LOCATIONAL COMPETITION AND AGGLOMERATION: THE ROLE OF GOVERNMENT SPENDING

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Abstract

With the completion of EMU, tax competition and, more in general, locational competition is high on the EU policy agenda. In contrast to the standard neo-classical reasoning, recent advances in the theory of trade and location have shown that tax competition does not necessarily lead to a 'race to the bottom'. In these recent discussions the relevance of government spending as an instrument for locational competition is unduly neglected. We therefore introduce a more elaborate government sector in a geographical economics model by analyzing government spending and government production. By changing the relative size, direction or efficiency of the production of public goods, our simulation results show that governments can change the equilibrium between agglomerating and spreading forces. In addition, we show analytically that the introduction of public goods fosters agglomeration. Ultimately, our paper shows that by restricting attention to taxes, one ignores that government spending also determines the attractiveness of a country as a location for the mobile factors of production.

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1. Introduction

Tax harmonization is high on the political agenda of the EU-countries. It is widely believed that with the arrival of the Economic and Monetary Union (EMU) the EU-countries are forced to harmonize taxes. The standard reasoning is that in the absence of a policy of tax harmonization full-fledged economic integration in the EU will lead to a 'race to the bottom'. For the EU Sinn (1990) has already aptly summarized this line of reasoning. A race to the bottom would mean that in a truly common market in the EU, the mobile factors of production (in particular high-skilled labor and capital) will locate in the country with the lowest tax rate, with the result that all EU-countries are forced to adopt this tax rate. Or, in other words, economic integration could go along with fierce tax competition between the EU-countries. Tax competition is thought to be harmful because it would imply a sub-optimal (*i.c.* too low) provision of public goods. In order to avoid this outcome a policy of tax harmonization is deemed necessary. However, taxes are only part of the story. Locational competition is not only about taxes but also about location specific government expenditures. In other words, the location decision of the mobile production factors also depends on the quality of a country's social and economic infrastructure.

In essence a discussion about locational competition is a discussion about the importance of geography. However, in the analysis of the effects of tax or expenditure differences the role of geography has been neglected. The recent literature on geographical economics shows the importance of including geography into the analysis. This leads potentially to very different conclusions with respect to tax competition and harmonization. In a much-discussed paper Baldwin and Krugman (2000), for instance, show that there is no need for a race to the bottom to begin with and, stronger still, a policy of tax harmonization could make all countries worse off. The main idea is that economic integration could lead to (or sustains) a core-periphery outcome, with an *agglomeration rent* for the production factors located in the core. This rent reflects the fact that the production factors earn more (in real terms) in the core than in the periphery. The rent can be taxed and up to a certain degree the agglomeration rent allows the core countries to have a higher tax rate than the peripheral countries (see also Andersson and Forslid, 1999). As a consequence, tax competition is not leading to a race to the bottom, which is an important result because it corresponds with the observed lack of a race to the bottom in reality.

Although the contributions of Baldwin and Krugman (2000), and Andersson and Forslid (1999) challenge the standard views about tax competition, their treatment of the government sector is still rather rudimentary. The emphasis is on taxes and not so much on the effects of public expenditures on the economy. In the context of EU integration this is rather one-sided because policy makers as a main policy instrument of locational competition also use public spending. Countries try to increase their attractiveness as a location by investing in location-specific infrastructure. The Dutch Ministry of Economic Affairs, for example, formulated three key characteristics of location policy: "*a competitive location policy is a comprehensive policy…that includes all aspects that define the attractiveness of a location*" (Dutch Ministry of Economic Affairs, 1999, p.114-5). Similarly, during the European Council meeting of the EU in Lisbon in March 2000, the EU member states agreed upon a (benchmarking) method to determine the competitiveness of the EU economies. To this end no less than 54 (!) indicators were devised and, besides taxes, the quality of the social and economic infrastructure features prominently in this set of indicators.

When the effects of agglomeration are thought to be important, tax and spending policies represent two opposing forces. All other things remaining the same, higher taxes stimulate spreading even though the existence of an agglomeration rent may prevent the spreading from actually taking place. Similarly, an increase in public spending stimulates agglomeration if this spending enhances the attractiveness of the location for the mobile factors of production.[1] But all things do not remain the same in the sense that higher taxes typically also imply higher public spending and vice versa. The extent to which a larger government sector (meaning higher public spending and taxes) really leads to a better quality of the country's infrastructure is an issue that has troubled EU policy-makers for a long time. In this paper we extend the Baldwin and Krugman (2000) and Andersson and Forslid (1999) approach in two ways. First, we allow for public spending to affect the cost of production, which has an impact on the location decisions of firms and workers. Second, we take not only into account that the production of public goods takes up resources which cannot be used in the production of the manufacturing (private) sector, but also that countries may differ in the efficiency of the provision of public goods. The paper therefore focuses on the interdependency between taxes and spending, and in doing so we focus on the role of government spending. As a consequence the paper is not about tax competition or tax harmonization because with respect to these two issues we have not much to add to the analysis of Baldwin and Krugman (2000).

The paper is organized as follows. Section 2 briefly presents some stylized facts for the EU about cross-country differences in corporate rate income taxation, public spending, location indicators and the corresponding differences in location decisions. Section 3 presents the 2-region model. Sections 4 and 5 illustrate and analyze the model for given, but not necessary equal levels, of public goods. Sections 6 and 7 take the analysis a step further by analyzing the stability of the symmetric equilibrium. In this break analysis it is assumed that both countries have opted for the same level of public goods. Section 8 summarizes and concludes.

2. Stylized facts about taxation and public spending in the EU

We first illustrate that a race to the bottom in the EU is not inevitable. We concentrate on the taxation of capital because in our model we assume that capital is mobile and labor is not. This is in accordance with the often-observed higher degree of capital mobility as compared to labor mobility. Tax competition is therefore concerned with capital taxation. Table 1 shows for the EU countries for the period 1990-1999 the development of the corporate income taxes. This period can be looked upon as a period of increasing economic integration. Table 1 gives the effective corporate income tax rates which differ from the “nominal” corporate tax rates because the former takes into account the implications of differences in tax base, allowances for depreciation etc. that exist between EU-countries. These effective rates reflect the real capital tax burden on a firm in any of these countries. The corporate income tax rates are the tax rates paid by individual firms and the data in Table 1 are based on micro data from the financial accounts of individual firms.

[1] We do not address the difficult question about the most likely outcome of locational competition between governments. In the absence of ideal market conditions international welfare maximization is not guaranteed (see Sinn, 2002).

Table 1 , Effective corporate income tax rates across the EU, %

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Austria	18	22	14	16	20	17	24	25	21	24
Belgium	17	16	22	23	23	24	23	22	21	17
Denmark	33	32	30	30	32	32	31	31	32	31
Finland	45	37	34	24	26	27	28	28	28	28
France	33	33	33	33	33	36	35	38	38	38
Germany	48	49	49	44	41	41	41	40	40	41
Greece	11	11	24	29	29	31	33	35	35	35
Ireland	20	22	19	20	17	22	21	21	24	22
Italy	38	41	47	50	44	46	45	43	44	40
Netherlands	31	32	32	31	31	31	32	31	31	30
Portugal	17	20	27	25	20	23	22	21	24	25
Spain	27	28	29	27	25	24	26	26	26	29
Sweden	31	32	30	19	28	27	28	28	28	28
U.K.	33	31	31	30	30	30	30	29	29	29
Average	28.7	29	30.2	27.7	28.4	29.3	29.9	29.8	30	29.8
Weight. Av.*	35.5	36.1	37.3	35.3	34.1	35	35.1	34.8	34.9	34.6
St. dev.	10.6	9.8	9.1	9.0	7.4	7.5	6.8	6.7	6.8	6.5

Source: CPB, 2001a, Capital Income Taxation in Europe, Trends and Trade-offs, The Hague, p. 27; data for Luxembourg not available; *weighted by a country's GDP

Table 1 offers, of course, no conclusive evidence but a number of things are worth pointing out:

- The large countries of the EU (Germany, the UK, France and Italy) clearly have an above-average tax rate.[2]
- The smaller and "peripheral" countries, notably Greece, Portugal and Spain started out with a below-average tax rate, but their corporate income tax rates clearly *in*creased during the 1990s (Ireland is a notable exception).
- The average EU corporate income tax rate is fairly constant through time, in any case shows no discernible downward trend.
- The standard deviation has strongly decreased from 1990 to 1999, so there is some tax rate convergence, but not towards the lowest rate

These four observations offer some (preliminary) support for the lack of a race to the bottom. Core/large countries persistently have higher tax rates and small/peripheral countries even display some "catching up" in terms of their tax rates.[3]

[2] These 4 countries are also the core countries in the sense that their share in total EU manufacturing production is about 75%. This share remains fairly constant through the 1990s.

[3] Note that we do not claim that there is no tax competition at all in the EU. Sinn (2002, p. 8), for instance, shows that the average tax burden for subsidiaries of US companies in the EU has decreased strongly in the various EU countries between 1986 an 1992. In general, tax competition seems more relevant where it concerns the taxation of foreign direct investment.

Table 2A Expenditure, total (% of GDP)										
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Austria	38.67	38.14	38.52	39.14	41.22	40.98	42.13	41.82	40.48	..
Belgium	48.21	48.13	48.83	49.46	49.96	49.19	48.16	47.07	46.63	..
Denmark	39.02	39.01	39.41	40.51	42.64	42.68	41.41	..	..	..
Finland	29.49	30.78	37.53	42.62	45.32	43.66	42.35	40.32	35.29	..
France	42.13	42.55	43.54	45.07	47.15	46.80	46.52	46.84	46.57	..
Germany	..	..	30.16	33.96	34.27	34.34	34.51	34.43	33.52	32.86
Greece	48.82	52.98	35.91	28.73	31.88	34.15	33.13	32.70	34.00	..
Ireland	38.43	39.03	40.34	40.41	40.39	39.19	36.81	35.45	..	..
Italy	47.32	47.82	48.94	52.06	53.07	49.97	48.54	49.53	48.24	44.65
Netherlands	52.90	51.62	52.28	52.70	53.21	51.92	50.46	47.92	47.62	..
Portugal	37.58	38.85	41.74	43.32	44.66	41.96	41.81	41.55	40.79	..
Spain	33.73	33.83	34.75	35.99	39.37	38.17	36.77	36.11	..	..
Sweden	39.30	40.80	42.53	46.19	51.66	48.52	49.37	46.11	44.33	42.72
U.K.	33.93	38.00	40.82	43.81	43.36	42.62	42.08	41.57	39.12	37.93
Source: World Bank. 2000 CD-ROM										

Baldwin and Krugman (2000) explain the lack of a race to the bottom for taxation in the EU by the fact that despite higher tax rates, the *after tax* income in the core EU countries is still larger than in the more peripheral EU countries due to a positive agglomeration rent. These rents are the result of positive pecuniary externalities. By looking only at taxation government policy either has no impact at all on the location of economic activity as long as the tax rate is not too high or, if the tax rate exceeds a specific threshold, the agglomeration equilibrium can no longer be sustained. A core country can thus afford a higher tax rate but in essence taxation is a potential spreading force. So, government policies, in principle, do not contribute to the agglomeration forces. However, we stress that public spending is also an essential part of the story. Our main point is that government policies can increase the attractiveness of a country (besides offering a sufficiently low tax rate).[4] We do, however, not simply add an extra agglomeration force; the (in)efficiency of the government sector might frustrate the effectiveness of extra spending.

