Regional integration, inequalities and public policy

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Abstract

We built an economic geography model featuring a public sector in order to investigate the capacity of the central authority to improve the welfare of its residents and to reduce regional inequalities under a policy creating productive infrastructure. The model shows that to achieve this objective the public expenditure must be low (high) and directed (only majoritarily) at the small country if the marginal impact of public investments on productivity is decreasing (increasing). This analysis also shows that public intervention could be efficient at the stage of total agglomration. However, outside this stage, public intervention is not justified even if the Rawlsian critirion is applied.

Keywords: Political economics, Industrial location, Spatial equity and efficiency.

JEL classification: F12; F15; H53; R12.

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1. Introduction

The impact of regional economic integration on spatial inequalities is the subject of a particular attention by policy makers and location theorists. This topic is a burning question in the European context. Actually, if one of the European Union's goals is to "*improve in all the Community....welfare and quality of life...*" (Treaty of Roma, Article 2), the EU must also help its poorer regions, whose per capita GNP is less than 75 % of the European average, in order to boost these poorer regions and reduce regional disparities (Objective 1 of the Structural Founds). The Structural Funds have expanded from 1.8 billion Ecus in 1980 to 32.1 billion in 2000, which is an increase from 11 % to 33 % share of the European Budget. During this period Portugal, Spain and Greece joined the EU, accentuated regional disparities. Moreover enlargement of the EU to Central and Eastern European Countries, such as Hungary, Poland, the Czech Republic, will be a further challenge to European policies. Per capita GDP of these countries is quite small, and a large proportion of the EU budget is already spend on support in Portugal, Greece and Ireland. Thus, it seems useful to examine the EU's capacity to improve the welfare of its residents and to reduce regional inequalities, i.e. to reconcile spatial equity and efficiency.

The considerable development of New Economic Geography has revived interest in the impact of regional integration, as a decrease in trade cost, on the location of economic activities and real income (for broad surveys see for example Baldwin and Venables, 1995; Puga, 2000). In the first stage of regional integration, when trade cost is high, dispersion occurs. As trade cost falls and takes intermediate values, there is agglomeration. Finally, in the last stage, when trade cost reachs very low level, there is once again dispersion. These models show that the total real income is highest and spatial inequalities are weakest when trade costs are very low (Puga & Venables, 1997, for example). They also show that

spatial disparities in terms of economic activities and real income occur in the intermediate stage of the integration process. However, none of them explicitly introduces public choice between spatial equity and efficiency, especially during the integration process. Moreover, these models assume that population is evenly distributed among regions. European regions are of actually very different sizes and like Baldwin and Krugman (2000), we emphasise the importance of working with "*the case of asymmetric-sized nations*" to analyse some of the effects of public policies in the context of regional integration.

This paper investigates the efficiency of public policies which maximise real income of all residents while minimising regional inequalities. With this aim in view, we construct an economic geography model, which is an enlargement of that of Krugman and Venables (1995), with a public sector. We introduce a supra national authority that spends public income, derived from taxation, on productive infrastructure, as in the EU. A large proportion of the Structural Funds (current budget approximatively 39 billion Euros) is allocated to improving infrastructure (about 30 % of the Structural Funds budget) or human capital (about 25 %.), in order to attain Objective 1. We also assume an unequal distribution of workers and analyse the consequences of this new assumption for equilibrium location.

The supra national government seeks to maximise the total real income under a constraint of balanced spatial allocation of per capita GDP. To achieve this, the supra national government may change the productivity level in the small country through public spending there. This assumption is derived from some of endogenous growth models with public spending (Barro,1990; Barro and Sala-Is-Martin, 1992). We introduce the idea that public spending can generate externalities because it can affect the productivity of firms without firms taking this effect into account. However, we do not consider the short run effect of public spending on income. Here we assume that taxation is spent by central government on

producing infrastructure, which increases the productivity of inputs. The public spending can be targeted at the small country. This last policy has two effects: a level effect and an allocation effect. For a given spatial distribution of public spending, the higher the level of public spending, the higher the productivity of firms located in the periphery (*level effect*). For a given level of public spending, the larger the allocation of public investments in favour of the small nation is, the greater the increase in productivity of local firms (*allocation effect*).

This paper is consistent with the general literature on economic geography and public policies, involving different forms of public intervention. A first set of models looks at the effects of policies of support for local demand. Such policies may be a direct aid: the government consumes manufacturing or agricultural goods (Trionfetti, 1997, Lambertini and Peri, 2000). Local demand may also indirectly rise: domestic trade costs fall owing to investments in infrastructure (Martin and Rogers, 1995). Other models examine the effect of local taxation in a framework of fiscal competition (Andersson and Forslid, 1999, Baldwin and Krugman, 2000, Kind et al., 2000 ; Ludema and Wooton, 2000). Nevertheless, there has been little analysis of central government policies of support of local supply and the trade-off between spatial equity and efficiency.

We begin by showing that the economic activity is more unequally distributed than population. The unequal distribution of workers reinforces the attraction of the large nation where the labour market is more competitive than that of the small nation. The demand of goods is also greater. The main results of our model relate to the efficiency of different policies. We then study how government can equalise per capita GDP while maximising total real income. Under this constraint, the allocation (level) effect can be favoured, if the marginal impact of public investments on productivity is decreasing (increasing). We also

compare total real income with and without public intervention. Analysis reveals that, at the stage of total agglomeration, there is not always trade-off between equity and efficiency for public authorities. Moreover, if we consider the Rawlsian criterion, public intervention is not justified outside this total agglomeration stage.

This paper is organised as follows. In section 2, the general model, the main assumptions and the short-run equilibrium conditions, are described. Section 3 describes the spatial allocation of activities without a public sector. Section 4 analyses the capacity of regional policy to achieve the European specific goal of maximasing the total real income under a constraint of equalisation of regional GDP per capita. In section 5, we present total real income with and without public intervention as a basis of discussion of the trade-off between equity and efficiency. A final section concludes the paper.

2. The general model

We consider two countries, referred to as c (core) and p (periphery). Each country may contain two sectors, a sector tied to the land (e. g. agriculture) and a manufacturing sector including foot-loose firms. Country p is endowed with L_p units of labor and country c is endowed with L_c units, such that $L_c = \lambda L_p$ with $\lambda \geq 1$. We normalise the population of country p, so that $L_p = 1$. Central government taxes manufacturing income of firms located in both countries in order to produce infrastructure which improves productivity.

2.1 Main Assumptions

Following Dixit-Stiglitz (1977) and most new economic geography models, preferences are identical across individuals and described by a Cobb-Douglas utility with a CES sub-utility, $U = C_m^{\gamma} C_a^{1-\gamma}$ where C_m is a composite index of manufactured goods consumed, and C_a is

the consumption of homogeneous good whose production is tied to the land (agricultural good). $\gamma \in]0;1[$ is a constant representing the share of expenditure on manufactured goods. Therefore, the indirect utility function of workers in country c (*core country*)[1] is

$$V_c = (P_{m_c})^{-\gamma} (P_{a_c})^{-(1-\gamma)} w_c \tag{1}$$

where P_{m_c} is the index price of manufactured goods in country c and can be written for country c as:

$$P_{m_c} = (n_c p_c^{1-\sigma} + t n_p p_p^{1-\sigma})^{1/(1-\sigma)} \quad \text{with} \quad t = \tau^{1-\sigma},\ \sigma > 1 \tag{2}$$

n_c and n_p are the numbers of goods produced in country c (*core*) and in country p (*periphery*) respectively. Manufactured goods can be exported from one country to the other with an *iceberg* trade cost paid by consumers: for each unit of goods shipped from one country to the other, only a fraction $1/\tau$ arrives. τ is therefore the global trade cost including trade and all other costs necessary to export from one European region to another. σ is the constant elasticity of substitution of manufactured goods. And w_c is the wage in country c.

The total of workers in the sector tied to the land and in the manufacturing sector are noted L_a and L_m respectively. We assume that workers are geographically immobile but mobile between sectors. Each worker works in the sector offering the higher wage in the country. Therefore there is competition between firms to attract labour.

