Is Agglomeration good for growth? The trade-off between equity and efficiency revisited

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Abstract

A well-established result in the New Economic Geography and Growth literature (Martin (1999), Baldwin et al. (2001) among others) is the existence of a trade-off between dynamic efficiency (aggregate real growth) and static equity (regional income levels). More precisely, when knowledge spillovers are localized, aggregate growth is faster when economic activities are concentrated in only one region. A related result is that the regional gap in the growth rate of real income is always zero region unregarding the spatial distribution of firms. As a consequence, in the core-periphery outcome, the periphery is always better off in the long-run and therefore promoting policies aimed at favouring the agglomeration of the increasing-return sector activities in only one region. is unambiguosly welfare enhancing by the point of view of a benevolent central planner. We challenge these optimistic results in our paper by extending the standard framework with an additional sector producing Non-tradable goods (services). By assuming intersectoral and localized knowledge spillovers from the innovation sector to the service sector, we show that: 1) regional growth rates of real income always diverge in the core-periphery outcome, being higher in the industrialized region; 2) the aggregate growth rate of real income is higher when the spatial distribution of economic activities is even when the innovation spillovers are sufficiently global; 3) the periphery might suffer a dynamic loss from agglomeration when the innovation spillovers are sufficiently global. These results have strong policy implications because as they suggest that concentrating economic activities in only one region may be welfare-harming for both the less industrialized region *and* at the aggregate level

Key words: economic geography, efficiency-equity trade-off, intersectoral localized knowledge spillovers, non tradables, growth, welfare

JEL Classifications: R10, O33, O41

1 Introduction

An important peculiarity of the recent developments in the new economic geography literature is the direct link between theoretical results and regional policy rules[1]. One of the policy implications that can be drawn from some of new economic geography models (Martin, 1999; Martin and Ottaviano, 1999; Baldwin and Forslid, 2000; Baldwin, Martin and Ottaviano 2001; Baldwin and Martin, 2004; Baldwin *et al.*, 2004) is particularly surprising at first sight: increasing the long-run aggregate economic growth and, at the same time, making it uniform across regions is possible by promoting policies aimed at favouring the agglomeration of the increasing-return sector activities in only one region.

This policy implication is drawn from models obtained by adding endogenous growth to a version of the core-periphery model developed by Krugman (1991): with localised intertemporal knowledge spillovers and capital and labour immobility, the maximum level of agglomeration of the industrial sector provides the maximum long-run rate of growth not only for the region in which this sector is agglomerated (the core), but also for the region where the whole manufacturing sector disappears (the periphery). That happens because, when knowledge spillovers are localized, the cost of innovation is minimized when all the innovating firms are close one another and for the same reason growth is enhanced.

The reason why the higher growth rate benefits the periphery as well as the core is because of a "terms of trade effect". In other words, thanks to the technological progress in the industrial sector, the price index of the manufacturing goods decreases faster than the price of the agricultural good. This implies that the relative value of the commodity which the periphery specializes in — traditional goods — increases overtime making the periphery's imports of manufacturing goods cheaper. As a result, the real income of the periphery grows, in the long-run, at the same rate of the core.

Hence policy makers when taking their decision face a trade off between equity (in terms of distribution of economic activities and thus income levels) and efficiency (in terms of real growth). According to the standard NEGG theory it is preferable to concentrate innovation (and thereby manufacture) in space because with localized knowledge spillovers in R&D the growth rate of innovation and thereby of knowledge capital is higher. Thus agglomeration can be the welfare counterpart of the static loss suffered by the economic agents

[1]The centrality of the new economic geography as a tool for regional policy has been recognized by european institutions such as the Bureau of European Policy Advisers (BEPA) of the European Commission. An example is the room devoted to the new economic geography literature in the "12th Jaquemin Seminar", where Jacques Thisse presented the background document "Paul Krugman's New Economic Geography: past, present and future"; and in the workshop "The geography of regional development in Europe: what cohesion policies can and cannot do", where Gianmarco Ottaviano presented the background documents "Migration and regional development" and "Regional convergence: The new economic geography perspective"

remaining in the periphery who have lower income levels (they don't enjoy firms' profits) and have to pay higher trade costs on the manufacture product that have to be imported from the core. So the policy makers should never try to prevent the agglomeration of economic activities (by the mean, say, of monetary transfers to the peripheral regions) in order not to harm aggregate growth.

Given the relevance of this theoretical statement and its appeal for the policy makers, it is useful to concentrate on the robustness of this result.

As shown by Cerina and Pigliaru (2007), this rather optimistic result crucially depends on the Cobb-Douglas specification of the individual preferences between the two kinds of goods. In particular, using a more general CES utility function and then allowing for the elasticity of substitution between the traditional and the manufactured good to differ from the unity, the authors show that real income in the core grows faster (slower) then in the periphery if the two classes of goods are good (poor) substitutes. However, the non-constancy of the expenditure shares of the two goods, due to the non-unitary elasticity of substitution, does not allow for the existence of a balance growth path. So that growth divergence cannot be appreciated as an equilibrium phenomenon. This same approach has been adopted by Cerina and Mureddu (2008), who deepened the analysis of the implications of endogenous expenditure shares by fully assessing the dynamics of the model, the mechanisms of agglomeration and the equilibria growth rate.

In this paper we maintain the assumption of unitary elasticity of substitution between traditional and manufacturing good, but real growth gap is obtained as an equilibrium phenomena by allowing for different departures from the standard New Economic Geography and Growth (NEGG) models. In order to do that, we build a model based on Baldwin, Martin and Ottaviano (BMO 2001) with an additional sector producing non-tradable goods (services) with constant returns to scale. We also assume that there are intersectoral and localized knowledge spillovers from the innovation sector to the service sector, so that the cost of producing an additional unit of the non-tradable good in one region decreases with the units of knowledge capital located in the same region. These localized intersectoral knowledge spillovers have the same nature of the intertemporal localized knowledge spillovers in the innovation sector introduced by BMO (2001): they are completely external to the firms and cannot be controlled by them.

Thanks to these departures, we are able to show that firms' allocation affects regional real growth and, as a corollary, equilibrium real growth rates in the two regions always diverge when firms allocation attains the core-periphery configuration. In particular, in the core-periphery equilibrium, the core grows faster in real terms with respect to the periphery because the (negative) growth rate of the global price index is positively affected by the local growth rate in the number of firms, being the latter positive in the core and zero in the periphery. In other words, regional real growth gaps stem from the decreasing price in the non-tradable goods which is a direct consequence of the local increase in the number of firms. Moreover, and most important, we are able to show that the real growth rate of income at the aggregate level might be lower in agglomeration than in case of symmetry. As already anticipated, this result is a novelty in the standard theoretical NEGG literature where regional gap in real growth rate is always zero. We also provide the complete analysis of the dynamic properties of the model and we show that they do not differ from BMO (2001) so that the presence of the additional non-tradable sector does not affect the allocation dynamics of firms. Finally, we analyze the trade-off between the dynamic gains of agglomeration (due to localized intertemporal spillovers) and the dynamic loss of agglomeration (due to localized intersectoral spillovers) experienced by the periphery.

Our results seem to have important consequences for policy makers: if we accept that the presence of a non-tradable sector which benefits from the local innovation sector is a realistic feature of the economy (i.e.: innovating and financial services), then policies that favour agglomeration may generate ever-increasing regional welfare inequalities and, most importantly, they may be detrimental to overall growth.

