Brain Drain and Fiscal Competition: a Theoretical Model for Europe*

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Abstract

In this paper we study Brain Drain (BD) and Fiscal Competition (FC) in a unified framework for the European Union (EU) specific context. Potential mobility of educated workers can increase the degree of FC through taxation or the provision of public education. An increase in FC can be caused by competition among different jurisdictions that aim to attract educated workers. When the importance of FC increases, then the European States may employ FC as a new policy tool. First, we analyze FC and BD with reference to EU regions. In this instance, the EU may find incentive to control the interactions between BD and FC in order to coordinate fiscal policies and/or the provision of public goods as education. Second, we furthermore consider the entry of new state inside the EU. The absence of coordination implies that, in addition to the FC, a "migration competition" may be generated in EU, where the region inside the union try to attract educated workers of the new entry. We derive the conditions which BD leads to a decrease (increase) in welfare and growth for new entry country.

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1 Introduction

In the European Union (EU hereafter) context, mobility of European citizens is free of institutional constrains so that cultural integration increases the probability to migrate inside the Union. For this reason, workers flows acquired a relevant position in the EU research agenda. The study of the Brain Drain (BD hereafter) is linked with the choice of education for both workers and/or by governments. If education is a public good, educated workers are free to migrate, as a side effect Fiscal Competition (FC hereafter) can arise. If governments do not coordinate taxation and provision of public goods, then the economy may suffer strong negative externalities. In fact, if the growth of the economies is associated with educated workers, we may record lower taxation, worse income redistribution, and lower provision of public goods. Furthermore, the system may record lower growth.

A though BD and FC are connected through agents mobility, the literature studied them separately due to the complexity of a joint analysis. In particular, previous studies developed two separate branches for BD and FC. The first one focuses on BD in a macroeconomic setup and studies its impact on the growth of different economies. The second one analyses FC using microeconomic tools and focuses on competitive interactions between workers and Jurisdictions. Several studies are focused on externalities stemming out from human capital migration but all these studies analyze only indirectly the interaction between BD and FC and so they are not adequate to simulate the new European framework. In fact, in the past this BD was an unidirectional flow of highly skilled labor from third-world countries and so the literature has explained the lower provision of human capital as a "negative fiscal externalities" due to migration[1]. More recently, increased integration in the labor markets, especially within the EU, has drawn attention to problems that arise from bi-directional movement of skilled labor between similarly developed countries. It is so necessary to define a new BD typology specific to the European context where the FC can be used as a "new policy tools" by the regions. Furthermore, when we analyze the enlarged EU then we can distinguish two different "clubs" of region, the former, with higher growth, and the new entries with lower growth and labour productivity. In this new context a new specification of BD and FC can arise. The former regions can compete to attract the educated workers of the new regions by use of the FC tool. This "migration competition", in the absence of a specific coordination inside the EU, can generate strong negative externalities to the new entry. There

[1] Berry and Soligo (1969), for example, show that, as far as the production of human capital (i.e. schooling and professional or academic education) is subsidized, the emigration country loses human capital when people with human capital leave their origin. Consequently (and according to the theory of public goods) the production of human capital in the emigration countries is too low in comparison to a world without migration. Bhagwati (1976a) shows the existence of a negative fiscal externality on the emigration country, if education is publicly subsidized. If the economy wide education is expanded in response to emigration the governmental deficit increases ceteris paribus. Furthermore educational subsidies can be regarded as an investment of the old generation into their pension which is lost in case of permanent emigration (Grubel & Scott, 1977).

exist numerously examples of the FC and the "migration competition" in EU.

For example, a recent Swedish policy reduces the tax burden for high level researchers going to Sweden for three years. Similar initiatives are being implemented in Denmark. Furthermore, scrutiny of the work permit system of most European states indicates clearly that professional, managerial and technical constitute the bulk of those accepted: Germany has introduced a "Green Card" system to attract 20,000 IT workers to fill shortages, although there are still difficulties in finding enough potential migrants with the necessary skills. The UK government has also adopted a more positive attitude towards skilled labor migration, making changes to the work permit system which are designed to increase the inflow of a range of skilled occupations, including IT and medical personnel[2]. Finally, much of the discussion of the migration of highly skilled has focused on the potential BD from east to west. Statistics[3] show a migration of scientists from Eastern Europe and the former Soviet Union to Western Europe.

This paper is organized as follows. In Section 2 we describe the structure of the model. In Section 3 we solve the model in an "autarchic context" where there is no migration. In Section 4 we describe the "full mobility case" where there is migration of educated worker between two regions. In Section 5 we describe the "partial mobility case" between two regions. In Section 6 we analyse the "partial mobility case" between three regions.

1.1 Survey of the literature

In this survey we analyse the BD's literature and its link with the FC's literature. Let us start by give a definition of the Brain Drain:

Brain Drain is an expression of British origin commonly used to describe one of the most sensitive areas in the transfer of technology. It refers to skilled professionals who leave their native lands in order to seek more promising opportunities elsewhere.

Causes Migration of this type has been linked to several possible causes. The most frequently cited are the lack of employment opportunities for returning graduates, lower salary levels in the indigenous country, preference of graduates to live abroad, asymmetric information in the labor market[4], different fiscal and

[2] See Salt (2001); Bauer and Zimmermann (1999) Salt, Compton, Densham, Hogarth, and Schmidt, (1999); Dauderstädt (2001); Straubhaar (2000).

[3] See, for example, Wolburg (1996, 1997) and Wolburg & Wolter (1997)

[4] Kwok Viem (1982) suggests as cause for the exodus of foreign -trained students: asymmetric information in the labor market. That is, employers in the country training the students have a more accurate (but not necessarily more optimistic) judgment of the true productivity of students than have employers in the students' native country. This asymmetry results from foreign employers' familiarity with their own academic system and with the curricula offered by different schools; their past experience in hiring large numbers of both foreign and domestic graduates of their universities; and the in-depth interviews which are a regular part of the employment process in many Western countries, and particularly in the United States. He also shows that the graduates who do return tend to be those of lesser productivity than those who remain abroad.

social packages[5] and the incentive to finance education[6].

Welfare and growth effects The BD literature is linked to the concept of "human capital" and its measurement has been developed by Schultz (1960) and Becker (1964). Positive technological externalities of immigration arise by the additional capital that is available to the host economy. The theoretical argument goes back to the development literature of 50's (Hirschman, Myrdal, Perroux, Wallerstein) They have seen a revival in the mid-1980's with the birth of the so called New Growth Theory. Starting with Paul Romer (1986, 1987, 1990) and Robert Lucas (1988) the immigration of skilled migrants has been evaluated as stimulating for the dynamics of economic growth.

The possibility that the welfare of those remaining in the LDCs could be reduced by an outflow of educated manpower had been recognized in the literature as well. From the work of Grubel and Scott, Berry and Soligo, and Harry Johnson in the 1960s, the main conclusion was that welfare of non-migrants would fall only if the migrants' contribution to national output were greater than their income (or consumption in a static model). For a number of reasons the literature believes that the conditions for a BD to be welfare-deteriorating are often verified. Differently from the standard results, Mountford (1997) find some conditions in which BD generates positive externalities for the regions where some educated workers migrate[7]. Similar results are in Stark and Wang (2002), Stark et al. (1997) and Stark (2004).

[5] When the choice is among countries, rather than among municipalities, mobility is much less, and the fiscal and social packages can be, and are, much more different. But the basic point [based on the model of Charles Tiebout's (1956) which explains how political jurisdiction s can offer quite different packages of services and tax rates, and where individuals vote with their feet to find the packages most suiting their tastes and values] remains those who move face, not only different taxes rates but different patterns and types of public services, as well. Perhaps even more relevant to the study of migration of the well- educated and well-off countries differ, not only in their average taxes rates and in the size and efficiency of their public services and transfer payments, but also in the distribution of costs and benefits among different groups of taxpayers and beneficiaries. Among those who do migrate whether domestically or abroad, the highly educated are over-represented, partly because they are more likely to posses skills that are in demand, but also because they are more likely to have contacts in and knowledge about possible places to move. To extent that migration of the highly skilled may to be triggered by different factors, survey data reported by Grubel and Scott (1966, 1976) suggests that job opportunities and challenges are even more important to the highly educated. It is also true that for many such workers, particularly in health care, education, and government-supported fundamental research, the 1990s have seen large cuts in government spending induced by budget pressures. For example the pre tax and post tax distributions of the income have become more unequal in the US relative to Canada. All of these factors may have increased the net attraction of migration for the better-educated. [Helliwell 1999]

[6] Beyond the overall package of taxes and public services, special attention has been given, especially in the context of BD discussions, to the structure of education finance. Many commentators have argued that because BD migrants take their taxpayer-supported educational capital with them, they should face an exit tax or an educational loan that is forgiven only for those who stay and work where they acquired their subsidized education.

[7] He shows that when migration is not a certainty, a BD may increase average productivity and equality in the source economy even though average productivity is a positive function of the past average levels of human capital in an economy.

Furthermore there are different studies about the BD[8] and considerable attention has been given to a proposal of Bhagwati's for a "brain drain tax" which would reduce the incentives for such a migration to take place[9]. Finally there are different methodologies to compute these benefits and costs. For example Usher (1977) suggests that "an assessment of the costs and benefits of migration need take account of the fact that a large portion of a country's property is publicly owned, so that a migrant on going from one country to another must as a rule abandon his share of publicly owned property of origin and acquire a share of publicly owned property in his country of destination. The emigrant exchange his right to send his children to school in his country of origin for the right to send his children in his country of destination, reducing the need for new school building in the former country and increasing it according in the latter". Grubel and Scott (1976) point out that "since our concern is with the gains to the United States, it is appropriate to use U.S. prices, so that our computations amount to estimating what it would have cost to bring a native American to the level of education held by the average immigrant at the time he arrives".

