Institut d'Economia de Barcelona

Document de treball de l'IEB 2010/31

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Fiscal Federalism

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ABSTRACT: This paper presents a model of local government policy competition in an New Economic Geography-setting. To maximize welfare, local governments can subsidize a mobile factor or provide public goods. In the local perspective, firms' vertical linkages promote colocation and policy (subsidy) setting is simultaneous, giving rise to mixed profiles. Agglomeration benefits lead larger regions to set higher subsidies, preventing a race to the top. We show the results numerically as well as in an analytical case. In contrast to related literature, policy harmonization can be welfare-improving, mainly due simultaneous policy-setting with a (local) utilitarian objective.

JEL Codes: R38, R50, R53, F12

Keywords: Spatial general equilibrium, local policy competition.

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1 Introduction

Wasteful tax competition is the main result of conventional analysis of strategic interaction among local governments. To compete for mobile factors, governments set their taxes suboptimally low and forego provision of public goods (see Wilson and Wildasin (2004) or Zodrow and Mieszkowski (1986) for "traditional" models). However, the result is not robust to the introduction of trade costs and imperfect competition in the analysis. In various new economic geography models that incorporate such features, tax competition for mobile factors leads to a tax "race to the top" between countries rather than to the bottom. Due to home market effects, the mobile factor is willing to accept a higher tax rate in the country that hosts a large market. As a result, governments that host an agglomeration possibly set higher taxes.

At the local level, the differences between the traditional and NEG-models are likely to be more pronounced. Typically, local governments face higher factor mobility and lower trade costs between them than national governments do. As a consequence, the policy that local governments set can have stronger repelling effects on economic activity, but at the same time, core-periphery outcomes are more likely. The potential of wasteful government behavior has led many authors to investigate spatial patterns consistent with wasteful policy competition. There is some evidence of spatial patterns in local governments' budget spending and taxing using spatial econometrics. However, the estimated intensity of competition varies by the type of tax or expenditure and by sample (Besley and Case, 1995; Brueckner and Saavedra, 2001; Bordignon et al., 2003; Solé Ollé, 2003; Allers and Elhorst, 2005). Popular motivations behind the empirical models are tax rate mimicking and yardstick competition, but rarely new economic geography models (Brueckner, 2003). Nevertheless, recent empirical evidence shows that agglomeration rents play a major role in tax setting. Firstly, there is direct evidence that economically larger regions more easily attract or retain firms given a tax rate (Koh and Riedel, 2010; Head et al., 1999; Devereux et al., 2007; Brülhart et al., 2007; Jofre-Monseny and Solé Ollé, 2007). Secondly, the size of a region positively affects the tax rate the local government sets (Jofre-Monseny and Solé Ollé, 2008; Charlot and Paty, 2007; Hill, 2008).

To study theory that is consistent with the evidence on agglomeration and local policy competition, this paper develops a new economic geography framework that focuses on local governments. In contrast to models inspired by international competition, we model local governments as welfare-maximizing subsidizers of footloose firms. Local governments are endowed with a centrally set budget and face a trade-off between attracting firms and providing public goods. This expenditure perspective yields spillovers of policies, which change the strategic nature of the policy competition. Moreover, we allow the local governments to set policy simultaneously, which is more in accordance with the intranational political organization of many countries. To our knowledge, this paper is one of the first to examine policy competition among local governments with centralized taxes (Paty, 2008).

1.1 Local policy competition: policy effects and strategic situation

The seminal article of Baldwin and Krugman (2004) examines international competition in tax rates using agglomeration rents. The crucial insight taken from the new economic geography models is that real factor rewards are higher in the core, and therefore the mobile factor can be taxed without fleeing the region. The government objective function assigns a positive weight to tax revenue, and the revenue is raised with a tax over the mobile factor's reward. Baldwin and Krugman use a Stackelberg equilibrium and argue that the core's government exploits the real reward difference between the regions to set a higher tax rate than the periphery's government does. The tax rate is so low, however, that it defers the peripheral government from effectively undercutting the core's tax rate and "stealing" the core. Baldwin and Krugman "conjecture that [their] results hold in a broad range of models" next to the footloose entrepreneur model they use. A number of modification have indeed confirmed the intuition. For instance, imcomplete agglomeration models (Borck and Pflüger, 2006), two-factor models (Kind et al., 2000), and models of welfare-maximizing instead of Leviathan governments (Ludema and Wooton, 2000) show that economically large regions exploit the benefits associated with colocation. The emerging literature of tax competition that incorporates the possibility of agglomeration is surveyed in chapter 15 and 16 of Baldwin et al. (2003).

The results of the model of Baldwin and Krugman differ once governments use tax revenue for expenditure, instead of consuming it. When taking into account the goals of levying taxes, taxation does not necessarily distort the mobile factors' decisions adversely. Brakman et al. (2002) argue that fiscal policy is relevant because there may be productive effects of government expenditure and investment. In particular, Brakman et al. show that increasing returns in public goods production or productivity-enhancing public investment may foster agglomeration, offsetting the repelling effects of taxes used to finance expenditure. Likewise, Commendatore et al. (2008) show that taxation decreases demand and thus promotes spreading of economic activity while productive public expenditure may concentrate it, making the outcome of government policy ambiguous on balance. Considering the effects of government spending is in line with the general equilibrium nature of new economic geography models. Abandoning the Leviathan motive in combination with modeling real effects of government expenditure yields new results in this paper. Given the high level of integration of local economies, the results of such expenditure are felt in neighboring regions. Such interdependencies also affect policy formation. This result is also much in line with the central message of new economic geography models - that regions are not independent economies.

Next to being economically dependent, regions may interact in policy-setting. In the model of Baldwin and Krugman, the larger region has a first-mover advantage in addition to the advantage stemming from its size. This allows the larger region to select a limit tax, and discourage the smaller region from setting a competitive tax [1] . When firms tend to agglomerate and the world is "lumpy", it is hard to specify simultaneous pure best response strategies. Often, when smaller regions compete for the agglomeration, the larger region's optimal response is to compete, in which case the smaller region's best response is not to compete. Therefore, the dynamic advantage of the large region simplifies the model considerably. While such an advantage may be justified by history or institutional advantages in international competition, it is less realistic in local policy competition. Local governments are often elected simultaneously and can change policy yearly. There are no differences in timing or legal status that ensure larger governments set policy earlier or with full commitment. Moreover, policy setting is a repeated process. If the policy game is repeated, the Stackelberg follower may adopt rational punishing strategies that affect the Stackelberg equilibrium (Cruz, 1975; Aoyagi, 1996).

To solve the competition game, we argue for an equilibrium in mixed strategies, because it relies less on simplifying assumptions. Firstly, the mixed strategy profile does not require priors on which government is the first mover. Also, the mixed strategy equilibrium is robust to repetition because it is a subgame-perfect solution to the game of simultaneous moves. The mixed profile solution consists of both governments specifying probabilities of playing every possible strategy. This solution concept allows governments strategy to depend on the current spatial distribution of firms, instead of timing. Compared to a limit pricing equilibrium, the peripheral government has some incentive to use its policy instruments. Effectively, it forces the larger region's government to increase firm variety, the benefits of which spill over to other regions.