The paper will proceed as follows: in section 2 we present the analytical framework and the mechanisms of agglomeration of the model. In section 3 and 4 we develop the growth and the regional welfare analysis. Finally, section 5 concludes.

2 The Analytical Framework

2.1 The structure of the economy

Our economy is modeled along the lines of Baldwin *et al.* (2001). The only (but crucial) departure from the latter is the additional sector producing non-tradable goods.

We assume two symmetric regions in terms of technology, preferences, transport costs and initial endowments. Each region is endowed with two production factors: labour L and capital K. Four production sectors are active in each region: modern (manufacture) M, traditional (agriculture) T, a capital producing sector I and a services producing sector S. Labour is assumed to be immobile across regions but mobile across sectors within the same region. The traditional good is freely traded between regions whilst manufactures are subject to iceberg trade costs[2]. For the sake of simplicity, most of the time we will focus on the northern region[3].

The manufactures are produced under Dixit-Stiglitz monopolistic competition (Dixit and Stiglitz, 1977) and enjoy increasing returns to scale: firms face a fixed cost in terms of knowledge capital. It is in fact assumed that producing a variety requires a unit of knowledge interpreted as a blueprint, an idea, a new technology, a patent, or a machinery. Moreover firms face a variable cost a_M in terms of labor. Thereby the cost function is $\pi + w_M a_M x_i$, where π is the rental

[2] It is assumed that a portion of the good traded melts in transit as in Samuelson (1954).

[3] Unless differently stated, the southern expressions are isomorphic.

rate of capital, w_M is the wage rate in the $M-$sector and a_M are the unit of labor necessary to produce a unit of output x_i.

Each region's K is produced by its I-sector which produces one unit of K with a_I unit of labour. So the production and marginal cost function for the I-sector are, respectively:

$$\dot{K} = Q_K = \frac{L_I}{a_I} \tag{1}$$

$$F = w_I a_I \tag{2}$$

Note that this unit of capital in equilibrium is also the fixed cost F of the manufacturing sector. As one unit of capital is required to start a new variety, the number of varieties and of firms at the world level is simply equal to the capital stock at the world level: $K + K^* = K^w$. We denote n and n^* as the number of firms located in the north and south respectively. As one unit of capital is required per firm we also know that: $n + n^* = n^w = K^w$. However, depending on the assumptions we make on capital mobility, the stock of capital produced and owned by one region may or may not be equal to the number of firms producing in that region. In the case of capital mobility, the capital may be produced in one region but the firm that uses this capital unit may be operating in another region. Hence, when capital is mobile, the number of firms located in one region is generally different from the stock of capital owned by this region. However, as in Baldwin, Martin and Ottaviano (2001), we assume capital immobility, so that each firm operates, and spends its profits, in the region where the capital's owner lives. In this case, we also have that $n = K$ and $n^* = K^*$. Then, by defining $s_n = \frac{n}{n^w}$ and $s_K = \frac{K}{K^w}$, we also have $s_n = s_K$: the share of firms located in one region is equal to the share of capital owned by the same region.

To individual I-firms, the innovation cost a_I is a parameter. However, following Romer (1990), endogenous and sustained growth is provided by assuming that the marginal cost of producing new capital declines (i.e., a_I falls) as the sector's cumulative output rises. In our specification, learning spillovers are assumed to be localised. The cost of innovation can be expressed as:

$$a_I = \frac{1}{AK^w} \tag{3}$$

where $A \equiv s_n + \lambda (1 - s_n)$, $0 < \lambda < 1$ measures the degree of globalization of learning spillovers and $s_n = n/n^w$ is the share of firms allocated in the north. The south's cost function is isomorphic, that is, $F^* = w^*/K^w A^*$ where $A^* = \lambda s_n + 1 - s_n$. For the sake of simplicity in the model version we examine, capital depreciation is ignored[4].

Because the number of firms, varieties and capital units is equal, the growth rate of the number of varieties, on which we focus, is therefore:

$$g \equiv \frac{\dot{K}}{K}; g^* \equiv \frac{\dot{K}^*}{K^*} \tag{4}$$

[4] See Baldwin (2000) and Baldwin *et al.* (2004) for similar analysis with depreciation

Finally, the T-sector produces a homogenous good in perfect competition and constant returns to scale. By choice of units, one unit of T is made with one unit of L.

2.2 The Service Sector

As already anticipated, the introduction of a sector producing non-tradable and which spills knowledge from the cumulative output of the innovation sector represents the main contribution of this paper. All the results related to regional growth patterns are driven by the interaction of this sector with the rest of the economy. We name this sector *service* because of its non-tradability, but since the focus of our paper is not about the role of the service sector in the agglomeration and growth patterns, we avoid a detailed and complex description of this sector. As far as our aims are concerned, our modeling strategy is to describe this sector in a very simple and stylized way. Our S - sector works in perfect competition and constant returns to scale, with $a_S(\cdot)$ units of labour necessary to produce one unit of output. Our $S-$sector production function is very similar to the innovation and traditional sector:

$$S = \frac{L_S}{a_S(\cdot)}; S^* = \frac{L_S}{a_S^*(\cdot)} \tag{5}$$

where S is the quantity of services produced at north and L_S is the labor force devoted to the production of services. $a_S(\cdot)$, represents the labor units requirements per unit of production and $S-$firms take it as given. The latter is a crucial variable in our model as it represents an inverse measure of labor productivity in the service sector.

Hence firm's optimization implies the following pricing rule:

$$p_S = w_S a_S(\cdot) \tag{6}$$
$$p_S^* = w_S^* a_S^*(\cdot) \tag{7}$$

where the price level depends upon the wage rate and the labor units requirements, whose inverse gives us a measure for the productivity of the firm.

Two are the crucial features of this sector.

The first is that $S-$goods cannot be traded across regions: they can be purchased and consumed only in the region where they are produced. Although the enormous progress in the information communication technology has led to a situation in which a relevant share of services can be interregionally and internationally traded[5], the existence of a massive category of non-tradables goods is a realistic and significant feature of real economies, particularly if referring to services to consumers[6]. One of the objective of this paper is to explore the

[5] See Grossman and Helpman (2005), Grossman and Rossi-Hansberg (2006) and GAO (2004).

[6] For instance Blinder (2005) distinguishes between personally-delivered services or simply personal services that cannot be internationally traded and the impersonally-delivered or impersonal services that are easily delivered across countries

implications for the introduction of such a category of goods in the context of a New Economic Geography and Growth model.

The second crucial characteristic of our S-sector is that it benefits from localized intersectoral knowledge spillovers from the cumulative output of the innovation sector[7]. The idea is that the larger the number of firms located in one region, the larger the stock of physical and knowledge capital units owned by the same region[8], the higher the intensity of knowledge spillovers to the service sector of the same region, the lower the cost of producing services in the same region. Similarly to the innovation sector, spillovers are localized in the sense that S - firms will also benefit from the stock of knowledge located in the other region, but to a minor extent. The existence of intersectoral spillovers of this kind has been documented by many empirical works. Among the others[9], van Mejil (1997) and Potì and Cerulli (2007) find significant intensities of knowledge spillovers from R&D activity to services like financial intermediation, computer services, transport, storage and communication. Park (2004) as well offers evidence that manufacturing R&D has a substantial intersectoral R&D spillover effect on domestic nonmanufacturing productivity growth while Park and Chan (1989) suggest that the intersectoral relationships between manufacturing and services generally characterize asymmetrical dependence, namely, service activities tend to depend on the manufacturing sector as a source of inputs to a far greater extent than vice versa. This finding is perfectly compatible with the way we model the interdependence between our manufacturing and service sectors.

