CeGE-Discussion Paper

17

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GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

Januar 2003

ISSN 1439-2305

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Abstract

A very prominent instrument of regional policy is to foster education and human capital formation in economically lagging regions. However, this type of regional policy might actually hurt instead of help the recipient areas. The reason is that individual geographical mobility increases with the personal skill level. Through education subsidies, particularly if targeted on relatively high skilled workers, individuals can cross some threshold level of qualification beyond which emigration pays off. Regional policies then result in a human capital flight harmful to individuals remaining in the economic periphery. This fatal result does not hold for policies that focus on the relatively low skilled.

Keywords: Regional Policy, Education Subsidies, Human Capital, Labour Mobility, European Union

JEL-classification: H 3, F 4, R 1

*) This paper has been presented at the CeGE Research Workshop on January 20, 2003, at the workshop "Current Developments in Regional Research", organized by the Hamburg Institute of International Economics (HWWA), and at the workshop "European Integration, Regional Convergence, Location of Industrial Activity and Labour Market Adjustment", organized by the Centre for European Integration Studies (ZEI), Bonn. The author thanks the participants of these workshops, in particular John Bradley, Gianmarco Ottaviano and Peter Ruehmann, for several very useful comments and discussions. Of course I remain responsible for all remaining errors and shortcomings.

1) Introduction

Many federal governments conduct regional policies, i.e. they aim to reduce spatial inequalities of real incomes and living standards within an integrated economic area. One of the most notable cases is the European Union, where roughly one third of the yearly budget is spent to achieve regional economic and social cohesion. The fear is that without corrective policy interventions regional asymmetries and "core-periphery-divides" might be strengthened that endanger the coherence of the European Union as such. Economic theory is underpinning this anxiety through approaches like endogenous growth theory or ´new economic geography´, which are telling that the free market mechanisms alone might not render regional convergence like neoclassical theories imply. Quite contrarily, these models predict the emergence and reinforcement of regional inequalities through cumulative and circular causation mechanisms.

One of the most prominent political strategies to support backward areas is to foster education and human capital formation of the local workforce. The European Commission devotes roughly 30 per cent of all resources transferred to the poor, peripheral ´objective 1´-regions to promote training and education activities. The underlying reasoning is straightforward: with better developed skills, productivity will rise, innovation activities are strengthened, and sooner or later the recipient areas will catch up with the rest of the European community.

The performance of European regional policy in the past, however, has been mixed at best (Boldrin/Canova, 2001; Martin, 1999b; Faini, 1995). Despite the considerable quantitative effort, a regional convergence process was absent over the last decade. If anything, there was rather a process of regional divergence unravelling in the EU-15, in which the main recipient areas of structural funds fell further apart economically (Giannetti, 2002). A natural task for economists is to ask, why regional policies have delivered so poorly.

Theoretical explanation have been offered in the literature for the weak performance of regional infrastructure policies (see Puga, 2002; Martin, 2000, 1999a,b, 1998; Martin/Rogers, 1995). These authors show that an improvement of interregional traffic networks between core and periphery can actually hurt the lagging areas, because it fuels the relocation of mobile business towards the developed centres. This does then not lead to the desired convergence process, but rather to the exact opposite. In other words, regional infrastructure policy

must be interpreted as a failure judged on the basis of its own intentions. Empirical support for this point of view has been provided by Faini (1983) and Combes/Lafourcade (2001).[1]

In this paper, we look at the other typical instrument of structural funding in the EU, education oriented regional policy, from a comparable perspective. Our central point is to show that this type of policy might also actually hurt instead of help the economic periphery. The underlying logic hinges on the interrelation of individual skill level and geographical mobility. It is well established that mobility increases with the personal level of human capital (see Gianetti, 2001; Hunt, 2000; Mauro/Spilimbergo, 1999). One simple theoretical rationale for this stylised fact that will also play a crucial role in our model is that the agglomeration wage premium is higher for skilled than for unskilled labour (Moeller, 2002), whereas approximately identical mobility costs accrue to all types of workers.[2] Now consider the role of regional policies designed to promote the skills of people from poor regions. The education subsidies induce young individuals to invest more heavily in human capital. At the end of the education period, however, they might have acquired enough skills in order to cross some threshold level beyond which migration to the economic centres pays off. This migration choice, or in general the location decision of single agents, affects others through (pecuniary) externalities. This is why workers left behind in the peripheral region suffer from the brain drain that has been induced by regional policies.

If on the other hand the recipient group of education subsidies is chosen such that training does not increase emigration, regional policies can in fact deliver a closing income difference between centre and periphery. There can thus be a case for focussing education subsidies on the relatively low skilled workers in the backward areas, since they are more distant towards geographical mobility.

The framework we use to illustrate our point is an OLG-model with heterogeneous agents who endogenously decide on education. The consumer side is modelled in a similar way as in Haque/Kim (1995), who analyse the growth impacts of brain drain in developing countries. But we adopt a technology that is characterised by localized increasing returns to scale. This

[1] Faini (1983) has argued that the infrastructure improvements between Northern and Southern Italy in the 1950s have led to a de-industrialisation of the Mezzogiorno, as many firms found it now profitable to shift production to the more efficient northern regions. Combes/Lafourcade (2001) report a similar finding for the case of France: the reduction in spatial transaction costs that was estimated to amount to 38% between 1978 and 1993 led to a higher concentration of production and employment.

[2] This requires come comment. One could argue that the mobility costs of skilled people with high personal incomes are higher, maybe due to a preference for more sophisticated housing. On the other hand, mobility costs can be the interpreted in a wider sense as capturing all sorts of "psychic costs" that arise when changing locations: costs to adapt to new cultural environment, costs of establishing new social networks, costs of gathering information about local market conditions etc. These costs are supposedly lower for high skilled labour, and therefore the assumption of skill invariant relocation costs seems reasonable on balance.

assumption is made in order to work within an environment where endogenous forces exist that push for spatial agglomeration of economic activity. The prevalence of such centripetal tendencies is apparently presumed by the architects of EU regional policy.[3] Furthermore, it has become quite common in economic theory to work with models that allow for endogenous agglomeration channels when addressing regional and spatial issues (Ottaviano/Tabuchi/Thisse, 2002). We consider an integrated economic area consisting of two regions. Since regional policy almost by definition is only pursued if there are real economic disparities between spatial units, we assume that one region is initially poorer than the other. This ´objective 1´-region receives structural funding in form of education subsidies mandated by a federal government authority (the EU commission) that collects taxes in the rich core region for the financing. At first we will only model the poor peripheral region explicitly in section 3, and take the economic variables of the core as exogenously given. After having described the equilibrium in section 4, we derive the spatial implications of an increase in the discretionary interregional transfers in section 5. Note that we do not intend to analyse *why* these transfers exist.[4] Instead, we are only interested in the spatial consequences of this type of regional policy. Afterwards we generalize our model in section 6 by endogenising the economic variables of the core region. Section 7 provides a conclusion of our main results with respect to the pervasiveness of education oriented regional policy, and addresses potential policy conclusions. But before we come to our theoretical model, we first briefly summarize the working of EU-regional policy and some aspects of the corresponding academic debate in section 2.

