INTERJURISDICTIONAL COMPETITION FOR HIGHER EDUCATION AND FIRMS

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Abstract

In this paper we consider two regions competing for the larger part of the investment by a mobile firm whose decision is based on the quality of human capital in each region. This in turn depends on the initial skill level and the amount of higher education in the region, with a possible spillover to the other region. Therefore each region, through subsidies, tries to attract a larger part of the academic community. Moreover a central government or agency helps the poorer region by providing it with an extra budgetary allocation. The game is nested in a series of settings which are compared, especially from the point of view of their redistributive efficiency. From a policy point of view, the paper, in line with the subsidiarity principle, first provides an argument for allocating a significant amount of the competence in matters of human capital formation, to the central authorities. It also set forth difficulties which can arise from centralizing such an amount of competence and pleas for clear rules governing the federation, especially ruling out discretionary and opportunistic behaviors of public authorities. Finally, it shows the importance of the central government being correctly informed, including being allowed to gather information by itself.

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1 Introduction

Interjurisdictional competition is probably one of the most frequently addressed topics in economic research. It is of interest to scholars active in public economics as well as those in economic geography. The most popular way to cope with this issue is certainly to develop models where two local or regional jurisdictions compete in a horizontal game, and where the tax rate levied on the local profits of a mobile firm is the instrument that local authorities use to attract the firm - see the survey proposed by Wilson (1999). However, empirical findings tend to downplay the role of tax differentials in the relative attractiveness of different areas. Other studies propose models where the instrument used to promote a region is the quantity of a specific public input such as public infrastructures – see, for example, the seminal contribution by Keen and Marchand (1997) and, more recently, Dembour and Wauthy (2004), Justman, Thisse and van Ypersele (2005) and Wilson (2005).

On the other hand, a large and increasing volume of literature focuses on education and human capital formation, including models of interuniversity competition (e.g. del Rey, 2001), and we know that the quality of human capital may be a decisive factor when a firm has to take a location decision, and is of primary importance for regional development.

This paper is inspired by del Rey's work, as well as by the literature on public infrastructure, or public input, as a mean of attracting mobile firms, and the contribution of Bordignon, Manasse and Tabellini (2001) on the optimal redistributive policy between regions when both regional and central authorities overlap. We propose a model of interjurisdictional competition which aims ultimately at attracting mobile firms, but where the instrument is the importance of the presence of a higher education institution in the region.

Regional authorities thus compete horizontally to have more of the academic community on their territory, without ignoring spillover effects such as a university in one jurisdiction improving human capital not only in that region (which in turn can be an incentive for mobile firms to locate in that region) but also in neighboring regions: students able to bear the extra cost of studying outside their region of residence may be educated in neighboring areas and firms can use the services of universities in those neighboring regions too. Not surprisingly, the location decisions of the university depend on the budget allocated by the regional government for each university activity located on its territory. In the real world that budget might consist not only in monetary transfers or direct subsidies, but also in the provision of facilities like grounds to build up a campus or a series of labs. Such situations are often observed in Europe where Universities are mostly government funded, and often receive funds from different public authorities.

Another feature of the paper is that the competition is not only horizontal, between the regional authorities: a central authority - which may be a central agency like the European Commission, or a true central government like the national government in France or the federal one in Belgium, Canada, Germany, Switzerland or the US - is also at work and finances university activity. As an

example, consider the case of the University of Saint-Etienne in France where 55 per cent of the resources come from the State (the national government), 36 per cent come from the Region and 9 per cent from more local authorities (Ahues, 2005). Another example is provided by the European Union where Structural Funds and Cohesion Funds are allocated to relatively poor regions by the EU Commission and can be used to increase the quality of human capital (Köthenbürger, 2002, Riou, 2006).

We adopt the point of view that the central authority pursues the best interest of the poor regions. That may seem an extreme assumption, but it is in line with the EU structural funds policy mentioned above - in the EU, even programs primarily intended to stimulate excellence in research, like Marie Curie grants, give preference to projects related to poorer regions. However, we also show what happens if other redistributive objectives are assigned to the central authority or agency, like reaching some targeted values for the distribution of university activities or investment by firms.

Notice that in this paper, we are not interested by the absolute level of university activity or firm's investment but by its distribution between the poorer and the richer region.

In Section 2 below, we present the various characters and the basic scenario of the game. In this scenario, central authority and regional governments, in some sense, sit around a table at an intergovernmental committee meeting, observe the current distribution of relevant characteristics across regions, and decide together how to proceed.

However such a scenario may not accurately reflect what happens in the real world. In many federations (such as Belgium, Canada and Germany) higher education policy is basically conducted at a regional (or, in Belgium, "community") level, while central authority's contribution consists of providing some extra funds. Therefore it makes sense to study the outcome of the game when central authority does not take part, and to compare that outcome with the situation in which only the central authorities are involved in university policy (like in France in the past). This debate between the centralization and decentralization of higher education policy is the topic of Section 3.

Despite the properties of the centralized solution, the real world, especially if we consider the European Union, is such that the power to subsidize university is shared between different levels of government and is expected to remain shared. As Keen (1998) notes, in the context of his contribution, "the federal government may simply (...) be restricted in the direction or extent of the vertical transfers between levels of government", which is clearly the case in the situations addressed by this paper.

As already mentioned, central authority's role might consist in providing extra funds. Then, often, it focuses on specific programs to help universities develop poles of excellence - see the Research Framework Programs and the Marie Curie actions of the EU Commission or the Belgian Federal Funds supporting this research - or targets specific geographical areas - see the EU Structural and Cohesion Funds already mentioned above - or population segments. We try to capture the joint effect of the two levels of power in Section 4. To do this we

imagine a series of scenarios.

In some of them, the two levels of government both observe the initial distribution of characteristics in the regions - we can then speak of the players having full information. However they do not play simultaneously. It may be that the central authority plays first, by announcing its commitment to a policy, while the regional governments play second. Nevertheless, the central authority's policy may be contingent on action at the lower level of power, and we cannot rule out the possibility that the regional authorities will not act in the way expected by the upper level; a moral hazard problem then arises. On the other hand, the central authorities may not pre-commit, and it is then the regions that face a moral hazard issue.

Moreover, information may be asymmetric, the central authority not being in a position to observe the characteristics of the regions by itself, but only to observe the budgetary efforts of the regions to attract extra activity. To illustrate such a situation, one can imagine that the central authority is the European Commission, which only observes the budgets devoted to higher education by Member States. An adverse selection problem may then arise, in which rich regions can protect themselves against the redistributive actions of the central authority.

