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Abstract

We study voting over higher education finance in an economy with two regions and two separated labor markets. Households differ in their financial endowment and their children's ability. Non-students are immobile. Students decide where to study; they return home after graduation with exogenous probability. The voters of the two regions decide on whether to subsidize higher education costs or whether to rely on tuition fees only. We find that in equilibrium, in both regions a majority votes for subsidies when the return probability is sufficiently small. When that probability is large, both regions opt for full tuition finance. Interestingly, the higher the return probability, the smaller are the equilibrium subsidy rates, but the larger are the numbers of exchange students.

JEL-Code: H520, H420, D720.

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1 Introduction

This paper is motivated by the growing mobility of students across regions and countries. 3.34 million individuals world-wide obtained tertiary education in a country different from their home country in 2008. Compared to 2007 (2.73 million), this is an increase of 23%, and compared to 2002 (1.89 mio) of even 77% (BMBF, 2009).

This trend can also be observed for Germany. In 2010, for instance, 181,000 foreigners were enrolled in German higher education institutions (corresponding to 8.5% of all students in Germany), an increase of 21% compared to 1997. Also the number of German natives studying abroad has grown in recent years, almost doubling between 2001 and 2008.

The increased mobility of students has important implications for national policies of higher education finance. On the one hand, with mobile students, there are incentives to increase subsidies in order to attract foreign students, since these foreign students - when staying on as skilled workers - generate benefits for the host country in the form of human capital externalities or positive direct wage effects and as tax-payers.[1] On the other hand, the realization of these benefits, strongly depends on the return probability of graduates. If this probability is too large, the positive effects of attracting high-ability students fall below the costs of educating them.[2] So, if many exchange students leave after graduation, they do not pay taxes and free-ride on the financing system.[3] This reduces the incentives for high subsidies.

A recent case in point is the Bologna Process of the European Union launched in 1999 and designed to increase student mobility by establishing a Higher Education Area by 2010.[4] This has so far led to greater interdependencies of government financed university systems. Another case in point is Germany where higher education is under the authority of the states (*Länder*). Some states have a traditional tax-financed free university system. Others have recently introduced tuition fees (at moderate rates), but the majority of these has subsequently abolished tuition fees again. Obviously, these choices are guided by

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

[2]Student subsidies are in general financed by taxes levied on all households of the particular region or country. Higher subsidies thus mean more 'reverse redistribution', since families of non-students, who tend to be relatively poor, contribute to finance students, who tend to be from relatively rich families. See for instance Fernandez and Rogerson (1995) or Anderberg and Balestrino (2008).

[3]It is assumed here and in the following that countries or regions cannot discriminate between in-state and out-of-state students similar to the legal framework within the European Union.

[4]The European Commission (2010) reported that all main goals of the Bologna process were reached successfully, except for validation of foreign student results.

strategic incentives. For instance, some regions may want to keep tuition fees low in order to attract students from other regions.[5] More precisely, it is not the regions as such that display strategic behavior, but rather different groups of voters within a region who expect benefits of immigration or emigration of students and skilled workers to realize.

We develop a model to describe the strategies of regions, as determined in a political process, for subsidizing higher education in the face of student mobility. To this end we model two regions which are populated by risk-averse individuals who differ in innate ability and financial endowment. Low-ability individuals never study while high-ability individuals do. We assume non-students to be immobile while students are mobile. Students who obtain education abroad return home after studying with a certain exogenous probability. Further, wages are determined endogenously by the supply of skilled and unskilled workers.

At the first stage, regions vote on the tax rate necessary to finance subsidies to all local (home and foreign) students. This proportional tax rate is levied on endowments of all natives, irrespective of their ability type or their migration decision. Voters take three effects of a larger tax rate into account: First, it obviously raises individual tax payments, which we denote as *tax effect*. Second, it ceteris paribus increases the subsidies to all students enrolled in the particular region. Clearly, this *subsidy effect* does not directly benefit non-students or emigrating students. Finally, variations of the tax rate change enrollment and consequently the regional numbers of skilled and unskilled workers, which affects the related wage levels (*wage effect*).

At the second stage, students decide where to study based on the subsidies and the respective skill premiums in the two regions. Graduation is uncertain so that the risk-averse students also take the different insurance aspects of different finance schemes into account.

We find that results strongly depend on the exogenous probability with which foreign graduates return home for work: When the probability is one, both regions rely on pure fee financing. The reason is that the incentive of low-ability individuals (who form the majority) to subsidize higher education is zero. These low-ability individuals only vote for positive subsidies if by doing so, they can attract foreign students who stay for work and increase unskilled wages. However, this is only the case when the return probability is sufficiently low. We find that the equilibrium tax rates increase with falling return probability, but interestingly, the number of exchange students decreases.

This paper is related to two strands of the literature: On the one hand, there is a

[5] In 2010, 37% of all foreign students in Germany stated to be guided by 'financial reasons' when deciding where to study, also including local subsidies. Taking only the low middle-income class this figure even rises to 42%. See again BMBF (2009).

growing number of papers discussing the political economics of higher education finance. For instance, Johnson (1984), Creedy and Francois (1990), Bevía and Iturbe-Ormaetxe (2002) and Borck and Wimbersky (2013) show that non-students may vote for positive subsidies despite positive tax payments, because they benefit from general equilibrium effects like higher low-skilled wages. But in contrast to our model, they all assume immobile individuals. On the other hand, there is a growing body of literature on education finance with mobile students. For instance, the idea that mobility of students or skilled labor gives rise to underinvestment of local education finance has been modeled by DelRey (2001) and Justmann and Thisse (2000). Besides, Lange (2009) shows that when students and skilled workers are mobile, regions might underinvest or overinvest in education. This is due to the fact that regions may want to attract mobile students, which counters the incentive for underinvestment due to mobility of skilled labor.[6] Poutvaara (2004, 2008) compares different financing schemes and argues that a graduate tax system instead of a tax-subsidy scheme increases the provision of internationally applicable education in a Pareto improving way. Closest to ours is Gérard (2007) who analyses the financing of exchange students in a two-country setting, where graduates return home for work with an exogenous probability, as is the case in our model. He finds that moving from a system where the costs of exchange students are financed by the host country to a system where education is supported by the country of origin is a Pareto improvement as it reduces the underprovision of education.

Our model contributes to the literature by explicitly combining the choice of the financing system for higher education by majority voting with the mobility of students. Within this framework, we study the incentives of regions or their voters, respectively, for subsidizing higher education students and the implications of the chosen financing scheme for students' decisions about where to study.

The structure of the paper is as follows: In the next section we introduce the general setup, and in Section 3 the financing scheme. Section 4 describes the equilibrium. The model is solved numerically in Section 5. The robustness of the results is checked using sensitivity analyses in Section 6, and the last section concludes.

2 Model

We consider a world with two regions indexed by $r \in \{A, B\}$. The population in each region consists of households of one parent and one child, and we assume that all decisions are

[6] See also Demange et al. (2013)

taken by the parent. Households are heterogeneous in two dimensions: children's ability a and parents' endowment ω. Ability follows a bivariate distribution. Low-ability individuals ($a = 0$) never study and high-ability individuals ($a = 1$) not only have the potential to study, but also sufficient financial means to do so. We will interchangeably denote low-ability individuals as 'non-students' and high-ability individuals as 'students'. Financial endowment or wealth is distributed with a cumulative distribution function $G_{r,a}(\omega)$ with density function $g_{r,a}(\omega)$, where $\omega_{r,a}^{av}$ stands for average and $\omega_{r,a}^{m}$ for median endowment of natives of region r with ability a.[7] Note that the two ability groups may differ in their endowment distribution within and across regions. Moreover, we assume that (children's) ability and (parents') endowment are positively correlated in each region in a way that the average endowment of the high-ability group is always above the average endowment of the low-ability group.

We consider two overlapping generations which belong to an endless number of overlapping generations with zero population growth. Individuals live for two periods. In the first period, low-ability individuals work and high-ability individuals study. In the second period, all individuals work. Low-ability individuals are assumed to be immobile, whereas high-ability individuals decide about their place of education by comparing the utility levels for studying at home or abroad. After graduation abroad, they return home with exogenous probability m or stay in the region of education with probability $(1 - m)$. Those who study at home are assumed to work in their home region.[8] As a consequence of the exogenous return probability, there is no arbitrage in net wages.[9] Note that even though the sizes of all ability groups are fixed ex ante, the number of skilled workers in each region is determined endogenously by student migration.

We assume graduation to be uncertain, i.e. only a fraction of all students finishes their studies successfully, with p as the success probability and $(1-p)$ the probability of failure. Those who fail receive the wage income of an unskilled worker w_r^L in period 2, whereas the successful graduates obtain the wage of a skilled worker w_r^H. Moreover, studying causes costs $e > 0$ which are the same in both regions. However, the fees levied on students might be (partly) subsidized by governments. Since we assume imperfect credit markets, students cannot borrow against their future income, and the net-of-subsidies education costs must

[7] More precisely, a denotes the ability of the child living in the respective household.