The effects of provision of public goods If one assumes that the allocation to human capital investments made by the region (e.g., local expenditures or state support for education in the national framework and national investment outlays in the international setting) depends on the returns expected to accrue internally (as the individual investment decisions are assumed to be determined by expected private returns), the existence of external benefits from investments made by a region will cause suboptimal allocation judged from marginal productivity rules[10].

The cost of education would be irrelevant to the assignment of gains and losses from migration if each man paid the full cost of his education, but it becomes important when education is subsidized or provided free of charge by the state. It is sometimes supposed that there is an implicit contract between the student and the state in which the latter supplies education at lower than cost on the understanding that the net income of educated labor will one way another, be lower than its marginal product. The immigration of educated labor generates the benefits of this arrangement without the cost[11].

[8]See Bhagwati and Hamada (1974); Bhagwati and Rodriguez (1975a; 1975b); McCulloch and Yellen (1975); Blomqvis (1986); Bodenhofer (1967); Sjaastad (1962); Rodriguez (1975); Romans (1974); Edding and Bodenhofer (1966); Johnson (1965); Kesselman (2000).

[9]Bhagwati and Dellafar (1973), Bhagwati (1975,1976a, 1976b) and Hamada (1977).

[10]There is a large literature on the efficency properties of a system of competing regional jurisdictions. One strand is the fiscal externality literature. The standard conclusion in this literature is that there is an externality associated with an individual's migration that generally leads to an inefficient distribution of population across region.

[11]Education in general accounts for as much as of 5% of GNP, and 10% or more of public spending in advanced industrialized countries, with public funding covering, on average, almost 90% of education costs in these countries. Higher education typically accounts for 15-20% of overall education expenditures. Migration of skilled labor implies that those who pay the bill for public higher education may find it difficult to fully capture its benefits.

2 The model

The model we analyze in this paper is based on Mountford (1997)[12].

The literature on BD identifies a negative externality of BD on regions growth. Differently from standard results, the Mountford's model finds some conditions in which BD generates positive externalities for the regions where some educated workers migrate[13]. This interesting result opens the way for a better identification of the negative effect generated by the mutual interaction of FC and BD. We extend Mountford's model in different directions. First, we introduce a role for the government in the educational decisions of agents though the introduction of educational subsidies and taxation. Second, we study the specific case in which the region analyzed is a member of the European Union where the mobility of workers is freely allowed[14].

The model analyses a small open economy, under perfect capital mobility, with only one good produced under constant returns to scale by two factors, capital and efficiency units of labor. There is a continuum of agents within each generation[15]. The education decision is assumed to be a discrete choice: agents can choose either to be educated or not be educated.

Let us define K_t to be the total amount of capital in time period t and L_t to be the efficiency units of labor. The productivity of labor (or the state of technology) in period t is given by λ_t. Production is generated by a constant returns to scale production function. The output produced at time t, Y_t , is

$$Y_t = F(K_t, \lambda_t L_t) = f(k_t)\lambda_t L_t,$$

where $k_t = \frac{K_t}{\lambda_t L_t}$.

We make the standard assumptions about this function, namely

$$f(k) > 0 \ , \ f'(k) > 0 \ , \ f''(k) < 0 \ \forall k > 0$$

and the "Inada conditions"

$$\lim_{k \to 0} f(k) = 0, \lim_{k \to 0} f(k) = \infty \text{ and } \lim_{k \to \infty} f(k) = 0.$$

[12]This model is a simple version of Miyagiwa (1991) studiing of the model of the brain drain and human capital formation.

[13]See note (7)

[14]In this analysis we do not take in account redistribution policies of the governments. Even if a partial redistribution of income derives from the progressive taxation uses to finance the educational costs. If we take in account the redistribution policies we accentuate the negative effects of the FC. According to the literature we will obtain less redistribution and less provision of public good with respect to the efficient value (which could be obtained in the absence of mobility or in the presence of coordination among jurisdictions). In Giannoccolo (2003) we have analyzed the negative externalities due to FC and to educated migration and we have analyzed their effect on the redistribution policies and on the supply of education as public good.

[15]For simplicity we normalize the population in each generation to unity.

Let us assume for simplicity that the world is in a steady state equilibrium and thus that the world net rate of return, r^*, is constant. Due to the perfect capital mobility and the narrow dimension of the economy, this fixes the domestic net rate of return to capital, r_t, equal to r^* and thus fixes the domestic capital to efficiency labor ratio, k_t, as well. Thus $k_t = k \; \forall t$ where k is a constant. Let us assume that the wage rate per efficency unit of labor is independent of labor supply (and thus of migration levels) and is dependent of the level of technology λ_t, that is given:

$$w_t = \lambda_t w.$$

The distribution of ability Individuals possess different levels of latent ability, where e^i denotes the latent ability level of individual i. These latent abilities are assumed to be distributed over the closed interval $[0, E]$ according to the density function $g\left(e^i\right)$, where, by definition,

$$\int_0^E g\left(e^i\right) de_i = 1 \text{ and } \; g\left(e^i\right) > 0 \; \forall e^i \in [0, E].$$

Let us assume that all generations have latent abilities which are picked up from the same distribution and that the abilities of children are independent from the abilities of their parents.

The growth externality Let us assume that there is an economy wide growth externality related to the proportion of educated workers in the economy in the previous period s_{t-1}. Thus we model λ_t to be a positive function of the proportion of educated workers in the previous period, that is

$$\lambda_t = \lambda\left(s_{t-1}\right) \text{ where } \; s_{t-1} = \int_{e^*_{t-1}}^E g\left(e^i\right) de^i. \tag{1}$$

Let's also assume that $\lambda(0) = 1$ and that $\lambda(1)$ is finite.

The individual's decision to be educated Agents live in a overlapping generations world and live for three periods, deriving utility only from the third period consumption[16]. In their first period of life agents can invest resources in education. They have not resources of their own, so they must borrow from the capital market at the world's rate of interest, r^*. Let us assume the "private" cost of education to be fixed at c^p units of output. Let us furthermore assume that, in absence of government's subsidies, $c^p = c^{\max}$.

[16]The introduction of three periods is necessary because agents borrow to finance their first period of life and they can evidently not borrow from agents who will not be alive to be repaid in the next period.

Agents that invest in education obtain e^i efficiency units of labor in their second period of life, where e^i is the level of the latent ability of agent i. Furthermore let's assume that the agents who do not invest in education have only one efficiency unit of labor in their second period of the life.

Agents can only work in their second period of life and in this period the agent must repay the debt of the first period. In the third period they are retired and use their savings to consume. All agents have the same preferences and access to the same technology, although they do not have the same levels of latent ability.

Let us now assume that the government subsidizes part of the educational costs sustained[17]. The government influences the education decision of the agents by taxing the educated workers and covering part of their education costs[18]. Let us assume that if the government sustain entirely or partially the education cost, then scale economies arise and we have a smaller unitarian cost. Let us define "public" cost of education for each agent to be fixed at c units of output. By assumption $c < c^{\max}$.

In the next session we analyse how the results change when we have different assumptions on the educational costs.

In presence of government subsidies The private cost becomes $c^p = c - \gamma_t$, where γ_t is the education subsidy defined as the unit of output reimbursed to educated agents in generation t and $\gamma_t \in [0, \gamma^{\max} = c]$.

Let us define T_t to be the marginal rate of taxation of educated workers in generation t. Introducing taxation, the wage rate per efficiency unit of labor becomes $w_t^i = \lambda_t w e^i [1 - T_t]$.

The optimal decision for agent i will be to invest in education if

$$[1 - T_t] \lambda_t w e^i > \lambda_t w + [c - \gamma_t] (1 + r^*) . \tag{2}$$

Thus, all agents with a latent ability greater than e^* will invest in education, were e^* is uniquely defined by the following equality:

$$e^{*J} = \frac{\lambda \left(s_{t-1}^J\right) w + (1 + r^*) \left[c - \gamma_t^J\right]}{\left(1 - T_t^J\right) \lambda \left(s_{t-1}^J\right) w}. \tag{3}$$

Let us assume that the model is such that $e_t^* \in [0 + \varepsilon, E - \varepsilon]$, where $0 < \varepsilon < \frac{E}{2}$.

Dynamics and steady state productivity

The only dynamics in the model derive from the growth externality. From equation (1) it is clear that the proportion of workers who are educated at time

[17] These subsidies are given directly to educated. The analysis does not change if we consider an equivalent average education investment of the government (academic and research infrastructures, school places, teachers, etc.).

[18] We assume that only the educated workers are taxed. Then we focus our analysis on a particular quota of the taxation reserved to pay the education's subsidies.

t is an increasing function of the proportion of workers who were educated at time $t-1$, that is

$$s_t = \psi\left(s_{t-1}\right). \tag{4}$$

Since

$$\frac{\partial e_t^*}{\partial s_{t-1}} = \frac{\lambda'\left(s_{t-1}^J\right)\left(1+r^*\right)\left(c-\gamma_t^J\right)}{\lambda^2\left(s_{t-1}^J\right) w\left[1-T_t^J\right]}, \tag{5}$$

thus

$$\frac{\partial s_t}{\partial s_{t-1}} = g\left(e_t^{*J}\right)\frac{\lambda'\left(s_{t-1}^J\right)\left(1+r^*\right)\left(c-\gamma_t^J\right)}{\lambda^2\left(s_{t-1}^J\right) w\left[1-T_t^J\right]}. \tag{6}$$

Let us assume that E is high enough so that the most able worker will always chooses to be educated even if no one was educated in the previous period. Since we know that agent i with $e^i = 0$ will never chooses to be educated, then this implies that there must exist at least one steady state equilibrium for s_t, which we denote as $\bar{s}$. Whether this is a unique steady state depends on the properties of the function $\lambda_t = \lambda\left(s_{t-1}\right)$. If this function has convex regions, representing "critical masses" of educated people in the economy, then there may be multiple steady states. The unique Steady State case is depicted in figure (1).

