^B_t b^B_t)\widetilde{H}^B_{i,t}] \\ = \;& G^B_t + x_t c_s F(\widehat{a}^B_t) + x_t c_i(1 - F(\widehat{a}^B_t)) + T^B_t. \end{aligned}$$

The left-hand side is the government budget revenue. The first term gives wage tax revenue from the educated residing in the country, and the second term graduate tax revenue from those who received their education in the country. The right-hand side reports the expenditures, consisting of the exogenous revenue requirement, the costs of providing the two types of education, and the budget-balancing endogenous transfer T_t^j.

Even when restricting the analysis to a utilitarian government, important questions remain. First, how does the government value the utility of different generations? As current education affects future production capacity and income, the government faces an intergenerational trade-off. Second, how does the government value the utility of emigrants and immigrants?

The analysis proceeds under the following assumptions. The government values the current consumption and the future income that investment in education generates for its citizens in the following period, using the same discount rate as individuals. The government values the after-tax income of its emigrating citizens, compared to the income of remaining citizens, at rate α, $0 \leq \alpha \leq 1$. The government weights the graduate tax revenue that it is able to collect from emigrants in the same way as it values the income of its remaining citizens. The privately chosen effort cost of students with internationally applicable education does not enter into government decision-making. The government attaches a zero weight to immigrants.[7] The social

[7]Importantly, the results are independent of whether the government also values the utility of immigrants or not. The assumption of zero weight simplifies notation.

welfare function is given by

$$\begin{aligned} SWF_t^A &= (1-\tau_t)H_{s,t}^A + (1-p_t^A)(1-\tau_t)\widetilde{H}_{i,t}^A + T_t^A \\ &\quad +\rho H_{s,t+1}^A + \rho(1-p_{t+1}^A)\widetilde{H}_{i,t+1}^A + \rho\tau_{g,t+1}p_{t+1}^A b_{t+1}^A \widetilde{H}_{i,t+1}^A \\ &\quad +\alpha p_t^A(1-\tau_t)b_t^A\widetilde{H}_{i,t}^A + \alpha\rho p_{t+1}^A(1-\tau_{t+1})b_{t+1}^A\widetilde{H}_{i,t+1}^A. \end{aligned}$$

The first line gives the utility of consumption in the current period of those citizens who stay, being the sum of the disposable income of those with education s, those with education i, and transfers to the rest of the population. The second line gives the sum of the discounted value of production of those citizens who stay, and graduate tax revenue from the emigrants. The allocation of these resources between consumption and investment in education are decided only in the following period. The third line reports the social valuation of the utility of emigrants. The first term is the valuation of the consumption of the emigrants in the current period, and the second term is the discounted value of the consumption of emigrants in the following period.

As the tax rates are given, the consumption of the educated in the current period is exogenous from the government's perspective. Omitting this and other exogenous variables, the government's objective function is in member state A

$$\begin{aligned} \overline{SWF}_t^A &= T_t^A + \rho H_{s,t+1}^A + \rho(1-p_{t+1}^A)\widetilde{H}_{i,t+1}^A \\ &\quad +\alpha\rho p_{t+1}^A(1-\tau_{t+1})b_{t+1}^A\widetilde{H}_{i,t+1}^A + \rho\tau_{g,t+1}p_{t+1}^A b_{t+1}^A\widetilde{H}_{i,t+1}^A. \end{aligned}$$

The first term on the right-hand side consists of current transfers to the rest of the population. These are directly affected by the costs of education currently provided. The second term is the discounted value of the income accruing to those with

country-specific education in the following period. As the government values the income accruing to different groups of citizens in the same way, this term does not depend on future taxation. The third term is the discounted value of income accruing to those with internationally applicable education who stay. The fourth term is the discounted social valuation of the after-tax income of emigrants. The fifth term is the discounted value of graduate tax revenue from emigrants, if any. Correspondingly, for member state B

$$\begin{aligned}\overline{SWF}_t^B &= T_t^B + \rho x_{t+1} H_{s,t+1}^B + \rho(1-p_{t+1}^B) x_{t+1} \widetilde{H}_{i,t+1}^B \\ &\quad + \alpha\rho p_{t+1}^B (1-\tau_{t+1}) b_{t+1}^B \widetilde{H}_{i,t+1}^B + \rho \tau_{g,t+1} p_{t+1}^B b_{t+1}^B \widetilde{H}_{i,t+1}^B.\end{aligned}$$

4. Results

This section focuses on education policy when no changes in taxes or productivity differential x are expected in the following period. For simplicity, the time indices from the tax rates and parameters x, p^A, p^B, b^A and b^B are omitted.