[8] One reason might be larger post-education migration costs, since these students have not obtained any international skills during their education. The assumption of immobility of graduated home students is introduced for simplification. We could also allow for a positive emigration rate, as long as the probability of working abroad is larger for exchange students than for home students.

[9] We discuss the assumption of an exogenous return probability at the end of Section 5.

be financed via households' net-of-tax endowments.

Parents are altruistic toward their children. We assume that parents take all decisions and maximize a utility function which depends on the present value of their own and their children's consumption:[10]

$$U_{i,r,a} = u(c^{P,O}_{i,r,a}, c^{J}_{i,r,a}, \delta c^{O}_{i,r,a}) \tag{1}$$

with $u' > 0 > u''$, where $c^J_{i,r,a}$ and $c^O_{i,r,a}$ are, respectively, consumption of the child of household i born in region r with ability a when young / old and $c^{P,O}_{i,r,a}$ is second-period consumption of the parent of this child.[11] Clearly, since non-students are immobile, the region of birth unambiguously determines their place of consumption in period 1 and 2, whereas for students this may vary due to migration before and after higher education. The parameter δ is the discount factor. Note that we assume parents to care only about lifetime consumption of their children, so the intertemporal elasticity of substitution is infinite.[12]

Regional outputs are produced by identical Cobb-Douglas production functions

$$Y_{t,r} = F(H_{t,r}, L_{t,r}) = \phi H^{\alpha}_{t,r} L^{1-\alpha}_{t,r} \tag{2}$$

with $0 < \alpha < 1$, where the technology parameter ϕ is the same in both regions. The number of unskilled workers in period t and region r amounts to

$$L_{t,r} = l_{t-1,r,r} + l_{t,r,r} + (1-p)N_{t-1,r,r} + m(1-p)N_{t-1,r,q} + (1-m)(1-p)N_{t-1,q,r} \tag{3}$$

with $r, q \in \{A, B\}$ and $r \neq q$. The first two terms on the right-hand side, $l_{t-1,r,r}$ and $l_{t,r,r}$, depict the ex ante unskilled workers in region r of the previous and the current generation.The third term, $(1-p)N_{t-1,r,r}$, shows all unsuccessful students of the previous generation $t-1$ who studied at home. The fourth term, $m(1-p)N_{t-1,r,q}$, shows all native exchange students who failed abroad and returned home, and the last term, $(1-m)(1-p)N_{t-1,q,r}$, depicts the unsuccessful foreign students of the previous generation who stay in region r for work. Note that although ex ante unskilled workers are immobile, unsuccessful exchange students are assumed to be mobile.

The number of skilled workers in period t and region r amounts to

$$H_{t,r} = pN_{t-1,r,r} + mpN_{t-1,r,q} + (1-m)pN_{t-1,q,r}, \tag{4}$$

[10] Since parents can achieve any distribution of their own and their children through transfers and bequests, below we write utility as a function of total discounted income.

[11] In the numerical analysis, we apply a functional form for the utility function with decreasing absolut and constant relative risk aversion.

[12] See also García-Peñalosa and Wälde (2000).

which is the sum of all successful home students of the previous period, $pN_{t-1,r,r}$, all successful exchange students from region r who returned home after graduation, $mpN_{t-1,r,q}$, and finally, all foreign exchange students from the previous period who succeeded and stay in region r for work, $(1-m)pN_{t-1,q,r}$. As cohorts are of same size in each generation, the time index will be dropped from now on.

We assume perfectly competitive labor markets in each region with profit maximizing firms. Hence, all workers are paid their local marginal products in each period. Due to immobility of low-ability households, marginal products (and wage levels) may differ between regions as net wage arbitrage is prevented. The wages for skilled and unskilled workers are given by:

$$w_r^H = \frac{\partial F(H_r, L_r)}{\partial H_r} = \phi\alpha \left(\frac{L_r}{H_r}\right)^{(1-\alpha)} \tag{5}$$

$$w_r^L = \frac{\partial F(H_r, L_r)}{\partial L_r} = \phi(1-\alpha) \left(\frac{H_r}{L_r}\right)^{\alpha}. \tag{6}$$

Increasing the number of skilled (unskilled) workers in region r decreases the local wage of skilled (unskilled) workers, but increases the local wage of unskilled (skilled) workers.[13] These adjustments in wage levels are one channel through which households' preferences for financing systems are affected.

3 Financing Scheme

Each region may rely on tuition fees, where all students pay their education costs without any subsidization by the government. Alternatively, a region may opt for a so called 'traditional tax-subsidy' system (TS), where the government subsidizes the fraction s_r of education costs e of all local students in region r, irrespective of their region of origin. Government expenditures are covered by a proportional tax rate t_r, levied on the endowments of all natives comprising low-ability and high-ability households.[14] Hence, exchange students pay taxes in their home region but do not benefit from the corresponding subsidies. Rather, they benefit from subsidies in their region of education, even though they do not

[13]There exists a large body of literature showing that skill premiums can be largely explained by the relative supply of skilled over unskilled labor because of imperfect substitutability between these groups. See for instance the surveys by Katz and Autor (1999) and Acemoglu and Autor (2011).

[14]See also García-Peñalosa and Wälde (2000) who analyze a similar TS system with lump-sum taxes. However, they argue that a tax on current income seems like a more natural scheme. See also De Fraja (2001).

contribute to their financing. This leads to the following government budget constraint

$$\left(t_r - \frac{(t_r)^{\eta_r}}{\eta_r}\right)(\theta_r \omega_{r,0}^{av} + \omega_{r,1}^{av}) = s_r e N_r, \tag{7}$$

where $\omega_{r,a}^{av}$ are the average endowments of the respective ability groups and θ_r weighs the mass of low-ability to the mass of high-ability individuals, since both groups are not necessarily of equal size. The term in the first brackets of the left-hand side depicts the effective tax rate in region r, that is the nominal tax parameter minus the deadweight costs of taxation. These might be due to incentive effects on labor supply. The size of these costs are parameterized by $\eta > 1$. They fall with increasing η. Finally, the total number of students in one region, N_r, is the sum of all home students, $N_{r,r}$, and all exchange students from the other region q, $N_{q,r}$.[15]

The utility of a low-ability household born in region r with endowment $\omega_{i,r,0}$ is[16]

$$U_{i,r,0} = u\,\left(\omega_{i,r,0}(1 - t_r) + \gamma w_r^L + \delta w_r^L\right). \tag{8}$$

Note that first period unskilled wages of non-students are multiplied by $\gamma < 1$, so their wage income in period 1 is effectively smaller than in period 2. The reason is that non-students are less qualified and still in training in their first period and therefore less productive compared to old workers (in their second period).

A high-ability household from region r with endowment $\omega_{i,r,1}$ whose children study at home achieves expected utility

$$\begin{aligned} EU_{i,r,1}^r &= p\,u\left(\omega_{i,r,1}(1 - t_r) - e(1 - s_r) + \delta w_r^H\right) \\ &+ (1 - p)\,u\left(\omega_{i,r,1}(1 - t_r) - e(1 - s_r) + \delta w_r^L\right), \end{aligned} \tag{9}$$

where the superscript 'r' indicates the region of education. For exchange students born in region r who study in region q the expected utility is

$$\begin{aligned} EU_{i,r,1}^q &= p\,u\left(\omega_{i,r,1}(1 - t_r) - e(1 - s_q) + \delta(m w_r^H + (1 - m) w_q^H)\right) \\ &+ (1 - p)\,u\left(\omega_{i,r,1}(1 - t_r) - e(1 - s_q) + \delta(m w_r^L + (1 - m) w_q^L)\right), \end{aligned} \tag{10}$$

where the indices for the tax and subsidy rates are different here due to education abroad. Note that the return probability m is only incorporated in the expected utility of exchange

[15]Note that given our assumption on endowments, a mixed (TS) financing system is not implemented because of imperfections of the capital market and credit constraints. A mixed system might be voted for to attract low-endowment / risk averse students with a large preference for subsidies due to their insurance function.

[16]Note that $\omega_{i,r,0}$ also includes parents' second-period wages.

students of equation (10), as home students are assumed immobile and work in their region of birth after graduation.

A region might also opt for full tuition finance, which would occur if a majority votes for a subsidy rate of zero.

4 Equilibrium

We assume three stages: At the first stage, all natives in both regions simultaneously determine the tax rate of the financing system of their home region. At stage 2, high-ability households decide where to study. And at stage 3, the fractions m of all foreign graduates return to their home region and work either as skilled or unskilled, depending on whether they studied successfully or not.

4.1 Stage 3: Region of work

We start with determining the region of work. Low-ability individuals are immobile by definition and always work in their region of birth. The same holds for high-ability individuals who obtain education at home. By contrast, high-ability individuals who study abroad return to their region of birth with the exogenous probability m, whereas with the probability $(1-m)$ they work abroad. It follows that the numbers of skilled and unskilled workers in each region are predetermined by the numbers of home and exchange students and the particular return probability.[17]

4.2 Stage 2: Region of education

When deciding about the region of education, high-ability households know the equilibrium tax (and subsidy) rates determined at stage one, and they also take into account the resulting migration flows and numbers of skilled and unskilled workers in both regions.