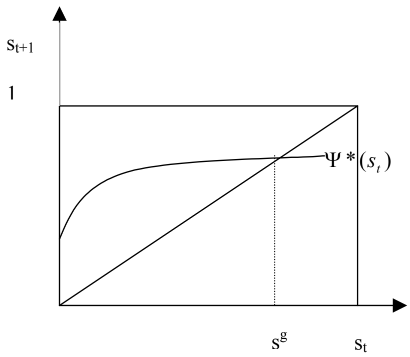

Figure 1: $\Psi^*\left(s_t\right)$ indicates the proportion of educated agents in autarkic case, when there is not migration and there are government's subsidies.

3 Autarchic case

In this section we solve the model in an "autarchic context" where there is not migration between regions. Let us resume the timing of the model.

- Time t — The government decides T_t and γ_t and influence the private cost of education. Each agent i decides whether to invest in education or not according to their latent ability e^i. Agents who invest in education receive γ_t and borrow $c - \gamma_t$ from the capital market.
- Time $t+1$ — The educated agents pay T_t to their government and repay the debt of the first period of the life.
- Time $t+2$ — All agents are retired and use their savings to consume.

It is possible to solve the government maximization problem through the Backward Induction method (BI hereafter)[19]. First we solve the maximization problem of the agents at time $t+1$ and then we solve the maximization problem of government.

In each period t we assume that s_{t-1}^J is given, then we can define

$$\lambda\left(s_{t-1}^J\right) w \equiv a. \tag{7}$$

The agent's decision is given by equation (3)

$$e^{*gJ} = \frac{a + (1+r^*)\left[c - \gamma_t^J\right]}{\left(1 - T_t^J\right) a}. \tag{8}$$

The government. Let us define Ω_t^J a measure of the welfare of the region J derived from the productivity of the agents that in time t are resident in region J.[20]

When there is not migration (Autarchic case), we define $\Omega_t^{A,J}$

$$\Omega_t^{A,J} \equiv s_t^J \left[a \int_{e_t^{*gJ}}^{E} de_{i,t} - c\,(1+r^*) - a \right] + a. \tag{9}$$

The first term on the right hand side of (9) denotes the net gain in productivity of region J due to the presence of educated workers. The second

[19] See the Appendix for all the computation of this autarchic case.

[20] This is a non-standard function of social welfare. It is a measure of the region's gain derived from the productivity of each generation, net of the educational costs. It allows to compare the different scenarios analyzed in this model and to capture the educational decisions of the government. In the next chapter the figure (2) gives a graphic intuition of Ω_t^J. It is possible extend this static simplification of the model by defining a social welfare function that take in account the externalities linked to the education. See in Appendix for furthermore details.

term corresponds to the total productivity of region J independently from the presence of educated workers.

For each time t the government J maximizes the Ω_t^J subject to a balance constraint for each generation t. Furthermore, let us assume that the government decides independently by the positive externality of education of generation t for the future generations and that the balance constraint is binding.

So we have

$$s_t^{g,J}\left(1+r^*\right)\gamma_t^J = \left[a\left(\int_{e_t^{*J}}^{E} de_{i,t}\right)T_t^J\right]s_t^{g,J}. \tag{10}$$

The maximization program for the government is

$$\underset{T_t^J}{Max}\colon\ s_t^{g,J}\left[a\int_{e_t^{*gJ}}^{E} de_{i,t} - c\left(1+r^*\right) - a\right] + a. \tag{11}$$

The optimal value of the taxation T_t^{*J} (and indirectly, by the equation 10, the optimal value of the subsidies to educated) is

$$T_t^{*J} = 1 + \frac{\left[E - e_t^{*gJ}\right]}{\left[E - 2e_t^{*gJ}\right]}, \tag{12}$$

where

$$0 < T_t^{*J} < 1 \ \text{ if } \ e_t^{*gJ} > \frac{2}{3}E. \tag{13}$$

We can resume this first result with the following proposition.

Proposition 1 *When the number educated it is not high* $\left(e_t^{*gJ} > \frac{2}{3}E\right)$*, then exists a positive optimal level of taxation and, consequently, a positive level of educational subsidies. This optimal level is* $T_t^{*J} = 1 + \frac{\left[E - e_t^{*gJ}\right]}{\left[E - 2e_t^{*gJ}\right]}$.

3.1 Role of government and effects on the region's growth

To understand better the role of the government on the educational decisions of the agents, we have to compare how the welfare changes in presence of positive subsidies to education. In figure (2) we show graphically these changes.

In absence of government subsidies equation (3) becomes

$$e^{*J} = \frac{a + \left(1+r^*\right)c^{\max}}{a} \equiv e^{*0}. \tag{14}$$

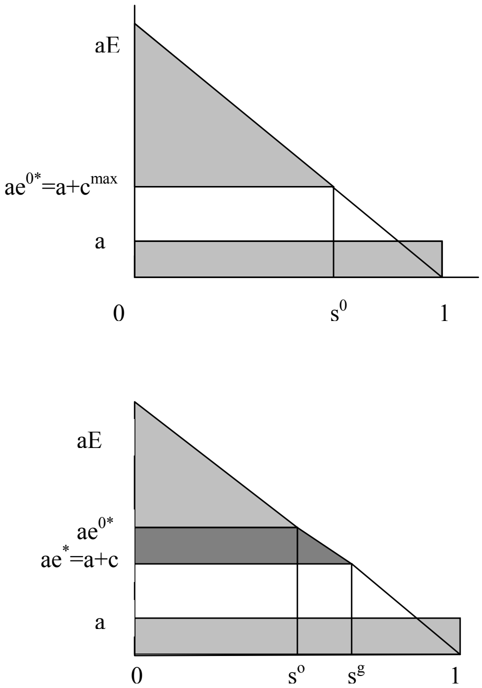

Figure 2: Autarchic case. Role of the educational subsidies on the welfare and on the number of educated workers.

Comparing expression (8) and (14) we have that

$$e^{*0} - e^{*gJ} = \frac{(1 + r^{*}) \left[c^{\max} - c\right]}{a} - \left[E - 2e^{*gJ}\right] T_t^{*J}. \tag{15}$$

By assumption $c^{\max} > c$ and, by the proposition 1, we know that there is positive taxation when $e^{*gJ} > \frac{E}{2}$. Then we can conclude that

$$e^{*0} > e^{*gJ} \text{ when } e^{*gJ} > \frac{E}{2}. \tag{16}$$

The equation (15) explains exactly the effect of an active role of the government. The first term shows the change due to the lower cost of the public education thanks the scale economies. It depends from the difference $(c^{\max} - c)$. When there is not difference between the public and private cost, this term disappeared. The second term shows the change due the presence of a proportional taxation to the educated. In this terms there is the redistributive role of the government that increases the educational costs for the agents with greater latent ability and decreases the costs for the agents with lower ability. In figure (3) are shown the effects of taxation on the individual income of the agents.

In Appendix we extend this static simplification of the model by defining a social welfare function that take in account the externalities linked to the education. In this extension, the optimal value of the taxation T_t^{*eJ} becomes

$$T_t^{*eJ} = T_t^{*J} - \frac{\frac{Z'(s_t^{g,J})}{a}}{\left(E - 2e_t^{*gJ}\right)} \tag{17}$$

In according to the economic intuition, when the government internalizes these positive externalities, then there is a greater level of taxation, a greater level of subsidies an so an increase in the number of educated workers.

The equation (15) becomes in this case

$$e^{*0} - e^{*gJ} = \frac{(1+r^*)\left[c^{\max} - c\right]}{a} - \left[E - 2e^{*gJ}\right] T_t^{*J} + \frac{Z'(s_t^{g,J})}{a}, \tag{18}$$

where the second term shows the change due the presence of the fact that the government take in account the positive externalities due to the education.

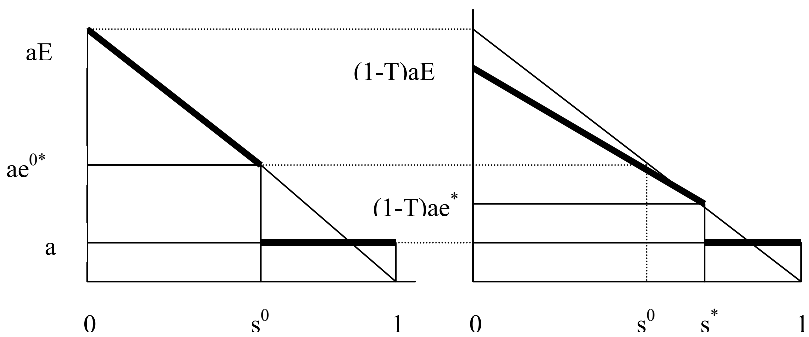

Figure 3: Effects of taxation on the individual income of the agents

In figure (2) is shown the effect of taxation on the welfare function. The government increases the number of educated workers by decreasing the education cost of the agents with lower latent ability and financing these subsidies by taxing more the agent with higher latent ability. When the number of educated workers increases, welfare and growth effects arise. Furthermore, if there are multiple steady state equilibria then the economy can move from a low to a high education steady state. The steady state of the two cases is shown in figure (4).