The sector tied to the land is in constant returns to scale under conditions of perfect competition and only uses labour as input. The product supplied by this sector and purchased by consumers is the *numéraire*. Therefore the wage of workers employed by this sector is equal to unity because of constant returns to scale. Thus, to ensure the existence of an agricultural sector, we assume that there is always agricultural activity in the smaller

country, i. e. periphery. Because of constant returns to scale in this sector, wage in country p is equal to unity**.** We can then write the equilibrium condition:

$$w_c \geq 1 \tag{3}$$

w_c, the wage in country c, is unity (in this case, this country produces agriculture), or exceeds it (agricultural production is nil).

The manufacturing sector produces n varieties of differentiated products (with $n = n_c + n_p$) in monopolistic competition *à la* Dixit-Stiglitz (1977). There is no strategic interaction among firms and each firm produces one good.

Firms use a $1-\mu$ share of labour and a μ share of composite manufactured intermediate goods as inputs in a Cobb-Douglas technology *à la* Ethier (1982). Like Krugman and Venables (1995), "*we make the major simplifying assumption that the composite intermediate good is the same as the composite consumption good.*" (p.863). Unlike most economic geography models, production technologies can differ from one country to another. The production of a quantity q_i of any variety i requires a fixed share α of inputs and a variable share of inputs, β_c, which may be specific for each country. β_c is also the inverse of marginal productivity of inputs and can express the national comparative advantage.

Because identical technology is used for all manufactured goods produced in one country, a representative firm can choosen for each country. The production function can be expressed as:

$$l_{mc}^{1-\mu} Q_c^{\mu} = \alpha + \beta_c q_c \quad \text{with} \quad Q_c = \left(\int_{i=1}^{n} q_i^{(1-1/\sigma)} di \right)^{\sigma/(\sigma-1)} \tag{4}$$

where l_{m_c} is the quantity of labour employed by each firm, $l_{m_c} = L_{m_c}/n_c$. Q_c is the aggregate of intermediate goods. Each manufacturing firm in country c offers a wage w_{mc}. The total cost function of a firm located in country c is therefore:

$$C_c = w_{mc} l_{mc} + P_{m,c} Q_c \tag{5}$$

Turning now to the central government, as in the European Union, its objective is to improve real income of all individuals and equalise regional per capita GDP. Central government levies a tax T on sales of the manufactured goods to finance public capital G, with $G = T = T_c + T_p$:

$$G = T = T_p + T_c = g \int_{j=1}^{n_p} p_j q_j dj + g \int_{j=n_p+1}^{n} p_j q_j dj = g \int_{j=1}^{n} p_j q_j dj \tag{6}$$

g, the tax rate, concerns the manufacturing sector alone. In Europe, agriculture is largely subsidised with the Common Agricultural Policy representing 41% of the European budget in 1999, while the contribution of agricultural rights to this budget is only 2 %. This sector is therefore not taxed. Concurrently, the direct contribution of member states represents 43 % of this budget and we assume it is levied by direct taxation of other sectors. Taxation is not a lump sum type because the contribution of members is proportional to their wealth.

Government can provide public services from public capital and it is assumed that these increase productivity (i. e., in our case, reduce variable cost β). Here taxation on manufacturing sales is spent by central government on producing local infrastructure, which reduces local variable cost of production, i. e. increases productivity of input. This assumption is a means of introducing the fact that "*productivity levels are just a proxy for low cost of production, which are generally affected by infrastructure, taxation industrial policies, and so on*" (Ricci, 1999, p. 359). Making this assumption is tantamount to making comparative advantages endogenous. Ricci (1999) introduces exogenous comparative and absolute advantages in a model *à la* Krugman (1991) and shows that "*if the effect through productivity advantage is stronger than the effect through market size, firms will move to the small more productive region*" and "*an increase in comparative advantage is not necessarily associated with an increase in specialisation*" (p. 373). Venables (1999) makes it as well but in a vertical-linkage model *à la* Venables (1996).

In the European context, most public income is spent on infrastructure, especially transport and communication infrastructure and human capital, to reduce regional disparities. Ford and Poret (1991) conclude that public spending has a positive impact on local productivity in Europe, even if the simultaneous bias, especially du to the effect of taxation on income, is controlled. It is therefore relevant to analyse the impact of European policy on location and welfare by assuming that public spending affects the productivity of firms.

The relationship between manufacturing productivity and productive public services available takes the following form :

$$\beta_p = [\theta G + 1]^{-\nu} \quad \beta_c = [(1-\theta)G + 1]^{-\nu} \tag{7}$$

The public services here are pur public goods in each country. There is no congestion and all firms located in the country supplying public services can use them as much as they wish. The marginal impact of public services on local productivity increases with G, if $\nu > 1$, decreases with G if $v \in]0;1[$, and remains constant if $v = 1$. This form of the relationship is flexible enough for both cases to be studied and will be important in determining the best policy for maximising welfare.

2.2 Short-run equilibrium

We now consider the short-run equilibrium conditions, when not only workers but also firms are immobile. We consider supply and demand conditions and then turn to equilibrium conditions on goods and labour markets.

On the supply side, firms minimise their production costs (5) under technological constraint (4). The optimal cost function for a firm located in country c is :

$$C_c = w_c^{1-\mu} P_{mc}^{\mu} (\alpha + \beta_c q_c) \tag{8}$$

The optimal price of goods supplied by a firm located in country c, and the optimal level of production when there is free entry (profits are nil), are therefore respectively:

$$p_c = \frac{1}{(1-g)} \frac{\sigma}{(\sigma-1)} \beta_c w_c^{(1-\mu)} P_{mc}^{\mu} \text{ and } q_c = \frac{(\sigma-1)\alpha}{\beta_c} \tag{9}$$

The equilibrium price is equal to the mark-up, weighted by the tax rate, multiplied by the marginal cost, which depends on the local price index, on the local wage and on local productivity. The level of production of each firm depends on its location because it depends on the production technology. It also depends on the position of the firm on the goods market (σ).

Demand addressed to firms is equal to the sum of goods demanded for consumption and of goods demanded as intermediate goods by firms in both countries. After simplifications, the total demand for a single variety produced in country c is:

$$D_c = \left(E_c \left(P_{mc}\right)^{\sigma-1} + tE_p \left(P_{mp}\right)^{\sigma-1}\right) p_c^{-\sigma} \tag{10}$$

where E_c and E_p, incomes spent on manufactured goods in each country, are respectively equal to:

$$\begin{aligned} E_c &= \gamma w_c L_c + (1-g)\mu n_c p_c q_c \\ E_p &= \gamma w_p L_p + (1-g)\mu n_p p_p q_p \end{aligned} \tag{11}$$

If we now turn to the labour market, we can write the wage bill:

$$w_c L_{mc} = (1-g)(1-\mu) n_c p_c q_c \tag{12}$$

where w_c is the wage in country c and L_{mc} is the share of population working in the manufacturing sector of country c. We can also derive equilibrium quantity of labour used by both the agricultural, L_a, and manufacturing sectors, $L_{mp} + L_{mc}$. Consumers spend a

share $1-\gamma$ of their income to buy agricultural good and as this sector is in constant returns to scale, the share of labour used by it can therefore be written as: $L_a = (1-\gamma)(w_c L_c + w_p L_p)$. By using this condition, and assuming that there is always agriculture in country p ($w_p = 1$), we obtain:

$$L_{mp} + L_{mc} = (1+\lambda) - (1-\gamma)(1+w_c\lambda) \tag{13}$$

And, finally, the taxes collected by government are:

$$T_c = g\frac{w_c L_{mc}}{(1-\mu)(1-g)} \text{ and } T_p = g\frac{w_p L_{mp}}{(1-\mu)(1-g)} \tag{14}$$

Tax rate has two effects on public income: it obviously increases public income directly, by a "rate effect", but it also reduces the public incomes by a "base effect", meaning reduces the manufacturing incomes.

