ANNALES D'ÉCONOMIE ET DE STATISTIQUE. – N° 73 – 2004

The provision of public services and industrial location

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ABSTRACT. – In this paper we insert the public sector into KRUGMAN'S seminal core-periphery model, focusing on the provision of public services financed through taxes on rents. Since public services are an element that attracts economic activity, while taxes have the opposite effect, we find that the net effect of government becomes indeterminate and depends on the individual's subjective valuation of the public services provided. Moreover, the new parameters related with government in some cases modify KRUGMAN'S results.

La provision des services publics et emplacement industriel

RÉSUMÉ. – Dans ce travail, nous introduisons le secteur public dans le modèle centre-périphérie de KRUGMAN, en accordant une importance particulière à la provision des services publics financés par les impôts sur les revenus. Étant donné que les services publics attirent l'activité économique, alors que les impôts produisent l'effet opposé, nous pouvons déduire que l'effet net du gouvernement reste indéterminé et dépend de la valorisation que les individus concèdent à la provision de services publics. En plus, les nouveaux paramètres relatifs au gouvernement modifient occasionnellement les résultats de KRUGMAN.

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The authors are grateful for the helpful comments and observations made by the Editor and by an anonymous referee.
JEL Classification: H59, R12

The literature reveals that only a limited amount of work has been devoted to studying the effects of government on the location of economic activity. In this paper we try to contribute towards rectifying this deficiency through the insertion of the public sector into Krugman's seminal core-periphery model. We focus on one of the functions of government, namely the provision of public services, which we consider to be financed through taxes on different rents. These public services increase individuals' welfare, and thus we have included them in the utility function.

There are two main results. First, since public services are an element that attract economic activity, while taxes have the opposite effect, the net effect of government becomes indeterminate. Whether or not public sector activity is able to encourage the location of new firms in a given region depends mainly on the subjective valuation made by individuals of the public services provided by their government and on their degree of rivalry. Thus, when individuals value public services highly, the welfare increase prevails, and therefore economic activity moves to those regions with a larger government size. By contrast, when individuals attach little value to the public services that are offered, the government fails to encourage the concentration of firms. On the other hand, the greater the degree of rivalry of public services, the smaller the impact of an increase in public expenditure on individual welfare, and thus rivalry of public services favours dispersion.

Secondly, we find that the introduction of the new parameters related with government in some cases modify the influence of those present in Krugman's model. In particular, the new interdependence linkages now make the influence of the representative parameter of the size of the manufacturing sector indeterminate. Moreover, the effects of the transport cost on the concentration-dispersion results are no longer monotonous (as they were in the original model). In the most representative case, they depend on the size of the transport cost. Thus, decreases in this cost, when it is high, favour concentration, but further decreases can eventually generate the dispersion of firms.

These results indicate that there is an important place for redistributive policies which could make depressed regions more attractive for firms to locate in. Since public services can attract economic activity, central government can exert a significant influence over the spatial configuration of the economy through the distribution of public expenditure among regions. With the tax shedules being the same, central government can achieve a more homogeneous distribution of economic activity in its territory through redistributive policies directed towards the deindustrialized regions.

1 Introduction

The new theoretical models of Economic Geography (see FUJITA *et al.*, [1999], for an exhaustive panoramic) are able to explain endogenously how the industrial sector in regions with similar factor endowments and natural resources can experience a totally asymmetric evolution, just like that found in the real world. These industrial core – agricultural periphery models are based on the interaction of several elements such as scale economies, transport costs and the mobility of the manufacturing labour force. A characteristic that many of these models share is that several different spatial configurations can be obtained in equilibrium, depending on the values of some key parameters. In this context, it is interesting to consider the possibility that some particular economic agent could drive the economy to one equilibrium or another, according to a prefixed criterion. This responsibility should, without doubt, correspond to government.

Surprisingly, the effects of government performance on industrial location decisions have been analysed to only a limited extent from a theoretical point of view. The available papers on this subject, which include those of MARTIN and ROGERS [1995], TRIONFETTI [1997] and ALONSO-VILLAR [2001], show that this area has not received sufficient attention and that additional research is required.

MARTIN and ROGERS [1995] study the effects of public infrastructures in a model with scale economies and capital goods. As their main contribution, they point to the distinct influence exercised by domestic and international infrastructures on the location of firms. In a model à la KRUGMAN, TRIONFETTI [1997] focuses on the role of public expenditures on the economic landscape, finding that an adequate allocation of these expenditures can prevent a higher integration (that is to say, a reduction in transport costs) from generating the total agglomeration of manufactures. Finally, ALONSO-VILLAR [2001], in another model à la KRUGMAN, includes a congestion cost as the centrifugal force, instead of the immobile agricultural population. She finds that the endogenization of the parameters of transport and congestion costs allows government to choose their values in the design of the optimal policy.