[4] To some extent, as shown below, the issue here is the difference between pure and pecuniary externalities. The former are absent in the standard geographical economics model. We, however, emphasize that the provision of public goods has a positive impact on the relationship between inputs and outputs (pure externalities).

Table 2B Capital expenditure (% of total expenditure)										
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Austria	8.98	8.70	8.11	7.90	7.58	7.38	7.27	7.37	6.48	..
Belgium	4.71	4.83	4.39	4.36	4.52	4.46	4.93	4.55	4.69	..
Denmark	3.22	3.29	3.13	3.94	3.63	3.48	3.51	..	..	..
Finland	8.97	6.84	5.80	5.03	3.83	4.12	4.80	3.95	3.11	..
France	4.78	5.97	5.04	5.16	4.64	4.99	4.63	4.38	4.26	..
Germany	4.63	4.51	6.44	5.76	5.15	4.13	4.86	4.38	3.80	4.33
Greece	9.96	7.77	10.34	15.32	15.42	12.29	13.43	13.04	..	..
Ireland	6.80	7.05	6.87	6.71	7.86	8.84	9.94	9.06	..	..
Italy	9.03	8.39	8.02	6.54	5.57	3.78	5.20	5.53	5.31	5.45
Netherlands	6.88	5.84	4.76	4.09	4.32	4.24	4.86	3.88	3.49	..
Portugal	12.88	11.61	12.22	12.67	13.63	11.41	12.07	12.80	12.68	..
Spain	9.29	9.41	9.51	6.92	6.56	5.31	5.17	5.35	..	..
Sweden	2.11	2.47	1.90	2.51	3.70	1.33	2.82	2.63	2.49	2.48
U.K.	6.95	10.05	7.90	8.74	6.80	5.96	6.08	5.63	4.40	4.03
Source: World Bank 2000, CD-ROM										

Tables 2A and 2B illustrate that, with respect to government spending, the EU-countries are not involved in a race to the bottom. Table 2A shows that for most EU countries there is no downward trend in (central) government expenditures as a percentage of GDP. This is certainly true for the core EU-countries Germany, France and the UK. Furthermore, in some of the peripheral EU-countries there is an *in*crease in this expenditure ratio. As a crude proxy for government expenditures that have a bearing on a country's attractiveness as a location Table 2B gives capital expenditures as a percentage of total government expenditure. Two observations can be made. First, for the core countries there is a downward trend in capital expenditures as a share of total government expenditure. Second, the reverse is true for peripheral EU-countries like Greece, Ireland and Portugal. To get a grasp of the cross-country differences in capital expenditures, data on capital expenditures as a percentage of GDP provide useful information. These data can be obtained by multiplying the corresponding data from Tables 2A and 2B. For Germany and Portugal, for example, capital expenditures as a percentage of GDP are 1.3% and 5.2% in 1997, respectively. Again, there are marked cross-country differences, but there is no evidence of a race to the bottom.

In recent years benchmarking has been a popular method among EU-policymakers to compare the relative location (dis-)advantages of the various EU-countries and regions for the mobile factors of production (notably capital). In the introduction we already referred to the Lisbon criteria. If we take North-West Europe as an example, the Dutch Ministry of Economic Affairs has identified the regions in Table 2C as having the most attractive location characteristics. This table only indicates the fact that the alleged attractiveness is to some extent thought to be the result of (past) regional public spending.

Table 2C Preferred Locations in North-West Europe	
Niedersachsen (Germany)	Close to Hannover.
Nordrhein Westfalen (Germany)	Enough space, good accessibility.
Saarland (Germany)	Near highways leading to Ruhrgebiet, Subsidies to start businesses, enough space, low land prices.
Picardie (France)	Near Paris (airport), good accessibility, low land prices.
Champagne (France)	Good infra-structure, always had a strong position (path-dependency).
Netherlands	Good accessibility, near airport (Schiphol), Good infra-structure (connections to Germany).
Source: Dutch Ministry of Economic Affairs, Location Patterns of leading companies in North-West Europe, 1999, p.36.	

Table 2C lists just a few reasons why some of the regions in these countries are found to be preferred locations, but it suggests that location decisions can be affected by regional government spending and not only by the levels of taxation. This last point also comes across from an UNCTAD survey on location and foreign direct investment (UNCTAD, 1996). Large companies like Samsung or Daimler-Chrysler stated that, apart from taxes and subsidies, the social and economic infrastructure (transport) are key determinants for their location decision. In order to show the last point formally we now turn to the model.

3. The Model

We extend the analytically solvable model developed by Ottaviano (2001), Forslid and Ottaviano (2001), and Forslid (1999), henceforth referred to as the Ottaviano-Forslid model, by including a more detailed analysis of the government sector, incorporating government spending effects, the efficiency of government production, and competition between the government and the private sector on the labor market. The reason to use this analytically solvable model is twofold. First, in the discussion of tax competition the main issue is that mobile and immobile factors of production react differently to taxation. Below we will call the immobile factor labor and the mobile factor human capital. In the European context this corresponds to the fact that labor is less mobile than capital. As argued by Ottaviano (2001) it is realistic to assume that the manufacturing or modern sector uses both skilled and unskilled labor to produce its output. The ability to distinguish between mobile and immobile factors in the manufacturing sector is also why Baldwin and Krugman (2000) and Andersson and Forslid (1999) take this model as their starting point in their analysis of tax competition and economic integration. A second reason to use the model is that it can be solved analytically and, contrary to standard models of geographical economics, some analytical results can be derived, see section 6 and 7 below.

There are two regions (j=1,2). Each region has L_j workers and K_j human capital.[5] Each agent is either a worker or a capital owner, where capital can be thought of as

[5] The main point here is to include a mobile and an immobile factor of production. The labelling of these two factors (unskilled versus skilled labor or labor versus capital) is not material as long as the

human or knowledge capital. Workers are geographically immobile, whereas human capital is mobile. Henceforth we make the following assumption:

- The two regions are identical with respect to the immobile factor of production, that is $L_1 = L_2 = 0.5$.

All agents have the same preferences given in (1), depending on consumption of manufactures M (a composite of n different varieties c_i, see equation (2)), consumption of food F, and consumption of public services Z.

(1) $$U = M^{\delta} F^{(1-\delta)} Z^{\theta}; \qquad 0 < \delta < 1; \quad 0 \leq \theta \leq 1$$

(2) $$M = \left(\sum_{i=1}^{n} c_i^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)}; \qquad \sigma > 1$$

where δ is the share of income spent on manufactures, θ measures the utility derived from the provision of public goods, and σ is the elasticity of substitution between different varieties of manufactures. The production of food, which is freely traded at zero transport costs, takes place under constant returns to scale and requires only workers. A suitable choice of units ensures that one unit of labor produces one unit of food. Labor is used in food production and in the manufacturing sector but in the latter it is only part of the variable cost of production. Using food as a numéraire and assuming free trade implies that its price, and hence the wage rate, can be set equal to one. This means that we only have to determine the return to human capital.

Firms in the manufacturing industry use labor and human capital to produce a variety of manufactures under increasing returns to scale. The fixed cost component requires $\alpha_j(.)$ units of human capital and the variable cost component requires $\beta_j(.)$ units of labor. The fixed cost component is assumed to represent the knowledge intensive part of the manufacturing production process like R&D, marketing and management, etc. The production of manufactures benefits from the availability of public goods Z_j in region j. This distinguishes our model from Baldwin and Krugman (2000) and Andersson and Forslid (1999). The former do not analyze public spending separately, taxes are returned to the factors of production in non-distortionary lump-sum manner while the latter include public goods in the utility function (as in equation (1) above) but do also not consider the effects of public goods on the cost of production. We take this into account as follows:

(3) $$\alpha_j(Z_j) = f_j(Z_j); \quad \beta_j(Z_j) = f_j(Z_j)[(\sigma - 1)/\sigma]; \qquad f_j(0) = 1, f_j' \leq 0$$

By choice of units the notation is simplified considerably. The quality aspect of public goods comes to the fore by making the parameters region-specific, this is a simple way of distinguishing between more and less useful public goods.

Let r_j be the return to human capital in region j, then the costs of producing x units of a manufacturing variety in region j are equal to

(4) $$\alpha_j(Z_j) r_j + \beta_j(Z_j) x$$

Note that the use of public services in manufactures does not influence the amount of public services available to consumers. Furthermore, the return to human capital can be looked upon as the operating profit of a typical variety, human capital gets paid what the firm earns net of payments to labor (Baldwin and Krugman, 2000, p. 5).

mobile factor (be it skilled labor or capital) spends it income in the region where it is used for production; see in particular Forslid (1999, p.11) for a discussion of the importance of this assumption.

The production of public goods requires human capital only, and is subject to constant or decreasing returns to scale. This is the second extension of our model, we assume that the production of public goods takes up net resources. It captures the idea that government production competes with private production and relates to the discussion about the optimal size of the government sector. As a first step we assume in equation (5) that government production is subject to variable returns to scale, that can be region-specific.

(5) $\quad Z_j = g_j(K_j^{public}); \qquad \text{with} \quad g_j(0) = 0, \quad g_j' > 0, \quad g_j'' \leq 0$

where K_j^{public} is the amount of human capital in the public goods sector in region *j*. Market clearing for human capital in region *j* ($K_j = K_j^{public} + K_j^{market}$) allows us to determine the number of varieties produced in region *j* (subject to the qualification of positive production etc.)

(6) $\quad n_j = (K_j - K_j^{public}) / f_j(Z_j)$

Equation (6) reflects the fact that the private and public sector compete with each other on the labor market. Equilibrium in the public sector requires that public spending is fully paid by taxes:

(7) $\quad r_j K_j^{public} = t_j Y_j$,

where t_j is the uniform income tax rate that applies to both labor and human capital.[6] Given the sector distribution of human capital and the return to human capital, choosing a level of public goods determines the tax rate and vice versa. In addition we assume that human capital employed in the public sector earns the same return as in the private sector. This reflects the notion that the public sector has to pay competing wages in order to attract human capital.

Standard monopolistic competition mark-up pricing gives (see equation (3)):

(8) $\quad p_j = [\sigma / (\sigma - 1)] \beta_j(Z_i) = f_j(Z_j)$

This pricing rule applies for locally produced and sold goods. Two observations with respect to this rule can be made. First, due to the production structure (equation (4)), the price p_j does not depend on wages. Second, we cannot choose units such that $p_j = 1$ because the marginal cost of production are a function of the level of public goods Z_j provided in region *j*. However, once we know the level of public goods provided, the local price level for manufacturing varieties is also determined.