We can resume these results with the following proposition.

Proposition 2 *In presence of optimal taxation (proposition 1), the number of educated workers increases respect the case with zero educational subsidies. This increase is* $e^{*0} - e^{*gJ} = \frac{(1+r^*)[c^{\max}-c]}{a} - \left[E - 2e^{*gJ}\right] T_t^{*J}$

Corollary 3 *The increase in the number of educated, given in the proposition 2, identifies two different effects of a direct role of the government in the educational decisions. First, a decrease in the individual educational costs thanks the scale's economies of a public education. Second, a redistributive role of the government that decreases the educational costs for the worker with lower latent abilities.*

Corollary 4 *The increase in the number of educated workers implies an increase in the welfare and in the growth of the economy respect the case with zero educational subsidies.*

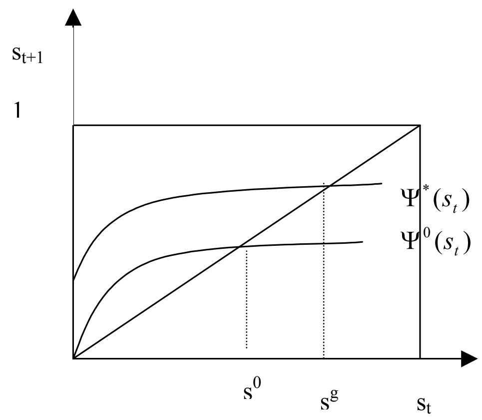

Figure 4: $\Psi^*(s_t)$ indicates the proportion of educated agents in autarkic case, when there is not migration and there are government's subsidies. $\Psi^0(s_t)$ indicates the proportion of educated agents in autarkic case,when there is not migration and there are not government's subsidies to educated.

4 Mobility case (full mobility - two regions)

Let us introduce in the model workers mobility. We examine the case in which only the educated agents can migrate (BD)[21]. We assume that there are only two regions A and B[22].

The timing of the model is the same of the Autarchic case. The only difference is that in time $t+1$ educated agents decide whether to migrate or not. They pay T_t to the government of the region in which they work and they repay the debt of the first period of the life.

It is possible to solve the government maximization problem through the BI method[23].

First, we solve the maximization problem of the agents at time $t+1$ and then we solve the maximization problem of government. In period t, the agent i chooses whether if educate himself or not given the government decisions about T_t^J and γ_t^J with $J = A, B$. The optimal decision for agent i, born in region J, is to invest in education if

$$\arg\max\left\{\left[1-T_t^J\right]a;\left[1-T_t^I\right]b\right\}e^i > a+\left(c-\gamma_t^J\right)(1+r^*) \tag{19}$$

where

$$\begin{aligned}\lambda\left(s_{t-1}^{g,J}\right)w &\equiv a\\ \lambda\left(s_{t-1}^{g,I}\right)w &\equiv b.\end{aligned}$$

Thus, all agents with a latent ability greater than e_t^{**g} invest in education, were e^{**} is uniquely defined by the following equality:

$$e_t^{**gJ}=\frac{a+\left(c-\gamma_t^J\right)(1+r^*)}{\arg\max\left\{\left[1-T_t^J\right]a;\left[1-T_t^I\right]b\right\}}. \tag{20}$$

The same result follows for agent i, born in region I,

$$e_t^{**gI}=\frac{b+\left(c-\gamma_t^I\right)(1+r^*)}{\arg\max\left\{\left[1-T_t^J\right]a;\left[1-T_t^I\right]b\right\}}. \tag{21}$$

[21] This hypothesis is compatible with the assumption that there are not mobility costs. The results do not change if we assume that the costs of mobility (transfers' costs, social costs, integration's costs, etc...) are very small for educated workers (closed to zero) and very high for non educated. It is furthermore possible extend the analysis to the case in which there are not educational requirement for emigration but becomes hard distinguish the BD aspects of the workers migration.

[22] It is possible, without changing the results, assume that the region B represents the rest of the Union and so the assumption that the region it is a small open economy is verified.

[23] See the Appendix for all the computation.

In this model we assume that for the educated agents there is not mobility costs so that educated workers decide whether migrate or not in response to different net wage that they receive. Their future wage is related to the taxation/subsidies policies of the governments and to the differences of technology between regions. It is straightforward to verify that the educated workers will prefer to stay in region J if

$$T_t^J < \eta + (1-\eta)\,T_t^I \tag{22}$$

where

$$\eta \equiv \frac{a-b}{a}.$$

Let us assume that $a \geq b$. We can therefore distinguish three different states of the world

Case (1) $T_t^J < \eta + (1-\eta)\,T_t^I$ all educated migrate in region J.
Case (2) $T_t^J > \eta + (1-\eta)\,T_t^I$ all educated migrate in region I.
Case (3) $T_t^J = \eta + (1-\eta)\,T_t^I$ there is no migration.

The three cases depicted in figure (5)

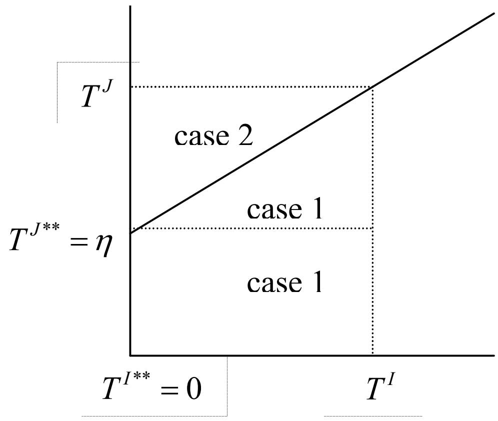

Figure 5: The three cases when a>b

The government. For each time t the government J maximizes the $\Omega_t^{M,J}$ subject to a balance constraint for each generation t.

We define $\Omega_t^{M,J}$

$$\Omega_t^{M,J} \equiv s_t^{J,J}\left[a\int_{e_t^{*J}}^{E} de_{i,t}\right] + s_t^{I,J}\left[b\int_{e_t^{*I}}^{E} de_{i,t}\right] - s_t^{J}\left[c\left(1+r^*\right)\right] + (1-s_t^{J})a \tag{23}$$

where $s_t^{J,J}$ is the number of agents which are educated in region J at time t and work in region J at $t+1$; $s_t^{I,J}$ is the number of agents which are educated in region I at time t and work in region J at time $t+1$ and $b = \lambda\left(s_{t-1}^{I}\right)w$ The first and the second terms on the right hand side of (23) denote the total production of region J due to the presence of educated workers. The third term corresponds to the education costs in region J. The fourth term corresponds to the productivity of non educated agents.

Furthermore, let us assume that the government decides independently by the positive externality of education of generation t for the future generations and that the balance constraint is binding.

So we have,

$$\left[\gamma_t\left(1+r^*\right)\right]s_t^{g,J} = \left[AT_t\right]s_t^{g,J} \tag{24}$$

where

$$A \equiv \frac{a}{s_t^{g,J}}\left(\int_{e_t^{**gJ}(T_t^J)}^{E} de_{i,t}\right)s_t^{g,J,J} + \frac{a}{s_t^{g,J}}\left(\int_{e_t^{**gI}(T_t^I)}^{E} de_{i,t}\right)s_t^{g,I,J}.$$

Let us now analyze the government's decision by using the BI for each different states of the world (See Appendix).

Case (1): Comparing the welfare functions, we have that

$$\begin{aligned}\Omega_t^{J**} &> \Omega_t^{J*} > \Omega_t^{J,0**}\\ \Omega_t^{I*} &> \Omega_t^{I,0**} > \Omega_t^{I**}\end{aligned} \tag{25}$$

where Ω_t^{J**} is the optimal value of the welfare function in the mobility case and where $T_t^{**J} > 0$, Ω_t^{J*} is the optimal value in the autarchic case and $\Omega_t^{J,0**}$ is the optimal value in the mobility case with zero taxation.

Case (2): Comparing the welfare functions we have

$$\begin{aligned}\Omega_t^{I**} &> \Omega_t^{I*} > \Omega_t^{I,0**}\\ \Omega_t^{J*} &> \Omega_t^{J,0**} > \Omega_t^{J**}.\end{aligned} \tag{26}$$

Case (3): We have the same results of the autarchic case.

$$\Omega_t^{**} = \Omega_t^{*} > \Omega_t^{0**}. \tag{27}$$

Comparing the (25), (26), and (27) it is straightforward see that, when , then the only Nash Equilibrium in this game is $\left[T_t^{**J} = \eta^*; T_t^{**I} = 0\right]$ when $a > b$ and $\left[T_t^{**J} = 0; T_t^{**I} = 0\right]$ when $a = b$. where $\eta^* = \eta - \varepsilon$, $\varepsilon > 0$ and $\varepsilon \to 0$.

The following proposition summarizes the results obtained in this section.

Proposition 5 *In presence of full mobility of educated agents, the only NE is zero taxation (and, consequently, zero subsidies) when the regions have the same initial technology ($a = b$). When the countries are asymmetric ($a > b \Rightarrow \eta > 0$), then the only NE is $\left[T_t^{**J} = \eta^*; T_t^{**I} = 0\right]$. Where η^* is the higher level of taxation sufficient to attract all the educated workers of the other region.*

Positive effects of the coordination

Let us assume that the two regions are member of an economic union like the EU so that the educated workers can migrate inside the union without impediments. Furthermore, let us assume that inside the Union there is a Central Authority (CA) and that may impose a coordination between taxation/subsidies policies of the regions. Let us analyse different coordination policies that can arise.

