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Federation's alternative tax constitutions and risky education

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Federation's Alternative Tax Constitutions and Risky Education

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Abstract

We analyze a two-period model where risk-averse students divide their time between risky education, leisure, and work. The educated can migrate. Wage-tax financed transfer to students acts as an insurance, and increases both investment in education and demand for leisure. We derive sufficient conditions for tax competition to lead to too low wage tax rates. We suggest, that the educated should pay their wage taxes to the region which has financed their education. We show that this would increase taxation and investment in education, and would benefit also the owners of the complementary factor.

Keywords: Fiscal federalism, tax competition, optimal taxation, education subsidies, tax constitution

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Non-Technical Summary

In a second-best world where there are missing markets for insurance against income risk related to education, a lump-sum transfer to students financed by a proportional wage tax acts as insurance. It offers welfare gains for risk-averse individuals, and induces them to invest more in education. At the same time, however, the wage tax distorts the allocation of time between labor and leisure, as it decreases the price of leisure. In the first period, individuals allocate their time between work for a constant wage, education, and leisure, and choose their net saving. Human capital depends on the duration of education and individual-specific random variable, which is revealed only after education is completed. In the second period, the educated enter the labor market supplying their human capital created in the first period. Second-period production combines human capital and fixed factor, i.e. capital and labor supply by those uneducated. We assume that the government is benevolent and maximizes the expected utility of those to be educated. Differences between students cannot be observed before education is completed.

Optimal insurance is not complete, that is, wage-tax rate is less than one, due to two forces: labor-leisure distortion and rent consideration. As investment in education increases, the increase in human capital lowers its marginal productivity and hence intramarginal rents. If the government can tax also the owners of the fixed factor, it receives more tax revenue resulting from education. This decreases the importance of rent in formulation of tax policy and leads to a higher wage tax rate also for those to be educated.

The educated are completely mobile after the formation of a federation. Other factors of production do not migrate. In a federation with tax competition, the educated pay their taxes to the region where they live. When each government maximizes the expected utility of those citizens who become educated, the possibility of tax competition creates a time inconsistency problem. The government has to commit itself to a transfer before individuals decide whether to stay in the region or to emigrate. Each government has an incentive to cut its tax rate to attract more human capital from other regions and thus increase tax base. When governments cut their tax rates, they ignore negative fiscal externalities they impose on other regions by reducing their tax base. Tax competition leads to the erosion of taxation as instrument to finance education. This discourages investment in education and leads to an inefficient outcome.

We suggest that the educated should pay an education tax to a region which has participated in financing their education. This would eliminate fiscal externalities, as differences in taxation would no longer affect migration. We show that at least if the fixed factor is not taxed more heavily than the educated, a federation without

tax competition would lead to a higher wage tax rate for those to be educated, and thus encourage investment in education. We discuss also the possibility of voluntary irrevocable redistribution contracts. In exchange for tuition and possibly some other benefits, a student would have to commit to paying an education tax independently of domicile. These contracts could be offered by governments or universities. Those students who would not like to participate in such a contract, would pay the market price for their education. The problem with voluntary contracts is adverse selection. The required contributions from those with high income would have to be moderate enough not to induce those with highest expected earnings to opt out. If contracts were offered by universities using entrance exams, those participating would form a more homogeneous group alleviating the adverse selection problem.

If regions are identical, those to be educated cannot benefit from the formation of a federation. If regions are not identical but face region-specific shocks like uncertainty about future export prices, the possibility to migrate offers a market insurance against region-specific shocks. This encourages education and benefits also the owners of the complementary fixed factor. The expected return to education can be higher or lower than in a closed economy, depending on the type of shocks and production technology. Market insurance allows scaling down public insurance through distorting taxation, but it does not cover individual-specific risks. At the same time, it shifts income risk arising from region-specific shocks entirely to the owners of the fixed factor. Welfare effects of the formation of a federation may go in either direction both for those to be educated and for the owners of the fixed factor.

As the mobility of the educated increases, the problems caused by tax competition become more severe. Uniform taxation may be an inefficient solution for the European Union, as member states are very different. Nationality-based taxation or irrevocable redistribution contracts offer a radical but promising solution combining the benefits of free migration and those of insurance through taxation and public financing of education.

1 Introduction

The European Union has created a vast single market where goods, services, labor and capital can, in principle, move freely across national borders. Migration of the factors of production, when based on differences in marginal productivity, ensures their most efficient use, and thus promotes the general welfare. However, mobility across national borders threatens national redistribution with adverse selection. Beneficiaries search for regions with higher benefits, and net contributors prefer regions with modest redistribution or no redistribution at all. Musgrave (1969) views such behavior as an argument for assigning redistribution to the national rather than to local governments. Sinn (1993, 1997) argues that without centralized action at the union level, free mobility will result in fierce tax competition threatening to dismantle national income redistribution in the European Union. Wildasin (1991, 1992, 1995, 1997) shows how mobility of either beneficiaries or net contributors restricts redistribution between groups and increases its costs if migration decisions are distorted by fiscal differences.

The standard approach in the literature on tax competition is to take factors of production as given for a federation and analyze how fiscal differences influence their allocation within federation. The efficiency costs of tax competition are restricted to inefficient allocation of the mobile factor of production in case of differences in taxation. The emphasis is generally on welfare costs of reduced possibilities of redistribution. (see Wildasin 1991, 1992, 1997) In our model, the mobile factor of production, human capital, is endogenous. This draws attention to a widely neglected efficiency cost of tax competition. In a world with uncertainty, part of what is conventionally seen as redistribution can be seen as an insurance ex ante. Sinn (1995) shows how redistribution between ex ante identical individuals can be efficiency enhancing in that it stimulates risk taking. When returns to education are uncertain, subsidies for education financed by a wage tax, whether it means publicly financed schools and universities or allocations to students, can be seen as an insurance. Such a tax and transfer scheme decreases total lifetime earnings when returns to education are higher than expected and increases them when returns are lower than expected. Given risk aversion and the absence of private insurance against income risk related to education, the allocation is more efficient with the government's intervention than without it. If tax competition results in the erosion of financial support to education, it may affect adversely the future stock of human capital and thus future production capacity and growth. These long run costs may exceed the short run efficiency cost of inefficient allocation of existing human capital.

This paper combines two questions that have previously been analyzed separately, that of optimal taxation when returns to education are uncertain, and that of the effects of tax competition and labor mobility. We analyze two alternative federal tax constitutions. In a federation with tax competition, the educated pay their wage taxes to the region where they live. In a federation without tax competition, the educated pay independently of their domicile their wage taxes to the region from which they have received financial support as students. A thrilling normative question is welfare comparison between these alternative constitutional arrangements and a closed economy.

The model has two periods. In the first period individuals divide their time between education, leisure and work, and decide on net saving in order to maximize the expected lifetime utility. In the second period, they supply labor inelastically. There is uncertainty concerning the returns to education, that is, the second-period wage is a random variable. Marginal utility of consumption is diminishing, and so individuals are risk-averse. This creates a motivation for a wage-tax financed transfer, which acts as an insurance because the government returns the expected tax revenue to ex ante identical students. The government chooses tax and lump-sum transfer to students to maximize the expected utility of its own citizens to be educated. We allow the government to tax also the owners of the fixed factor possibly under a constraint, and distribute tax revenue to students.

Eaton and Rosen (1980b) and Hamilton (1987) have analyzed the interplay between investment in education under uncertainty and taxation in a closed economy. In their analysis, the production function is implicitly assumed to be linear in the work effort of the educated. Our analysis includes a complementary factor of production, which is assumed to be fixed. This complementary factor includes, for example, physical capital, natural resources and work effort of those who remain uneducated. The existence of a fixed factor of production is a central assumption in the literature analyzing tax competition. The key additional mechanism is that the complementary factor creates diminishing marginal productivity of human capital. This suggests that even if the educated can migrate without cost, small differences in tax treatment cannot create corner solutions with all the educated migrating to an area with a marginally more favorable tax treatment. It is assumed that the educated can migrate after their education is completed and choose the region where their after-tax income is the highest.

Higher net wages are certainly not the only motivation to emigrate abroad. Working abroad may offer superior possibilities to accumulate human capital and acquire experience. Emigration of young, high-ability individuals, when it is temporary, will thus benefit the economy. The “brain exchange” can benefit all those involved. If differences in after-tax wages are large, “brain exchange” can turn into “brain drain”.

What this paper analyzes is the "brain drain", i.e. permanent emigration motivated by interregional differences in net wages.

Investment in human capital is treated as endogenous also by Wildasin (1996). However, in his model any worker may acquire the skills necessary to become a skilled worker in a particular industry at a given cost. Moreover, there are no individual, but only industry-specific, risks. In our model, the number of students is exogenous, but time devoted to education is endogenous. Konrad (1999) analyzes investment in risky education when the government cannot commit to the second-period tax scheme in the first period. In his model, costs of education are non-pecuniary, and taxation affects only return to education. Even a benevolent government chooses ex post excessive redistribution compared to what would be efficient ex ante. An education subsidy is a second-best policy to encourage education. If the government cannot commit to a certain tax scheme in advance, a federation with tax competition may solve time inconsistency problem from the governments' side.[1] In our model, there is no uncertainty concerning future taxation, and costs of education are lost wage income. The absence of the time inconsistency problem from the government's part could be justified by modeling the maximization problem explicitly in an OLG-framework. A deviation from the announced tax policy would influence investment decisions by future generations.