The intersectoral spillovers between R&D and services are specified in the following way:

$$\begin{aligned} a_S(\cdot) &= a_S(K, K^*) \\ a_S^*(\cdot) &= a_S^*(K, K^*) \end{aligned}$$

with:

$$\frac{\partial a_S(K, K^*)}{\partial K}, \frac{\partial a_S(K, K^*)}{\partial K^*}, \frac{\partial a_S^*(K, K^*)}{\partial K}, \frac{\partial a_S^*(K, K^*)}{\partial K^*} < 0$$

so that the production cost of services is negatively affected by an increase in the stock of knowledge capital in any of the two regions. However, as already said, intersectoral knowledge spillovers are localized in the sense that:

$$|\theta_K(K, K^*)| > |\theta_{K^*}(K, K^*)| \text{ for every } (K, K^*)$$

and:

$$|\theta_{K^*}^*(K, K^*)| > |\theta_K^*(K, K^*)| \text{ for every } (K, K^*)$$

[7] It is a matter of definition whether the spillovers come from the innovation or from the manufacturing sector. What is important is that the productivity of services is an increasing function of the number of firms located in the same region and, to a less extent, of the number of firms located in the other region.

[8] Following Martin (1999) and the whole NEGG literature we interpret K as a mix of knowledge and physical capital.

[9] See also Midelfar-Knarvik et al. (2000) and Franke and Kalmbach (2005). For an analysis of the empirical literature on the intersectoral localized knowledge spillovers classic references are Griliches (1979), Audretsch and Feldman (1996) and Feldman and Audretsch (1999).

where $\theta_K(K,K^*) = \frac{\partial a_S}{\partial K}\frac{K}{a_s} < 0$ is the elasticity of labor units requirements for a northern firms with respect to northern capital and other elasticities are defined analogously. Since regions are symmetric in terms of technology, we should have

$$\begin{cases} \theta_K(K,K^*) = \theta^*_{K^*}(K,K^*) \\ \theta_{K^*}(K,K^*) = \theta^*_K(K,K^*) \end{cases} \text{for every } (K,K^*) \tag{8}$$

that is, the elasticity of labor units requirement in the northern service sector with respect to northern capital units ($\theta_K(K,K^*)$) should be equal to the elasticity of labor units requirement in the southern service sector with respect to southern capital units ($\theta^*_{K^*}(K,K^*)$) *and* the elasticity of labor units requirement in the northern service sector with respect to southern capital units ($\theta_{K^*}(K,K^*)$) should be equal to the elasticity of labor units requirement in the southern service sector with respect to northern capital units ($\theta^*_K(K,K^*)$).

Two observations are worth at this point. First, we remind that all these four elasticities take negative values. Second, and most importantly, at this stage we need not specify an explicit functional form for the cost parameters $a_S(K,K^*)$ and $a^*_S(K,K^*)$. However, it is important ot highlight that, in order for the growth rate of real income to be constant in both regions, the cost parameters functional form should be such that the all the related elasticities are constant, that is:

$$\text{for any } (K,K^*), \begin{cases} \theta_K(K,K^*) = \theta_K \\ \theta_{K^*}(K,K^*) = \theta_{K^*} \\ \theta^*_{K^*}(K,K^*) = \theta^*_{K^*} \\ \theta^*_K(K,K^*) = \theta^*_K \end{cases}$$

2.3 Preferences and consumers' behaviour

As in the standard NEGG models, the infinitely-live representative consumer's optimization is carried out in three stages. In the first stage the agent intertemporally allocates consumption between expenditure and savings. In the second stage she allocates expenditure between manufacturing goods, traditional goods and services, while in the last stage she allocates manufacture expenditure across varieties. The preferences structure of the infinitely-live representative agent are then given by:

$$\begin{aligned} U_t &= \int_{t=0}^{\infty} e^{-\rho t} \ln Q_t dt &(9)\\ Q_t &= \ln\left(C_M^{\alpha} C_T^{\beta} C_S^{\gamma}\right) &(10)\\ C_M &= \left[\int_{i=0}^{K+K^*} c_i^{1-1/\sigma} di\right]^{\frac{1}{1-1/\sigma}} \\ \alpha+\beta+\gamma &= 1 &(11) \end{aligned}$$

Where C_M, C_T and C_S are respectively the preference index aggregator for the manufacturing varieties, the consumption level of the traditional good and the consumption level of services. As a result of the intertemporal optimization program, the path of consumption expenditure E across time is given by the standard Euler equation:

$$\frac{\dot{E}}{E} = r - \rho \tag{12}$$

with the interest rate r satisfying the no-arbitrage-opportunity condition between investment in the safe asset and capital accumulation:

$$r = \frac{\pi}{F} + \frac{\dot{F}}{F} \tag{13}$$

where π is the rental rate of capital and F its asset value which, due to perfect competition in the I-sector, is equal to its marginal cost of production.

In the second stage of the utility maximization the agent chooses how to allocate the expenditure between M-, S- and the T- good according to the following optimization program:

$$\begin{aligned} \max_{C_M, C_T, C_S} Q_t &= \ln\left(C_M^{\alpha} C_T^{\beta} C_S^{\gamma}\right) \\ s.t.\ E &= P_M C_M + p_T C_T + p_S C_S \end{aligned} \tag{14}$$

Yielding the following demand functions:

$$C_M = \alpha \frac{E}{P_M}$$

$$C_T = \beta \frac{E}{p_T}$$

$$C_S = \gamma \frac{E}{p_S}$$

where p_T is the price of the Traditional good, p_S is the price ofther Service good services, and $P_M = \left[\int_{i=0}^{K+K^*} {p_i}^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$ is the Dixit-Stiglitz price index for the manufacturing differentiated good.

Finally, in the third stage, the amount of $M-$ goods expenditure αE is allocated across varieties according to the a CES demand function for a typical M variety $c_j = \frac{p_j^{-\sigma}}{P_M^{1-\sigma}} \alpha E$, where p_j is variety j's consumer price.

2.4 Wages and Prices

Due to perfect competition in the T-sector, the price of the agricultural good must be equal to the wage of the T-sector's workers: $p_T = w_T$. Moreover, *as long as both regions produce some* T, the assumption of free trade in T implies that not only price, but also wages are equalized across regions. It is therefore convenient to choose home labour as numeraire so that:

$$p_T = p_T^* = w_T = w_T^* = 1$$

It's not always the case that both regions produce some T. In order to avoid complete specialization we need to assume that a single country's labour endowment must be insufficient to meet global demand. Formally:

$$L = L^* < \beta E^w$$

where $s_E = \frac{E}{E^w}$ is the northern expenditure share and $E^w = E + E^*$.