Free entry and exit in the manufacturing sector ensures that profits are zero, which implies that the equilibrium output per firm equals:

(9) $\quad x_j = (\sigma - 1)\, [\alpha_j(Z_j) / \beta_j(Z)]\, r_j = \sigma\, r_j$

Using our normalization of wages, the income in region *j* is equal to

(10) $\quad Y_j = r_j K_j + L_j$

As usual, we use Samuelson's (1952) iceberg transport costs *T* (= the number of goods shipped from a region to ensure that 1 unit arrives in the other region) in the manufacturing sector. These costs imply that the price charged in the other region is *T*

[6] Differentiating between labor and capital income taxation raises the complication why to tax the mobile factor at all, see also Sinn (2002).

times as high as the mill price. It is convenient to define the 'free-ness of trade' parameter ϕ as a function of transport costs and the elasticity of substitution as follows: $\phi \equiv T^{1-\sigma}$. The free-ness of trade parameter ranges between 0 and 1; $\phi = 0$ represents autarky and $\phi = 1$ represents free trade (no obstacles to the movement of manufacturing varieties of any kind whatsoever).

The manufacturing sector market clearing condition is given by

$$(11) \qquad p_j x_j = \frac{p_j^{1-\sigma}\delta\, Y_j}{P_j^{1-\sigma}} + \frac{\phi\, p_k^{1-\sigma}\delta\, Y_k}{P_k^{1-\sigma}}$$

$$(12) \qquad P_j = \left(p_j^{1-\sigma} n_j + \phi\, p_k^{1-\sigma} n_k\right)^{1/(1-\sigma)}$$

where P_j is the price index for manufactures in region *j*. The left-hand side of equation (11) gives the equilibrium (value of) output per firm and the right-hand side the associated demand. Using equations (8), (9), (11), and (12) gives:

$$(13) \qquad r_1 = \left(\frac{1}{f_1\sigma}\right)\left[\frac{f_1^{1-\sigma}\delta Y_1}{n_1 f_1^{1-\sigma} + \phi n_2 f_2^{1-\sigma}} + \frac{\phi f_2^{1-\sigma}\delta Y_2}{n_2 f_2^{1-\sigma} + \phi n_1 f_1^{1-\sigma}}\right]$$

$$r_2 = \left(\frac{1}{f_2\sigma}\right)\left[\frac{f_2^{1-\sigma}\delta Y_2}{n_2 f_2^{1-\sigma} + \phi n_1 f_1^{1-\sigma}} + \frac{\phi f_1^{1-\sigma}\delta Y_1}{n_1 f_1^{1-\sigma} + \phi n_2 f_2^{1-\sigma}}\right]$$

In the sequel we let λ denote the share of human capital in region 1. As shown in Appendix I, the ratio of the rewards to human capital is equal to:

$$(14) \qquad \frac{r_1}{r_2} = \frac{f_2\sigma\,[\phi\, n_1(1+\psi_1) + n_2(1+\phi^2\psi_2)] + (\phi^2-1)(1-\lambda)\delta}{f_1\sigma\,[\phi\, n_2(1+\psi_2) + n_1(1+\phi^2\psi_1)] + (\phi^2-1)\lambda\delta}; \qquad \psi_j \equiv f_j^{1-\sigma} / f_k^{1-\sigma}$$

Once the functional form of the provision of public goods, see equation (5), is specified, as well as the impact of the provision of public goods on the cost structure, see equation (3), in addition to a public policy rule determining the level of public goods, equation (14) can be explicitly written as a function of λ, the share of human capital in region 1. The analysis below will investigate two different public policy rules. In sections 4 and 5 the government in each region allocates a fixed share of human capital located in the region to the production of public goods. The level of public goods provided is then determined by equation (5) and varies as the share of human capital located in the region varies. In section 6, on the other hand, the government in each region decides on the level of public goods provided in the region, irrespective of the share of human capital located in the region.

To round up the discussion of our model, we note that the location decision of human capital involves not only the factor rewards r_1 and r_2 but also the respective price levels, tax rates, and the provision of public services. The incentive of human capital to re-locate is therefore determined by the ratio ρ of indirect utilities (or *welfare*):[7]

$$(15) \qquad \rho = \left(\frac{(1-t_1)r_1}{(1-t_2)r_2}\right)\left(\frac{P_2}{P_1}\right)^{\delta}\left(\frac{Z_1}{Z_2}\right)^{\theta}$$

[7] Note that the indirect utility of a capital owner in region *j* equals $\left(\frac{\delta r_j}{P_j}\right)^{\delta}\left((1-\delta)r_j\right)^{1-\delta} Z_j^{\theta}$

This ratio is central in the analysis in the next sections. Apart from the case of complete agglomeration, human capital has no incentive to re-locate if welfare is the same in the two regions ($\rho = 1$), while human capital moves from region 2 to region 1 if welfare is higher in region 1 ($\rho > 1$) and from region 1 to region 2 if welfare is lower in region 1 ($\rho < 1$). This completes our discussion of the model.

4. Share of human capital allocated to the production of public goods

To illustrate the interaction between the provision of public goods and the location decision of capital-owners in our model we make the following assumptions:

- The elasticity of the production of public goods in region *j* with respect to human capital is a constant $\mu_j \leq 1$, that is $g_j(K_j^{public}) = \left(K_j^{public}\right)^{\mu_j}$ in equation (5).
- The elasticity of the costs of production in region *j* with respect to public goods is equal to $-\eta_j Z_j$, that is $f_j(Z_j) = e^{-\eta_j Z_j}$ in equation (3).
- The government in region *j* chooses a constant share κ_j of the human capital located in region *j* for the provision of public goods.

An important advantage of the above public policy rule to determine how much human capital in a region is employed in the government sector is that, other things equal and in accordance with casual observation, a 'large' region (that is a region with a large share of human capital) will provide more public goods than a 'small' region. A disadvantage of the above public policy rule is that it leads to more involved expressions, thus complicating the derivation of analytical results (see section 6). The public policy rule allows us to simplify equation (14), see appendix II:

$$\text{(14')} \quad \frac{r_1}{r_2} = \frac{\sigma[\phi(1-\kappa_1)\lambda(1+\psi_1)(f_2/f_1) + (1-\kappa_2)(1-\lambda)(1+\phi^2\psi_2)] + (\phi^2-1)(1-\lambda)\delta}{\sigma[\phi(1-\kappa_2)(1-\lambda)(1+\psi_2)(f_1/f_2) + (1-\kappa_1)\lambda(1+\phi^2\psi_1)] + (\phi^2-1)\lambda\delta}$$

In the absence of a government sector, that is if $\kappa_1 = \kappa_2 = 0$ and $f_1 = f_2 = 1$, this expression reduces to the Ottaviano-Forslid model, see appendix II. To simplify the exposition, we choose a combination of benchmark parameter values, see Table 3, such that we can focus attention on deviations from this benchmark in our discussion. Unless stated otherwise, the same parameter values apply to both regions.

Table 3 Base parameter values

Parameter	δ	σ	ϕ	η	μ	κ	θ
value	0.6	4	0.25	1	1	0	0.1

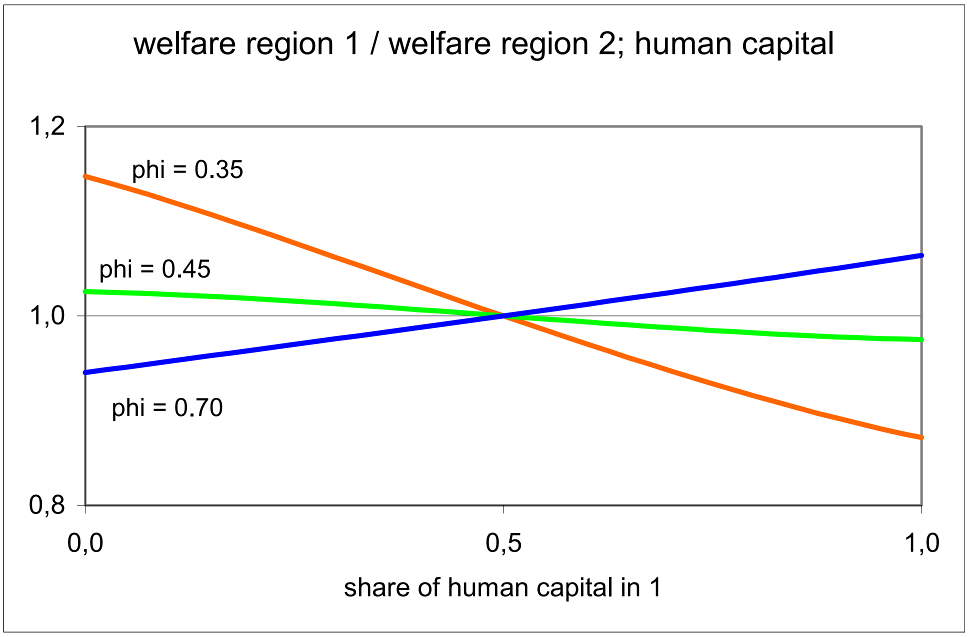
4.1 Does government policy matter?

We first show that without the government sector our model entails the standard economic geography effects as shown by Krugman (1991), known as the core model of geographical economics (Neary, 2001). In the absence of a government sector all human capital is employed in the manufacturing sector, that is $\kappa_1 = \kappa_2 = 0$ which implies $f_1 = f_2 = 1$. Figure 1 depicts the welfare for capital-owners in region 1 relative to the welfare of capital-owners in region 2 as a function of the share λ of human capital in region 1 ($\lambda = 0$ implies that all human capital is located in region 2, while $\lambda = 1$ implies that all human capital is located in region 1).[8] Figure 1 shows that

[8] Strictly speaking, equation (15) does not apply in the absence of a government sector. In this case, the tax rates t_j are 0 and we may ignore the direct impact of public goods on welfare, see also footnote 7.