Parents decide on their off-springs' place of study by comparing the expected utility of studying at home, $EU^r_{i,r,1}$, and studying abroad, $EU^q_{i,r,1}$. In the case of studying abroad, two effects must be considered: on the one hand, students might obtain a subsidy rate

[17]Note that some workers always leave the country of education due to the exogenous migration probability, even though the obtained wage is then lower for them. See Baruch, Budhwar and Khatri (2007) for a survey of migration determinants of foreign students in the US and the UK, also including non-economic motives. See also Dreher and Poutvaara (2011), Finn (2003), Lowell et al. (2007) or Rosenzweig (2008), who analyze permanent immigration in a more general context.

different from their home level, and on the other hand, they face the wages of skilled and unskilled workers in the host region with probability $(1 - m)$. Clearly, the last effect is only relevant for $m < 1$, as otherwise, all students definitely work at home. Then, there exists a native household in region r with endowment $\hat{\omega}_{i,r,1}$ who is just indifferent between studying at home or abroad,

$$EU^r_{i,r,1}(\hat{\omega}_{i,r,1}) = EU^q_{i,r,1}(\hat{\omega}_{i,r,1}). \tag{11}$$

Suppose that region r has the higher subsidy rate. Then, the skill premium is larger in region q than in region r, since for the indifferent households it must be true that the benefits of the extra subsidy payment if studying in region r are exactly offset by the smaller skill premium in region r. Then, all poorer households with $\omega_{i,r,1} < \hat{\omega}_{i,r,1}$ prefer education in region r. Due to decreasing absolute risk aversion, they benefit more from subsidy payments in both states of the world than from the uncertain skill premium, since with probability $(1 - p)$ they fail in education and only obtain the wage of an unskilled worker. By contrast, rich households are less risk-averse, and hence, they prefer the larger skill premium and accept the lower subsidy in region q. Note that this may even result in a situation where rich households emigrate from a region paying high subsidies to a region with fee financing, if the difference in skill premiums is sufficiently large and the return probability is sufficiently low.

Since there is a continuum of households, we assume that students treat the numbers of home and foreign students as given. That is, they do not take into account the consequences of their own mobility decision on the total numbers of students and workers as well as equilibrium wages.

4.3 Stage 1: Equilibrium tax rates

At this stage, the equilibrium tax rates of both regions are determined endogenously by majority voting.

Low-ability households maximize their utility $U_r(\omega_{i,r,0})$ with respect to the local tax rate t_r, taking the government budget constraint of equation (7) as well as the implications for the numbers of students and workers in each region into account. High-ability households maximize their expected utility, which is the maximum of the expected utility of studying at home $EU^r_{i,r,1}$ and expected utility of studying abroad $EU^q_{i,r,1}$ with respect to the local tax rate t_r. They also take the government budget constraint as well as the resulting effects on the numbers of students and workers into account.

This generates the optimal tax rate for every low- and high-ability household $t_{r,a}(\omega_{i,r,a}, t_q)$. The equilibrium tax rate from voting for a given tax parameter of the other region, $t_r(t_q)$, must then satisfy the condition that no other local tax rate is preferred by a majority in region r. Finally, solving the voting reaction functions of both regions reveals the equilibrium tax rates t_A^* and t_B^*. Substituting in the results of the previous stages generates the number of home and exchange students as well as total enrollment and consequently, skilled and unskilled wages for both regions in equilibrium.

Let us now analyze in detail the relevant effects a household considers when determining its optimal tax rate. Applying the government budget constraint and the results of the previous stage, we can rewrite the subsidy of region r as $s_r(t_r, N_r(t_r, t_q))$, which simplifies to $s_r(t_r, t_q)$. It clearly depends on the tax rate as well as enrollment in region r, which is equivalent to the number of beneficiaries. The wage levels can be expressed as $w_r^H(t_r, t_q)$ and $w_r^L(t_r, t_q)$. This leads to the following utility levels for low-ability households from region r,

$$U_{i,r,0} = u(\omega_{i,r,0}, t_r, w_r^L(t_r, t_q)). \tag{12}$$

High-ability households choose the maximum of the utility level for studying at home,

$$\begin{aligned} EU^r &= pu_{ss}(\omega_{i,r,1}, t_r, s_r(t_r, t_q), w_r^H(t_r, t_q)) \\ &+ (1-p)u_{sn}(\omega_{i,r,1}, t_r, s_r(t_r, t_q), w_r^L(t_r, t_q)), \end{aligned} \tag{13}$$

and for studying abroad,

$$\begin{aligned} EU^q &= pu_{ss}(\omega_{i,r,1}, t_r, s_q(t_r, t_q), m, w_r^H(t_r, t_q), w_q^H(t_q, t_r)) \\ &+ (1-p)u_{sn}(\omega_{i,r,1}, t_r, s_q(t_r, t_q), m, w_r^L(t_r, t_q), w_q^L(t_q, t_r)), \end{aligned} \tag{14}$$

where the latter depends on the wage levels of both regions because of the exogenous return probability m for exchange students (if $0 < m < 1$). The subscripts ss and sn refer to the utility levels if being successful and unsuccessful. Differentiating equations (12), (13) and (14) reveals the effects of an increase of t_r on households' utilities.

Low-ability households

Let us begin by analyzing the effects for low-ability households who do not study by assumption. The effect of increasing the tax rate on their utility is given by:

$$\frac{dU_r}{dt_r} = \frac{\partial u}{\partial t_r} + \frac{\partial u}{\partial w_r^L}\frac{dw_r^L}{dt_r}. \tag{15}$$

The first term denotes the direct *tax effect* since also non-students contribute to finance local subsidies. The second term depicts the indirect *wage effect* and captures the impact of an increase of the tax rate of region r on local unskilled wages. This involves adjustments of the numbers of home and exchange students in both regions. The sign of this effect is a priori unclear, and the size depends on the particular migration probability m. To show this let us for instance assume the extreme value $m = 1$, where all exchange students return to their home regions. It follows that the numbers of skilled and unskilled workers are completely predetermined by the initial numbers of low- and high-ability households (but not equal due to the positive probability of failure p). As a consequence, the *wage effect* is zero and all low-ability households vote for a zero tax rate. On the contrary, taking for instance $m = 0$ means that all students can be attracted permanently since they do not return home after graduation. This in turn makes the *wage effect* highly positive ceteris paribus.

High-ability households

Looking now at the effects of high-ability households, one must distinguish between home and exchange students. Let us start with immobile home students. The effect of increasing the tax rates on their utility is given by:

$$\begin{aligned} \frac{dEU^r_{i,r,1}}{dt_r} &= p\left(\frac{\partial u_{ss}}{\partial t_r} + \frac{\partial u_{ss}}{\partial w^H_r}\frac{dw^H_r}{dt_r} + \frac{\partial u_{ss}}{\partial s_r}\frac{ds_r}{dt_r}\right) \\ &+ (1-p)\left(\frac{\partial u_{sn}}{\partial t_r} + \frac{\partial u_{sn}}{\partial w^L_r}\frac{dw^L_r}{dt_r} + \frac{\partial u_{sn}}{\partial s_r}\frac{ds_r}{dt_r}\right) \end{aligned} \quad (16)$$

The negative direct *tax effect* is pictured by the first terms on the first and second lines of the right-hand side of equation (16), and is analogous to that for low-ability individuals, since all natives contribute to finance local subsidies. Also the *wage effect* appears, but is split now. As can be seen by the second terms in both lines, students are successful and obtain the wage of skilled workers with probability p, but fail and receive the wage of unskilled workers with probability $(1 - p)$. Note that these partial wage effects are of opposite sign, due to complementarity of skilled and unskilled workers in the production process (see equation (5)). Finally, the third terms show the effects of a larger tax rate on the subsidy level. This *subsidy effect* is somewhat complex as it involves adjustments of the total number of students, i.e. beneficiaries of subsidies, in region r. We show this in detail in the numerical analysis.

Let us now proceed to the effects for exchange students. Clearly, their place of work is a priori ambiguous (if $0 < m < 1$) since they return home with probability m, but stay abroad with probability $(1 - m)$. The effects of increasing the tax rates on their utility is given by:

$$\begin{aligned}\frac{dEU^q_{i,r,1}}{dt_r} &= p\left(\frac{\partial u_{ss}}{\partial t_r} + m\frac{\partial u_{ss}}{\partial w^H_r}\frac{dw^H_r}{dt_r} + (1-m)\frac{\partial u_{ss}}{\partial w^H_q}\frac{dw^H_q}{dt_r}\right) \\ &+ (1-p)\left(\frac{\partial u_{sn}}{\partial t_r} + m\frac{\partial u_{sn}}{\partial w^L_r}\frac{dw^L_r}{dt_r} + (1-m)\frac{\partial u_{sn}}{\partial w^L_q}\frac{dw^L_q}{dt_r}\right). \qquad (17)\end{aligned}$$

Note that the first terms denote again the direct negative *tax effect*, since all natives contribute to finance the system in their home region, even if they study abroad and do not enjoy the related subsidies. In fact, this is the reason why the *subsidy effect* is absent here. Exchange students receive subsidies in the other region but are not allowed to vote on the tax rate of that region. Also, their *wage effects* now consist of two parts: Exchange students return home after graduation with probability m and obtain the corresponding skilled wage with probability p and the unskilled wage with probability $(1-p)$. However, with probability $(1-m)$ they stay abroad and receive the wage levels of the other region.