2) Regional policies and its spatial effects: An overview

The EU-Commission has a very particular strategy to achieve spatial equity, summarized in the Second Cohesion Report (EU Commission, 2001:117)

[3] See e.g. the important Delors-report: "Historical experience suggests […] that in the absence of countervailing policies, the overall impact [of more economic integration] on peripheral regions could be negative. Transport costs and economies of scale would tend to favor a shift in economic activity away from less developed regions, especially if they were at the periphery of the Community, to the highly developed areas at its center." (Delors, 1989. cited after Boldrin/Canova, 2001)

[4] More specifically, we do not address the issue why regional policy is implemented against the background of the voting and decision making procedures in the European Union. We also abstract from any other policy measure that subordinate governments might pursue and focus exclusively on the discretionary interregional transfers mandated by the federal government authority. Yet, we do not model this government as a benevolent social planner that aims to maximize total welfare for the integrated economic area as a whole by means of interregional transfers. The reason is that we subscribe to the conventional view, described in greater detail in section 2, that there is no convincing economic case for regional policies based on efficiency considerations. We therefore take the existence of the transfers for granted and focus exclusively on their spatial consequences.

> "*The Treaty [of the European Community], by making explicit the aim of reducing disparities in economic development, implicitly requires that EU policies, and cohesion measures in particular, should influence factor endowment and resource allocation and, in turn, promote economic growth. More specifically, cohesion policies are aimed at increasing investment to achieve higher growth and are not specifically concerned either with expanding consumption directly or with redistribution of income*."

Thus, Brussels does not satisfy itself by redistributing income through fiscal transfers. It rather explicitly tries to influence the spatial resource allocation in order to reduce agglomeration of economic activity. The funds available to pursue this goal are substantial. In the time period 2002-2006, an amount of 213 billion € is spent for cohesion policy, from which 64% are used for interventions under ´objective 1´. Since EU-funding is only available as an additional source of financing for specific projects, the true amount of resources transferred to the economic periphery is actually understated by the above number, as typically the national governments of the single member countries also contribute. Eligible areas for ´objective 1´ are NUTS II-regions with a GDP per capita below 75% of the community's average. This comprises exclusively the remote areas at the outside boarders of EU-15: nearly all of Greece, Spain and Portugal as well as Southern Italy, East Germany, the Burgenland (AT), as well as parts of the UK and Ireland.[5] In total, remarkable 22% of the total EU-population are covered under ´objective 1´-funding.[6]

Structural interventions in these regions have three broad priorities. About 35% of the ´objective 1´ funds are spent on the improvement of infrastructure with a special focus on interregional transportation networks. Direct subsidies to firms located in the periphery are of decreasing importance, but also still amount to 35%. The remaining share is spent to promote education, with a special emphasis on promoting rather sophisticated skills compatible with the "information society" and with new technologies (Guersent, 2001). The short- and medium-run goals of regional policies can roughly be described as trying to enhance the regional productivity level and thereby foster investment and growth in the recipient areas. In view of mobile factors of production, the Commission is trying to guide factors to settle, or respectively to remain in the periphery.

[5] Northern Finland and Northern Sweden are also covered under objective 1 despite of having a per capita income well above 75% of the EU average. This exception is being made, because they are considered "extremely remote areas".

[6] This illustrates how pronounced regional differences are within the EU. If an identical policy would be conducted in the US, the eligible regions would only make up for 2% of the American population (Puga, 2002).

As many authors have pointed out, such a policy is questionable given the theoretical models that motivate regional policies in the first place. If the EU-Commission thinks that the regional divergence theories with increasing returns, localised spillovers etc. are an appropriate description of reality, it is unclear why it should try to offset or hinder agglomeration. If increasing returns are at work, spatial concentration is efficient since production costs are saved on aggregate (Boldrin/Canova, 2001; Martin, 1999a; Fujita/Thisse, 1996). Moreover, agglomeration and growth tend to be mutually reinforcing processes, so that an asymmetric distribution of economic activity also tends to increase growth (Martin/Ottaviano, 2001; Quah, 1997), and to lower aggregate unemployment (Suedekum, 2002a). An efficiency oriented policy would therefore allow for agglomeration or even subsidize it, and subsequently redistribute the gains through income transfers (Suedekum, 2002b). EU regional policies on the other hand end up in a trade-off between efficiency and regional equity (Martin, 2000, 1999b), as the interventions that retain production in the periphery invoke efficiency losses at the pan-European level. The conventional result is thus that one can not make a convincing economic case for regional policies.[7]

However, even if one accepts that regional policy can not be defended on normative grounds as a welfare improving policy intervention, and if one acknowledges that it are really equity or political considerations on which the very existence of regional policies is grounded, the list of problematic aspects is not over yet. It was pointed out already in the introduction that there exist additional problems. Infrastructure oriented regional policies that intend to achieve less agglomeration and more territorial equity can, through secondary market adjustments, effectively result in their exact opposite. As we will show in this paper, a similar point can be made for the case of education oriented regional policies. Their potential failure is also based on secondary adjustments that policymakers in reality might not be fully aware of..

3) The Model

Let the peripheral region in our model be labelled as r = 1, whereas the core region is named r = 2. In this section, we will only model region r = 1 explicitly and take all economic variables of the economic centre as exogenously given.

[7] One should note that recently Ottaviano/Thisse (2002) have presented a model where markets produce over-agglomeration, and consequently a government should lower the equilibrium degree of spatial inequity from a normative point of view. However, at the moment this result should be seen as a distinct theoretical possibility originating in assumptions on properties of the utility function.

3.1. Consumers

Region r = 1 is populated by two generations of heterogeneous agents. For simplicity we abstract both from output and population growth, and assume that in each period a new generation of size L_1 is born. Young and old individuals in both regions are endowed with one unit of non-leisure time. The young can invest in human capital by devoting time to education. Investments pay off in the old age period by expanding the available effective time budget that is then solely used for working. The learning productivity differs across individuals of each generation depending on personal characteristics denoted by η^i. There are no financial markets and hence no savings in the model, so that the education choice is the only means for consumption smoothing. Individuals born in region 1 are tied to their location of birth during young age. They can not move to the rich core region at the beginning of their lifetime. However, it is possible to emigrate after the first period and to spend the second lifetime period in the core region 2. Interregional labour migration imposes mobility costs that are equal for all individuals regardless of their personal ability level.

For simplicity, we work with a logarithmic utility function with a time discount rate β. The regional superscript $s = \{1,2\}$ denotes the residence region of the individual at old age. Lifetime utility $U^{i,rs}$ is given by

$$U^{i,1s} = \log c_{t,t}^{i,1s} + \beta \log c_{t,t+1}^{i,1s} \quad , \tag{1}$$

where $c_{t,t+1}^{i,1s}$ denotes consumption of some individual i born at time t in region 1 and residing in region $s = \{1,2\}$ at time t+1. $\ell_t^{i,1s}$ is the time fraction devoted to education during young age. There are no direct costs of education, but only opportunity costs for foregone earnings.