This paper contrasts the seminal article of Krugman and Baldwin in a three ways. Firstly, we look at local rather than national government policy competition. To model a local government, we allow little discretion in tax setting, making expenditure decision the main government instrument instead. Government expenditure has explicit impacts in the economy, namely to subsidize firms or to provide public goods. Moreover, we introduce vertical linkages as another agglomeration mechanism between local economies. Because regions in one country are relatively integrated so large consumer price differences are not obvious, we model a need for intermediate goods in the production function. Even when consumer prices do not differ much throughout cities, a need for inputs assures firms care about their location. We assume inhabitants are relatively immobile, and firm mobility determines the generation of cores and peripheries. Secondly, we model the government as explicitly optimizing the utility of its inhabitants. Considering their inhabitant's

[1] Ludema and Wooton (2000) use a parallel requirement, namely that in a stable equilibirum, the core re-emerges as the core after the policies have been set.

welfare, governments are concerned with the impact of its policy, rather than consuming the tax revenues themselves. Thirdly, as we solve for the policy game, we investigate the mixed strategy equilibrium as a solution method. Mixed strategies can relax some restricitive assumptions about the dynamics of the game, in particular the first mover advantage and one-shot play.

The paper is set up as follows. First, in section 2, we lay out the model of the economy, and we treat government policy as given. This sketches how the economy responds to changes in government policy, and in terms of game theory, it shows how strategy pairs pay off. In section 3, we endogenize government policy, and investigate the solutions to the strategic situation that arises in this economy. Section 4 concludes.

2 The economy

The model is based on a "footloose entrepreneur" model, as synthesized in Forslid and Ottaviano (2003). We adopt a setup where firms require other firms' products as input for production. These ties through intermediate goods create an agglomeration force because it is useful for a firm to locate near its input suppliers, i.e. there are benefits of co-location. As we are most interested in the results on policy competition under agglomeration, we will solve the model for levels of trade cost that permit agglomeration. The vertical linkages provide an explanation for economic concentration that is alternative to the concentration of labor through migration. Using vertical linkages, the key to agglomeration becomes firm mobility rather than population mobility. Without population determining the size of regions, the model relates to most literature in the introduction, that assumes governments compete for firms or capital, rather than residences.

The specific new economic geography model we use is a footloose entrepreneur model with vertical linkages (FEVL). In this model, firms construct their fixed factor from inputs bought from other firms. This assumption is restrictive on the technology used in firms. However, as **?** decisively show, this assumption retains all qualitative results that emerge from a model where firms use intermediates in the variable stage of production (i.e. the core-periphery model with vertical linkages). Moreover, the conclusions regarding welfare analysis are very similar. Analytically, the FEVL is far more tractable because it uses the numéraire wage in the variable stage of production, which greatly simplifies the price indexes. This allows for explicit solution to nearly all of the model's equations.

We will very briefly lay out the structure of the economy, and proceed to detail in the following subsection. There are three types of actors in the economy: consumers/workers, firms, and a government. There are two sectors in the economy. The agricultural sector produces under constant returns to scale, employing only labor. The manufacturing sector acquires a fixed factor that is constructed from the output of other firms. This poses a fixed cost, ensuring increasing returns to scale in production. Workers can offer their labor in either sector, this equalizes wage rates between the sectors. Workers consume some of the manufacturing and agricultural good, and a public good. A government provides the public goods and subsidizes each firm in its region. The budget is raised through a centrally set tax rate. There are two regions, and workers are fixed at their location. The agricultural good is traded freely, which equalizes wages between agricultural sectors in both regions. With intersectoral mobility, manufacturing wages are also equalized. Therefore, we will pick the wage as numéraire, and set agricultural productivity to 1. The wage rate can only function as numeraire if no region completely specializes in manufacturing. We present the necessary restrictions on the parameters in appendix A. For convenience, we will denote one region as North (subscript N) and the other as South (subscript S), and world-level variables are superscripted w. Whenever an equation holds in both location, we will drop the subscript. To denote the distribution parameters, we choose λ, ν and η the denote the Northern share in world population (L), number of firms and expenditure, respectively.

2.1 Consumers

In this model, every location is home to a fixed number of individuals. The inhabitants of a region are spatially immobile, but sectorally mobile. Individuals derive utility from two items: the consumption of private goods and the consumption of government goods. We use a generic homogenous government good, that can be thought of as publicly provided services, ranging from playgrounds and green areas to police services and local infrastructure. The utility function consists of two tiers. The first tier is a Cobb-Douglas function with agricultural goods, aggregate manufacturing goods and the public goods as arguments.

$$U = C_a^{1-\mu} C_m^{\mu} C_g^{\gamma} \tag{1}$$

The second tier refers to the range goods over which the consumer has Dixit Stiglitz preferences, i.e. a CES utility function. It is usually referred to as the "manufacturing sector". Using a continuum of manufacturing firms over i, and elasticity $1 - {}^{1}\!/_{\sigma}$, the utility of an individual over the manufacturing goods is

$$C_m = \left(\int_0^n c\left(i\right)^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}} \tag{2}$$

Firm profits are equally distributed over the inhabitants of the region in which they operate. The budget is therefore the net wage plus the per capita firm profit, and it may be spent on the agricultural good or the manufacturing good. The public good does not enter the budget constraint, since it is not priced. In a later stage, we endogenize the consumption of C_g in the government's decisions. Using Y as the per capita disposable income, the budget constraint reads

$$\text{s.t.} p_a C_a + \int_0^n c(i)\, p(i)\, di = Y = (1-t)\, w + \frac{\Pi}{L} \tag{3}$$

The demand function for manufacturing varieties is the standard solution to the Dixit-Stiglitz setup:

$$c(i) = p(i)^{-\sigma}\, \mu Y P^{\sigma-1} \tag{4}$$

where P denotes the harmonized price index:

$$P \equiv \int_0^n p(i)^{1-\sigma}\, di^{\frac{1}{1-\sigma}} \tag{5}$$

Public good consumption does not change the standard demand function, because the utility function is unit elastic. The manufacturing demand function intuitively states that demand for a manufacturing good decreases in its own price, but increases in the budget and the price of other manufacturing goods. In the two region case with trade cost, the consumer price is higher than what the producer receives since trade cost are incurred on the product. Therefore, for similar producer prices ("factory door prices"), the quantity a consumer demands is lower, the more distant the producer. The demand function for the agricultural good is derived from the fact that share $1-\mu$ is spent on agricultural products: $C_a = (1-\mu)\, Y/P_a$. It is useful to note that there is an indirect representation of the utility function. Filling out the demand equations for $c(i)$ and C_a yields (an affine transformation of):

$$V = \frac{Y}{P^{\mu}} C_g^{\gamma} \tag{6}$$

This equation shows that the well-being of consumer is determined by two items. The first is the height of public goods provided. The second is the real income, i.e. disposable income divided by the aggregate goods price index. As noted, we will use wage as a numeraire, making the indirect utility a trade-off between the price index and public goods.

2.2 *Firms*

The technology of the manufacturing firms requires an up-front investment. This investment is done with a basket of final goods. For simplicity, and following convention, the technology by which the up-front investment is done is similar to the consumer Cobb-Douglas with nested CES-form with the same elasticity[2]. After the upfront investment, the firm starts producing using labor L. The inverse productivity of L is a_m, and the wage rate is w. Using this technology, the firm faces the following total cost function:

$$TC = a_m q\left(i\right) + FP^{\mu} \tag{7}$$

The differentiation of varieties and the fixed cost in production result in a monopolistically competitive market. When profits vanish in the long run, the positive operating profits exactly cover the fixed cost. The cost of the fixed factor depend on the transport cost of the inputs - the further the average input, the higher the average cost of the fixed factor.