From another point of view, there is empirical evidence – see CHARNEY [1983] and HEAD *et al.* [1999], among others – about an important role of government in the location of the economic agents, mainly concerning the effects of different tax schedules.

Against this background, the purpose of this paper is to shed more light on the influence of government on the spatial distribution of economic activity. The importance of this issue is clear for policy makers when their aim is to correct the disequilibriums between different geographical areas.

More particularly, we study the effects that the services provided by government, when these are financed with taxes on rents, have on industrial activity in terms of its spatial concentration or dispersion. To that end, the rest of the paper is organised as follows. The model, which is based on KRUGMAN [1991], is presented in Section 2. Section 3 is devoted to the equilibrium of that model. In Section 4, and using the starting hypothesis of industrial concentration in one region, we analyse how several elements affect the stability of this asymmetric equilibrium. The main result from the point of view of government activity shows that, while taxes work against industrial concentration, public services encourage it. The analysis is completed in Section 5, where we consider the budget constraint that links public income and expenditure, and where we allow for taxes on both agricultural rents and industrial rents. Finally, Section 6 closes the paper with a review of the main conclusions.

2 The model

We consider two regions (j = 1, 2) in which three kinds of agents operate: consumers, who consume agricultural goods as well as a variety of differentiated industrial products, and who obtain rents from work in either agriculture or industry; firms, which hire a fraction of the workers and produce the differentiated goods; and, finally, government, which provides public services that improve individuals' welfare.

Consumers. We normalise the aggregate population of the two regions to one. Each individual derives welfare from consumption and public services through the same utility function (for the sake of simplicity, we omit the subindex indicative of the region):

$$(1) \qquad U = C_M^{\mu} C_A^{1-\mu} \left[G/N^{\eta}\right]^{\xi},$$

where C_A is the consumption of the agricultural good, whereas C_M is the aggregate consumption of the wide range of manufactures, defined as:

$$(2) \qquad C_M = \left[\sum_{i=1}^{n} c_i^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}},$$

with c_i being the consumption of the ith variety. Expression (2) is of the CES type. It is frequently used in the literature, given that it allows for the endogenous analysis of firms' entries into each of the regions, which will, in short, characterize the geographical placement of the industrial sector. Furthermore, the CES function assumes that no pair of differentiated goods is perfectly substitutable, and hence the output of any firm will be consumed by all the consumers in the economy.

In turn, G is the government expenditure on public services and N the total population (both agricultural and industrial) in the region. The parameter η captures the degree of rivalry of the public services, with $\eta \in [0,1]$. Thus, $\eta = 0$ corresponds to the case of nonrival services, in which each individual derives welfare from the total public expenditure. On the other hand, $\eta = 1$ stands for complete rivalry: the services that an individual enjoys cannot be enjoyed simultaneously by the rest, and thus the individual utility function includes the per cápita public expenditure, G/N. Finally, intermediate values of η capture less important congestion problems in the use of public services.

From the consumer's optimisation problem we deduce that the expenditure on agricultural and manufactured goods amounts to the shares μ and $1 - \mu$ of the disposable income Y_D, respectively, and that the demand function for each variety of the manufactured goods takes the form:

$$c_i = \frac{\mu Y_D}{\sum p_i^{1-\sigma}} p_i^{-\sigma},$$

where the only difference with KRUGMAN [1991] lies in the fact that the disposable income replaces the total income due to the existence of taxes. Obviously p_i denotes the price of variety i.

We assume that there are $(1 - \mu)/2$ immobile agricultural workers in each region, whereas the rest are industrial workers who are perfectly mobile between regions. The fact that the agricultural workers are tied to the land represents the centrifugal force in this model. In effect, firms want to be close to this immobile factor so as to better satisfy their demand. Let the industrial workers of the j-th region, $j = 1, 2$, be represented by L_j. Thus $L_1 + L_2 = \mu$. Then, the total population in each region is given by $N_j = \frac{1-\mu}{2} + L_j$, with $N_1 + N_2 = 1$.

Firms. The unit labour requirement in agriculture is assumed to be one, whereas the production of the ith variety of manufactured goods is governed by:

$$L_{Mi} = \alpha + \beta x_i \tag{3}$$

where L_{Mi} is the amount of labour needed to produce x_i units of the ith variety. Note how parameter α implies the existence of increasing returns at the level of the firm.