Since region 1 is considered eligible for structural funding from the federal government, the individuals receive an education subsidy. For simplicity we only consider linear subsidies δ proportional to the schooling time. Subsidies are financed through taxes in the rich region 2. With these assumptions, the budget constraints can be written as

$$c_{t,t}^{i,1s} = w_{1,t}(1-\ell^{i,1s}) + \delta \ell^{i,1s} \tag{2}$$

$$c_{t,t+1}^{i,1s} = w_{s,t+1}(1+\eta^i \ell^{i,1s}) - m_{1s} \tag{3}$$

The variables $w_{1,t}$ and $w_{s,t+1}$ denote the after-tax wages per effective labour unit devoted to work in the respective region and time period. We denote the gross unit wage in region s by $W_{s,t+1}$ and the (proportional) income tax rate by φ_s. Since income is taxed only in the core region, we can write $w_{s,t+1} = (1-\varphi_s) W_{s,t+1}$ and impose φ_1=0. The gross unit wage of region 2 is

assumed to be sufficiently high to ensure a higher net unit wage in the economic centre than in the periphery.[8] Mobility costs m_{1s} arise only for individuals who choose to leave region 1 after the first period of life.

$$m_{1s} = \begin{cases} 0 & if\ s = 1 \\ m > 0 & if\ s = 2 \end{cases} \tag{4}$$

The individual simultaneously decides on the amount of education and the old age residence region at the beginning of period t. Utility maximization with respect to $\ell^{i,1s}$ yields the following first-order-condition

$$\frac{c_{t,t+1}^{i,1s}}{c_{t,t}^{i,1s}} = \beta\eta^{i}\,\frac{w_{s,t+1}}{w_{1,t}-\delta} \quad . \tag{5}$$

Together with the budget constraints (2) and (3), the optimal education choice can be computed as

$$\ell^{i,1s} = \frac{\beta}{1+\beta}\Phi_1 \; - \; \frac{1-(m_{1s}/w_{s,t+1})}{\eta^{i}(1+\beta)} \quad , \tag{6}$$

where $\Phi_1 = \frac{w_{1,t}}{w_{1,t}-\delta} \geq 1$ is a measure of how intensively education is subsidized for individuals from region 1.

Proposition 1. *$\ell^{i,1s}$ increases with η^{i}, m and δ, it decreases with $w_{s,t+1}$, and it is greater if $s = 2$ than if $s = 1$.*

An evaluation of (6) shows that more able people spend more time on education than individuals with a low learning efficiency η^{i}. Education subsidies δ induce individuals to devote more time to schooling. Interestingly, individuals who plan to emigrate after period t (m_{rs}=m) ceteris paribus demand more education than do people who are going to remain in the same region in t+1 (m_{rs}=0). The anticipation of future emigration already induces stronger educational attainment today, which is an argument close to Stark/Helmenstein/Prskawetz (1997).
By substituting (6) into the budget constraints, we can compute the optimal consumption paths for given residence choices. An individual who remains in region 1 during t+1 will reveal the following consumption profile

[8] Note that this assumption rules out migration flows from the centre to the periphery.

$$c_{t,t}^{i,11} = w_{1,t}\left(\frac{1+\eta^i-\delta/w_{1,t}}{\eta^i(1+\beta)}\right)$$

$$c_{t,t+1}^{i,11} = \beta w_{1,t+1}\left(\frac{1+\eta^i-\delta/w_{1,t}}{(1+\beta)(1-\delta/w_{1,t})}\right)$$

If she spends her second lifetime period in region s=2, the consumption path is

$$c_{t,t}^{i,12} = w_{1,t}\left(\frac{1+\eta^i-\delta/w_{1,t}-m\,J^{i,12}}{\eta^i(1+\beta)}\right)$$

and $$c_{t,t+1}^{i,12} = \beta w_{2,t+1}\left(\frac{1+\eta^i-\delta/w_{1,t}-m\,J^{i,12}}{(1+\beta)(1-\delta/w_{1,t})}\right),$$

where $J^{i,12} = \left(1-\frac{\delta}{w_{1,t}}\right)\left(\frac{1}{w_{2,t+1}}\right)$.

Obviously, not only education activity, but also consumption in both periods differs depending on the old age residence choice that is anticipated in the first period of the lifetime. By inserting these consumption levels in the utility function (1), we can compute individual i's utility levels for the case that she remains in her original location ($U^{i,11}$), and for the case of emigration ($U^{i,12}$).

$$U^{i,11} = \log\left(\left[1+\eta^i-\delta/w_{1,t}\right]^{1+\beta} w_{1,t+1}{}^{\beta}\ \mathrm{K}^{i,12}\right) \qquad (7)$$

$$U^{i,12} = \log\left(\left[1+\eta^i-\delta/w_{1,t}-m\,J^{i,12}\right]^{1+\beta} w_{2,t+1}{}^{\beta}\ \mathrm{K}^{i,12}\right)$$

where $\mathrm{K}^{i,12} = w_{1,t}\left(\frac{1}{\eta^i(1+\beta)}\right)\left(\frac{\beta}{(1+\beta)(1-\delta/w_{1,t})}\right)^{\beta}$.

Any individual i will reside in that location during old age that offers the higher utility level for given net unit wage rates $w_{1,t+1}$ and $w_{2,t+1}$. By equating $U^{i,11}$ and $U^{i,12}$ we find after some manipulation the level of personal ability η^i at which an individual is indifferent between migrating and remaining in region r=1 *for given unit wages*

$$\tilde{\eta}^i = \frac{1}{\Phi_1}\left(\frac{m/w_{2,t+1}}{1-\omega}-1\right) \qquad (8)$$

where $\omega_1 = \left(w_{1,t+1}/w_{2,t+1}\right)^{\frac{\beta}{1+\beta}}$ is a measure of region 1's relative net unit wage. It can be shown that individuals with personal ability below $\tilde{\eta}^i$ derive higher utility from remaining in the original location of birth ($U^{i,11} > U^{i,12}$), whereas individuals with ability larger than $\tilde{\eta}^i$ are better of spending their second lifetime period in region 2. Thus, (8) can be understood as the theoretical value of the *cut-off ability level* beyond which migrating to region 2 is more attractive than staying in region 1.

What fraction of each generation L_1 has learning abilities larger than $\tilde{\eta}^i$ is a matter of the distribution of learning skills. Suppose that η^i is uniformly distributed across the L_1 individuals in the range [1;d], i.e. the least talented individual (indexed i=0) can not expand her effective labour units through education, whereas the average learning efficiency is 1+d/2. With this distribution, the fraction μ of each generation L_1 that is going to remain in region 1 is given by

$$\mu = \frac{1}{d}\left(\tilde{\eta}^i - 1\right) \qquad (9)$$

From (9) it can be seen that emigration is attractive to a smaller fraction of the population (i.e. μ is larger), the higher is the regional unit wage $w_{1,t+1}$ relative to region 2, the higher are mobility costs m and the lower is the education subsidy δ.

3.2. Production

We now turn to the production side of this economy, which is characterised by localized agglomeration economies in spirit of Ethier (1982). There is a single final consumption good Y_r which is produced in both regions $r = \{1, 2\}$ without direct use of labour by assembling a large number of symmetrical intermediate inputs X_r. We assume that there is perfect competition in the Y-sector and that the final good can be traded freely across space. This implies that there is price equalization on the market for Y across regions. Without loss of generality we can use the price p^Y as the numeraire and normalize it to one. This construction has been proposed in the trade model of Matusz (1996) and offers a great deal of analytical simplification.