The purpose of making this assumption, which is standard in most NEGG models[10], is to maintain wages fixed at the unit value: since labour is mobile across sector, as long as the T - sector is present in both regions, a simple arbitrage condition would suggest that wages of the three sectors cannot differ. Hence, $M-$ and $S-$sector wages are tied to T -sector wages which, in turn, remain fixed at the level of the unit price of the T-good. Therefore:

$$w_M = w_M^* = w_T = w_T^* = w_S = w_S^* = w = 1 \tag{15}$$

Finally, since wages are uniform and all varieties' demands have the same constant elasticity σ, firms' profit maximization yields local and export prices that are identical for all varieties no matter where they are produced: $p = w a_M \frac{\sigma}{\sigma-1}$. Then, by imposing the normalization $a_M = \frac{\sigma-1}{\sigma}$ and equation (15), we finally have:

$$p = w = 1 \tag{16}$$

As usual, since trade in M is impeded by iceberg import barriers, prices for markets abroad are higher:

$$p^* = \tau p; \ \tau \geq 1$$

By labeling as p_M^{ij} the price of a particular variety produced in region i and sold in region j (so that $p^{ij} = \tau p^{ii}$) and by imposing $p = 1$, the $M-$goods price indexes might be expressed as follows:

$$P_M = \left[\int_0^K (p_M^{NN})^{1-\sigma} di + \int_0^{K^*} (p_M^{SN})^{1-\sigma} di \right]^{\frac{1}{1-\sigma}} = (s_K + (1 - s_K)\, \phi)^{\frac{1}{1-\sigma}} \, K^{w \frac{1}{1-\sigma}} \tag{17}$$

$$P_M^* = \left[\int_0^K (p_M^{NS})^{1-\sigma} di + \int_0^{K^*} (p_M^{SS})^{1-\sigma} di \right]^{\frac{1}{1-\sigma}} = (\phi s_K + 1 - s_K)^{\frac{1}{1-\sigma}} \, K^{w \frac{1}{1-\sigma}} \tag{18}$$

where $\phi = \tau^{1-\sigma}$ is the so called "phi-ness of trade" which ranges from 0 (prohibitive trade) to 1 (costless trade).

[10] See Bellone and Maupertuis (2003) and Andrès (2007) for the analytical implications of removing this assumption

3 Stability of locational equilibria

Agglomeration patterns in our model are identical to Baldwin *et al.* (2001). In other words, the presence of a service sector (the way we modeled it) does not affect the standard mechanisms of industry agglomeration. This is because the interaction between the S and the M sector is assumed to be unidirectional: services productivity is positively affected by manufactures but *not* vice-versa[11]. Hence, the equilibrium spatial distribution of manufacturing firms and its stability are totally independent from the what happens in the S - sector. of locational equilibria.

For the same reason, as shown in the appendix, the dynamic system describing the evolution of the economy overtime is the same as the one illustrated in Baldwin *et al.* (2001). As in the latter, the stability of the location equilibria in our model is determined by the interaction between two destabilizing forces - the market access effect and the localised spillovers effect - and one stabilizing force, the market crowding effect. The market access effect is due to the fact that the more agglomerated region is more attractive because manufacturing firms enjoy increasing returns to scale and therefore are attracted by larger markets, while the localised spillovers effect is determined by the fact that innovation activity is more productive in the region owning a higher capital share. By contrast the dispersion force called market crowding effect is given by the fact that competition is tougher in the more industrialized region.

When transport costs are high, the market crowding effect is stronger than the market access and the localised spillovers effects. On the contrary when trade costs become to fall, the strength of the market crowding effect weakens faster than the market access effect and the localised spillovers effects (which is not affected by trade costs) thereby leading to catastrophic agglomeration.

The map of locational equilibria is then described by the following picture, taken from Baldwin et. al. (2001)

As the figure shows, when ϕ is sufficiently high and trade is not as easy ($\phi \leq \phi^{cat}$), the only stable equilibrium is the symmetric one, where $s_K = 1/2$. When trade costs fall and ϕ becomes larger than ϕ^{cat}, two additional steady states appear. In other words, when ϕ rises from below to above ϕ^{cat}, the symmetric steady state loses its stability to the two new neighboring interior steady states. As ϕ becomes larger, these two interior steady states approach to the two core-periphery equilibria ($s_K = 0$ and $s_K = 1$)[12] and when $\phi^{cat} \geq \phi^{CP}$ they collapse to them. We then have three kinds of stable locational equilibria: 1) a symmetric equilibrium (for $\phi \leq \phi^{cat}$) where $s_K = 1/2$; 2) two interior non-symmetric equilibria where s_K can take any value as ϕ^{cat} approaches ϕ^{CP};

[11] As already said, an empirical support of this assumption can be found in Park and Chon (1989). However, an interesting future line of research might be the analysis of the implications of a reciprocal influence of the manufacturing and service sector with the productivity of $M-$ firms either being positively affected by the presence of firms producing non-tradable services or using non-tradable services as an intermediate input.

[12] For $s_K = 1$ to be an equilibrium, it must be that continuous accumulation is profitable in the north but not in the south so no southern agent would choose to setup a new firm. Defining the core-periphery equilibrium this way, it implies that it is stable whenever it exists.

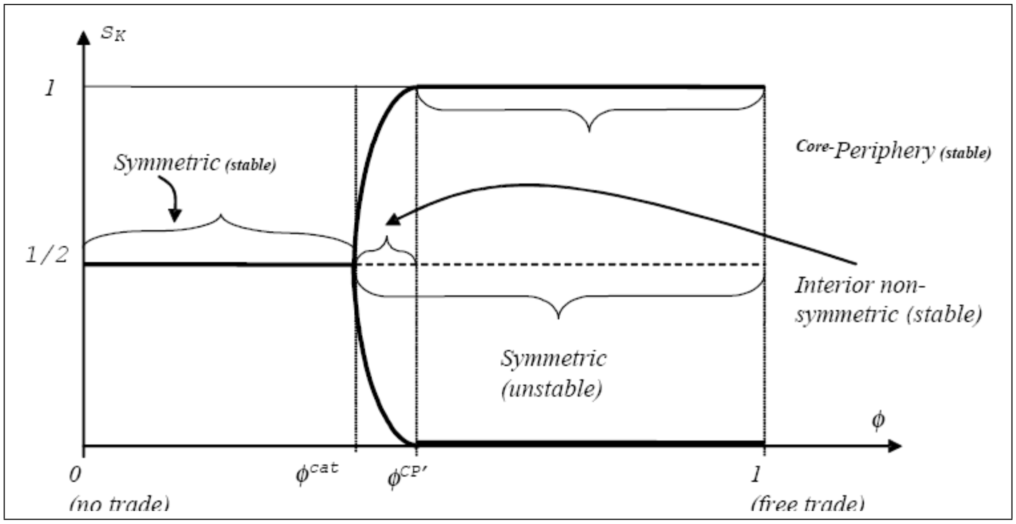

Figure 1: The map of locational equilibria (from Baldwin et al. (2001).

3) two core-periphery equilibria where $s_K = 0$ or $s_K = 1$ according to the initial condition or to the particular self-fulfilling expectations[13].

It is important to notice that, in steady state, the growth rate of the world capital stock K^w (or of the number of varieties) will be constant and will either be common ($g = g^*$ in any interior equilibrium where $s_K \in (0,1)$) or north's g (in the core-periphery case)[14]. In fact, by time-differentiating $s_K = \frac{K}{K^w}$, we obtain that the dynamics of the share of manufacturing firms allocated in the north is:

$$\dot{s}_K = s_K (1 - s_K) \left(\frac{\dot{K}}{K} - \frac{\dot{K}^*}{K^*} \right)$$

so that only two kinds of steady-state ($\dot{s}_K = 0$) are possible: 1) a steady-state in which the rate of growth of capital is equalized across countries ($g = g^*$); 2) a steady-state in which the manufacturing industries are allocated and grow in only one region ($s_K = 0$ or $s_K = 1$). As a consequence, for any interior allocation to be an equilibrium ($s_K \in (0,1)$), the growth rate of capital in the

[13] Again, see Baldwin et al. (2001) for a detailed explanation.