4.1. Welfare effects of graduate taxes

Governments choose the cutoff levels of ability that maximizes their objective functions. Differentiating $\overline{SWF}_t^A$ with respect to a_t^A gives as the first-order condition

$$\rho - c_s = \rho\left[1 - p^A + p^A b^A (1-\tau)\alpha + p^A b^A \tau_g\right](a_t^A + e_t^A) - c_i.$$

On the left-hand side, we have the marginal social benefit of a student receiving country-specific education. This is independent of ability. On the right-hand side, we have the marginal social benefit of a student receiving internationally applicable education. This value is increasing in the student's ability. The first-order condition

allows us to solve for the cutoff level of ability below which the government provides country-specific education, and above which internationally applicable education:

$$\widehat{a}_t^A = \frac{\rho - c_s + c_i}{\rho\left[1 - p^A + p^A b^A(1-\tau)\alpha + p^A b^A \tau_g\right]} - e^A. \tag{9}$$

Comparative statics yield that investment in education i is increasing in c_s and α and decreasing in c_i and β, as $\partial e^A/\partial\beta < 0$. Correspondingly, the first-order condition of the $\overline{SWF}_t^B$ allows to solve as the cutoff ability level

$$\widehat{a}_t^B = \frac{x\rho - xc_s + xc_i}{\rho\left[(1-p^B)x + p^B b^B(1-\tau)\alpha + p^B b^B \tau_g\right]} - e^B. \tag{10}$$

A general result with graduate taxes is derived.

Proposition 1 *Governments invest more in internationally applicable education with graduate taxes than with only domicile-based taxation. Investment in internationally applicable education is increasing in the graduate tax rate.*

Proof. Insert (7) into (9) and (8) into (10). The first terms on the right-hand side of the resulting expressions are decreasing in τ_g, while the second terms are independent of it. ■

Notice that this result is independent of the weight assigned to emigrants, and of the relative importance of private investment in effort. A central result is then:

Proposition 2 *Allowing member states to levy graduate taxes is welfare improving.*

Proof. See Appendix. ■

4.2. International applicability and education policy

While the analysis of the welfare effects of graduate taxes yields general results, welfare effects of changes in the international applicability parameter γ are more difficult to determine. To simplify, the analysis focuses on two polar cases: a federation of two symmetric member states, and an asymmetric federation in which migration goes only from the poor to the rich member state.

An increase in international applicability of human capital encourages private investment in it. Given that private and public investments are complementary, this would leave the effect of an increased international applicability of education i on public investment in it a priori unclear. On one hand, brain drain effect would push the government to reduce public investment in it, while brain gain effect would render investing in it more attractive. Remarkably, this analysis finds that the brain drain effect always dominates in public investment, provided that the government cares only about its citizens staying.

Proposition 3 *If $\alpha = \tau_g = 0$ and $x = 1$, then governments always reduce investment in internationally applicable education when its applicability increases.*

Proof. See Appendix. ■

Due to the presence of the brain gain effect, however, the aggregate stock of internationally applicable human capital may either increase or decrease when its international applicability increases:

Proposition 4 *If $\alpha = \tau_g = 0$ and $x = 1$, then an increase in the applicability of internationally applicable education may result in either a larger or smaller pre-migration stock of it.*

Proof. See Appendix. ■

Proposition 4 suggests that in addition to the cost of private effort, β, also ability distribution plays an important role in determining whether an increase in international applicability of internationally applicable human capital increases or decreases its formation. The intuition is as follows. If the density of abilities around the marginal ability of internationally applicable education is low, then the negative effect at the extensive margin from reduced public provision is small, and the positive effect from the increased private effort at the intensive margin dominates. On the other hand, if the density of abilities around the cutoff level is high, then an increase in the minimum ability above which the government provides internationally applicable education excludes a large number of students, and the extensive margin may dominate.

Importantly, an increased mobility of labor need not always reduce total resources used to finance education. Whether this is the case or not depends on which type of education is more expensive. Also when internationally applicable education is less expensive, an increased probability of migration reduces individual government's incentives to invest in it.

When the government attaches the same weight to emigrants as to citizens staying, increased mobility may lead to either a larger or smaller investment in internationally applicable education. On the one hand, efficiency gains from brain exchange for emigrants encourage governments to invest more in internationally applicable education. On the other hand, governments are pushed toward less investment because they lose tax revenue from emigrants.