Unlike the final good Y_r, intermediate inputs are assumed to be non-tradable. For the production of Y_r in region r=1, only local intermediates X_1 can be used. The production function is given by a symmetrical CES function

$$Y_1 = \left(N_1 (X_1)^{\theta} \right)^{1/\theta} \qquad \text{with } 0 < \theta < 1 \text{ [9]} \qquad (10)$$

N_1 indicates the number of intermediates available in region 1. Due to symmetry, one can write down the following minimum cost function for producing one unit of Y_1.

$$G_1 = \left(N_1 (p_1)^{\frac{\theta}{\theta-1}} \right)^{\frac{\theta-1}{\theta}} \qquad (11)$$

p_1 is the price for one of the symmetrical intermediates. The function G_1 is decreasing in N_1. As put by Matusz (1996), this is "intended to capture Adam Smith's notion that output is increasing in the division of labour", because an increase in N_1 represents the deeper partition of a specific production task into more narrowly defined sub steps.

The production of the single intermediate inputs is done by small, monopolistically competitive firms that use labour only. The requirement of labour units necessary to produce the quantity X_r of an intermediate good is given by

$$\varsigma_1 = a + bX_1 \qquad \textit{with } a>0,\ b>0 \qquad (12)$$

Note that the labour requirement ς_1 is for effective labour units, not for people working. Due to the fixed input requirement a, and the unlimited number of potential varieties in the X-sector, every single intermediate will be produced by only one firm and thus N_1 also indicates the number of active firms in region 1. Following Dixit/Stiglitz (1977) we say that each firm is small relative to the market. We can then abstract from strategic interactions and apply the Chamberlinian "large group" assumption according to which profit maximizing prices are a constant mark-up over marginal costs, $p_{1,t} = \frac{b}{\theta} w_{1,t}$.

The firm's profits are driven down to zero by the entry of potential competitors, i.e. $\pi_1 = p_{1,t} X - w_{1,t} (a + bX_1) = 0$. Without loss of generality we choose units such that $b=\theta$. It follows that profit maximizing prices $p_{1,t}$ are equal to the unit wage rate $w_{r,t}$. And by using (12), we can rewrite the zero profit condition in the X-sector as

$$X_1 = \varsigma_1 = \frac{\alpha}{1-\theta} \qquad (13)$$

All X-firms in either region are operating at the same scale of output, which in our case is identical to the demand for effective labour units per firm. Note however, that firm sizes can

[9] The parameter θ is a measure of the differentiability of single intermediate inputs. If θ is close to one, they are nearly perfect substitutes. Rearranging yields $\sigma = 1/(1-\theta)$, the elasticity of substitution between single varieties.

very well differ with respect to the number of employed persons, as a firm does not care if it employs one worker with ς embodied labour units or ς workers with one labour unit each. The maximum number of intermediates that can be produced in region r is restricted by labour supply. Let $S_{1,t}$ denote labour supply at time t. The number of firms and varieties is then simply

$$N_{1,t} = \frac{S_{1,t}}{X} = \frac{(1-\theta)}{\alpha} S_{1,t} . \qquad (14)$$

It is now straightforward to compute the equilibrium remuneration per labour unit $w_{1,t}$. Since the price for the final consumption good is given with $p^Y=1$, unit costs G_1 must also adjust to one in order to ensure zero profits in the Y-sector. By (11), this implies that

$$w_{1,t} = W_{1.t} = \left(N_{1,t}\right)^{\frac{1-\theta}{\theta}} = \left(\frac{1-\theta}{a} S_{1,t}\right)^{\frac{1-\theta}{\theta}} \qquad (15)$$

As can be seen, the equilibrium (unit) wage $w_{1,t}$ is an increasing function of effective regional labour supply $S_{1,t}$. The intuition for this result is the following: with more labour in region 1, more intermediate inputs can be produced and the technology for producing Y_1 becomes more sophisticated. Unit costs G_1 decline, while the sales price p^Y remains unchanged. Temporary profits arise in the Y-sector in region 1 that induce producers to enter the market. Prices for intermediates X_1 are competed up, and by the zero profit condition for the X-sector these higher prices must be completely absorbed by higher unit remunerations. Note that (15) must not be confused with the personal income of an individual i, which is given by the unit wage multiplied with the effective labour units offered in either period. Thereby, talented workers of course have higher income levels than unskilled workers. Note further that in (15) we have established a purely regional pecuniary externality. The regional unit wage only depends on the effective labour supply in region 1, not on the scale of the other region.

3.3 Labour supply

The crucial variable in this model is the regional labour supply $S_{1,t}$, which not only depends on the population size in region 1, but also on the education and migration choices of the individuals. Labour supply at time t consists of the number of labour units that the two generations offer. For the young generation with size L_1 this is the amount of time that they do not devote to education. The old generation only has the size μL_1, since the $(1-\mu)L_1$ most talented workers spend their old age in region 2. Recall that members of the young generation reveal different educational behaviour depending on their old age residence choice. Labour supply in region 1 can be written as

$$S_{1,t} = \int_{i=0}^{\mu L_1} (1-\ell_t^{i*,1}) + \int_{i=\mu L_1}^{L_1} (1-\ell_t^{i*,2}) + \int_{i=0}^{\mu L_1} (1+\eta^i \ell_{t-1}^{i*,1})$$

or

$$S_{1,t} = (1+\mu)L_1 + \int_{i=0}^{\mu L_1} \ell^{i*,1}(\eta^i - 1) - \int_{i=\mu L_1}^{L_1} \ell^{i*,2} \qquad (16)$$

The first term in (16) represents the pure population size that is constant in steady state when μ is at its equilibrium level. The second term are the net returns to education of those who remain in region 1 during both periods. The third term indicates the costs for region 1 that arise because later emigrants do not use their entire time budget for working. From (16) it can be seen that labour supply $S_{1,t}$ increases with μ for several reasons. Firstly, because the pure population mass is larger the fewer people migrate to region 2. Secondly, because more people realize the returns to education in region 1. And thirdly, because fewer opportunity costs arise in region 1 for educating people whose private and social returns will be realized elsewhere.

It also becomes clear that the linkage that runs from labour supply to equilibrium remunerations in (15) can represent both a pure scale effect and a human capital externality: $S_{1,t}$ and thereby $w_{1,t}$ can be high either because many people are around ("agglomeration wage premium"), or because they embody a high number of labour units. A final important thing to note is that skilled workers gain more in absolute terms from these regional linkages, since they embody a higher number of labour units to which (15) applies.

3.4. Government

To close the model, we finally have to describe government's behaviour. The government in our model is a federal authority with only one objective: It collects income taxes in region 2 to subsidize education in region 1, i.e. it pursues education oriented regional policies. The government's budget constraint can be written as

$$\varphi_2 \, S_{2,t} \, W_{2,t} = \delta \left(\int_{i=0}^{L_1} \ell_t^{i,1s} \right) \qquad (17)$$

4) Equilibrium

In this section we derive the spatial equilibrium allocation of workers (μ*). For the time being we will treat the wage in the core region r = 2 as an exogenous parameter $\bar{w}_{2,t+1}$, and we assume that it does not change with μ.[10]

The equations (8) and (15) together establish a cumulative causation mechanism in this model. In section 3.1. we have derived the fraction (1-μ) of each generation L_1 that leaves home after the first period of lifetime. This fraction is larger, the lower is the unit wage rate in region 1 relative to region 2. On the other hand, in section 3.2. it has been shown that the equilibrium unit wage in region 1 decreases the lower is labour supply. Put differently, people leave if wages are low, and wages are low if people leave. This circular logic in particular applies to individuals with strong learning capabilities η^i. Their emigration has a stronger bearing on region 1, firstly because they have demanded a high amount of education during young age. At time t+1, when the investment pays off both privately and socially, the high skilled workers leave the small region, which consequently foregoes the positive linkages that originate in their human capital.