Using firm level subsidies, pure profits Π can be written as revenues less fixed and variable cost, plus the subsidy. The demand the firm faces is the aggregate demand of two regions, one of which faces trade cost. The tradecost take an iceberg form, where τ goods need to be shipped for 1 to arrive. The demand for a variety in the North is:

$$q\left(i\right) = p\left(i\right)^{-\sigma} \mu \left[\frac{\eta}{P_N^{1-\sigma}} + \phi \frac{1-\eta}{P_S^{1-\sigma}}\right] E^w \tag{8}$$

where $\phi = \tau^{1-\sigma}$, the freeness of trade. E^w is the aggregated world income, where we assume fraction η is earned in North, and the complement in South. Optimizing firm profits with respect to the price, using this demand function gives the pricing rule

$$p\left(i\right) = \frac{\sigma}{\sigma - 1} w a_m \tag{9}$$

This is a standard result of markup pricing in the monopolistic competition model (Combes et al., 2008). Since the subsidy does not affect the marginal cost, it is not surprising that the markup is unchanged by the subsidies we have added. Following convention, we will normalize the markup to the inverse productivity, which simplifies the algebra. Using the pricing equation and the normalization, the manufacturing price indexes (5) raised to the power $1 - \sigma$ can be written as

$$P_N^{1-\sigma} = \left(\nu + \phi\left(1-\nu\right)\right) n^w, P_S^{1-\sigma} = \left(\phi\nu + 1 - \nu\right) n^w$$

where νn^w is the share of the world firms located in North multiplied by the world number of firms, yielding the number of firms in the North. With free entry in of

[2] The cost for the fixed factor is thus set by minimizing total cost which is similar to the consumer budget constraint, subject to a quantity minimum F, which is governed by technology similar to consumer preference. The problem is therefore dual to the consumer problem, i.e. the firm maximizes quantity subject to a cost constraint. Therefore, the price of the fixed factor equals the aggregate consumer price index.

manufacturing firms, profits are driven to zero. The pricing equation shows that the payments to the fixed factor must equal a fraction of the revenue times the markup minus one, i.e. $1/\sigma$. Using this result, firm profits can finally be written as the sum of positive operating profits, costs of producing the fixed factor and the government subsidy given to the firm:

$$\Pi = \frac{p(i)\,q(i)}{\sigma} - FP^{\mu} + S \tag{10}$$

The agricultural sector is characterized by homogeneity of the goods, absence of fixed cost and perfect competition. Using unit productivity and wage as numeraire, the price of agricultural goods equals 1.

2.3 Government

This paper's subject is the behavior of local governments. The model of the local government in this paper is inspired by Dutch municipalities. Dutch municipalities rely on a national municipality fund for the large majority of their budget. This central fund is raised by centralized taxation, preventing municipalities from setting local wage and capital tax rates. While the budget is virtually given for the local goverment, the allocation of the budget is not restricted, and there is great variation among municpalities within expenditure on different items.

In this paper, following this fiscal organization, the regional governments face a centrally set labor tax rate, but have discretion in their budget allocations. Specifically, the allocation choice is a tradeoff between providing a public consumption good and subsidizing the firms in the region. Firm subsidies can be used to expand the population of firms, and, crucially, affect the spatial allocation of economic activity.

We have chosen subsidies as the government instrument, rather than public investments of emmission allowances, for instance. The reason is that FEVL models are static. This complicates the role of other obvious government instruments, like investment in public capital or productivity of firms, because capital stocks accumulate and depreciate over time. Additionally, in the strategic game, this would give rise to complex strategies. The subsidy could be interpreted as public capital investment, but possibly additional assumptions are needed regarding the steady-state or depreciation.

The government is benevolent, and maximizes the sum of utility of its inhabitants. Since the number of inhabitants is fixed, this corresponds to maximizing average utility. This yields a richer set of results, because government expenditure has real effects in the economy. The maximization problem for the government is

$$\max_{s} \sum U \qquad \text{s.t.} C_g + n * S \leq G = twL \tag{11}$$

where G is the government budget, and $n * S$ reflects total subsidy handed out, as a product of the firm subsidy and the number of firms. When profits are driven to zero ((10) equal to zero), the equilibrium firm size q is smaller when the subsidy is higher. Intuitively, the operating profits and so the firm size needed to cover the fixed cost is lowered by the level of subsidy. The subsidy hence decreases the size of existing firms, and expands the variety of firms. Due to the consumer's love of variety, this increases welfare by reducing the manufacturing price index. On the other hand, provision of public goods directly increases utility. In a closed economy, the government's task would be to balance manufacturing variety with public good provision. In that case, a socially optimal subsidiy would rarely be zero, since the subsidy targets a market failure in monopolistic competition. In an open economy, the local effect of subsidy on firm variety is affected by subsidies in surrouding jurisdictions. Because marginal production is not affected by the subsidy, the benefit of a subsidy effectively accrues to the fixed factor. In this model, the firms are defined by the upfront investment in the fixed factor, so subsidies can be argued to attract footloose firms. Finally, to simplify notation, we rewrite the government spending decision in a fraction of its budget. The governments spend share s of its budget (twL) on subsidizing, so the per-firm subsidy S becomes

$$S_N \equiv s_N \frac{t\lambda}{\nu} \frac{L^w}{n^w}, S_S \equiv s_S \frac{t(1-\lambda)}{(1-\nu)} \frac{L^w}{n^w} \tag{12}$$

where λ denotes the share of world population in the North. We will use the budget share s rather than the absolute level of subsidy in the strategic analysis, but since they are directly related, the analysis is the same.

2.4 *Equilibrium of producers and consumers*

Government behavior is the key interest of this paper. To study the strategic interaction between governments, we first define the spatial equilibrium outcomes as a function of government policies, treating the policies as given. Once we know the result of different policies, it is possible to investigate the strategies that governments use to steer outcomes. In equilibrium, the firm distribution is such that profits are non-positive in both locations. Since profits are a function of expenditure shares and firm distribution, we proceed by expressing expenditure shares (η) in terms of firm distribution (ν) and solving for profits. This follows the same reasoning as the standard FEVL model (Baldwin et al., 2003, section 8.4).

By simple accounting, the expenditure originating in one region is the sum of expenditure from inhabitants and local firms buying intermediate inputs. By the zero profit condition, the expenditure on intermediates is equal to the operating profits plus the firm subsidy:

$$E = (1-t)\,L + n\left(\frac{pq}{\sigma} + S\right) \tag{13}$$

The world expenditure is obtained by adding the expenditure of the two regions:

$$E^w = (1-t)\,L^w + \frac{n^w p}{\sigma}\left(\nu q_N + (1-\nu)\,q_S\right) + n^w\left(\nu S_N + (1-\nu)\,S_S\right) \tag{14}$$

Filling out the demand function for both regions (8) and the expression for subsidies (12), the world expenditure simplifies to:

$$E^w = \frac{1 - t\,(1 - \lambda s_N - (1-\lambda)\,s_S)}{1 - \frac{\mu}{\sigma}} L^w \tag{15}$$

where $\lambda s_N + (1-\lambda)\,s_S$ can be thought of as the size-weighted average subsidy share in the world government budget. By dividing Northern expenditure over world expenditure, the share of Northern expenditure can be written as:

$$\begin{aligned} \eta &= \left(1 - \tfrac{\mu}{\sigma}\right)\delta + \tfrac{\mu}{\sigma}\left[\tfrac{\eta}{P_N^{1-\sigma}} + \tfrac{\phi(1-\eta)}{P_S^{1-\sigma}}\right]\nu \\ \delta &\equiv \tfrac{(1-t(1-s_N))}{1-t(1-\lambda s_N-(1-\lambda)s_S)}\lambda \end{aligned} \tag{16}$$

where δ reflects the policy-adjusted share of expenditure stemming from the population in North. The second term in 16 reflects that operating profits are used to buy inputs for the fixed factor. Solving for η gives the market size equilibrium as a relation between North's share of expenditure and North's share of firms.

$$\begin{aligned} \eta = \delta &+ \tfrac{\frac{\mu}{\sigma}\phi}{(\nu+\phi(1-\nu))(\phi\nu+1-\nu)-\frac{\mu}{\sigma}(1-\phi^2)\nu(1-\nu)} \\ &\times\left[(1-2\delta)\,(1-\phi)\,\nu\,(1-\nu) + \nu - \delta\right] \end{aligned} \tag{17}$$

In equilibrium, the share of expenditure stemming from North comprises a consumer budget and firm subsidy share (the first term) and firm level expenditure, increasing in the share of firms in North (the product on the right hand side of equation 17). Equation (17) differs from the standard result in FEVL model (equation (28) in Ottaviano & Robert-Nicoud). However, if we assume symmetry both in regional size and policy, the market size equilibrium condition reduces to the exact same equation. In that sense, the standard market size condition is a special case of this market size condition allowing for policy.

