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IS AGGLOMERATION REALLY GOOD FOR GROWTH? GLOBAL EFFICIENCY, INTERREGIONAL EQUITY AND UNEVEN GROWTH

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Is Agglomeration *really* good for Growth? Global Efficiency, Interregional Equity and Uneven Growth*

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Abstract

According to NEG literature, spatial concentration of industrial activities increases growth at the regional and aggregate level without generating regional growth differentials. This view is not supported by the data. We extend the canonical model with an additional sector producing non-tradable goods which benefits from localized knowledge spillovers coming from the R&D performing industrial sector. This view, motivated by the evidence, generates both an anti-growth and a pro-growth effect of agglomeration for both the deindustrializing and the industrializing regions and leads to two novel results: 1) when agglomeration takes place, growth is lower in the periphery; 2) agglomeration may have a negative effect on the growth rate of real income, *both* at the regional *and* at the aggregate level. Our conclusions have relevant policy implications: contrary to the standard view, current EU and US regional policies favouring industrial dispersion might be welfare-improving both at the regional *and* the aggregate level and may reduce regional income disparities.

Key words: agglomeration; aggregate real growth; regional real growth; interregional equity; non-tradables; localized knowledge spillovers.

JEL Classifications: R10, O33, O41

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1 Introduction

An important aspect of new economic geography literature is the direct link between theoretical results and regional policy rules. One of the policy implications that can be drawn from some of these models (surveyed by Baldwin *et al.* (2004)) is particularly surprising at first sight: it is possible to increase the long-run aggregate economic growth and at the same time, leave it uniform across regions by promoting policies aimed at favouring the agglomeration of the increasing-return sector activities in only one region. This conclusion is shared by many works belonging to a research programme - which we will dub as New Economic Geography and Growth (NEGG) - emerged in the late 1990s and inaugurated by Martin and Ottaviano (1999), who were the first to add endogenous growth features *à la* Romer (1990) to a version of the Krugman (1991) core-periphery model.

This rather optimistic view stems from the lack of any anti-growth effect of agglomeration for both the industrializing and the deindustrializing region. On the one hand, spatial concentration is good for growth because of localized intertemporal knowledge spillovers within the innovating sector: when the spatial range of knowledge spillovers from the R&D activity is limited in space, concentrating the industrial sector in only one region will minimize the cost of innovation and, then, maximize overall growth. This implies that regional policies favouring industrial dispersion, for instance improving infrastructures in the poor region in order to attract firms, may not generate the equilibrium firms' allocation most favorable to aggregate growth. Hence, policy makers may be forced to choose between supporting lagging regions and promoting growth at the national level (Martin 1999). On the other hand, although when agglomeration takes place knowledge capital stock grows at different rates in the two regions, regional real incomes *always* grow at the same rate so that real growth rate differential is nil whatever the degree of agglomeration. The reason is a "terms of trade effect". 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 - agricultural good - increases overtime, making the periphery's imports of manufacturing goods cheaper. As a result, the real income of the periphery grows at the same rate as the core[1]. Remarkably, these results are are unaffected by changes in factors mobility[2].

Unfortunately, the empirical evidence does not support these predictions. Brühlart and Sbergami (2009) investigate the impact of within-country spatial concentration of economic activity on country-level growth. They find evidence that supports the so-called "Williamson hypothesis" (Williamson, 1965) according to which agglomeration boosts growth only up to a certain level of economic development[3]. The trade-off between growth and inter-regional equality may then gradually lose its relevance as the economy continues to grow. Henderson's (2003) analysis of the impact of urbanization on growth is also supportive of the Williamson hypothesis: he finds that urbanization *per se* has no significant growth-promoting effect, but that urban primacy (the share of a country's largest city) is good for growth in low-income countries.[4] As for regional growth differentials, the increasing regional disparities within European countries, which followed the spatial concentration trend during the 80s, is a widely accepted stylized fact (Puga, 2002). Moreover, a relevant number of works (Gardiner *et al.* (2004), Giannetti

[1] 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.

[2] The absence of trade-off between aggregate growth and interregional equity and the absence of regional real growth differentials are confirmed either when capital is assumed to be interregionally mobile (as in Martin and Ottaviano (1999) or Martin (1999)) or when it is assumed to be interregionally immobile (as in Baldwin *et al.* (2001), Bellone and Maupertuis (2003)) and either when labor is mobile between regions (as in Baldwin and Forslid (2000) and Fujita and Thisse (2003)) or when it is not (as in all the other cited papers).

[3] Roughly the current per-capita income level of Brasil and Bulgaria.

[4] Also Henderson *et al.* (2001) and Sbergami (2002) do not support the growth-promoting effect of agglomeration.

(2002), Paci and Pigliaru (2002) among others) show that western EU regions exhibit divergence in real growth rates and this divergence reduces the aggregate growth rate in some countries (like Italy and France).

In this paper we show that NEG theory might still be able to account for such evidence once non-tradable products are introduced in the analysis. As is well known, the largest share of GDP in middle and high income countries is, by far, represented by the production of *non-tradable goods*. Despite its importance in the world economy, NEG literature has never dedicated particular attention to this category of products. Yet, non tradable goods have an exclusive characteristic which should be of interest for any location theory of economic activity: unlike most industrial and agricultural goods, they cannot be consumed (too) far away from the location where they are produced. This fact is rich in consequences if there is any kind of local interdependency between the non-tradable sector and the rest of the economy.

We explore this possibility by building a model which extends the literature along the following lines: we add an additional sector producing non-tradable products (call it "services") whose productivity benefits from a positive externality coming from the local and, to a lesser extent, from the foreign stock of knowledge capital. This externality might be justified in several ways but the most natural way to do it is to assume that - beside the industrial sector - also the non-tradable sector may enjoy *localized intersectoral knowledge spillovers* from the R&D output. By generating an additional pro-growth effect and a novel anti-growth effect of agglomeration for both the deindustrializing *and* the industrializing region, the introduction of such sector leads to two novel results: 1) regional growth rates of real income differ when agglomeration takes place, being lower in the periphery; 2) agglomeration may have a negative effect on the growth rate of real income, *both* at the regional *and* at the aggregate level.

The first result introduces the possibility of ever-increasing regional disparities and occurs because firms have no incentive to invest in knowledge in the deindustrializing region. As a consequence, because of localized intersectoral knowledge spillovers, peripheral consumers enjoy a slower decrease in the price of the non-tradable goods since, by definition, their regional price dynamics follow different paths.

The second result means that agglomeration might be bad for growth for the periphery, the core and at the aggregate level. In particular, the economy as a whole might suffer a dynamic loss from agglomeration, meaning that aggregate growth and interregional equity do not necessarily conflict. That happens when: 1) the spatial range of the intrasectoral spillovers within the R&D sector, 2) the strength of the external benefit of local and foreign knowledge capital on non-tradable sector productivity and 3) the expenditure share of non-tradable goods are *all* large enough. When these conditions hold true, the loss of productivity suffered by the deindustrialized region (and possibly but less likely by the industrialized region) is not compensated, at the aggregate level, by the reduced cost of innovation due to higher spatial concentration of knowledge capital. Therefore, aggregate real growth is lower when industrial agglomeration takes place.

If we consider that the stylized facts on structural change (Kuznets 1973, Buera and Kaboski 2009) and on the technology of knowledge diffusion (Baldwin *et al.*, 2001, Keller 2002) suggest that all these parameters increase as the economy reaches more advanced stages of development, then our model offers a natural mechanism to reduce the gap between theory and data, particularly in advanced countries.

From the policy perspective, an interesting application of our model is given by the current European Regional Policies. As clearly stated in official documents of the EU Commission, the explicit goal of EU regional policy appears to be not simply to redistribute income between rich and poor regions, but to attract production to peripheral locations[5]. This goal is all the more confirmed by the fact that a

[5]Consider, for instance, the Second Cohesion Report: "The Treaty [of the European Community], by making explicit the aim of reducing disparities in economic development, implicitly requires that EU policies, and cohesion measures in particular, should influence factor endowment and resource allocation and, in turn, promote economic growth. More

substantial share of the budget of EU regional policies (which by themselves amount to one third of the total EU budget), consists of direct or indirect subsidies to private firms located in poor regions (Dupont and Martin 2006). We believe that our results might have important consequences for policy makers: if we accept that the presence of a non-tradable sector which benefits from the local innovating sector (e.g.: innovating and financial services, health, education, military services, technical support, IT services, retail, communications, real estate and housing) is a realistic feature of the economy, then policies that favor agglomeration may generate ever-increasing regional inequalities and may be detrimental to overall growth. In our paper we formalize the conditions under which pro-dispersion policies are good for aggregate real growth. In other words, while other NEGG works raise relevant doubts regarding the efficiency of EU regional policies, we provide a theoretical framework where EU policies might be justified on the basis of both equity and efficiency arguments. In doing so, we also provide a candidate explanation for the recent empirical findings by Busillo *et al.* (2010) who show, using a regression discontinuity design approach, that Cohesion policies have had a positive growth effect on EU poorest regions.

The paper will proceed as follows: in section 2 we present the analytical framework and provide empirical motivation for our key assumptions. Section 3 is dedicated to the stability analysis of locational equilibria. Section 4 develops the analysis of regional and aggregate real growth while section 5 analyses in detail the trade-off between global efficiency and interregional equity. Finally, section 6 concludes.