It is expected that a federation with tax competition results in a suboptimal wage tax rate, whereas a federation without tax competition may have a higher wage tax rate than a closed economy. The possibility to migrate creates a time inconsistency problem, as governments have to commit to financing education before individuals choose whether to stay in the region. Individual regions have an incentive to cut wage taxes in order to increase their tax bases, thus imposing a negative fiscal externality on other regions.

In the second section we analyze a closed economy. We show that increasing wage taxation induces students to allocate more time both to risky education and leisure, when labor supply is inelastic in the second period and utility from the first-period consumption is a linear function. The novel feature of this result is incorporation of endogenous leisure choice. We also analyze optimal wage tax rates. The third section finds the sufficient conditions under which the formation of a federation with tax competition between identical regions leads to a lower wage tax rate than in a closed economy. Scaling down public support for education is detrimental to the formation of human capital. On the other hand, it is shown that in the presence of region-specific shocks the formation of a federation increases expected returns to education

[1] I am indebted to Kai A. Konrad and David E. Wildasin for raising this point.

if production technology is Cobb-Douglas. This mechanism rests on efficiency gains from migration. Migration opens new possibilities to utilize human capital in a more efficient way. Thus the duration of education can be longer or shorter than in a closed economy. With certain production technologies and shocks, migration is shown to decrease the expected return to education. The fourth section shows that a federation without tax competition increases wage taxation at least in the absence of region-specific shocks if fixed factor is not taxed more heavily than the educated. We also discuss the possibility of voluntary irrevocable redistribution contracts, where the state or university would act as a venture capitalist participating in the investment in risky education. The fifth section discusses the effects of migration costs and the sixth section concludes with implications to the European Union.

2 Closed Economy

2.1 Production

We analyze a two-period model with two production sectors. There are three types of inputs used in the production: human capital provided by the educated, work effort of those who are not yet educated but are going to be educated (students), and all other inputs. These other inputs, which include capital and the work effort of the uneducated who are not students, will be referred to simply as a fixed factor. In one sector, human capital provided by the educated is combined with the fixed factor. The other sector uses only labor supplied by students and is characterized by a linear production function with no other inputs. One interpretation for this is that students work in a labor-intensive service sector. Labor supply of the educated is inelastic, and human capital is homogeneous. The total human capital used in production is denoted by Ω. It is reasonable to expect that the marginal productivity of human capital is diminishing, because in utilizing it other inputs are also needed. Suppressing the fixed factor, we can denote the concave production function using human capital as input by $F(\Omega)$.

There is no uncertainty concerning the value of production. Students receive as wage their marginal product. This is denoted by w_1. In subsection 3.2 we analyze the consequences of macroeconomic uncertainty. We assume that all goods are perfect substitutes in consumption, in the sense that it is the total value of production that counts. This can be explained by the possibility of international trade. We have taken the price of the composite good produced in second period as numeraire and then chosen w_1 so that the value of the first period's production is also calculated in the numeraire. We will concentrate our analysis on a cohort of those to be educated and will define the government's budget constraint and political process so that there is no need to have an OLG-model.

2.2 Individual's Maximization Problem

During the first period those who become educated divide their time between studying, leisure, and working for a constant wage. The second-period wage depends on the duration of education. The duration of both periods is one. The individual's maximization problem is to choose the duration of education H, leisure L and net saving S in the first period in order to maximize the expected total utility. It is assumed that human capital is produced using only time as an input, so that lost wages are the only cost of investment in human capital.

The wage for an educated person is his or her amount of human capital times the marginal productivity of human capital. The individual's human capital is assumed to be the product of the duration of education H, and a random variable x, for which $E(x) = 1$ and $x \in [a,b], a > 0$. A natural interpretation for the random variable x is that it reflects inherited ability differences. However, x could reflect also imperfect knowledge about the quality of schooling the individual chooses, and imperfect knowledge about the relative desirability of a particular education in the future labor market. The marginal product of human capital is F'. Here we have suppressed the argument Ω. Thus, the second-period wage w_2 of individual i is given by

$$w_2^i = x_i H_i F'.$$

The individual-specific random variables x_i are unknown to everyone in the first period. They are revealed at the beginning of the second period, when the talented are already educated. From now on, the individual index i will be suppressed. It should be noted, however, that wages between the educated differ due to the presence of the individual-specific random variable.

Interest rate r is given and is the same for each individual and the government. A natural interpretation for this is that consumption goods can be borrowed and lent internationally at a given rate without any transaction costs. Thus, in any given period, the total income of the economy and its total consumption may differ.[2] The

[2] Another possibility would be to model an endogenous determination of the interest rate. The idea of international loan markets is more suitable because capital is taken as given. Modeling an endogenous interest rate would call for modeling an endogenous determination of physical capital. This might lose important insights to questions analyzed here in the sense that assumptions made about the determination of savings and investments might become crucial to at least some results.

wage tax rate t is the same in the first and in the second period, and cannot be higher than one. A lump-sum transfer B is given to students. The educated do not own any fixed factor, have no income other than wages and interest on saving, and have no initial wealth. The owners of the fixed factor face tax rate T, possibly constrained to zero. There are no other taxes or public expenditures in the model. Interest income is not taxed and interest payments are not deductible. There are no moral hazard problems related to borrowing. If the marginal utility of the second-period consumption approaches infinity as the second-period consumption approaches zero, and individuals cannot conceal their wealth or income, no one will take out a greater loan than he or she can repay with certainty.

The individual's utility is assumed to be separable. Moreover, the utility from the first-period consumption C_1 is linear, the utility from first-period leisure $V(L)$ is concave, and the utility from the second-period consumption discounted to the first period is also concave and denoted by $U(C_2)$. Thus the individual's maximization problem is

$$\begin{aligned} &\max_{H,S,L}\{C_1 + V(L) + E[U(C_2)]\} \\ &C_1 = (1 - H - L)(1 - t)w_1 + B - S \\ &C_2 = (1 - t)xHF' + S(1 + r). \end{aligned} \tag{1}$$

In choosing H an individual takes Ω as given, because the effect of his or her educational choice on Ω is negligible. The first-order conditions for the optimal choices of H, S, and L are

$$-(1 - t)w_1 + (1 - t)F'E(xU') = 0 \tag{2}$$

$$-1 + (1 + r)E(U') = 0 \tag{3}$$

$$-(1 - t)w_1 + V' = 0. \tag{4}$$

The second-order conditions are satisfied.

2.3 Government's Budget Constraint

We now analyze an economy of many talented citizens whose individual random variables are independent. The law of large numbers tells us that the variance of the average human capital approaches zero as the number of citizens approaches infinity. We simplify the analysis by assuming that the variance of the aggregate human capital is zero. The present value of tax revenue from a generation has to be equal to the total cost of its lump-sum transfers. The average time spent in education $\overline{H}$ and the average leisure choice $\overline{L}$ are the same as H and L chosen by each individual. If there are N citizens who become educated, economy's human capital is given by $\Omega = NH$. We normalize the population size of citizens who become educated to unity, so that $\Omega = H$. This does not mean that there would be a single citizen. Citizens who become educated seem ex ante identical, but differences become visible at the beginning of the second period. There is not representative educated citizen. The government's budget constraint per citizen who becomes educated is

$$B = t(1 - \overline{H} - \overline{L})w_1 + \frac{t}{1+r}\Omega F' + \frac{T}{1+r}(F - \Omega F'). \tag{5}$$

The government acts like an insurance company pooling individual-specific risks by pooling uncertain tax revenues from different individuals. The last term captures eventual redistribution from the owners of the fixed factor to those to be educated.

2.4 Lump-sum Transfer to Students and Investment in Education

A wage-tax financed lump-sum transfer B to students operates as an insurance for investment in risky human capital: it increases lifetime earnings when they are lower than expected and decreases them when they are higher than expected. We will see that this mechanism is independent of eventual redistribution between the groups, and holds for any T. At the same time, the wage tax lowers the opportunity cost of leisure from an individual's point of view. We now prove

Proposition 1 *A proportional tax on wage income creates an incentive for students to increase their investment in human capital. At the same time, it increases the demand for leisure and decreases labor supply in the first period.*

Proof. See Appendix 1.

The idea of the proof of proposition 1 is the following: we totally differentiate the first-order conditions with respect to the individual's decision variables and wage tax rate. After that, we use Cramer's rule to find out how a change in the wage tax rate affects the individual's decision variables we are interested in.

The intuition behind the increase in demand for leisure is straightforward. A proportional tax on wage income decreases the private cost of leisure, which is equal to foregone after-tax wage income. Individual moves resources from consumption to leisure.