In figure 1 this cumulative logic is represented by two equilibrium relations between μ and the wage rate $w_{1,t}$ for given parameter values $\bar{w}_{2,t+1}$, m, δ and θ. This graphical approach offers the essential insights of this section and is thus chosen for expositional purposes.[11] The locus V_0V_1 is derived from (9), the optimal residence choice based on consumers' utility maximization. It shows the fraction μ as a function of $w_{1,t}$ and for given parameter values. The positive slope represents the result derived from (9) that μ is increasing in ω. The locus R_0R_1 represents the technological relation (15) and depicts equilibrium unit wage $w_{1,t}$ as a function of labour supply $S_{1,t}$, which is endogenously increasing in μ.

Within the feasible range $\mu \in \{0;1\}$ the adjustment mechanisms in this system work as following: for points above (below) the R_0R_1 schedule, the wage $w_{1,t}$ is too high (low) for any given value of μ. Using the zero profit condition described in section 3.2. the wage must realign such that it is consistent with the equilibrium locus R_0R_1. This determines the phase ar-

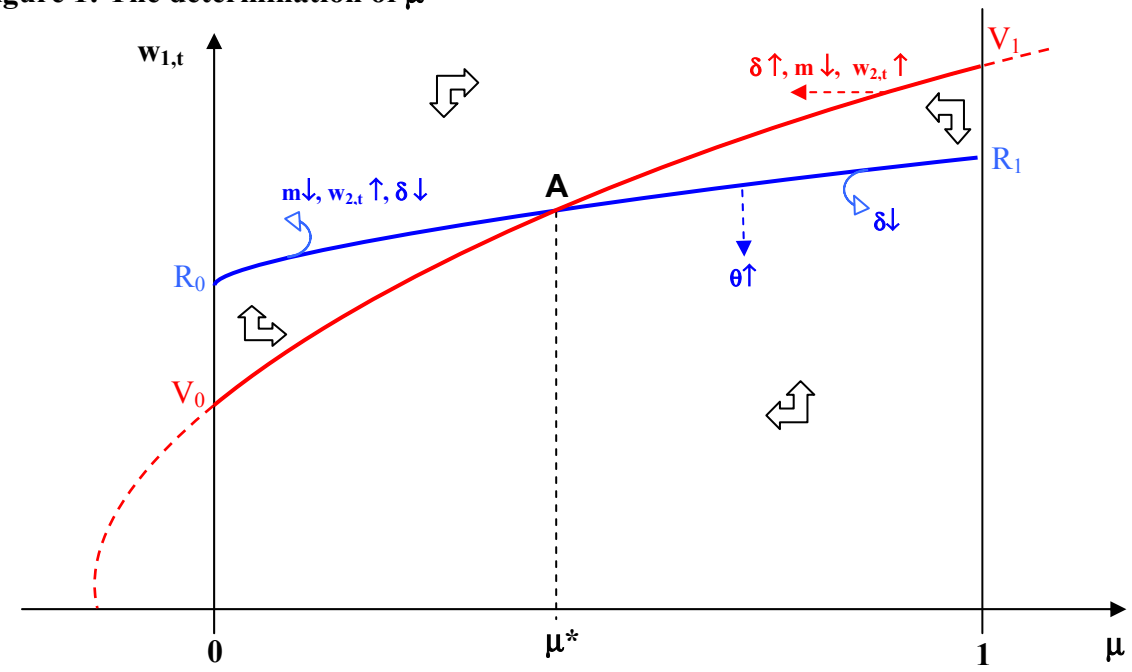
[10] The net wage in region 2 must be higher than the gross wage in region 1 even if μ=1. If region 2 has the same technology as region 1, this higher wage $w_{2,t}$ must be due to an sufficiently higher effective labour supply $S_{2,t}$ that would even endogenously increase as workers immigrate from the small region 1. We come back to this issue in section 6.

[11] An exact analytical expression of μ* can be obtained by plugging (15) and (16) into (9). This yields the following expression that only depends on exogenous parameters, and that in principle can be solved for μ*:

$$\mu = \frac{1}{d\Phi_1}\left((m/\bar{w}_{2,t+1}) \Big/ \left[1 - \left[\frac{1-\theta}{a} S_{1,t}(\mu) \right]^{\frac{1-\theta}{\theta}} / \bar{w}_{2,t+1} \right] - 1 \right) - \frac{1}{d}$$

rows in the vertical direction. Similarly, for points to the right (left) of V_0V_1, μ is too high (low) for any given wage $w_{1,t}$. Individuals can still increase lifetime utility through changing locations, and migration will occur until μ is consistent with V_0V_1.

Figure 1: The determination of μ^*



As long as V_0V_1 is steeper than R_0R_1, which will be the only case we consider throughout, there is a unique and stable equilibrium at point A with a spatial equilibrium configuration μ^*.[12] This μ^* is consistent both with efficient production and with optimal residence choice. The system in figure 1 can now be used to analyse the impact of various parameter changes on μ^*, out of which a change in δ is of particular interest and will be analysed in the next section. But before it is also instructive to look at the comparative statics of changes in m, $w_{2,t}$ and θ.

Changes in θ are most easy to analyse, since only the R_0R_1 locus is affected. The parameter θ reflects the differentiability of the single intermediate inputs in region 1 and can be understood as an inverse measure of the degree of increasing returns in this region. The higher is θ, the lower is the equilibrium wage $w_{1,t}$ for any given value of μ. The curve R_0R_1 shifts down as θ increases, which implies that μ^* is a decreasing function of θ. There is thus more population drain from region 1 the less important are the localized increasing returns.

[12] in the other case with R_0R_1 steeper than V_0V_1 the system is characterised by dynamic instability of μ^*, and will in general be driven towards a corner solution.

A change in the (exogenous) wage $\overline{w}_{2,t}$ affects both curves in figure 1. The impact on V_0V_1 is obvious: if the attainable wage in region 2 increases, the incentive to leave home after the first period is larger for given values of $w_{1,t}$ and m. The curve V_0V_1 is shifted to the left. The curve R_0R_1 is also affected, because education demand and thereby labour supply change. This can be seen best by considering the following: the point R_1 shows the equilibrium wage $w_{1,t}$ if nobody of the young generation L_1 will emigrate after the first lifetime period ($\mu=1$). This wage can be computed as $w_{1,t} = \left(\frac{1}{X} \left[2L_1 + \int_{i=0}^{L_1} \ell^{i*,1}(\eta^i - 1) \right] \right)^{(1-\theta)/\theta}$, which is independent of $\overline{w}_{2,t}$.

Yet, at all other points along the R_0R_1 schedule, any given fraction of later emigrants $(1-\mu)L_1$ will spend less time on education as $\overline{w}_{2,t}$ increases. This consequently increases labour supply of later emigrants during their young age in region 1 and thus has positive impacts on wages $w_{1,t}$ for any given value of μ. Graphically, an increase in $\overline{w}_{2,t}$ implies a clockwise rotation of R_0R_1 around the point R_1. The net effect of an increase in $\overline{w}_{2,t}$ on μ^* is thus theoretically ambiguous.