Those scenarios deserve study, especially in terms of the gain for the poorer regions relative to the total budget involved. Therefore we have created and computed a redistributive efficiency index.

We conclude the paper in Section 5 with a summary and some observations on the implications of our findings for the conduct of public policy in higher education.

Three conclusions seem to arise. First, there is room for centralization of competences in higher education; however increased mobility of students across regions, for the purposes of studies, reduces the gain from centralization. Second, in the case of the EU where the central authority - the EU Commission - is like an agency created by the Member States and accountable to them (and to the European Parliament as well), it is of primary importance for the Member States that the institutional design rules out discretionary power at central level and forces the central authority to commit *ex ante*. Finally, the paper sets forth the consequences which may arise from the impossibility for the European Commission to get information directly and thus from the need for that authority to rely on informations provided by the Member States.

Let us add already that applications of the approach used in this paper outside the field of higher education are numerous. They include game to attract a private provider of services to firms or residents, like a provider of electric power, or in the area of development economics, a NGO providing education or health services.

2 The Model

In this section we present the players and the basic scenario of the two-jurisdiction game discussed throughout the paper. The game is two-jurisdiction in the following sense: we consider a large federation, so that each of the two jurisdictions we focus on is small relative to the entire federation; those two jurisdictions are geographically close to each other but initially differ in terms of economic development. Initial difference in economic development is measured comparing the two regions initial endowment in university and firm and their initial level of human capital skill.

The game is a three-step one: governments play in the first step, then the university community plays second, deciding of the distribution of its activities. The mobile firm plays last: based on the comparison of skill levels across the two regions, and taking into account the cost of moving economic activity from one location to another, the firm decides on the distribution of its investment in order to maximize its value. Second in order of appearance is the university community, which decides on the distribution of its campuses across regions by maximizing the utility of the academic community, a decision which is influenced (positively) by the budget allocated per unit of activity on each campus location, and (negatively) by the cost of moving departments and laboratories from one location to another. The presence of the university improves the quality of human capital locally, with a possible spillover effect on the quality of the labor force in neighboring regions. Finally there are three arms of government (two different regions and the central authority) which decide on a budget for each university campus in the best interest of either their own region (regional government) or of the poorer region (central authority).

Although at the end of this section we combine the effects of the two levels of government, it is important to bear in mind the different outcomes observed when a single level of government is in operation. In the remainder of this paper various situations will be investigated with various institutional arrangements.

2.1 The firm

The firm takes decision in 3rd step.

Suppose a firm deemed to be mobile across jurisdictions. It decides on the distribution of a given investment, standardized to unity, between two jurisdictions i and j, in order to maximize its value. The fraction invested in i is denoted by α and that invested in j is $1-\alpha$. Initially - to compare with the EU integration process imagine it is before the free circulation of investment being permitted - the values of those parameters are respectively equal to α_0 and $1-\alpha_0$ and departing from these values has a cost represented by the quadratic function $(\gamma/2)(\alpha-\alpha_0)^2$. This cost can be regarded as that of dismantling, transporting and rebuilding a plant, firing and hiring labor force and pushing up the wage rate in the hosting region. The production in either jurisdiction depends on the local investment and on the skill of the human capital available

in the jurisdiction, x_h, $h = i, j$. Thus the firm maximizes

$$V = \alpha x_i + (1 - \alpha)\, x_j - (\gamma/2)(\alpha - \alpha_0)^2 \tag{1}$$

The first order condition of this maximization gives the firm's equilibrium distribution of investment, as

$$\alpha = \alpha_0 + \frac{x_i - x_j}{\gamma} \tag{2}$$

We verify that the second derivative of (1) w.r.t. α is negative.

2.2 The university

The academic community takes decision in 2d step.

It has to decide on the distribution of its activities, standardized to unity, between two campuses, one in each region. The decision is taken with the aim of maximizing the welfare, or the utility, of the academic community which depends positively on the budget received per unit of activity performed in the region, and negatively on the cost of moving departments and laboratories from their initial distribution across regions. Let m and m_0 characterize the distribution of the university's activity after and before the maximization of utility; $(\mu/2)(m - m_0)^2$ is the cost of departing from the initial distribution, and F_i and F_j represent the budget per unit of activity in i or in j allocated to the university by the various authorities. Therefore the university maximizes

$$U = mF_i + (1 - m)\, F_j - (\mu/2)(m - m_0)^2 \tag{3}$$

The first order condition provides us with the equilibrium value of m,

$$m = m_0 + \frac{F_i - F_j}{\mu} \tag{4}$$

As for the firm, the second order condition is fulfilled.

2.3 The human capital

The quality of human capital in region i , x_i depends on a initial value $\underline{x}_i$ and on the activity of the university. In particular, the relationship between the local human capital and the university's activities is given by the equation

$$x_i = \underline{x}_i + m + \delta\,(1 - m) \tag{5}$$

This equation implies that the skill of the workers in region i increases with the activity of the university in region i and, possibly - if $\delta > 0$, also with the activity of the university in the region j. Moreover, whatever the level of activity of the university, the initial level of human capital in the region matters, what is actually in line with empirical observation. The same is true for the other region (j).

As a consequence, higher education can be regarded as a local public good, $\delta = 0$, or as a pure public good, $\delta = 1$, or even as a mixed public good, $0 < \delta < 1$.

Using equations (5) and (4), equation (2) becomes

$$\alpha = \lambda_i + \frac{2(1-\delta)}{\gamma}\frac{F_i - F_j}{\mu} \tag{6}$$

with

$$\lambda_i = \alpha_0 + \frac{\underline{x}_i - \underline{x}_j}{\gamma} - \frac{1-\delta}{\gamma} + \frac{2(1-\delta)}{\gamma} m_0 \tag{7}$$

Remember that α_0 is the initial distribution of investment, $\underline{x}_i$ and $\underline{x}_j$ the initial levels of human capital, δ the indicator of possible spillover effect, and m_0 the initial distribution of university activities. Obviously, if spillover is complete, by which is meant that university affects the two regions whatever it is located, then $\delta = 1$ and there is to reason to spend money to change its distribution across territories.

Parameter λ_i will play a key role in the sequel of the paper since it summarizes the characteristics of the regions; indeed region i can be regarded as poorer than region j if $\lambda_i < \lambda_j$ and λ_i will be more likely to be smaller than λ_j, the less endowed is region i in initial investment α_0, human capital $\underline{x}_i$ and university m_0. Therefore without loss of generality we assume region i is the poorer region, by which we mean that $\alpha_0 < 1 - \alpha_0$, $\underline{x}_i < \underline{x}_j$ and $m_0 < 1 - m_0$, sufficient conditions to have $\lambda_i < \lambda_j$.