The manufacturing sector is composed by many firms, each one producing a different brand under a market structure of monopolistic competition with free entry. The demand and costs symmetry of each variety within any region leads to equal prices and quantities produced for each of the varieties. Thus, the conditions of maximum profit and of zero profit lead, respectively, to:

$$p_j = \frac{\sigma}{\sigma - 1} \beta w_j, \quad j = 1,2 \tag{4}$$

$$x_j = \frac{\alpha(\sigma - 1)}{\beta}, \quad j = 1,2 \tag{5}$$

where p_j and w_j are the price of any of the manufactures and the wage rate in j, respectively. As a consequence of (4), the relative prices between regions reflect the differences in costs, that is to say, the relative wages: $p_1/p_2 = w_1/w_2$. The labour each firm needs to hire in order to produce the quantity given in (5) is $\alpha\sigma$, and so the amount of manufacturing workers L_j in each region is proportional to the number of firms (or varieties) n_j produced in that region: $L_j = n_j \alpha\sigma$. Thus, $L_1/L_2 = n_1/n_2$.

Government. We consider both sides of the public sector activity, that is to say, income and expenditure. We assume that the whole expenditure is devoted to the provision of public services which, as we have already stated, increase the individuals' welfare in the region. Since we take government expenditure as the indicator of the quantity and/or quality of public services, this is the variable included in the utility function.

The government's income comes from taxes on the agricultural and/or manufacturing rents, having the effect of reducing net wages. The consequences of this kind of tax on the spatial configuration of industry have already been partly analysed in LANASPA *et al.* [2001].

Since the public budget must be balanced, at least in the long-run, the amount of public services is limited by the government's capacity to collect taxes. Therefore, in order to analyse the government's influence on the location of the firms, attention should simultaneously be given to both public income and expenditure, taking into account the government's budget constraint:

$$G_j = t_{ja} \frac{1-\mu}{2} + t_{jm} w_j L_j,$$

where t_{ja} is the tax rate on the agricultural rents and t_{jm} that on the industrial rents in region j.

Transport costs. We assume that there are no transport costs on the agricultural good, which is taken as the numeraire. Nevertheless, manufactures are subject to transport costs of the iceberg type: of each unit sent from one region to the other, only a fraction $\tau < 1$ reaches its destination. It is precisely the interaction between transport costs, economies of scale and mobility of manufacturing labour that generates the pecuniary externality which, in this type of model, is capable of endogeneously explaining the formation of industrial agglomerations.

3 The equilibrium

Short-run equilibrium. Since government expenditure does not affect either the relative demand for the varieties of manufactured goods or the production costs and prices, the short-run equilibrium is only affected by the taxes: the consumers' disposable income in each region is reduced by the different taxes on their wages. As a result, the short-run equilibrium is described by these expressions:

(6) $$Z_{11} = \frac{L_1}{L_2} \left(\frac{w_1 \tau}{w_2} \right)^{-(\sigma-1)},$$

(7) $$Z_{12} = \frac{L_1}{L_2} \left(\frac{w_1}{w_2 \tau} \right)^{-(\sigma-1)},$$

(8) $$w_1 L_1 = \mu \left(\frac{Z_{11}}{1+Z_{11}} Y_{D1} + \frac{Z_{12}}{1+Z_{12}} Y_{D2} \right),$$

(9) $$w_2 L_2 = \mu \left(\frac{1}{1+Z_{11}} Y_{D1} + \frac{1}{1+Z_{12}} Y_{D2} \right),$$

(10) $$Y_{D1} = (1-t_{1a}) \frac{1-\mu}{2} + (1-t_{1m}) w_1 L_1,$$

(11) $$Y_{D2} = (1-t_{2a}) \frac{1-\mu}{2} + (1-t_{2m}) w_2 L_2,$$

where Z_{11} is the ratio between the expenditure of region 1 on its own local manufactures and its expenditure on foreign manufactures, whereas Z_{12} is the ratio between the expenditures of region 2 on manufactures from 1 and on its own manufactures.

The system of expressions (6)-(11) determines the values of wages, disposable incomes and relative expenditure on domestic and foreign manufactures for both regions. The first two expressions arise from the resolution of the optimization problem of a representative consumer in each region. Expressions (8) and (9) respond to the fact that, with null profits, the rents of the manufacturing workers in each region coincide with the total expenditure that is dedicated to the sector in question. In other words, the aggregate costs and revenues of all the firms must be equal. Finally, (10) and (11) directly reflect the disposable income of each region.

Long-run equilibrium. The interest of the model lies in the fact that it allows for movements on the part of the manufacturing labour force between the regions, relaxing the short-run equilibrium assumption that its allocation is given. Once mobility is allowed, manufacturing workers will move to the region that provides them with a higher welfare.