5 Numerical Simulation

In this section, we simulate the model numerically. We start with detailed calculations of a scenario of symmetric regions which will then serve as a benchmark. Thereafter, in Section 6, we analyze scenarios of asymmetric regions. The purpose is to understand the interaction of the effects introduced above, and the emerging general equilibrium outcome. By varying relevant regional characteristics as for instance population sizes, we are able to draw conclusions about the qualitative results for the financing schemes and the enrollment rates.

5.1 Specification

We assume the following Cobb-Douglas production function:

$$Y_r = \phi H^\alpha_r L^{1-\alpha}_r, \qquad (18)$$

where the technology parameter is set to $\phi = 100$ and the output elasticity for skilled and unskilled workers is $\alpha = 0.5$. Note that the Cobb-Douglas production function has an elasticity of substitution between skilled and unskilled workers of one.

We use the following utility function

$$u = \frac{1}{1-\rho}c^{1-\rho}, \qquad (19)$$

where ρ is the coefficient of relative risk aversion. Hence, we have decreasing absolute but constant relative risk aversion. For the simulation we set $\rho = 2.25$ which is an empirically plausible value. The discount factor is set to $\delta = 0.8$.[18] The costs of education are measured in 1,000 euros and are set to $e = 35$.[19] The probability of educational success is $p = 0.77$, which corresponds well to the proportion of beginning students graduating with a university degree.[20] Further, we assume $\gamma = 0.3$, that is the unskilled wage when young (period 1) is 30% of the unskilled wage when old (period 2). Finally, the parameter determining the size of the tax costs is set to $\eta_r = 2$ for both countries.

We assume lognormal distributions for financial endowments, which differ for high- ($a = 1$) and low-ability households ($a = 0$), but ability-specific distributions are equal in both regions in this benchmark. For the low-ability households we assume $\ln \omega_{r,0} \sim N(\mu_{r,0}, \nu_{r,0})$ with $\mu_{r,0} = 2.7$ and $\nu_{r,0} = 1$, resulting in average and median endowments of $\omega^{av}_{r,0} = 24.533$ and $\omega^{m}_{r,0} = 14.880$. The distributions of high-ability natives in both regions are given by $\ln \omega_{r,1} \sim N(\mu_{r,1}, \nu_{r,1})$ which is truncated at the lower limit $\omega_{i,r,1} = 35$. This assumption ensures that all households can afford education, which seems plausible for developed countries like Germany.[21] The parameters of the distributions are $\mu_{r,1} = 3.7$ and $\nu_{r,1} = 1$ with resulting post-truncated high-ability average and median endowments of $\omega^{av}_{r,1} = 104.523$ and $\omega^{m}_{r,1} = 72.715$. The average endowment of low-ability households is thus below the average endowment of high-ability households which reflects our assumption of a positive correlation between (children's) ability and (parents') endowment. Moreover, we set the ratio of low-ability to high-ability households in each region to $\theta_r = 2$, with a mass of low-ability households of $M_{r,0} = 2$ and a mass of high-ability households of $M_{r,1} = 1$.[22]

[18]In Appendix A we show how this value of δ can be derived from discounting the payment streams of students and non-students over their entire lifespan.

[19]The value for the education costs e comes from OECD (2008), where Table B1.1a shows annual expenditures for tertiary education per student for Germany in 2005 of $ 12,446 (weighted with PPP), multiplied by 3 years of higher education for the bachelor degree amounts to roughly 35,000 euros.

[20]The probability p is shown in Table A4.1 of OECD (2008). Since the risk of unemployment for college graduates is generally low, this seems to be a good approximation of the probability of finding a skilled job.

[21]In fact, developed countries like Germany offer various options for high-ability individuals to obtain higher education, even though they lack sufficient financial funds. On the one hand, there are scholarships which offer financial support or even cover the total individual costs of higher education. On the other hand, there exist varying programs which allow combining higher education and working such as distance universities, extra occupational studies or in-company courses.

[22]According to Table A1.1a OECD (2008), the OECD average participation rate for the 25-to-64-year-old population of tertiary education was 27% in 2006, which roughly corresponds to the assumed fraction of local high-ability individuals $M_{r,1}$ to the entire regional population $M_r = M_{r,0} + M_{r,1}$ of one-third.

Then, the regional characteristics of the combined low- and high-ability distributions for this benchmark are an average endowment of $\omega_r^{av} = 51.196$ and a median endowment of $\omega_r^m = 29.209$. This distribution is a combination of the data for income distribution and wealth distribution.[23] The reason for this choice is that parents might finance their children's education out of current income or out of accumulated savings. Since we do not distinguish between the two, we take a combination of wealth and current income to be our measure of parental support here.

We derive the results for three different values of the return probability: First, $m = 0$, where all exchange students stay abroad for work. Second, $m = 0.5$, meaning that 50% of all students abroad return to their home region, and finally, $m = 1$, where all graduates work in their region of birth.

5.2 Stage 2: Regions of education

In this section we determine total enrollment as well as the numbers of home and exchange students for region A and B, as functions of the two regions' tax rates. We proceed as follows.

Using the government budget constraints of equation (7), we first compute the tax combinations where *all* students are exactly indifferent between studying in region A or in region B. This is satisfied if subsidy rates as well as skilled and unskilled wages are identical in both regions. For the symmetric benchmark it is obviously fulfilled for $t_A = t_B$.[24] From that we know all tax combinations where the poor high-ability households of both regions are allocated in region A and the rich high-ability households in region B, and all tax combinations where the allocation is reversed and the poor high-ability households study in region B and the rich high-ability households in region A. Assuming for instance a larger tax rate in region A increases in a first step the subsidy in region A above the level of B, conditional on the initial symmetric allocation of low-ability and high-ability households. Leaving wage adjustments aside, all students would be in favor of studying in region A. However, immigration of high-ability households to region A decreases the local skill premium and increases the skill premium in region B. For the rich students, it now

[23] The assumed average and median endowments are smaller than in Borck and Wimbersky (2013). The reason is that their models assume a single region and data are calibrated to the German case. However, since we consider a two region setting with mobile individuals, we additionally include OECD data for income distribution and wealth distribution. The data are taken from BMBF (2006) as well as the homepage of the *OECD.StatExtracts*.

[24] As we will show in the sensitivity analysis in Section 6, the condition $t_A = t_B$ is not necessarily true for asymmetric regions.

becomes beneficial to study and work in region B and obtain the larger skill premium due to their low risk aversion, even though they lose extra subsidy payments.

Thereafter we derive the endowments of the indifferent high-ability households for studying at home or abroad, for discretely varying tax rates t_A and t_B, taking the particular allocation of poor and rich students into account.[25] The regional numbers of poor and rich students for each tax combination are then defined by the region-specific distributions of high-ability individuals who are poorer, or richer, than the indifferent households with endowments $\hat{\omega}_{i,r,1}$.

Interpolating the data generates functions for both regions which determine the numbers of home and exchange students, $N_{r,r}(t_A, t_B)$ and $N_{q,r}(t_A, t_B)$, for all tax combinations, thereby incorporating the varying allocations of poor and rich students of both regions. Note that for the particular tax combinations where all students are indifferent between studying at home or abroad, multiple equilibria for the numbers of home and exchange students exist as long as enrollments are equal in region A and B and result in identical supply of skilled workers. In these cases we assume that all students obtain education at home.

The right panel of Figure 1 shows the number of exchange students from region A to region B as function of t_A, if region B chooses pure fee financing, $t_B = 0$, and the return probability is zero, $m = 0$. As a consequence, poor students gather in region A due to positive subsidies. As can be seen, the number of (rich) students going from region A to region B is low and even decreases with rising tax rate. At the same time, region A attracts a large number of (poor) students from region B where the inflow even increases with A's tax rate. This can be seen in the right panel of Figure 2. The reason is that a higher tax rate in region A corresponds to a higher subsidy for students from region B, which makes studying in region A attractive for a larger number of (poor) households. However, even for extensive tax and subsidy rates about 20% of the (rich) students of region B still study at home, since skilled wages in region B are then extremely high compared to skilled wages in region A.

The total numbers of students in region A and B are shown in the left panels of Figure 1 and 2. As can be seen, total enrollment in region A rises with higher tax rates, whereas the opposite is true for region B.

[25]Note that deriving the number of poor and rich students for region A as well as region B is redundant for this symmetric benchmark, since results are identical but with reversed labels. However, it becomes relevant for the heterogeneous scenarios of the sensitivity analyses.