When labor supply is inelastic in the second period, increasing wage taxation reduces proportionally the costs of investment in education and its returns. This decreases the variance of the second-period consumption and induces people to use more time for education. With quasilinear utility from the first-period consumption, wage taxation increases investment in education even when tax revenues are not returned to students. Income effects of taxation would be absorbed by the first-period consumption. Quasilinearity eliminates also the effects of T. Poutvaara (1998) analyzes a model where leisure is exogenous, but the utility from consumption is a concave function in both periods. In that model taxation might decrease investment in education if expected tax revenues were not returned.

If the wage tax rate is very high, or the expected return on education sufficiently high relative to the first-period wage, individuals might demand more leisure and education than their first-period time endowment allows, that is, they may wish to offer a negative amount of labor in the first period. To rule this out we restrict our analysis to cases where individuals would never wish to supply a negative amount of labor in the first period.

2.5 Optimal Wage Taxation

We assume that the government wants to maximize the expected utility of its citizens who become educated. The justification for taxation is the missing market of private insurance against income risk related to education. A government with its budget constraint can act as an insurance company, pooling individual income risks and thereby reducing the variance of after-tax income. Despite distortions in labor supply in the first period, the government can offer efficiency gains for risk-averse individuals. The justification of public intervention is markedly different from traditional Pigouvian taxation used to correct externalities.

The government maximizes social welfare Δ, which is the individual's maximization problem in (1) after substituting B from (5), $\overline{H} = H$, $\overline{L} = L$, and taking t and T as the optimizing variables. The tax rate of the fixed factor is constrained to be no higher than $\widetilde{T}$, allowing $0 \leq \widetilde{T} \leq 1$. The government's maximization problem can be presented as

$$\max_{t,T} \Delta = C_1 + V(L) + E[U(C_2)].$$

It is evident that the government would choose as high T as possible, as always $\frac{d\Delta}{dT} > 0$. Thus the government chooses $\widetilde{T}$. Let us first keep H and Ω as separate, although the government takes into account that $\Omega = H$. This makes comparisons with federations easier. $\frac{d\Omega}{dH} = 1$ because population size is normalized to unity and there is no migration. However, we directly substitute $\overline{H} = H$ and $\overline{L} = L$. Using the individual's first-order conditions, the welfare effect of a budget constraint maintaining change in the wage tax rate is given by

$$\begin{aligned} &\tfrac{d\Delta}{dt} = \tfrac{1}{1+r}\Omega F' - HF'E(xU') - tw_1\tfrac{dH}{dt} \\ &+\{\tfrac{t}{1+r}F' + \tfrac{t}{1+r}\Omega F'' + (1-t)HF''E(xU') - \tfrac{\widetilde{T}}{1+r}\Omega F''\}\tfrac{d\Omega}{dH}\tfrac{dH}{dt} - tw_1\tfrac{dL}{dt}. \end{aligned} \tag{6}$$

Next substitute into this $\Omega = H$ and use again individual's first-order conditions to obtain:

$$\begin{aligned} &\tfrac{d\Delta}{dt} = -HF'Cov(x,U') \\ &+\left\{-t(F' + HF'')Cov(x,U') + HF''E(xU') - \tfrac{\widetilde{T}}{1+r}HF''\right\}\tfrac{dH}{dt} - tw_1\tfrac{dL}{dt}. \end{aligned} \tag{7}$$

Setting (7) equal to zero and organizing positive terms to the left and negative terms to the right we obtain:

$$\begin{aligned} &-HF'Cov(x,U') - t(F' + HF'')Cov(x,U')\tfrac{dH}{dt} - \tfrac{\widetilde{T}}{1+r}HF''\tfrac{dH}{dt} \\ &= -HF''E(xU')\tfrac{dH}{dt} + tw_1\tfrac{dL}{dt}. \end{aligned} \tag{8}$$

This social first-order condition equalizes the marginal social benefit and cost of a tax increase. The covariance terms capture the insurance benefits from a tax increase. By taxing and returning the expected tax revenue to the educated, the government eliminates proportion t of the uncertainty associated with the wage income in the second period. Welfare gains from this result from diminishing marginal utility of consumption.

From the individual's point of view, the whole return to education is risky. From the social point of view, only proportion $1-t$ of returns to education in the economy is associated with income risk. The rest is pooled and returned as insured income to those to be educated. This eliminates proportion t of income uncertainty associated with the return to education. This allows a more efficient allocation of consumption. Thus, the expected social return to a given education is more valuable than the expected private return. The second term is the value of insurance for marginal educational investment induced by the change in the tax rate. It is the product of the expected return to educational investment for the educated as a group, $F' + HF''$, the change in educational investment, $\frac{dH}{dt}$, the gain from insurance per income unit, $-Cov(x, U')$, and the extent of coverage of taxation, t.[3] The second term is positive if and only if an increase in human capital does not decrease the income accruing to the educated as a group, that is, $\frac{d}{d\Omega}[\Omega F'] = F' + \Omega F'' \geq 0$. The covariance terms are analogous but not equal to those in Dixit and Sandmo (1977). Dixit and Sandmo analyze socially optimal taxation without uncertainty but in presence of heterogeneous individuals. The third term captures the increase in the tax revenue from the owners of the fixed factor resulting from increased investment in education.

The first term on the right hand side of (8) reflects costs of lower marginal productivity of human capital caused by increased investment in human capital. The second term on the right hand side of (8) captures the welfare loss from a distorted labor supply in the first period. $\frac{dL}{dt}$ describes the effect of a change in the wage tax rate on leisure choice, whereas tw_1 is the wedge between social and private cost of leisure.

An alternative way to characterize welfare effects of a change in taxation is to divide effects into those without any change in the duration of education or leisure, the pure insurance effect, and the welfare effects of a change in the duration of education and in the duration of leisure. This is done in (7). Pure insurance effect is unambiguously positive, whereas the effect of a change in leisure is unambiguously negative and can be called the dead-weight loss of labor-leisure distortion. Let us denote the income accruing to the educated by I. Pure insurance effect is the product of the expected income of the educated as a group, $E(I) = HF'$, and the gain from insurance per income unit, $Ins = -Cov(x, U')$. Pure insurance effect gives the welfare gain from a marginal increase in the coverage of insurance through an increase in t. Dead-weight loss from labor-leisure distortion is described by the notation $DWL_L = tw_1 \frac{dL}{dt}$. It turns out that the sign of the term capturing the welfare effect of the change in the duration of education, $EduDur = \left\{-t(F' + HF'')Cov(x, U') + HF''E(xU') - \frac{\widetilde{T}}{1+r}HF''\right\} \frac{dH}{dt}$, is essential in analyzing the effects of the formation of a federation. The social first-order condition can be written as:

$$E(I) \times Ins + EduDur - DWL_L = 0.$$

The sign of $EduDur$ is determined by opposite effects. On one hand, the social return to education is higher than the private return, as taxation and transfer eliminate proportion t of uncertainty associated with the social return to education. In addition to this, an increase in investment in education increases tax revenue from the

[3]The expected return to education for the educated as a group is calculated by differentiating the expected income of the educated, $\Omega F'$, with respect to human capital, Ω. After that, substitute $\Omega = H$ to obtain the stated result.

fixed factor. On the other hand, an increase in education decreases the marginal productivity of human capital. If the marginal productivity of human capital is constant or sufficiently close to constant, the duration effect of education is positive. Duration effects is positive also if $\widetilde{T}$ is sufficiently high. If the duration effect is negative in the tax optimum, the government keeps the wage tax rate lower than it would if investment in education were exogenous, in order to induce students to invest less in human capital. If $EduDur$ is positive, taxation is restricted by labor-leisure distortion, and not by the rent consideration. $EduDur$ is positive, if the second term in (7) is positive. Next we introduce

Remark 1. *If the second term in (7) is positive (negative) when (7) goes to zero, we say that the government would prefer, in the closed economy's tax optimum, higher (lower) educational investment than individuals would choose.*

The motivation behind this definition is the following: as the second term of (7) captures the welfare effects of a change in the wage tax rate through the change in the duration of education, it shows, whether the government would like to increase or decrease educational investment compared to what individuals would choose. As long as this effect is positive (negative), the government would prefer individuals to invest more (less) in education than they do.

Proposition 2 *With constant marginal productivity of human capital, the optimal wage tax rate is strictly between zero and one. With diminishing marginal productivity of human capital, the optimal wage tax rate may be lower.*

Proof. The first term in (7) is positive, because the second-period consumption is an increasing function of x and the marginal utility of consumption is diminishing. Marginal productivity of human capital is constant if $F'' = 0$. In this case (7) is positive if $t = 0$, and negative if $t = 1$. Full insurance, that is, $t = 1$, would eliminate the covariance terms. The bigger t is, the stronger is the distortion in the first-period labor supply, which is captured by the last term. If $F'' < 0$, the value of (7) becomes smaller at least if $\widetilde{T}$ is small enough. ■

A wage tax rate is also strictly between one and zero with diminishing marginal productivity of human capital if the government prefers higher investment in education than what individuals would choose in the closed economy's tax optimum. This means that offering partial insurance is optimal as long as rent maximization is not the dominating motivation in the government's decision-making. The partiality of insurance follows from the need to restrict labor-leisure distortion. The ambiguity of the sign of t follows entirely from rent consideration. If $\widetilde{T} = 1$, rent consideration does not restrict wage taxation. The following analysis in federal context will be relevant when optimal wage tax rate is positive in a closed economy.