Two observations are useful at this stage, one is about the possible mobility of students and the meaning of the spillover effect, the other aims at making a distinction between funding the university in order to improve labor skill and ultimately attract a larger fraction of the mobile firm, and directly subsidizing firm location.

2.3.1 The mobility of the student and the spillover effect

In this model students - including adults enrolled in continuous learning programs - are deemed to have a strong attachment to their own region so that there is no migration of labor across regions. However, a non zero value of parameter δ reflects that studying in the other region is possible - in that sense higher education is a relatively public good for the entire geographic area considered in the model - but more costly than studying at home which refrain students to go outside their own region to acquire skill. Accordingly that cost difference goes down when the public good character of higher education for the entire area goes up - the cost of studying outside the region decreases, or new technologies appear which enable local students to benefit from courses taught abroad, or the mere existence of the federation changes the culture of the students and prospective workers, making them more interjurisdictional; we can then read δ as an indicator of students' mobility. As a consequence, even if no higher education facility locates in, say, region i, the skill level of human capital in that region will increase from $\underline{x}_i$ up to $\underline{x}_i + \delta$, $0 \leq \delta \leq 1$.

Moreover mobility of students does not exhaust the spillover effect. Another interpretation of the parameter δ is that the affiliate of the firm located in one jurisdiction may benefit from services of the university located in the other jurisdiction, like having some tests performed by a laboratory on that campus.

2.3.2 Funding the university or subsidizing the firm

Although the firm ultimately benefits from the subsidies granted to the academic community to attract it on a particular location, funding the university is not equivalent to directly subsidizing the firm. Indeed the effect of public subsidies is channelled through the distribution of two factors - real investment and human capital - and in both cases the impact of the public expenditures depends on the spillover parameter. Thus it depends on the factors related to that spillover effect mentioned above.

2.4 The regional governments

The regional governments take decision in 1st step

Each regional government tries to attract university activity in order to increase the human capital in its jurisdiction and thus to attract the mobile firm, which in turn is deemed to create jobs or to improve labor income in the jurisdiction. To this end it fixes the level of its funding of local campus t_h, $h = i, j$, assumed to be financed through a lump sum tax levied on the jurisdiction. However transforming a lump sum tax into a transfer to the university has a cost u, the shadow price of public funds. Moreover, we denote the shadow price of labor income by w - see Boadway and Bruce (1984) on the shadow prices of public funds and labor income, and Laffont-Tirole (1993) on the former. We also assume that the total public expenditure on a campus is the sum of the budgets provided by the regional and federal governments i.e. $F_h = t_h + \tau_h$.

Thus the regional government i maximizes[1]

$$W_i = w\alpha - umt_i \tag{8}$$

with respect to t_i. From the first order condition of this maximization we obtain the reaction function

$$t_i = M_i - \frac{\tau_i - \tau_j}{2} + \frac{t_j}{2} \tag{9}$$

with

$$M_i = \frac{w(1-\delta)}{u\gamma} - \frac{\mu m_0}{2} \tag{10}$$

A similar maximization by the other region government implies

$$t_j = M_j - \frac{\tau_j - \tau_i}{2} + \frac{t_i}{2} \tag{11}$$

[1] Notice that it does not take into account the cost of public funds spent by the central government since the two regions considered in this model are assumed to be small relative to the entire federation (this assumprion is equivalent to that of the regions being small open economies).

with

$$M_j = \frac{w\,(1-\delta)}{u\gamma} - \frac{\mu\,(1-m_0)}{2} \tag{12}$$

Observe that

$$M_j = M_i - \frac{\mu\,(1-2m_0)}{2} < M_i \tag{13}$$

since $m_0 < 1 - m_0$. And notice that

$$\frac{dM_i}{d\delta}, \frac{dM_j}{d\delta} < 0$$

so that the existence of spillover effects from higher education - and thus some degree of students' mobility - reduces the intercept of the reaction function and thus the level of subsidies granted by local governments to local campuses. However we constrain M_i - and M_j as well - to be nonnegative for any value of m_0 between 0 and 1, which implies that $\delta < 1 - (\mu u\gamma/2w)$. Since $0 < \delta < 1$, it is essential that $\mu u\gamma < 2w$. These reaction functions are correctly shaped, in the sense that the slopes are smaller than one. Local subsidies are strategic complements, while local and central subsidies are strategic substitutes.

Again, the second derivative of (8) with respect to t_i is negative.

2.5 The horizontal game

Using equations (9) and (11), we can solve the horizontal game. Then

$$\begin{aligned} t_i &= \frac{4M_i + 2M_j}{3} - \frac{\tau_i - \tau_j}{3} \\ t_j &= \frac{4M_j + 2M_i}{3} - \frac{\tau_j - \tau_i}{3} \end{aligned} \tag{14}$$

Those expressions are increasing in M_i and M_j and thus decreasing in δ, and we observe that the existence of a spillover effect reduces the investment of regional authorities in higher education, and horizontal competition as well. But we also note that in the event of co-funding by the central authority, the contribution of the benefiting region will go down.

Should the regions be symmetric - which is not the case here -, the Nash equilibrium of the horizontal game between regional governments gives the following regional subsidies

$$\begin{aligned} t_i &= 2M - \frac{\tau_i - \tau_j}{3} \\ t_j &= 2M - \frac{\tau_j - \tau_i}{3} \end{aligned} \tag{15}$$

2.6 The central authority

The central authority takes decision in 1st step too.

We assume that the central authority pursues the best interest of the poorer region so that, observing the sufficient conditions above for $\lambda_i < \lambda_j$, it selects τ_i in such a way that it maximizes a Social Welfare Function defined on $w\alpha$ and the cost of funds transferred to the poorer region. Notice that $\lambda_i < \lambda_j$ implies $\tau_j = 0$ since region j is not the poorer region. The objective of the central authority is thus to maximize

$$W = w\alpha - um\tau_i \tag{16}$$

The first order condition of the maximization of equation (16) w.r.t. τ_i implies that

$$\begin{aligned} \tau_i &= \frac{w(1-\delta)}{u\gamma} - \frac{\mu m_0}{2} - \frac{t_i - t_j}{2} \\ &= M_i - \frac{t_i - t_j}{2} \end{aligned} \tag{17}$$

Strategic substitutability between central and regional interventions implies that central authority will reduce its budgetary contribution to the university campus in the poorer region if the authorities of that region increase their contribution. Conversely, if the government of the richer region increases its contribution, in order to deter the university activity from moving, the contribution of central authority goes up.