Given the existence of public goods provided by government, in our model we cannot directly relate welfare and real wages, at least when these capture only the prices of the goods acquired in the market. Therefore, we have to compare the utility enjoyed by workers in both regions. Taking into account that the disposable income of any worker in the industry is given by $(1-t_m)w$, from which μ and $1-\mu$ shares are devoted to industrial and agricultural goods, respectively, the worker's utility is given by:

$$(12)\quad U = C_M^{\mu} C_A^{1-\mu}\left[G/N^{\eta}\right]^{\xi} = \mu^{\mu}(1-\mu)^{1-\mu} P_M^{-\mu}\left[G/N^{\eta}\right]^{\xi}(1-t_m)w.$$

Note from (12) that the term $P_M^{\mu}\left[G/N^{\eta}\right]^{-\xi}$ equals, except for a constant, the quotient between the disposable income of any industrial worker and utility. Thus, it is now equivalent to the price index in KRUGMAN, in the sense that it captures the minimum expenditure for obtaining one unit of utility (it is immediate that the presence of public services which increase an individual's welfare without having to pay for such services reduces this expenditure). Therefore, we denote this aggregate price index by

$$(13)\qquad \bar{P} = P_M^{\mu}\left[G/N^{\eta}\right]^{-\xi}$$

and the corresponding real wage by $\omega = w/\bar{P}$. From expression (12), the long-run equilibrium condition of an equal utility in both regions requires equal real wages net of taxes. That is to say, since the real wages ω received by the workers of the manufacturing sector in each region come given by:

$$\omega_1 = \frac{w_1(1-t_{1m})}{\overline{P_1}} = \frac{w_1(1-t_{1m})}{P_{M1}^{\mu}\left[G_1/N_1^{\eta}\right]^{-\xi}},$$

$$\omega_2 = \frac{w_2\,(1-t_{2m})}{\overline{P_2}} = \frac{w_2\,(1-t_{2m})}{P_{M2}^{\mu}\left[G_2/N_2^{\eta}\right]^{-\xi}},$$

the long-run equalisation of both real wages implies the following relation between the nominal wages paid in both regions:

(14) $$\frac{w_2}{w_1} = \frac{1-t_{1m}}{1-t_{2m}}\left(\frac{P_{M2}}{P_{M1}}\right)^{\mu}\left(\frac{G_2/N_2^{\eta}}{G_1/N_1^{\eta}}\right)^{-\xi},$$

where P_{Mi} is the standard price index of the manufactures in region i:

(15) $$P_{M1} = \left[f p_1^{-(\sigma-1)} + (1-f)\left(\frac{p_2}{\tau}\right)^{-(\sigma-1)}\right]^{-\frac{1}{(\sigma-1)}},$$

(16) $$P_{M2} = \left[f\left(\frac{p_1}{\tau}\right)^{-(\sigma-1)} + (1-f)\,p_2^{-(\sigma-1)}\right]^{-\frac{1}{(\sigma-1)}},$$

and $f = L_1/\mu$ is the share of the manufacturing workers located in region 1. The intuition behind (15) and (16) is as follows: P_{Mj}, $j = 1{,}2$, is a weighted average of the respective prices in force in the two regions, with the weighting factor being the manufacturing population. Note, in turn, how the parameter τ causes an increase in the c.i.f. prices of the trade in goods which is subjected to transport costs. Finally, the exponents $-(\sigma-1)$ reflect, by way of (6) and (7), the price elasticities with respect to the quotient of the value of the purchases from each region.

4 Stability of the equilibrium with manufacturing concentration

As in KRUGMAN'S [1991] model, we first consider a departure equilibrium in which industry concentrates in one region (a core-periphery equilibrium), and then analyse whether several characteristics of the economy reinforce or weaken this concentration result.

Assuming arbitrarily that the industrial firms are concentrated in region 1 ($L_1 = \mu, L_2 = 0$), the value of the sales of a firm in region 1, V_1, is given by:

(17) $$V_1 = \frac{\mu}{n}\left(Y_{D1} + Y_{D2}\right),$$

and the hypothetical value of the sales of a firm defecting from 1 to 2, V_2, is:

$$(18) \qquad V_2 = \frac{\mu}{n}\left[\left(\frac{w_2}{w_1 \tau}\right)^{-(\sigma-1)} Y_{D1} + \left(\frac{w_2 \tau}{w_1}\right)^{-(\sigma-1)} Y_{D2}\right].$$

where the disposable incomes are weighted by the change in the relative price (in this model, by (4), $\frac{w_2}{w_1} = \frac{p_2}{p_1}$) experienced by the defecting firm in each market raised to the corresponding elasticity. Note how the transport cost prejudices the defecting firm in region 1, but favours it in region 2. From (10) and (11), the disposable income in each region can be obtained as:

$$(19) \qquad Y_{D1} = (1 - t_{1a})\left(\frac{1-\mu}{2}\right) + (1 - t_{1m})\,\mu(Y_{D1} + Y_{D2}),$$

$$(20) \qquad Y_{D2} = (1 - t_{2a})\left(\frac{1-\mu}{2}\right),$$

where we have applied that expression (8) now becomes $w_1 L_1 = \mu(Y_{D1} + Y_{D2})$. After some algebra, we deduce:

$$(21) \qquad Y_{D2} = \frac{(1 - t_{2a})\,[1 - \mu\,(1 - t_{1m})]}{(1 - t_{1a}) + \mu\,(1 - t_{1m})\,(1 - t_{2a})} Y_{D1}.$$