3 Tax Competition in a Federation

3.1 Migration Equilibrium

In this section we analyze a federation of n jurisdictions where the educated pay taxes only to the jurisdiction in which they live. In each jurisdiction, the government maximizes the expected utility of its citizens who become educated. Jurisdictions and regions coincide. Regions are assumed to be identical. It is assumed that only the educated can move. Migration decisions are made after individual-specific random variables are revealed. The educated choose the region in which their net income is the highest. There are no migration costs.

Let us first analyze how a change in the tax rate in one region affects the allocation of human capital in the federation, when tax rates in other regions are given and identical. We denote the variables relating to other regions by hat. Ωs denote post-migration human capital. A federation's human capital Ω_F is divided to human capital in one region and identical amounts of human capital in other $n-1$ regions. This means that $\widehat{\Omega} = \frac{\Omega_F - \Omega}{n-1}$. Substituting this into condition for migration equilibrium $(1-t)F'(\Omega) = (1-\widehat{t})F'(\frac{\Omega_F-\Omega}{n-1})$ and totally differentiating with respect to t and Ω we obtain

$$\left(\frac{d\Omega}{dt}\right)_{TC} = \frac{(n-1)F'(\Omega)}{(n-1)(1-t)F''(\Omega) + (1-\widehat{t})F''(\frac{\Omega_F-\Omega}{n-1})}. \tag{9}$$

Here $\left(\frac{d\Omega}{dt}\right)_{TC}$ is the effect of a change in the wage tax rate on post-migration human capital in a federation with tax competition. With a given human capital, the changes in human capital in different regions total zero. Thus the effect of a change in t on $\widehat{\Omega}$ is

$$\left(\frac{d\widehat{\Omega}}{dt}\right)_{TC} = -\frac{F'(\Omega)}{(n-1)(1-t)F''(\Omega) + (1-\widehat{t})F''(\frac{\Omega_F-\Omega}{n-1})}. \tag{10}$$

3.2 Taxation, Region-specific Shocks, and Educational Decisions

We analyze first a federation without region-specific shocks. The wage tax rate for each generation has to be chosen in each region at the beginning of the first period and cannot be changed. The governments are thus engaged in a static Cournot-Nash game of complete information. Budget constraint holds exactly when each region chooses its tax rate, and after that each region returns as a lump-sum transfer the present value of tax revenues. The lump-sum transfer has to satisfy

$$B = t(1 - \overline{H} - \overline{L})w_1 + \frac{t}{1+r}\Omega F' + \frac{T}{1+r}(F - \Omega F').$$

The maximization problem of the representative citizen is

$$\max_{H,S,L}\{C_1 + V(L) + E[U(C_2)]\}$$
$$C_1 = (1 - H - L)(1 - t)w_1 + B - S$$
$$C_2 = (1 - t)xHF' + S(1 + r).$$

The first-order conditions are as in a closed economy.

We proceed along the lines of subsection 2.4. The difference is that, in a federation, a change in the wage tax rate affects the amount of human capital also through migration. This affects the marginal productivity of human capital, tax revenues and thus lump-sum transfers to students.

Proposition 3 *In a federation with tax competition and without region-specific shocks, a marginal increase in the wage tax rate in one region increases investment in education in that region, at least if tax rates are initially equal in all regions. Investment may increase more or less than in a closed economy with the same initial tax rate. The effect on investment in education in other regions may be positive or negative. The total effect on the federation's human capital is, however, the same as in a closed economy. The demand for leisure responds in the region changing the wage tax rate as in a closed economy. In other regions, demand for leisure does not change.*

Proof. See Appendix 2.

The preceding proposition captures the effects of a federation without region-specific shocks. Wildasin (1997) analyzes the effect of migration on total income accruing to the mobile and fixed factors, when initial allocation of the mobile factor differs from efficient allocation by a mean-preserving spread. He shows that if identical concave production functions are either Cobb-Douglas or their third derivative is non-positive, migration increases the total income of the mobile high-skilled labor in federal level. With a given uniform wage-tax rate, the possibility of migration would create an incentive to increase investment in education in two ways: by increasing the expected return to education and by decreasing its variance. Whether migration increases the income of the mobile factor in the federal level or not, depends on the formulation of the shock also with identical production functions and opposite shocks. In the next lemma, we assume that the value of the production in which the educated participate contains a multiplicative random component, z, which is unknown when the duration of education is chosen. Wildasin (1995) interprets a multiplicative shock as price uncertainty of the exported good of the region. One industry faces a positive shock $z = 1 + v$, and another a negative shock $z = 1 - v$, where $0 \leq v < 1$.

Lemma 1. *With multiplicative and opposite region-specific price shocks, migration increases the total income of the educated with Cobb-Douglas technology, but decreases it if the third derivative of the production function is non-positive.*

Proof. Let Ω be human capital in each region before migration, and α human capital's share of production. Fixed factor is normalized to unity in both regions. Without migration the total value of production in the federation is

$$Y^N = (1+v)\Omega^\alpha + (1-v)\Omega^\alpha = 2\Omega^\alpha. \tag{11}$$

If migration is allowed and we choose indices so that the region with a positive (negative) shock gets index p (n), and marginal productivity is equalized, Ω_p and Ω_n have to satisfy the identity $(1+v)\alpha\Omega_p^{\alpha-1} = (1-v)\alpha\Omega_n^{\alpha-1}, \Omega_p + \Omega_n = 2\Omega$. Solving Ω_p and Ω_n, we get as the total value of production in a federation with migration:

$$Y^W = [(1+v)^{\frac{1}{1-\alpha}} + (1-v)^{\frac{1}{1-\alpha}}]^{1-\alpha}(2\Omega)^\alpha. \tag{12}$$

Subtracting (11) from (12) we get the increase in the value of the federation's total production with migration compared to the situation without migration:

$$P = [(1+v)^{\frac{1}{1-\alpha}} + (1-v)^{\frac{1}{1-\alpha}}]^{1-\alpha}(2\Omega)^\alpha - 2\Omega^\alpha. \tag{13}$$

The effect of an increase in v on the income gains created by migration is

$$\frac{\partial P}{\partial v} = [(1+v)^{\frac{1}{1-\alpha}} + (1-v)^{\frac{1}{1-\alpha}}]^{-\alpha}(2\Omega)^\alpha[(1+v)^{\frac{\alpha}{1-\alpha}} - (1-v)^{\frac{\alpha}{1-\alpha}}]. \tag{14}$$

From (14) we see that an increase in v always increases the income gains created by migration and so increases the total value of production. Total income of the educated being proportional to the value of production, an increase in the total value of production also increases the total income of the educated.

Next assume production function $F(\Omega)$, $F' > 0$, $F'' \leq 0$, $F''' \leq 0$. Without migration, the total income of the educated is $\Omega(1+v)F'(\Omega) + \Omega(1-v)F'(\Omega) = 2\Omega F'(\Omega)$. If migration is allowed, in equilibrium

$$(1+v)F'(\Omega_p) = (1-v)F'(\Omega_n).$$

Substituting $\Omega_n = 2\Omega - \Omega_p$ and totally differentiating with respect to v and Ω_p gives us

$$\frac{d\Omega_p}{dv} = -\frac{F'(\Omega_p) + F'(\Omega_n)}{(1+v)F''(\Omega_p) + (1-v)F''(\Omega_n)}. \tag{15}$$

As the value of the marginal product of human capital is equalized, total income of the educated in a federation is given by $2\Omega(1+v)F'(\Omega_p)$. With $v = 0$, this is the same as without migration. Thus, migration increases (decreases) the total income of the educated if $(1+v)F'(\Omega_p)$ is increasing (decreasing) in v. With (15), derivation with respect to v gives

$$\begin{aligned}\frac{d}{dv}[(1+v)F'(\Omega_p)] &= F'(\Omega_p) - (1+v)F''(\Omega_p)\frac{F'(\Omega_p) + F'(\Omega_n)}{(1+v)F''(\Omega_p) + (1-v)F''(\Omega_n)} \\ &= -\frac{-(1-v)F'(\Omega_p)F''(\Omega_n) + (1+v)F'(\Omega_n)F''(\Omega_p)}{(1+v)F''(\Omega_p) + (1-v)F''(\Omega_n)}.\end{aligned}$$

If $F''' \leq 0$, $-F''(\Omega_p) \geq -F''(\Omega_n)$ as $\Omega_p > \Omega_n$. As $F'' < 0$, $F'(\Omega_n) > F'(\Omega_p)$. Thus $\frac{d}{dv}[(1+v)F'(\Omega_p)] < 0$ and migration decreases the total income of the educated. ■

With Cobb-Douglas technology, the possibility of migration increases the expected return to education as in Wildasin (1997). This creates a further incentive to invest in education. If the third derivative of the production function is non-positive, including quadratic production function as a special case, migration with multiplicative price shocks decreases the expected return to education. This is an opposite result to the effect of a mean-preserving spread analyzed by Wildasin (1997).