First, the CA can impose to each region the optimal level of subsidies and taxes that is chosen in the Autarchic case. This policy maximizes the welfare of all regions if the regions are symmetric, otherwise one of the three case described above arises and so there is a region that looses all is educated workers.

Second, the CA can impose a minimum level of taxation/subsidies ($T^{\min} > \eta$). This policy changes the play off of the game described above. The three cases are depicted in figure (6). The only NE becomes $\left[T_t^{**J} = T^{\min}; T_t^{**I} = T^{\min}\right]$. Also in this case when the regions are asymmetric this policy imply a lower welfare for the region lower productive that looses all educated workers.

Third, the CA can impose that the taxation/subsidies of the region more productive are proportional to the taxation of the lower productive region. If $T_t^J = \eta + (1 - \eta) T_t^I$, then the only NE becomes $\left[T_t^{**J} = \eta - (1 - \eta) T_t^{*I}; T_t^{**I} = T_t^{*I}\right]$ when $a > b$ and $\left[T_t^{**J} = T_t^{**J}; T_t^{**I} = T_t^{**I}\right]$ when $a = b$. It is straightforward see that this NE is a Pareto Improvement respect the NE obtained in absence of a CA. The new cases despised in figure (6).

This analysis can be extended without changing the results to a Union with most regions..

The results obtained in this section can be summarized by the following propositions.

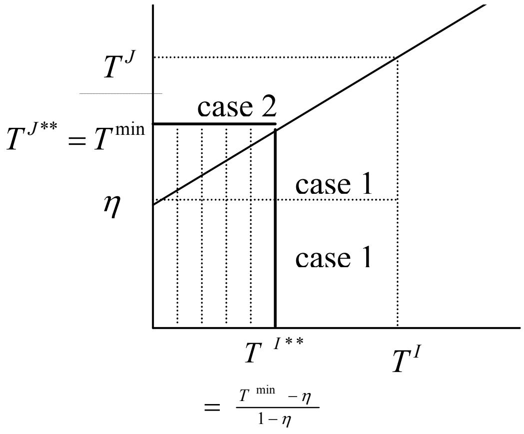

Figure 6: "Different technology scenario" with minimum tax specific for each region.

Proposition 6 *The presence of a Central Authority that is able to impose that* $T_t^J = \eta + (1-\eta) T_t^I$ *implies a new NE* $\left[T_t^{**J} = \eta - (1-\eta) T_t^{*I}; T_t^{**I} = T_t^{*I}\right]$. *This NE is Pareto Optimum respect the NE obtained in absence of CA.*

Corollary 7 *When the region are symmetric, then the new NE obtained implies the optimal level of taxation and subsidies chosen in the Autarchic Case.*

5 Mobility case (partial mobility-two regions)

Let us assume that there are only two regions U and N, where U is a representative State of the "Union"[24] and N is a new State that enters inside the Union[25]. Let us assume that the wage per efficiency unit of labor of this economy is always lower than the wage of region U independently of its fiscal policies and technology characteristics.

Let us assume that in the region N the mobility of its educated workers is not perfect but there is a probability of a successful emigration in the region U, π^U, that is independent of the number of workers who are eligible to migrate[26]. Furthermore, we assume that emigration policy is fully anticipated. We assume that $\pi < 1$ and that it is very small for workers of region N. This assumption can be justified by the presence of strong mobility costs (pecuniary and social). We assume that U can influence π^U by migration policies that remove this costs.

[24]Let us assume that there is no differences between the formes states of the Union.

[25]This analysis can be extended without changing the results to the new entry of most regions.

[26]This assumption follows from the small country hypothesis.

When there is a probability of emigrating and earning a higher wage, the agent's educational decision becomes an expected utility problem. For simplicity, we assume that agents are risk neutral, that only the educated workers can migrate and that all the other assumptions of the previous section are verified[27].

Let us define

$$\lambda\left(s_{t-1}^{N}\right)w^{N}\equiv w^{N} \tag{28}$$

as the wage rate per efficiency unit of labor for the educated of region N.

By assumption, in each period we have that

$$w^{U}>w^{N} \tag{29}$$

where

$$w^{U}\equiv\lambda\left(s_{t-1}^{U}\right)w^{U}\left[1-T_{t}^{U}\right]. \tag{30}$$

The optimal decision for agent i born in N will be to invest in education if

$$\left[\pi^{U}w^{U}+\left(1-\pi^{U}\right)\left(1-T_{t}^{N}\right)w^{N}\right]e^{i}>w^{N}+c\left(1+r^{*}\right). \tag{31}$$

Thus, all agents with a latent ability greater than e^{*N} will invest in education, were e^{*} is uniquely defined by the following equality:

$$e_{t}^{*N}=\frac{w_{t}^{N}+\left(1+r^{*}\right)\left[c-\gamma_{t}^{N}\right]}{\left[\pi^{U}w^{U}+\left(1-\pi^{U}\right)\left(1-T_{t}^{N}\right)w_{t}^{N}\right]}. \tag{32}$$

As in the previous analysis it is possible to identify the optimal level of taxation for the new entry:

$$T_{t}^{**N}=\frac{\left[E-e_{t}^{*N}\left(\frac{\pi^{U}w^{U}+(1-\pi^{U})w_{t}^{N}}{w_{t}^{N}}\right)\right]}{\left(1-\pi^{U}\right)\left[E-2e_{t}^{*N}\right]}+\frac{\left[E-2e_{t}^{*N}\right]}{\left(1-\pi^{U}\right)\left[E-2e_{t}^{*N}\right]} \qquad \text{for } \pi\neq 0$$

$$T_{t}^{**N}=0 \qquad \text{for } \pi=0. \tag{33}$$

When $\pi\rightarrow 1$ (full mobility case), then $T_{t}^{**N}\rightarrow 0$.

When $\pi\rightarrow 0$ (autarchic case), then $T_{t}^{**N}\rightarrow T_{t}^{*N}$,

where

[27] Same distribution of ability, same education costs, etc.

$$T_t^{*N} = 1 + \frac{\left[E - e_t^{*N}\right]}{\left[E - 2e_t^{*N}\right]} \tag{34}$$

is the optimal value of the taxation for the region N in the autarchic case.

The average proportion of educated people in the economy N is given by the following identity

$$s_t^N = \frac{\left(1-\pi^U\right)\int_{e_t^{*N}}^{E} g\left(e^i\right) de^i}{1-\pi^U \int_{e_t^{*N}}^{E} g\left(e^i\right) de}. \tag{35}$$

If $\pi = 1$ then the source economy loses all his educated workers and $s_t^N = 0$. If $\pi = 0$ then there is not migration inside the union. Thus, a sufficient condition for the existence of a positive level of BD such that the source economy benefits in terms of productivity is that $\frac{ds_t^N}{d\pi} > 0$ when $\pi = 0$. The optimal level of π will be given where $\frac{ds_t^N}{d\pi} = 0$. Differentiating equation (35) we obtain

$$\frac{ds_t^N}{d\pi} = \frac{\partial s_t^N}{\partial \pi} + \frac{\partial s_t^N}{\partial e_t^{*N}} \frac{\partial e_t^{*N}}{\partial \pi}, \tag{36}$$

where

$$\frac{\partial s_t^N}{\partial \pi} = -\frac{\int_{e_t^{*N}}^{E} g\left(e^i\right) de^i \left[1 - \int_{e_t^{*N}}^{E} g\left(e^i\right) de\right]}{\left[1-\pi^U \int_{e_t^{*N}}^{E} g\left(e^i\right) de\right]^2} < 0 \tag{37}$$

$$\frac{\partial s_t^N}{\partial e_t^{*N}} = -\frac{\left(1-\pi^U\right) g\left(e_t^{*N}\right)}{\left[1-\pi^U \int_{e_t^{*N}}^{E} g\left(e^i\right) de\right]^2} \tag{38}$$

$$\frac{\partial e_t^{*N}}{\partial \pi} = -\frac{\left\{w_t^N + (1+r^*)\left[c-\gamma_t^N\right]\right\}\left[w^U - \left(1-T_t^N\right) w_t^N\right]}{\left[\pi^U w^U + \left(1-\pi^U\right)\left(1-T_t^N\right) w_t^N\right]^2} < 0. \tag{39}$$

Setting $\pi^u = 0$ and noting that $\int_{e_t^{*N}}^{E} g\left(e^i\right) de^i \left[1 - \int_{e_t^{*N}}^{E} g\left(e^i\right) de\right]$ is at most a quarter, we obtain the results summarized by the following proposition.

Proposition 8 *If there are strong differences on the wage per efficiency unit of labor and there are imperfect mobility of educated workers, then a positive optimal level of BD emigration arise if* $g\left(e_t^{*N}\right) \frac{\left\{w_t^N+(1+r^*)\left[c-\gamma_t^N\right]\right\}\left[w^U-\left(1-T_t^N\right)w_t^N\right]}{\left[\left(1-T_t^N\right)w_t^N\right]^2} > \frac{1}{4}$ *and* $0 < T_t^N \leq T_t^{Max}$.

This proposition states that the source economy can benefit from the BD in the extent that there are a sufficient number of people who would be entitled to invest in education. The introduction of taxes and subsidies implies two different results. The subsidies increase the number of educated workers and so decrease the probability for the new entry to be in the "optimal BD conditions". Furthermore, the taxes increase the wage differentials between the entry region and the others and so increase the probability to gain from the BD.