2 The Analytical Framework

2.1 The Structure of the Economy

We assume two symmetric regions in terms of technology, preferences, transport costs and initial endowments. Each region is endowed with two production factors: labor L and capital K. Four production sectors are active in each region: modern (manufacture or industrial) M, traditional (agriculture) T, a capital producing sector I and a service producing sector S. Labor is assumed to be immobile across regions but mobile across sectors within the same region. The traditional good is freely traded between regions, manufactures are subject to iceberg trade costs, while services cannot be traded at all. For the sake of simplicity, we will mainly focus on the Northern region[6].

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 so that producing a variety requires a unit of knowledge interpreted as a blueprint, an idea, a new technology, a patent, a machine or even a particular entrepreneurial skill. 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 rate of capital, w_M is the wage rate in the $M-$sector and a_M are the units of labor necessary to produce a unit of output x_i.

Each region's K is created by its I-sector which produces one unit of K with a_I units of labor. 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 capital unit in equilibrium is also the fixed cost F of the manufacturing sector. As one capital unit 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^* the number of

specifically, cohesion policies are aimed at increasing investment to achieve higher growth and are not specifically concerned either with expanding consumption directly or with redistribution of income"(EU Commission (2001), p. 117).

[6]Unless differently stated, the Southern expressions are isomorphic.

firms located in the North and South respectively. As one capital unit per firm is required 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 (as in Martin and Ottaviano, 1999), a capital unit may be produced in one region but the firm that uses this capital unit may be operating in another region. Hence the number of firms located in one region is generally different from the stock of capital owned by this region: n (n^*) needs not equal K (K^*). In this case, K is better interpreted as physical capital (mobility then means delocation of plants) or codified knowledge capital tradable through patents. By contrast, when capital is immobile, as in Baldwin *et al.* (2001), each firm operates - and its owner spends his profits - in the region where the capital unit has been created. If this is the case, we 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. This second case, is more consistent with the interpretation of K as tacit embodied knowledge capital or human capital. In this case, labor immobility implies capital immobility. Remarkably, our growth analysis encompasses both cases and our main results are unaffected by assumptions on capital mobility.

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 local. Specifically, these spillovers are localized in the sense that the cost of R&D in one region also depends on the stock of knowledge capital (one unit for each firm) *located* in the same region. Hence, the northern cost of innovation is more affected by knowledge capital units located in the North than in the South so that the cost of innovation can be expressed as:

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

where $A \equiv s_n + \lambda (1 - s_n)$, $0 < \lambda < 1$ measures the degree of globalization of learning spillovers. The southern cost function is isomorphic, that is, $F^* = w_I^*/n^w A^*$ where $A^* = \lambda s_n + 1 - s_n$.

The growth rates of knowledge capital operating in the North and in the South are then:

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

The structure of the traditional sector is very simple. It produces a homogeneous good in perfect competition and constant returns to scale. By choice of units, one unit of T is made with one unit of L.

We will now describe the production structure of the non-tradable sector, the S-sector. Given the strong implication of this assumption, a thorough discussion of its implications and scope of application will be developed in section 2.4. However, as far as our aims are concerned, our non-tradable sector might be formally represented 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 labor necessary to produce one unit of output. Its production function is very similar to that of the innovation and traditional sectors:

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

where S is the quantity of services produced in the North and L_S is the labor force devoted to the production of services. Moreover $a_S(\cdot)$ represents the labor units requirements per unit of production and $S-$firms take it as given.

Firms' optimization implies the following pricing rule:

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

where the price depends on the wage rate and labor requirements. Given non-tradability, S-goods can only be consumed in the region where they are produced. Hence, regional prices need not equalize.

Even if it is not our aim to provide a microfoundation analysis of the aforementioned external effect, we believe that the most natural justification is to consider it as a form of *localized intersectoral knowledge spillover*. The intersectoral spillovers between R&D and services are introduced as a natural extension of the intrasectoral spillover within the innovation sector. More precisely, we assume that :

$$a_S(\cdot) = a_S(n, n^*) ; a_S^*(\cdot) = a_S^*(n, n^*) \tag{7}$$

with:

$$\frac{\partial a_S(n, n^*)}{\partial n}, \frac{\partial a_S(n, n^*)}{\partial n^*}, \frac{\partial a_S^*(n, n^*)}{\partial n}, \frac{\partial a_S^*(n, n^*)}{\partial n^*} < 0 \tag{8}$$

so that, as for the innovation good, the production cost of non-tradables is negatively affected by an increase in the stock of knowledge capital (e.g. the amount of blueprints, which are the cumulative output of the innovating sector) used by firms located in any of the two regions (n or n^*). However, as already said, intersectoral knowledge spillovers are *localized* in the sense that the cost reduction is not smaller, and generally larger, when knowledge is spilled from the stock located in the same region:

$$|\theta_n(n, n^*)| \geq |\theta_{n^*}(n, n^*)|, \forall (n, n^*) \tag{9}$$

$$|\theta_{n^*}^*(n, n^*)| \geq |\theta_n^*(n, n^*)|, \forall (n, n^*) \tag{10}$$

where

$$\begin{bmatrix} \frac{\partial a_S(n,n^*)}{\partial n}\frac{n}{a_s(n,n^*)} & \frac{\partial a_S(n,n^*)}{\partial n^*}\frac{n^*}{a_s(n,n^*)} \\ \frac{\partial a_S^*(n,n^*)}{\partial n}\frac{n}{a_s^*(n,n^*)} & \frac{\partial a_S^*(n,n^*)}{\partial n^*}\frac{n^*}{a_s^*(n,n^*)} \end{bmatrix} \equiv \begin{bmatrix} \theta_n(n, n^*) & \theta_{n^*}(n, n^*) \\ \theta_n^*(n, n^*) & \theta_{n^*}^*(n, n^*) \end{bmatrix} \tag{11}$$

is the matrix of the elasticities of labor units requirements of the $S-$sector with respect to both local and foreign knowledge capital (*spillover matrix* from now on). It is important to highlight that the case of *global* intersectoral knowledge spillovers is therefore just a particular case of localized spillover, i.e., when (9) and (10) hold with equality. As we will see, regional and aggregate growth patterns differ widely according to whether intersectoral knowledge spillovers are global or local.

Since regions are symmetric in terms of technology, we assume a symmetric spillover matrix:

$$\begin{cases} \theta_n(n, n^*) = \theta_{n^*}^*(n, n^*) < 0 \\ \theta_{n^*}(n, n^*) = \theta_n^*(n, n^*) < 0 \end{cases} \forall (n, n^*) \tag{12}$$

Remarkably, at this stage we do not need to specify an explicit functional form for the cost parameters $a_S(n, n^*)$ and $a_S^*(n, n^*)$. However, we emphasize that, in order for the growth rate of *real* income to be constant in both regions, the above elasticities should be constant.

2.2 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-lived representative agent is then given by:

$$U_t = \int_{t=0}^{\infty} e^{-\rho t} \ln(C_M^{\alpha} C_T^{\beta} C_S^{\gamma}) dt \quad ; \quad \alpha + \beta + \gamma \quad = \quad 1 \tag{13}$$

$$C_M = \left[\int_{i=0}^{K+K^*} c_i^{1-1/\sigma} di \right]^{\frac{1}{1-1/\sigma}} \tag{14}$$

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[7]. As a result of the intertemporal optimization program, the path of consumption expenditure E across time is given by the standard Euler equation $\frac{\dot{E}}{E} = r - \rho$ with the interest rate r satisfying the no-arbitrage-opportunity condition between investment in the safe asset and capital accumulation $r = \frac{\pi}{F} + \frac{\dot{F}}{F}$, 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:

$$\max_{C_M, C_T, C_S} \ln\left(C_M^{\alpha} C_T^{\beta} C_S^{\gamma}\right) \tag{15}$$
$$s.t.\ E = P_M C_M + p_T C_T + p_S C_S$$

Yielding the following demand functions[8]:

$$C_M = \alpha \frac{E}{P_M}; C_T = \beta \frac{E}{p_T}; C_S = \gamma \frac{E}{p_S} \tag{16}$$

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

Finally, in the third stage, the M-good 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.

2.3 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 labor as numeraire so that $p_T = p_T^* = w_T = w_T^* = 1$.

Since labor is mobile across sectors, 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 so that[9] $w_M = w_M^* = w_T = w_T^* = w_S = w_S^* = w = 1$. Finally, since wages are uniform and all varieties' demands have the same constant elasticity σ, firms' profit maximization yields local and export prices

[7]In our model, services are not differentiated and therefore there is no love for variety as in Leite et al. (2013). The introduction of a Dixit-Stiglitz services sector in a dynamic context raises interesting questions related to the interaction of innovation activities in manufacturing and services but it would also unnecessarily obscure the mechanism we have in mind. We leave the investigation of the consequences of a Dixit-Stiglitz services sector to future research.

[8]Our model, as most of the NEGG literature, assumes a unitary elasticity of substitution among goods. Hence, expenditure shares are always exogenous and are not affected by relative prices or income. Since one of our key parameter is the share of expenditure in services, it would be interesting to endogenize the latter quantity. This could be done in several ways. A first way is to combine Manufacture, Traditional and Services goods in a CES utility function with non-unitary elasticity of substitution, alike Cerina and Mureddu (2012) who introduce it in the second step of the consumer's optimization program (without services). A second route to follow would be to introduce a non-tradable good into a Stone-Geary utility used by Murata (2008) and Cerina and Mureddu (2013). In both cases, the expenditure share in services will be ultimately affected by trade costs and the spatial distribution of firms.