A similar point applies to changes in the parameter m, the level of mobility costs. V_0V_1 shifts to the left as migration barriers are removed, because emigration is more attractive for given values of $w_{1,t}$ and $\overline{w}_{2,t}$. But again, as shown in proposition 1, a decrease in m implies a reduction in the education demand of later emigrants, thereby an increase in labour supply and thus a clockwise rotation of R_0R_1 around R_1. Supposedly (given our numerical simulations) the "direct" effect on V_0V_1 will dominate over the effect on R_0R_1 that originates in the individuals' intertemporal substitution, but theoretically the other possibility can not be excluded.

5) The effect of education oriented regional policies

How does an increase in δ affect the two equilibrium loci in figure 1? The immediate effect of higher education subsidies is an increase in education demand of *all* L_1 individuals regardless where they are going to live in the time period t+1.[13] This has drawbacks both on labour supply as well as on the equilibrium residence choice.

The effect of more education on labour supply is ambiguous and depends on the range of μ. If μ is high, i.e. if a large fraction of the L_1 young individuals remains in region 1, the consoli-

[13] From evaluating (6) it can be seen that $\frac{\partial \ell^{i,1}}{\partial \delta} = \frac{\partial \ell^{i,2}}{\partial \delta}$, i.e. the effect of an increase in subsidies on the optimal learning time does itself not depend on the residence choice for the second time period.

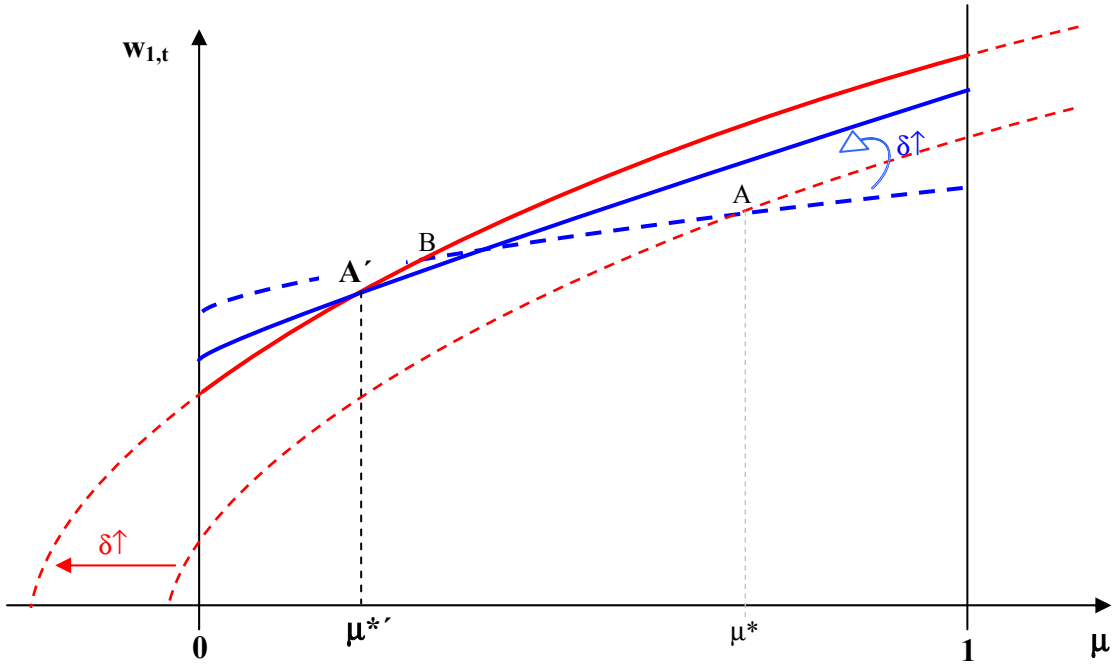
dated impact on effective labour supply is positive. The time used for education by the young is overcompensated by the returns to it during old age.[14] This latter effect weakens as μ gets lower. If the returns to education are largely realized elsewhere, an increase in education demand of the young generation results in lower overall labour supply $S_{1,t}$. Graphically the R_0R_1 locus in figure 1 is stretched in the counter-clockwise direction, as the point R_1 on the axis shifts upwards, whereas R_0 is shifted down.

The second effect of an increase in δ is a shift of the curve V_0V_1 to the left. At any level of $w_{1,t}$, a larger fraction $(1-\mu)$ of the generation L_1 crosses the threshold level of qualification beyond which emigrating to region 2 yields a higher lifetime utility. The intuition here is the following: any individual has stronger incentives to devote time to schooling upon receiving more education subsidies. Simultaneously, however, the individual who will embody a higher number of effective labour units during old age now also has a stronger incentive to move to the region that offers the higher unit labour remuneration, i.e. region 2.

The net effect of an increase in δ can be seen graphically in figure 2. Prior to the regional policy intervention the equilibrium has been at point A, with a spatial configuration μ^*. Afterwards the new equilibrium is at A´ with a lower value $\mu^{*\prime}$ and also a lower equilibrium unit remuneration $w_{1,t}$. This implies that the education oriented regional policy effectively has led to more emigration, and to a lower equilibrium wage for each labour unit that is supplied by individuals in region 1. In figure 2, which is of course just a graphical example for one particular parameter constellation, this final result is compounded of two complementary forces pushing in the same direction. Taking the shift of V_0V_1 alone, i.e. only considering the labour mobility effect of the regional policy, the new equilibrium would be at point B. Yet, the "bad news" for region 1 are still amplified by the rotation of the R_0R_1 curve, which is stemming from the alternation of optimal education and labour supply decisions. Put differently, region 1 suffers from the regional policy not only because more people will leave once it is possible. Additionally, the prospective emigrants also reduce labour supply and devote more time to schooling in order to "prepare" better for their old age in region 2. This higher education demand of later emigrants is solely a burden for region 1, since it does not receive any of the returns associated with it.

[14] This can be seen in (16): with μ large enough, the second term is greater than the third.

Figure 2: An increase in δ



For regional policy there is an interesting implication to be drawn. Apparently the individuals who remain in the recipient region suffer especially if μ is low to begin with. Recall that the reaction of labour supply $S_{1,t}$ on a change in δ depends on the range of μ. If μ is close to one, the policy shock δ↑ induces an overall increase in labour supply. This is then counteracting the other effect, the shift of V_0V_1, and not complementing it. Hence, the actual effects of regional policy seem to be particularly problematic for the poorest, most lagging regions (like e.g. Greece or Southern Portugal) with a low initial value of μ, and not so much for the advanced candidates within the group of ´objective 1´-regions.