Combining equation (17) with those defining the values of regional funding at horizontal Nash equilibrium (14), it turns out that

$$\tau_i = M_i + \frac{1}{2}M_j \tag{18}$$

In that case, the values of the regional expenditures at horizontal Nash equilibrium become

$$\begin{aligned} t_i &= M_i + \frac{1}{2}M_j \\ t_j &= M_i + \frac{3}{2}M_j \end{aligned} \tag{19}$$

with the contribution of the poorer region equaling that of the central authority in its favor, and being smaller than that of the rich region. The total budgets for higher education amount to

$$\begin{aligned} F_i &= t_i + \tau_i = 2M_i + M_j \\ F_j &= t_j = M_i + \frac{3}{2}M_j \end{aligned} \tag{20}$$

implying an increase in investment in the poorer region of

$$\Delta\alpha = \frac{2(1-\delta)}{\gamma\mu}\left(M_i - \frac{1}{2}M_j\right) \tag{21}$$

for an overall budget $F = 3M_i + (5/2)M_j$.

A redistributive efficiency index I can then be defined as the ratio of the investment gain of the poorer region $\Delta\alpha$ to the overall budget devoted to higher education F

$$I = \frac{\Delta\alpha}{F} \tag{22}$$

In this case

$$I = \frac{\Delta\alpha}{F} = \frac{2(1-\delta)}{\gamma\mu}\frac{2M_i - M_j}{6M_i + 5M_j} \tag{23}$$

Notice that alternative redistributive objectives could be assigned to the central authority. Consider for instance that the central authority decides to choose τ_i such that $m = m^*$ a targeted value. As a consequence, it will selects

$$\tau_i = \mu(m^* - m_0) - t_i + t_j \tag{24}$$

which, like in equation (17) shows the subsidy granted by the central authority as negatively related to m_0 and to the subsidy decided by region i, but positively related to that provided by the other region to keep university activity on its own territory. The same appears if the central authority decides to finance reaching a target value α^* of α. Then, we have

$$\tau_i = \mu(\theta\alpha^* - m_0) - g - t_i + t_j \tag{25}$$

with

$$\begin{aligned} \theta &= \frac{\gamma}{2(1-\delta)} \\ g &= \frac{\gamma\alpha_0 + \underline{x}_i - \underline{x}_j - 1 + \delta}{2\gamma(1-\delta)} \end{aligned} \tag{26}$$

Equations (24) and (25) are formally similar to (17); therefore, in the sequel of the paper, we will use only the assumption that the central authority pursues the best interest of the poorer region.

3 Centralization *vs* decentralization

We are now ready to exploit the model described so far and to use it to examine a series of situations which depart from this simple game. Indeed the game investigated so far corresponds to a situation where the three governments are equally and fully informed about the initial situation and the actions of the other governments, and where they all move simultaneously. We refer to that situation using a superscript S.

We can start the discussion and use of the results obtained so far by comparing the centralized and decentralized situations. Let us assume that responsibility for higher education rests exclusively either with the regional governments

or with the central authority. Joint, or overlapping, responsibility is discussed in the next section of the paper.

Using equation (14) and assuming that the central authority has no competence to influence higher education policy, so that $\tau_i = \tau_j = 0$, we obtain

$$\begin{aligned} F_i^D &= t_i = \frac{4M_i + 2M_j}{3} \\ F_j^D &= t_j = \frac{4M_j + 2M_i}{3} \end{aligned} \tag{27}$$

observing that $F_i^D > F_j^D$ since $m_0 < 1/2$ and $M_i > M_j$, which is consistent with intuition.

In the opposite case, where higher education is of the sole responsibility of the central authorities, those equations become

$$\begin{aligned} F_i^C &= \tau_i = M_i \\ F_j^C &= \tau_j = 0 \end{aligned} \tag{28}$$

and again we note that $F_i^C > F_j^C$.

Moreover the overall budget is smaller when the funding of higher education is centralized. The overall budget is $2(M_i + M_j)$ in the decentralized situation compared to only M_i in the centralized case. Obviously the reason is that, in the centralized case, the central authority has not to take into account the subsidy given to the university by the richer region to keep as most as possible of its activity on its own territory.

However, equation (6) shows that it is the difference between the budgets, $\Delta F = F_i - F_j$ which matters, and that the net benefit to the poorer region is larger in the centralized setting than in the decentralized one,

$$\begin{aligned} \Delta\alpha^C &= \frac{2(1-\delta)}{\gamma\mu} M_i, \text{ centralized setting} \\ \Delta\alpha^D &= \frac{2(1-\delta)}{\gamma\mu} \frac{2(M_i - M_j)}{3}, \text{ decentralized setting} \end{aligned} \tag{29}$$

since $F^C = M_i$ is larger than $F^D = (2/3)(M_i - M_j)$. Using the Redistributive Efficiency Index defined by equation (22) it is clear that the benefit to the poorer region is obtained in a less costly way in the centralized setting. Obviously, however, a more equitable distribution is not the goal of all the parties in the decentralized game. The index takes the values,

$$\begin{aligned} I^C &= \frac{\Delta\alpha}{F} = \frac{2(1-\delta)}{\gamma\mu}, \text{ centralized setting} \\ I^D &= \frac{2(1-\delta)}{\gamma\mu} \frac{M_i - M_j}{3(M_i + M_j)}, \text{ decentralized setting} \end{aligned} \tag{30}$$

with

$$\frac{M_i - M_j}{3(M_i + M_j)} < 1$$

Moreover, defining $\tilde{\Delta} = \Delta\alpha^C - \Delta\alpha^D$, we have that

$$\frac{d\tilde{\Delta}}{d\delta} < 0 \tag{31}$$

and an increased spillover effect like an increased mobility of students across jurisdictions is a partial substitute for centralization, in the sense that it reduces the gain from centralization.

This result can be summarized in,

Proposition 1 *To increase the level of investment in the poorer region through a higher education based increased skill of human capital, a central authority pursuing the best interest of the poorer region is more redistributive efficient than a decentralized setting where regions act non-cooperatively.*
Proof. *see equation (30),* $M_i - M_j < 3\,(M_i + M_j)$ ■

and

Proposition 2 *To increase the level of investment in the poorer region through a higher education based increased skill of human capital, an increased mobility of students across jurisdictions reduces the gain from centralization compared to decentralization.*
Proof. *see equation (31)* ■

Despite the superiority of centralization, whose outcome we will consider as a benchmark, reality is multileveled government (Keen, 1998) and we now turn to cases where both levels of government are involved.