3.3 Optimal Wage Taxation

In this section we analyze a federation without region-specific shocks. This allows us to compare the optimal wage tax rate in a federation to that in a closed economy. When each government maximizes the expected utility of its own representative citizen, we get as the maximization problem of the government:

$$\begin{aligned}&\max_{t,T} \Delta_{TC} = C_1 + V(L) + E[U(C_2)] \\ &C_1 = (1-H-L)w_1 + \tfrac{t}{1+r}\Omega F' + \tfrac{T}{1+r}(F - \Omega F') - S \\ &C_2 = (1-t)xHF' + S(1+r).\end{aligned}$$

As in a closed economy, it is optimal to set $T = \widetilde{T}$. The effect of a change in the wage tax rate on the representative citizen's expected utility is

$$\begin{aligned}
&\left(\tfrac{d\Delta}{dt}\right)_{TC} = \tfrac{1}{1+r}\Omega F'(\Omega) - HF'(\Omega)E(xU') - tw_1\left(\tfrac{dH}{dt}\right)_{TC} \\
&+\left\{\tfrac{t}{1+r}F' + \tfrac{t}{1+r}\Omega F'' + (1-t)HF''(\Omega)E(xU') - \tfrac{\widetilde{T}}{1+r}\Omega F''\right\}\tfrac{\partial\Omega}{\partial H_F}\left(\tfrac{dH_F}{dt}\right)_{TC} \\
&+\left\{\tfrac{t}{1+r}F' + \tfrac{t}{1+r}\Omega F'' + (1-t)HF''(\Omega)E(xU') - \tfrac{\widetilde{T}}{1+r}\Omega F''\right\}\left(\tfrac{d\Omega}{dt}\right)_{TC} - tw_1\left(\tfrac{dL}{dt}\right)_{TC}.
\end{aligned} \tag{16}$$

In (16), $\left(\frac{dH_F}{dt}\right)_{TC}$ is the change in the federation's human capital induced by a change in t, as calculated in Appendix 2. $\frac{\partial\Omega}{\partial H_F}$ expresses the effect of a change in the federation's human capital on post-migration human capital in one region. The fifth term captures the welfare effects of a change in the wage tax rate through the change in the tax base. Changes in tax bases total zero, and in the symmetric initial situation the negative of the fifth term measures fiscal externality imposed on other regions. As regions do not take into account these externalities, it is expected that uncoordinated solution leads to an inefficient outcome.

If $\left(\frac{d\Delta}{dt}\right)_{TC} < 0$ at the closed economy's tax optimum, the closed economy's tax optimum is not a Nash equilibrium in a federation with tax competition. Instead, a federation with tax competition leads to a lower wage tax rate because it is in the interest of each government to lower its wage tax rate. We can derive a robust result:

Proposition 4 *A sufficient condition for the formation of a federation between identical regions to result in a lower wage tax rate than in a closed economy is*
1. the government would prefer in the closed economy's tax optimum higher educational investment than individuals would choose or, alternatively,
2. the wage tax rate is at least $\frac{-\Omega F''}{F'}$ *in the closed economy and* $\left(\frac{dH}{dt}\right)_{TC} \geq \frac{dH}{dt}$.
If at least one of these conditions is met, an enlargement of a federation leads to an even lower wage taxation.

Proof. See Appendix 3.

Proposition 4 shows two alternative sufficient conditions under which Cournot-Nash tax competition between benevolent governments leads to wage tax rates that are too low, and thus, according to proposition 3, to too low an investment in education. Thus tax competition is detrimental to the formation of human capital, and imposes an efficiency cost on the federation. To gain an intuition of case 2, note that with Cobb-Douglas technology it would simplify into the requirement that the wage tax rate is at least as $1-\alpha$, where α is the share of human capital of production. These results hold for all $\widetilde{T}$. Note that also $\widetilde{T} = 1$ is sufficient to ensure that tax competition lowers wage taxation.

4 Decentralized Taxation without Tax Competition

In our model, centralized taxation would clearly solve all the problems created by tax competition. However, when member states are as heterogeneous as they are in the European Union, uniform taxation and social security are potentially inefficient because of different tastes concerning redistribution. Furthermore, centralized uniform social security and taxation would create extensive income transfers between member states. This could distort the decision-making process, for example, with poor regions voting for excessive benefits and rich regions wanting to scale down the existing social security, perhaps especially unemployment benefits. Sinn (1993, 1995) has suggested restructuring taxes and social security to be based on nationality rather than on domicile as a remedy against tax competition. If differences in expected revenues of those to be educated were not too large at the age of 18, say, one could substitute irrevocable redistribution contracts for mandatory redistributive taxation. A citizen would have to commit to participating in a given redistribution scheme for the rest of his or her life independently of the domicile, or opt out without a possibility for social security in case of bad luck. Sinn notes that even such an arrangement would suffer from adverse selection problem, because most differences are already visible before the age of 18.

The main problem with voluntary redistribution contracts is adverse selection. In order to be feasible, the required contribution from the high-income earners in an irrevocable redistribution contract would have to be low enough not to induce those with the highest expected earnings to opt out. A binding irrevocable redistribution contract would be easier to apply to financing education than to social security in general, in which it is evidently impossible. In the field of higher education, all public finance for education, whether by allocations to students or subsidies to purchasing education from universities, should be made conditional upon accepting an irrevocable redistribution contract. The contract could apply to both private and public universities, although different tuition fees and costs in different study programs would certainly pose serious problems. The solution would probably be to introduce either a lump-sum voucher or an adjustable voucher which would pay for a certain level of education. The problem with adjustable vouchers would naturally be in preventing the universities from charging unreasonably high fees. Those opting out would pay the same amount of tuition fees as what universities receive from the state for those students participating in the irrevocable redistribution contract.

Even if students studied in more than one country, they should retain the benefits and obligations of the first contract they signed. One interesting question, discussed to some extent by Sinn (1993), is introducing system competition in social security without adverse-selection effects with the help of an irrevocable choice of redistribution program. Applied to education, the students could perhaps have alternative packages of benefits and tax schedules. However, the need to avoid adverse selection strongly restricts the available scope of voluntary programs, and might make the redistribution scheme preferred by a vast majority infeasible.

An alternative approach could be to give students a loan instead of a transfer and make the repayment conditional on subsequent wage income, say a certain percentage of wage until the loan is repaid. In case of emigration, such a loan would have to be fully repaid. This would, however, only alleviate, but not solve the problem. Even in a closed economy, subsidies would be needed in the system where only those with higher than expected income would repay the loan and interest while those with lower than expected income would pay less than the loan and interest. In an open economy, those with higher than expected income would then be the first to emigrate.

It may be possible to offer market insurance without public intervention to students against those risks which are not observable ex ante. This could be achieved by allowing universities to offer binding contracts in which students would pay, irrespective of their domicile, an education tax to the university in exchange for tuition and possibly some other benefits. Tax schedules could be non-linear. This kind of solution would reduce ex ante visible redistribution. To secure the financing of education, for example to the disabled, public intervention or guarantees against discrimination would be needed. On the other hand, universities should be able to screen students by means of entrance exams, tests, and applications. Thus, also the universities where students have the highest expected earnings could offer attractive enough contracts. In any case, insurance programs organized by universities could significantly reduce the present cross-subsidization between different academic fields. It would also require sufficient funds for universities to be able to absorb macroeconomic risks and, of course, would be limited by the need to avoid adverse selection.

Voluntary irrevocable redistribution contracts would be equivalent to taxation, provided that each state provides contracts only to those receiving education inside its borders, that the contracts themselves do not induce any migration of students, that the contracts are attractive enough for adverse selection problems not to arise, and that $\widetilde{T} = 0$. However, we perform the analysis using a more conventional system of involuntary nationality-based taxation allowing $\widetilde{T}$ to differ from zero. The proposed system means that differences in taxation do not induce any migration, and everyone lives in the area where his or her marginal productivity is the highest. Human capital is divided equally between the regions. An individual's maximization problem is the same as in a federation with tax competition, with the difference being that marginal productivity of human capital is now the same in each region and the lump-sum transfer is given by

$$B_{NB} = t(1 - \overline{H} - \overline{L})w_1 + \frac{t}{1+r}\overline{H}F' + \frac{T}{1+r}(F - \Omega F').$$

In the absence of region-specific shocks, the effect of a marginal change in the wage tax rate on investment in human capital is exactly the same as in a closed economy. To see this, note that now Ω is independent of the tax rates, and when regions are identical, $\Omega = H$. The effect of a change in the wage tax rate on education is as in Appendix 1. The government's maximization problem in a federation with nationality-based taxation is

$$\begin{aligned} &\max_{t,T} \Delta_{NB} = C_1 + V(L_1) + E[U(C_2)] \\ &C_1 = (1 - H - L)w_1 + \tfrac{t}{1+r}HF' + \tfrac{T}{1+r}(F - \Omega F') - S \\ &C_2 = (1 - t)xHF' + S(1 + r). \end{aligned} \tag{17}$$

It is again optimal to set $T = \widetilde{T}$. The derivative of (17) with respect to t tells us the following:

Proposition 5 *A federation with nationality-based taxation without region-specific shocks leads to a higher wage tax rate than in a closed economy at least if the highest allowed tax rate for the owners of the fixed factor is not higher than the tax rate for those to be educated in the closed economy's tax optimum.*

Proof. See Appendix 4.