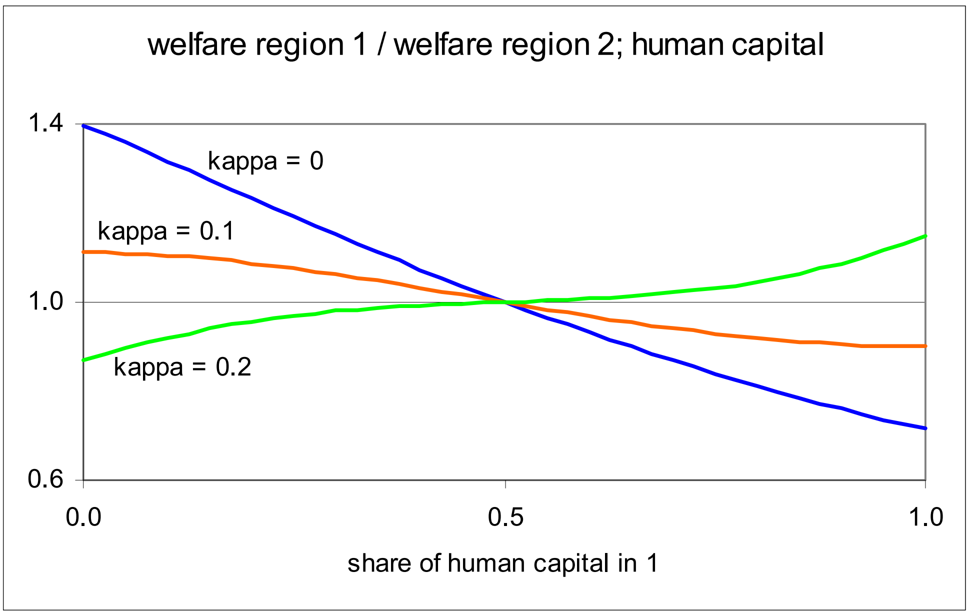
"economic integration", measured as an increase in the free-ness of trade parameter ϕ, results in the familiar anti-clockwise rotation of the short-run equilibrium curve displaying the relative welfare of human capital as a function of the share of human capital in region 1. For low values of the free-ness of trade parameter ϕ (in Figure 1, if $\phi = 0.35$ or $\phi = 0.45$) there is a stable symmetric long run equilibrium (at $\lambda = 0.5$). For higher values of the free-ness of trade parameter ϕ (in Figure 1, if $\phi = 0.70$), the symmetric equilibrium becomes *un*stable and only complete agglomeration of human capital in either region 1 or region 2 is a stable equilibrium.

Figure 1 No government; $\kappa_1 = \kappa_2 = 0$



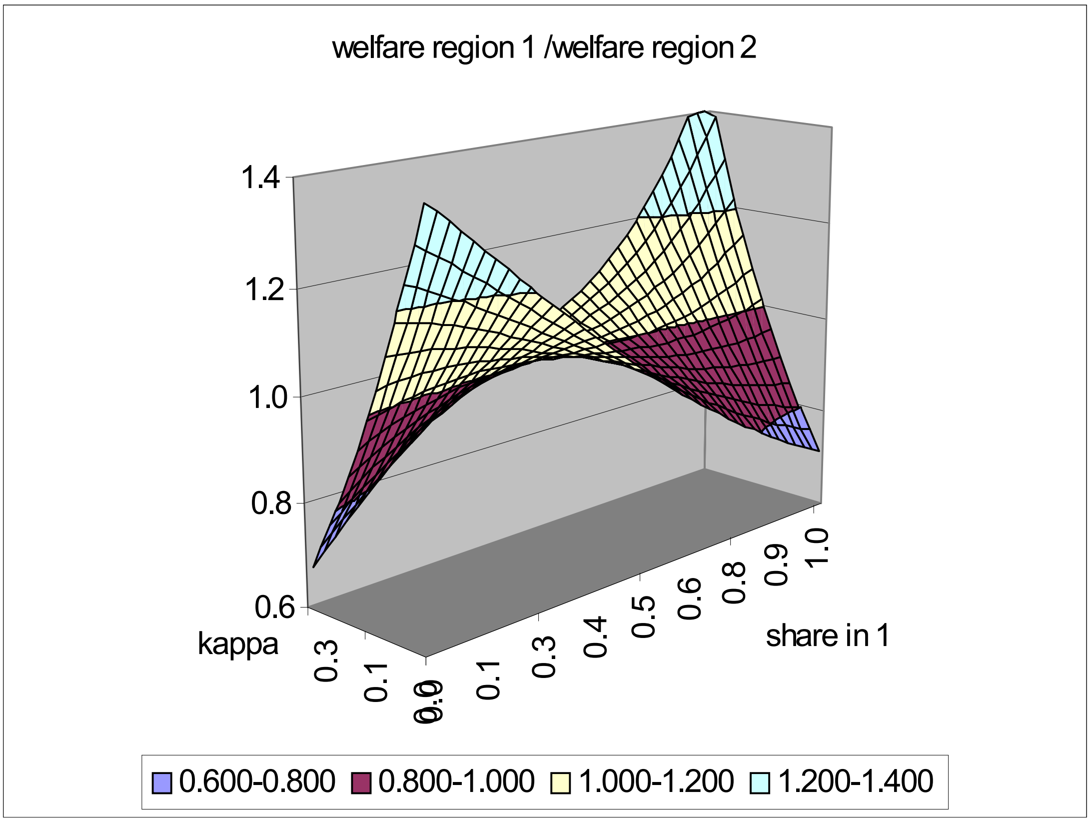
For a symmetric equilibrium ($\lambda = 0.5$) the relative real return to human capital is always equal to one. If full agglomeration is a stable equilibrium, the real return to human capital is higher for the region where human capital agglomerates. This creates an agglomeration rent which, in principle, enables this region to apply a higher tax rate if taxation is introduced, as long as the after tax return to human capital in the core exceeds the net return to human capital in the periphery.

Figure 2A The impact of the government sector; different values of κ



We now introduce the government sector. To ensure positive production of public goods Z we have to take $\kappa > 0$, such that a positive amount of human capital is employed in the public sector. Given that the base parameter values for η and θ are positive (see Table 3), the production of public goods has an impact on both the costs of production and utility. In contrast to our approach, Andersson and Forslid (1999) assume that the production of public goods uses a part of the consumption basket as an input. The net effect is that the production side is not affected by the introduction of public goods. By choice of the parameter values in the utility function, the consumption effect is not taken into account in their analysis, which essentially concentrates on the distribution effects of taxes between and within regions. In our model, the production of public goods uses human capital (equation (5)) and as such also influences the production side of the economy and redistributes resources between the sectors.[9] An inspection of equations (4) and (5) reveals that the production function of the manufacturing sector differs from that of the public sector because the latter is not subject to fixed costs. This is another distinction between the production of public goods and manufactures.

Figure 2B Relative welfare for different combinations of λ and κ



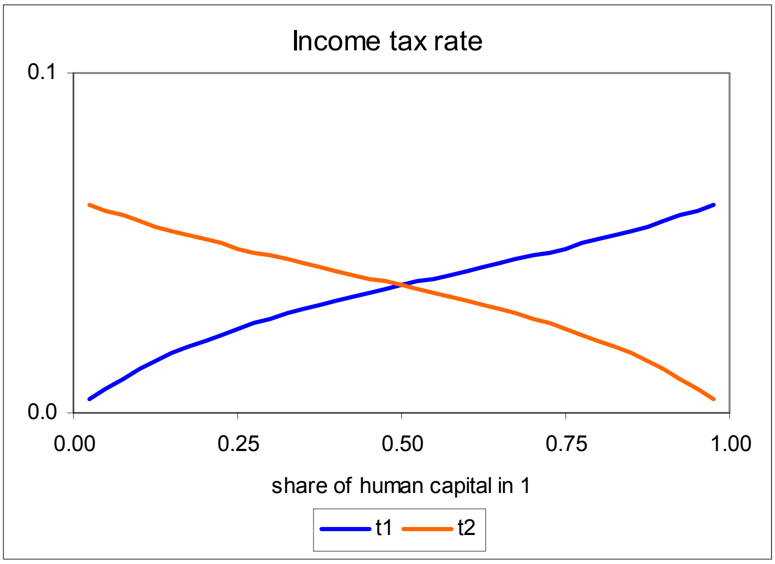
We can now analyze the consequences of imposing different tax rates on the location decision of human capital in this model. As illustrated in Figure 2A, the symmetric equilibrium may become *un*stable, rather than stable, if an increasing share of human capital is employed in the government sector (in Figure 2A if $\kappa = 0.2$ full

[9] Also we think it makes more sense to tax the mobile factor (here, capital) when at least part of the tax revenues is used to produce public goods that benefit the mobile factor, instead of the situation (as in Andersson and Forslid's model) where the mobile factor is taxed but the public goods are only consumed by (immobile) consumers.

agglomeration is a stable long run equilibrium). As such, the introduction of a government sector producing public goods directly affecting utility or indirectly reducing the costs of production clearly fosters agglomeration. This general conclusion holds for all intermediate values of the free-ness of trade parameter ϕ, hence it holds for almost any degree of economic integration, with the exception of the extreme cases $\phi = 0$ and $\phi = 1$. The introduction of public goods *Z* is clearly not neutral with respect to the location decisions of capital-owners. Figure 2B illustrates that a region's *relative* welfare is best served if it attracts all human capital if the share of human capital κ devoted to the production of public goods is sufficiently high.

Given the equilibrium solutions, the government budget constraint gives the associated income tax rate for each level of public goods, see equation (7). Even if the same share of human capital is devoted to the production of public goods, the larger region, that is the region with more human capital, tends to produce a larger share of GDP on the production of public goods. This is illustrated in Figure 2C. In particular, if $\kappa = 0.2$ such that complete agglomeration is the stable equilibrium, the tax rate in the core is positive and the zero tax rate in the periphery does not induce a re-location of human capital. The underlying reason is the agglomeration rent, as emphasized by Baldwin and Krugman (2000).

Figure 2C Income tax rates; $\kappa = 0.2$



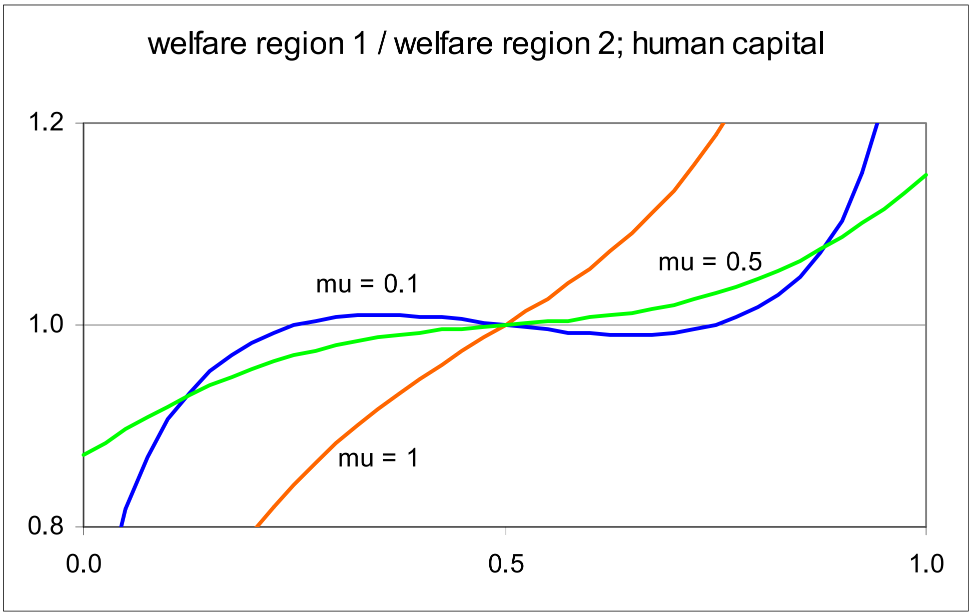
The conclusions based Figures 2A and 2C do not change qualitatively if we choose different values for the share κ of human capital allocated to the production of public goods, or by allowing this share to differ between regions.[10] The same is true for alternative values of θ, the weight of public goods in the utility function, although increasing this weight obviously strongly stimulates agglomeration. With respect to the impact of public goods on reducing the costs of production (infrastructure) as measured by the parameter η a similar conclusion holds. The more public goods lower the costs of production of manufactures, see equations (3) and (4), the more the agglomeration tendencies as illustrated by Figure 2A are reinforced.