Finally, the market size equilibrium condition (17) can be inserted into the profit equation (10). This yields profits as an explicit function of the distribution of firms,

ν. Some straightforward but tedious algebra gives

$$\begin{aligned}
&\Pi_N = \tfrac{\mu}{\sigma}\tfrac{E^w}{n^w}\times \\
&\left[1 - \tfrac{(1-\nu)(\nu-A)}{(1-\nu)\nu+\frac{1-\Psi^2}{4\Psi\left(\Psi-\frac{\mu}{\sigma}\right)}}\tfrac{\left((1-\phi)^2(1-\nu)\nu+\phi\right)\Psi\left(\Psi-\frac{\mu}{\sigma}\right)+\phi\frac{\mu}{\sigma}\Psi\left(1-\frac{\nu+Z}{\nu-A}\right)}{\left((1-\phi)^2(1-\nu)\nu+\phi\right)\Psi\left(\Psi-\frac{\mu}{\sigma}\right)}\right] \\
&-F\left[n^w\left(\nu+\phi\left(1-\nu\right)\right)\right]^{\frac{\mu}{1-\sigma}} + \tfrac{s_N t\lambda L^w}{\nu n^w} \\
&\\
&\Pi_S = \tfrac{\mu}{\sigma}\tfrac{E^w}{n^w}\times \\
&\left[1 + \tfrac{\nu(\nu-A)}{(1-\nu)\nu+\frac{1-\Psi^2}{4\Psi\left(\Psi-\frac{\mu}{\sigma}\right)}}\tfrac{\left((1-\phi)^2(1-\nu)\nu+\phi\right)\Psi\left(\Psi-\frac{\mu}{\sigma}\right)+\phi\frac{\mu}{\sigma}\Psi\left(1-\frac{\nu+Z}{\nu-A}\right)}{\left((1-\phi)^2(1-\nu)\nu+\phi\right)\Psi\left(\Psi-\frac{\mu}{\sigma}\right)}\right] \\
&-F\left[n^w\left(\phi\nu+\left(1-\nu\right)\right)\right]^{\frac{\mu}{1-\sigma}} + \tfrac{s_S t(1-\lambda) L^w}{(1-\nu)n^w}
\end{aligned} \tag{18}$$

where we have used the definitions (much following convention)

$$\begin{aligned}
&Z \equiv \left(1-2\delta\right)\left(1-\phi\right)\nu\left(1-\nu\right)-\delta \\
&A \equiv \tfrac{2\delta-\phi}{1-\phi}-\delta \\
&\Psi \equiv \tfrac{1-\phi}{1+\phi}
\end{aligned} \tag{19}$$

Again, the operating profits (the first term on the right hand side in either profit equation) are a general form of the standard model [3]. The profits consist of three factors. The first is the operating profit, which is a share of world expenditure. It depends non-linearly on the spatial distribution of firms and on regional integration, but the terms simplify significantly in a core-periphery structure (when ν is 0 or 1). This is the first agglomeration force, because firm location in one region increases the demand exerted from that region. The second factor is the the cost of the fixed factor, which is decreasing with the number of firms in the own region. This is a second agglomeration force in the model, because next to to demand faced, firms reduce cost by locating near their inputs. Finally, profit is directly affected by the government budget share spent on subsidies.

The equilibrium is a combination of ν and n^w, such that $\Pi_N \leq 0$ and $\Pi_N \leq 0$. Using these two non-profit conditions, we can investigate what effect different subsidy pairs have on the spatial distribution of the economy.

[3] The equivalent expression for Northern profits in **?** is

$$\Pi = \frac{\mu}{\sigma}\frac{E^w}{n^w}\left[1-\frac{\left(1-\nu\right)\left(\nu-\frac{1}{2}\right)}{\left(1-\nu\right)\nu+\frac{1-\Psi^2}{4\Psi\left(\Psi-\frac{\mu}{\sigma}\right)}}\right]-\left[n^w\left(\nu+\phi\left(1-\nu\right)\right)\right]^{\frac{\mu}{\sigma-1}}$$

Using symmetry in policy and share of laborers, as in Ottaviano and Nicoud, the expressions operating profits in this paper reduces to the standard model because $\delta = 0.5$ and hence $Z = -A$. If $S_N = S_S = 0$, the total profit equations are identical.

3 Strategic policy

So far, we have only set the stage for local government and treated the level of subsidies as given. To explore the model's outcomes, we now allow government to manipulate its budget allocation to subsidies, i.e. s_N and s_S become endogenous. Compared to traditional models, the strategic situation is different because the spatial equilibria are "lumpy" - firms may locate in a core-periphery outcome. This leads government to compete over the selection of a specific spatial equilibrium. In the following, we will assume the Northern government to host the agglomeration initially (i.e. it is the core). Since the regions can be made symmetric, parallel results would hold for South (intially the periphery), by simply switching their names. We will first discuss the effect of different subsidy pairs, and then turn to a solution concept.

3.1 Policy options: destabilizing subsidies

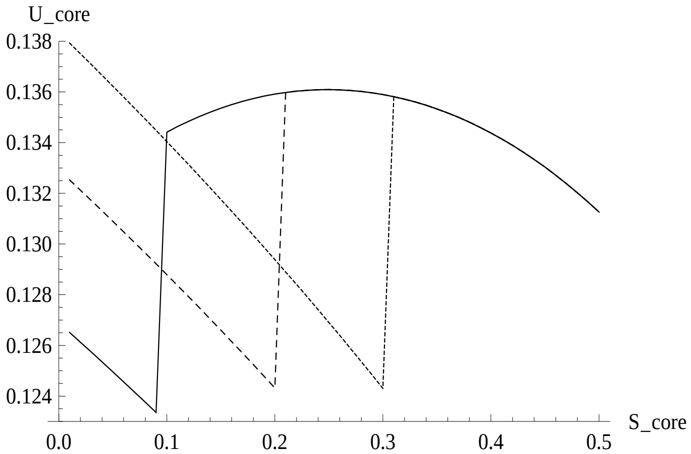
For an equilibrium spatial distribution of firms to be stable in the North, it must hold that $\nu = 1$, $\Pi = 0$ and $\Pi^* < 0$. More intuitively, this implies no entry or exit in North due to zero Northern profits, and negative potential profits of setting up a firm in South. If South wishes to destabilize the agglomeration in the North in favor of one in the South, South must choose a policy such that $\Pi = 0$ and $\Pi^* \geq 0$. This is the point where new firms will set up in the South, following (policy-induced) profit opportunities. Once the Southern government succeeds in attracting one firm, it attracts all. The reason is that relocation of the first firm increases profit opportunities in the South, and decreases them in the North. The profit equation (18) shows that demand in the South becomes higher, and the cost of inputs fall. This first implies that the subsidy that destabilizes the agglomeration in North in favor of one in South is the subsidy that convinces the first firm to move. This is the breakpoint subsidy. The second implication is that the subsidy is given to all firms that move. Technically, this avoids division by zero in equation (12), i.e. it becomes $\frac{s_N t(1-\lambda)L^w}{n^w}$.