The intuition behind proposition 5 is that migration dampens the negative effect of decreased marginal productivity of human capital, which follows an increase in human capital induced by an increase in the wage tax rate. Thus, a federation without tax competition leads to a more complete insurance than in a closed economy. This is bad for those to be educated because it leads to excessive investment in education from their point of view and thus to lower rents. If tax rate for the owners of the fixed factor is higher than the tax rate for those to be educated, a federation with nationality-based taxation may lead to lower tax rate than in a closed economy. Even with nationality-based taxation, that part of welfare gains of increased investment in education that results from higher tax revenue from the owners of the fixed factor leaks partly to other regions.

5 The Effects of Migration Costs

We analyze a model where a proportion c of human capital is lost in migration because of language and other differences between regions. This proportion is constant across educated citizens in different regions. Regions are identical in respects other than taxation, and pre-migration human capital is Ω_B in each region. We assume that the net return to human capital is lower in one region because of higher taxation. The tax rate is t in region with high taxes and $\widehat{t}$ in all other regions. For simplicity, we assume production function to be Cobb-Douglas and normalize the fixed factor to unity. Let α be the share of human capital. A necessary condition for there to be migration is

$$\begin{aligned} (1-t)\alpha\Omega_B^{\alpha-1} &< (1-\widehat{t})(1-c)\alpha\Omega_B^{\alpha-1} \\ t &> 1-(1-\widehat{t})(1-c) \\ t &> \widehat{t}+c-\widehat{t}c. \end{aligned} \tag{18}$$

If the tax rate were 0.5 in other regions and the migration cost were proportion 0.2 of human capital, t could be 0.6 without inducing emigration of human capital. The presence of migration costs decreases the attractiveness of cutting wage taxation under the closed economy's optimum, because the tax rate would have to undercut that defined in (18) in order to attract human capital from other regions. In addition to this, the inflow would be smaller than without migration costs. If Φ units of human capital migrates to other regions, post-migration equilibrium requires that human capital originally situated in the high-tax region earns the same return in that region and in any other region. Net return to human capital has to be sufficiently high in other regions to compensate for the fact that part c of human capital is lost in migration. Post-migration equilibrium reads as

$$(1-t)\alpha(\Omega_B-\Phi)^{\alpha-1} = (1-c)(1-\widehat{t})\alpha\left[\Omega_B+\frac{(1-c)\Phi}{n-1}\right]^{\alpha-1}.$$

Solving for Φ we obtain

$$\Phi = \frac{(1-c)^{\frac{1}{1-\alpha}}(1-\widehat{t})^{\frac{1}{1-\alpha}} - (1-t)^{\frac{1}{1-\alpha}}}{(1-t)^{\frac{1}{1-\alpha}}\frac{1-c}{n-1} + (1-c)^{\frac{1}{1-\alpha}}(1-\widehat{t})^{\frac{1}{1-\alpha}}}\Omega_B. \tag{19}$$

Let us next solve for tax rate maximizing tax revenue from the educated with migration costs and a given amount of human capital and tax rates in other regions. Substituting (19) into $t\alpha(\Omega_B-\Phi)^{\alpha}$ we get tax revenues from post-migration human capital for high-tax region with each tax rate t, provided that t satisfies (18). Dividing this with Ω_B^α gives

$$t\alpha\left[\frac{(1-t)^{\frac{1}{1-\alpha}}\frac{1-c}{n-1}+(1-t)^{\frac{1}{1-\alpha}}}{(1-t)^{\frac{1}{1-\alpha}}\frac{1-c}{n-1}+(1-c)^{\frac{1}{1-\alpha}}(1-\widehat{t})^{\frac{1}{1-\alpha}}}\right]^{\alpha}. \tag{20}$$

Assume that $\widetilde{T}=0$. We can now solve numerically that with $\widehat{t}=0.5$, $c=0.2$, $\alpha=0.5$, and $n=2$ maximum tax revenue is obtained with $t=0.63$, whereas if there were no migration costs, that is, $c=0$, maximum tax revenue would be obtained with $t=0.61$. If c were 0.3 and n were 15, tax revenues would be maximized with $t=0.65$, the highest wage tax rate satisfying (18) and thus not inducing migration, whereas if c were 0 and n 15, tax revenues would be maximized with $t=0.52$.[4] If $\widetilde{T}>0$, tax rate for those to be educated which maximizes tax revenue from the educated and from the owners of the fixed factor is decreased. However, the qualitative conclusion is unchanged: the presence of migration costs significantly increases the range of feasible taxation from the viewpoint of an individual region. However, this comes at an efficiency cost.

Qualitatively similar results can be obtained by analyzing psychic migration costs. Psychic migration cost can be defined as a situation in which an emigrant obtains less utility from the same level of consumption in any other region than his or her home region. Mansoorian and Myers (1993) stress that the idea of psychological benefit from living in one's home region is of special interest in a federation that consists of culturally separate regions, such as the European Union. The presence of net saving makes psychic migration costs more problematic to analyze. If migration costs were defined per educated person, we would have to make an extra assumption concerning the distribution of human capital amongst the educated. Those with the most human capital would be the first ones to migrate.

In our model, a decrease of migration costs is always beneficial for the educated with a given human capital. Possible costs of a decrease of migration costs come from too low an insurance against individual shocks because of increased tax competition. Schöb and Wildasin (1997) analyze a model where implicit labor contracts insure workers against region-specific shocks. In their model, a decrease in migration costs may hurt workers because increased labor mobility leads to a more flexible labor market.

[4] Numerical calculations were obtained with Mathematica.

6 Conclusion

Welfare comparisons between a federation of any type and a closed economy are simple in absence of region-specific shocks and complicated when region-specific shocks are included. Without region-specific shocks, a federation just replicates the closed economy solution. Thus, a federation of any type is detrimental to the expected welfare of those to be educated if it changes the wage tax rate from the optimal wage tax rate chosen in the closed economy. A federation increases the welfare of the owners of the fixed factor if it increases human capital in the economy. Only if the owners of the fixed factor face a higher tax rate than those to be educated, a federation without tax competition may lead to a lower wage tax for those to be educated. *If this is not the case, the owners of the fixed factor prefer a federation without tax competition to both a closed economy and a federation with tax competition.* In the plausible case where federation with tax competition leads to lower tax rates than in the closed economy, the owners of the fixed factor would prefer the economy to remain closed. *With region-specific shocks, the welfare effects from the formation of a federation may go in either direction both for those to be educated and the owners of the fixed factor.* The possibility of migration insures the educated against region-specific shocks. For example with Cobb-Douglas technology, possibility of migration encourages education also by increasing its expected returns. The insurance effect of free migration also allows scaling down the insurance through distorting taxation. If these effects are strong enough, a federation of any type may be beneficial for those to be educated. Migration may increase the expected utility of the owners of the fixed factor by increasing their expected income, but it also increases the variance of that income, thus hurting risk-averse owners of the fixed factor. The owners of capital and other non-human resources should be able to alleviate the increased risk through security markets, but this option is not available to uneducated labor.

The current tax constitution in the European Union is one of unlimited tax competition in regard to wage taxation. That is, taxation is decided at the national level. We have shown that this threatens to scale down public financing for education, which would be a significant problem in Europe. The enlargement of a federation may increase the negative effects of tax competition both for the educated and for the owners of the fixed factor. Present member candidates to the European Union increase pressure from tax competition less in the public financing of education than in other fields of redistribution. Instead, tax competition may intensify between current member states as the mobility of highly skilled professionals increases. Thus tax competition may erode at least part of the gains from integration.

The qualitative conclusions of this paper do not rely on the total absence of migration costs; it is enough that there is a significant number of people whose migration costs are not prohibitively high. Clearly, migration flows between member states of the European Union are much smaller than those between different states in the United States. Only 1.5 % of the citizens of the European Union work in another member country, while in the United States, as much as 2.4 % of people older than 1 year migrated to another state between March 1996 and March 1997 (Eklund 1998, U.S. Census Bureau 1997). Nonetheless, extensive exchange programs and improved language skills effectively lower the barriers to mobility, and highly skilled professionals especially become increasingly mobile. In Sweden, 15 % of those who graduate from university emigrate each year (Eklund 1998).

Dismantling public participation in the financing of education is likely to increase polarization in the sense that those who are talented may welcome decreasing redistribution, whereas those of average ability, or even somewhat above average ability, may consider investing less in education if income risks increase. As migration costs diminish, insurance against region-specific shocks becomes more complete, but at the expense of the erosion of redistributive taxation which insures against individual risks. Thus, the benefits from the elimination of tax competition also grow.