[10] If $\kappa_1 \neq \kappa_2$ the main impact is the movement of the dispersed equilibrium away from symmetry.

The conclusion is that the introduction of the government sector matters. The way in which the government affects equilibria crucially depends on the difference in the production structure of the government compared to the manufacturing sector. Releasing human capital from the manufacturing sector, which reduces production of manufactures, has two effects. First, the production of public goods does not incur fixed costs, which makes it less "wasteful" than manufactures production. Second, the provision of public goods through an expansion of infrastructure directly benefits the production possibilities of the manufacturing sector. The fact that labor and human capital can be used more efficiently implies that the larger region offers a higher return on human capital, which stimulates agglomeration.

Does this last conclusion also hold if the size of the government sector has a bearing on the efficiency of the production of public goods itself? That is, what happens if the production of public goods is no longer constant returns to scale ($\mu = 1$) but decreasing returns to scale ($\mu < 1$), indicating a diminished efficiency of the government sector as it expands production.[11] Figure 3 illustrates for three different values of μ and for $\kappa = 0.2$ the relevance of the scale effect in government production. With sufficiently decreasing returns to scale the symmetric equilibrium ultimately becomes stable again, due to the weakening of agglomeration forces. With respect to taxation, the symmetric equilibrium ($\lambda = 0.5$) becomes a stable equilibrium again despite the fact that $\kappa = 0.2$. Hence a stable dispersed equilibrium (at which $t_1 = t_2$) is associated with spontaneous (not policy induced) tax harmonization, this is in sharp contrast with the conclusion based on Figure 2C for the case of agglomeration.

Figure 3 The impact of returns to scale (μ) in the production of public goods



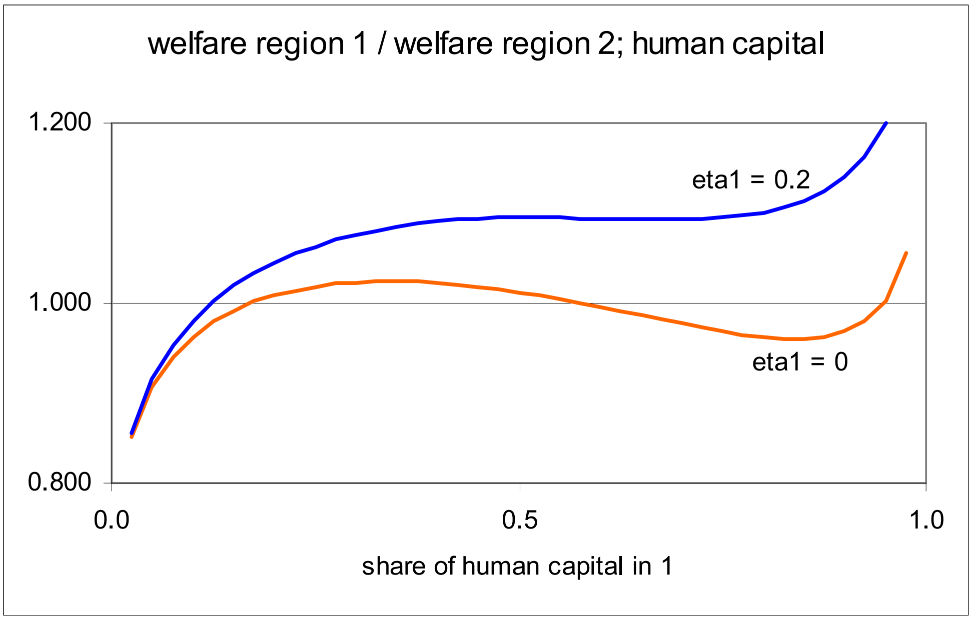
4.2 Asymmetric governments

[11] Decreasing returns to scale with respect to capital in the production of public goods Z also implies that for small values of capital the marginal productivity can be higher than in the benchmark case with constant returns to scale. For regional differences in μ one has to be careful in comparing productivity differences because conclusions depend also on the level human capital used.

The discussion on tax competition or, more general, locational competition is ultimately based on the idea that it pays for national governments to behave differently, that is, to have lower taxes or better policies than other countries. From the perspective of geographical economics we showed that, in the absence of a coordinated policy of tax harmonization, tax competition need not arise as countries try to benefit from the agglomeration rent in core countries, a rent that can be taxed without resulting in a re-location of the mobile factors (recall Figure 2C). We now use our model to highlight the relevance of regional differences in the way the provision of public goods affects the economy. Because taxation is a means to an end, we focus on the public spending financed by an income tax. In models in which government policy is the same thing as tax policy, the government provides a negative force in the sense that taxation always decreases the net return to the (mobile) factors of production. The main issue then is simply the extent to which after-tax returns interfere with pre-tax spatial equilibria. This sub-section shows that through its production of public goods the location effects of government polices become subtler.

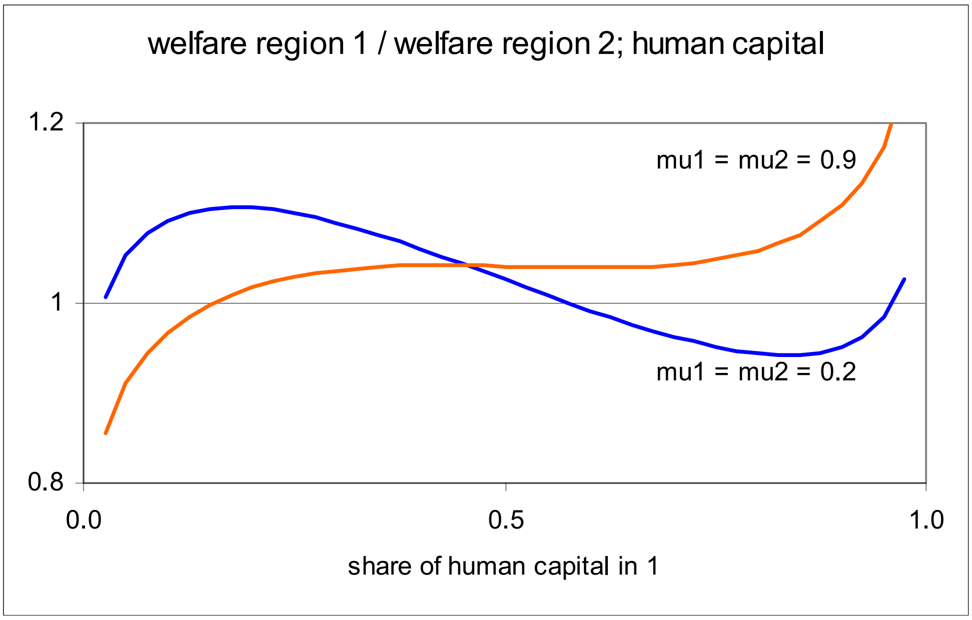
From section 4.1 we know that a region with more public goods (higher κ) which is more effective in lowering the costs of manufacturing production (higher η) and has a more efficient production of public goods (higher μ) tends to attract the mobile factor of production, human capital. Agglomeration thus results if the other region lags behind in these respects. Complications arise if the differences between the government sectors of the two regions do not differ in such a systematic manner. We show this for two examples, both of which are characterized by (other things equal) region 1 having a larger government sector ($\kappa_1 > \kappa_2$) in conjunction with (i) a smaller impact of the production of public goods in region 1 on reducing the costs of production, and (ii) a less efficient production of public goods as the government sector expands.

Figure 4 Asymmetric governments and effectiveness; $\kappa_1 = 0.4 > 0.2 = \kappa_2$; $\eta_2 = 0.5$



Ad (i). Figure 4 depicts a situation in which the share of human capital allocated to the production of public goods is larger in region 1 ($\kappa_1 = 0.4 > 0.2 = \kappa_2$) combined with a lower impact of public goods on reducing the cost of manufacturing production in region 1. Even if the effectiveness of public goods in lowering production costs in region 1 is substantially lower than in region 2 ($\eta_1 = 0.2 < 0.5 = \eta_2$), the larger share of human capital allocated to the production of public goods in region 1 makes (incomplete) agglomeration in region 1 very attractive. In contrast, if spending on public goods in region 1 does not lead to any reduction in production costs (if $\eta_1 = 0 < 0.5 = \eta_2$) there are three dispersed equilibria, the middle-one being stable. So despite the fact that region 1 deploys a larger share of its human capital in the public goods sector (which consumers directly appreciate in the utility function), the ineffectiveness in lowering the costs of production in region 1 makes region 2 a more attractive location.

Figure 5 Asymmetric governments and inefficiencies; $\kappa_1 = 0.3 > 0.25 = \kappa_2$; $\eta = 0.3$



Ad (ii). Figure 5 depicts a situation in which the share of human capital allocated to the production of public goods is larger in region 1 ($\kappa_1 = 0.3 > 0.25 = \kappa_2$) combined with a less efficient production of public goods as the government sector expands ($\mu < 1$). If the production of public goods is reasonably efficient as the government sector expands, that is if $\mu = 0.9$ in Figure 5, the strategy of region 1 to allocate a higher share of human capital to the production of public goods pays off as it makes region 1 a more attractive location for human capital to (incompletely) agglomerate. However, if the production of public goods becomes rapidly less efficient as the government sector expands, that is if $\mu = 0.2$ in Figure 5, the strategy of region 1 to allocate a higher share of human capital to the production of public goods does not succeed in making region 1 an attractive location as this comes at too high costs. Instead, region 2 benefits slightly from this policy and is able to attract more human capital than region 1. In this particular case, tax competition and a partial 'race to the bottom' is more likely to occur. Given the circumstances, this tax competition is beneficial as it prevents governments from expanding the government sector if this expansion is inefficient. Analyzing differences between regions in the efficiency of the production of public goods (differences in μ) shows that the positioning of (stable) dispersed equilibria can change significantly (not shown here). In particular, when comparing equilibria the initially smaller region attracts more human capital if it succeeds in increasing the efficiency of its production of public goods.

The main conclusion that arises from the two examples underlying Figures 4 and 5 is that in our model the balance between the spreading forces and the agglomeration forces depends strongly on the chosen government policies and on the (differences in) the efficiency of the functioning of the government sector in the two regions. The important implication is that governments may to a large extent determine the fate of their country with respect to its attractiveness for mobile factors of production.

5. Symmetry analysis

Extending the Ottaviano-Forslid model, in which the manufacturing sector uses both a mobile and an immobile production factor, not only allows us to analyze and illustrate locational competition, but also enables us to derive some analytical results supporting the intuitive reasoning and illustrations of the previous section. We focus attention on the analysis of the symmetric equilibrium, that is if both regions allocate the same share of human capital to the production of public goods and attract the same share of human capital. In doing so, we basically try to underpin some of the simulation results as presented in the previous section.