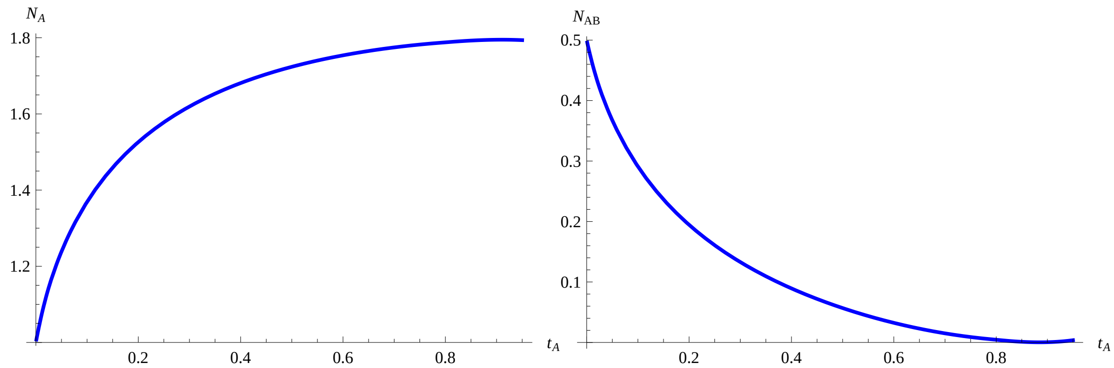

Figure 1: Total number of students in, and exchange students from region A for $t_B = 0$ and $m = 0$

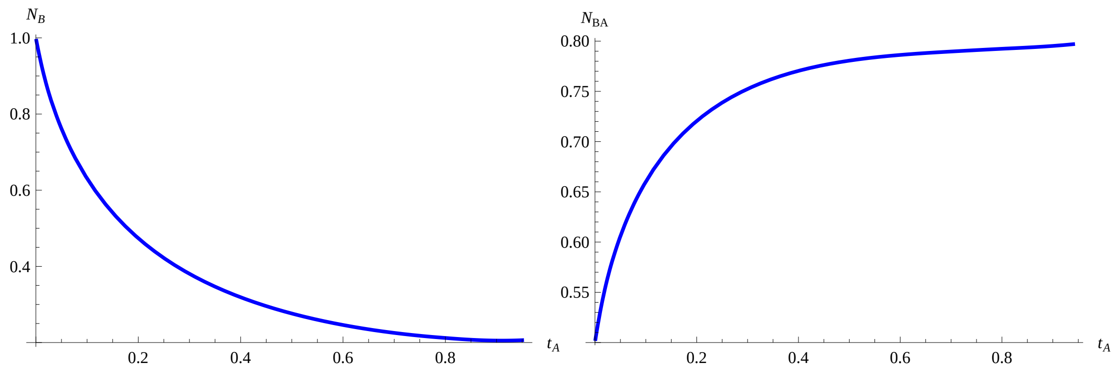

Figure 2: Total number of students in, and exchange students from region B for$t_B = 0$ and $m = 0$

Table 1: Benchmark results

	$m = 0$		$m = 0.5$		$m = 1$	
	A	B	A	B	A	B
t_r	0.26	0.26	0.16	0.16	0	0
s_r	0.99	0.99	0.65	0.65	0	0
N_r	i.d.	i.d.	i.d.	i.d.	i.d.	i.d.
$N_{r,r}$	i.d.	i.d.	i.d.	i.d.	i.d.	i.d.
$N_{r,q}$	i.d.	i.d.	i.d.	i.d.	i.d.	i.d.
L_r	2.23	2.23	2.23	2.23	2.23	2.23
H_r	0.77	0.77	0.77	0.77	0.77	0.77
w_r^H	85	85	85	85	85	85
w_r^L	29	29	29	29	29	29

5.3 Stage 1: Equilibrium tax rates

In this section we analyze the equilibrium tax (and subsidy) rates for the three scenarios: First for $m = 1$, where all exchange students return home after graduation, second, for $m = 0.5$, where 50% of them do so, and finally, for $m = 0$, where all exchange students stay abroad for work. The results for region A and B are shown in Table 1, where 'i.d.' denotes 'indeterminate'.[26]

Let us begin with a return probability of $m = 1$, i.e. all exchange students definitely return home after graduation. Hence, all results of the previous subsections are irrelevant, because the numbers of skilled workers are already defined by the initial numbers of high-ability households of each region who graduate successfully. As a consequence, all *wage effects* are zero since permanent migration is excluded. Then there exists no incentive for low-ability households to vote for positive tax rates as they only incur the negative *tax effect*. The preferences for high-ability individuals strictly decrease in endowment since the negative *tax effect* intensifies with the endowment because of proportional taxation, but the positive *subsidy effect* is constant. Due to the assumed relation of low-ability to high-ability households of $\theta_r = 2$, students who favor a positive tax (and subsidy) rate are in the minority, which results in full fee financing in equilibrium.

Let us now proceed to the cases of $m = 0$ and $m = 0.5$ where the numbers of skilled workers are determined endogenously. On substituting the interpolated functions for home and exchange enrollments of the previous stage into the utility functions, we can derive

[26]Remember, for these cases we assume that all students obtain education in their home regions.

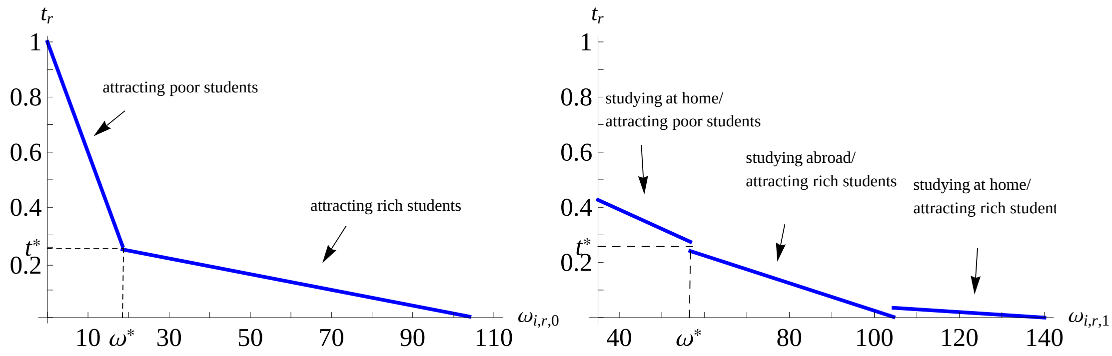

Figure 3: Individual preferences of low-ability and high-ability households for $t_B = t^*$

the optimal individual tax rates for low- and high-ability households, subject to the other region's tax rates $t_r(\omega_{i,r,0}, t_q)$ and $t_r(\omega_{i,r,1}, t_q)$. A voting equilibrium in region r for a given tax rate t_q then requires that there are two decisive households, one low-ability with endowment $\omega^*_{i,r,0}$ and one high-ability with endowment $\omega^*_{i,r,1}$, who prefer the same tax parameter and divide the total population in two equal parts. That is, all poorer low-ability households with $\omega_{i,r,0} < \omega^*_{i,r,0}$, in combination with all poorer high-ability households with $\omega_{i,r,1} < \omega^*_{i,r,1}$, who prefer a larger tax rate, make up 50% of the total population. Likewise, there are 50% households who are richer than the respective pivotal individuals and prefer lower tax rates. Hence, there is no majority that prefers a tax rate different from the optimal rate of the two pivotal households.[27]

However, determining as well as ordering the preferences for low-ability and high-ability households is non-trivial. The incentives for staying or going abroad for education as well as attracting the poor or rich students vary for different endowment and ability levels, and preferences may be non-monotonic in endowment. For this reason we describe in detail the preferences of households from region A for $m = 0$, conditional on the equilibrium tax rate in region B, $t^*_B = 0.26$ (see the left column of Table 1).

Analyzing the preferences of low-ability households as pictured in the left panel of Figure 3 reveals that all households with $\omega_{i,A,0} < 18.5$ prefer relatively high tax rates in order to attract a large number of poor students from both regions. This is clear since their positive *wage effects* exceed the negative *tax effects* due to their low endowments. In contrast, all rich low-ability households with $\omega_{i,A,0} > 18.5$ prefer relatively low tax rates

[27]As is often the case in voting problems of this type, the equilibrium tax rate (if it exists) does not necessarily correspond to the optimal tax rate of the household with the median endowment, since preferences satisfy neither single peakedness nor single crossing. We have to check by hand that there does not exist another tax rate which commands a majority against our proposed equilibrium.

and attract the rich students from both regions. Their negative *tax effects* are strong due to large endowments. The indifferent household between attracting the rich or the poor students with $\omega_{i,A,0} = 18.5$ always prefers the tax rate $t_A(\omega_{i,A,0} = 18.5, t_B = 0.26) = 0.26$. Note that the optimal tax rates decrease in endowment due to proportional taxation.

Let us now proceed to the preferences of high-ability households from region A, where four strategies are available: one for studying at home and attracting the poor students to region A, and one for studying at home but attracting the rich students to region A. And the same if studying abroad in region B, one for attracting the poor students to the home region A and one for attracting the rich students to the home region A.

First of all, we find that for all m the strategy of obtaining education abroad but attracting the poor students to the home region is strictly dominated for all high-ability households in this benchmark, as it requires large tax rates without enjoying the related subsidies.