We can now describe centripetal and centrifugal forces by writing the profits of each manufacturing firm in region c :

$$\pi_c = \frac{p_c}{\sigma}(D_c - q_c) \tag{15}$$

When there is no public sector, as in the model of Krugman and Venables, there are two main agglomeration forces connected with the presence of vertical linkage. On the one hand, the rise in the number of local firms reduces the price index and therefore the production cost (8). This is the *cost* or *forward linkage* effect. On the other hand, the increase in the number of firms in one region spreads the local manufacturing demand which leads to increase demand addressed to each firm (11) and so to grow their profits (15). Concurrently, agglomeration of firms generates two dispersion forces: the entry of a new firm in one region leads to an increase in demand for local labour, which puts up local wages (12). This mechanism works better when the manufacturing sector is more labour-intensive. The growth of the number of firms lowers the price index. Therefore, for a given price and

a given income, local demand for each variety of good will be weaker (10). The fiercer the competition in the manufacturing sector, the more intense this centrifugal force will be. Competition in both local labour and goods markets tends to favour the dispersion of foot-loose activity.

In our model two further agglomeration forces exist in the *core* country; the larger population strengthens the home market effect and reduces the degree of competition on the local labour market. *Ceteris paribus*, the manufacturing wage bill is higher in the smaller country.

Concerning the matter of policy, public income, T, is centralised and public capital is redistributed between both countries by central government. As we assume a comparative advantage, due to a specific public policy, there is a new agglomeration force in the country that enjoys that advantage. This may become a dispersion force if we assume that this comparative advantage is in the smaller country. In our case, when the tax rate is equal in both countries, public services may be redistributed in favor of the smaller region. Furthermore, in order to reduce inequalities between two countries, government may increase the tax rate to increase its income or distribute public spending unevenly between the two countries. Central government therefore has two instruments for reducing inequalities between countries: taxation and the spatial distribution of infrastructure. Before describing the effects of public policy, we determine the spatial allocation of manufacturing activities in the absence of any regional policy.

3. Spatial allocation without regional policy

In this section, we assume that there is no public sector and that countries differ by their population size alone, manufacturing technologies are the same in both countries: $g = 0$

and $\beta_p = \beta_c = 1$, in order to focus on the consequences of unequal spatial distribution of population on location equilibrium.

We determine a long-run spatial equilibrium, which is defined as stationary state in which the number of firms in each country no longer changes in response to short run profits, i. e. when $w_c \geq 1$, $w_p = 1$ and $\pi_c = \pi_p = 0$. This equilibrium leads to the geographical distribution of manufacturing firms given by the sectorial distribution of employment L_m in each country. This equilibrium depends on the trade cost, τ, on the share of income spent on manufactured goods, γ, the relative size of the core, λ, the elasticity of substitution between manufactured goods, σ, and the share of intermediate goods in technology, μ.

We first determine the spatial equilibrium by numerical illustrations. We consider this distribution when trade cost is high ($\tau = 3$) and is low ($\tau = 1.5$), in Figure 1, for three cases[2]. The first line represents the case with equal spatial distribution of population among countries and is the same as that Krugman and Venables ($\lambda = 1$). The other two cases are with unequal spatial distribution of population; we successively consider the location of firms when $\lambda = 1.25$, meaning that the core has a 25 % larger population than the periphery, and when $\lambda = 1.5$. Equilibrium locations (given by equations $A5$ and $A6$ in Appendix A) are represented by the following figures showing the sectorial distribution of workers for the larger country, country c.

[Figure 1 about here]

In those graphs the length of the horizontal axis is L_{mc}/L_c, the proportion of the labour force employed in the manufacturing sector, in core. The vertical axis represents the wage differential between countries, $\widetilde{w}$ ($\widetilde{w} = w_c$, because $w_p = 1$). The equilibrium on the labour market is given by the intersection between the curves representing demand for labour from the manufacturing sector (L_m^D) and from the activity tied to the land (L_a^D). L_a^D does not

depend on the level of activity in the country or on the location; because of constant returns to scale and of exchange without any cost in this sector, $w_a = 1$, regardless of the spatial distribution and equilibrium conditions on the manufactured goods market.

In Figure 1, Equilibrium 1 corresponds to the figure of Krugman and Venables, when population is evenly distributed. We fortunately confirm their results: both countries have the same industrial structure and the proportion of workers in the manufacturing sector is equal to the share of income spent on manufactured goods, i. e. γ which is equal to 0.6 here. Assuming now that country c has a larger population ($\lambda = 1.25$ and then $\lambda = 1.5$), the proportion of population employed in the manufacturing sector in this country becomes greater than γ, this share is 0.75 and 0.9, respectively. In the other country, this share declines in the same proportion and country p is specialised in the agricultural sector.

In Figure 1, we examine the impact of integration between the two countries measured by a fall in the cost of trading manufactured goods ($\tau = 1.5$). Whatever the spatial distribution of population, the only stable equilibrium is total specialisation of the large country in the manufacturing sector. This result is identical to those found by Krugman and Venables. The unequal distribution of population also has an impact on the wage level in country c, which is specialised in the manufacturing sector. This is the consequence of the lower degree of competition on the labour market, and also of the greater demand of manufactured goods in this country.

These two simulations show that the larger population has a positive effect on the spatial distribution of firms. This stems from the market size effect on the goods market and the competition effect on the labor market, which increases the agglomeration forces.

We can generalise these results, whatever the trade cost. We can therefore make the following proposition:

Proposition 1: *Whatever the trade cost, the uneven spatial distribution of footloose firms is greater than the uneven spatial distribution of population.*

At the equilibrium, two cases pertain:

Case 1: $w_c = 1$ and $\gamma\lambda \leq L_{mc} \leq \lambda$. If $w_c = 1$, then $L_{mp} = (1+\lambda)\gamma - L_{mc}$. In this case, $\gamma - (1-\gamma)\lambda \leq L_{mp} \leq \gamma$. Therefore, $\frac{Lm_c}{Lm_p} > \lambda$.

Case 2: $w_c > 1$ and $L_{mc} = \lambda$. In this case, $w_c = \frac{\gamma - Lm_p}{(1-\gamma)\lambda}$, by definition $w_c > 0$. Therefore, in this case, the following inequality is invariably holds: $L_{mp} < \gamma$. Therefore, $\frac{Lm_c}{Lm_p} > \lambda$.

We find the same result as Krugman and Venables (1990), who did not introduce endogenous income, showing that the share of manufacturing in a country is larger than its share of initial endowment in workers. Thus the distribution of industries may be really different in the two countries with intense specialisation in one sector. Moreover, the proof of result 1 also shows that:

Proposition 2: The share of manufacturing activity in the periphery varies with the share of household spending on manufactured goods, γ. It is always less than γ, and always positive if $\lambda w < \frac{\gamma}{(1-\gamma)}$, i. e. if the income of the population of country c is less than the relative share of income spent on manufactured goods.

In the first case, when $w_c = 1$ and the difference in population size λ is greater than the relative share of manufacturing expenditure, $\gamma/1-\gamma$, the higher this relative share, the more concentrated manufacturing firms in the small country.

In the second case, the difference in population size is greater than the relative share of manufacturing expenditure multiplied by the inverse of the relative wage, w. Thus the higher this relative share, and the lower the relative wage, the greater the concentration of firms in the small country. If $w \geq \frac{\gamma}{(1-\gamma)\lambda}$, then $L_{mp} = 0$.

This last result contradicts those of Krugman (1991). Krugman shows that agglomeration is likely to occur when the relative share of the manufacturing sector is quite large. In our model, the share of manufacturing firms located in the periphery is positively related to this share, because workers are immobile. In Krugman's (1991) model, manufacturing workers are perfectly mobile and so the higher the manufacturing expenditure, the greater the incentive to access a large variety of goods. Workers are therefore attracted by regions where sellers are numerous, which involves a reduction in wage. And, firms are drawn to the region where consumers are numerous. In our model, the immobility of workers leads to a labour shortage in the large country when demand for manufactured goods grows. Therefore, some manufacturing firms may be located in periphery.