[9]See Bellone and Maupertuis (2003) for the analytical implications of removing this assumption in a NEGG model without a non-tradable sector. An unpleasant consequence of this assumption is that in our setup when regional wages are equalized, the price of services decreases faster, and becomes permanently lower, in the core. This assumption may look against the evidence according to which (Bhagwati, 1984a among the others) services are cheaper in less industrialized countries. This is true even for housing which is undoubtedly much cheaper in the periphery than in the core because of higher land prices due to large demand density and (almost) fixed supply. However, apart from the agglomeration effect, one reason why non-tradables are more expensive in the core is because the quality of services is higher in more industrialized economies. If we interpret p_s as the price of service per unit of quality, then the implication of our assumption may look less counterintuitive. Second, as far as our aim is concerned, we should not worry too much about the agglomeration effect on non-tradables price. The agglomeration effect on price is a level effect in that it works through a variable (s_n) which is

that are identical for all varieties no matter where they are produced: $p = wa_M \frac{\sigma}{\sigma-1}$. Then, by imposing the normalization $a_M = \frac{\sigma-1}{\sigma}$ we finally have: $p = w = 1$.

As usual, since trade in M is costly, 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 indices might be expressed as follows:

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

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

where $\phi = \tau^{1-\sigma}$ is the so called "phi-ness of trade" which ranges from 0 (no trade) to 1 (costless trade).

2.4 Discussion: the non-tradable sector

As will be clear later, the introduction of a non-tradable sector whose productivity benefits from the proximity of the stock of knowledge capital created by the R&D sector is rich in implications in NEGG models. In this section we aim at giving more empirical content to its formal description.

A good starting point is offered by the literature on service innovation and structural change. In particular, the works by Castellacci (2008, 2010) present and demonstrate the usefulness of a new sectoral taxonomy combining manufacturing and service industries within the same framework.

The taxonomy is built up by focusing on two main characteristics of industrial sectors - the function they assume in the economic system as providers and/or recipients of advanced products, services and knowledge and the dominant innovative mode that characterizes their technological activities - and identifies 4 main groups: 1) Advanced knowledge providers (AKP); 2) Supporting infrastructural services (SIS); 3) Mass-production goods (MPG); 4) Personal goods and services (PGS). The first group AKP - including both manufacturing (specialized suppliers of machinery, equipment and precision instruments) and services (Software, R&D, engineering and consultancy) - may resemble our I-sector given the high level of technological capability and its function in the innovation system as a provider of advanced technological knowledge to other industrial sectors. The third group MPG - including chemicals, office machinery, rubber plastic and fabricated metal products - might be easily included in our M-sector with the exception that the goods which are meant to be produced within this macro-sector might be used both as intermediate inputs and as final consumer goods, while our model does not take into account intermediate products. But for our purposes, a major interest should be addressed to the characteristics of the second and the fourth groups.

SIS includes both physical (wholesale trade and commission trade; land, water and air transport) and network infrastructures (post and telecommunications, financial intermediation), are defined as producers of both intermediate and final consumption services and "differ from advanced knowledge providers in terms of their technological capability, especially regarding their more limited ability to develop new knowledge internally. Their innovative trajectory tends to be based on the acquisition of machinery, equipment and various types of advanced technological knowledge created elsewhere in the economic system.(...) Firms in the latter group typically make heavy use of ICTs developed by other advanced sectors in order to increase the efficiency of their productive process and the quality of their services"

constant in steady state. However, our spillover mechanism involves a growth effect as it works through variables (n and n^*) which may (or may not) grow at rate g in equilibrium. Hence, even by taking into account the agglomeration effect on prices, our dynamic spillover mechanism on prices will be preserved in the long-run.

(Castellacci 2008 p.985). Finally, PGS, which includes both supplier-dominated goods (e.g. food and beverages, textiles, furniture among the others) and supplier-dominated services (e.g. sales, maintenance and repair of motor vehicles, hotels and restaurants) are located at the final stage of the vertical chain, being characterized by a lower technological content and a more limited ability to develop new products and processes internally. Moreover, the dominant innovation strategy of this macro-sector "is typically based on the acquisition of machinery, equipment and other types of external knowledge produced by their suppliers, while they commonly lack the capability and resources to organize and maintain their own R&D labs" (*ibid.*) and are mostly recipients of advanced knowledge. Finally, to the extent that they are able to implement new technologies created elsewhere in the economy, they may use them to increase the efficiency of the production process as well as to improve the quality of the final goods and services they commercialize.

As far as the *final* services are concerned - i.e. with the exclusion of the intermediate service in SIS and of the supplier-dominated goods in PGS - these two macro-sectors seem to fit the formalization of our S-sector as they share its two crucial features: 1) they mainly produce non-tradable goods (i.e.: they require the physical proximity between the producer and the consumers); 2) they usually have limited capability to develop internal technological knowledge with their own R&D labs and thereby bear the necessity to drain knowledge from other sectors (AKP and MPG) in order to increase their productivity[10]. We have then identified, albeit broadly, the kinds of services which are meant to be part of our S-sector: those are services devoted to final consumption (entering the utility function) such as physical infrastructures (like wholesale trade, land, water and air transport, etc.), network infrastructures (post and telecommunications, financial intermediation, etc.) and personal services (like sales, maintenence and repair of motor vehicles, health services, social care, hotels and restaurants but even public services). To these products we need to add an important sector which is not generally considered a service sector per se but which is nevertheless highly non-tradable: housing and constructions.

Are these sectors important in actual economies? And are these goods really non-tradable? And, finally, to what extent is the assumption of localized knowledge spillovers from knowledge-producing sectors to services appropriate? The next two subsections aim at providing an answer to these questions.

2.4.1 Non-tradability

As is well known, the largest share of GDP in middle and high income countries is, by far, represented by the production of non-tradable goods. According to OECD data, the share of non-tradable goods (identified, following the literature, as services and construction) reaches about 70 percent in middle income countries like Turkey, Brazil, Russia and Mexico and often surpasses 80 percent in high-income countries like USA, UK, Italy, France and Germany. Moreover, and consistently with the literature on structural change (Buera and Kaboski 2009 among many others), this share has tremendously increased over the past 40-50 years and it is still increasing especially in middle income countries.

Traditionally, services have been regarded as intangible and their consumption indivisible from their production. Consequently they have been considered non-tradable. On the other hand, one might observe (as Blinder (2005)) that the enormous progress in ICT has led to a situation in which a relevant share of services (essentially business related like IT services and consultancy) can be - and will increasingly be in the future - interregionally and internationally traded.

[10]Obviously we concede that services might have an impact on the productivity of other sectors (Guerrieri and Meliciani (2005), and Castellacci (2008, 2010). The implications of a bi-directional interdepedency between Services and Manufacturing are very interesting, especially in the theoretical context of the New Economic Geography. However our focus in this paper is confined to *final* consumer services (Supporting infrastructural services and personal services) in which, as stated by Castellacci (2008, 2010) himself, the direction of knowledge linkages goes essentially from industry to services. We leave the analysis of the implications of the role of intermediate knowledge-intensive services to our future research

However, according to world bank data (World Bank 2007), although the share of internationally traded services over GDP has increased from 1990 to 2005 at about the same rate as manufacturing goods, such share is still about six times smaller that the latter (10 vs. 60% as world average). International trade in services is even smaller, relative to manufactures, when we measure it as the share of each sector's GDP which, in the case of services, is more than 3 times the sectoral GDP of manufacturing in most countries. Moreover, as highlighted by Guerrieri and Meliciani (2005), international trade in services grew essentially in the sub-group of intermediate producer services which is not the focus of our paper as our mechanism only involves final demand of consumer services.

For all those reasons, considering the service sector as a basically non-tradable sector still appears to be a good approximation of reality and the fact that other growing sectors like housing and real estate are intrinsically non-tradable suggests that the existence of a massive category of non-tradable final goods is still - and will remain - a significant feature of real economies.

Despite its importance, and quite surprisingly, NEG literature has never dedicated particular attention to this category of products[11], especially when growth issues are taken into account. Yet, non-tradable goods and services have an exclusive characteristics which should be of interest for any theory of economic activity location: they cannot be consumed (too) far away from the location where they are produced.

In other words, by definition, local consumption of non-tradable goods implies local production and vice-versa so that

any loss in the productivity of local non-tradable sector will 1) negatively affect the prosperity of local individuals only and 2) negatively affect the average performance of the whole economy. This fact is rich in consequences if there is any kind of interdependency between the local non-tradable sector and the stock of knowledge employed locally. In what follows we discuss and explore this possibility.

2.4.2 Localized Intersectoral knowledge spillovers

Our assumption of intersectoral spillovers may be grounded on at least two different arguments.

First, as already anticipated, it is quite natural to extend the (widely accepted) localized knowledge spillovers enjoyed by the industrial sector within the innovation sector to the (local) service sector. On the other hand, as Martin and Ottaviano (1999) point out in their seminal NEGG paper: "in our framework, what decreases the R&D cost is not the presence of other researchers but the presence of producers of different goods. From that perspective, our formalization of external effects is closer to the Jacobs' type of knowledge spillovers than to the so-called Marshall—Arrow—Romer (MAR) ones. In our model, the mechanism for agglomeration of R&D activities in one location will come from the benefit of interactions with producers of other goods, the Jacobs type of external effect, rather than producers in the same industry as in the MAR theories" (p.291). Hence, why innovation should only be restricted to manufacturing and not also generate pure externalities to the non-traded sector?

In this respect, we support the view according to which the local proximity of knowledge capital created for the industrial sector might be helpful to induce the local non-tradable sector to implement technological and organizational innovation which eventually have a positive effect on individuals' welfare.