Using the core-periphery outcome, we can proceed to find the break policy as the peripheral policy that convinces the first firm to set up in the periphery. The stable agglomeration of all firms in the North implies zero profits in the North, which, in turn, implies a world number of firms. Given $\nu = 1$, the requirement $\Pi_N = 0$ implies that

$$n^w = \left(\frac{\mu}{\sigma-\mu}\left(1 - t\left(1 - \frac{\sigma}{\mu}\lambda s_N - (1-\lambda)\, s_S\right)\right)\right)^{\frac{1-\sigma}{1-\sigma+\mu}} \tag{20}$$

The solution to the breakpoint subsidy for South is the smallest s_S that makes Southern profits non-negative , given the solution to n^w. In other words, in equation (18), $\Pi_S \geq 0$. Unfortunately, there is no general closed form solution to the break-point subsidy, because the expenditure share η is related non-linearly to the distribution of firms. However, since we know the home market effects in expenditure and the vertical cost linkages cause positive externalities, the subsidy share in South always needs to compensate these two effects in addition to Northern subsidies. Hence, the destabilizing subsidy for South is always higher than the Northern subsidy.

Figure 1. Utility for different policies in the agglomeration (North)

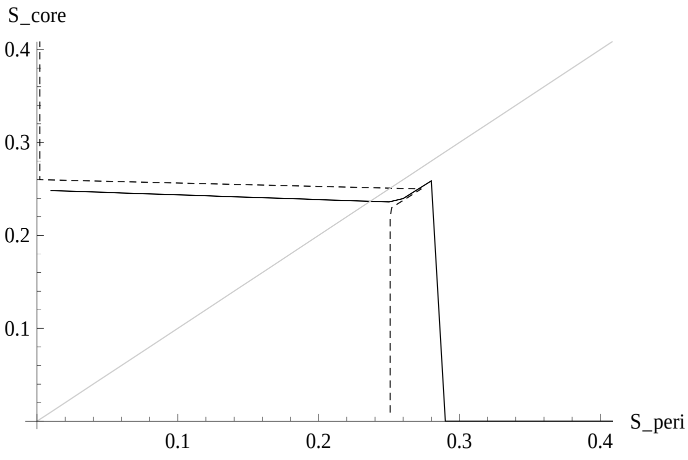


$L^w = 1$,$\mu = 0.5$, $\sigma = 5$, $t = 0.3$, $\lambda = 0.5$, $F = 1$, $a_m = 1$, $\phi = 0.7$, $\gamma = 0.3$. Lines: utility if s_S is 0.1 (solid), 0.2 (dash), 0.3 (dotted)

Given the policy pairs that shift the equilibrium, we can examine the effects of different policies on welfare. Conditional on the other government's policy, we can calculate utility levels when a region is the core (its policy is higher than the break policy) and when a region is the periphery (its policy is lower than the break policy). As an example in figure 1, the North hosts the agglomeration (i.e. it is the core), and the North's objective function value for different subsidies are plotted. If the Northern subsidy is below its breakpoint value, the value of the objective function is defined as utility given that the North is not the core. When the Southern government spends 10% of budget on subsidies ($s_S = 0.1$, the solid line), the North becomes a periphery if it sets a subsidy share s_N below 0.097. To the left of the critical value, objective function is decreasing in s_N, because subsidies reduce public good consumption, but no firm benefits from the subsidies. To the right of the critical subsidy, the utility function is inverse-U shaped in the subsidy shares in the budget. This reflects that at low rates of subsidy, an increase in variety of firms increases the inhabitants' utility, but at higher rates of subsidies the opportunity cost (public good provision) dominate such benefits. The optimal subsidy from the perspective of Northern workers is thus at the top of the inverse U-shaped curve. Note that this is not true for Southern workers, generally. Since they benefit from firm variety but do not suffer opportunity cost of the subsidy, they would prefer a higher Northern subsidy share. Therefore, I will define this subsidy share the local optimal subsidy s_{lo}- it is the subsidy that a welfare maximizing core government would set in absence of the possibility of losing the agglomeration.

If the Southern government's subsidy is low, the Northern government chooses a subsidy for hosting the agglomeration: it will choose the subsidy that corresponds to the maximal utility on the right hand segment of the utility curve, local optimal subsidy. However, the payoffs change when the subsidy share of South increases. First, to maintain the agglomeration, the North needs to set a higher subsidy, which is higher than the North's social optimum if South sets a competitive subsidy. Second, the payoff from setting a zero subsidy increases, because the Southern government subsidizes variety when it gets the core. The optimal response to the subsidy of South is either to pick a zero subsidy, or to set a competing subsidy and retain the agglomeration, depending on which payoff is higher. Calculating the optimal responses to every opponent strategy generates a reaction function. Figure 2 plots a numerical solution of optimal responses. At low values of the opponent subsidy, both governments maximize welfare by setting set a subsidy in concordance with their local social optimum, which induces an agglomeration in their region. Vice versa, at high levels of opponent subsidy, both government return to using their full budget for public goods. In the intermediate range, the reaction curves lie on either side of the curve of breakpoints. The intuition is that the cost of providing fewer public goods are lower than the gains of hosting the core. The optimal response is to minimally "outsubsidize" the opponent: for the North to set a subsidy that just retains the agglomeration and for the South to set a subsidy that just convinces firms to move. This intermediate segment is ended by the opportunity cost in public goods of the South. Since it requires a higher subsidy to attract the agglomeration than to retain it, the South will refrain from outbidding competitive subsidies at lower subsidy levels than the North does.

Figure 2. Reaction curves



$L^w = 1$,$\mu = 0.5$, $\sigma = 5$, $t = 0.3$, $\lambda = 0.5$, $\phi = 0.7$. Lines: optimal response for Core (solid, North in text) and Periphery (dash, South in text). s_core and s_peri are the budget shares devoted to subsidies by the core (North) and periphery (South) governments, respectively.

Figure 2 shows no pure strategy Nash equilibrium [4]. If a government plays a local optimal subsidy, the opponent has incentive to set a competing subsidy. At the intermediate segment of subsidies, governments want to set a subsidy that is marginally higher than the break policy, because that is necessary to host the agglomeration. At the higher end of the intermediate segment, the North can set a subsidy that deters the South from competing for the core. However, at that point the optimal response of South is to set zero subsidies, to which the deterring subsidy in the North is not an optimal response. The game has no coincidence of best responses, so it needs another solution than simultaneous pure strategies.

The limit-price solution of this game, following Baldwin and Krugman (2004), also holds in this model. In this version of the game, the North selects a subsidy first, then South selects a subsidy, and finally the spatial distribution of firms materializes, yielding the payoffs. With positive agglomeration externalities, the subgame perfect solution is that the North sets a subsidy that deters the South from competing for the agglomeration. Effectively, the North acts as a limit pricer. Given that the indirect utility is proportional to $V = n^{w\frac{\mu}{\sigma-1}} (\nu + \phi(1-\nu))^{\frac{\mu}{\sigma-1}} (1-s)^{\gamma}$, the South has no incentive to set competing subsidies if the welfare cost of competing are sufficiently high:

$$n_N^{\frac{\mu}{\sigma-1}} \phi^{\frac{\mu}{\sigma-1}} \geq n_S^{\frac{\mu}{\sigma-1}} (1-s_s)^{\gamma}$$

where n_N is the world number of firms if the agglomeration is in the North and n_S is the world number of firms under and agglomeration in the South given its subsidy. Rewriting the condition gives

$$\left(\frac{n_N}{n_S}\right)^{\frac{\mu}{\sigma-1}} \tau^{-\mu} \geq (1-s_s)^{\gamma}$$

Since the number of firms n_N rises faster in s_N than in s_S (see eq. (20)), a higher subsidy in the North makes it more likely for this condition to be met. If trade cost rise, so does minimal Northern subsidy to deter the South from competing. Thus, the two major conclusion from Baldwin and Krugman re-emerge: first, the core (North) sets a positive subsidy, to which the agglomeration (South) responds with a zero subsidy. Second, as trade integration increases, the limit subsidy falls, reducing the subsidy gap.