All other three strategies can be optimal depending on the particular endowment level as pictured in the right panel of Figure 3 by the three sections: (*i*) All poor students from region A with $\omega_{i,A,1} < 56.7$ prefer to study at home and favor large tax rates, due to their small negative *tax effects*. Their high risk aversion makes them prefer the riskless subsidies and they even accept the relatively small skill premium caused by the large inflow of poor students from region B. (*ii*) By contrast, all students with $56.7 < \omega_{i,A,1} < 104.5$ prefer to emigrate to region B and choose moderate tax rates for their home region A. On the one hand, the incentive for large tax rates is dampened since they are relatively rich and do not benefit directly from the subsidies. On the other hand, they want to make education in their home region A attractive for many (rich) students from region B in order to reduce home enrollment in region B and enjoy large subsidies and skill premiums there. (*iii*) All rich students with $\omega_{i,A,1} > 104.5$ prefer to study at home and vote for small tax rates. Their *tax effects* are highly negative due to the large endowment levels. The corresponding low subsidies only convince few students of obtaining education in region A, which results in a large skill premium.

Note that for each group, the preferred tax rate strictly falls with increasing endowment levels due to the intensifying negative *tax effect*. However, there are two discontinuities: The first is for the poor student household with endowment $\omega_{i,A,1} = 56.7$, indifferent between obtaining education at home with the poor or abroad with the poor (case (*i*) and (*ii*)). If staying at home she prefers $t_A^A(\omega_{i,A,1} = 56.7, t_B = 0.26) = 0.28$ and if studying abroad $t_A^B(\omega_{i,A,1} = 56.7, t_B = 0.26) = 0.24$. The second discontinuity emerges for the rich household with endowment $\omega_{i,A,1} = 104.5$, indifferent between studying abroad with the poor students (case (*ii*)), or studying at home with the rich (case (*iii*)). In the first case she prefers $t_A^B(\omega_{i,A,1} = 104.5, t_B = 0.26) = 0$, and in the second case she chooses $t_A^A(\omega_{i,A,1} = 104.5, t_B = 0.26) = 0.04$. Note that this is an upward jump, hence, the condition of single crossing is violated which may give rise to an equilibrium akin to the 'ends against the middle' (EATM) equilibrium (see Epple and Romano (1996)). However, as depicted by the dashed line, the equilibrium tax rate from voting is above the two preferred tax rates of 0% and 4% of the indifferent high-ability household with $\omega_{i,A,1} = 104.5$. Hence, the discontinuity is irrelevant for the voting outcome conditional on the equilibrium tax rate for region B.

Repeating this procedure for all tax rates of the other region and interpolating the data generates the voting reaction functions $t_r(t_q)$, as shown in Figure 4 for $m = 0$. The blue curve depicts the optimal tax rate of region A and the green that of region B as functions of the tax parameter of the other region. Note that both curves are symmetric and consist of three parts, where the first two are separated at $t_q = 0.26$ by a kink, and the latter by a discontinuity jump at $t_q = 0.85$. The sections depict varying strategies of the pivotal low-ability and high-ability households with respect to the group of students to attract and the region of education of the decisive student:[28] In the left part, comprising tax rates of region q between 0 and 0.26, the pivotal low- and high-ability households of region r prefer to attract poor students and the high-ability households stay at home for education. The low tax (and subsidy) rates in region q make attracting the larger number of poor students relatively cheap for region r. In the middle part, comprising the range between $t_q = 0.26$ and $t_q = 0.85$, the pivotal low- and high-ability household from region r prefer to attract the rich students, and the high-ability households obtain education abroad in region q. The large tax rates of region q make the necessarily higher subsidies for attracting the poor students expensive for households from region r, and the negative *tax effect* is then too strong for a majority of them. Finally, for tax rates in region q beyond $t_q = 0.85$, attracting the rich students is still optimal for the pivotal voters of region r, but the decisive high-ability household prefers now to study at home. The skill premium in region r is large due to the massive outflow in consequence of the extremely high tax (and subsidy) rate in the other region q.

Interestingly, the voting reaction functions have strictly positive slopes. This is because a larger tax and subsidy rate in region q ceteris paribus reduces the inflow of students to region r. This raises preferences for larger tax rates of low-ability households in order to avoid a strong fall of their own unskilled wages. Since non-students form the majority they

[28]Since monotonicity of the voting reaction functions is violated, we cannot generally be sure about the existence of an equilibrium. However, in the cases presented here we have checked existence by hand.

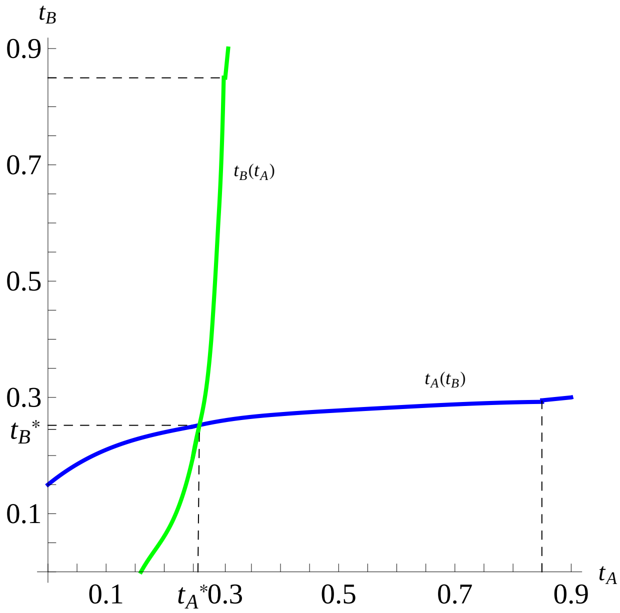

Figure 4: Voting reaction functions

are able to impose their preferences.

Solving the reaction functions generates the equilibrium tax rates for region A and B. For the assumed parameters, the decisive voters are made up of the low-ability household with endowment $\omega^*_{i,r,0} = 18.5$ and the high-ability household with $\omega^*_{i,r,1} = 56.7$. Due to symmetry, the equilibrium tax rates are the same in both regions with $t^*_r = 0.26$ (see again the left column of Table 1). As described before, this implies that all students are indifferent where to study, and the pivotal households are also indifferent whom to attract, either the poor or the rich students. This can be seen in the right panel of Figure 3 since the horizontal dashed line, denoting the equilibrium tax rate, hits the function of individual preferences of high-ability households in the middle of the jump. However, the equilibrium tax rate is well-defined by the unique preference of the pivotal low-ability household.

The equilibrium tax and subsidy rates fall from $t^*_r = 0.26$ to $t^*_r = 0.16$ and from $s^*_r = 0.99$ to $s^*_r = 0.65$, if the return probability rises from $m = 0$ to $m = 0.5$. The intuition is as follows: In the case of $m = 0.5$, it is ex ante clear that at least 50% of all native students definitely work at home. If they study at home they are immobile afterwards, and if they obtain education abroad they return home with the exogenous probability. This reduces the incentive for low-ability households to opt for large tax rates as the number of skilled workers that can be attracted falls. The preferred tax rates of home students slightly increase when m rises, since the negative impact of attracting students on skilled wages only occurs with probability $m = 0.5$. By contrast, the preferred tax rates of exchange students decrease with rising m: Making the home region attractive for more students is less rewarding, since the foreign graduates return home with probability $m = 0.5$. Besides, their place of work is also uncertain. With probability $(1 - m) = 0.5$ they stay abroad for work and prefer relatively high tax and subsidy rates at home. The large inflow of students to their home region leads to a large number of local skilled workers and a small number of skilled workers in their region of work, which raises their obtained skill premium. However, with probability $m = 0.5$ they return home, and in that case, they prefer relatively low tax and subsidy rates at home. The small number of attracted students results in a small number of skilled workers, and the obtained skill premium is large. Obviously these two aspects are of opposite signs.

Hence, the number of students whose region of work can be influenced falls with increasing return probability, attenuating the strength of the *wage-effects*.

We are now in a position to briefly comment on the implications of allowing for an endogenous return probability. With no exogenous restrictions, foreign graduates will migrate back to their home country until (net) wages are equalized. But this makes it impossible for the (unskilled) voters to affect their wages by voting for a positive subsidy level. In a way analogous to the previously analyzed case of an exogenous return probability $m = 1$ where all exchange students definitely return home after graduation also here all *wage effects* are zero.

6 Sensitivity Analysis

In the last section we studied the equilibrium tax and subsidy rates for the symmetric benchmark. This section now analyses how asymmetric variations of regions' characteristics affect the results. We consider differences in population size in Section 6.1 and in the ability distribution in Section 6.2.