As member states in the European Union are very different, uniform taxation is not an optimal solution. Tax competition is a problem mostly when it comes to the redistributive activities of the government, although Sinn (1993, 1997) argues that in the presence of fixed costs or declining marginal costs, tax competition poses problems even to the financing of local public goods. A solution allowing different systems to survive and even compete with each other on a sound basis would be to base redistributive taxation on nationality rather than on domicile. Another possible solution would be to make participation in some forms of redistribution a voluntary but irrevocable choice that an individual would have to make at an early stage of life when there was still uncertainty concerning future revenues. With these irrevocable redistribution contracts, those to be educated would pay, irrespective of their domicile, a certain percentage of their wage income to the region or university which participated in financing their education. The state or university would act as a venture capitalist.

Domicile-independent taxation and especially a transition to financing education with irrevocable redistribution contracts would mean a radical change. The main problem in implementing such a change is that it would considerably alter the status quo. States benefiting from the net migration of skilled professionals are not likely to accept such a change without compensation. A less radical solution would be to impose a certain minimum level on taxation used to finance education. This would alleviate the problems created by tax competition, but might, at the same time, impose inefficient harmonization. In any case, the enlargement of the European Union and the increased mobility of the educated are likely to encourage a constitutional change to eliminate or at least to restrict tax competition.

Appendix 1. Wage Tax Rate, Investment in Education, and Leisure Choice in a Closed Economy

Total differentiation of an individual's first-order conditions (2), (3), (4) with respect to H, S, L, and t gives us

$$\begin{bmatrix} A_{11} & A_{12} & 0 \\ A_{21} & A_{22} & 0 \\ 0 & 0 & A_{33} \end{bmatrix} \begin{bmatrix} dH \\ dS \\ dL \end{bmatrix} = \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} dt \text{ where}$$

$$A_{11} = (1-t)^2 F'^2 E(x^2 U'')$$
$$A_{12} = A_{21} = (1-t)(1+r)F'E(xU'')$$
$$A_{22} = (1+r)^2 E(U'')$$
$$A_{33} = V''$$
$$X_1 = (1-t)HF'^2 E(x^2 U'')$$
$$X_2 = (1+r)HF'E(xU'')$$
$$X_3 = -w_1$$

When differentiating with respect to an individual's decision variables we take Ω as given, because an individual does not take into account the effect of his or her educational choice on the marginal productivity of human capital in the economy.

Proposition 1. *A proportional tax on wage income creates an incentive for students to increase their investment in human capital. At the same time, it increases the demand for leisure and decreases labor supply in the first period.*

Proof. Cramer's rule gives us the effect of a change in the wage tax rate on the individual's choice of H:

$$\frac{dH}{dt} = \frac{X_1 A_{22} - X_2 A_{12}}{A_{11}A_{22} - A_{12}A_{21}} = \frac{H}{1-t}. \tag{A2}$$

This is positive. For the use of Appendix 3, we record that the nominator can be written

$$X_1 A_{22} - X_2 A_{12} = (1-t)(1+r)^2 HF'^2 \{E(x^2U'')E(U'') - [E(xU'')]^2\}. \tag{A3}$$

The effect of a change in the tax rate on leisure is given by

$$\frac{dL}{dt} = \frac{X_3}{A_{33}} = \frac{-w_1}{V''}.$$

This is positive. ■

Appendix 2. Wage Tax Rate and Investment in Education in a Federation with Tax Competition

Total differentiation of an individual's first-order conditions in the region changing the wage-tax rate and in the other region with respect to H, S, L, $\widehat{H}$, $\widehat{S}$, $\widehat{L}$, and t gives us

$$\begin{bmatrix} A_{11} & A_{12} & 0 & 0 & 0 & 0 \\ A_{21} & A_{22} & 0 & 0 & 0 & 0 \\ 0 & 0 & A_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & A_{44} & A_{45} & 0 \\ 0 & 0 & 0 & A_{54} & A_{55} & 0 \\ 0 & 0 & 0 & 0 & 0 & A_{66} \end{bmatrix} \begin{bmatrix} dH \\ dS \\ dL \\ d\widehat{H} \\ d\widehat{S} \\ d\widehat{L} \end{bmatrix} = \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \\ X_6 \end{bmatrix} dt \text{ where}$$

$$A_{11} = (1-t)^2[F'(\Omega)]^2 E(x^2U'')$$
$$A_{12} = A_{21} = (1-t)(1+r)F'(\Omega)E(xU'')$$
$$A_{22} = (1+r)^2 E(U'')$$
$$A_{33} = V''$$
$$A_{44} = (1-\widehat{t})^2[F'(\widehat{\Omega})]^2 E(x^2\widehat{U}'')$$
$$A_{45} = A_{54} = (1-\widehat{t})(1+r)F'(\widehat{\Omega})E(x\widehat{U}'')$$
$$A_{55} = (1+r)^2 E(\widehat{U}'')$$
$$A_{66} = \widehat{V}''$$
$$X_1 = (1-t)H[F'(\Omega)]^2E(x^2U'') - (1-t)F''(\Omega)E(xU')\left(\tfrac{d\Omega}{dt}\right)_{TC} - (1-t)^2HF'(\Omega)F''(\Omega)E(x^2U'')\left(\tfrac{d\Omega}{dt}\right)_{TC}$$
$$X_2 = (1+r)HF'(\Omega)E(xU'') - (1-t)(1+r)HF''(\Omega)E(xU'')\left(\tfrac{d\Omega}{dt}\right)_{TC}$$
$$X_3 = -w_1$$
$$X_4 = (1-\widehat{t})\widehat{H}F''(\widehat{\Omega})E(x\widehat{U}')\tfrac{1}{n-1}\left(\tfrac{d\Omega}{dt}\right)_{TC} + (1-\widehat{t})^2\widehat{H}F'(\widehat{\Omega})F''(\widehat{\Omega})E(x^2\widehat{U}'')\tfrac{1}{n-1}\left(\tfrac{d\Omega}{dt}\right)_{TC}$$
$$X_5 = (1-\widehat{t})(1+r)\widehat{H}F''(\widehat{\Omega})E(x\widehat{U}'')\tfrac{1}{n-1}\left(\tfrac{d\Omega}{dt}\right)_{TC}$$
$$X_6 = 0.$$

When differentiating with respect to an individual's decision variables we take Ω and $\widehat{\Omega}$ as given, because individuals do not take into account the effect of their educational choice on the marginal productivity of human capital in the federation. When differentiating with respect to the government's decision variable t we use (9) and (10), because governments do take into account the effect of taxation on post-migration human capital. Where necessary, we have distinguished the terms referring to the other region with hat. Before proceeding, we prove

Lemma B1. *With a discrete random variable x with expected value one having only positive values in the argument of a concave utility function*

$$E(x^2U'')E(U'') - [E(xU'')]^2 \geq 0. \tag{B1}$$

Proof. Discrete random variable x can be presented using $n, n \in N$ pairs with expected value one. We take an arbitrary pair and note the conditional probability of the first value of the pair with the condition that one of the pair's values is chosen p. If $p = 0$ or $p = 1$, the left-hand side of (B1) is zero. Next we assume that $0 < p < 1$. If the value of the point with conditional probability p is $(1 + a)$, the value of the point with conditional probability $(1 - p)$ has to be $1 - \frac{p}{1-p}a$. Both values have to be positive. Putting these values and their conditional probabilities into (B1) and suppressing arguments other than the random variable from U'' gives

$$\begin{aligned}
&E(x^2U'')E(U'') - [E(xU'')]^2 \\
&= [p(1+a)^2U''(1+a) + (1-p)(1-\tfrac{p}{1-p}a)^2U''(1-\tfrac{p}{1-p}a)] \\
&\times[pU''(1+a) + (1-p)U''(1-\tfrac{p}{1-p}a)] \\
&-[p(1+a)U''(1+a) + (1-p)(1-\tfrac{p}{1-p}a)U''(1-\tfrac{p}{1-p}a)]^2 \\
&= \tfrac{p}{1-p}a^2U''(1+a)U''(1-\tfrac{p}{1-p}a),
\end{aligned}$$

which is positive for each $a \neq 0$. Because this is true for each pair, it is true for a sum of these pairs equipped with positive multipliers (probabilities). ■

Lemma B1 is presented for a discrete probability function. It holds also for an arbitrarily exact approximation for continuous functions of x. We can next prove

Proposition 3. *In a federation with tax competition and without region-specific shocks, a marginal increase in the wage tax rate in one region increases investment in education in that region, at least if tax rates are initially equal in all regions. Investment may increase more or less than in a closed economy with the same initial tax rate. The effect on investment in education in other regions may be positive or negative. The total effect on the federation's human capital is, however, the same as in a closed economy. The demand for leisure responds in the region changing the wage tax rate as in a closed economy. In other regions, demand for leisure does not change.*

Proof. We evaluate the effects of a change in the wage tax rate in the symmetric initial situation, where $\widehat{t} = t$, which implies that $A_{44} = A_{11}$ etc. Cramer's rule gives us after simplification:

$$\left(\frac{dH}{dt}\right)_{TC} = \frac{\begin{vmatrix} X_1 & A_{12} \\ X_2 & A_{22} \end{vmatrix}}{\begin{vmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{vmatrix}}$$

and

$$\left(\frac{d\widehat{H}}{dt}\right)_{TC} = \frac{\begin{vmatrix} X_4 & A_{12} \\ X_5 & A_{22} \end{vmatrix}}{\begin{vmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{vmatrix}}.$$