From (20) and (21), we can solve the values of the disposable income in both regions. On the other hand, the price indexes become now $P_{M1} = w_1$ and $P_{M2} = w_1/\tau$, while the total population in each region is $N_1 = \frac{1-\mu}{2} + \mu = \frac{1+\mu}{2}$ and $N_2 = \frac{1-\mu}{2}$. Therefore, in order for manufacturing workers to be willing to move to region 2, the ratio of the nominal wages, according to (14), must verify:

$$(22) \qquad \frac{w_2}{w_1} = \frac{1 - t_{1m}}{1 - t_{2m}}\left(\frac{1}{\tau}\right)^{\mu}\left(\frac{G_2}{G_1}\right)^{-\xi}\left(\frac{1+\mu}{1-\mu}\right)^{-\eta\xi}.$$

Taking expressions (21) and (22) to (17) and (18), we obtain the following ratio, which relates the sales of any firm if it moves to region 2 with the sales if it stays in region 1:

$$\frac{V_2}{V_1} = \left[\frac{1 - t_{1m}}{1 - t_{2m}}\left(\frac{1}{\tau}\right)^{\mu}\left(\frac{G_2}{G_1}\right)^{-\xi}\left(\frac{1+\mu}{1-\mu}\right)^{-\eta\xi}\right]^{1-\sigma}$$

$$\cdot \frac{\tau^{\sigma-1}\,[1 - t_{1a} + \mu\,(1 - t_{1m})\,(1 - t_{2a})] + \tau^{1-\sigma}\,(1 - t_{2a})\,[1 - \mu\,(1 - t_{1m})]}{2 - t_{1a} - t_{2a}}.$$

Firms will be interested in moving to region 2 only if this ratio is greater than the ratio of wages given by (14). This condition is equivalent to $V > 1$, with

$$V = \tau^{\mu\sigma} \left(\frac{1-t_{1\mathrm{m}}}{1-t_{2\mathrm{m}}}\right)^{-\sigma} \left(\frac{G_2}{G_1}\right)^{\sigma\xi} \left(\frac{1+\mu}{1-\mu}\right)^{\sigma\eta\xi}$$

$$\cdot \frac{\tau^{\sigma-1} \left(1 - t_{1a} + \mu \left(1 - t_{1m}\right) \left(1 - t_{2a}\right)\right) + \tau^{1-\sigma} \left(1-t_{2a}\right) \left(1 - \mu \left(1 - t_{1m}\right)\right)}{2 - t_{1a} - t_{2a}}.$$

(23)

As is usual in this kind of models, when $V > 1$ firms find it advantageous to move from 1 to 2, and thus the initial concentration is no longer a stable equilibrium. By contrast, the core-periphery equilibrium is stable when $V < 1$, because there are no incentives for firms to defect.

We should note that, up to this point, we have made no reference to the government's budget constraint, which links public expenditure and income in such a way that the changes in the tax rates and the volume of public services cannot be considered as independent. Nevertheless, for the sake of clarity, we will first analyse the influence of each of these variables separately.

The novel results we have obtained are related to the effects of public expenditure. From (23), we can see that the greater the amount of public services in region 2 and the smaller the amount in region 1, the more probable it is that V is bigger than 1 and therefore, the less probable it is that the concentration remains stable:

$$\frac{\partial V}{\partial G_1} < 0, \quad \frac{\partial V}{\partial G_2} > 0.$$

This is the case because the public services in 2 attract manufacturing workers to that region, given that these services increase their welfare. With the nominal wages net of taxes being equal, the manufacturing workers will obtain a greater welfare in the region with the highest provision of public services. As a consequence, governments can use this variable in order to configure the industrial location in their territory.

On the other hand, the degree of rivalry between the public services reduces the above-mentioned effects. The greater this rivalry, that is to say, the larger the parameter η, the smaller is the impact of an increase in public expenditure on the individual's welfare. Thus, increases in the parameter η favour dispersion:

$$\frac{\partial V}{\partial \eta} = V\sigma \ln \frac{1+\mu}{1-\mu} > 0.$$

Finally, the influence of public services on industrial location also depends on ξ. This parameter captures the elasticity of the consumers' utility with respect to public services. We can interpret it either as an indicator of the value of these services for the individuals, or as a measurement of the government's effectiveness in satisfying the individuals' requirements. In this sense, high values of ξ indicate an important weight of public services on welfare and/or an important adjustment between the services provided by the public sector and the needs of the individuals. In these circumstances, government activity through the provision of services can play an important role on the location decisions taken by firms. By contrast, in the extreme case of $\xi = 0$, public expenditure would not influence firm location at all. The effect of increases in this parameter comes given by:

$$\frac{\partial V}{\partial \xi} = V\sigma \ln\left(\frac{G_2}{G_1}\left(\frac{1+\mu}{1-\mu}\right)^{\eta}\right) = V\sigma \ln\left(\frac{G_2/N_2^{\eta}}{G_1/N_1^{\eta}}\right),$$

in such a way that when the amount of public services (once the congestion effect is discounted) is higher in 2 that in 1, the derivative is positive; that is to say, an increase in the value given to the public services favours the movement of manufacturing workers towards region 2. By contrast, if the provision of public services is greater in 1, then the increase in the preference for these services reinforces concentration in region 1.