Proposition 5 *Assume that* $x = 1$. *Governments with a sufficiently high* α *may increase investment in internationally applicable education when its applicability in-*

creases, provided that τ_w is not too high. Ceteris paribus, a decrease in β widens the scope for the government to increase investment in i when γ increases.

Proof. To prove its existence, set $\tau_w = 0$, $c_s = c_i$, $x = 1$ and $\alpha = 1$ in (9), after inserting (7). Then differentiating yields $\partial \widehat{a}_t^A / \partial \gamma < 0$ by $\gamma \geq 2/3$. Without restrictions on the value of τ_w, c_s, or c_i, $\partial^2 \widehat{a}_t^A / \partial \gamma \partial \beta > 0$ in (9). ■

The latter finding relates to results by Stark et al. (1997) and Stark and Wang (2002): a positive probability of migration encourages private investments in human capital. The results of this analysis arise from a common labor market of two symmetric countries. Previous literature on brain drain and brain gain has focused on migration from a less developed country to a more developed country. (See Stark et al. (1997), Beine et al. (2001) and Stark and Wang (2002))

Assume next an asymmetric federation with $\gamma x \leq 2/3$. Parallel to the analysis of a symmetric federation,

Proposition 6 *If $\alpha = \tau_g = 0$ and $\gamma x \leq 2/3$, the government of member state B always reduces investment in internationally applicable education when its applicability increases.*

Proof. See Appendix. ■

This proposition shows that even as brain gain from the possibility of migration intensifies, the government of the poorer member state still reduces its investment in internationally applicable human capital, as its applicability increases. Interestingly,

Proposition 7 *An increased probability of emigration from member state B to member state A, resulting from an increase in γ or a decrease in x, may either increase or decrease welfare in member state A when $\alpha = \tau_g = 0$ and $\gamma x \leq \frac{2}{3}$.*

Proof. See Appendix. ■

To summarize, the welfare effects of international applicability may be non-monotonic. Also the member state benefiting from immigration may be hurt if its attractiveness increases too much, relative to the other member state. The reason why an increase in the mobility of labor from the poorer to the richer member state may decrease welfare in the richer member state hinges on the policy response of the government in the poorer member state. If a further increase in the probability of emigration results in the government of the poorer member state switching to offering country-specific education, the richer member state suffers also as it no longer receives immigrants and the tax revenue they would offer.

5. Conclusion

This paper shows that decentralized decision-making on public education encourages the member states of the European Union to distort the provision of public education away from internationally applicable education, toward country-specific skills. If governments focus on the utility of those citizens (and voters) who stay, they reduce the provision of internationally applicable education even when students would increase complementary private investment in effort. This analysis thus suggests that the brain drain effect would dominate the brain gain, at the extensive margin of a government deciding how many students it provides internationally applicable education. At the intensive margin of students deciding on their complementary private investment in effort, an increase in international applicability results in more effort. The net effect can then go either way.

Whether the behavioral responses at the intensive margin by students or at the extensive margin by governments dominate, behavioral responses at the extensive margin

lead to inefficiently low number of students receiving internationally applicable education. As a remedy, this study suggests introducing graduate taxes or income-contingent loans, paid according to the same rules independently of future domicile. Giving member states a stake in efficiency gains also earned elsewhere would encourage governments to invest more in human capital benefiting also the other member states. The enlargement of the European Union increases potential benefits of establishing graduate taxes or income-contingent loans. With current tax rules, incentives of citizens and those of governments would diverge. Students would find incentives to study for migration, thanks to higher expected earnings elsewhere. Governments, on the other hand, would face incentives to educate students to stay, by offering them too little internationally applicable human capital, and too many country-specific skills.

This analysis relies on several simplifying assumptions, some of which should not change the underlying results, while others can be expected to affect policy conclusions. It assumes that production technologies are linear in the two types of human capital. This implies that wages of a given occupation do not change as a result of changes in the number of those educated in that occupation. This assumption should not affect any qualitative results. This paper analyzes the effects of marginal changes in international applicability or graduate tax rates. Any changes in the relative wage rates are induced effects of changes in the relative stocks, and are thus induced second-order effects. A quantitative analysis of non-marginal changes should, naturally, aim at capturing complementarities and substitutabilities in production. Also, tax rates are taken as given, following Keen and Marchand (1997). Endogenizing these tax rates is left for future research, as are possible interactions that such tax rates or educational investments could have with public provision of infrastructure.