The assumption that an immobile population is unevenly distributed between the countries has two effects: first, competition between firms to attract workers is weaker in the core, and second, demand for manufactured goods is higher. Agglomeration forces are therefore intensified and firms are more concentrated in the core than the population, challenging the ability of the public authorities to reduce regional divergence.

4. Public spending, equal regional per capita GDP and welfare

By studying the consequences of public expenditure when it affects the productivity of firms, we seek to explain how public spending and taxation affect location decisions and therefore regional per capital GDP and welfare. We examine the conditions under which policy leads to maximal real income and equal per capita GDP among countries. With this aim in view, the central authorities dispose of two instruments: the tax rate and the spatial distribution of public spending.

The constraint for central government is to achieve the same per capita GDP, Y, in both

countries, i. e. $Y_c/L_c = Y_p/L_p$, with:

$$\begin{aligned} Y_c &= Y_{ac} + (1-g)n_c p_c q_c = L_{mc}\frac{w_c - 1 + \mu}{1-\mu} + L_c \\ Y_p &= L_{mp}\frac{\mu}{1-\mu} + L_p \end{aligned}$$

This constraint is equivalent to (see Appendix B):

$$\frac{L_{mc}}{L_{mp}} = \lambda$$

The inverse productivity of firms located in country p and c respectively is still equal to: $\beta_p = (\theta G + 1)^{-\nu}$ and $\beta_c = ((1-\theta)G + 1)^{-\nu}$ with:

$$\beta_c/\beta_p = \beta = \left[\frac{(1-\theta)G + 1}{\theta G + 1}\right]^{-\nu} \tag{16}$$

where $\theta > 1/2$. The productive infrastructure policy has two effects: a level effect and an allocation effect. Given the spatial distribution of public spending, the higher the level of this spending, the higher the productivity of firms located in the periphery (level effect). For a given level of public spending, the greater the allocation to the small nation, the greater the increase in productivity of local firms (allocation effect).

In order to achieve the specific equilibrium, as a first step, central government determines a β^* such that $Y_c/L_c = Y_p/L_p$. Then, as a second step, central government determines a tax rate g^* which maximises total utility, calculated as the sum of indirect utility achieved by consumers located in both countries. Thus, like the European Union, central government maximises the global welfare of all its residents under the constraint of equalisation of regional per capita GDP.

Stage 1. At this stage, β becomes the endogenous variable. We first determine β^* for each stable equilibrium leading to $Y_c/L_c = Y_p/L_p$, as a function of the value of trade cost.

The equilibrium conditions (see Appendix B) become

$$\begin{cases} \lambda\left(\frac{\beta^*\gamma\lambda p^{-\sigma}+t\gamma}{\gamma+t\beta^*\gamma\lambda p^{-\sigma}}\right)^{-1} = \frac{t\beta^*-p^\sigma}{tp^\sigma-\beta^*} \\ p^{(1-\sigma)/\mu}\beta^{*(\sigma-1)/\mu} = \frac{\beta^*\gamma\lambda p^{-\sigma}+t\gamma}{\gamma+t\beta^*\gamma\lambda p^{-\sigma}} \end{cases}$$

The variation in trade cost does not affect the possibility of attaining a stable equilibrium, however, the policy should be designed to achieve this equilibrium. In the following graph, β^* is plotted for each value of trade cost[3]:

[Figure 2 about here]

Result: Whatever the trade cost, there is a spatial differential of productivity, β^*, which leads to equalisation of regional per capita GDP. The higher the trade cost, the greater public intervention should be. However, while β^* slowly declines with τ at the beginning of the integration process, this decline is faster at the end of the process.

Classically, the degree of competition within the manufacturing sector, σ, and the labour intensity, $1-\mu$, reduce agglomeration forces and therefore the level of public intervention necessary to observe equal real per capita GDP.

Even if the trade cost is very high, the level of public intervention is never very high, in our numerical illustrations, because the dispersion of demand, which is a centrifugal force, remains one of the deciding factors of the choice of location. The differential of local productivity due to policy should just fill the gap between the relative "natural" dispersed equilibrium and the more dispersed equilibrium we fixed as target. When the trade cost declines more, the slope of curve plotted above steepens, because we have a case of intermediate values of trade cost and strong agglomeration forces. In this last case, firms are concentrated to exploit increasing returns to scale, on the supply side, and to avoid paying

the trade cost when they purchase intermediate goods, on the demand side. Finally, when τ is low, because of competition on the labour market, some manufacturing firms have an advantage of moving to the periphery to cut their production costs, and dispersion forces are intense.

As Trionfetti (1997) shows in a different context, appropriate public expenditure eliminates the possibility of regional integration bringing about total agglomeration of manufacturing firms. Thus, Trionfetti (1997) concludes that in a model *à la* Krugman (1991) public government can counteract agglomeration by spending on manufacturing goods in the smaller region thereby increasing the home market effect in this region. This model considers a demand policy contrary to ours, where policy has an impact on the productivity of firms and therefore on supply.

Central government now knows the value of β^* which corresponds to identical added value per capita in all regions, for each trade cost.

Stage 2. The last stage for government is to determine the optimal tax rate at the stable equilibrium, meaning the tax rate leading to β^* and to relative optimal global welfare, given the above objective.

To bring about this specific stable equilibrium, government can use the tax rate or the uneven spatial distribution of public investments. By using equations (6), (12), (13) and (7), the relationship between the spatial distribution of public investments and the tax rate, corresponding to the differential of productivity at the stable equilibrium (β^*), is:

$$\theta^* = \frac{\beta^{*\frac{1}{\nu}}(G^*+1)-1}{G^*(1+\beta^{*\frac{1}{\nu}})} \text{ where } G^* = \frac{g^*}{1-g^*}\frac{(1+\lambda)\gamma}{1-\mu}$$

with $\partial\theta^*/\partial g^* < 0$, $\partial^2\theta^*/\partial g^{*2} < 0$. So, to reach the specific target, there is a trade-off between low levels of spending directed massively at the smaller region (increasing θ), and high levels of spending directed majoritarily, but only slightly so, at the periphery. The

absolute value of θ^* is always greater than 1/2.

Central government now chooses the combination of θ^* and g^* that gives equal per capita GDP (β^*) and which also maximises welfare.

Total utility is

$$V_T = Pm_c^{-\gamma} + Pm_p^{-\gamma}$$

with:

$$\begin{aligned} P_{mp} &= (1-g^*)^{(\sigma-1)\Psi}\left(\beta_p^*\right)^{(1-\sigma)\Psi} B\gamma^{\Psi}\left(1+\tau^{1-\sigma}p^{*1-\sigma}\lambda\right)^{\Psi} \\ P_{mc} &= (1-g^*)^{(\sigma-1)\Psi}\left(\beta_p^*\right)^{(1-\sigma)\Psi}(\beta^*)^{(1-\sigma)\Psi} B(\gamma\lambda)^{\Psi}\left(1+\frac{\tau^{1-\sigma}}{p^{*1-\sigma}\lambda}\right)^{\Psi} \end{aligned}$$

where $B = \left(\frac{1}{1-\mu}\right)^{\Psi}\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma\Psi}$, $\beta_p^* = (\theta^*\frac{g^*}{1-g^*}\frac{(1+\lambda)\gamma}{1-\mu}+1)^{-1/\upsilon}$, $p^* = \frac{p_c^*}{p_p^*}$, $\Psi = (1-\sigma(1-\mu))^{-1} < 0$ if $\sigma > (1-\mu)^{-1}$, and g^* and θ^* are endogenous variables. Note that the tax rate has the same effect on P_{mp}, i.e. utility in the small country, as on P_{mc}, i.e. utility in the large country. Therefore maximising global utility is the same as maximising welfare in each country. The direct effect of tax rate is negative and the indirect effect, *via* the impact of public spending on productivity, is positive. There is no interior solution but only corner solutions for the optimal tax rate (see Appendix C). We obtain the following result:

Proposition 3: *When central authorities maximise total real income with a constraint of balanced spatial allocation of activities, the share of public investments made in the small country should be*

- massive and the tax rate should be low, if the marginal impact of public investments on productivity is decreasing, $\nu < 1$,

- small, if the marginal impact of public investments on productivity is increasing, $\nu > \frac{\gamma(1+\lambda)}{2(1-\mu)} > 1$.