Second, there are many empirical works which support the existence of such knowledge spillovers. A first support of this view can be traced back to Glaeser *et al.* (1992) in their analysis of the relationship between localized knowledge spillovers and the growth of the cities. By analyzing a data set on geographic concentration and competition of some manufacturing and service firms in 170 of the largest US cities, they find that important knowledge spillovers might occur *between* (Jacobs spillovers) rather than *within* industries (MAR spillovers).

[11] Three exceptions, without the growth dimension, are Behrens (2004), Leite et al. (2013) and Tabuchi and Thisse (2002).

Our view is also supported by van Meijl (1997) and Potì and Cerulli (2009) who find significant knowledge spillovers from industrial R&D on services like financial intermediation, computer services, transport, storage and communication. Park (2004) as well offers evidence that industrial R&D has a substantial intersectoral spillover effect on domestic non-manufacturing productivity growth while Park and Chan (1989) suggest that the intersectoral relationships between manufacturing and services generally characterize asymmetrical dependence, namely, that service activities tend to depend on the manufacturing sector as a source of inputs to a far greater extent than vice versa. A similar finding is reported by Kaiser (2002) in his analysis of a large dataset of German manufacturing and services firms (wholesale and retail trade, transport, traffic, banking, insurance, software, technical consultancy, marketing, and 'other' business related services): he finds that the probability that a service firm uses customers from the manufacturing sector as a source for innovation is much higher than the probability that a manufacturing firm uses customers from the service sector as a source of innovation.

Finally, Quella (2009) reported evidence according to which, among six large macroeconomic sectors (Manufacturing, Mining, Construction, Services, Trade & Transportation, Agriculture) covering the totality of that US civilian economy from 1948 to 1991: 1) most knowledge flows occur between industrial knowledge and the tertiary sector; 2) these knowledge flows are largely unidirectional because manufacturing is the main source of spillovers in the economy while services (and agriculture) do not contribute at all to the generation of knowledge, neither internally nor externally; 3) Agriculture is last in the ranking of the capacity of both *creating* knowledge internally and *absorb* knowledge from elsewhere in the economy. These findings are confirmed in a recent survey by Belderbos and Mohnen (2013) who report a technology flow matrix based on patent citations. As expected, the large majority of intersectoral technology flows are unidirectional from the knowledge created from hi-tech industrial sectors (essentially chemicals, industrial machines, electrical goods, medical, precision and optical instruments) to market and non-market services (like real estate, financial intermediation, post and telecommunications, defense, public administration etc.). Moreover, this paper confirms that the ability of the agricultural sector to produce new knowledge and to absorbing knowledge from other sectors is negligible.

These findings are perfectly compatible with the way we model knowledge spillovers. In particular, they offer empirical support to the assumption that neither the S nor T sectors are sources of knowledge spillovers (whether intra- or inter-sectoral), while only the S-sector (and not the T-sector) is able to take advantage from knowledge created by industrial R&D. [12]

3 Stability of Locational Equilibria

The presence of a non-tradable sector (the way we model it) does not affect the standard mechanisms of industry agglomeration in NEGG models. This is because, as suggested the by the empirical evidence, the interaction between the S-sector and the production of knowledge capital is assumed to be unidirectional: services productivity is positively affected by R&D output but *not* vice-versa. Hence, the equilibrium spatial distribution of industrial firms and its stability are totally independent from what happens in the S-sector. Remarkably, this conclusion holds either if we assume capital mobility (as in Martin and Ottaviano 1999) or capital immobility (as in Baldwin et al. 2001). And, even more importantly, the real growth implications of our deviation from the baseline models are the same whatever the assumption on

[12] There is actually another good analytical reason to abstract from knowledge spillovers enjoyed by the T-sector. Since the T-good is homogenous and freely traded, its price should be the same in both regions. Hence, if we introduced intra- or inter-sectoral spillovers from the R&D output, T-sector productivities will differ across regions since regional prices should be equal and such differences should be absorbed by regional wage differences in the T-sector. As a consequence we would be forced to give up regional wage equalization and the analysis will become too complicated.

capital mobility. Here we briefly review the elements which are key for our purposes and we refer the reader to the above papers or to Baldwin et al. (2004) for further details.

As is well known, in NEGG models the stability of the location equilibria is determined by the interaction between agglomeration forces (essentially the demand-linked effect and the localized spillovers effect) and dispersion forces (essentially the market crowding effect). Each interior equilibria (such that $0 < s_n < 1$) is stable or unstable according to whether agglomeration forces are respectively weaker or stronger than dispersion forces. By contrast, for a core-periphery allocation ($s_n = 1$ or $s_n = 0$) to be an equilibrium, agglomeration forces should be stronger in the core and weaker in the periphery so no agent living in the periphery would choose to setup or relocate a new firm there. Defining the core-periphery equilibrium this way, it implies that it is stable whenever it exists.

According to whether capital is immobile or mobile, the stability properties of locational equilibria are very different. In the first case (as in Baldwin et al. 2001) the owner of each capital unit is forced to spend her capital income in the region where he lives. As a consequence $s_n = s_K$ and this creates a linkage between s_n - the share of firms located, say, in the North - and $s_E = \frac{E}{E^w}$ - the market size or the share of global expenditure in the North which is itself a function of s_K and then of s_n. This linkage, together with the home market effect - which tells us that an increase in local market size s_E leads to a more than proportional increase in the share of local firms s_n - may create the so-called *circular causality* which leads to catastrophic agglomeration in only one region. More precisely, when the freeness of trade is low enough ($\phi \leq \phi^{cat}$), the only stable equilibrium is the symmetric one, where $s_n = 1/2$. When trade costs fall and ϕ becomes larger than ϕ^{cat}, two additional stable steady states appear and the symmetric steady state loses its stability. As ϕ becomes even larger, these two interior steady states approach the two core-periphery equilibria ($s_n = 0$ and $s_n = 1$) and when $\phi \geq \phi^{CP} = \frac{L}{L+\rho}$ they collapse to them.

When capital is mobile, things are different. Each owner of a capital unit can freely choose where to locate his firm but she will not necessarily spend its capital income in the region where his firm is located. As a consequence, s_n is generally different from s_K and so there is no demand-linked effect between the local share of firms s_n and the local share of world expenditure s_E. Hence, no circular causality is activated and catastrophic agglomeration is not possible. Moreover, each initial allocation of capital s_K leads to a stable equilibrium for industrial location s_n according to the formula

$$s_n = \frac{1}{2} + \frac{\rho}{2LA + \rho} \frac{(1+\phi)}{(1-\phi)} \left(s_K - \frac{1}{2} \right)$$

which results from the no-arbitrage condition according to which regional operating profits should be equalized. The fact that each equilibrium industrial allocation s_n is stable does not mean that a core-periphery allocation is unreachable. It is easy to see that when $\phi > \phi^{CP} = \frac{L}{L+\rho}$, then $s_n = 1$ even if $s_K = \frac{L(1-\phi)+\rho}{\rho(1+\phi)} < 1$. Hence, we can have a complete relocation of industrial firms in the North and a complete deindustrialization in the South even if some capital units are owned by southern agents.

Notice that, in both cases of capital mobility and immobility, a core-periphery allocation is a stable equilibrium for the same values of the freeness of trade, i.e. for any $\phi > \phi^{CP} = \frac{L}{L+\rho}$. This is enough to guarantee that our growth analysis is able to encompass both assumptions on capital mobility. As a matter of fact, by analogy with the commonly accepted knowledge spillovers within the innovation sector, S firms enjoy a pure externality from the stock of knowledge capital *located* in the North and not necessarily from the stock of knowledge capital owned by the North. This makes capital mobility and immobility equivalent from the viewpoint of regional real growth patterns.

Finally we emphasize that the equilibrium growth rate of world firms n^w will be constant and will either be common ($g = g^*$ in any interior equilibrium) or North's g (in the core-periphery case). By time-differentiating $s_n = \frac{n}{n^w}$, we obtain the dynamics of the share of firms located in the North:

$$\dot{s}_n = s_n (1 - s_n) \left(\frac{\dot{n}}{n} - \frac{\dot{n}^*}{n^*} \right)$$

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

4.1 The Growth Rate of Knowledge 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. Again, the derivation of g is standard and not significantly affected by the presence of a non-tradable sector. Recalling that: 1) no R&D is performed in the region where the cost of innovation is higher (and therefore where the share of firms located is less than 1/2); 2) in steady state the growth rate is either common to the two regions ($g = g^*$) or equal to North's g; and 3) the world sectoral consumers' expenditures should be equal to the sectoral value of total production, implies that the world labor market condition looks as follows both in the case of capital mobility or immobility:

$$L_T + L_T^* + L_M + L_M^* + L_S + L_S^* + L_I^* + L_I = \beta E^w + \alpha E^w \frac{\sigma - 1}{\sigma} + \gamma E^w + \frac{g}{A} \tag{19}$$

Consumers set world expenditure at the permanent income hypothesis level in steady state. That is, they consume labor income plus ρ times their steady-state wealth, $FK^w = \frac{1}{A}$. Hence $E^w = L + \frac{\rho}{A}$.