4 Both levels of government in action

Suppose now that both levels of government are involved in financing higher education. However, unlike in Section 2, they do not move simultaneously but sequentially. This situation is more in line with real world, especially in Europe, where, when two levels of power are involved in funding higher education, one is primarily responsible. The primarily responsible level of power may be either the central government (France) or the regional ones (Belgium, Germany) depending on the structure of the country. We can assume then that the level of power which is primarily responsible for higher education policy plays first. However, if we consider the EU as a whole *vis-à-vis* the Member States, a case we have especially in mind throughout this paper, the situation is different since the central authority - the EU Commission - is more like an agency which has received a mission from the Member States and which is accountable to them - to the European Council actually -, as well as to the European Parliament.

Let us add that, in a further case, we will suppose that the central authority cannot observe which region is actually poorer, but only the policy undertaken by each regional government. That case again corresponds to actual EU situation where the EU Commission needs to rely on information provided by the Member States, not being allowed to get direct information by itself.

4.1 Full information and pre-commitment of the central authority, no moral hazard

In this and subsequent situations, the first step of the game, that played by the three governments, is organized in three sub-steps numbered 1a, 1b and 1c respectively.

In the present case, the central authority plays first. This corresponds to an institutional arrangement where it is primarily responsible for higher education and determines the framework in which public funding is organized. Then, in step 1a, the central authority and regional governments observe that region i is the poorer one, $\lambda_i < \lambda_j$. In step 1b, the central authority decides on its policy according to equation (17) of Section 2, defining a budgetary contribution contingent on those of the regions. Finally, in step 1c, the regions set their subsidies in line with equations (9) and (11). Then the first step of the game is completed and it is up to the university and the firm to play.

The outcome obtained here is similar to that of Section 2 where the governments play simultaneously. Comparing with Section 3, we observe in particular that, denoting the present and Section 2 framework by means of the superscript S,

$$\begin{aligned}
\Delta\alpha^C &= \frac{2(1-\delta)}{\gamma\mu} M_i, \text{ centralized setting} \\
\Delta\alpha^D &= \frac{2(1-\delta)}{\gamma\mu} \frac{2(M_i - M_j)}{3}, \text{ decentralized setting} \\
\Delta\alpha^S &= \frac{2(1-\delta)}{\gamma\mu} \frac{2M_i - M_j}{2}, \text{ simultaneous move}
\end{aligned} \tag{32}$$

and $\Delta\alpha^C > \Delta\alpha^S > \Delta\alpha^D$ so that the action of the central authority partly offsets the inefficiency implied by the horizontal game with complete decentralization.

In the present case - see equations (18), (19) and (20) - $t_i^S = \tau_i^S = M_i + M_j/2$ and $t_j^S = M_i + (3/2)M_j$ so that the expenses for higher education amount to $F_i^S = t_i^S + \tau_i^S = 2M_i + M_j$ for region i and $F_j^S = t_j^S = M_i + (3/2)M_j$ for region j. Thus the total budget jointly devoted by the central authority and region i government to higher education is larger in the present setting: $F_i^S > F_i^D > F_i^C$. Adding to that amount the expenses for higher education by region j, we obtain F^S, the total budget dedicated to higher education by the three governments - the pro-redistributive budgets decided by the central authority and the one of region i, and the defensive or anti-redistributive expenses decided by region j - and we observe $F^S > F^D > F^C$. Therefore in terms of our redistributive efficiency index,

$$\begin{aligned}
I^C &= \frac{2(1-\delta)}{\gamma\mu} \frac{F_i - F_j}{F} = \frac{2(1-\delta)}{\gamma\mu}, \text{ centralized} \\
I^D &= \frac{2(1-\delta)}{\gamma\mu} \frac{F_i - F_j}{F} = \frac{2(1-\delta)}{\gamma\mu} \frac{1}{3} \frac{M_i - M_j}{M_i + M_j}, \text{ decentralized} \\
I^S &= \frac{2(1-\delta)}{\gamma\mu} \frac{F_i - F_j}{F} = \frac{2(1-\delta)}{\gamma\mu} \frac{2M_i - M_j}{6M_i + 5M_j}, \text{ simultaneous}
\end{aligned} \tag{33}$$

and $I^C > I^S > I^D$.

In the present case, whose outcome is similar to that of the simultaneous move case, the central authority allocates a larger amount of money to the poorer region than in the centralized case, while the local administration of region i allocates less money to higher education than in the decentralized setting. Moreover the government of region j devotes more resources to higher education in the simultaneous move setting. In other words, $\tau_i^S > \tau_i^C$, $t_i^S < t_i^D$ and $t_j^S > t_j^D$.

This results illustrates a feature which is at least twofold. On the one hand, in this and simultaneous move setting the central authority is also engaged in a vertical non-cooperative game with the regional government of the richer region. On the other hand, the contribution of the central authority is regarded by the regional government of the poorer region as a substitute for its own budgetary allocation.

Then, assuming

H0: The central authority and regional governments are fully informed and move simultaneously

and

H1: Full information and pre-commitment of the central authority, no moral hazard

we have,

Proposition 3 *If **H0** or **H1** holds, both the central authority and richer region dedicate a larger budget to higher education than when only one level of government is at work, while the budgetary allocation of the poorer region is smaller, being substituted by that of the central authorities; this situation is more redistributive efficient than pure decentralization, but less so than pure centralization.*
Proof. *See equations (32) and (33), showing that $I^C > I^S > I^D$.* ■

4.2 Full information and pre-commitment of the central authority, moral hazard

When the central authority plays first, in the best interest of the poorer region, it faces the risk, however, that the poorer region does not make the effort it is expected to do, being tempted to free ride.

Therefore, leaving aside, tentatively, the question of the rationality of that belief, which is that of the best interest for the poorer region to free ride, let us suppose that when deciding on its policy in step 1b, the central authority expects that its partner government in the poorer region may not play its part, or not play its part entirely. Then, denoting the situation by a superscript M referring to moral hazard, the central authority considers that $t_{ih}^M = ht_i^S$, $0 \leq h \leq 1$. One can show that the outcome of the game, in terms of investment by the firm, will lie between $\Delta\alpha^S$, if $h = 1$ and $\Delta\alpha^D$ if $h = 0$.