3.2 Mixed policy responses

To discuss the mixed profile strategies, we select relevant strategies and solve for the simplified case. This is no exact solution to the mixed game over all strategies

[4] The curves do not intersect because the visual intersection is numerical, it reflects the "jump" from break policy to zero policy for the periphery.

Table 1
Payoff matrix for selected strategies

		South	
		Zero	Competitive
North	LO	$\underline{n_{lo}^{\frac{\mu}{\sigma-1}}\left(1-s_{lo}\right)^{\gamma}}, \tau^{-\mu} n_{lo}^{\frac{\mu}{\sigma-1}}$	$\tau^{-\mu} n_{c}^{\frac{\mu}{\sigma-1}}\left(1-s_{lo}\right)^{\gamma}, \underline{n_{c}^{\frac{\mu}{\sigma-1}}\left(1-s_{c}\right)^{\gamma}}$
	Competitive	$n_{c}^{\frac{\mu}{\sigma-1}}\left(1-s_{c}\right)^{\gamma}, \underline{\tau^{-\mu} n_{c}^{\frac{\mu}{\sigma-1}}}$	$\underline{n_{c}^{\frac{\mu}{\sigma-1}}\left(1-s_{c}\right)^{\gamma}}, \tau^{-\mu} n_{c}^{\frac{\mu}{\sigma-1}}\left(1-s_{c}\right)^{\gamma}$

in the support, but it it shows qualitatively which strategies are played relatively often and it increases understanding. Table 1 present two relevant strategies for both governments, namely a competing and a non-competing. We assume that the competitive subsidy is in the intermediate range, i.e. where it is rational for both governments to just outbid the other government. Since the competitive subsidy is the same, the North retains the agglomeration if both governments play the competitive subsidy. The alternative for North is the local optimal (lo) solution, which it would play if the agglomeration could not move. For South, the alternative strategy is to spend all of its budget on public goods, which is a best response if the agglomeration cannot move. The payoff can be written as $(1-s)^{\gamma}\left(n^{w}\right)^{\frac{\mu}{\sigma-1}}$ for the government that hosts the agglomeration, and $(1-s)^{\gamma}\left(\phi n^{w}\right)^{\frac{\mu}{\sigma-1}}$ for the peripheral government. In the payoff matrix of table 1, best responses have been underlined. As argued above, there is no pure strategy Nash equilibrium because South wishes to compete if North does not, and does not compete if North sets a competitive subsidy. Vice versa, North's optimal response to a competitive subsidy is a competitive subsidy, and its best response to a zero subsidy is the local optimal subsidy. In the mixed profile, strategies are chosen such that the opponent's payoff for all is his strategies is equalized. Using this requirement, the odds of North and South playing a competitive strategy are given by

$$
\begin{aligned}
P\left(s_{N}=s_{c}\right)=p&=\frac{1-\frac{\phi}{\left(1-s_{c}\right)^{\gamma}}\left(\frac{n_{l}}{n_{c}}\right)^{\frac{\mu}{\sigma-1}}}{1-\frac{\phi}{\left(1-s_{c}\right)^{\gamma}}\left(\frac{n_{l}}{n_{c}}\right)^{\frac{\mu}{\sigma-1}}+\phi\left(1-s_{c}\right)^{-\gamma}-\phi} \\
P\left(s_{S}=s_{c}\right)=q&=\frac{1-\left(\frac{1-s_{c}}{1-s_{l}}\right)^{\gamma}\left(\frac{n_{c}}{n_{l}}\right)^{\frac{\mu}{\sigma-1}}}{1-\phi\left(\frac{1-s_{c}}{1-s_{l}}\right)^{\gamma}\left(\frac{n_{c}}{n_{l}}\right)^{\frac{\mu}{\sigma-1}}}
\end{aligned}
\tag{21}
$$

Given the best responses in table 1, both governments have a positive probability of playing a competitive strategy. Since $\left(1-s_{c}\right)^{-\gamma}>1$ and $\left(\frac{1-s_{c}}{1-s_{l}}\right)^{\gamma}\left(\frac{n_{c}}{n_{l}}\right)^{\frac{\mu}{\sigma-1}}<1$, this positive probability of playing a competitive strategy shows in the explicit solution (21). While the North's subsidies are higher on average, due to agglomeration externalities, this formulation allows us to consider how often each local government deviates from the local optimal subsidy. It depends on the parameters whether the North plays a competitive strategy more often than the South. In particular, the

North select s_c more often than South ($p > q$) if [5]

$$\phi^{\frac{\mu}{\sigma-1}} < \frac{1 + \left(\frac{n_c}{n_l}\right)^{\frac{\mu}{\sigma-1}}}{1 - (1-s_c)^{\gamma}\left(\frac{n_c}{n_l}\right)^{\frac{\mu}{\sigma-1}} + \left(\frac{1-s_c}{1-s_{lo}}\right)^{\gamma} + (1-s_{lo})^{\gamma}} \tag{22}$$

Requirement (22) shows that the North is more likely to play a competitive subsidy than South when the trade integration is low, because the value of hosting the agglomeration is larger. Likewise, the likelihood of North selecting competitive strategies more often than South unambiguously increases in the ratio of the number of firms under a competitive subsidy compared to a local optimal subsidy (n_c/n_{lo}), see eq. (20). Given that $s_c < s_{lo}$ the government budget (t) unambiguously increases n_c/n_{lo}, so higher central taxation and bugets lead the North to compete more often. The intuition is that with decreasing returns to public good consumption, a larger government budget decreases the price of setting a competitive subsidy for both governments. Finally, the North is more likely to set most competive subsidies if s_{lo} is higher, and s_c is lower, which reflects that the competitive subsidy is closer to the local optimal subsidy (since $s_{lo} < s_c$) and costs of competing are relatively low.

While the mixed game with selected strategies is more insightful, assessing the game with all non-dominated strategies is more complete. Since we have no analytical expression for the payoffs following different policy-pairs, we approximate the strategy profiles numerically. We make the strategy space discrete by dividing the policy in segments. This is needed for the numerical solution, but it also guarantees the existence of a mixed strategy equilibrium (Fudenberg and Tirole, 1991, 12.2), which is not certain in the continuous case (Dasgupta and Maskin, 1986). To approach the mixed strategy profile, we use the Lemke-Howson algorithm, as programmed in Gambit software.