Perhaps the most important assumption is that the governments are benevolent,

and do not suffer from the time-consistency problem. In the analyzed model with benevolent governments and without the commitment problem, there is no motivation for relying on income-contingent loans, as opposed to graduate taxes. Allowing for a commitment problem or governments which are not entirely benevolent would likely to change this. In a world where the benevolence of governments is not universally guaranteed, constitutional design has to trade-off the adverse selection problem and the need to tame Leviathan governments. Accepting a certain degree of adverse selection would then be optimal, and could be interpreted as a federation's insurance premium against potential abuses by governments. Voluntary contracts would also solve the time-consistency problem that may arise even when governments are benevolent.

Appendix.

Proof of Proposition 2.

Welfare effects of education policy of either member state can be divided into internalized effects and externalities on the other member state. Country-specific education does not generate externalities, while internationally applicable education generates a positive externality to the other member state as the other member state benefits from migrants who pay wage taxes there. By Proposition 1, an increase in the graduate tax rate increases the provision of internationally applicable education. As either country could have left its education policy unchanged, both countries perceive their own social welfare to increase as a result of providing more internationally applicable education. But as this increases also the welfare of the other member state, it clearly increases the sum of welfare in the two member states.

Proof of Proposition 3.

Inserting (7) and setting $\alpha = 0, \tau_g = 0, x = 1$ in (9), $\widehat{a}_t^1 = \frac{\rho - c_s + c_i}{\rho\left[\frac{1}{\gamma} - \frac{1}{2}\right]} - \frac{(1-\tau)\rho(\frac{9}{8}\gamma + \frac{1}{2\gamma} - \frac{1}{2})}{2\beta}$.

Differentiate

$$\frac{\partial \widehat{a}_i^1}{\partial \gamma} = \frac{\rho - c_s + c_i}{\rho(\frac{1}{\gamma} - \frac{1}{2})^2 \gamma^2} + \left(- \frac{(-\frac{1}{2\gamma^2} + \frac{9}{8})(1-\tau)\rho}{2\beta} \right). \tag{A1}$$

The first term is positive, and the second negative. Notice that when both types of education are provided, social surplus from providing education s has to exceed that from providing education i with $a = 0$. That is, $\rho - c_s > (1 - p^A)\rho e^A - c_i$. By (3) and (7), this implies that

$$\frac{2\beta(\rho - c_s + c_i)}{(\frac{1}{\gamma} - \frac{1}{2})(1-\tau)} > (-\frac{1}{2} + \frac{1}{2\gamma} + \frac{9\gamma}{8})\rho^2. \tag{A2}$$

The right-hand side of (A1) is positive if $\frac{2\beta(\rho - c_s + c_i)}{(\frac{1}{\gamma} - \frac{1}{2})(1-\tau)} > (-\frac{1}{2\gamma^2} + \frac{9}{8})(\frac{1}{\gamma} - \frac{1}{2})\gamma^2\rho^2$. By (A2), this holds if $\frac{9\gamma^2}{16} + \frac{1}{\gamma} - \frac{3}{4} > 0$. This condition always holds as $\gamma \leq 1$.

Proof of Proposition 4.

It is useful to write the stock of internationally applicable human capital explicitly as a function of γ :

$$\widetilde{H}_i^j = \int_{\widehat{a}^j(\gamma)}^1 f(a) a da + \left[1 - F(\widehat{a}^j(\gamma))\right] \frac{\rho(-\frac{1}{2} + \frac{1}{2\gamma} + \frac{9\gamma}{8})(1-\tau)}{2\beta}.$$

Differentiation with respect to γ yields

$$\begin{aligned} \frac{\partial \widetilde{H}_i^j}{\partial \gamma} &= \left[-\widehat{a}^j(\gamma) - \frac{(-\frac{1}{2} + \frac{1}{2\gamma} + \frac{9\gamma}{8})\rho(1-\tau)}{2\beta} \right] f(\widehat{a}^j(\gamma)) \frac{\partial \widehat{a}^j(\gamma)}{\partial \gamma} \\ &\quad + \left[1 - F(\widehat{a}^j(\gamma))\right] \frac{\rho(-\frac{1}{2\gamma^2} + \frac{9}{8})(1-\tau)}{2\beta} \\ &= -\frac{\rho - c_s + c_i}{\rho(\frac{1}{\gamma} - \frac{1}{2})} f(\widehat{a}^j(\gamma)) \frac{\partial \widehat{a}^j(\gamma)}{\partial \gamma} + \left[1 - F(\widehat{a}^j(\gamma))\right] \frac{\rho(-\frac{1}{2\gamma^2} + \frac{9}{8})(1-\tau)}{2\beta}. \end{aligned}$$