Let us consider that latter case (complete free riding by the poorer region, $h = 0$), where the central authority anticipates that $t_i = 0$.

Therefore the first step of the game is as follows.

Sub-Step 1a

The central authority and regional governments observe that $\lambda_i < \lambda_j$.

Sub-Step 1b

The central authority announces its policy: using equations (9), (11) and (17) subject to the restriction that $t_i = 0$, it decides that

$$\tau_i^M = \frac{4M_i + 2M_j}{3} \tag{34}$$

In this case the budgetary allocation from the central authority is higher than in the previous case but smaller than the joint effort of both the central and poorer regional government in the previous case; in other words, $\tau_i^M > \tau_i^S$ but $F_i^M < F_i^S$. However the allocation from the central authority amounts to exactly that of the poorer region in the decentralized situation: the central authority acts as a full substitute for the poorer regional government.

Sub-Step 1c

The regional governments, using the same equations, decide on

$$\begin{aligned} t_i^M &= 0 \\ t_j^M &= \frac{4M_j + 2M_i}{3} \end{aligned} \tag{35}$$

respectively, so that $F = 2(M_i + M_j)$. Compared to the simultaneous move or no moral hazard case, the budgetary allocation of the richer region is smaller, in line with the reduced total budget for the poorer region. But it is exactly the same as that of the richer region in the decentralized case. Then the investment gain of the poorer region is the same as in the decentralized case, i.e. smaller than in the situation with no moral hazard just discussed,

$$\Delta\alpha^M = \frac{2(1-\delta)}{\gamma\mu} \frac{2(M_i - M_j)}{3} = \Delta\alpha^D \tag{36}$$

while in terms of redistributive efficiency this situation is

$$I^M = \frac{2(1-\delta)}{\gamma\mu} \frac{1}{3} \frac{M_i - M_j}{M_i + M_j} = I^D \tag{37}$$

and we can state, defining

H2: Moral hazard such that the central authority expects a zero contribution of the poorer region

Proposition 4 *If **H2** holds, then the outcome of the game is identical to that obtained under pure decentralization.*
Proof. *See equations (36) and (37),* $\Delta\alpha^M = \Delta\alpha^D$ *and* $I^M = I^D$. ■

Now the question arises of the rationality of that belief of the central authority. If the government of region i decides on its strategy comparing the two different $\Delta\alpha$, it will never free ride since $\Delta\alpha^M < \Delta\alpha^S$. On the other hand, if it decides comparing the two ΔW_i, then it will be more likely to free ride the larger the size of the spill over effect and the larger its part in the initial endowment in university activity; more precisely it is the best interest of the poorer region to free ride if

$$w\Delta\alpha^M > w\Delta\alpha^S - um^S t_i^S \tag{38}$$

and, using equations (36) and (21), that will be the case if

$$\delta > 1 - \frac{3\mu u\gamma}{2w}(1 + m_0)$$

In such a situation the budgetary cost for the central authority is larger than in the absence of moral hazard, since $\tau_i^M > \tau_i^S$ so that it is in the best interest of the central authority to limit free riding opportunities or then, to decide not to commit *ex ante*.

4.3 Full information but lack of pre-commitment of the central authority

Now let us reverse the scenario: the regional authorities are primarily responsible for higher education policy, they play first and the central authority plays after them. Then in sub-step 1a, the governments observe $\lambda_i < \lambda_j$. In sub-step 1b, they play non-cooperatively, not knowing if the central authority will later move. The central authority plays in sub-step 1c if it does.

This corresponds to a frequent situation where the poorer region is uncertain as to, for example, its eligibility for specific support from the central authority.

That situation needs that the regions compare all possible cases in order to form rational beliefs. Such a comparison is proposed in appendix. Using the maximin criterion, we can infer that a pessimistic belief is in the best interest of the poorer region while the alternative belief is in that of the richer region. Therefore we focus on that case thereafter.

Sub-Step 1a

The central authority and regional governments observe that $\lambda_i < \lambda_j$.

Sub-Step 1b

The regions realize that they are anticipating the behavior of the central authority differently. Then, using equations (9), (11) and (17), subject to the restriction that the expected value of $\tau_i = 0$ for player i, denoted by $\tau_i^i = 0$, the regions decide that

$$\begin{aligned} t_i &= \frac{4M_i + 2M_j}{3} + \frac{\tau_i^j}{3} \\ t_j &= \frac{4M_j + 2M_i}{3} + \frac{2\tau_i^j}{3} \end{aligned} \tag{39}$$

with the value of τ_i expected by the j-region authorities being,

$$\tau_i^j = \frac{2}{5}(2M_i + M_j) \tag{40}$$

Introducing this value in equation (39) gives

$$\begin{aligned} t_i &= \frac{4}{5}(2M_i + M_j) \\ t_j &= \frac{2}{5}(4M_j + 3M_i) \end{aligned} \tag{41}$$

Sub-Step 1c

If the central authority commits *ex post* and allocates to the poorer region the budget which the richer region had predicted

$$\tau_i = \tau_i^j = M_i - \frac{t_i - t_j}{2} = \frac{4M_i + 2M_j}{5} \tag{42}$$

so that

$$F_i^A = \frac{6}{5}(2M_i + M_j), \; F_j^A = \frac{2}{5}(4M_j + 3M_i) \tag{43}$$

where the superscript A indicates the risk aversion of the regional players.

As a consequence,

$$\Delta\alpha^A = \frac{2(1-\delta)}{\gamma\mu} \; \frac{6M_i - 2M_j}{5} \tag{44}$$

and

$$I^A = \frac{2(1-\delta)}{\gamma\mu} \; \frac{3M_i - M_j}{9M_i + 7M_j} \tag{45}$$

This situation is less redistributive efficient that the centralized scenario. However it is more redistributive efficient than the simultaneous move, and *a fortiori* than the decentralized setting. In that framework we cannot exclude the possibility that the effect on α will be better for the poorer region than centralized decision-making. This is basically because the budgetary allocation in this situation is especially high: the poorer region's expenditures go up to offset the expected default of the central authority while *ex post* the central authority does not default.