The assumption that all the regions inside the Union are similar, it is equivalent to assume that there is a Central Authority that collects the migration policies of the regions inside the union and decides the optimal value of π^U for the region N, that $\pi = 1$ for the former regions and that $\eta = 0$.

Let us consider the case of uniformly distributed abilities

$$g\left(e^i\right) = \frac{1}{E} \tag{40}$$

$$\int_{e_t^{*N}}^{E} g\left(e^i\right) de^i = 1 - \frac{e_t^{*N}}{E} \tag{41}$$

$$\frac{ds_t^N}{d\pi} > 0 \text{ iff } \left(1-\pi^U\right) \frac{w^U - \left(1-T_t^N\right) w_t^N}{\pi^U w^U + \left(1-\pi^U\right)\left(1-T_t^N\right) w_t^N} > \left(1 - \frac{e_t^{*N}}{E}\right) \tag{42}$$

Thus, a BD will increase the proportion of educated people in the economy if π is low, if w^U is very high relative to $\left(1-T_t^N\right) w_t^N$ and if the proportion of educated people in the economy was previously low.

Equation (42) implies that when abilities are distributed uniformly, if w^U is large enough there is a positive level of π^U such that next period productivity increases in the source economy.

As in Mountford (1997), in presence of an optimal migration policy under a BD, the return function $s_t = \psi\left(s_{t-1}\right)$ is everywhere above the return function compared with the case of no emigration. Thus clearly an optimal emigration policy will increase the short and long run productivity in the source economy. Finally, if there are multiple steady state equilibria then a temporary emigration policy might lift a source economy from a low to a high education steady state.

The figure (7) despicts these results

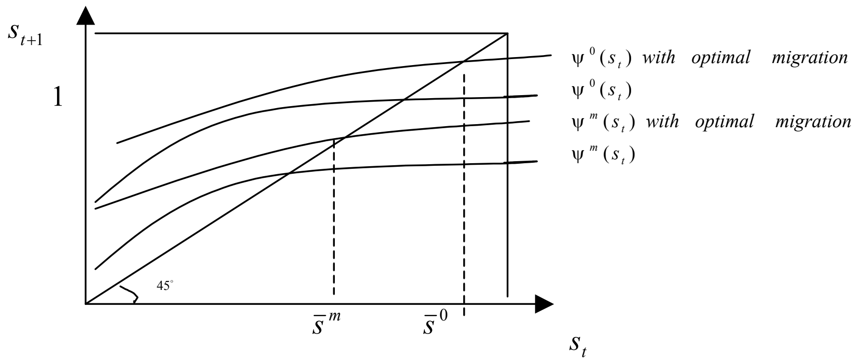

Figure 7: despicts the dynamics of the economy when there is a unique steady state equilibrium for the case where there is not migration and when there is optimal emigration (Ψ^0 is the case with optimal taxation and Ψ^m is the case without taxation).

6 Mobility case (partial mobility-three regions)

Let us assume that there are three regions A, B and N. Where A and B are former member of the Union and N is a new region that enters inside the Union. According the previous case, let us assume that when the new region (N hereafter) is admitted inside the union the mobility of its educated workers is not perfect but there is a probability of a successful emigration in the region J , π^J with $J = A, B$. Let us also assume that $\pi = 1$ for educated workers of the Union.

Let us assume that the wage per efficiency unit of labor of this economy is always lower than the wage inside the union independently of the specific fiscal policy and technology characteristics of each region inside the union.

Then, by assumption, in each period we have that

$$w^U > w^N \tag{43}$$

where

$$w^U \equiv \arg\max \left\{ \lambda \left(s_{t-1}^J \right) w^J \left[1 - T_t^J \right] ; \lambda \left(s_{t-1}^I \right) w^I \left[1 - T_t^I \right] \right\} \tag{44}$$

the best wage rate per efficiency unit of labor available inside the union.

The optimal decision for agent i born in N will be to invest in education if

$$\left[\pi w^U + (1 - \pi) \left(1 - T_t^N \right) w^N \right] e^i > w^N + \left(c - \gamma^N \right) (1 + r^*) \tag{45}$$

Let us assume that there is not a coordination between regions and that each region of the union decided independently the value of π maximizing his own welfare and do not take in account the welfare of the region N. Let us also assume that this value can not be higher than $\pi^{\max} < 1$. Then, we assume that $0 < \pi < \pi^{\max}$.

Let us define Ψ_t^J a measure of the welfare of region J.

$$\Psi_t^J \equiv \Omega_t^J + \Gamma(\pi^J) \quad \text{with } J, I = A, B \tag{46}$$

were $\Gamma(\pi^J)$ is the "brain drain gain" for the region J deriving by the attraction of educated workers of region N. We define

$$\Gamma(\pi^J) \equiv \pi^J s_t^{N,J} \left[\lambda \left(s_{t-1}^J \right) w \int_{e_t^{*N}}^{E} de_{i,t} \right] \tag{47}$$

Where $\pi^J s_t^{N,J}$ is the number of agents which are educated in region N at time t and work in region J at $t+1$.

It is straightforward to show that

$$\text{If } \pi^J a \left[1 - T_t^J\right] > \pi^I b \left[1 - T_t^I\right] \text{ then } \Gamma(\pi^J) = \pi^J s_t^N \left[a \int_{e_t^{*N}}^{E} de_{i,t} \right] \tag{48}$$

$$\text{and } \Gamma(\pi^I) = 0 \tag{49}$$

$$\text{If } \pi^J a \left[1 - T_t^J\right] < \pi^I b \left[1 - T_t^I\right] \text{ then } \Gamma(\pi^J) = 0 \tag{50}$$

$$\text{and } \Gamma(\pi^I) = \pi^I s_t^N \left[b \int_{e_t^{*N}}^{E} de_{i,t} \right] \tag{51}$$

we also assume that

$$\text{If } \pi^J a \left[1 - T_t^J\right] = \pi^I b \left[1 - T_t^I\right] \text{ then } \Gamma(\pi^J) = \frac{1}{2} \pi^J s_t^N \left[a \int_{e_t^{*N}}^{E} de_{i,t} \right]$$

$$\text{and } \Gamma(\pi^I) = \frac{1}{2} \pi^I s_t^N \left[b \int_{e_t^{*N}}^{E} de_{i,t} \right] \tag{52}$$

Let us assume the same timing defined before. Then, it is possible to solve the maximization problem through the BI method.

The optimal decision for agent i born in N is uniquely defined by e^{*N} (eq. 32)

For simplicity, we analyze only the optimal decision of government J and I about the value of π. Hence we focus our attention on the "migration competition" inside the union. It is straightforward see that all these analysis can be extended to the fiscal competition between the two regions without changing the results.

Each government of the union maximizes the value of $\Gamma(\pi)$ and it is straightforward see that, without coordination the only NE of this "migration competition" is

$$\pi^J = \pi^I = \pi^{\max} > \pi^U \tag{53}$$

The government N decides T_t and γ_t according to the optimal decision of the agents (eq. 32) and of the region inside the union (eq. 53). The presence of a Central Authority that collects migration policies of the region inside the union and decides the optimal value of π^U for the region N implies a "positive Brain Drain" when we are in the condition delineated in the proposition (7). Differently, when there is not coordination, then there is a "migration competition" between the governments inside the union which involves in a value of $\pi > \pi^U$, the value of π is too high to have positive externalities from BD also for the region N. In this case the BD had negative effect on the growth of the region N and their optimal decision is to have zero subsidies. This result is most important when the new entry region is required to have standard in the growth to remain in the Union. The CA can help the New region to do not decrease its growth, indeed the competition between the former region implies positive effects for these ones in the short period but in the long period have negative effects for the Union because the poorest countries can not satisfy the standard required.

7 Conclusion

In this paper we introduce a role for the government in the educational decisions of the agents through the introduction of educational subsidies and taxation. This make it possible to study BD and FC in a unified framework and analyze the impact of the absence of coordination inside the EU.

In Section 3, we solve the model in an "autarchic context" and we obtain the optimal level of taxation and subsidies [Proposition 1]. This optimal level implies an increase in the number of educated workers [Proposition 2]. Furthermore, this increase implies lower educational costs [Corollary 3] and an increase in the growth of the region [Corollary 4].

In Section 4, we solve the model in a "full mobility context" where there is perfect migration of the educated worker inside a Union. The FC among the regions destroyed the positive externalities due to the subsidies. According to the literature, the FC causes a fall in the provision of public goods. Lower taxation and lower educational subsidies arise [Proposition 5]. The presence of a Central Authority which coordinates the fiscal policies, it is necessary to obtain a new NE that is Pareto Optimum respect the NE obtained without coordination.[Proposition 6]. Finally, when the regions are symmetric, then the new NE is the same obtained in the autarchic case.[Corollary 7].

In Section 5, we solve the model in a "partial mobility case" where there is a new entry inside the Union. If the mobility of the educated workers of the new entry is not perfect and can be influenced by the "migration policies" of the former members of the Union. Then, It is possible identify same circumstances in which the migration of educated worker does not imply negative externalities for the sending region. [Proposition 8]. These circumstances implies the so called "Brain Gain". In Section 6, we analyse the absence of coordination between the former regions inside the union. This absence implies a "migration competition". The former region tries to attract educated workers of the new entry. This competition implies positive effects for these ones in the short period but in the long period have negative effects for the Union because the poorest countries must quit the union.

Extensions of the model

The model presented in this paper can be extended in order to analyze different economic and political analyses.