Substituting in the labor market clearing condition and considering that $L_T + L_T^* + L_M + L_M^* + L_S + L_S^* + L_I^* + L_I = 2L$, we can solve for the equilibrium value of the growth rate of capital:

$$g = \frac{2\alpha LA}{\sigma} - \frac{\sigma - \alpha}{\sigma} \rho \tag{20}$$

Again, the presence of a non-tradable sector does not affect the growth rate of capital, which is equal to the standard case. Using $A = s_n + \lambda(1 - s_n)$ and calculating the equilibrium growth rate for the symmetric ($s_n = \frac{1}{2}$) and for the core-periphery ($s_n = 1$) steady states we can easily see that agglomeration leads to a faster growth of knowledge capital:

$$g(s_n)|_{s_n=1/2} = g^*(s_n)|_{s_n=1/2} = \frac{(1+\lambda)L\alpha - \rho(\sigma - \alpha)}{\sigma} \tag{21}$$

$$g(s_n)|_{s_n=1} = \frac{2L\alpha - \rho(\sigma - \alpha)}{\sigma} \tag{22}$$

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

4.2 The Growth of Nominal and Real Income

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

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

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

Accordingly, as in Martin and Ottaviano (1999) (where $s_K \neq s_n$) and Baldwin *et al.* (2001) (where $s_K = s_n$), the growth rates of nominal income are constant for any (interior or CP) steady state: $\frac{\dot{Y}}{Y} = \frac{\dot{Y}^*}{Y^*} = 0$. Intuitively, both in the case where capital is mobile or immobile, Y and Y^* are constant because the growth of capital units 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 the spatial distribution of manufacturing firms significantly affects the aggregated and regional growth rate of *real* income once our non-tradable sector is taken into account.

To see this in detail, consider the North and South perfect price indices associated to the second stage Cobb-Douglas utility function which are given by:

$$P = \frac{P_M^\alpha p_T^\beta p_S^\gamma}{\alpha^\alpha \beta^\beta \gamma^\gamma}; P^* = \frac{P_M^{*\alpha} p_T^{*\beta} p_S^{*\gamma}}{\alpha^\alpha \beta^\beta \gamma^\gamma} \tag{23}$$

Taking logs, differentiating and considering that regional real income levels are given by $\frac{Y}{P}$ and $\frac{Y^*}{P^*}$ respectively, the two growth rates of real income, $\varphi(s_n, n, n^*)$ and $\varphi^*(s_n, n, n^*)$ are as follows:

$$\varphi(s_n, n, n^*) = \frac{\dot{Y}}{Y} - \frac{\dot{P}}{P} = -\left(\alpha\frac{\dot{P}_M}{P_M} + \beta\frac{\dot{p}_T}{p_T} + \gamma\frac{\dot{p}_S}{p_S}\right) \tag{24}$$

$$\varphi^*(s_n, n, n^*) = \frac{\dot{Y}^*}{Y^*} - \frac{\dot{P}^*}{P^*} = -\left(\alpha\frac{\dot{P}_M^*}{P_M^*} + \beta\frac{\dot{p}_T^*}{p_T^*} + \gamma\frac{\dot{p}_S^*}{p_S^*}\right) \tag{25}$$

so that, in both regions, the growth rate of real income is given by the negative of the growth rate of prices.

We know that the price of the traditional good is constant ($p_T = p_T^* = 1$). As for the price index for the manufacturing good, its value is obtained by log-differentiating (17) and (18) so that $\frac{\dot{P}_M}{P_M} = \frac{\dot{P}_M^*}{P_M^*} = -\frac{g(s_n)}{\sigma-1}$. Finally, taking into account the fact that $w_S = w_S^* = 1$, the regional prices of services are given by $p_S = a_S(n, n^*)$ and $p_S^* = a_S^*(n, n^*)$. Taking logs and differentiating we find that:

$$\frac{\dot{p}_S}{p_S} = g(s_n)\,\theta_n(n, n^*) + g^*(s_n)\,\theta_{n^*}(n, n^*) \leq 0 \tag{26}$$

$$\frac{\dot{p}_S^*}{p_S^*} = g(s_n)\,\theta_n^*(n, n^*) + g^*(s_n)\,\theta_{n^*}^*(n, n^*) \leq 0 \tag{27}$$

As we can see, unlike the previous goods, regional $S-$price dynamics may well differ as long as $\theta_{n^*}(n, n^*) = \theta_n^*(n, n^*) < \theta_n(n, n^*) = \theta_{n^*}^*(n, n^*)$ - i.e. intersectoral knowledge spillovers are localized. Furthermore, as long as the cross elasticities $\theta_{n^*}(n, n^*) = \theta_n^*(n, n^*)$ are different from zero - i.e. intersectoral spillovers are not perfectly localized - both regional $S-$price dynamics depend on both local *and* foreign growth rate of knowledge capital $g(s_n)$ and $g^*(s_n)$.

After exploiting the symmetry of the spillover matrix, we substitute all the sectoral growth rate of prices in the expressions for the regional growth rates of real income to obtain[13]:

$$\varphi(s_n, n, n^*) = \underbrace{\frac{\alpha g(s_n)}{\sigma - 1}}_{\text{M-price effect}} - \underbrace{\gamma g(s_n)\,\theta_n(n, n^*)}_{\text{Home (North) S-price effect}} - \underbrace{\gamma g^*(s_n)\,\theta_{n^*}(n, n^*)}_{\text{Foreign (South) S-price effect}} \quad (28)$$

$$\varphi^*(s_n, n, n^*) = \underbrace{\frac{\alpha g(s_n)}{\sigma - 1}}_{\text{M-price effect}} - \underbrace{\gamma g^*(s_n)\,\theta_n(n, n^*)}_{\text{Home (South) S-price effect}} - \underbrace{\gamma g(s_n)\,\theta_{n^*}(n, n^*)}_{\text{Foreign (North) S-price effect}} \quad (29)$$

These expressions represent the core contribution of our paper and deserve some comments.

First, it is important to highlight that, when $\gamma = 0$, these values collapse to the standard case described in Baldwin *et al.* (2001) and Martin and Ottaviano (1999).

Second, since all elasticities are negative, we have that the growth rate of each regional real income can be viewed as the sum of *three* non-negative distinct elements:

1. **The $M-$price effect:** this effect is represented by the term $\frac{\alpha g(s_n)}{\sigma-1}$. It is equal across regions and it is larger the farther s_n from $\frac{1}{2}$, (i.e., the more concentrated is industry in space) being maximum when $s_n = 0$ or $s_n = 1$. Hence, if this were the only one effect, as in the standard NEGG literature, *agglomeration would be good for growth both at the regional and aggregate level.*

2. **The home $S-$price effect:** this effect is represented by the term $-\gamma g(s_n)\,\theta_n(n, n^*)$ in the North and by the term $-\gamma g^*(s_n)\,\theta_n(n, n^*)$ in the South. It differs across regions as long as $g(s_n) \neq g^*(s_n)$ - i.e. in any core-periphery equilibrium or along the transitional dynamics to a new equilibrium. This effect captures the dynamic gain enjoyed by the local non-tradable sector productivity from the growth of *local* knowledge capital. As a consequence, this effect introduces an *anti-growth effect of agglomeration for the deindustrializing region* and *a pro-growth effect for the industrializing region.*

3. **The foreign $S-$price effect:** this effect is represented by the term $-\gamma g^*(s_n)\,\theta_{n^*}(n, n^*)$ in the North and by the term $-\gamma g(s_n)\,\theta_{n^*}(n, n^*)$ in the South. Again, it differs across regions as long as $g(s_n) \neq g^*(s_n)$ - i.e. in any core-periphery equilibrium or along the transitional dynamics to a new equilibrium. It is smaller than the **home $S-$price effect** as long as $|\theta_{n^*}(n, n^*)| < |\theta_n(n, n^*)|$ - i.e. intersectoral knowledge spillovers are localized. When knowledge spillovers are perfectly localized - i.e. $\theta_{n^*}(n, n^*) = 0$ - this effect is nil. It captures the dynamic gain benefited by the local non-tradable sector productivity from the growth of *foreign* knowledge capital. As a consequence, this effects introduces an *anti-growth effect of agglomeration for the industrializing region* and *a pro-growth effect for the deindustrializing region.*

In the next sections we will give an answer to the following questions:

1. Can agglomeration reduce the aggregate growth rate of real income and when?

2. Can agglomeration reduce the growth rate of real income in the *periphery* and when?

[13]One might observe that what really matters is welfare dynamics, not real income growth. However, in this case, welfare and real income always grow at the same rate in steady state. Welfare in the North is measured by the indirect utility of the representative agent which is given by $U = \ln\left(\frac{E}{P}\right)$. By differentiating it we find:

$$\frac{\dot{E}}{E} - \frac{\dot{P}}{P} = r - \rho + \varphi(s_n, n, n^*)$$

Since, as already said, $r = \rho$ in steady state, we find that also welfare growth is equal to $\varphi(s_n, n, n^*)$. Hence a benevolent social planner willing to maximize aggregate welfare growth will actually try to maximize aggregate real income growth.

3. Can agglomeration reduce the growth rate of real income in the *core* and when?
   And finally:

4. Can the regional real incomes diverge and when?

In the existing literature, the answer to all these questions is clear: "No". This rather optimistic role of agglomeration, which as we have seen is not supported by the empirical evidence, is here challenged even by the analytical point of view. As we can see, the introduction of our $S-$sector makes regional and aggregate growth patterns far more complex than in the benchmark model. We will identify the conditions under which the answer to each of the previous questions is "yes"or "no". We will start by answering the fourth question.