In case the shift of the V_0V_1-locus is small, which is the case when individuals are particularly reserved towards migration, the overall effect of an increase in δ is determined by the reaction of the R_0R_1-curve. If in the relevant area the curve rotation is upwards, then the intended objective, an increase in the unit wage level of region1, might actually be achieved. Put differently, the actual and the intended effects of public policies deviate less if the degree of factor mobility is low. With labour mobility, however, secondary effects exist that run counter to the political intentions. The important insights of this section are finally summarized in the following proposition 2

Proposition 2. *An increase in δ leads to lower values of μ* and $w_{1,t}$ if labour is sufficiently mobile. The reaction is stronger, the lower is the initial value of μ.*

5.1. Policy alternatives

Intuitively, regional policies aiming to improve the living standards of region 1 by means of education subsidies should pay attention to the induced migration incentives in order to perform better judged on the basis of their own intents. This could be achieved if the subsidy would not be levied upon all individuals alike, but if instead the recipients could be chosen such that improving their education does not alter their optimal residence choice.

Suppose we allow the proportional education subsidy to differ between individuals (δ_i).

From (8) it follows that all individuals from the young generation L_1 are going to leave region 1 whose ability level is greater than $\hat{\eta}^i = \left(\frac{m / w_{2,t+1}}{1-\omega} - 1 \right)$, even when they receive no education subsidies ($\Phi_1^i = 1$).

If the federal authority's objective is to *maximize* the income level *in region 1*, it obviously has no interest in subsidizing those individuals who will emigrate anyway.[15] For all individuals with abilities η^i below $\hat{\eta}^i$, the subsidy rate δ_i should be chosen such that emigration is just prevented. Manipulating (8), we can show that this is the case if

$$\delta_i = w_{1,t} \left(1 - \eta^i \Big/ \left(\frac{m / w_{2,t+1}}{1-\omega} - 1 \right) \right). \qquad (18)$$

From (18) it follows that the least talented individuals should receive the highest subsidy and that subsidization should fade out with increasing personal ability levels. It is an open issue whether enough funds can be raised in region 2 to finance exactly this policy rule. But the important implication of (18) is that it gives the upper bound of education subsidies to individual i in order to prevent brain drain.

6) Endogenising the core region

The unfortunate consequences of regional policy are even more pronounced when we generalize our approach and explicitly model the wage formation in the core region 2. Consumer behaviour and goods production in region 2 is structurally identical to region 1 as described in section 3. This specifically means that the final output Y_2 is manufactured under the use of N_2 symmetrical local intermediates X_2, and that each single firm in the X-sector operates at a

[15] If feasible, the Commission could even consider to levy a ´negative education subsidy´ on the most talented individuals, i.e. to charge tuition fees. Such proposals have occurred in the literature, e.g. in form of Bhagwati's "brain drain tax" (see Bhagwati, 1976), but will not be discussed further in this paper.

unique output scale, given by (13), also in region 2. The number of firms N_2 as well as the equilibrium producer wage for each effective labour unit $W_{2,t}$ are then functions of *regional* labour supply alone,[16] i.e.

$$W_{2.t} = \left(\frac{1-\theta}{a} \, S_{2,t} \right)^{\frac{1-\theta}{\theta}} \qquad W_{1.t} = w_{1,t} = \left(\frac{1-\theta}{a} \, S_{2,t} \right)^{\frac{1-\theta}{\theta}} \qquad (19)$$

We have claimed that an analysis of regional policy only makes sense if one region is richer than the other. Equation (19) makes clear that a regional disparity in our model has to be due to a sufficiently larger labour supply in region 2. In the vein of our OLG-model, it is natural to think that the higher labour supply in region 2 is due to a larger size of each new born generation L_2. This larger size translates via the inherently regional pecuniary externality into higher unit wages in region 2. But recall that income in region 2 is taxed in order to finance the education subsidies in region 1. The size of the generation L_2 must therefore be sufficiently larger than L_1 in order to ensure that after-tax unit wages in region 2 are still larger than gross unit wages in region 1.[17]

If this is warranted, we can easily apply the consumer problem described in section 3.1. also to individuals from region 2 and compute the optimal education choice $\ell^{i*,22}$ as

$$\ell^{i,22} = \frac{\beta}{1+\beta} - \frac{1}{\eta^i (1+\beta)} \quad .$$

The overall labour supply in region 2, $S_{2,t}$, is given by

$$S_{2,t} = 2L_2 + \int_{i=0}^{L_2} \ell^{i*,22} (\eta^i - 1) + (1-\mu) L_1 + \int_{i=\mu L_1}^{L_1} \eta^i \ell^{i*,12} \, , \qquad (20)$$

which is an increasing function of the immigrant population $(1-\mu)L_1$. Hence, the only substantial difference of this generalized model approach compared to the equilibrium determination in section 4 is that $W_{2,t+1}$ will no longer be independent of μ, as labour supply and thus unit wages in region 2 increase endogenously with emigration from region 1.

This has drawbacks on the optimal location decision of individuals from region 1 as described by (9). Since $W_{2,t}$ is larger the lower is μ, the actual cut-off ability level beyond which emi-

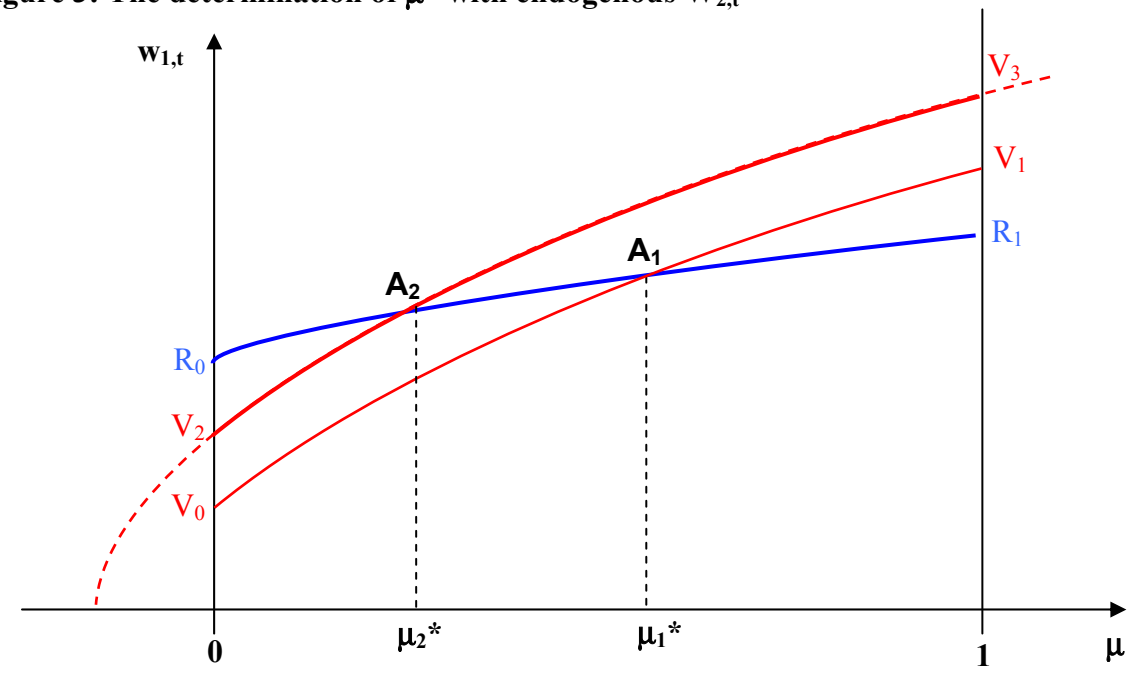
[16] The same were true if we allow for trade in intermediate inputs, but impose (´iceberg´)-transportation costs for the shipping of intermediates. In this case, the larger region wastes fewer resources for transportation, the zero profit conditions for the sectors X and Y are only consistent with a higher equilibrium wage rate in the larger region. For a discussion of this type of technology with tradable intermediates see Suedekum (2002a).