[14] By time-differentiating $s_K = \frac{K}{K^w}$, we obtain that the dynamics of the share of manufacturing firms allocated in the north is

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two regions should be equal. We are now ready to face the analysis of growth patterns of our economy.

4 Growth analysis

Although services play no role in the dynamics of spatial distribution of industrial firms, they become crucial when we analyze the growth patterns of the two regions. We will show that the introduction of a non-tradable service sector which enjoys localized intersectoral knowledge spillovers from the cumulative output of the innovation sector leads significant departures from the standard NEGG models both at the aggregate and at the regional level.

4.1 The growth rate of capital

The first step is to find the expression for the growth rate of capital units in both regions and for both the interior and the core-periphery equilibria. To do this, we need to define the labor market equilibrium. We remind that workers are mobile across sector but immobile across regions. They can be occupied either in the innovation sector, in manufacture, in services or in the traditional sector. In any case the world sectoral consumers' expenditure should be equal to the sectoral value of total production, so that:

$$L_M + L_M^* = \alpha E^w \frac{\sigma - 1}{\sigma} \tag{19}$$

$$L_T + L_T^* = \beta E^w \tag{20}$$

$$L_S + L_S^* = \gamma E^w \tag{21}$$

$$L_I + L_I^* = \frac{g s_K}{A} + \frac{g^* (1 - s_K)}{A^*} \tag{22}$$

Hence the labour market condition requires that:

$$L_T + L_T^* + L_M + L_M^* + L_S + L_S^* + L_I^* + L_I = \beta E^w + \alpha E^w \frac{\sigma - 1}{\sigma} + \gamma E^w + \frac{g s_K}{A} + \frac{g^* (1 - s_K)}{A^*} \tag{23}$$

Now, it can be shown that optimizing consumers set expenditure at the permanent income hypothesis level in steady state. That is, they consume labor income plus ρ times their steady-state wealth, $FK = \frac{s_K}{A}$ and $F^* K^* = \frac{(1-s_K)}{A^*}$ in the north and in the south respectively. Hence $E = L + \rho \frac{s_K}{A}$ and $E^* = L + \rho \frac{(1-s_K)}{A^*}$. By summing up we find the expression for the world expenditure:

$$E^w = 2L + \rho \left(\frac{s_K}{A} + \frac{1 - s_K}{A^*} \right) \tag{24}$$

Finally, substituting in the labor market clearing condition, considering that in steady state the growth rate is either common to the two regions ($g = g^*$) or north's g and given that $L_T + L_T^* + L_M + L_M^* + L_S + L_S^* + L_I^* + L_I = 2L$

we find the equilibrium value of the growth rate of capital for any equilibrium spatial distribution of firms:

$$g(s_K) = \frac{2\alpha LAA^*}{\sigma(s_K A^* + (1-s_K)A)} - \frac{\sigma-\alpha}{\sigma}\rho \tag{25}$$

Again[15], the presence of a service sector the way we modeled it does not affect the growth rate of capital, which is equal to the standard case. As in Baldwin *et al.* (2001), this rate of growth depends on the location of firms. By substituting for the value of A and A^* we find:

$$\frac{\partial g(s_K)}{\partial s_K} = \frac{(1-\lambda^2)\,2L\frac{\alpha}{\sigma}\lambda(2s_K-1)}{(2s_K+\lambda-2s_K\lambda+2s_K^2\lambda-2s_K^2)^2}$$

It can be noticed that this derivative is positive when s_K is larger than $1/2$ meaning that increasing the share of firms in the most-industrialized region is growth-enhancing. We can also notice that geography matters for growth only in the case of localized innovation spillovers. When spillovers are global ($\lambda = 1$), we have in fact $\frac{\partial g}{\partial s_K} = 0$.

The effect of geography on growth is all the more appreciated if we calculate the equilibrium growth rate for the symmetric ($s_K = \frac{1}{2}$) and for the core-periphery ($s_K = 1$) steady states. In this case we have:

$$g(s_K)|_{s_K=1/2} = \frac{(1+\lambda)L\alpha - \rho(\sigma-\alpha)}{\sigma} \tag{26}$$

$$g(s_K)|_{s_K=1} = \frac{2L\alpha - \rho(\sigma-\alpha)}{\sigma} \tag{27}$$

with clearly $g(s_K)|_{s_K=1} > g(s_K)|_{s_K=1/2}$.

4.2 The growth of nominal and real income

In our model the nominal income level is analogous to the standard NEGG one where:

$$Y = L + \pi s_K K^w = L + \frac{\alpha E^w A}{\sigma}\left[\frac{s_E}{(s_K+(1-s_K)\phi)} + \frac{\phi(1-s_E)}{(\phi s_K+1-s_K)}\right] \tag{28}$$

$$Y^* = L + \pi^*(1-s_K)K^w = L + \frac{\alpha E^w A^*}{\sigma}\left[\frac{\phi s_E}{(s_K+(1-s_K)\phi)} + \frac{1-s_E}{(\phi s_K+1-s_K)}\right] \tag{29}$$

Accordingly, as in Baldwin *et al.* (2001), the growth rates of nominal income are constant for any (interior or CP) steady state:

$$\frac{\dot{Y}}{Y} = \frac{\dot{Y}^*}{Y^*} = 0 \text{ for any } s_K \in [0,1]$$

[15] Thanks to the homogeneity of degree 1 of the utility function.

Intuitively, Y and Y^* are constant because the growth of capital is perfectly compensated by the reduction in profits π and π^* which decrease at the same rate g. As a consequence, regional nominal income levels never diverge. Once again then, services do not affect nominal income growth rate.

However, unlike the benchmark model without services, the spatial distribution of manufacturing firms affects the growth rate of real income a great deal once our non-tradable sector is taken into account. The transmission mechanism works through the (negative) growth rate of the aggregate price index. To see this, imagine we are moving from the symmetric equilibrium to another (interior or CP) equilibrium in which industry is more concentrated in the north ($s_K > \frac{1}{2}$). As we have already seen, this will increase the growth rate of capital units but it will not affect the growth rate of nominal income which is nil for any s_K. However, following the increase in the northern capital stock K, because of localized intersectoral spillovers, northern $S-$ sector will be able to produce the non-tradable goods at a minor cost with respect to southern S - firms. Since services are non-tradable, the price of southern services will be then be higher. As long as the growth rate of capital is common to both regions (i.e. for any interior equilibria), this will only have an effect on the *level* of prices, but not on its growth rate. Nevertheless, in the core-periphery equilibrium, northern growth rate of capital is g while southern growth rate is 0 because no firm has incentive to invest in the south. As a consequence, because of localized intersectoral spillovers from the manufacturing sector, the price of northern services will decrease faster than the price of southern services and this growth gap in service prices will not be filled because services are non-tradable. This permanent gap in the growth rate of prices clearly has a consequence in the regional growth rate of real income which, in the core-periphery equilibrium, is permanently higher in the north. We then have two possible outcomes which are excluded from the model without services:

1. the periphery may suffer of a dynamical loss following the catastrophic agglomeration in the north

2. the average growth rate of real income for the economy as a whole might be lower in the core-periphery equilibrium meaning that the trade-off between (static) equity and (dynamic) efficiency is canceled out.