Thus, in the case of equal regional per capita GDP, thanks to the public intervention, welfare falls with g^*, when the marginal impact of public investments on productivity is decreasing. In this case, the allocation effect is favoured.

When the marginal impact of public investments on productivity is increasing, welfare grows with g^*, if the gap between population sizes, λ, and the share of household spending on manufactured goods, γ, is narrow enough or if labour intensity, $1-\mu$, is high enough. Under these conditions, the agglomeration forces are weaker. The level effect is given precedence in this case.

Public policies using investments in productive infrastructure can be a relatively efficient way of reducing regional disparities. They can achieve dispersion of manufacturing firms in line with the dispersion of population and maximise welfare under the constraint of equal value added between countries. This is the avowed goal of the European Union and it does not appear unrealistic; the current policy of investments in productive infrastructure in poorer regions, does not seem a bad way of achieving this. The policy must take into account the form of the marginal impact of public investments on the productivity of manufacturing firms and the parameters describing the economy.

So far, we have sought to evaluate whether the public target described above could be achieve and how intense a policy was required to observe it. In fact, the impact of suchs policy on welfare should be compared with the situation in the absence of public intervention and should be discussed in the light of equity criteria.

5. Efficiency and Spatial Equity

In this section, we compare real income with and without public policy in order to determine the effect on welfare of the kind of public intervention described above. We attempt to find

out whether public intervention is more efficient than "*laisser faire*". If it is found not to be, we look at whether government should intervene, in light of different equity criteria. With this aim in view, real income for all individuals, regardless of their location, and the real incomes of individuals located in each country are measured by numerical illustrations. Although this way of evaluating welfare is not general, it partly fills the gap in the efficiency and spatial equity analysis in economic geography, which is reported by Puga (2000, p. 31).

Does public intervention improve the real income for households located in each country? To answer this question, we first look at the sum of real income of all individuals. This is shown by the following graphs, i. e. $\lambda V_c + V_p$, with and without public policy designed to equalise per capita GDP and maximised welfare, for all values of trade cost[4]. The impact of public investments on private productivity is decreasing ($\nu = 0.9$) and increasing ($\nu = 1.1$).

[Figure 3 about here]

This Figure shows real per capita income and four situations arise depending on the value of the trade cost: at the beginning of the integration process, the manufacturing firms are dispersed and the larger country is not completely specialised in manufacturing, while the smaller one not completely specialised in agriculture. The real per capita income is higher in the core, when λ is greater than unity. When trade cost begins to fall, all workers in the larger country are employed by manufacturing sector, but there are some manufacturing firms in the smaller country too, and real income is clearly higher in the core. When trade cost is about 2, all manufacturing firms are located in the core, there is total agglomeration, and real income is higher in this region. Finally, when trade cost is close to 1.2, the same configuration as before is observed, i.e. all workers in the core are employed by manufacturing sector, but there are some manufacturing firms in the periphery, and real income is higher in the core.

In both cases, with or without public intervention, welfare is maximum when there is total integration, when there is no trade cost. If we consider the "*laisser faire*" situation alone, the real income in both countries falls when agglomeration of firms in one country is total. In this case, as the smaller country imports all its manufactured goods, $P_{mp} = \tau P_{mc}$. The price index in country C, when total agglomeration takes place is higher than the price index in country C without total agglomeration and therefore the price index also increases in country P. This result derives from the assumption of geographical immobility of population between nations. Because the labour supply is constant, the concentration of all manufacturing firms in one country intensifies tension on the labour market in this country and increases wages and therefore prices. We also note that the wage increase in country C has a positive direct effect on real income. In numerical illustrations, the rise in the price index is greater than the rise in wage[5].

If we now compare both situations, with and without policy, when there is total agglomeration in the "*laisser faire*" case, for intermediate values of trade cost, real income is comparable. And, not surprisingly, by comparing both figures, an increase in the marginal impact of public spending on productivity (a high v) leads to a rise in the total real income and increases the likelihood that real income in this latter case will be higher than it would be in the absence of any public policy.

So far an utilitarian efficiency criterion has been used, which assumed that the real incomes of each individual could be added. Another way to analyse the efficiency of public policy would be observe whether the welfare of individuals located in each country is improved, i. e. to apply the Pareto criterion. We therefore plot different combinations of real per capita income in each country in two situations: the link between public investments and productivity of firms is first decreasing ($\nu = 0.9$) and then increasing ($\nu = 1.1$). Figure

4 represents the real income in each country when a policy is in place minus the real income when there is no policy, for each country: $dV_p = V_p^p - V_p^{wp}$ and $dV_c = V_c^p - V_c^{wp}$, where V^p and V^{wp} are respectively the indirect utility with and without public intervention.

[Figure 4 about here]

Individuals located in the larger country invariably loose real income, when there is a public policy compared with the "*laisser faire*", despite the increased impact of public investments. Public intervention is therefore never Pareto optimal.

Nevertheless, in the agglomeration area, the real income in the smaller country is improved when there is public intervention, and we can naturally question the compensation principle. There is compensation when the global gain, obtained by some individuals, is larger than the lost, withstood by other individuals. To study this principle, we plot the net benefit when a public policy is introduced. This net benefit is positive if $V_p^p - V_p^{wp} > V_c^{wp} - V_c^p$, i. e. $dV_p + dV_c > 0$.

[Figure 5 about here]

The compensation principle is sometimes carried out, and this possibility depends on the marginal impact of public investments on private productivity. Actually, our numerical simulations show that if this latter is positive, the net benefit is positive, otherwise it is negative. Thus the way in which public services affect private productivity really matters for the efficiency of public intervention.

The above criteria do not introduce spatial equity considerations which are important in public choices made in the regional context. Spatial equity is defined as the conditions for which an equity criterion is fulfilled whatever the location of individuals. There are a lot of equity criteria and we chose two of them to compare situation with and without

public policy. The first and possibly better known criterion is given by Rawls. Under this criterion, the more equitable situation is that where the real income of the poorest individual is maximum. This means choosing the situation whereby the utility of the worst-off individual, i. e. individuals located in periphery (see Figure 6), is the greatest:

$$\max \min\{V_p^p; V_p^{wp}\}$$

In the light of the Rawlsian criterion, the public intervention is justified in the total agglomeration area because it improves the satisfaction attained of individuals located in the periphery (see Figure 6). For other values of trade cost, outside the total agglomeration area, the "laisser faire" equilibrium is more equitable, considering the Rawls' criterion.

[**Figure 6 about here**]

Finnaly, the egalitarian criterion is considered. This definition of equity leads to choose the situation where the differential of real per capita income are minimised. In Figure 7, the real income in the core minus the income in the periphery is plotted, for "laisser faire" and public intervention.

[**Figure 7 about here**]

In the egalitarian case, public policy is always more equitable, it always reduces the gap between real income in the core and in the periphery. Nevertheless, this example shows the limits of this criterion because this kind of equity is always attained at the cost of a reduction in the welfare of numerous individuals.

In some very specific cases, public policy therefore increases real the income of all individuals regardless of their location, and in more cases it increases real income of households located in the periphery, comparing with the global agglomeration situation. However, this

per capita real income is very sensitive to parameter values and to technology in the public services sector.

Finally, if economies are in an integration phase, corresponding to the global agglomeration of mobile activities, it may be not only equitable but also efficient to conduct a policy of productive investments, in specific cases (depending of their marginal impact on private productivity). These results must be taken with the greatest of caution because, as in most economic geography models with endogenous incomes, they stem from simulations and therefore represent specific instances. This result is the same as that found analytically by Thisse and Ottaviano (forthcoming) in an economic geography model ignoring income effects. As in our general equilibrium model with income effect, there is not always trade-off between equity and efficiency for public authorities.