4.3 Divergence of regional real incomes

As already anticipated, although when agglomeration takes place knowledge capital stock may grow at different rates in the two regions, in standard NEGG models regional real incomes *always* grow at the same rate for any allocation of firms, due to a "terms of trade effect". Thanks to technological progress in the industrial sector, the price index of manufacturing goods decreases faster than the price of agricultural goods. This implies that the relative value of the commodity which the periphery specializes in — traditional goods — increases over time 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 as that of the core. This figure changes dramatically when the interaction with our S - sector is taken into account. As we have seen, $g(s_n) = g^*(s_n)$ in any interior equilibria, hence:

$$\varphi(s_n, n, n^*) = \varphi^*(s_n, n, n^*) = g(s_n)\left(\frac{\alpha}{\sigma - 1} - \gamma\left(\theta_n(n, n^*) + \theta_{n^*}(n, n^*)\right)\right), \forall s_n \in (0, 1) \qquad (30)$$

Then, in any interior equilibrium allocation, there is no gap in the regional rate of growth of real income. Moreover, since the real growth rate depends on the location of industry only through $g(s_n)$, and we know that $g(\cdot)$ is increasing (decreasing) in s_n when $s_n > (<) \frac{1}{2}$, the positive relation between agglomeration and growth is confirmed too. Things are significantly different in the core-periphery allocation which, both in the case of capital mobility or immobility, turns out to be a stable equilibrium for any $\phi > \phi^{CP}$. Let's concentrate on $s_n = 1$ (the case $s_n = 0$ can be easily deduced being perfectly symmetric to the former). In this case we have that $g(1) > g^*(1) = 0$ so that the Southern service sector cannot benefit from productivity growth due to the local component of intersectoral spillovers. Therefore, there is a permanent positive gap between growth in the Northern and Southern real income given by:

$$\varphi(1, n, n^*) - \varphi^*(1, n, n^*) = \gamma g(1)\left(\theta_{n^*}(n, n^*) - \theta_n(n, n^*)\right) > 0 \qquad (31)$$

This proves the following

Proposition 1 *(Real growth differentials between regions) When intersectoral knowledge spillovers are localized - i.e.* $|\theta_{n^*}(n, n^*)| < |\theta_n(n, n^*)|\ \forall (n, n^*)$ *- then regional growth rate of real incomes differs when agglomeration takes place, being lower in the periphery. That is, for any* (n, n^*)

$$\varphi(1, n, n^*) > \varphi^*(1, n, n^*) \Leftrightarrow |\theta_n(n, n^*)| > |\theta_n(n, n^*)| \qquad (32)$$

When intersectoral knowledge spillovers are global - i.e. $|\theta_{n^*}(n, n^*)| = |\theta_n(n, n^*)|\ \forall (n, n^*)$ *- there is no real growth differential between regions for any degree of agglomeration.*

Hence in our model the core-periphery equilibrium is characterized by an ever-increasing real income gap between North and South and the latter may suffer from dynamic loss from deindustrialization.

What is the economic intuition behind this result? Imagine we are moving from the symmetric equilibrium to another equilibrium (interior or CP) where industry is more concentrated in the North ($s_n > \frac{1}{2}$). 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_n. However, following the increase in knowledge capital located in the North n, because of localized intersectoral spillovers, the Northern $S-$sector will be able to produce the non-tradable goods at a lower cost with respect to the Southern S-firms. Since services are non-tradable and wages are equal across regions, the price of Southern services will 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 (leading to additional static losses for the periphery), but not on its growth rate. Nevertheless, in the core-periphery allocation, Northern growth rate of capital is $g(1)$ while Southern growth rate is $g^*(1) = 0$ because no firm has incentive to locate in the South. As a consequence, the price of Northern services will decrease faster than the price of Southern services and this growth gap in $S-$goods price dynamics will not be filled because there is no integrated market for S-goods. 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[14].

Notice that regional real incomes will diverge even during the transitional dynamics to *any* other interior equilibrium where industry is more concentrated in the North. This is because, by definition, during this transitional dynamics there is no incentive for firms (and then for units of knowledge capital) to locate in the South. Thus, the growth rate of Southern firms is nil while that of Northern firms is clearly positive. Once the new interior equilibrium is reached then regional real incomes grow at the same rate but it is important to emphasize that the gap in regional growth rate of real incomes is not limited to the CP equilibrium.

Quite intuitively, the more spillovers are localized, the larger the gap. When spillovers are perfectly localized, $\theta_{n^*}(n, n^*) \equiv 0$, so that the gap is maximized. Moreover, the regional real growth gap positively depends on γ, which represents the relevance given by agents to services. From this viewpoint, if we imagine an increase in γ compatible with a widely accepted stylized fact about structural change and the development phase, we should conclude that our model predicts that agglomeration policies lead to ever-increasing regional real growth gaps as development advances.

4.4 The effect of agglomeration on regional and aggregate real growth

We now analyze how the growth rates of regional and aggregate real income are affected by degrees of industrial agglomeration. So imagine that a hypothetical central planner wants to choose between the symmetric and the core-periphery allocation in order to maximize the growth rate of real income at the aggregate level. By analyzing his choice we answer the first three questions of section 4.2.

For any equilibrium allocation s_n, aggregate real growth is just the weighted sum of the growth rate in the two regions, the weight being $\frac{1}{2}$ because regions are perfectly symmetric. In any interior equilibrium $s_K \in (0,1)$ then, the aggregate real growth rate is simply the common real growth rate given by (30). In particular, if $\bar{\varphi}(s_n, n, n^*)$ stands for the aggregate real growth rate, in the symmetric equilibrium:

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

[14] It is worth to emphasize that the growing regional inequality would be even stronger in the presence of consumer mobility.

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

$$\begin{aligned}
\varphi(1,n,n^*) &= g(1)\left(\frac{\alpha}{\sigma-1} - \gamma\theta_n(n,n^*)\right) \\
\varphi^*(1,n,n^*) &= g(1)\left(\frac{\alpha}{\sigma-1} - \gamma\theta_{n^*}(n,n^*)\right)
\end{aligned}$$

$$\bar{\varphi}(1,n,n^*) = \frac{\varphi(1,n,n^*) + \varphi^*(1,n,n^*)}{2} = g(1)\left(\frac{\alpha}{\sigma-1} - \gamma\frac{(\theta_n(n,n^*) + \theta_{n^*}(n,n^*))}{2}\right) \quad (33)$$

for the North, the South and the whole economy respectively. Notice that, in any case, North, South and aggregate real growth are increasing in the intensity of intersectoral knowledge spillovers.

The answers for the three previous questions is then the simple result of three comparisons between growth rate of real income in each area (North, South and the whole economy) computed in the core-periphery allocation and the same (common) growth rate computed in the symmetric one. To keep things simple we assume that all spillovers elasticities are constant. We then have, for any (n,n^*):

$$\theta_n(n,n^*) = \theta_n < 0 \;\; ; \;\; \theta_{n^*}(n,n^*) = \theta_{n^*} < 0$$

In this case, the results of the three comparisons yield:

$$\varphi\left(\frac{1}{2}\right) > \varphi(1) \Leftrightarrow \gamma\frac{g(1)\theta_n - g\left(\frac{1}{2}\right)(\theta_n + \theta_{n^*})}{g(1) - g\left(\frac{1}{2}\right)} > \frac{\alpha}{\sigma-1} \quad (34)$$

$$\varphi^*\left(\frac{1}{2}\right) > \varphi^*(1) \Leftrightarrow \gamma\frac{g(1)\theta_{n^*} - g\left(\frac{1}{2}\right)(\theta_n + \theta_{n^*})}{g(1) - g\left(\frac{1}{2}\right)} > \frac{\alpha}{\sigma-1} \quad (35)$$

$$\bar{\varphi}\left(\frac{1}{2}\right) > \bar{\varphi}(1) \Leftrightarrow \gamma\frac{g(1)\frac{(\theta_n + \theta_{n^*})}{2} - g\left(\frac{1}{2}\right)(\theta_n + \theta_{n^*})}{g(1) - g\left(\frac{1}{2}\right)} > \frac{\alpha}{\sigma-1} \quad (36)$$

By considering that $|\theta_n| \geq |\theta_{n^*}|$, it is easy to see that these conditions imply:

$$\varphi\left(\frac{1}{2}\right) > \varphi(1) \Rightarrow \bar{\varphi}\left(\frac{1}{2}\right) > \bar{\varphi}(1) \Rightarrow \varphi^*\left(\frac{1}{2}\right) > \varphi^*(1) \quad (37)$$

However, when spillovers are global ($|\theta_n| = |\theta_{n^*}|$), the three conditions are identical because in this case, as stated in proposition 1, $\varphi(s_n) = \varphi^*(s_n) = \bar{\varphi}(s_n)$ for any $s_n \in [0,1]$. Hence:

$$\varphi\left(\frac{1}{2}\right) = \varphi^*\left(\frac{1}{2}\right) = \bar{\varphi}\left(\frac{1}{2}\right) > \varphi(1) = \varphi^*(1) = \bar{\varphi}(1) \Leftrightarrow -\gamma\theta_n\frac{2g\left(\frac{1}{2}\right) - g(1)}{g(1) - g\left(\frac{1}{2}\right)} > \frac{\alpha}{\sigma-1} \quad (38)$$

This proves the following:

Proposition 2 *(Growth effects of agglomeration at the regional and aggregate level) Agglomeration negatively affects the growth rates of real income in the North, in the South and in the whole economy according to conditions stated, respectively, in (34), (35) and (36).*

When intersectoral knowledge spillovers are local, agglomeration has different impacts at the regional and aggregate levels: a dynamic loss from agglomeration in the North implies a dynamic loss from agglomeration for the whole economy which implies a dynamic loss from agglomeration in the South, but not vice-versa. However, when intersectoral knowledge spillovers are global, agglomeration has the same negative impact both at the aggregate and regional level and is detrimental to growth in the North, in the South and in the whole economy whenever condition (38) holds.