To give a formal representation of these intuitions, consider the northern and southern perfect price indexes associated to the second stage Cobb-Douglas utility function which are given by:

$$P = P_M^{\alpha} p_T^{\beta} p_S^{\gamma} \tag{30}$$

$$P^* = P_M^{*\alpha} p_T^{*\beta} p_S^{*\gamma} \tag{31}$$

Taking logs and differencing we can decompose the growth rate of prices in both regions:

$$\begin{aligned}\frac{\dot{P}}{P} &= \alpha\frac{\dot{P}_M}{P_M}+\beta\frac{\dot{p}_T}{p_T}+\gamma\frac{\dot{p}_S}{p_S} &(32)\\ \frac{\dot{P}^*}{P^*} &= \alpha\frac{\dot{P}_M^*}{P_M^*}+\beta\frac{\dot{p}_T^*}{p_T^*}+\gamma\frac{\dot{p}_S^*}{p_S^*} &(33)\end{aligned}$$

Northern and southern real income levels are given by $\frac{Y}{P}$ and $\frac{Y^*}{P^*}$ respectively. The two growth rates of real income, $\varphi(s_K, K, K^*)$ and $\varphi^*(s_K, K, K^*)$ are then given by:

$$\begin{aligned}\varphi(s_K,K,K^*) &= \frac{\dot{Y}}{Y}-\frac{\dot{P}}{P}=-\left(\alpha\frac{\dot{P}_M}{P_M}+\beta\frac{\dot{p}_T}{p_T}+\gamma\frac{\dot{p}_S}{p_S}\right) &(34)\\ \varphi^*(s_K,K,K^*) &= \frac{\dot{Y}^*}{Y^*}-\frac{\dot{P}^*}{P^*}=-\left(\alpha\frac{\dot{P}_M^*}{P_M^*}+\beta\frac{\dot{p}_T^*}{p_T^*}+\gamma\frac{\dot{p}_S^*}{p_S^*}\right) &(35)\end{aligned}$$

that is, in both regions, the growth rate of real income is given by the negative of the growth rate of prices. It is important to highlight that, when $\gamma = 0$, these values collapse to the standard case described in Baldwin *et al.* (2001). Finding the expressions for the growth rate of prices in the three sectors for both regions will shed light on how the allocation of manufacturing firms will affect aggregate and regional real income growth.

By log-differenciating (17) and (18) we find the growth rate of manufacturing prices is always common for the two regions. That happens because since the $M-$ goods are traded across regions, benefits of price reduction are enjoyed by the south as well even in the core-periphery outcome, when southern firms have no incentive to invest:

$$\frac{\dot{P}_M}{P_M}=\frac{\dot{P}_M^*}{P_M^*}=-\frac{g}{\sigma-1}$$

Something similar happens with the price of the traditional good which, being our numeraire ($p_T = p_T^* = 1$), is constant in both regions by definition:

$$\frac{\dot{p}_T}{p_T}=\frac{\dot{p}_T^*}{p_T^*}=0$$

Finally, once we define the growth rate of the price of services we can appreciate key departure from the benchmark model. Taking into account the fact that $w_S = w_S^* = 1$, the price of services in the two regions are given, respectively, by:

$$\begin{aligned}p_S &= a_S(K,K^*) &(36)\\ p_S^* &= a_S^*(K,K^*) &(37)\end{aligned}$$

Taking logs and differentiating we find that:

$$\begin{aligned}\frac{\dot{p}_S}{p_S} &= g\theta_K(K, K^*) + g^*\theta_{K^*}(K, K^*) \\ \frac{\dot{p}_S^*}{p_S^*} &= g\theta_K^*(K, K^*) + g^*\theta_{K^*}^*(K, K^*)\end{aligned}$$

where we remind that the four elasticities all take negative values.

We are now ready to substitute all the sectoral growth rate of prices in the expressions for the regional growth rates of real income:

$$\varphi(s_K, K, K^*) = \frac{\alpha g}{\sigma - 1} - \gamma\left(g\theta_K(K, K^*) + g^*\theta_{K^*}(K, K^*)\right) \quad (38)$$

$$\varphi^*(s_K, K, K^*) = \frac{\alpha g}{\sigma - 1} - \gamma\left(g\theta_{K^*}(K, K^*) + g^*\theta_K(K, K^*)\right) \quad (39)$$

where we have exploited the symmetric technology relation given by (8)

4.3 Aggregate growth and growth divergence

As we have seen, $g(s_K) = g^*(s_K)$ in any interior equilibria ($s_K \in (0,1)$). Hence:

$$\varphi(s_K, K, K^*) = \varphi^*(s_K, K, K^*) = g(s_K)\left(\frac{\alpha}{\sigma - 1} - \gamma\left(\theta_K(K, K^*) + \theta_{K^*}(K, K^*)\right)\right) \quad (40)$$

Then, in any interior equilibria, there is no gap in the regional rate of growth of real income: when $s_K \in (0,1)$ our extension of Baldwin et. al (2001) confirms the conclusion of the benchmark model.

Things are significantly different in the core-periphery equilibrium which, we remind, turns out to be stable for any $\phi > \phi^{CP}$. Let's concentrate on $s_K = 1$ (the case $s_K = 0$ can be easily deduced being perfectly symmetric to the former). In this case we have that $g(1) > g^*(1) = 0$. Therefore:

$$\varphi(1, K, K^*) = g(1)\left(\frac{\alpha}{\sigma - 1} - \gamma\theta_K(K, K^*)\right) \quad (41)$$

$$\varphi^*(1, K, K^*) = g(1)\left(\frac{\alpha}{\sigma - 1} - \gamma\theta_{K^*}(K, K^*)\right) \quad (42)$$

so that, given that intersectoral spillovers are localized, there is a permanent positive gap between growth in northern and southern real income given by:

$$\varphi(1, K, K^*) - \varphi^*(1, K, K^*) = \gamma g(1)\left(\theta_{K^*}(K, K^*) - \theta_K(K, K^*)\right) > 0 \quad (43)$$

Hence, unlike the benchmark model, in our extension the core-periphery equilibria is characterized by ever-increasing real income differential between north and south. Quite intuitively, the more spillovers are localized, the larger the gap. When intersectoral spillovers are global ($\theta_{K^*}(K, K^*) = \theta_K(K, K^*)$), there is no gap in the real growth rate in the core-periphery outcome. On the other hand, when spillovers are perfectly localized, $\theta_{K^*}(K, K^*) \equiv 0$, the gap is maximized.

Two are the main consequences of this fact. First, the periphery may suffer from both a static and dynamic loss from agglomeration of firms in the north. Second, and most importantly, by the point of view of an hypothetical central planner aiming at maximizing aggregate real growth of the whole economy, agglomeration might be bad for growth. We now find the conditions for these to happen starting from the second possible outcome.

4.3.1 Aggregate real growth

For any equilibrium allocation s_K, aggregate real growth is just the weighted sum of the growth rate in the two regions. In any interior case then, it is simply given by the the common real growth rate (40):

$$\bar{\varphi}(s_K, K, K^*) = g(s_K)\left(\frac{\alpha}{\sigma-1} - \gamma\left(\theta_K(K, K^*) + \theta_{K^*}(K, K^*)\right)\right)$$

By contrast, in the CP equilibrium where $g(1) > g^*(1) = 0$, we have:

$$\bar{\varphi}(1, K, K^*) = g(1)\left(\frac{\alpha}{\sigma-1} - \gamma\frac{\left(\theta_K(K, K^*) + \theta_{K^*}(K, K^*)\right)}{2}\right)$$

Notice that, in any case, aggregate real growth is a positive function of the intensity of intersectoral knowledge spillovers whatever their degree of globalization.