If we consider the Rawlsian criterion, public intervention is not justified outside the total agglomeration area. Moreover, our analysis shows that the total real income is highest and spatial inequalities are weakest when trade costs are very low, as suggested by Puga & Venables (1997).

6. Conclusion

In this paper, we have investigated the ability of the central authority to improve the real income of its residents and to reduce regional inequalities through a policy of creation of regional productive infrastructure. We have also analysed whether the public intervention is desirable from the collective standpoint. To do this, we have built an economic geography model *à la* Krugman Venables (1995), introducing unequal sizes of countries, as are found in Europe and central public authorities that distribute public investments.

We show first that the uneven distribution of population between the countries reinforces

agglomeration economies because it decreases the wage bill and increases the home market effect in the larger country and firms are therefore more concentrated than the population.

If the objective of public authorities is the same as that of the European Union, i. e. to equalise local per capita wealth and to maximise welfare, this public target can be reached. The intensity of public intervention depends on the way public services affect private productivity. Indeed, the model shows that public expenditure must be low (high) and directed massively (only majoritarily) at the small country if the marginal impact of public investments on productivity is decreasing (increasing).

Then, to determine whether public intervention is desirable, we compare welfare with and without public intervention in the light of different efficiency and equity criteria, as Pareto, compensation, Rawlsian and egalitarian principles. The model shows that investing in public infrastructure in the smaller country could be not only equitable but also efficient, if values of trade costs correspond to the agglomeration area in the "laisser faire" case. In our model, when trade costs take intermediate values, the market outcome is total agglomeration of mobile economic activities for which welfare is lower than other spatial configurations. Thus, as in Ottaviano and Thisse's article (forthcoming), this paper concludes that there is not always a trade-off between efficiency and equity, contrary to the widespread belief (Martin, 1998). Nevertheless, outside the agglomeration area, public intervention does not seem justified, under the efficiency and equity criteria, even under the Rawlsian criterion.

The results we obtain concerning the possibility for government to reduce regional disparities are quite optimistic. In the European context, if trade costs take intermediate values, corresponding the agglomeration configuration, regional policy is warranted.

Actually we have not considered the consequences of public spending in terms of transfer of purchasing power which may be important in the European context (Martin, 1999).

Moreover, the policy maximising welfare without any constraint was not study because the model choosen here is too complex. Further investigations of optimal spatial allocation resulting from a central planner are required.

Appendix A

In order to determine location equilibrium, we resolve equilibrium on goods and labour markets. Let us assume relative values of endogenous variables

$$p = \frac{p_c}{p_p}; w = \frac{w_c}{w_c}; E = \frac{E_c}{R_p}; P_m = \frac{P_{mc}}{P_{mp}}; n = \frac{n_c}{n_p}; \beta = \frac{\beta_c}{\beta_p}$$

From (5) and (13),

$$P_m^{1-\sigma} = \frac{\beta g^{-1} w L_{m,c}^{-\sigma} p^{-\sigma} + t L_{mp}}{L_{m,p} + t\beta w L_{mc} p^{-\sigma}} \tag{A1}$$

From (9) :

$$E = \frac{\gamma(1-\mu)\lambda + L_{mc}}{\gamma(1-\mu) + L_{mp}} \tag{A2}$$

From (11),

$$p = \beta w^{1-\mu} P_m^{\mu} \tag{A3}$$

From (8),

$$p^{\sigma} = \beta \frac{E P_m^{\sigma-1} + t}{1 + t E P_m^{\sigma-1}} \tag{A4}$$

From $(A4)$, $(A1)$ and $(A2)$, we obtain

$$\frac{\gamma(1-\mu)\lambda + L_{mc}}{\gamma(1-\mu) + L_{mp}} \left\{ \frac{\beta w L_{mc} p^{-\sigma} + t L_{mp}}{L_{mp} + t\beta w L_{mc} p^{-\sigma}} \right\}^{-1} = \frac{t\beta - p^{\sigma}}{t p^{\sigma} - \beta} \tag{A5}$$

From $(A3)$ and $(A1)$, we obtain,

$$p^{(1-\sigma)/\mu} \beta^{(\sigma-1)/\mu} w^{(\mu-1)(1-\sigma)/\mu} = \frac{\beta w L_{mc} p^{-\sigma} + t L_{mp}}{L_{mp} + t\beta w L_{mc} p^{-\sigma}} \tag{A6}$$

$(A5)$ and $(A6)$ are equilibrium conditions.

Appendix B

The constraint for central government is to attain the same GNP, Y, per capita in both countries, i. e. $Y_c/L_c = Y_p/L_p$, with:

$$\begin{aligned} Y_c &= Y_{ac} + (1-g)n_c p_c q_c = L_{mc}\frac{w_c - 1 + \mu}{1-\mu} + L_c \\ Y_p &= L_{mp}\frac{\mu}{1-\mu} + L_p \end{aligned}$$

Under this constraint, we can write the following proposition:

Proposition 3: If the spatial distribution of added value is identical to the distribution of population, the nominal wage in the core is equal to the nominal wage in the periphery.

Proof: If $Y_c/L_c = Y_p/L_p$ then $\frac{w_c}{1-\mu} = L_{mp}\frac{\mu}{1-\mu} + 1$. If $w_c > 1$, $L_{mc} = \lambda$.and thus, in this case, $w_c = 1 + \mu(L_{mp} - 1)$. $L_{mp} - 1 < 0$ and thus $w_c < 1$, which is impossible. Therefore, if $Y_c/L_c = Y_p/L_p$, w_c is always equal to 1.

Therefore, if $Y_c/L_c = Y_p/L_p$, $w_c = w_p$, and the constraint is equivalent to:

$$\frac{L_{mc}}{L_{mp}} = \lambda$$

Because of equilibrium conditions on labour market (13), in this case, we also have:

$$L_{mc} = \gamma\lambda \qquad\qquad L_{mp} = \gamma$$

Equilibrium conditions (A5) and (A6) become therefore:

$$\lambda\left\{\frac{\beta\gamma\lambda p^{-\sigma} + t\gamma}{\gamma + t\beta\gamma\lambda p^{-\sigma}}\right\}^{-1} = \frac{t\beta - p^{\sigma}}{tp^{\sigma} - \beta} \tag{A5'}$$

$$p^{(1-\sigma)/\mu}\beta^{(\sigma-1)/\mu} = \frac{\beta\gamma\lambda p^{-\sigma} + t\gamma}{\gamma + t\beta\gamma\lambda p^{-\sigma}} \tag{A6'}$$

Thus, under the constraint, the global resources of government are:

$$G = g \int_{i=1}^{n} p_j q_j dj = \frac{g}{1-g} \frac{(1+\lambda)\gamma}{1-\mu}$$

Appendix C

The global welfare under constraint of equal regional added value per capita is minimal when tax rate is:

$$g' = \frac{(\gamma/v)(1+\lambda) - 2(1-\mu)}{\gamma(1+\lambda) - 2(1-\mu)}$$

If $\nu < 1$, then $g' > 1$ and V_T increases with g,when $g \in]0;1[$,

if $\nu > \nu_b = \frac{\gamma(1+\lambda)}{2(1-\mu)}$, then $g' < 0$, V_T decreases with g,when $g \in]0;1[$, and

if $\nu \in \left]1; \frac{\gamma(1+\lambda)}{2(1-\mu)}\right[$, then $g' \in]0;1[$, V_T decreases with g,when $g \in]0;g'[$ and increases with g,when $g \in]g';1[$:

[**Figure 8 about here**]

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Footnote

[1]For the periphery just substitute p for c.

[2]As in Krugman and Venables (1995), in the following simulations, $\sigma = 5$, $\gamma = 0.6$, $\mu = 0.55$.