Figure 3 plots the mixed equilibrium probability distribution of playing any possible policy. The graph is consistent with the two-strategy result: the Northern government has a higher probability of playing relatively high subsidies, while the South will choose lower subsidies more often (as shown in the probability-weighted average strategy). In accordance with the interpretation of mixed strategies offered by Harsanyi (1973), the South then sometimes plays competitive strategies because it has imperfect imformation - about North's government objectives or about the economy. Likewise, the North plays subsidies that are higher than the local optimum because it is unsure what strategy South plays. North chooses its strategy

[5] North playing more competitive strategies ($p > q$) can be written as $\frac{1-\phi\kappa_1}{1-\phi\kappa_2} > \frac{1-\phi\kappa_3}{1-\phi\kappa_4}$, with $\kappa_1 = (1-s_c)^{-\gamma}\left(\frac{n_l}{n_c}\right)^{\frac{\mu}{\sigma-1}}$, $\kappa_2 = (1-s_c)^{-\gamma}\left(\frac{n_l}{n_c}\right)^{\frac{\mu}{\sigma-1}} + (1-s_c)^{-\gamma} + 1$, $\kappa_3 = \phi^{-1}\left(\frac{1-s_c}{1-s_l}\right)^{\gamma}\left(\frac{n_c}{n_l}\right)^{\frac{\mu}{\sigma-1}}$ and $\kappa_4 = \left(\frac{1-s_c}{1-s_l}\right)^{\gamma}\left(\frac{n_c}{n_l}\right)^{\frac{\mu}{\sigma-1}}$. This is true if $\kappa_3 > \frac{\kappa_1-\kappa_2}{1-\kappa_2}$ and $\kappa_4 < \frac{\kappa_2\kappa_3+\kappa_2+\kappa_3-\kappa_1}{1-\kappa_1}$, which simultaneously hold in (22).

profile such that it equates the payoffs for all pure strategies in South. That means if it pays off attempting to steal the agglomeration pays off for the South, the North will play a competitive strategy more often, to reduce South's expected payoff of competing. The rate at which governments set high, competitive subsidies thus reflects their belief of how competitive the opponent is. The asymmetry in setting competitive subsidies is fully attributed to the current number of firms in a government's region, which determines the payoff structure to competitive subsidies. This is in contrast to sequential, limit-pricing solution, where the asymmetry is generated by the first mover advantage.

3.3 Harmonization

An obvious question that rises with the policy competition as we have sketched is what institutional settings improve the welfare of all inhabitants. Subsidy harmonization is possibly a Pareto improvement in this model. To demonstrate this result, we look for a harmonized policy $\bar{s}$, for which either region's welfare exceeds the expected welfare from playing the policy game in previous section. For the North (core) region, it is easy to show that such a policy exists. Under the mixed strategy equilibrium, payoff to all strategies are equal, so the expected payoff of participating in the policy game is $n_c^{\frac{\mu}{\sigma-1}}(1-s_c)^\gamma$, the payoff of the competitive strategy. Since the strategic considerations push the competitive subsidy higher the local optimal subsidy (s_{lo}), a harmonized subsidy $\bar{s}$ between s_c and s_{lo} (and slightly lower) improves the North's welfare.

For the South, a harmonized subsidy is welfare-improving if $\bar{n}^{\frac{\mu}{\sigma-1}}(1-\bar{s})^\gamma > pn_{lo}^{\frac{\mu}{\sigma-1}} + (1-p)\, n_c^{\frac{\mu}{\sigma-1}}$ (the expected payoff of not subsidizing), where $\bar{n}$ is the number of firms resulting from policy $\bar{s}$. This requires

$$p < \frac{1-(1-\bar{s})^\gamma \left(\frac{\bar{n}}{n_c}\right)^{\frac{\mu}{\sigma-1}}}{1-\left(\frac{n_{lo}}{n_c}\right)^{\frac{\mu}{\sigma-1}}}$$

So that the harmonized subsidy improves South's welfare if North is not competitive. The reason is that if North subsidizes relatively little, a higher harmonized rate increases firm variety in the economy. North's probability of playing a competitive subsidy, p, can be written as

$$p = \frac{1-(1-s_c)^\gamma}{1-\left(\frac{n_{lo}}{n_c}\right)^{\frac{\mu}{\sigma-1}} + (\tau^\mu - 1)(1-s_c)^\gamma}$$

Filling out this level of p in the previous requirement, and rewriting gives

$$\frac{1-(1-\bar{s})^{\gamma}\left(\frac{\bar{n}}{n_c}\right)^{\frac{\mu}{\sigma-1}}}{1-(1-s_c)^{\gamma}} > \frac{1-\left(\frac{n_l}{n_c}\right)^{\frac{\mu}{\sigma-1}}}{1-\left(\frac{n_l}{n_c}\right)^{\frac{\mu}{\sigma-1}}+(\tau^{\mu}-1)(1-s_c)^{\gamma}}$$

The right hand side of this inequality is always a positive amount smaller than 1 (since $\tau > 1$ and $n_l < n_c$). From North's welfare problem, $(1-\bar{s})^{\gamma}\,\bar{n}^{\frac{\mu}{\sigma-1}} > (1-s_c)^{\gamma}\,n_c^{\frac{\mu}{\sigma-1}}$, so that the left hand side of the inequality is 1 if $\bar{s} = s_c$, and lower than 1 if $\bar{s} < s_c$. Thus, a harmonization of the subsidy rates is welfare-increasing for South if the harmonized subsidy is sufficiently close to competitive subsidy.

As a final note, subsidy harmonization would never be Pareto-improving in the case of a limit subsidy in this model. This contrasts the results of Baldwin and Krugman (2004) regarding the limit tax. The intuition is simple: if firm subsidies have a spillover effect through firm variety expansion and local public goods do not, the peripheral region is always worse off if the core region devotes less budget to firm subsidies. The result that harmonization can be Pareto-improving is recovered, however, when recognizing that the core responds to a periphery government's policy options. It is possible that harmonization increases welfare in both regions if the periphery's threat of competition is low, and hence the core's incentive to set subsidies larger than its local optimum is low. A harmonized subsidy increases firm variety, but avoids oversubsidizing to the competitive level (in comparison to the core's optimal subsidy if the agglomeration was immobile).

4 Conclusions

This paper puts forward a model of local governments that compete to host firms. The governments use part of their budget to subsidize firm location in their region, but the subsidy has an opportunity cost in providing a public good. In the presence of increasing returns to scale, trade cost, and vertical linkages between the firms, an agglomeration of firms may occur, which is generally desirable to host.

Due to the agglomeration effects, the model does not yield the classic results of wasteful policy competition (the "race to the bottom"). This in line with much of the literature on agglomeration and policy competition. When there is an agglomeration rent in the mobile factor's rewards, the core government needs to subsidize its firms less than the neighboring periphery in order to sustain the agglomeration. This model therefore predicts core governments set higher subsidies than the periphery, preserving the agglomeration and deterring the periphery from competing.

Compared to other literature on agglomeration and policy competition, this paper explicitly models a local government policy setting. Government expenditure effects are felt in nearby regions, and policy-setting is simultaneous. The core's best response is to meet a competitive subsidy with a competitive subsidy and a low subsidy with a low subsidy. The periphery wishes to set a competitive subsidy when the core does not, and a low subsidy when the core sets a high subsidy. Under simultaneous responses, governments hence respond to the probability that the opponent plays a competitive strategy. Because local subsidies affect the variety of consumption goods in other locations, a peripheral government benefits from high subsidies in the core. To promote firm subsidies in the core, the peripheral government exploits its threat of stealing the agglomeration, to force the core to behave competitively and set higher subsidies.

As the subsidy is also an instrument to correct the market failure of imperfect competition, the core government that hosts all firms always sets a positive subsidy. This leads the core government's subsidy to exceed the periphery's on average. However, the probability with which the core government selects a competitive subsidy over a non-competitive subsidiy does not need to exceed the periphery's probability of playing competitive subsidies. In particular, the core exhibits more competitive behavior when the budgets are high, trade cost are high and if the competitive subsidy is close to optimal subsidy from a closed economy point of view. Overall, the intensity of competition increases in trade cost and government budget, and decreases in preference for the public good.

In contrast to the seminal article on agglomeration and policy competition (Baldwin and Krugman, 2004), harmonization of policy can be a Pareto-improvement. A subsidy range exists for which a harmonized subsidy gives a higher number of firms than the number of firms expected when the periphery plays a non-competitive subsidy. For the periphery, this increase in number of firms outweighs the loss of public good provision. For the core, compared to the competitive subsidy, the harmonized subsidy is closer to the optimal subsidy if the core could not move (which indeed it does not, if subsidies are equal). Harmonization can be welfare-improving because we relax two assumptions of related literature: the Leviathan assumption (i.e. there is government expenditure) and the first mover advantage for the large region. As argued in the introduction, simultaneous moves are more general than the Stackelberg structure. The core's advantage is not in timing but in the share of firms, moreover, the solution is robust to repetition.