Of course, if the central authority finally does not commit, the payoff for the poorer region is negative both in terms of investment and welfare and

$$\Delta\alpha = \frac{2(1-\delta)}{\mu\gamma}\left[\frac{2}{3}M_i - \frac{4}{3}M_j\right] < 0 \tag{46}$$

This leads to, defining

H3: (1) the central authority does not commit *ex ante* but commits *ex post*, (2) the poorer regional government expects no help from the central authority, and (3) the richer regional government expects that the central authority will help the poorer region,

and

H3': (1) the central authority does not commit *ex ante* nor *ex post*, (2) the poorer regional government expects no help from the central authority, and (3) the richer regional government expects that the central authority will help the poorer region,

Proposition 5 *If **H3** holds, then the outcome of the game is less redistributive efficient than full centralization but it is more redistributive efficient than simultaneous moves or pre-commitment by the central authorities, and a fortiori than full decentralization. Moreover the investment gain for the poorer region may be larger than with full centralization.*

Proof. *See equations (44) and (45),* $I^C > I^A > I^S > I^D$ *and* $\Delta\alpha^A \gtreqless \Delta\alpha^C$. ■

Proposition 6 *If **H3'** holds, then the outcome of the game for the poorer region is negative both in terms of investment and welfare, and thus worse than in the purely decentralized setting.*

Proof. *See equation (46).* ■

Committing *ex post* rather than *ex ante* allows the central authority to save budgetary expenditures. Its subsidy to the poorer region amounts then to

$$\tau_i^A = \frac{4M_i + 2M_j}{5} < M_i + \frac{M_j}{2} = \tau_i^S$$

while every region has to devote a larger budget to higher education,

$$\begin{aligned} t_i^A &= \frac{8M_i + 4M_j}{5} > M_i + \frac{M_j}{2} = t_i^S \\ t_j^A &= \frac{6M_i + 8M_j}{5} > M_i + \frac{3M_j}{2} = t_j^S \end{aligned}$$

It turns out that one may conceive that in a true federation, the central government prefers not to commit *ex ante*. On the contrary, in a "soft" federation like the European Union, where the central authority is more like an agent of the federation members, those will find their best interest ruling out any possibility of discretionary behavior by the centre and requiring from the centre that it pre-commits.

4.4 Asymmetric information and adverse selection

In this final case the central authority again plays last in the first step. Now, however, it cannot observe the values of λ_i and λ_j but only the actions undertaken by the regional governments, i.e. the budgetary expenditures of these governments. A typical example of such a situation could be again the European Union, where the European Commission's intervention is decided on the basis of information transmitted by the Member states, especially budgetary statistics.

In the simultaneous move setting, the subsidy granted by the central authority to the poorer region was equal to the own effort of that region, which was smaller than the effort undertaken by the richer region. It is then legitimate to consider that, unable to directly observe which region is poorer, the central agency will decide that the poorer region is the one which devotes a smaller budget to higher education.

Therefore, there is the possibility of an adverse selection problem. If the government of region j wants to protect itself against a transfer from the central authority to region i in order to push up m and ultimately α, it will try to portray its own region as being as poor as the i region by mimicking i's expenditure. But being aware that the richer region will behave in such a way, the poorer region will rationally decide for a zero effort. We can easily imagine the game thereafter.

Sub-Step 1a

The regional governments observe that $\lambda_i < \lambda_j$.

Sub-Step 1b

The poorer region could decide, according to equations (19) and (18), that

$$t_i = M_i + \frac{M_j}{2} \tag{47}$$

However the richer region cheats, and portrays itself as being as poor as the poorer region by mimicking the poorer region's expenditure

$$t_j = M_i + \frac{M_j}{2} \tag{48}$$

Aware of that both regions will actually decide for

$$t_i^P = t_j^P = 0 \tag{49}$$

where the superscript P refers to a pooling equilibrium.

Sub-Step 1c

Observing that $t_j^P = t_i^P$, the central authority concludes that the two regions are equally poor and does not make any transfer. As a consequence $F_i - F_j = 0$. Then

$$\Delta\alpha^P = 0 \tag{50}$$

and

$$I^P = 0 \tag{51}$$

Here the redistributive efficiency is zero, since there is no redistribution at all. However from the point of view of the richer region this is a positive result: it gets a more favorable outcome with a zero budgetary contribution. It turns out that, defining

H4 : The central authority cannot observe which region is poorer but only the regions' budgetary allocations,

Proposition 7 *If **H4**, the richer region's best interest lies in mimicking the poorer one; by so doing it protects itself against redistribution in favor of the poorer region, and does so at a zero cost. In terms of investment this situation is worse than the purely decentralized one, for the poorer region.*
Proof. *See equations (49) and (50).* ■

5 Conclusion

In this paper we have considered two regions which are competing to attract the larger part of a given investment. The location decision of a mobile firm is based in part on a comparison of the quality of human capital available in each region. That quality in turn depends both on the initial skill level of the labor force and on the amount of higher education provided in the region, with a possible spillover from the other region; therefore each region, through subsidies, tries to attract a larger fraction of the university to its territory. Moreover the central authority helps the poorer region to get an increased part of the university (and ultimately of the investment) by allowing it an extra budget; for the determination of that budget the central authority pursues the best interest of the poorer region.

We have nested the analysis in a series of settings which are compared, especially from the point of view of their redistributive efficiency.

We have first compared two opposite cases, full centralization and full decentralization. In the first, where only the central authority acts, the redistributive effect in favor of the poorer region is largest and requires the smallest budget; therefore this situation can be regarded as a benchmark. In the second, a non-cooperative game between the two regions develops and central authority is silent. Both regions devote a lot of money subsidizing the university for a limited redistributive outcome.

As we already mentioned in the introduction, despite the properties of the centralized solution, the real world, especially if we consider the European Union, is such that the power to subsidize university is shared between different levels of government and is expected to remain shared. As Keen (1998) notes, in the context of his contribution, "the federal government may simply

(...) be restricted in the direction or extent of the vertical transfers between levels of government", which is clearly the case in the situations addressed by this paper. Moreover an increased spillover effect, like an increased mobility of students across jurisdictions is a partial substitute for centralization in the sense that it reduces the gain from centralization.

If the central authority is able to observe which region is poorer, and if it pre-commits to help that region, moving first among the public authorities, the outcome of the game is equivalent to simultaneous moves by the three authorities. The result is less favorable for the poorer region and less efficient in budgetary terms than the outcome under centralization, but more favorable and more efficient than pure decentralization.

However, knowing that the central authority has committed to help it, the government of the poorer region might be tempted to behave opportunistically and not allocate any of its budget, or allocate only some part of it, to attracting the university; such behavior constitutes a moral hazard. In this setting the outcome lies between that occurring under simultaneous move (no moral hazard) and the same as in the decentralized game, with the central authority substituting for the poorer regional government (total substitution occurring in case of complete free riding by the poorer region government).