6.1 Heterogeneous Population Size

Let us begin with a modification of the absolute size of region A's population. We assume a mass of low-ability individuals of $M_{A,0} = 16$ and of high-ability individuals of $M_{A,1} = 8$ which sums up to $M_A = 24$. Region B retains the benchmark values with $M_B = 3$, composed of a mass of low-ability individuals of $M_{B,0} = 2$ and high-ability individuals of $M_{B,1} = 1$. Note that the population in region A is eight times that of region B, but the

Table 2: Results for heterogeneous population size

	$m = 0$		$m = 0.5$		$m = 1$	
	A	B	A	B	A	B
t_r	0.14	0.30	0.10	0.23	0	0
s_r	0.61	0.73	0.47	0.51	0	0
N_r	7.46	1.54	7.23	1.77	i.d.	i.d.
$N_{r,r}$	6.76	0.30	6.34	0.11	i.d.	i.d.
$N_{r,q}$	1.24	0.70	1.66	0.89	i.d.	i.d.
L_r	17.72	2.35	17.75	2.32	17.84	2.23
H_r	5.74	1.19	5.86	1.06	6.16	0.77
w_r^H	88	70	87	74	85	85
w_r^L	28	35	29	34	29	29

share of low skilled is identical in both regions with $\theta_r = 2$.[29]

First of all we can state that the increase of region A's low- and high-ability population for constant ability distribution $\theta_A = 2$ does not alter the overall proportion of skilled to unskilled workers, hence, leaves the skilled and unskilled wages identical to the benchmark for given tax rates. It follows that all students are again indifferent where to obtain education if $t_A = t_B$ is fulfilled. Hence, the region with the larger tax rate also provides larger subsidies and gathers the poor students in equilibrium, whereas the low-tax region contains the rich students.

However, the asymmetric variation of the population size affects individual preferences. In the populous region A, the marginal *wage effects* for skilled and unskilled workers are attenuated since permanent high-ability immigration leads to a smaller increase of unskilled and a smaller fall of skilled wages compared to the benchmark (see equation (5)). As a consequence, almost all low-ability households opt for lower tax rates and are content with attracting fewer rich students. The pivotal low-ability household is now poorer with $\omega^*_{i,A,0} = 11$ compared to the benchmark.

By contrast, high-ability households from region A are now in favor of larger tax rates compared to the benchmark, even though this raises the attracted number of (either rich or poor) students. If studying at home they can enjoy higher subsidies than in the benchmark since equal immigration causes a smaller fall of skilled wages. If studying abroad, making

[29]This significant difference of regional populations with a relation of 8 : 1 pictures a mix of the situations for Germany and Austria with 10 : 1 and France and Belgium with 6 : 1.

education in their home region attractive is more effective due to the less pronounced fall of skilled wages via immigration. However, since the ability distribution is constant with $\theta_A = 2$, preferences of low-ability households for reduced tax rates dominate. Consequently, the decisive high-ability household $\omega^*_{i,A,1} = 114$ is richer than in the benchmark and prefers to be educated at home with the rich.

In region B, wage adjustments from varying the local tax rate are stronger now, due to the increased number of immigrants from region A. As a consequence, the majority of low-ability households is in favor of attracting the large group of poor students and therefore opts for relatively high tax rates compared to the benchmark, since their unskilled wages increase by more now.

All high-ability households prefer now to study abroad in region A due to the relatively insensitive skilled wages there, thus they are in favor of lower tax rates for their home region B compared to the benchmark. In fact, we find that for the equilibrium value in region A ($t^*_A = 0.14$), all students choose a tax rate of zero in order to fully avoid the negative *tax effect* (remember, the minimum endowment of high-ability households is already $\omega_{i,r,1} = 35$).

It follows that there exists only one pivotal voter in region B, since all high-ability households are in favor of a zero tax rate (but are in minority due to $\theta_r = 2$). This is the low-ability household with endowment $\omega^*_{i,B,0} = 29.2$ who prefers to attract the large number of poor students from region A.

When looking at the left column of Table 2, one can see that the densely populated region A chooses indeed a lower, and region B a higher tax rate in equilibrium of $t^*_A = 0.14$ and $t^*_B = 0.30$ compared to the benchmark scenario. As a consequence, the subsidy rate in region B, $s^*_B = 0.73$, exceeds the level of region A, $s^*_A = 0.61$, and all poor students migrate permanently to region B (since $m = 0$) whereas all rich migrate to region A. This results in a net inflow to region B of $N_{A,B} - N_{B,A} = 0.54$ (corresponding to an equal net outflow of region A), obviously caused by the larger high-ability population in region A. However, the number of emigrants relative to the absolute population size is smaller in region A than in region B, as only a minority of $N_{A,B} = 1.24$ studies abroad in region B but a majority of $N_{B,A} = 0.70$ emigrates from region B to A. This implies that region A has a higher proportion of rich households than region B and a lower proportion of poor households. In fact, 85% of the total number of high-ability households from region A but only 70% from region B study in region A. This is caused by the substantially larger tax rate in region B, making the natives effectively poorer. Note that the decision criterion for the region of education is net-of tax endowment, since tax payments are sunk.

Proceeding now to the case of $m = 0.5$, one can see in the middle column of Table 2 that the equilibrium tax rates in both regions fall to $t_A^* = 0.10$ and $t_B^* = 0.23$. Similar to the benchmark, the optimal tax rates of low-ability households are reduced compared to the scenario of $m = 0$, since the number of skilled workers that can be attracted for permanent immigration is smaller. Consequently, also the equilibrium subsidy rates fall to $s_A^* = 0.47$ and $s_B^* = 0.51$, and the poor households still gather in region B. But interestingly, migration flows in both directions intensify to $N_{A,B} = 1.66$ and $N_{B,A} = 0.89$, resulting in an even larger net inflow to region B of 0.77. The intuition is as follows: A positive return probability encourages more students from region A to go abroad, since they may enjoy the higher subsidy rate in region B as well as the larger skill premium at home. Instead, more rich students from region B aim at the larger skill premium in region A, since the loss of subsidies if studying in region A is smaller now. However, even though total enrollment falls in region A and increases in region B compared to the case of $m = 0$, with $N_A = 7.23$ and $N_B = 1.77$, the number of skilled workers is now larger in region A and smaller in region B with $H_A = 5.86$ and $H_B = 1.06$, due to the positive return probability.

Finally, the scenario of $m = 1$ produces full fee financing in both regions. As in the benchmark, low ability households have no incentive to opt for positive subsidy rates since the numbers of skilled workers are predetermined. Hence, the *wage effects* are zero and they solely face the negative *tax effects*. Since the ability distribution is still $\theta_r = 2$, low-ability households can impose their preferences of $t_r = 0$ in both regions.

6.2 Heterogeneous Ability Distribution

In this section we analyze the effects of region-specific ability distributions for identical total population sizes of $M_A = M_B = 3$. For region B we assume the benchmark distribution of $\theta_B = 2$, resulting in a number of low- and high-ability individuals of $M_{B,0} = 2$ and $M_{B,1} = 1$. For region A we set $\theta_A = 1$, meaning that the numbers of low- and high-ability households are equal with $M_{A,0} = M_{A,1} = 1.5$. This scenario could reflect a more efficient school system in region A, which produces a larger number of school graduates with a university-admission certificate. The simulation results are shown in Table 3.

Before describing the implications for the preferences of all households, let us first consider the effect on the t_A-t_B-combinations where all students are indifferent where to study. In contrast to the previous section, this is no longer fulfilled for $t_A = t_B$ but now requires here a higher tax rate in region B than in region A. To show this, consider an allocation of high-ability households such that both regions exhibit the same skilled and unskilled wages. This is obviously true for a smaller number of students, i.e. skilled

Table 3: Results for heterogeneous ability distributions

	$m = 0$		$m = 0.5$		$m = 1$	
	A	B	A	B	A	B
t_r	0.25	0.23	0.15	0.13	0	0
s_r	0.91	0.77	0.56	0.46	0	0
N_r	1.34	1.16	1.37	1.13	i.d.	i.d.
$N_{r,r}$	0.81	0.47	0.68	0.31	i.d.	i.d.
$N_{r,q}$	0.69	0.53	0.82	0.69	i.d.	i.d.
L_r	1.81	2.27	1.83	2.24	1.85	2.23
H_r	1.03	0.89	1.10	0.82	1.16	0.77
w_r^H	66	80	64	83	63	85
w_r^L	38	31	39	30	40	29

workers, in region A, since also the number of ex ante unskilled workers is lower there with $M_{A,0} = 1.5$ whereas $M_{B,0} = 2$. Assuming further identical tax rates leads to higher subsidies in region A than in B for two reasons: First, the tax base in region A is larger due to the modified ability distribution. And second, the number of beneficiaries, which is equivalent to all local students, is smaller in region A (conditional on the allocation for equal wages in both regions).[30] To sum up, both aspects lead to higher subsidies in region A. It follows that the equilibria where *all* students are indifferent where to study require a smaller tax rate in region A than in region B, where the difference must exactly balance the larger tax base in order to ensure again $s_A = s_B$, conditional on identical wage levels for skilled and unskilled workers in both regions. In other words, attracting the poor students is 'cheaper' for region A than for region B.

Let us proceed now with the influence of the modified ability distribution on individual preferences for $m = 0$. Beginning again with region A, we find that low-ability households are now in favour of attracting the poor students and opt for higher tax rates than in the benchmark for the following reasons: First, as already mentioned, the tax base in region A is larger, which makes subsidies less expensive. Second, due to the lower number of low-ability households in region A, the unskilled wage is more sensitive to student immigration. And third, the absolute number of students that can be attracted is larger now due to

[30]The weighted sum of the ability-specific average endowments determines the tax base of the financing system. Since the mean of the high-ability distribution is above the level of the low-ability distribution, shifting the weight towards more high-ability households conditional on a constant total population increases the tax base.