Proposition 1. The impact of public policy and exogenous parameters on the symmetric equilibrium is summarized in Table 4 and derived in appendix III.

We can, somewhat arbitrarily, divide the parameters into two groups: (i) those parameters that are present in all geographical economics models (the elasticity of substitution σ, the share income spent on manufactures δ, and the free-ness of trade parameter ϕ), and (ii) the parameters that are central in our model (the share of human capital allocated to the production of public goods κ, the efficiency of government production of public goods μ, and the impact of government spending on reducing production costs η).

Ad (i). The impact of the standard geographical economics parameters on the spreading equilibrium are not surprising. An increase in the free-ness of trade parameter has no direct effect on most variables as measured relative to the numéraire, but of course reduces the price index (as more manufactured goods arrive on their destination) and thus increases real income and the real return to capital (and labor). As the free-ness of trade increases beyond a certain level the symmetric equilibrium will become unstable (see also Figure 1). An increase in the elasticity of substitution increases competition between varieties, which therefore reduces the return to human capital and thus income. In addition, an increase in the ease with which consumers can substitute between different varieties reduces the price index.[12] An increase in the share of income spent on manufactures increases the importance of human capital relative to labor and thus increases the return to capital and income.

[12] The net effect on welfare cannot be discussed as a change in the elasticity of substitution affects the utility function itself. This also holds for a change in the share of income spent on manufactures.

Table 4 Symmetric equilibrium						
Endogenous variable in Symmetric equilibrium	Impact of rise in					
	σ	δ	ϕ	κ	μ	η
$r = \dfrac{\delta}{\sigma(1-\kappa)-\delta}$	-	+	0	+	0	0
$Y = \dfrac{\sigma(1-\kappa)}{2[\sigma(1-\kappa)-\delta]}$	-	+	0	+	0	0
$p = f(Z) = e^{-\eta Z}$	0	0	0	-	-	-
$P = \left[\dfrac{(1+\phi)(1-\kappa)}{2}\right]^{\frac{1}{1-\sigma}} f(g(\kappa/2))^{\frac{\sigma}{\sigma-1}}$	-	0	-	?	-	-
$n = \dfrac{(1-\kappa)}{2f(g(\kappa/2))}$	0	0	0	?	+	+
$Z = g(\kappa/2) = (\kappa/2)^{\mu}$	0	0	0	+	+	0
$t = \dfrac{\kappa\delta}{(1-\kappa)\sigma}$	-	+	0	+	0	0

Ad (ii). The impact of the parameters that are central to our model on the symmetric equilibrium is also readily understood. Increasing the share of human capital κ allocated to the production of public goods, increases the production of public goods, reduces the cost of production (and thus the price) of an individual variety, and (through the increased scarcity of human capital) increases the return to capital and income. All of this comes at the costs of an increased tax rate because the government has to pay competitive returns to human capital. Since the share of human capital allocated to the production of manufactures decreases while at the same time the "wast" in terms of the fixed cost to produce varieties decreases, the net effect on the number of varieties produced and on the price index is unclear. Enlarging the government sector is therefore a mixed blessing, the wisdom of which depends on the particular circumstances. If the production of public goods has a larger impact on reducing the costs of production, that is if η increases, the improved efficiency of the economy is beneficial through a reduction in the price of a variety and the price index and through an increase in the number of varieties produced (love-of-variety effect, see Brakman, Garretsen, and Van Marrewijk (2001, ch. 7)). These cases are illustrated in Figure 2A. An increased efficiency of the government sector in producing public goods, that is an increase in μ, has similar positive effects on the number of varieties produced and the efficiency of the economy because the same input leads to a higher production of public goods, as is illustrated in Figure 3.

The above analysis shows that the impact of the government on the symmetric equilibrium can in general be well-understood, but may lead to ambiguity in some cases. Table 4 gives an intuitive and qualitative understanding of some of the results of the graphs discussed in section 4 (note that symmetry does not hold in all of our examples in that section). In figure 4, for instance, an improved efficiency of public goods in reducing the costs of production η indeed increases welfare for the country with the largest government sector (largest κ). In figure 5, similarly, improving the efficiency of the government sector μ increases welfare more in the country with the largest government sector (largest κ).

6 Choosing the level of public goods

The analyses and illustrations in sections 4 and 5 are based on the assumption that the government in each region chooses the share of human capital located in its region allocated to the production of public goods. Although this has certain advantages, as explained in section 4, one of the disadvantages is that it leads to more involved analytical expressions, such as equation (14'), which complicates the derivation of analytical results.[13] To circumvent this problem and continue our analysis, this section and the next section focus attention on the impact of a redistribution of human capital (λ_i) in two otherwise identical regions which, as a public policy rule, have chosen a specific level of public goods to be produced for the economy under constant returns to scale. More specifically, we use the following assumptions:

- The two regions have a constant and given level of public goods $Z_1 = Z_2 = Z$.
- The influence of government spending on the cost of production in the two regions are identical (see equations (3)), in particular $f_1 = f_2 = f$
- The production function for the provision of public goods has constant returns to scale, $\mu_1 = \mu_2 = 1$.

First, we note that the above assumptions ensure that the terms ψ_j defined in equation (14) are equal to 1. Second, we note that the number of varieties produced in each region can be readily determined as a function of the available human capital in the region and the amount of public goods produced using equations (5) and (6). Substituting this in equation (14) and collecting terms shows that the relative return to human capital simplifies to:

$$(14'') \quad \frac{r_1}{r_2} = \frac{b_1(1-\lambda) + b_2\lambda - b_3 Z}{b_1\lambda + b_2(1-\lambda) - b_3 Z} \equiv h_2(\lambda | Z); \quad where$$

$$b_1 \equiv \sigma(1+\phi^2) - \delta(1-\phi^2); \quad b_2 \equiv 2\phi\sigma \ ; \quad b_3 \equiv \sigma(1-\phi)^2$$

The function $h_2(\lambda|Z)$ is defined for future reference.[14] As the notation clarifies, the return to human capital is an implicit functions of the share λ of human capital located in region 1, given the level of public goods Z produced in each region. The direction of the impact of the provision of public goods on the ratio of rewards to human capital is readily determined.

Proposition 2. If region 1 has a higher reward to human capital than region 2 in the absence of public goods, an equal provision of public goods in both regions magnifies the relatively higher reward to human capital in region 1.

Similarly, using the above conditions, the relative price index P_2 / P_1 simplifies to:

$$(16) \quad \frac{P_2}{P_1} = \left(\frac{(1-\lambda) + \phi\,\lambda - (1+\phi)Z}{\lambda + \phi\,(1-\lambda) - (1+\phi)Z} \right)^{1/(1-\sigma)}$$

---

[13] Obviously, this problem does not arise in the symmetry analysis in section 5 as the analytical expressions simplify considerably.

[14] This expression readily simplifies to the Ottaviano-Forslid model if there are no public goods, see e.g. Ottaviano (2001), equation (10).

Again, the direction of the impact of the provision of public goods on the relative price ratio can be readily determined.

Proposition 3. If region 2 has a higher price index than region 1 in the absence of public goods, an equal provision of public goods in both regions magnifies the relatively higher price index of region 2.

Obviously, if a higher return to human capital in a particular region (for instance $r_1>r_2$) is also associated with a higher price index in that region ($P_1>P_2$), the combination of propositions 2 and 3 shows that the net effect on the real rate of return to human capital of the introduction of public goods depends on the relative magnitude of the impact on the rate of return compared to the impact on the price index. In the core geographical economics model upon which the Ottaviano-Forslid model is based, it is typically true that the region with a larger share of the mobile factor of production (say, region 1) would have a higher return to human capital ($r_1>r_2$) as well as a *lower* price index ($P_1<P_2$) in which case the introduction public goods would unambigiously foster agglomeration.
As the next section will show, at least at the margin, the introduction of public goods tends to foster agglomeration as already suggested in section 4. In this sense the analytical results are in line with the basic simulation results for the case of the symmetric equilibrium in section 4.1, recall Figures 1 and 2A and how the symmetric equilibrium became unstable once public goods were introduced .

7 Break analysis

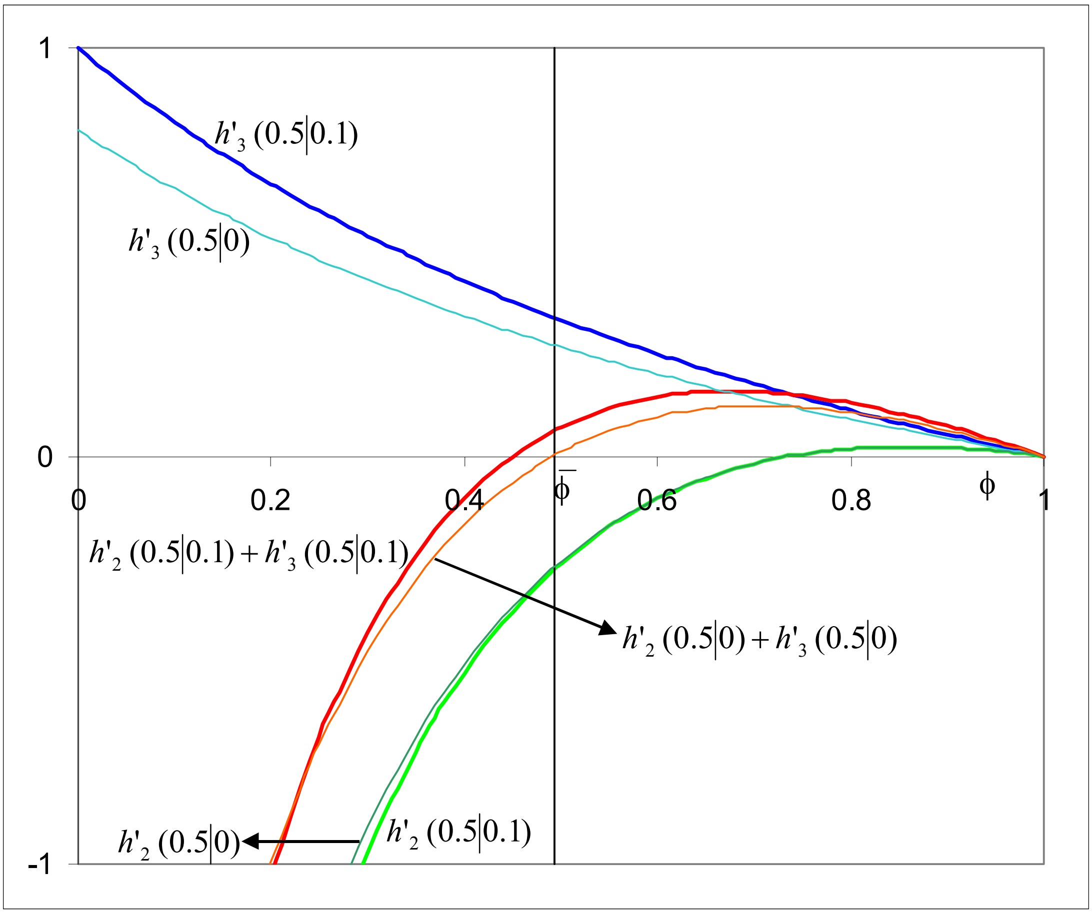
Our simulation results indicate that the introduction of public goods in the geographical economics model increases the possibilities for active government policies by fostering agglomeration of manufacturing production rather than spreading of manufacturing production. Based on the propositions derived in the previous section, this section formally addresses that question by analyzing the stability of the symmetric spreading equilibrium. In particular, we will determine for which value of the free-ness of trade parameter ϕ spreading of manufacturing production is no longer a stable equilibrium. First, we note that, since there is an equal provision of public goods in both regions, the welfare ratio for human capital given in equation (15) simplifies to:

$$\begin{aligned} &\rho(\lambda|Z) = \frac{(1-t_1)}{(1-t_2)} \frac{r_1}{r_2} \left(\frac{P_2}{P_1}\right)^{\delta} \equiv h_1(\lambda|Z)\, h_2(\lambda|Z)\, h_3(\lambda|Z), \quad \textit{where} \\ (15') \quad &h_1(\lambda|Z) \equiv \frac{(1-t_1)}{(1-t_2)}, \quad h_2(\lambda|Z) \equiv \frac{r_1}{r_2}, \quad h_3(\lambda|Z) \equiv \left(\frac{P_2}{P_1}\right)^{\delta} \end{aligned}$$