In the penultimate case we assume that central authority does not pre-commit, but plays last among the public authorities, after the regions have moved. In this framework the poorer one behaves as if the central authority will not help it, while the richer region adopts the opposite position. If *ex post* the central authority helps the poorer region, the overall budgetary effort is large; in this setting the redistributive effect may be even larger than in the centralized case. However, if the central authority *ex post* does not help the poorer region, its fate is worse than in the purely decentralized case.

Finally we imagine that the central authority, again playing last among the governments, is not able to observe which region is poorer and which is richer: it can only observe the budgetary allocations of the regions and it assumes, as in the simultaneous move case discussed above, that the poorer region will allocate a smaller budget. In such a setting the richer region finds that its best interest is to mimic the poorer one: the central authority, unable to discriminate between the regions, considers that neither is poorer than the other and does not allocate a budget to either region. Then neither region nor the central authority will undertake effort to attract university and again the fate of the poorer region will be worse than in the purely decentralized case.

From a policy point of view we can draw three lessons from the exercise conducted in this paper.

First of all it illustrates the important role that a central agency or authority can play in a redistributive game. The two settings which appear to be the most favorable to the poorer region are those in which the central authority is either the sole player or pre-commits in favor of the poorer region. This is an argument for keeping a significant level of competence in matters of human capital formation at federal level in decentralized countries, as well as for giving such competencies to the center in a federation in progress such as the European

Union. In other words, the subsidiarity principle here calls for centralization. However, despite the fact that the model tends to suggest that complete centralization is a desirable design, we need to be aware that the model actually only indicates a direction: centralizing presently decentralized competences has limitations and costs not taken into account in the paper. Related to that, an increasing mobility of students, represented in the model by an increased spillover effect, for purposes of studies, even if they are otherwise much attached to their region and then rather immobile, reduces the gain from centralization and may be regarded as a - maybe partial - substitute for that institutional device. Such increased mobility may arise from a reduction in the monetary cost of studying outside the region of residence, like that of transportation, accommodation or tuition for non resident students, but it may also come from the appearance of new learning and communication technologies like courses on the internet, or from the mere change in students' cultural attitude, the students becoming more interjurisdictional. However increased mobility of students is only one aspect of the spillover effect across regions; another aspect is the use by the affiliate firm in one jurisdiction, of university services provided on a campus located in the other jurisdiction.

Second, when a central authority has been established, it is important to enforce its *ex ante* commitment as well as to ensure that no region will free ride. The first requirement is a plea for clear rules governing the relations between the centre and the regions, especially to rule out discretionary power at central level. To interpret that first requirement correctly, a distinction needs however to be made between a "true" federation like Germany where one may conceive that the federal government does not commit *ex ante* since it is in its best interest, and a "soft" federation like the European Union where the central authority looks like an agent of the federation members: the best interest of the latter is to have the central authority committing *ex ante* and avoiding discretionary decisions. The second requirement also implies such clear rules and the enforcement of penalties against free riders.

Finally the paper also illustrates the importance of central authority having access to good quality information, or even having its own sources of information; otherwise, as we have seen, the rich region can protect itself against the redistributive policy of the center by creating an asymmetric information framework and taking advantage of the situation. This is an issue of practical importance in a "bottom up federation" or a federation in progress like the European Union, where the centre needs to rely on informations provided by the Member States, not being permitted to get it by itself.

This research can undoubtedly be refined and extended. However it already provides some directions for the organization of higher education in either a true federation or a one like the European Union. Refinements and extensions could include modelling the behavior of the students in a more advanced way, like introducing migration opportunities.

Moreover, as also mentioned in the introduction, applications of the approach used in this paper outside the field of higher education are also numerous; they include games to attract a private provider of services to firms or residents, like

a provider of electric power, or in the area of development economics, a NGO providing education or health services.

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Appendix

In order to determine the rational beliefs of the regional governments in case of lack of pre-commitment of the central authority, we have created two trees. In the first one region i announces its belief at the first node, then region j forms its own in the second node and the central authority plays at the third node. Resolving backward and assuming that regions decide using the maximin criterion we can find out the best choice of region i. In the second tree region j starts and region i follows. Resolving backward again and using the same criterion we find out the best belief for region j. Then region i expecting that the central authority will not commit *ex post* (pessimistic belief) and region j expecting that the central authority will commit *ex post* (optimistic belief) emerges as the rational behavior.

This result is based on the comparison of the following outcomes where the first superscript corresponds to the belief of region i, the second to that of region j and the last one to realization (actual behavior of the central authority).

1. Imagine first that both regional governments believe that the central authority will commit *ex post*. Then the gain in terms of investment for the poorer region will be either

$$\Delta\alpha^{CoCoCo} = \frac{2\left(1-\delta\right)}{\mu\gamma}\left[M_i - \frac{1}{2}M_j\right] = \Delta\alpha^{S}$$

if the central authority actually decides to help the poorer region, but it will be

$$\Delta\alpha^{CoCoNo} = \frac{2\left(1-\delta\right)}{\mu\gamma}\left[-\frac{1}{2}M_j\right] << 0$$

if it does not. That latter situation is especially unfavorable for the poorer region and favorable for the richer one.

2. At the other end, if both regional authorities have the alternative belief, the outcome will be either

$$\Delta\alpha^{NoNoCo} = \frac{2\left(1-\delta\right)}{\mu\gamma}\left[\frac{4}{3}M_i - \frac{1}{3}M_j\right] >> \Delta\alpha^{S}$$

or

$$\Delta\alpha^{NoNoNo} = \frac{2\left(1-\delta\right)}{\mu\gamma}\frac{2}{3}\left[M_i - M_j\right] > 0$$

depending on the central authority action; the latter expression is positive since $M_i > M_j$.

3. Should beliefs of the regional governments diverge, then

$$\Delta\alpha^{NoCoCo} = \frac{2\left(1-\delta\right)}{\mu\gamma}\left[\frac{6}{5}M_i - \frac{2}{5}M_j\right] > \Delta\alpha^{S}$$

and

$$\Delta\alpha^{NoCoNo} = \frac{2\left(1-\delta\right)}{\mu\gamma}\left[\frac{2}{5}M_i - \frac{4}{5}M_j\right] < 0$$

Notice that the comparison has been conducted using the difference in investment in the regions. That $\{No, Co\}$ - no commitment of the centre expected by the poorer, and the converse expected by the richer - is the most rational belief should be - and might be - confirmed by an inspection of the differences in welfare.

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