5 Provision of public services financed by taxes

Let us consider the general case in which the rents coming from both agriculture and industry are taxed (although at some different rates). The budget constraint of the government in region j comes given by:

$$G_j = t_{ja}\frac{1-\mu}{2} + t_{jm}w_j L_j,$$

and thus, with the industrial population concentrated in region 1, we have:

$$\frac{G_2}{G_1} = \frac{t_{2a}(1-\mu)/2}{t_{1a}(1-\mu)/2 + t_{1m}w_1\mu},$$

From (20) and (21) we can obtain the salary mass paid by the industrial sector in region 1:

$$(24) \qquad w_1 L_1 = w_1\mu = \mu(Y_{D1} + Y_{D2}) = \frac{2 - t_{1a} - t_{2a}}{1 - \mu(1 - t_{1m})}\frac{\mu(1-\mu)}{2}$$

from which we obtain the following relation between the public expenditure in both regions:

$$(25) \qquad \frac{G_2}{G_1} = \frac{t_{2a}[1-\mu(1-t_{1m})]}{t_{1a}[1-\mu(1-t_{1m})] + t_{1m}\mu(2 - t_{1a} - t_{2a})}.$$

It can be verified that, as could be expected, this ratio is increasing in the agricultural tax rates of region 2 (which not only increases the amount of taxes collected in 2, but also decreases the amount collected in 1) and decreasing in both the agricultural and industrial taxes of region 1.

Carrying (25) to (23), we obtain the following value for V:

$$V = \tau^{\mu\sigma}\left(\frac{1-t_{1\mathrm{m}}}{1-t_{2\mathrm{m}}}\right)^{-\sigma}\left(\frac{t_{2a}\left[1-\mu\left(1-t_{1m}\right)\right]}{t_{1a}\left(1-\mu\right)+t_{1m}\mu\left(2-t_{2a}\right)}\right)^{\sigma\xi}\left(\frac{1+\mu}{1-\mu}\right)^{\sigma\eta\xi}$$

$$\cdot\frac{\tau^{\sigma-1}\left(1-t_{1a}+\mu\left(1-t_{1m}\right)\left(1-t_{2a}\right)\right)+\tau^{1-\sigma}\left(1-t_{2a}\right)\left(1-\mu\left(1-t_{1m}\right)\right)}{2-t_{1a}-t_{2a}}$$

(26)

Effects of agricultural taxes. Agricultural taxes have an ambiguous influence on location as a result of two opposite effects. Let us consider the case of region 1. On one hand, agricultural taxes reduce the disposable income of agricultural workers in 1, and thus the local demand for manufactures, which works against concentration. On the other, since higher taxes lead to increases in public services, they also increase welfare in 1, which reinforces concentration in this region. The corresponding derivatives of V (valued in $V = 1$) are now:

$$\frac{\partial V}{\partial t_{1a}} = -\frac{\sigma\xi\left(1-\mu\right)}{t_{1a}\left(1-\mu\right)+\mu t_{1m}\left(2-t_{2a}\right)}+\frac{1-\mu\left(1-t_{1\mathrm{m}}\right)}{2-t_{1a}-t_{2a}}$$

$$\frac{\left(1-t_{2a}\right)\left(\tau^{1-\sigma}-\tau^{\sigma-1}\right)}{\tau^{\sigma-1}\left(1-t_{1a}+\mu\left(1-t_{1\mathrm{m}}\right)\left(1-t_{2a}\right)\right)+\tau^{1-\sigma}\left(1-t_{2a}\right)\left(1-\mu\left(1-t_{1\mathrm{m}}\right)\right)},$$

$$\frac{\partial V}{\partial t_{2a}} = \frac{\sigma\xi}{t_{2a}}\frac{t_{1a}\left(1-\mu\right)+2\mu t_{1m}}{t_{1a}\left(1-\mu\right)+\mu t_{1m}\left(2-t_{2a}\right)}-\frac{1-\mu\left(1-t_{1m}\right)}{2-t_{1a}-t_{2a}}$$

$$\frac{\left(1-t_{1a}\right)\left(\tau^{1-\sigma}-\tau^{\sigma-1}\right)}{\tau^{\sigma-1}\left(1-t_{1a}+\mu\left(1-t_{1m}\right)\left(1-t_{2a}\right)\right)+\tau^{1-\sigma}\left(1-t_{2a}\right)\left(1-\mu\left(1-t_{1m}\right)\right)},$$

where the first addend corresponds to the effect of public expenditure and the second to the reduction of demand.