In both expressions, the denominator is positive. The sign of the effect of an increase in t on an individual's educational choice is thus the sign of the nominator. In the region changing the wage tax rate, this simplifies after substituting (9) into the form

$$\begin{aligned} &X_1A_{22} - X_2A_{12} = \\ &(1-t)(1+r)^2H[F'(\Omega)]^2\{E(x^2U'')E(U'') - [E(xU'')]^2\}\tfrac{1}{n} \\ &-(1+r)^2F'(\Omega)E(xU')E(U'')\tfrac{n-1}{n}. \end{aligned} \tag{B2}$$

By Lemma B1 both terms are positive. Comparing this with the effect in a closed economy, it is evident that with identical t, one cannot say without further restrictions which expression is bigger. By symmetry of the regions, $\widehat{H} = H$, $\widehat{U}'' = U''$ etc. when evaluated in the initial situation. Thus we can write:

$$\begin{aligned} &X_4A_{22} - X_5A_{12} = \\ &(1-t)(1+r)^2H[F'(\Omega)]^2\{E(x^2U'')E(U'') - [E(xU'')]^2\}\tfrac{1}{n} \\ &+(1+r)^2HF'(\Omega)E(xU')E(U'')\tfrac{1}{n}. \end{aligned} \tag{B3}$$

The first term in the right-hand side is positive, the second term is negative, and thus the sign is ambiguous. The effect of a marginal tax increase in one region on the federation's human capital is denoted by $\frac{dH_F}{dt}$. It is the sum of the effect in the region changing the wage tax rate and the induced effects in $n-1$ other regions:

$$\left(\frac{dH_F}{dt}\right)_{TC} = \left(\frac{dH}{dt}\right)_{TC} + (n-1)\left(\frac{d\widehat{H}}{dt}\right)_{TC}.$$

Substituting (B2) and (B3) to this expression we see that the combined effect is the same as the effect in the closed economy, calculated in Appendix 1.

To see how the demand for leisure responds, we use Cramer's rule and simplify to get

$$\left(\frac{dL}{dt}\right)_{TC} = -\frac{w_1}{V''}$$

which is the same as in a closed economy, and

$$\left(\frac{d\widehat{L}}{dt}\right)_{TC} = 0.$$

■

Appendix 3. Optimal Wage Tax Rate in a Federation with Tax Competition

Proposition 4. *A sufficient condition for the formation of a federation between identical regions to result in a lower wage tax rate than in a closed economy is*
1. the government would prefer in the closed economy's tax optimum higher educational investment than individuals would choose or, alternatively,
2. *the wage tax rate is at least* $\frac{-\Omega F''}{F'}$ *in the closed economy and* $\left(\frac{dH}{dt}\right)_{TC} \geq \frac{dH}{dt}$.
If at least one of these conditions is met, an enlargement of a federation leads to an even lower wage taxation.

Proof. We want to show that (16) is negative in the closed economy tax optimum. We analyze first case 1. By (A2), (A3) and (B2) we can write

$$\left(\frac{dH}{dt}\right)_{TC} = \frac{1}{n}\frac{dH}{dt} - \frac{n-1}{n}\frac{(1+r)^2 F' E(xU')E(U'')}{A_{11}A_{22} - A_{12}A_{21}}. \tag{C1}$$

By symmetry and concave production function, $\frac{\partial \Omega}{\partial H_F} = \frac{1}{n}$. With this result and results from Appendix 2 we can next write (16) as

$$\begin{aligned}
&\tfrac{1}{1+r}\Omega F' - HF'E(xU') - tw_1\tfrac{1}{n}\tfrac{dH}{dt} + tw_1\tfrac{n-1}{n}\tfrac{(1+r)^2F'E(xU')E(U'')}{A_{11}A_{22}-A_{12}A_{21}} \\
&+ \left\{\tfrac{t}{1+r}F' + \tfrac{t}{1+r}\Omega F'' + (1-t)HF''E(xU') - \tfrac{\widetilde{T}}{1+r}\Omega F''\right\}\tfrac{1}{n}\tfrac{dH}{dt} \\
&+ \left\{\tfrac{t}{1+r}F' + \tfrac{t}{1+r}\Omega F'' + (1-t)HF''E(xU') - \tfrac{\widetilde{T}}{1+r}\Omega F''\right\}\left(\tfrac{d\Omega}{dt}\right)_{TC} - tw_1\tfrac{dL}{dt}.
\end{aligned} \tag{C2}$$

The first two terms and the last in (C2) are the same as in (6). The sum of the third and fifth terms is less than the sum of the third and fourth terms in (6). The negative fourth and sixth terms of (C2) are not present in (6). Therefore, (C2) and thus also (16) are negative in the closed economy's tax optimum. As the positive sum of the third and fifth terms is decreasing in n and the negative fourth and sixth terms are increasing in absolute value in n, an enlargement of a federation leads to a lower value of (C2) and thus to a lower wage taxation.

In case 2, we can write the term in parentheses in (16) in the following form using individual's first-order conditions and the fact that in a symmetrical equilibrium without migration, $H = \Omega$:

$$tF'E(U') + t\Omega F''E(U') + (1-t)\Omega F''E(xU') - \frac{\widetilde{T}}{1+r}\Omega F''. \tag{C3}$$

If we evaluate this downwards by substituting $E(U')$ for $E(xU')$ and simplify using condition for case 2, we see that (C3) and thus the term in parentheses in (16) are positive.

The first two and the last term of (16) are the same as in (6). The negative third term is not smaller in absolute value than in (6) as $\left(\frac{dH}{dt}\right)_{TC} \geq \frac{dH}{dt}$. The fourth term is smaller in (16). The fifth term is not present in (6) and it is negative, as the multiplier $\left(\frac{d\Omega}{dt}\right)_{TC}$ is negative. Thus, (16) is negative at the closed economy's tax optimum, where (6) has value zero.

The multiplier $\frac{\partial\Omega}{\partial H_F} = \frac{1}{n}$ of the positive fourth term is decreasing in n whereas the negative multiplier $\left(\frac{d\Omega}{dt}\right)_{TC}$ of the fifth term increases in absolute value as n increases. If $\left(\frac{dH}{dt}\right)_{TC} \geq \frac{dH}{dt}$, then $\left(\frac{dH}{dt}\right)_{TC}$ is increasing in n. Thus, negative third term in (16) is increasing in n in absolute value. Therefore, an increase in n decreases the wage tax rate in a federation with tax competition. ■

Appendix 4. Optimal Wage Tax Rate in a Federation with Nationality-based Taxation

Proposition 5. *A federation with nationality-based taxation without region-specific shocks leads to a higher wage tax rate than in a closed economy at least if the highest allowed tax rate for the owners of the fixed factor is not higher than the tax rate for those to be educated in the closed economy's tax optimum.*

Proof. As we take derivative of (17) with respect to t and use an individual's first-order conditions, we obtain as the effect of a change in the tax rate on the representative citizen's expected utility:

$$\begin{aligned}&\left(\tfrac{d\Delta}{dt}\right)_{NB} = \tfrac{1}{1+r}HF' - HF'E(xU')\\ &+\{-tw_1 + \tfrac{t}{1+r}F'\}\tfrac{dH}{dt}\\ &+\{\tfrac{t}{1+r}HF'' + (1-t)HF''E(xU') - \tfrac{\widetilde{T}}{1+r}\Omega F''\}\tfrac{\partial\Omega}{\partial H_F}\left(\tfrac{dH_F}{dt}\right)_{NB}\\ &-tw_1\left(\tfrac{dL}{dt}\right)_{NB}.\end{aligned} \tag{D1}$$

As a marginal change in t alters investment in human capital only in region 1, $\left(\frac{dH_F}{dt}\right)_{NB} = \frac{dH}{dt}$. Substituting this, $\frac{\partial \Omega}{\partial H_F} = \frac{1}{n}$, and $H = \Omega$ to the first term inside the second brackets of (D1), we get

$$\begin{aligned}
\left(\frac{d\Delta}{dt}\right)_{NB} &= \frac{1}{1+r}HF' - HF'E(xU') + \left\{-tw_1 + \frac{t}{1+r}F'\right\}\frac{dH}{dt} \\
&+ \left\{\frac{t}{1+r}\Omega F'' + (1-t)HF''E(xU') - \frac{\widetilde{T}}{1+r}\Omega F''\right\}\frac{1}{n}\frac{dH}{dt} \\
&-tw_1\frac{dL}{dt}.
\end{aligned}$$

The expression inside the second brackets is negative if $\widetilde{T} \leq t$. Thus $\left(\frac{d\Delta}{dt}\right)_{NB}$ is greater than the expression one would get by taking away term $\frac{1}{n}$ which multiplies the term inside the second brackets. But after removing $\frac{1}{n}$, $\left(\frac{d\Delta}{dt}\right)_{NB}$ is identical to (6). Thus $\left(\frac{d\Delta}{dt}\right)_{NB} > 0$ at the closed economy's optimum if $\widetilde{T} \leq t$, and thus a federation with nationality-based taxation leads to a higher tax rate than in a closed economy. ■

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