1. We can introduce a "mobility cost" for the educated workers. This cost can be not only referred to the pecuniary costs directly linked to the migration (transport, new house, etc.) but also it can be referred to the "non pecuniary cost" indirectly linked to the migration (live in a new nation, different language, etc.). The introduction of this costs do not change the main results obtained in this paper but there are some important results:

    - The more are the "mobility cost", the lower is the role of FC.

- While the "pecuniary cost" are normally similar between the different regions, on the contrary the "non pecuniary costs" can be very different and they can be directly influenced by the policies of the government. These differences may increase or decrease eventually technology's differences and so the FC and BD externalities. Furthermore, by decreasing these costs, the government of the former region inside the EU can try to attract the educated workers of the new entry (migration competition).

2. We can introduce a "enlarged role of the government". In this paper we have analyzed a government which do not take in account redistribution income policies. If we consider a new version of the social welfare function that the government want maximize then we have other important results:

   - The FC implies not only lower provision of public good but also lower income redistribution. This results, in according to the FC literature, is due to the fact that each government decreases the tax in order to attract the educated worker and so it must decrease the income redistribution.
   - If we analyze the redistribution policies, then we must take in account also the "non educated" migrations. The risk to attract many non educated workers implies lower income redistribution and so increase the negative externalities of the FC.

3. We have analyzed the impact of the FC and BD when the new entry region has just decided to be in the EU. It is also possible enlarge this analysis by studying a new step in which the new entry decides even if it is convenient be a member of the EU.

4. We can substitute the assumption that the abilities of children are independent from the abilities of their parents with the assumption of externalities of education of the precedent education. In this case we obtain a more realistic model with more rich dynamics and we increase the negative externalities due to the FC. Otherwise, the main results showed before do not change.

8 Appendix

Autarchic Case (fixed costs) The maximizations for the government is

$$\underset{T_t^J}{Max}: \; s_t^J \left[a \int_{e_t^{*gJ}}^{E} de_{i,t} - c\left(1+r^*\right) - a \right] + a$$
$$\text{sub to } \gamma_t^J = \frac{a}{(1+r^*)} \left(\int_{e_t^{*J}}^{E} de_{i,t} \right) T_t^J.$$

The First Order Condition is

$$Foc(T_t^J) : \frac{\partial s_t^{g,J}}{\partial T_t^J} \left[a \int_{e_t^{*gJ}(T_t^J)}^{E} de_{i,t} - c^g\left(1+r^*\right) - a \right] + s_t^{g,J} \left(-a \frac{\partial e_t^{*g,J}}{\partial T_t^J} \right) = 0.$$

By $\frac{\partial s_t^{g,J}}{\partial T_t^J} = -\frac{\partial e_t^{*g,J}}{\partial T_t^J} g\left(e_t^{*g,J}\right)$and by the optimal value of e^{*gJ} equation the FOC becomes

$$-a \frac{\partial e_t^{*g,J}}{\partial T_t^J} \left\{ g\left(e_t^{*g,J}\right) \left[\int_{e_t^{*gJ}(T_t^J)}^{E} de_{i,t} \left(1 - T_t^J\right) - \left(1 - T_t^J\right) e^{*gJ} \right] + s_t^{g,J} \right\} = 0$$

The optimal value of the taxation T_t^{*J} is

$$T_t^{*J} = 1 + \frac{\left[E - e_t^{*gJ}\right]}{\left[E - 2e_t^{*gJ}\right]}$$

Where $0 < T_t^{*J} < 1$ if $\frac{E}{2} < e_t^{*gJ} < E - 1$.

Autarchic case (variable costs) In the initial statement of the model we have assumed that when the government subsidizes the education than lower educational costs arise thanks scale's economies. Let us now introduce a new specification of the educational costs that take in account this effect. Let us define g a parameter which captures the scale economies of a public education. Where $g > 0$ and $\gamma_t \in \left[0, \gamma^{\max} = \frac{c}{1-g}\right]$.

$$\begin{cases} c^p = c - (1+g)\gamma_t \\ c^g = c - g\gamma_t. \end{cases} \tag{54}$$

Then e^* is uniquely defined by the following equality:

$$e^{*J} = \frac{a + (1+r^*)\left[c - (1+g)\gamma_t^J\right]}{\left(1 - T_t^J\right) a}.$$

The government's objective function is

$$\Omega_t^{A,J} \equiv s_t^J \left[\lambda\left(s_{t-1}^J\right) w \int_{e_t^{*gJ}}^{E} de_{i,t} - \left(c - (1-g)\gamma_t\right)(1+r^*) - a\right] + a.$$

The maximizations for the government is

$$\underset{T_t^J}{Max} : s_t^J \left[a \int_{e_t^{*gJ}}^{E} de_{i,t} - \left(c - g\gamma_t\right)(1+r^*) - a\right] + a$$

$$\text{sub to } \gamma_t^J = \frac{a}{(1+r^*)} \left(\int_{e_t^{*J}}^{E} de_{i,t}\right) T_t^J.$$

The First Order Condition is

$$Foc(T_t^J) : \frac{\partial s_t^{g,J}}{\partial T_t^J} \left\{ a \int_{e_t^{*gJ}(T_t^J)}^{E} de_{i,t} - \left[c - g\gamma_t^J\right](1+r^*) - a \right\} +$$
$$+ s_t^{g,J} \left[-a \frac{\partial e_t^{*g,J}}{\partial T_t^J} + ga \left(\int_{e_t^{*J}}^{E} de_{i,t}\right) - ga \frac{\partial e_t^{*g,J}}{\partial T_t^J} T_t^J \right] = 0.$$

By $e^{*J} = \frac{a+(1+r^*)\left[c-(1+g)\gamma_t^J\right]}{\left(1-T_t^J\right)a}$ and by $\frac{\partial s_t^{g,J}}{\partial T_t^J} = -\frac{\partial e_t^{*g,J}}{\partial T_t^J} g\left(e_t^{*g,J}\right)$, the FOC becomes

$$\left(1 - T_t^J\right) \int_{e_t^{*gJ}(T_t^J)}^{E} de_{i,t} - \left(1 - T_t^J\right) e^{*gJ} + \frac{s_t^{g,J}\left(1 + gT_t^J\right)}{g\left(e_t^{*g,J}\right)} +$$
$$- \frac{s_t^{g,J} g \int_{e_t^{*gJ}(T_t^J)}^{E} de_{i,t}}{\frac{\partial e_t^{*g,J}}{\partial T_t^J} g\left(e_t^{*g,J}\right)} = 0,$$

$$T_t^J = 1 + \left[- \frac{s_t^{g,J} g \int_{e_t^{*gJ}(T_t^J)}^{E} de_{i,t}}{\frac{\partial e_t^{*g,J}}{\partial T_t^J} g\left(e_t^{*g,J}\right)} \right] \left[\left(E - 2e_t^{*gJ}\right) + \frac{s_t^{g,J} g}{g\left(e_t^{*g,J}\right)} \right]^{-1}.$$

The optimal value of the taxation T_t^{*J} is

$$T_t^{*J} = 1 + \left(-\frac{g\left(E - e_t^{*gJ}\right)^2}{\frac{\partial e_t^{*g,J}}{\partial T_t^J}} \right) \left[E\,(1+g) - e_t^{*gJ}\,(2+g) \right]^{-1} \tag{55}$$

where

$$T_t^{*J} < 1 \ \text{ if } \ e_t^{*gJ} > \frac{E\,(1+g)}{(2+g)}. \tag{56}$$

Comparing e^{*0} and e^{*gJ} we have that

$$e^{*0} - e^{*gJ} = (1+g)\left[E - 2e^{*gJ}\right] T_t^{*J}.$$

By assumption $g > 0$, then

$$e^{*0} > e^{*gJ} \text{ when } e^{*gJ} > \frac{E}{2}. \tag{57}$$

According with the economic intuition, higher g higher is the increase in the number of educated workers respect the case without subsidies. Furthermore, when g increase then the optimal level of taxation and of subsidies increase.

Mobility Case (full mobility - two regions) Let us solve the Mobility Case by the BI method.

The government maximization problem is for the region J

$$\underset{T_t^J}{Max}: \ s_t^{g,J,J}\left[a\int_{e_t^{**gJ}}^{E} de_{i,t}\right] + s_t^{g,I,J}\left[b\int_{e_t^{**gI}}^{E} de_{i,t}\right] - s_t^{g,J}\left[c\,(1+r^*)\right] + $$
$$+(1-s_t^{g,J})a$$
$$\text{sub to}: \ (1+r^*)\,\gamma_t^J = AT_t^J$$

where

$$A \equiv a\left[\frac{\left(\int_{e_t^{**gJ}(T_t^J)}^{E} de_{i,t}\right)s_t^{g,J,J} + \left(\int_{e_t^{**gI}(T_t^I)}^{E} de_{i,t}\right)s_t^{g,I,J}}{s_t^{g,J}}\right]$$

$$B \equiv b\left[\frac{\left(\int_{e_t^{**gI}(T_t^I)}^{E} de_{i,t}\right)s_t^{g,I,I} + \left(\int_{e_t^{**gJ}(T_t^J)}^{E} de_{i,t}\right)s_t^{g,J,I}}{s_t^{g,I}}\right].$$

Let us now analyze the government's decision by using the BI for each different states of the world when $a > b$.

Case (1): $T_t^J < \eta + (1-\eta)\, T_t^I$ We have that $s_t^{g,J,J} = s_t^{g,J}$; $s_t^{g,I,J} = s_t^{g,J}$ and $s_t^{g,I,I} = s_t^{g,J,I} = 0$.