In the benchmark model, when $\gamma = 0$, an hypothetical central planner aiming to maximize aggregate real growth would always choose to concentrate firms in only one region. That's because $g(1) = g(0) > g(s_K)$ for any $s_K \in (0, 1)$. However, in our model, the aggregate rate of growth of real income might not be maximized in the CP equilibrium.

To see this, imagine that the central planner wants to choose between the symmetric and the core-periphery equilibrium[16]. For the sake of simplicity we can assume a constant elasticity[17] form for both $a_S(K, K^*)$ and $a_S^*(K, K^*)$ such that all elasticities are constant for any value of (K, K^*). We then have, for any (K, K^*)

$$\begin{aligned}\theta_K(K, K^*) &= \theta_K < 0 \\ \theta_{K^*}(K, K^*) &= \theta_{K^*} < 0\end{aligned}$$

[16] The choice of any other equilibrium might be difficult to justify because any other equilibrium will be stable for one and only value of ϕ, while while both the symmetric and the core-periphery equilibrium will be stable for an entire interval (respectively $\left[0, \phi^{cat}\right]$ and $\left[\phi^{CP}, 1\right]$ and then for infinite values of ϕ.

[17] An functional form of this kind would then be

$$a_S(K, K^*) = AK^{\theta_K}K^{*\theta_{K^*}}$$

with A constant parameter and θ_K and θ_{K^*} taking constant negative values.

In this case, the aggregate real growth is faster in the periphery ($\bar{\varphi}(\frac{1}{2}, K, K^*) > \bar{\varphi}(1, K, K^*)$) if

$$\frac{\alpha}{\sigma-1}\left(g\left(1\right)-g\left(\frac{1}{2}\right)\right)<\gamma\left(\theta_K+\theta_{K^*}\right)\left(\frac{g\left(1\right)}{2}-g\left(\frac{1}{2}\right)\right)$$

We know that the left-hand side is surely positive. The right-hand side is 0 without services ($\gamma = 0$) but it can be positive and larger than the LHS if $g\left(\frac{1}{2}\right)$ - the growth rate of capital in symmetry - is sufficiently larger than $\frac{g(1)}{2}$, i.e., half the growth rate of capital in core-periphery. Interestingly, the larger the intensity of the intersectoral spillovers (whatever their degree of globalization), the larger the probability for real growth in symmetry to be faster. That happens because, when spillovers are more intense (i.e. $\theta_K + \theta_{K^*}$ is larger), the aggregate dynamic loss when industry disappears from the south is larger because the southern contribution to the aggregate growth rate in symmetry is higher.

By using (26) and (27) we can find a condition involving the intensity of intertemporal knowledge spillovers in the innovation sector. We then have

$$\bar{\varphi}(\frac{1}{2}, K, K^*) > \bar{\varphi}(1, K, K^*) \Leftrightarrow \lambda > \frac{2L\alpha^2 - \gamma\left(\sigma-1\right)\left(\theta_K+\theta_{K^*}\right)\rho\left(\sigma-\alpha\right)}{2L\alpha\left(\alpha-\gamma\left(\sigma-1\right)\left(\theta_K+\theta_{K^*}\right)\right)}$$

Hence, in order for real growth to be faster in symmetry, the intensity of intertemporal knowledge spillovers in the innovation sector should be high enough. That happens because, when λ is large, the difference between $g\left(\frac{1}{2}\right)$ is not so smaller than $g\left(1\right)$ and then the aggregate dynamic loss associated in the disappearence of industry from the south is larger.

If, along the lines of Martin (1999) and Baldwin et al. (2001), we interpret λ in an historical perpective and hence we expect an overtime increase in the degree of globalization of technology spillovers as a result of the continuous progress in the technology of information diffusion, we should conclude that the probability that aggregate real growth is faster when the spatial distribution of firms is even becomes higher and higher as time goes by.

Summing up, in this subsection we have find the condition that has to hold in order for aggregate real growth to be faster when firms are evenly distributed in the two regions. Since when this is the case also income levels are evenly distributed among the two regions, we conclude that, unlike Martin (1999) or Baldwin et al. (2001), the trade-off between (dynamic) efficiency and (static) equity disappears. We believe that policy makers should take these findings into account when they implement policies which may favour agglomeration.

4.3.2 Static and dynamic loss for the periphery

Both with and without services, the periphery suffers from a static loss given by the lower permanent income level and by higher price level due to higher transport costs. However, in the standard NEGG framework without the service sector, this static loss is more than compensated by a dynamic gain given by the fact that in the CP equilibrium the (common) real growth is higher than in symmetry. As we have seen, this is not always the case in our model. In particular, the dynamic gain of the periphery may turn into a dynamic loss. We know explore the condition for this to happen.

The south dynamically loses from agglomeration in the north when the southern real growth rate is higher in simmetry than in the core-periphery equilibrium. While in Martin (1999) and Baldwin et al. (2001) this outcome is impossible, our model provides this possibility. Once again we assume constant elasticities θ_K and θ_{K^*} so that we can get rid of the argument (K, K^*) in our functions and we look for an equilibrium where $\varphi^*\left(\frac{1}{2}\right) > \varphi^*(1)$. In order for this to happen we need

$$-\gamma\theta_K > \left(\frac{\alpha}{\sigma-1} - \gamma\theta_{K^*}\right)\frac{g(1) - g\left(\frac{1}{2}\right)}{g\left(\frac{1}{2}\right)} \tag{44}$$

The economic meaning of this condition is not as straighforward as the other.

First of all, both sides are strictly positive so that this condition is not meaningless.

Second, and unsurprisingly, the higher (lower) the intensity of the regional counterpart of intersectoral spillovers (θ_K), the more (less) likely this condition to hold. When θ_K is very high (low), the periphery will suffer more (less) from the disappearence of the manufacturing sector because its contribution to southern real growth is very high (low) in the symmetric equilibrium.

Third, the higher (lower) θ_{K^*}, the lower (higher) the probability for the periphery to dinamically lose from agglomeration. That happens because, when the interregional counterpart of intersectoral spillovers is very high (say close to θ_K), the periphery's $S-$ sector will still benefit a great deal from northern industry in terms of growth rate of price reduction.

Fourth, this condition is more likely to be satisfied when, ceteris paribus, the relative gap between the growth rate of capital units in the two equilibria ($\frac{g(1)-g\left(\frac{1}{2}\right)}{g\left(\frac{1}{2}\right)}$) is not too high. As we know, that happens when λ is sufficiently high: if this is the case, the periphery will enjoy a lower growth rate of real income with respect to the symmetric equilibrium. How large should be λ for this to happen? By using (26) and (27) we find that

$$\varphi^*\left(\frac{1}{2}\right) > \varphi^*(1) \Leftrightarrow \lambda > \frac{\left(\frac{\alpha}{\sigma-1} - \gamma\theta_{K^*} + \gamma\theta_K\right)L\alpha - \gamma\theta_K\rho(\sigma-\alpha)}{\left(\frac{\alpha}{\sigma-1} - \gamma\left(\theta_{K^*} + \theta_K\right)\right)L\alpha}$$

Finally, the role of the importance of services for the representative consumer is ambiguous. Surely, when intersectoral spillovers are perfectly localized ($\theta_{K^*} = 0$), the more agents care about services, the higher the probability of a dynamic loss for the periphery. However, when θ_{K^*} is sufficiently close to θ_K, the effect of an increase in the importance of service is reversed: inf this is the case, when γ is high, the periphery enjoys faster growth of real income with respect to symmetry[18].