$M_{A,1} = 1.5$ instead of 1. Therefore, we find that the pivotal low-ability voter $\omega^*_{i,A,0} = 22$ is richer than in the benchmark since the equilibrium tax rate slightly falls to $t^*_A = 0.25$.

By contrast, preferences of high-ability households of region A remain more or less constant, and the decisive high-ability voter who chooses $t^*_A = 0.25$ is almost identical to the benchmark with $\omega^*_{i,A,1} = 57$. However, the number of (poor) students obtaining education at home grows. The reason is as follows: If studying at home, the positive effect of the larger tax base on student financing balances two negative effects that appear: on the one hand, the more sensitive skilled wages in region A due to the smaller number of local unskilled workers, and on the other hand, the higher total number of students, causing a stronger fall of skilled wages via enlarged immigration. Instead, region B is only affected negatively by the higher number of students, which makes studying there less attractive.

Proceeding to region B, we find that most low-ability households (apart from some very poor low-ability households) are satisfied with attracting the few rich students since providing subsidies is expensive for them relative to region A due to the smaller tax base in B. However, they nevertheless benefit from the increased total number of high-ability individuals and prefer slightly higher tax rates than in the benchmark (but smaller than region A). Hence, the endowment of the pivotal low-ability voter rises to $\omega^*_{i,B,0} = 21$.

Most of the (poor) high-ability households of region B favor education abroad in region A, and attracting the rich students to their home region B. They opt for small tax rates relative to the benchmark. This is clear since they only incur the negative effect of a higher number of students and the corresponding stronger fall of skilled wages if studying at home. The positive effect of a larger tax base is absent for them. Consequently the pivotal (exchange) student is poorer than in the benchmark with an endowment of $\omega^*_{i,B,1} = 47$.

Interestingly, even though the preferred tax rates of region A's households are larger (low abilities) or constant (high abilities), the equilibrium tax rate is slightly below the benchmark with $t^*_A = 0.25$. This is caused by the positive slope of the voting reaction function, and can be explained as follows: As before, the heterogeneous ability distributions establish an implicit agreement of all decisive households about the allocation of poor students to region A and rich students to region B. Therefore, region B chooses a smaller equilibrium tax rate compared to the benchmark of $t^*_B = 0.23$, which implies that the larger tax (and subsidy) level necessary for attracting the poor students falls. As a consequence, region A also implements a lower tax rate than in the benchmark due to the negative *tax effect*, although the preferred tax rates of the decisive households are constant or increase conditional on the benchmark tax rate in region B. However, there also exists a political effect: Due to the modified ability distribution in region A with $\theta_A = 1$, the numbers of low- and high-ability voters are now of equal size there. Hence, the constant preferences of students gain more importance in the voting process and the equilibrium tax rate increases by less compared to a situation with the benchmark ability distribution.

All results are shown in the left column of Table 3. One can see that the equilibrium subsidy rate in region A is substantially higher with $s_A^* = 0.91$ compared to $s_B^* = 0.77$, even though the number of beneficiaries is larger there with $N_A = 1.34$ and $N_B = 1.16$, and tax rates are almost equal in region A and B. As mentioned before, this is caused by the enlarged tax base in region A. Hence, all poor students indeed migrate to region A and all rich go to region B in equilibrium. But interestingly, despite the larger subsidy rate, region A experiences a net outflow of rich native students of $N_{A,B} - N_{B,A} = 0.16$, caused by the larger number of high-ability individuals with $M_{A,1} = 1.5$ but $M_{B,1} = 1$. However, the fractions of poor and rich students are almost equal in both regions. For instance, region A's poor (home) students, $N_{A,A} = 0.81$, make up 54% of all high-ability households of region A, and region B's poor (exchange) students, $N_{B,A} = 0.53$, make up 53% of all high-abilities individuals from B. Clearly, the opposite holds for the rich students, composed of region B's home students, $N_{B,B} = 0.47$, as well as region A's exchange students, $N_{A,B} = 0.69$, making up 47% respectively 46% of the corresponding regional number of high-ability households. This is caused by the almost identical tax rates in region A and B, leaving the relative income of high-ability households between both regions more or less unchanged.

Let us turn now to the second column for the case of $m = 0.5$. As before, the equilibrium tax rates in both regions fall to $t_A^* = 0.15$ and $t_B^* = 0.13$ since the number of attractable students is lower compared to $m = 0$. However, the numbers of exchange students in both directions increase again for the reasons given above: On the one hand, more students from region A study in region B since the loss of subsidy is now less extreme for them with $s_A^* = 0.56$ and $s_B^* = 0.46$, and the extra benefit of the skill premium in region B is even larger than for $m = 0$. On the other hand, more high-ability households from region B study in region A now, since they can enjoy the higher subsidy rate while still obtaining the larger skill premium in their home region with probability one half.

Finally, we consider the case of a return probability of $m = 1$. As before, low-ability households face zero *wage effects* but negative *tax effects*, hence, they prefer pure fee financing again. In fact, this outcome is clear for region B since low-ability households form the majority. However, we also observe a zero tax and subsidy rate in region A, even though the numbers of high- and low-ability households are equal. The reason is that sufficiently rich student households are also in favor of pure fee financing since they face a highly negative *tax effect* due to their large endowments. Then, low-ability households in combination with rich high-ability individuals form the majority again and vote for zero taxes.

7 Conclusion

In this paper, we have developed a model where two regions or their voters, respectively, decide on subsidizing higher education in the face of mobile students. We find that if graduates return home with low enough probability, regions choose to subsidize higher education. In fact, the size of financial support increases with a falling return probability. Low-ability individuals are then strongly interested in attracting foreign students who immigrate permanently with high probability and raise the unskilled wages. In turn, if the return probability is too high, the pool of attractable skilled workers is small. Low-ability individuals solely face tax payments, hence, vote for a zero tax (and subsidy) rate. Interestingly, the numbers of exchange students rise with increasing return probability. We have also analyzed how the results are affected by asymmetric population sizes and ability distributions.

Thus, it would seem that in countries linked by high mobility, complete tuition finance will not be politically feasible. This finding has implications for the political economy of higher education finance. For instance, some German states (*Länder*) have recently introduced modest tuition fees, following a ruling by the Constitutional Court which allowed them to do so. However, not all states have used this new possibility, and some which did subsequently repealed the tuition fees later. Obviously, these outcomes are political choices of voters in the presence of mobile students. Models like ours here may help to understand these outcomes. In particular, the model can be used to predict under what configurations of distribution functions and other parameters subsidies or tuition finance obtain in equilibrium.

Some extensions of the model suggest themselves. In particular, it would be desirable to explicitly endogenize the return decision of students who obtain education abroad. This would in effect allow us to combine the models of Del Rey (2001) and Justman and Thisse (2000). Second, endogenizing the education decision of households would also be desirable. This would allow for home enrollment effects from education policies, as in Borck and Wimbersky (2013). Third, it would be interesting to study differentiated in-state and out-of-state tuition fees. While simple intuition might suggest a preference for reduced in-state tuition, the incentives for attracting out-of-state students may provide a countervailing force. Finally, the different quality of higher education systems could be captured by allowing for different success probabilities. This would allow studying the interaction between quality and financing of higher education.

Appendix

A The value of δ

The parameter γ captures the length of the first period (studying for low-ability, working for high-ability individuals) relative to the length of the second period (working for both). Additionally taking additionally the discount factor δ into account, the multiplier for generating lifetime income for low-ability households amounts to $q_n = \gamma + \delta$. Relating this to the multiplier for high-ability individuals, $q_s = \delta$ reveals the ratio $\frac{q_n}{q_s} = \frac{\gamma+\delta}{\delta}$. Applying the values of the numerical simulation with $\gamma = 0.3$ and $\delta = 0.85$ then results in $\frac{q_n}{q_s} = 1.35$. This ratio is almost identical to a more realistic calculation via annuity value factors with payments in arrear. The particular formula for low-ability individuals is $\tilde{q}_n = \frac{(1+r)^T-1}{r(1+r)^T}$, where r denotes the market interest rate and T the total years of working life from entering the labor market until retirement. Instead, the annuity value factor for high-ability households modifies to $\tilde{q}_s = \frac{1}{(1+r)^{T_e}} \frac{(1+r)^{T_s}-1}{r(1+r)^{T_s}}$ with $T_s = T - T_e$ and T_e is the length of the study period. Note that the number of wage payments is now reduced by the years of higher education. Therefore, the present value must be additionally discounted by this period. Considering a realistic scenario with average labor market participation by the age of 20, retirement by the age of 60, duration of studies of 5 years and an interest rate of 5% leads to $\tilde{q}_n = 17.159$ and $\tilde{q}_s = 12.830$, which results in $\frac{\tilde{q}_n}{\tilde{q}_s} = 1.34$.

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