Proposition 2 states the conditions for agglomeration to be bad for growth at the regional and aggregate levels and implies a less optimistic role for agglomeration with respect to the existing literature. The role of γ, the expenditure share on non-tradable goods, is very clear: provided that the numerators in the LHS of (34), (35) and (36) are positive (negative), an increase in γ helps these conditions to be fulfilled (unfulfilled) and enhances the positive (negative) effect of dispersion on regional and aggregate growth.

The next step is then to understand when the numerators in the LHS of (34), (35) and (36) are positive or negative. As already anticipated, the effect of agglomeration on regional and aggregate growth crucially depends on the interplay between three effects: the $M-$price effect, the home $S-$price effect and the foreign $S-$price effect. When agglomeration takes place in the North expressions (28) and (29) become:

$$\varphi(1) = \underbrace{\frac{\alpha g(1)}{\sigma - 1}}_{\text{M-price effect}} - \underbrace{\gamma g(1)\,\theta_n}_{\text{Home S-price effect}} - \underbrace{0}_{\text{Foreign S-price effect}} \tag{39}$$

$$\varphi^*(1) = \underbrace{\frac{\alpha g(1)}{\sigma - 1}}_{\text{M-price effect}} - \underbrace{0}_{\text{Home S-price effect}} - \underbrace{\gamma g(1)\,\theta_{n^*}}_{\text{Foreign S-price effect}} \tag{40}$$

It is then clear in which cases agglomeration might be bad for regional and aggregate growth.

First consider the North: when $s_n = 1$ both the M-price effect and the home $S-$price effect increase because $g(1) > g\left(\frac{1}{2}\right)$. In other words, real growth is enhanced by agglomeration for two different reasons: 1) innovation cost is reduced and this leads to a faster decrease in the price of $M-$ goods; 2) the Northern $S-$sector productivity dynamics benefit from a faster growth of local knowledge capital. However, as long as intersectoral knowledge spillovers are not perfectly localized ($|\theta_{n^*}| > 0$), agglomeration in the North has also a negative effect on Northern growth: when agglomeration takes place, the foreign $S-$price effect (which is positive and equal to $-\gamma g\left(\frac{1}{2}\right)\theta_{n^*}$ in the symmetric case) goes to zero because the North cannot benefit from positive spillovers coming from a growing foreign knowledge capital base. If θ_{n^*} is large enough and $g\left(\frac{1}{2}\right)$ is not much smaller than $g(1)$, then the negative effect of agglomeration on Northern real growth might even overcome its positive effects, then leading to a net dynamic loss. When this is the case, local industrialization is paradoxically detrimental to local growth.

The reason why agglomeration might be bad for Southern real growth is a bit more straightforward. Again, Southern real growth is boosted by agglomeration in the North for two different reasons: 1) innovation cost is reduced and this leads to a faster decrease in the price of $M-$ goods (produced in the North but also traded in the South); 2) as long as intersectoral spillovers are not perfectly localized the Southern $S-$sector productivity growth also benefits from a faster growth of knowledge capital located in the North. However, agglomeration in the North means deindustrialization in the South: when manufacturing firms have no incentive to invest in knowledge capital in the South, the home $S-$price effect (which is positive and equal to $-\gamma g\left(\frac{1}{2}\right)\theta_n$ in the symmetric case) goes to zero. When θ_n is large enough and $g\left(\frac{1}{2}\right)$ is not too smaller than $g(1)$, then the negative effect of agglomeration on Southern real growth might well overcome its positive effects, then leading to a net dynamic loss in the South. When this is the case, local deindustrialization is detrimental to local growth.

Finally, the potential dynamic aggregate loss stems from a combination of these two outcomes. On the one hand, overall real growth is boosted by agglomeration in the North for three reasons: 1) innovation cost is reduced 2) northern and (to a lesser extent) 3) southern $S-$goods price dynamics are positively affected by a faster growth of knowledge capital. On the other hand, agglomeration in the North reduces aggregate real growth because *both* Southern and (to a lesser extent) Northern $S-$ goods productivity cannot benefit from knowledge capital located in the South. Again, when θ_n, θ_{n^*} are large enough and

$g\left(\frac{1}{2}\right)$ is not too far from $g(1)$, then agglomeration is bad for aggregate growth.

But proposition 2 also tells us that, as long as $|\theta_n| > |\theta_{n^*}|$, the (negative or positive) impact of agglomeration on growth is different among regions and for the whole economy. In particular, it is more likely that agglomeration will be more harmful for the South because, when intersectoral spillovers are not global, the damage due to local deindustrialization (home $S-$price effect) is larger than the damage due to foreign deindustrialization (foreign $S-$price effect). As for aggregate real growth, the latter being simply the average between Southern and Northern growth, an aggregate loss from agglomeration in the North is more likely than a Northern loss and less likely than a Southern loss.

5 Agglomeration, interregional equity and global efficiency

In this section, we analyze in detail the existence of a trade-off between interregional equity and global efficiency. We measure the latter in terms of aggregate growth of regional real income (or consumption), while the measure of interregional equity requires some more observations.

The most common (inverse) measure of interregional equity in the literature is $s_E = \frac{E}{E^w}$, i.e. the share of expenditure in the north, which also can be thought as a measure of income inequality between north and south (Baldwin et al. 2004). Such measure is for instance used by Martin (1999) who explicitly assesses the trade-off between regional equity and aggregate growth. A slightly different measure is used by Martin and Dupont (2006) who also deal with regional equity problems: they use $s_y = \frac{Y}{Y^w}$ i.e. the share of global income in the north but since their model is static expenditure and income coincide. Finally, Dupont (2007), who analyses the relation between agglomeration, growth and individual and regional disparity, focuses on the differential between regional real consumption levels (in our symbolism $\frac{E}{P}/\frac{E^*}{P^*}$) and shows that reasoning with welfare function or real income yields to the same conclusions.

It is possible to show [15] that in NEGG models more agglomeration (i.e. a more unequal spatial distribution of industrial activities) is always associated to more interregional inequality (and then less interregional equity) in terms of the three measures above presented. More precisely, the core-periphery equilibrium ($s_n = 1$) is associated to a higher value of s_E, a higher value of s_Y and a higher value of $\frac{E}{P}/\frac{E^*}{P^*}$ with respect to the symmetric equilibrium ($s_n = 1/2$). Remarkably, such conclusion holds both when capital is immobile and when capital is mobile across regions. Since this conclusion also holds (and it is actually reinforced) in our model, we are entitled to use s_n, the degree of agglomeration and of spatial inequality, as a proxy for the degree or interregional inequality.

As already said, according to standard NEGG models, agglomeration is always good for long-run real growth as there are no dynamic losses (for both the core and the periphery) associated to a higher degree of spatial concentration of industrial activities. Hence, given the previous observations, such models do exhibit a trade-off between global efficiency and interregional equity: when industry is concentrated in the north, the growth rate of real income in both regions is higher because the cost of innovation is lower (due to localized spillovers) but the degree of regional inequality is also higher as the north enjoys a higher share of regional *nominal* and *real* consumption/income.

However, such common agreement on the role of agglomeration is not confirmed by the empirical evidence according to which the positive relation between agglomeration and aggregate growth appears to be limited to early stages of development. In this section we propose a rationale in order to reconcile theory with empirical evidence. As we have seen in proposition 2, the introduction of a non-tradable sector gives rise to some negative effects of agglomeration for both the periphery and the core. When the dynamic losses from agglomeration offset the dynamic gains of agglomeration, the trade-off between

[15] Computations are straighforward and they are available at request.

aggregate growth and interregional equity simply disappears. And, interestingly, our model predicts that such result, as the empirical evidence suggests, is more likely to hold in more advanced stages of development. In order to see this, rewrite expression (36) as:

$$-\gamma\left(\theta_n+\theta_{n^*}\right)\left(g\left(\frac{1}{2}\right)-\frac{g\left(1\right)}{2}\right)>\frac{\alpha}{\sigma-1}\left(g\left(1\right)-g\left(\frac{1}{2}\right)\right) \tag{41}$$

which reveals that, the RHS being strictly positive, a necessary (but not sufficient) condition for agglomeration to be detrimental to aggregate growth is the LHS to be strictly positive as well. Since $\gamma\left(\theta_n+\theta_{n^*}\right)$ is negative, that happens when $\frac{g(1)}{2}<g\left(\frac{1}{2}\right)$ - i.e. the growth rate of knowledge capital in the symmetric equilibrium is larger than half of the growth rate of knowledge capital in the core-periphery outcome. It is clear how λ, the spatial range of intertemporal spillovers within the innovating sector, has a crucial role in this condition. By using ((22) and (21)) we obtain:

$$\frac{g\left(1\right)}{2}<g\left(\frac{1}{2}\right)\Leftrightarrow\lambda>\frac{\rho\left(\sigma-\alpha\right)}{2L\alpha} \tag{42}$$

which tells us that λ should be large enough in order for the trade-off to disappear. This condition on λ is very important because when it does not hold, the role of γ and $\left(\theta_n+\theta_{n^*}\right)$ is *reversed*.