The maximization problem of the government J becomes

$$\underset{T_t^J}{Max}: \; s_t^{g,J}\left[a\int_{e_t^{**gJ}}^{E} de_{i,t} - c\,(1+r^*) - a\right] + s_t^{g,I}\left[a\int_{e_t^{**gI}}^{E} de_{i,t}\right] + a$$
$$\text{sub to}: \; (1+r^*)\,\gamma_t^J = AT_t^J.$$

The (20) and the (21) become

$$e_t^{**gJ} = \frac{a+(1+r^*)\,c - AT_t^J}{\left[1-T_t^J\right]a} \leq e_t^{*gJ} < e_t^{**0J}$$

$$e_t^{**gI} = \frac{b+(1+r^*)\,c}{\left[1-T_t^J\right]b} \geq e_t^{**0I} > e_t^{*gI}.$$

The First Order Condition is

$$Foc(T_t^J): \frac{\partial s_t^{g,J}}{\partial T_t^J}\left[a\int_{e_t^{*+gJ}(T_t^J)}^{E} de_{i,t} - c\,(1+r^*) - a\right] + s_t^{g,J}\left(-a\frac{\partial e_t^{**g,J}}{\partial T_t^J}\right) = 0.$$

Computing the FOC we obtain

$$g\left(e_t^{*g,J}\right)\left[\left(1-T_t^J\right)\left(\int_{e_t^{*gJ}(T_t^J)}^{E} de_{i,t} - e^{*gJ}\right) - \frac{s_t^{g,I}\left(\int_{e_t^{**gI}(T_t^I)}^{E} de_{i,t}\right)}{s_t^{g,J}}T_t^J\right] +$$
$$+ s_t^{g,J} = 0,$$
$$\left(1-T_t^J\right)\left(\left[E-e_t^{*gJ}\right] - e^{*gJ}\right) - \frac{s_t^{g,I}\left[E-e_t^{*gI}\right]}{s_t^{g,J}}T_t^J + \frac{s_t^{g,J}}{g\left(e_t^{*g,J}\right)} = 0,$$
$$\left[\left[E-2e_t^{*gJ}\right] + \frac{s_t^{g,I}\left[E-e_t^{*gI}\right]}{s_t^{g,J}}\right]T_t^J = \left[E-2e_t^{*gJ}\right] + \left[E-e_t^{*gJ}\right].$$

The optimal value of the taxation T_t^{**J} is

$$T_t^{**J} = 1 + \frac{s_t^{g,J}\left[E-e_t^{*gJ}\right] - s_t^{g,I}\left[E-e_t^{*gI}\right]}{s_t^{g,J}\left[E-2e_t^{*gJ}\right] + s_t^{g,I}\left[E-e_t^{*gI}\right]} < T_t^{*J},$$

where

$$T_t^{**J} < 1 \text{ if } e_t^{*gJ} > \frac{E}{2} + \frac{s_t^{g,I}\left[E - e_t^{*gI}\right]}{2s_t^{g,J}}.$$

For region I, the maximization problem in case (1) becomes

$$\begin{aligned} &\underset{T_t^I}{Max}: \ s_t^{g,J}\left[-c\left(1+r^*\right)\right] + \left(1 - s_t^{g,J}\right)a \\ &\text{sub to}: \left(1+r^*\right)\gamma_t^J s_t^{g,J} = 0 \text{ or } \gamma_t^J = 0. \end{aligned}$$

It is easy to verify that the maximization is solved by

$$T_t^{**I} = 0$$

where $T_t^{**I} < T_t^{*I}$ and where the subsidies are zero.
Comparing the region gains we have that

$$\begin{aligned} \Omega_t^{J**} &> \Omega_t^{J*} > \Omega_t^{J,0**} \\ \Omega_t^{I*} &> \Omega_t^{I,0**} > \Omega_t^{I**}. \end{aligned}$$

Case (2): $T_t^J > \eta + (1-\eta)\,T_t^I$ It is symmetric to the case (1), so we have

$$\begin{aligned} s_t^{g,I,I} &= s_t^{g,I}; s_t^{g,J,I} = s_t^{g,J} \\ s_t^{g,JJ} &= s_t^{g,I,J} = 0, \end{aligned}$$

$$\begin{aligned} e_t^{**gI} &= \frac{b + (1+r^*)\,c - BT_t^I}{\left[1 - T_t^I\right]b} \leq e_t^{*gI} < e_t^{**0I} \\ e_t^{**gJ} &= \frac{a + (1+r^*)\,c}{\left[1 - T_t^J\right]b} \geq e_t^{**0J} > e_t^{*gJ} \end{aligned}$$

and

$$\begin{aligned} T_t^{**I} &= 1 + \frac{s_t^{g,I}\left[E - e_t^{*gI}\right] - s_t^{g,J}\left[E - e_t^{*gJ}\right]}{s_t^{g,I}\left[E - 2e_t^{*gI}\right] + s_t^{g,J}\left[E - e_t^{*gJ}\right]} < T_t^{*I} \\ T_t^{**J} &= 0. \end{aligned}$$

Comparing the welfare functions we have

$$\begin{aligned} \Omega_t^{I**} &> \Omega_t^{I*} > \Omega_t^{I,0**} \\ \Omega_t^{J*} &> \Omega_t^{J,0**} > \Omega_t^{J**}. \end{aligned}$$

Case (3): $T_t^J = \eta + (1-\eta)\, T_t^I$ This is the autarchic case. The solutions are:

$$\begin{gathered} s_t^{g,I,I} = s_t^{g,I} \; ; \; s_t^{g,J,I} = s_t^{g,J} \; ; \; s_t^{g,J,J} = s_t^{g,J} \; ; \; s_t^{g,I,J} = s_t^{g,J} \\ A = a \; ; \; B = b \\ e_t^{**gJ} = e_t^{*gJ} \; ; \; e_t^{**gI} = e_t^{*gJ} \\ T_t^{**I} = T_t^{*I} \; ; \; T_t^{*J} = T_t^{**J}. \end{gathered}$$

We have the same results of the autarchic case

$$\Omega_t^{**} = \Omega_t^{*} > \Omega_t^{0**}.$$

Autarchic and Mobility Case with externalities To simplify the model, we assumed that each government chooses the optimal value of taxes and subsidies that maximize the direct productivity gain deriving from the education.

It is possible extend this static simplification of the model by defining $\Omega_t^{A+} \equiv \Omega_t^A + Z(s_t^J)$ where $Z(\cdot) \geq 0$, $Z(0) = 0$ and $Z'(\cdot) > 0$. The new term is an increasing function of the number of educated agents and denotes all the other gains (not only pecuniary) that the presence of educated gives to region J. In this terms can be aggregate the positive externalities that the number of educated in period t imply to the other generations. It is possible demonstrate that the results obtained in this case do not change more respect simple case analyzed in the model.

In the Autarchic case the maximizations for the government is

$$\begin{gathered} \underset{T_t^J}{Max}: \; s_t^J \left[a \int_{e_t^{*gJ}}^{E} de_{i,t} - c\,(1+r^*) - a \right] + a + Z(s_t^J) \\ \text{sub to } \gamma_t^J = \frac{a}{(1+r^*)} \left(\int_{e_t^{*J}}^{E} de_{i,t} \right) T_t^J. \end{gathered}$$

The First Order Condition is

$$Foc(T_t^J): \frac{\partial s_t^{g,J}}{\partial T_t^J} \left[a \int_{e_t^{*gJ}(T_t^J)}^{E} de_{i,t} - c^g\,(1+r^*) - a \right] + s_t^{g,J} \left(-a \frac{\partial e_t^{*g,J}}{\partial T_t^J} \right) + \\ + Z'(s_t^J) \frac{\partial s_t^{g,J}}{\partial T_t^J} = 0.$$

The optimal value of the taxation T_t^{*eJ} is

$$
\begin{aligned}
T_t^{*eJ} &= 1+\frac{\left[E-e_t^{*gJ}\right]}{\left[E-2e_t^{*gJ}\right]}-\frac{\frac{Z'(s_t^{g,J})}{a}}{\left(E-2e_t^{*gJ}\right)} \\
&= T_t^{*J}-\frac{\frac{Z'(s_t^{g,J})}{a}}{\left(E-2e_t^{*gJ}\right)}
\end{aligned}
$$

where $0 < T_t^{*J} < 1$ if $e_t^{*gJ} > \frac{E}{2}$ and $e_t^{*gJ} > E - \frac{Z'(s_t^{g,J})}{a}$.

In according to the economic intuition, when the government internalizes these positive externalities, then there is a greater level of taxation, a greater level of subsidies an so an increase in the number of educated workers.

In the Mobility case we have $\Omega_t^{M',J} \equiv \Omega_t^{M',J} + Z(s_t^{J,J} + s_t^{I,J})$ where $Z(\cdot) \geq 0$, $Z(0) = 0$ and $Z'(\cdot) > 0$.

The maximizations for the government is

$$
\begin{aligned}
\underset{T_t^J}{Max}:\ & s_t^{g,J,J}\left[a\int_{e_t^{**gJ}}^{E} de_{i,t}\right]+s_t^{g,I,J}\left[b\int_{e_t^{**gI}}^{E} de_{i,t}\right]-s_t^{g,J}\left[c\left(1+r^*\right)\right]+ \\
& +(1-s_t^{g,J})a+Z(s_t^{J,J}+s_t^{I,J}) \\
& \text{sub to}:\ \ (1+r^*)\,\gamma_t^J = AT_t^J.
\end{aligned}
$$

It is possible demonstrate that the results obtained in this case do not change more respect simple case analyzed in the model.

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