At the symmetric equilibrium $\lambda = 0.5$ we have

$$\begin{aligned} &h_1(0.5|Z) = h_2(0.5|Z) = h_3(0.5|Z) = 1 \quad \textit{such that} \\ (17) \quad &\rho'(0.5|Z) = h'_1(0.5|Z) + h'_2(0.5|Z) + h'_3(0.5|Z) \end{aligned}$$

Figure 6. Break analysis $(\sigma = 4, \delta = 0.6)$



Using this notation the break analysis consists of finding values of ϕ for which $\rho' = 0$. As shown in appendix IV for the real rental rate this implies solving equation (18).

$$(18) \qquad \frac{4\delta(1-\phi)}{(\sigma-1)(1+\phi)(1-2Z)} - \frac{4(\sigma(1+\phi^2) - \delta(1-\phi^2) - 2\phi\sigma)}{[\sigma(1+\phi^2) - \delta(1-\phi^2) + 2\phi\sigma - 2\sigma(1-\phi)^2 Z]} = 0$$

Let $\bar{\phi}$ be the solution to equation (18) if there are no public goods provided, that is if $Z = 0$ (see appendix IV). We can determine the impact of the introduction of public goods on the break condition at the margin, that is evaluated at $Z = 0$, $\lambda = 0.5$, and $\phi = \bar{\phi}$. Appendix IV shows that at the margin the break condition for the free-ness of trade parameter falls if, and only if, condition (19) holds.

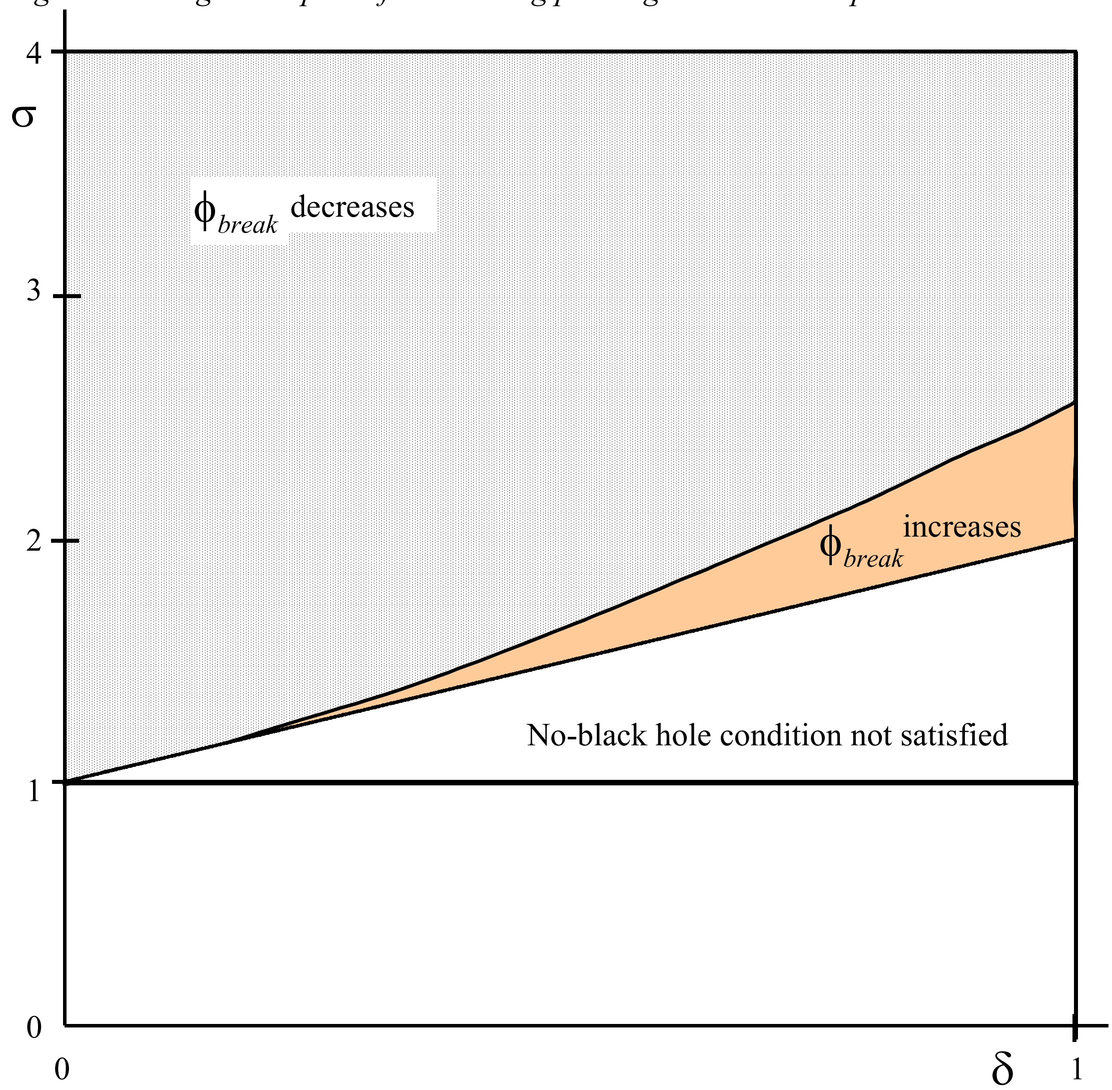
$$(19) \qquad \bar{\phi}(\delta\bar{\phi} + 4\sigma) > \delta$$

Proposition 4. The introduction of an equal provision of public goods in both regions at the margin reduces the free-ness of trade index for the break-point if, and only if, condition (19) holds.

Proposition 4 is illustrated if condition (19) holds in Figure 6, showing that the break-point is reached for a *lower* value of the free-ness of trade parameter ϕ if there are public goods $(Z = 0.1)$ than in the absence of public goods $(Z = 0)$. Since condition (19) is rather weak and holds for a wide range of parameter combinations (δ, σ), the introduction of public goods usually leads to a fall in the free-ness of trade break-point, tending to reduce the stability of the spreading equilibrium, as illustrated in

Figure 7. For Europe, for example, this suggests that incorporating the impact of the provision of public goods on the stability of the economic process, the process of continued economic integration (EU enlargement), which increases the free-ness of trade parameter ϕ , is more likely to lead to instability of the spreading equilibrium, or equivalently more likely to result in core-periphery outcomes. This analytical result is very much in line with the basic simulation result, as shown by Figure 2A in section 4.1, that the introduction of public goods stimulates agglomeration and that this is the case for all intermediate values of the free-ness of trade parameter ϕ .

Figure 7. Marginal impact of introducing public goods on break-point



8. Summary and conclusions

Recent advances in the theory of trade and location have shown that increasing economic integration does not lead to a race to the bottom with respect to taxation. This important result challenges the standard views about tax competition but the treatment of the government sector is still rather rudimentary. The emphasis is almost exclusively on taxes and its distribution consequences. This is rather one-sided because taxes are a means to an end and tax-financed public spending can also be used an instrument of locational competition. Countries try to increase their attractiveness as a location by investing in location-specific infrastructure. When the effects of agglomeration are thought to be important tax and spending policies represent two opposing forces. All other things remaining the same, higher taxes stimulate spreading even though the existence of an agglomeration rent may prevent the spreading from actually taking place. Similarly, an increase in public spending stimulates agglomeration if this spending enhances the attractiveness of the location for the mobile factors of production. But all things do not remain the same in the sense that higher taxes typically also imply higher public spending and vice versa. Also, the extent to which a larger government sector (meaning higher public spending and taxes) really leads to a better quality of the country's infrastructure is an issue that has troubled policy-makers for a long time.

In the present paper we extend the recent work on tax competition by Baldwin and Krugman (2000) and Andersson and Forslid (1999) in two ways. First, we allow for public spending to affect the cost of production and this has an impact on the location decisions of firms and workers. Second, we also take into account that the public sector has to compete with the private sector on the labor market and that countries may differ in the efficiency of the public sector.

The main contribution of this paper is that it takes the interdependency between taxes and spending as a starting point. By changing the relative size, direction or efficiency of the provision of public goods, governments can change the equilibrium between agglomerating and spreading forces. Ultimately this means that by restricting locational competition to tax competition, one neglects that the provision of public goods also determines (positively or negatively) the attractiveness of locations for footloose economic activity. This is true for both core and peripheral countries. This last conclusion is important for it indicates that, depending on its relative position with respect to the production of public goods, a periphery can (also) become a core (and vice versa)! For core countries it may not be enough, in contrast with Baldwin and Krugman (2000), to limit their tax differential with peripheral countries in order to prevent their mobile factors of production from leaving the country, they must also take the manner in which tax revenues are spent into account.

Our conclusions are based on simulation results as well as analytical results. In general the results indicate that the introduction of public goods stimulates agglomeration and that, compared to the "no public goods" case, the symmetric equilibrium becomes unstable for lower degrees of economic integration (higher trade costs). In the context of the EU this seems re-assuring news for the core EU-countries but this conclusion is subject to some important qualifications. Our simulation results also show that this general conclusion can be easily overturned when the public goods provision is subject to decreasing returns to scale. This qualification also holds when larger countries or countries with a larger public goods sector are either relatively less efficient in the production of public goods or where public goods have a relatively smaller impact in reducing the firms' costs of production. The bottom line is therefore that the only a relatively well-functioning public goods sector stimulates agglomeration in the face of economic integration. Both core and peripheral EU countries may take this as good news.