5 Conclusions

A well established result in the NEGG literature is that, In presence of intertemporal localized knowledge spillovers in the innovation sector, policy makers face a trade off between equity and efficiency. If the industrial pattern is scattered, and the income distribution is therefore even, equity requirements are satisfied but the aggregate growth of real income is minimized. By contrast if industry and innovation are clustered the real growth rate is maximized, favouring both the core and the periphery. This dynamic gain counterbalances (and being dynamic, at some point overcomes) the static loss suffered by the south due to the lower permanent income levels and to the trade costs on varieties that have to be imported from the north. Hence agglomeration is undoubtedly welfare enhancing for both regions.

In our paper, we have challanged these results. By introducing intersectoral localized knowledge spillovers between innovation and the newly added services sector (a deviation which is supported by empirical works), we have shown that the growth effect of agglomeration is more puzzling. In particular, our main findings were the following: 1) regional growth rates of real income always diverge in the core-periphery outcome, being higher in the industrialized region; 2) the aggregate growth rate of real income is higher when the spatial distribution of economic activities is even provided that the degree of knowledge spillovers enjoyed by the innovation sector is sufficiently high; 3) the periphery might suffer a dynamic loss from agglomeration provided that the degree of knowledge spillovers enjoyed by the innovation sector is sufficiently high.

Considering the appeal that NEG theoretical statements have on (european) policy-makers, we believe these results have strong policy implications. In particular, our results suggest policy rules which, in some cases, are opposite from those suggested by the commonly accepted models like Martin (1999) and Baldwin et. al (2001): concentrating economic activities in only one region may be welfare-harming for both the less industrialized region *and* at the aggregate level

[18] A rise in the importance of services will make the periphery more likely to lose from agglomeration if $(\theta_K - \theta_{K^*})\, g\left(\frac{1}{2}\right) < \theta_{K^*} g\,(1)$.

Appendix

Let's compute the law of motion for expenditure in the north. We start from the expression for the capital replacement cost in the north:

$$F = wa_I = \frac{1}{AK^w} = \frac{1}{(K + \lambda K^*)}$$

By time differentiation we have:

$$\dot{F} = -\frac{\dot{K} + \lambda \dot{K}^*}{(K + \lambda K^*)^2}$$

Now, using equations (1) and (4):

$$\dot{K} = \frac{L_I A}{s_K} K$$

$$\dot{K}^* = \frac{L_I^* A^*}{1 - s_K} K^*$$

Substituting in the expression for $\dot{F}$ we obtain:

$$\dot{F} = -\frac{1}{(K + \lambda K^*)^2} \left(\frac{L_I A}{s_K} K + \frac{\lambda L_I^* A^*}{1 - s_K} K^* \right) = -\frac{K^w}{(K + \lambda K^*)^2} \left(L_I A + \lambda L_I^* A^* \right)$$

As we know labour in the I-sector is equal to the value of investments (i.e. income minus expenditure) so it is given respectively in each region by:

$$L_I A = LA + \pi K A - EA = LA + \frac{E^w}{\sigma} B s_K A - EA$$

$$L_I^* A^* = LA^* + \frac{E^w}{\sigma} B^* (1 - s_K) A^* - E^* A^*$$

Moreover we know that:

$$A = s_K + \lambda (1 - s_K) = \frac{K + \lambda K^*}{K^w}$$

$$A^* = \lambda s_K + (1 - s_K) = \frac{\lambda K + K^*}{K^w}$$

Thus we can write:

$$\frac{\dot{F}}{F} = -L (1 + \lambda) \frac{(\lambda K + K^*)}{(K + \lambda K^*)} + \lambda E^* \frac{(\lambda K + K^*)}{(K + \lambda K^*)} + E - \frac{E^w}{\sigma} \left(B s_K - \lambda B^* (1 - s_K) \frac{(\lambda K + K^*)}{(K + \lambda K^*)} \right)$$

By substituting this last expression first in the no-arbitrage condition (equation (11)) and then in the Euler equation (equation (10)) we finally have:

$$\frac{\dot{E}}{E} = \frac{E^w}{\sigma} \left(AB - B s_K - \lambda B^* (1 - s_K) \frac{(\lambda K + K^*)}{(K + \lambda K^*)} \right) - L \left(1 + \lambda \frac{(\lambda K + K^*)}{(K + \lambda K^*)} \right) + \lambda E^* \frac{(\lambda K + K^*)}{(K + \lambda K^*)} + E - \rho$$

The expression for the south is symmetric:

$$\frac{\dot{E}^*}{E^*} = \frac{E^w}{\sigma}\left(A^*B^* - \lambda B^*\left(1-s_K\right) - Bs_K\frac{(\lambda K + K^*)}{(K+\lambda K^*)}\right) - L\left(1+\lambda\frac{(\lambda K + K^*)}{(K+\lambda K^*)}\right) + \lambda E^*\frac{(\lambda K + K^*)}{(K+\lambda K^*)} + E - \rho$$

Concerning the law of motion of the capital location, from equation (17):

$$\dot{s}_K = s_K\left(1-s_K\right)\left(g-g^*\right)$$

We then substitute equations (1) to (4) in order to find:

$$\dot{s}_K = s_K\left(1-s_K\right)\left(\frac{L_I a_I}{s_K} - \frac{L_I^* a_I^*}{1-s_K}\right)$$

Given the expressions for labour in the I-sector:

$$L_I = L + \pi K - E = L + \frac{E^w}{\sigma}Bs_K - E$$

$$L_I^* = LA^* + \frac{E^w}{\sigma}B^*\left(1-s_K\right) - E^*$$

We finally find:

$$\dot{s}_K = \left(\left(1-s_K\right)\left(L + \frac{E^w}{\sigma}Bs_K - E\right)A - s_K\left(L + \frac{E^w}{\sigma}B^*\left(1-s_K\right) - E^*\right)A^*\right)$$

The dynamic of our model is then described by three differential equations. We have two Euler equations (one for each region) representing the evolution of expenditure and another equation representing the evolution of capital location:

$$\frac{\dot{E}}{E} = \frac{E^w}{\sigma}\left(AB - Bs_K - \lambda B^*\left(1-s_K\right)\frac{(\lambda K + K^*)}{(K+\lambda K^*)}\right) - L\left(1+\lambda\frac{(\lambda K + K^*)}{(K+\lambda K^*)}\right) + \lambda E^*\frac{(\lambda K + K^*)}{(K+\lambda K^*)} + E - \rho$$

$$\frac{\dot{E}^*}{E^*} = \frac{E^w}{\sigma}\left(A^*B^* - \lambda B^*\left(1-s_K\right) - Bs_K\frac{(\lambda K + K^*)}{(K+\lambda K^*)}\right) - L\left(1+\lambda\frac{(\lambda K + K^*)}{(K+\lambda K^*)}\right) + \lambda E^*\frac{(\lambda K + K^*)}{(K+\lambda K^*)} + E - \rho$$

$$\dot{s}_K = \left(\left(1-s_K\right)\left(L + \frac{E^w}{\sigma}Bs_K - E\right)A - s_K\left(L + \frac{E^w}{\sigma}B^*\left(1-s_K\right) - E^*\right)A^*\right)$$

These equation are identical to those who caracherize the stability of the system in Baldwin et. al (2001). Hence, we have demonstrated that the introduction of services will not affect the stability of the locational equilibria.

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