[17] One can show that this condition holds if the relative overall labour supply $S_{2,t}/S_{1,t}$ is larger than $(1-\varphi_2)^{\theta/\theta-1}$, even if there is no emigration from region 1 (i.e. if $\mu=1$).

gration starts off is actually lower than implied by section 4, where the endogenous impact on the $W_{2,t}$ has been neglected. This effect can again be graphically illustrated in figure 3. The technological relation R_0R_1 is unaffected by the endogenous dependence of $W_{2,t}$ on μ and remains unchanged compared to figure 1.

The "true" graphical relation that describes utility equalization across the two regions is, however, not given by the V_0V_1-curve from section 4. It is rather given by some curve V_2V_3 that runs strictly to the left of the V_0V_1-schedule. For any given value of $w_{1,t}$, the corresponding value of μ consistent with interregional utility equalization is strictly lower if individuals take into account the endogenous effects of migration on the wage in region 2. The "true" equilibrium point is thus given by A_2 rather than by A_1, and the fraction μ of the generation L_1 that remains in region 1 during t+1 is only μ_2^* rather than μ_1^*.

Figure 3: The determination of μ^* with endogenous $W_{2,t}$



The cumulative causation spiral described above is thus accentuated if we endogenise the wage formation of the core region. Any emigration out of region 1 puts the relative wage ω under strain from two sides. And thus, the true amount of equilibrium brain drain has been understated by section 4. But other than that, the central insights with respect to parameter changes, most notably with respect to changes in the education subsidy rate δ, remain qualitatively unchanged.[18]

[18] It is also possible to show that with the technology assumed in this paper, a core-periphery-structure can develop endogenously when starting from a situation where both regions are ex-ante completely identical. The

7) Conclusion and discussion of the policy implications

Basically two important conclusion follow from our analysis with respect to the pervasiveness of education oriented regional policies. Firstly, we have shown that this type of regional policy might be ineffective or even counterproductive based on the self-defined political goal to reach more territorial equity. This is so because the actual effect of regional policy can be more emigration of human capital out of the already poor recipient areas. And secondly, we have argued that policymakers might be able to avoid this brain drain if they focus education subsidies on the relatively low skilled workers in the ´objective 1´-areas.

With respect to our first conclusion we feel that we have complemented a view that prevails at various other points in the literature. The intentions and the actual effects of any policy can deviate, in particular if there is factor mobility in the economy. This general point also applies to cohesion policies, as it has been shown by Martin (1998, 1999) for the case of infrastructure subsidization. Our analysis verifies this point also for the case of education oriented regional policies. It seems reasonable to say that policymakers in reality are not always fully aware of the hidden pitfalls that are described in this paper. One contribution is thus to demonstrate that short sighted political interventions motivated by well-meant intentions are insufficient to guarantee the desired outcome. The results of this paper might help to explain why regional policy has performed so poorly over the last decade or so.

Furthermore, our central argument that the provision of more education and skills might lead to more exit behaviour seems plausible also against the background of other economic contexts. For example, any firm will face a similar trade-off if it provides its workers with training and non-specific human capital. If workers become more skilled, they also become more attractive to other firms or even to direct competitors of their current employer.[19] Any firm therefore has to consider that more training of its incumbent workforce can also lead to a higher probability of quits (e.g. Booth/Zoega, 1999) and ultimately to a loss of qualified human resources. Our analysis on the basis of regions rather than of firms seems to be quite closely related. Considerations in a similar vein are even known from development econom-

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increasing returns constitute a motive for spatial agglomeration (a "centripetal" force), that is only opposed by the presence of mobility costs. This centrifugal force is more pervasive for individuals with low individual ability levels, for whom agglomeration rents play a lesser role. A social planner who has to take into account the skill-invariant mobility costs would therefore relocate some interior population fraction from region 1 to region 2. He would draw the subpopulation of migrants from the top of the skill distribution in region 1. After the core-periphery structure prevails, the analysis on the positive effects of education subsidies from sections 4 and 5 applies.

[19] In perfect markets, a firm would not pay for general human capital, but only for the provision of firm-specific skills. In reality, however, it is hardly possible to distinguish general and specific human capital.

ics. Bhagwati (1976) has pointed out that a brain drain can cause considerable welfare losses to developing countries, and Haque/Kim (1995) have used this reasoning to show that governments of developing countries might therefore have little interest to provide higher education.

This leads us to the discussion of our second main policy conclusion, namely that regional policy should focus on relatively low skilled workers. This is a very stark result that gives rise even to quite cynical interpretations ("do not support clever students"). Most economists working on regional development would probably give exactly the opposite advice, namely that local authorities should take maintenance of a qualified stock of human resources and try to introduce "innovation clusters" to their area. However, these policy prescriptions do not need to stand opposite to our results.

Our analysis by its construction also acknowledges the crucial importance of human capital for regional development. It only shows that a naive way of supporting education can be quite misleading. Our intention was simply to reveal *one particular mechanism* that is relevant when *one particular method* of regional education policies is pursued. Recall that the human resource policy in our analysis was simply introduced as a transfer to individuals proportional to their time spend in education. However, there might be other education oriented regional policies that reveal a better performance. For example, suppose that instead of direct subsidies to individuals, the federal authority would rather sponsor the foundation of universities or innovation centres in peripheral regions. Supposedly continuous positive externalities would spill out from such institutions, benefiting mainly those individuals who are actually located in the peripheral region. The government might pay wage subsidies to skilled workers who are willing to locate in the economic periphery, or it might issue education loans that are only turned into pure subsidies if an individual realizes the private and social returns to education in the targeted recipient area. In other words, almost surely there are other forms of education oriented regional policies that work better than the instrument described in our model. But the understanding about the specific impact of different policies on the spatial structure of an economy is still at an infant stage. Therefore it seems worthwhile to point out that certain types of education policies will probably not work so well.

A final point to note is that our analysis was preoccupied with the political goal of achieving territorial equity. As it has been pointed out in section 2, this goal might actually lack a convincing economic justification. Given that the political goal is fuzzy, we have not derived any welfare implications on the overall pervasiveness of education subsidies for the integrated area as a whole. It is quite possible that the brain drain out of the periphery is actually welfare

improving, because the positive feedback effects in the core region are larger than the negative feedback effects in the periphery. If this were so, the agglomeration rents could be redistributed and the periphery could be compensated for the centripetal economic tendencies through income transfers, and still the economy as a whole would be better off.[20]

But the focus of this paper was different. It was simply to point out that it might be more difficult to sponsor regional convergence and the catching up of poor regions than previously thought. There is an inherent hazard that the recipients of education subsidises do not remain in the areas that were intended to be sponsored. This hazard is particularly great if skills are supported that are also badly needed in the economic centres. Arguably, European regional policies today are sponsoring precisely such sophisticated types of skills. A strong emphasis is put on the support of human capital compatible with the IT- and the telecommunication sector (Guersent, 2001). Our theoretical analysis suggests that these priorities might be wrongly chosen if it is regional convergence that shall be supported.

[20] For a more complete elaboration of this argument see Suedekum (2002b).

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