Appendix I Derivation of equation (14)

Using the income equations (10), equations (13) can be written as

$$r_1 = \left(\frac{1}{f_1\sigma}\right)\left[\frac{f_1^{1-\sigma}\delta(r_1K_1 + L_1)}{n_1 f_1^{1-\sigma} + \phi n_2 f_2^{1-\sigma}} + \frac{\phi f_2^{1-\sigma}\delta(r_2K_2 + L_2)}{n_2 f_2^{1-\sigma} + \phi n_1 f_1^{1-\sigma}}\right]$$

$$r_2 = \left(\frac{1}{f_2\sigma}\right)\left[\frac{f_2^{1-\sigma}\delta(r_2K_2 + L_2)}{n_2 f_2^{1-\sigma} + \phi n_1 f_1^{1-\sigma}} + \frac{\phi f_1^{1-\sigma}\delta(r_1K_1 + L_1)}{n_1 f_1^{1-\sigma} + \phi n_2 f_2^{1-\sigma}}\right]$$

Two linear equations in the unknowns r_1 en r_2 which can be solved analytically:

$$\begin{aligned} r_1 &= a_{11}r_1 + a_{12}r_2 + d_1 \\ r_2 &= a_{21}r_2 + a_{22}r_2 + d_2 \end{aligned} \quad \Rightarrow \quad \begin{bmatrix} r_1 \\ r_2 \end{bmatrix} = \frac{1}{(1-a_{11})(1-a_{22}) - a_{12}a_{21}}\begin{bmatrix} (1-a_{22})d_1 + a_{12}d_2 \\ a_{21}d_1 + (1-a_{11})d_2 \end{bmatrix}$$

where $a_{11} = \left(\frac{1}{f_1\sigma}\right)\bar{h}_1K_1 \qquad a_{12} = \left(\frac{1}{f_1\sigma}\right)\phi\,\bar{h}_2K_2 \qquad a_{21} = \left(\frac{1}{f_2\sigma}\right)\phi\,\bar{h}_1K_1$

$$a_{22} = \left(\frac{1}{f_2\sigma}\right)\bar{h}_2K_2 \qquad d_1 = \left(\frac{1}{f_1\sigma}\right)\left(\bar{h}_1L_1 + \phi\,\bar{h}_2L_2\right) \qquad d_2 = \left(\frac{1}{f_2\sigma}\right)\left(\phi\,\bar{h}_1L_1 + \bar{h}_2L_2\right)$$

$$\bar{h}_j \equiv \left(\frac{f_j^{1-\sigma}\delta}{n_j f_j^{1-\sigma} + \phi\, n_k f_k^{1-\sigma}}\right)$$

For $K = 1, \quad K_1 = \lambda, \quad L_1 = L_2 = 1/2$ the derivation of r_i is now straightforward

$$r_1 = \frac{\dfrac{1 - \dfrac{\bar{h}_2(1-\lambda)}{\sigma f_2}}{2\sigma f_1}\left(\bar{h}_1 + \phi\bar{h}_2\right) + \dfrac{\phi\bar{h}_2(1-\lambda)(\bar{h}_2 + \phi\bar{h}_1)}{2\sigma^2 f_1 f_2}}{\left(1 - \dfrac{\bar{h}_1\lambda}{\sigma f_1}\right)\left(1 - \dfrac{\bar{h}_2(1-\lambda)}{\sigma f_2}\right) - \dfrac{\phi^2\bar{h}_1\bar{h}_2\lambda(1-\lambda)}{\sigma^2 f_1 f_2}}$$

and similarly for r_2. Using the definitions of $\bar{h}_j$ and defining ψ_j gives equation (14):

$$\frac{r_1}{r_2} = \frac{f_2\sigma\,[\phi\, n_1(1+\psi_1) + n_2(1+\phi^2\psi_2)] + (\phi^2 - 1)(1-\lambda)\delta}{f_1\sigma\,[\phi\, n_2(1+\psi_2) + n_1(1+\phi^2\psi_1)] + (\phi^2 - 1)\lambda\delta}; \qquad \psi_j \equiv f_j^{1-\sigma} / f_k^{1-\sigma}, \quad j \neq k$$

Appendix II Derivation of equation (14')

Using: $K_1^{public} = \kappa_1\lambda$, $K_2^{public} = \kappa_2(1-\lambda)$, so $n_1 = \dfrac{(1-\kappa_1)\lambda}{f_1}$; $n_2 = \dfrac{(1-\kappa_2)(1-\lambda)}{f_2}$ in the above derivation of equation (14) gives equation (14'):

$$\frac{r_1}{r_2} = \frac{\sigma[\phi\,(1-\kappa_1)\lambda(1+\psi_1)(f_2/f_1) + (1-\kappa_2)(1-\lambda)(1+\phi^2\psi_2)] + (\phi^2 - 1)(1-\lambda)\delta}{\sigma[\phi\,(1-\kappa_2)(1-\lambda)(1+\psi_2)(f_1/f_2) + (1-\kappa_1)\lambda(1+\phi^2\psi_1)] + (\phi^2 - 1)\lambda\delta}$$

In the absence of a government sector, that is if $f_1 = f_2 = 1$ and $\kappa_1 = \kappa_2 = 0$, this expression simplifies to the Ottaviano-Forslid model:

$$\frac{r_1}{r_2} = \frac{\sigma[2\phi\,\lambda + (1-\lambda)(1+\phi^2)] + (\phi^2 - 1)(1-\lambda)\delta}{\sigma[2\phi\,(1-\lambda) + \lambda(1+\phi^2)] + (\phi^2 - 1)\lambda\delta}.$$

Appendix III Derivation of Table 4

At the symmetric equilibrium we have: $\lambda = 0.5$; $f_1 = f_2 = f$; $\bar{h}_1 = \bar{h}_2 = \bar{h}$; $n_1 = n_2 = n$; and $\kappa_1 = \kappa_2 = \kappa$. Use this in appendix I to calculate the rental rate:

$$r_1\big|_{\lambda=0.5} = \frac{(1+\phi)\bar{h}}{2\sigma f - (1+\phi)\bar{h}}; \qquad \bar{h} = \frac{\delta}{(1+\phi)n}$$

Since $n = \dfrac{(1-\kappa)}{2\alpha} = \dfrac{(1-\kappa)}{2f(g(\kappa/2))}$ we have:

$$r_1\big|_{\lambda=0.5} = r_2\big|_{\lambda=0.5} \equiv r = \frac{\delta}{\sigma(1-\kappa)-\delta}$$

such that: $Y_1 = Y_2 \equiv Y = \dfrac{r}{2} + \dfrac{1}{2} = \dfrac{\sigma(1-\kappa)}{2[\sigma(1-\kappa)-\delta]}$ and $t_1 = t_2 \equiv t = \dfrac{\kappa\, r}{2Y} = \dfrac{\kappa\delta}{(1-\kappa)\sigma}$

These results allow us to calculate the impact of changes of policy parameters on the endogenous variables of the model. The results are summarized in Table 4.

Appendix IV Derivation of equations (18) and (19)

- The function h_1 transfers the pre-tax return to the post-tax return:

$$h_1(\lambda|Z) \equiv \frac{1-t_1(\lambda|Z)}{1-t_2(\lambda|Z)}$$

At the point of symmetry: $t_1 = t_2 = t$, $h_1(0.5|Z) = 1$, and $t'_1(0.5|Z) = -t'_2(0.5|Z)$, such that the derivative of h_1 simplifies to: $h_1'(0.5|Z) = -[2/(1-t)]\, t'_1(0.5|Z)$. We therefore have to determine the impact of a change in the distribution of human capital on the tax rate. Since $Y_1 = r_1 K_1 + L_1$ and $r_1 Z = t_1 Y_1$ in the symmetric equilibrium:

$$t'_1(0.5|Z) = t_1\left[\frac{r'_1(0.5|Z)}{2r_1 Y_1} - \frac{r_1}{Y_1}\right]$$

Evaluating this expression at the margin at which no public goods are provided (such that the tax rate $t_1 = 0$) shows that $t'_1(0.5|0)$ is identically 0, such that $h'_1(0.5|0)$ is identically 0 and at the margin the post-tax break-point analysis coincides with the pre-tax break-point analysis (note that this will simplify the break analysis below).

- The function h_2 gives the relative return on human capital. Using the assumptions of section 6, the ratio of rewards to human capital r_1/r_2 is given in (14”). It is obvious that $h_2(0.5|Z) = 1$. Taking the derivative of the function h_2 and evaluating it at the symmetric equilibrium gives:

$$h'_2(\lambda|Z) = \frac{-(b_1-b_2)(b_1+b_2-2b_3Z)}{[b_1\lambda + b_2(1-\lambda) - b_3Z]^2}, \quad h'_2(0.5|Z) = \frac{-4(b_1-b_2)}{[b_1+b_2-2b_3Z]}$$

- The function h_3 gives the relative price index effect in the utility function:

$$h_3(\lambda|Z) \equiv \left(\frac{P_2}{P_1}\right)^{\delta} = \left(\frac{(1-\lambda)+\phi\,\lambda-(1+\phi)Z}{\lambda+\phi\,(1-\lambda)-(1+\phi)Z}\right)^{\delta/(1-\sigma)}$$

It is obvious that $h_3(0.5) = 1$. Taking the derivative of h_3 and evaluating it at the symmetric equilibrium gives:

$$h'_3(0.5|Z) = \frac{4\delta(1-\phi)}{(\sigma-1)(1+\phi)(1-2Z)}$$

- Combining the results above implies that the break condition is equation (18) in the text. If there are no public goods, that is if $Z = 0$ the solution for the free-ness of trade parameter, $\bar{\phi}$ say, that solves equation (18) is given by (see Forslid (1999), equation (13), or Forslid and Ottaviano (2001), equation (15)):

$$\phi_{break}\big|_{Z=0} \equiv \bar{\phi} = \frac{(\sigma-\delta)(\sigma-1-\delta)}{(\sigma+\delta)(\sigma+\delta-1)}$$

We can determine the impact of the introduction of public goods at the margin by differentiating condition (18) with respect to Z and evaluating the result at $Z=0$, $\lambda = 0.5$, and $\phi = \bar{\phi}$:

(A1) $$\left.\frac{\partial h'_2(0.5|0)}{\partial Z}\right|_{\phi=\bar{\phi}} + \left.\frac{\partial h'_3(0.5|0)}{\partial Z}\right|_{\phi=\bar{\phi}}$$

It can be shown that, as a function of ϕ, equation (18) always cuts the horizontal axis from below if $\delta < \sigma - 1$, which corresponds to the standard no-black-hole condition.[15] The break point will be reached for a smaller value of the free-ness of trade index ϕ if equation (A1) is positive, and for a larger value if equation (A1) is negative. This is illustrated in figure 6. Straightforward, but tedious, calculations show that equation (A1) is positive if, and only if condition (19) in the text holds.

[15] This condition is somewhat less restrictive than the no-black hole condition in Fujita, Krugman, and Venables (1999). See also the appendix of Ottaviano (2001).

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