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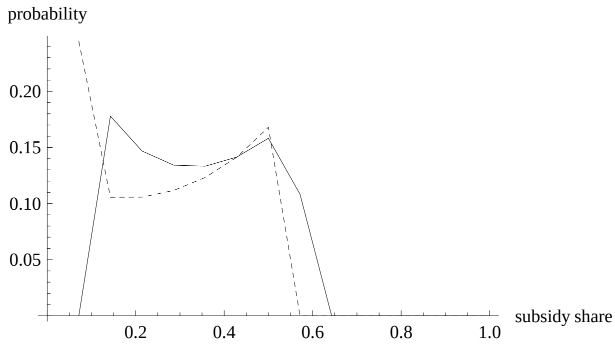
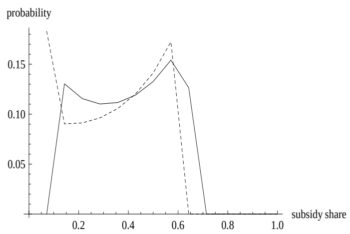
Figure 3. Strategy profiles

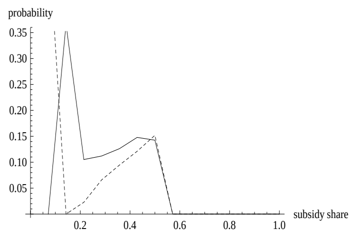
(a) Standard



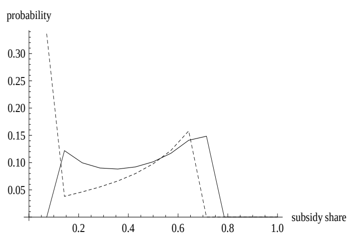
(b) Higher trade cost ($\phi = 0.5$), $\bar{s}_N = 0.40$, $\bar{s}_S = 0.33$



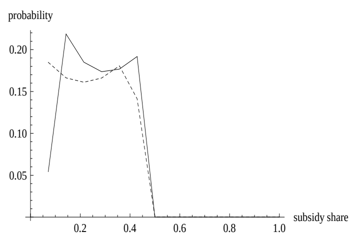
(c) Lower trade cost ($\phi = 0.7$), $s_N = 0.29$, $s_S = 0.28$



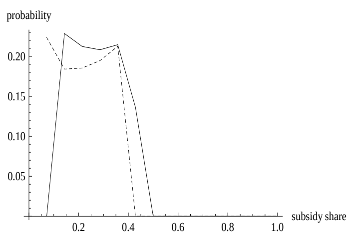
(d) Lower public good preference ($\gamma = 0.2$), $\bar{s}_N = 0.45$, $\bar{s}_S = 0.33$



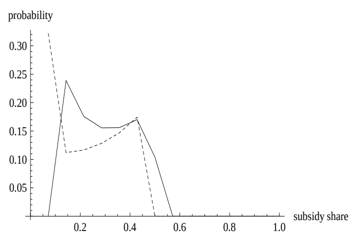
(e) Higher public good preference ($\gamma = 0.4$), $\bar{s}_N = 0.27$, $\bar{s}_S = 0.24$



(f) Lower central tax rate ($t = 0.2$),$\bar{s}_N = 0.27$, $\bar{s}_S = 0.21$



(g) Higher central tax rate ($t = 0.4$), $\bar{s}_N = 0.30$, $\bar{s}_S = 0.23$



$\mu = 0.2$; $\sigma = 5$; $Lw = 1$; $t = 0.3$; $sl = 0.5$; $F = 1/\sigma$; $am = (\sigma - 1)/\sigma$; $\gamma = 0.3$; $\phi = 0.7$. Lines: Nash mixed profile probability distribution for North (solid) and South (dash). is used to indicate probability-weighted average subsidy.

A Condition for incomplete specialization

To use the wage as a numeraire, we must ensure that it is equal between the two regions. With sectoral mobility and free trade of the constant returns to scale agricultural goods, equal nominal wage occurs when the most specialized region still uses a marginal worker in agriculture. Using this observation, a condition to use the wage as numeraire is that the aggregate manufacturing labor requirement in a region where production has completely agglomerated does not exceed the labor force in that region. More formally;

$$L_{M,N} \leq \lambda L \tag{A.1}$$

The manufacturing labor requirement can be found by looking at the labor input needed for equilibrium firm output, and aggregating over firms. Firm output is (following (8))

$$q\left(i\right) = \frac{\left(\frac{\sigma}{\sigma-1} a_m w\right)}{n} \mu \left[E_N + E_S\right] \tag{A.2}$$

where we can substitute the definition for world expenditure (15) into the last term and aggregate over all firms, and use the normalization of the productivity:

$$L_{M,N} = nq = \frac{\mu}{w} \left[\frac{w\left(1-t\right)L + stw\lambda L}{1-\frac{\mu}{\sigma}}\right] \tag{A.3}$$

Filling out this term in (A.1) and rewriting gives

$$st\lambda \leq t\lambda + \lambda\left(\frac{1}{\mu} - \frac{1}{\sigma}\right) - 1 \tag{A.4}$$

where we have assumed $w = 1$ as numeraire and the empty region has no firms to give its subsidy to. This condition states that the maximum subsidy for which the wage can be used as a numeraire decreases in the tax rate and the preference for manufacturing goods μ, and increases in the price and σ (i.e. decreases in market power). A typical constellation of $\lambda = 0.5$ and $\mu \leq 0.5$ supports subsidy rates up to 100%.

B Explanation of variables

Where variables can be defined for general, North or South, they are represented plain, or with subscripts N and S, respectively.

Table B.1: List of variables and definitions

Variable	Explanation
Δ	$\nu + \phi(1-\nu)$
Π	Pure firm profits
Ψ	$\frac{1-\phi}{1+\phi}$
γ	weight of public good consumption in Cobb-Douglas utility function
δ	$\frac{(1-t(1-s_N))}{1-t(1-\lambda s_N-(1-\lambda)s_S)}\lambda$
ϕ	$\tau^{1-\sigma}$, trade freeness
σ	measure of consumer love of variety over manufactures
τ	Samualsonian (iceberg) trade cost
μ	weight of aggregate manufacturing good consumption in Cobb-Douglas utility function
π	firm operating profits
a_m	labor productivity in manufacturing
b	$\frac{\mu}{\sigma}$
$c(i)$	private consumption of individual manufacturing variety i
n	number of firms
$p(i)$	price of manufacturing variety i
$q(i)$	quantity produced of manufacturing variety i
s	share of local government budget allocated to firm subsidies
η	share of world expenditure originating from North
ν	share of world number of firms located in North
t	national tax rate
w	wage rate (numéraire)
A	$\frac{2\delta-\phi}{1-\phi} - \delta$
B	$\left[\frac{\eta}{\Delta} + \frac{\phi(1-\eta)}{\Delta^*}\right]$
C_a	Private consumption of agricultural goods

Table B.1: List of variables and definitions

Variable	Explanation
C_m	Private consumption of aggregate manufacturing goods
C_g	Private consumption of public goods
E	Expenditure (originating from North if no asterisk)
F	Fixed factor requirement
L	Mass of labor
P	Harmonized manufacturing price index
S	Amount of the per firm subsidy
Y	Per capita disposable income (wage after tax and per capita firm profits)
Z	$(1-2\delta)(1-\phi)\,\nu\,(1-\nu)-\delta$

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