[3]With $\sigma = 5$, $\gamma = 0.6$, $\lambda = 1.25$, $\mu = 0.5$.

[4]$\lambda = 1.25$, $\sigma = 5$, $\gamma = 0.6$, $\mu = 0.5$, in all the following graphs.

[5]Notice that in Krugman and Venables (1995), where the population is symetrically distributed, the area of total agglomeration of firms does not appear because the authors present only specific values of parameters which do not lead to such a situation. But the location equilibrium of total agglomeration may arise with certain values of parameters in the Krugman and Venables' case.

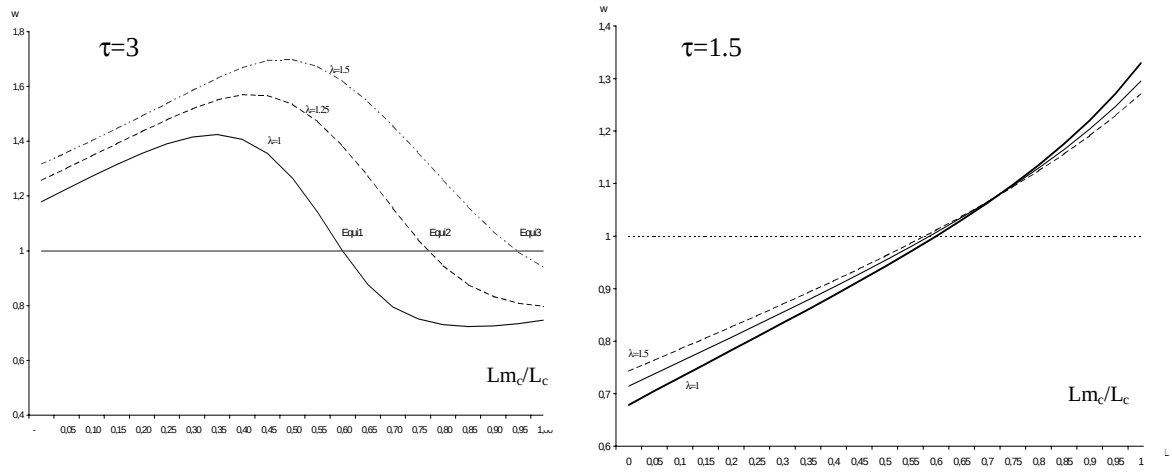