If the term $\gamma\left(\theta_n+\theta_{n^*}\right)$ is not large enough, condition (42) is not sufficient for (41) to be true. Assuming (42) holds and by substituting for the value of $g\left(1\right)$ and $g\left(\frac{1}{2}\right)$ in (41), the latter becomes:

$$-\gamma\left(\theta_n+\theta_{n^*}\right)>\frac{2\left(1-\lambda\right)L\alpha^2}{\left(\sigma-1\right)\left(2\lambda L\alpha-\rho\left(\sigma-\alpha\right)\right).} \tag{43}$$

Condition (43) is the main target of our analysis. Notice that the RHS (positive by (42)) is *decreasing* in λ while the LHS is *increasing* in γ and in $\left|\theta_n+\theta_{n^*}\right|$. This proves the following

Proposition 3 *(Trade off between equity and efficiency) There is no trade-off between interregional equity and global efficiency when condition (42) and condition (43) hold. That happens when*

1. *the intertemporal knowledge spillovers λ is **large enough** and necessarily larger than $\frac{\rho(\sigma-\alpha)}{2L\alpha}$*
2. *the expenditure share on non-tradable goods γ is **large enough***
3. *the absolute value of the sum of the home and foreign components of the intersectoral knowledge spillovers $\left|\theta_n+\theta_{n^*}\right|$ is **large enough***

This proposition deserves some comments. First of all, it states that the trade-off disappears when the *intrasectoral* spillovers are globalized enough. If we interpret λ in a historical perspective - along the lines of Martin (1999), Baldwin *et al.* (2001) - we should expect an over time increase in the degree of globalization of technology spillovers as a result of the continuous progress in the technology of information diffusion (Keller (2002)). Hence, condition (43) predicts that the strength of the trade-off between aggregate growth and interregional equity is likely to lose importance and eventually disappear as time goes by. Moreover, if we accept (as Peri (2005) argues among others) that the spatial range of technological spillovers is larger in more developed and innovative countries, then condition (43) also predicts, once again in agreement with the empirical evidence, that the positive effect of agglomeration on aggregate growth is more likely to be a prerogative of developing countries while such positive effect is doomed to disappear, and eventually turn into a negative effect, with the process of economic development.

Second, the proposition states that, in order for the trade-off to disappear, non-tradable goods should be important enough for the representative consumer. As argued in section 2.4, the empirical evidence on structural change shows how such importance has been constantly increasing over time at the world level in the last 30 years. Moreover, it is widely accepted that the importance of non-tradable services in the utility function is larger in more advanced stages of development. In other words, condition (43) predicts that the trade-off between interregional equity and global efficiency is more likely to exist in developing countries where services are less important. By contrast, agglomeration is more likely to slow down aggregate real growth in more developed countries.

Finally, proposition 3 gives a crucial role to the intensity of home and foreign *intersectoral* spillovers, $(\theta_n + \theta_{n^*})$, which should be large enough in order for the trade-off to disappear. Intuition suggests that, if intersectoral and intrasectoral knowledge spillovers share a common nature, the behaviour of $(\theta_n + \theta_{n^*})$ across time and across countries should resemble λ's behaviour. Hence, $(\theta_n + \theta_{n^*})$ is expected to increase overtime and to be larger in richer countries where knowledge diffusion is less constrained.

These considerations, together with the recent empirical findings which support the "Williamson hypothesis" - agglomeration boosts GDP growth only up to a certain level of economic development - suggest that the mechanism introduced in our model might be a good candidate to reconcile the theoretical and empirical counterparts of NEGG literature.

5.1 A simple calibration exercise

To the best of our knowledge, there are no empirical studies aimed at measuring the strength and intensity of intersectoral spillovers between manufactures and non-tradables in an NEGG framework. Hence, to give an idea of the required magnitude of the externality $(\theta_n + \theta_{n^*})$ for condition (43) to hold, we perform a simple calibration exercise as displayed in table 1. The last column of the table reports the implied minimum value of $|\theta_n + \theta_{n^*}|$ such that condition (43) is satisfied - and than the trade-off between aggregate real growth and interregional equity disappears - for some given values of the parameters σ, L, γ, ρ, α and λ. The first line, which we call the base case, presents numerical values which are consistent with those usually chosen in the literature (see especially Martin and Ottaviano (1999)). The other lines illustrate how the results are sensitive to each single parameter involved in condition (43) with respect to the base case. While the values of σ, L and ρ are quite standard in the literature, it is worth spending some words on the baseline values chosen for γ, α and λ.

γ and α, representing respectively the expenditure share for the S and for the M-goods, are strictly connected as their sum must be strictly smaller than unity (being $\gamma + \alpha + \beta = 1$). For these reason, their deviation from baseline values is jointly computed. The baseline values chosen for these parameters - respectively 0.7 and 0.2 - are computed from the STAN database in order to fit a middle-income economy like Turkey, South Africa or Russia. On the other hand, the values $\gamma = 0.8$ and $\alpha = 0.15$ and $\gamma = 0.5$ and $\alpha = 0.25$ are suitable for more developed and less developed countries respectively.

As for λ, an estimate which fits with the meaning of this parameter in our model cannot easily be found in the literature. Two important empirical works on this subject are Peri (2005) and Keller (2002). Peri (2005) finds that only 20% of average knowledge is learned outside the average region of origin which suggests that, in an economy with only two regions, a plausible value for λ could be 0.2. On the other hand, Keller (2002) finds that the productivity effect from foreign R&D is 20% larger than home R&D, suggesting a value of 1.2 for λ, which is not feasible in our model. Taking all these into account, and still being conservative with λ in order not to underestimate the implied values of $|\theta_n + \theta_{n^*}|$, we choose a reference value of 0.6, with 0.4 and 0.8 as lower and upper deviations.

The implied value for $|\theta_n + \theta_{n^*}|$ in the reference case is 0.11 meaning that, with the reference parameter values, a 100% increase of home and foreign knowledge capital should reduce the local S-sector production cost by at least 11% in order for agglomeration to be *bad* for aggregate growth of real income. By considering the deviations from the reference case, the implied values for $|\theta_n + \theta_{n^*}|$ range from 3% (with

Table 1: Sensitivity Analysis

σ	**L**	γ	α	ρ	λ	$\lvert\theta_n + \theta_{n^*}\rvert$
4	2	0.7	0.2	0.05	0.6	0.11 base case
...	...	...	...	...	0.4	0.35
...	...	...	...	...	0.8	0.03
...	...	...	...	0.02	...	0.08
...	...	...	...	0.08	...	0.17
...	...	0.5	0.25	...	...	0.16
...	...	0.8	0.15	...	...	0.09
...	2000000	...	...	...	...	0.06
...	20000000	...	...	...	...	0.06
3	...	...	...	...	...	0.13
5	...	...	...	...	...	0.10

λ=0.8) to 35% (with λ=0.4), showing that condition (43), and therefore the existence or non-existence of the trade-off, is highly sentitive to the spatial range of intrasectoral knowledge spillovers. We think that the implied values of $|\theta_n + \theta_{n^*}|$ are highly plausible and therefore our model predicts that the trade-off between interregional equity and global efficiency might not exist for a wide range of real economies, especially those who are less-developed.

6 Conclusions

A robust implication of the NEG theoretical literature is that, in the presence of intertemporal localized knowledge spillovers in the innovation sector, it is possible to increase the long-run aggregate economic growth and, at the same time, to leave it uniform across regions, by promoting policies aimed at favoring the agglomeration of the industrial sector in only one region. This theoretical statement encompasses four results: 1) agglomeration is always good for growth in the core region; 2) agglomeration is always good for growth in the peripheral region; 3) agglomeration is always good for growth at the aggregate level; 4) for any degree of agglomeration, the growth rates of regional real income are always the same.

These results, which are not supported by the empirical evidence, are challenged in our paper. By introducing intersectoral localized knowledge spillovers between innovation and the newly added service sector (a deviation for which we provide empirical support), we have shown that the growth effect of agglomeration is more puzzling. As this deviation generates both an anti-growth and a pro-growth effect of agglomeration for both the deindustrializing and the industrializing regions, we find that 1) regional growth rates of real income are always different when agglomeration takes place, being lower in the periphery; 2) agglomeration may have a negative effect on the growth rate of real income, *both* at the regional *and* at the aggregate level. In particular, we have found that the trade-off between interregional equity (in terms of spatial allocation of firms) and global efficiency (in terms of growth rate of aggregate real income), loses relevance and is eventually reversed when: 1) the spatial range of the intrasectoral spillovers within the R&D sector; 2) the external benefit of local and foreign knowledge capital on non-tradable sector productivity; 3) the expenditure share on non-tradable goods are *all* large enough. These findings are consistent with the recent empirical evidence which supports the "Williamson hypothesis": agglomeration boosts GDP growth only up to a certain level of economic development. A simple calibration exercise shows that the minimum implied values of the intersectoral knowledge spillovers in order for agglomeration to be bad for growth are highly plausible. Hence, our paper provides a natural mechanism to reconcile theory with the empirical evidence.

Considering the appeal that NEG theoretical statements have on policy-makers, we believe these results have strong policy implications as they suggest policy rules which, in some cases, are opposite from those recommended by the existing literature: concentrating economic activities in only one region may be welfare-harming both at the regional *and* at the aggregate level and may generate ever-increasing regional income disparities. Applying these implications to the EU case, our claim would be that European Regional Policies - which clearly favor industrial dispersion - may have a growth effect not only for the peripheral regions (as empirically evidenced by Busillo *et al.* (2010)) but also for the whole economy and even, quite surprisingly, for the core regions. Our model suggests that the likelihood of these conclusions increases with the level of economic development. It is important to highlight that, as long as integration is believed to strengthen concentration forces and to activate the agglomeration process, our conclusions also imply that, especially in more developed countries, integration policies might be bad for both regional and aggregate growth.

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