The last line uses (9) and (7). The first term is negative as $\partial \widehat{a}^j(\gamma)/\partial \gamma > 0$ by Proposition 3. The second term is positive by $\gamma > 2/3$. If $f(\widehat{a}^j(\gamma)) \to 0$, the first

term vanishes. Then the second term dominates, and $\partial \widetilde{H}_i^j/\partial\gamma > 0$. If $\beta \to \infty$, then $\partial \widetilde{H}_i^j/\partial\gamma < 0$ by Proposition 3.

Proof of Proposition 6.

With $\alpha = \tau_g = 0$ and (8), (10) simplifies to

$$\widehat{a}^B = \frac{\rho - c_s + c_i}{\rho(\frac{x}{\gamma} - \frac{1}{2})} - \frac{\rho(1-\tau)(\frac{9\gamma}{8} - \frac{x}{2} + \frac{x^2}{2\gamma})}{2\beta}.$$

Differentiation with respect to γ yields

$$\frac{\partial \widehat{a}^B}{\partial\gamma} = \frac{(\rho - c_s + c_i)x}{\rho(\frac{x}{\gamma} - \frac{1}{2})^2\gamma^2} - \frac{\rho(1-\tau)(\frac{9}{8} - \frac{x^2}{2\gamma^2})}{2\beta}$$

This is positive if and only if

$$\frac{2\beta(\rho - c_s + c_i)}{\rho^2(\frac{x}{\gamma} - \frac{1}{2})(1-\tau)} > (\frac{9}{8} - \frac{x^2}{2\gamma^2})(\frac{x}{\gamma} - \frac{1}{2})\frac{\gamma^2}{x} \tag{A3}$$

On the other hand, we have a requirement that in order to have any country-specific education being provided, it must hold that the expected social surplus from providing this exceeds that of providing internationally applicable education for a citizen with zero ability. That is, $\rho x - xc_s > \rho(1-p^B)xe^B - xc_i$. Inserting yields

$$\rho x - xc_s > \rho(\frac{x}{\gamma} - \frac{1}{2})x\frac{\rho(1-\tau)(\frac{9\gamma}{8} - \frac{x}{2} + \frac{x^2}{2\gamma})}{2\beta} - xc_i$$

This implies that

$$\frac{2\beta(\rho - c_s + c_i)}{\rho^2(\frac{x}{\gamma} - \frac{1}{2})(1-\tau)} > (\frac{9\gamma}{8} - \frac{x}{2} + \frac{x^2}{2\gamma}). \tag{A4}$$

The left-hand sides of (A3) and (A4) are identical. (A4) thus implies that (A3) holds if the right-hand side of (A3) is less than the right-hand side of (A4). This is the case if

$$(\frac{9}{8} - \frac{x^2}{2\gamma^2})(\frac{x}{\gamma} - \frac{1}{2})\frac{\gamma^2}{x} < (\frac{9\gamma}{8} - \frac{x}{2} + \frac{x^2}{2\gamma}).$$

This simplifies as $\frac{9}{16} + \frac{x^3}{\gamma^3} - \frac{3x^2}{4\gamma^2} > 0$. If $x \geq \gamma$, this always holds as the sum of the two last terms is positive. Assume next that $x < \gamma$. To simplify notation, define $y \equiv x/\gamma$, noting that $0 < y < 1$. What remains to prove is that $g(y) = \frac{9}{16} + y^3 - \frac{3}{4}y^2 > 0 \forall y \in (0, 1)$. Differentiating $g(y)$, we find that it is decreasing in the area to be studied when $y < \frac{1}{2}$, and increasing when $y > \frac{1}{2}$. It thus suffices to study the value of the function at $y = \frac{1}{2}$. As $g(\frac{1}{2}) = \frac{1}{2}$, the claim is proven.

Proof of Proposition 7.

Assume first that the probability of migration from B to A is zero. Then an increase clearly benefits the member state A as it receives tax revenue from immigrants. If, however, the probability of migration increases to one and α is sufficiently low, then the government of member state B stops investment in internationally applicable education. Thus, an increase in γ (or a decrease in x) improves welfare in member state A when migration is sufficiently small, but reduces welfare in member state A when migration is sufficiently large.

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