In fact, the result depends on the values of the parameters of the model, particularly ξ. Sufficiently high values of this parameter make the sign of the first addend prevail, in such a way that the effect of expenditure is more important than that of taxes. Thus, whenever the individuals' valuation of the public services (or the efficiency in their provision by government) is sufficiently high, the government's size in region 2 encourages the movement of firms to that region, favouring convergence between regions, while its size in region 1 reinforces concentration in that region.

Effects of manufacturing taxes. These taxes again generate the two opposite effects we have just referred to. Thus, on one hand, an increase in industrial taxes allows government to increase the amount of public services (expenditure effect), which favours industrial concentration. On the other, the market effect (taxes reduce local demand) favours movement out of the region.

However, taxes on industrial wages generate an additional effect, that is to say, the tax effect, which is in fact the most immediate: they reduce the net wages of industrial workers, which works against concentration.

From the expression of V, the influence of industrial taxes in the region in which the industrial activity is concentrated is given by the following expression, in which the addends corresponds to the tax, expenditure and market effects, respectively:

$$\frac{\partial V}{\partial t_{1m}} = \frac{\sigma}{1-t_{1m}} - \frac{\sigma\xi\mu(1-\mu)}{1-\mu(1-t_{1m})}\frac{2-t_{1a}-t_{2a}}{t_{1a}(1-\mu)+\mu t_{1m}(2-t_{2a})}$$
$$+\frac{\mu(1-t_{2a})\left(\tau^{1-\sigma}-\tau^{\sigma-1}\right)}{\tau^{\sigma-1}(1-t_{1a}+\mu(1-t_{1m})(1-t_{2a}))+\tau^{1-\sigma}(1-t_{2a})(1-\mu(1-t_{1m}))}.$$

The combined influence of the market and expenditure effects was indeterminate in the case of agricultural taxes, but the additional tax effect does not solve the indetermination in the case of industrial taxes. Again, the higher the preference of individuals for the public services (a higher ξ), more probable it is that the expenditure effect prevails, reinforcing the concentration of firms.

The effects are simpler for the region without industrial activity. Since there is no industry, the change in industrial taxes neither increases government income nor reduces the workers' disposable income, and therefore there is no place for either expenditure or market effects, with the only effect being the tax effect. Therefore, the industrial taxes of region 2 reinforce concentration in region 1:

$$\frac{\partial V}{\partial t_{2m}} = -\frac{\sigma}{1-t_{2m}} < 0.$$

Effect of the size of the industrial population. The derivative of V with respect to the parameter μ takes the form:

$$\frac{\partial V}{\partial \mu} = \sigma \ln\tau$$
$$+\frac{(1-t_{1m})(1-t_{2a})\left(\tau^{\sigma-1}-\tau^{1-\sigma}\right)}{\tau^{\sigma-1}[1-t_{1a}+\mu(1-t_{1m})(1-t_{2a})]+\tau^{1-\sigma}(1-t_{2a})(1-\mu(1-t_{1m}))}$$
$$+\frac{2\sigma\eta\xi}{(1+\mu)(1-\mu)} - \frac{\sigma\xi t_{1m}(2-t_{1a}-t_{2a})}{(1-\mu(1-t_{1m}))((1-\mu)t_{1a}+\mu t_{1m}(2-t_{2a}))}.$$

The first and second terms are negative and correspond to the « forward linkage » and « backward linkage », as in KRUGMAN'S model, whereas the third is positive, capturing the fact that the larger the share of the population engaged in industry, the more congested are the public services in the region in which industry concentrates. According to this new term, a larger size of the industrial population reduces the welfare that individuals derive from public expenditure, encouraging their movement to region 2. The last term, which captures the expenditure effect, is also negative, therefore favouring industrial concentration. This effect appears because an increase in the industrial population widens the demographic disequilibrium between the two regions and, therefore, the rents generated in each of them. As a consequence, following an increase in the industrial population, the government's income increases in the region where this is concentrated, whereas it is reduced in the other. Thus, the disequilibrium generated in the amount of public services provided in both regions acts as a disincentive to the movement of workers.

As a consequence, when all the effects are considered, the influence of the size of the industrial population on the location of firms in the territory becomes indeterminate, with the parameter ξ again playing an important role. When the individuals' valuation of public services or the efficiency of the public sector is sufficiently high, the third effect becomes the most important, in such a way that increases in the size of the industrial population favour the dispersion of firms. That is to say, for a sufficiently high value of ξ, the usual results are reversed. The same result can be obtained when the public services become quickly congested as the population grows. By contrast, if they are not congested ($\eta = 0$), the third addend disappears, making the size of the industry always favour concentration.