Figure 1. Labour demand in country C

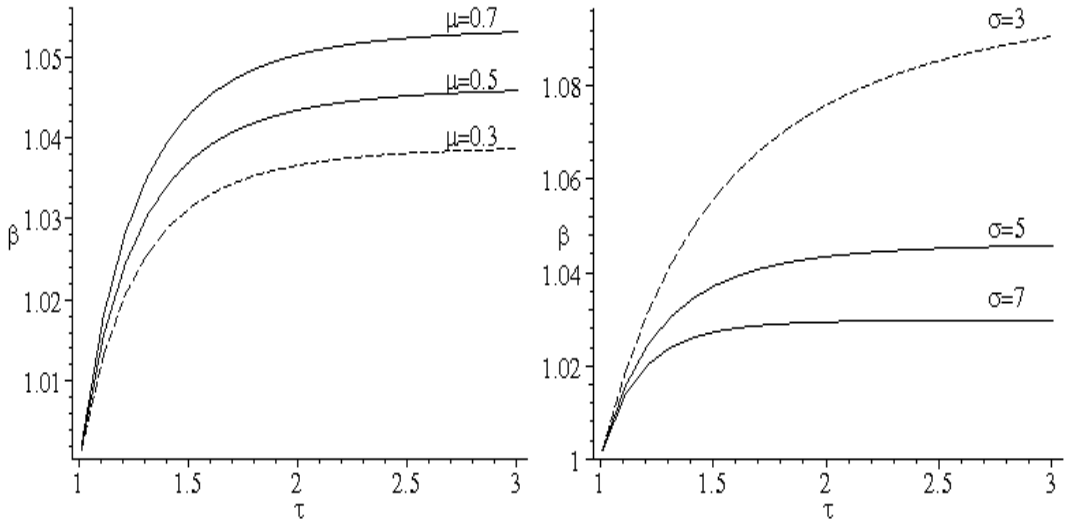

Figure 2. Relative productivity at the symetric equilibrium

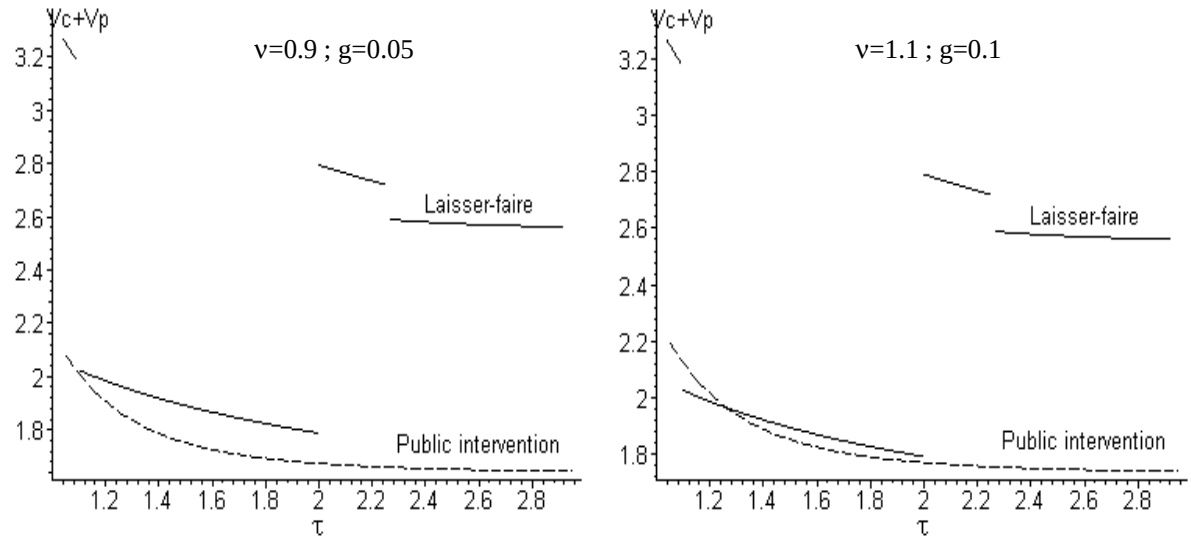

Figure 3. Total real income

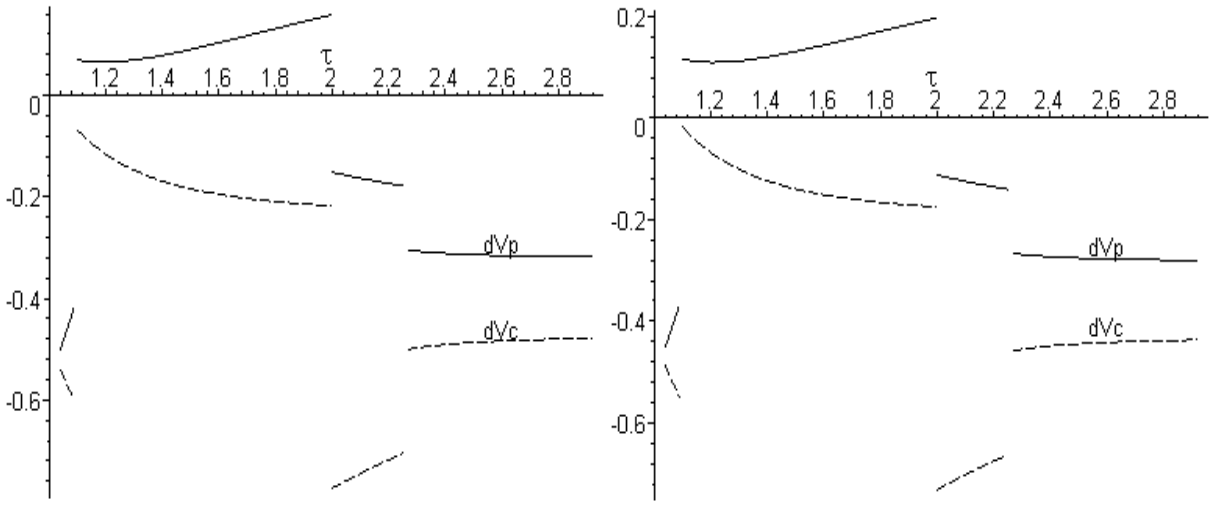

Figure 4. Pareto Criterion

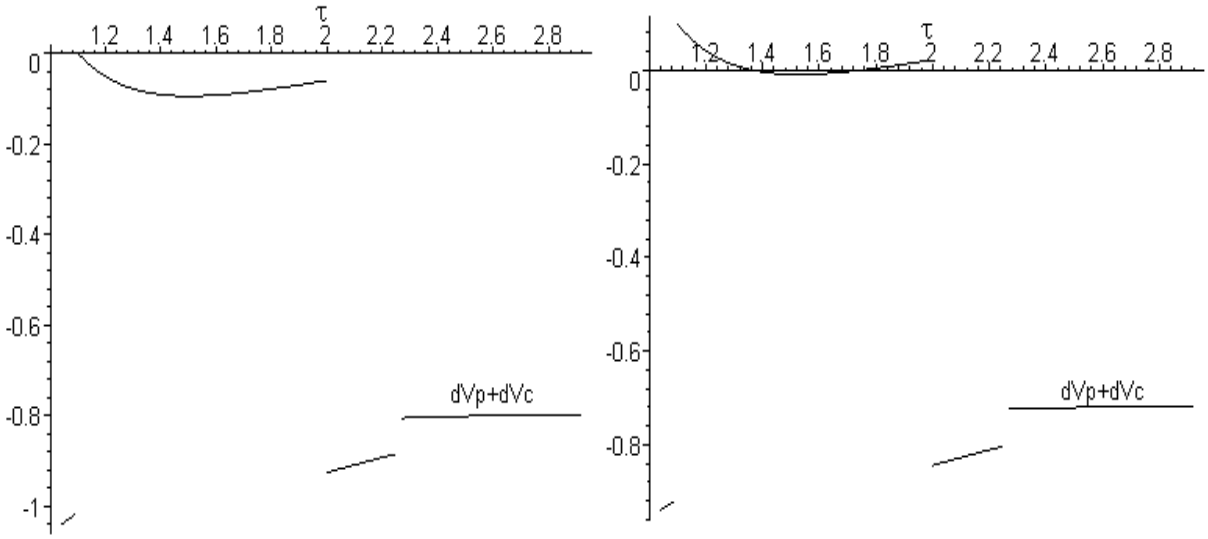

Figure 5. Compensation Principle

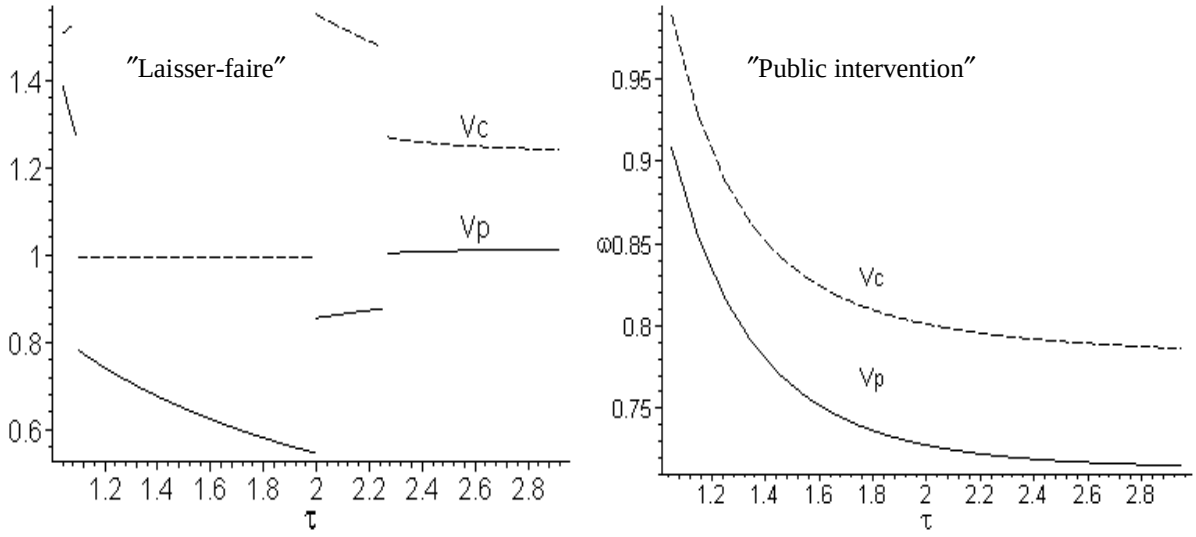

Figure 6. Real per capita income

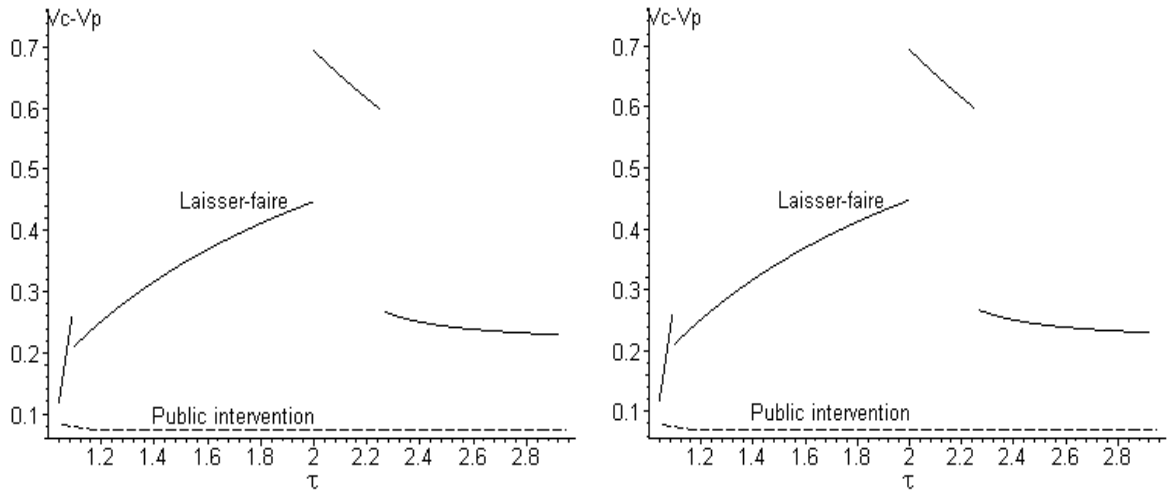

Figure 7. Egalitarian criterion

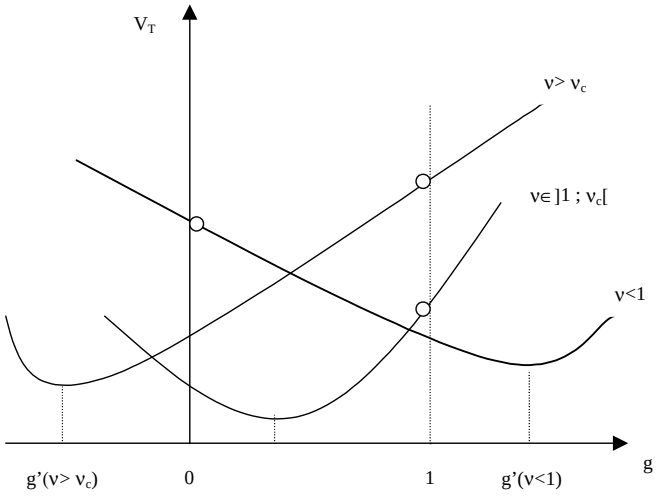

Figure 8. Total real income and tax rate