Effects of transport costs. In this case the derivative of (23) with respect to τ is:

$$\frac{\partial V}{\partial \tau} = \frac{1}{\tau} \frac{\sum_{i=1,2} \tau^{(-1)^i(1-\sigma)} \left(1 - t_{ia} - (-1)^i A\right) \left(\mu\sigma - (-1)^i (\sigma - 1)\right)}{\sum_{i=1,2} \tau^{(-1)^i(1-\sigma)} \left(1 - t_{ia} - (-1)^i A\right)}$$

where $A = \mu (1 - t_{1m}) (1 - t_{2a})$, in such a way that the function $V(\tau)$ is always increasing in τ when $\sigma (\mu - 1) \geqslant 1$ and is U-shaped otherwise. On the other hand, the value of V in $\tau = 1$ is given by:

$$V(\tau = 1) = \left(\frac{1 - t_{1\mathrm{m}}}{1 - t_{2\mathrm{m}}}\right)^{-\sigma} \left(\frac{t_{2a}[1 - \mu(1 - t_{1m})]}{t_{1a}(1 - \mu) + t_{1m}\mu(2 - t_{2a})}\right)^{\sigma\xi} \left(\frac{1 + \mu}{1 - \mu}\right)^{\sigma\eta\xi},$$

which can be greater than one. Therefore, as an innovative result, we find that the combined action of government size and the degree of congestion of public services can mean that a decrease in transport costs favours the dispersion of firms. The centrifugal force that can generate this outcome when the transport costs are sufficiently low takes the form of a larger government size in region 2 and/or a lower congestion of public services in that region (that is to say, the term that captures the welfare derived from public services, G/N^{η}, is higher in region 2).

Effects of a redistributive policy. So far, we have considered that the whole amount collected through taxes in each region is devoted by the respective regional governments to provide public services for the residents in that region. However, we can extend our analysis to allow for redistributive policies among regions. To that end, we will now assume that both of the regions we have been considering belong to the same country, in which tax collecting corresponds to a central government. As a consequence, both regions share the same tax schedule, although government can decide about the distribution of the amount collected between them.

The results obtained earlier indicate that, since public services can attract economic activity, central government can exert a significant influence over the spatial configuration of the economy through the distribution of public expenditure among regions. We can corroborate this result by making the tax rates for both regions in (23) equal, and computing the effect of a public expenditure redistribution towards the deindustrialized region:

$$\frac{\partial V}{\partial G_2} = \sigma \xi V \frac{G_1 + G_2}{G_1 G_2} > 0,$$

where we have taken into account that, for a given public income, the increase in public services in 2 can only come from an equivalent spending cut in 1 $(dG_2 = -dG_1)$. The positive derivative indicates that this redistributive policy makes region 2 more attractive for firms to locate in.

6 Conclusions

In this paper we have analysed how the results in KRUGMAN'S core-periphery model are modified with the introduction of the public sector. We consider that the government's function is to provide public services, and that these are financed by taxing rents derived from the production sectors.

We have obtained some interesting conclusions. First, since public services are an element that attracts economic activity, while taxes act in the contrary sense, the net effect of government performance on location decisions becomes indeterminate. Whether or not public sector activity is able to encourage the location of new firms in a given region mainly depends on the subjective valuation given by individuals to the public services provided by their government. Thus, when individuals value these highly, the welfare increase prevails and, therefore, economic activity moves to the regions with a larger government size. By contrast, when they attach little value to the public services that are offered, government fails to encourage the concentration of firms. Although resting on a different framework, this result connects with the pioneering work of TIEBOUT [1956], according to which the agents « vote with their feet », moving to the locations that better fit their preferences with respect to public income and expenditure.

Secondly, the introduction of the new parameters corresponding to the public sector in some cases modify the influence of those present in KRUGMAN'S model. In particular, the new interdependence linkages now make the influence of the representative parameter of the size of the manufacturing sector indeterminate. Moreover, the effects of the transport cost on the concentration-dispersion results are no longer monotonous, as they were in the original model. In the most representative case, these effects depend on the size of the transport cost: decreases in this cost, when it is high, favour concentration, but further decreases can eventually generate the dispersion of firms.

Finally, this paper must be regarded as no more than a first attempt to understand the role of the public sector in the location of economic activity, an objective that clearly requires a greater research effort in the future. Since government can achieve a more homogeneous distribution of economic activity, an interesting and important extension of this paper lies in making endogenous the policy of the government, which can be considered as a benevolent planner or a self-interested politician. Another extension to which attention could well be devoted refers to the empirical validation of the results derived from the thoretical model. ▼

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