Interregional and international trade: Seventy years after Ohlin*

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Abstract

We study the impact of falling trade costs and falling national transport costs on the economic geography of countries involved in an integration process. Each country is formed by two regions between which labor is mobile, whereas there is no international factor mobility. Commodities can be traded both nationally and internationally at positive but different costs.

In our setting, a decrease in trade costs and/or in national transport costs has a direct impact on prices and wages in both countries. This allows us to study how the variations of these parameters affect the terms of trade, the levels of welfare as well as to account for their impact on the economic geography of each country in a way that significantly differs from what has been accomplished so far.

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1 Introduction

One of the most distinctive features of trade theory when compared to location theory is that in the former *countries are generally considered as being dimensionless*. While instrumental to our understanding of international trade under many respects, such a simplifying assumption has long been considered as a handicap:

> "*international trade theory cannot be understood except in relation to and as part of the general location theory, to which the lack of mobility of goods and factors has equal relevance*" (Ohlin, 1968, p. 97, emphasis in the original).

The reason being that changes in the transportability of commodities as well as in the mobility of factors *between and within* countries affect the location of economic activities, the distribution of labor and capital, the geography of demand and, therefore, the pattern of trade.[1]

This handicap is becoming increasingly heavy as new empirical evidence is gathered, suggesting that growing openness to international trade has a significant impact on the degree of agglomeration of economic activities within countries. First, using a cross-section of 85 countries, Ades and Glaeser (1995) show that higher tariff barriers lead to a higher degree of urban primacy. Their findings have been confirmed and extended by Henderson (2002). Second, studying the "cohesion group" of the European Union (Greece, Ireland, Portugal and Spain, but no regional data are available for Ireland), Quah (1996) notes that the two countries that have reached the highest rates of economic growth, Spain and Portugal, are those that have experienced the most striking rise in regional imbalances. This is consistent with the evidence reported by de la Fuente and Vives (1995) who observe that the process of economic integration within the European Union fosters international convergence across countries rather than interregional convergence across regions within countries. Indeed, about half of the divergence across European regions is due to an increased polarization within some member-states. Finally, Hayward (1995) notes that the impact of European integration on the US might differ from state to state. In particular, he shows that, while some US states could thrive, others might suffer from stronger import or export competition.

All this evidence raises crucial policy issues that are often neglected when countries decide on trade agreements, especially those of a preferential kind.

[1] See, Ohlin (1967), Ch. XI-XII.

For example, it suggests that the next enlargement of the European Union to 10 new countries is very unlikely to leave the economic geography of the new and old members unaffected. Moreover, the ensuing changes will probably differ across countries, depending on their degree of internal integration and the quality of their transportation infrastructures. Thus, some anticipation of the likely outcomes is required to avoid major political disturbances and social turmoils, triggered by a potentially uneven distribution of the gains and losses from enlargement as the geography of competition and employment changes. The practical importance of those outcomes should make it clear that the question that motivates us is both relevant and important for circles that are not just academic.

In this paper we provide a theoretical framework to address the foregoing issues by developing an integrated model of interregional and international trade in the wake of Ohlin (1933). In so doing, we abstract from his spaceless factor proportions model (Ohlin, 1967, Part Two, pp. 49-93), which still represents the backbone of international trade theory and with which Ohlin's contribution is essentially identified. We focus instead on Ohlin's less popularized spatial insights on how the explicit consideration of space affects (and, sometimes, even reverses) some of the main conclusions of the neoclassical paradigm of trade theory (Ohlin, 1967, Part Three, pp. 97-165). The interest of focusing on those insights is due to the fact that in the original work their robustness is often undermined by the lack of a model dealing with both increasing returns and imperfect competition.[2] Consequently, Ohlin's contribution is mainly identified with his spaceless theory, someway paradoxically labeled "International Trade Simplified" (Ohlin, 1967, pp. 49-93). Seventy years after Ohlin, new analytical tools being available, we can start from where Ohlin had to stop.

The specific framework we adopt is borrowed from the so-called 'new economic geography' (Krugman, 1991; Fujita *et al.*, 1999). In particular, we model the endogenous formation of the economic landscape in a spatial economy consisting in two countries each made of two point regions. Countries and regions are distinguished from each other by differences in both barriers to trade and factor mobility. Specifically, as Ohlin would have it, while goods are assumed to be mobile between both countries and regions, *factors move only between regions within the same country.* Moreover, trade is hampered by 'transport' costs between regions and by 'trade' costs between countries. Albeit particular and simple, this framework is sufficient to study how changing transport and/or trade costs affect the distribution

[2] See, Ohlin (1967), Ch. III.

of activities within and between countries and how the resulting economic geography of countries influences the type as well as the intensity of international trade.

Section 2 presents the model as an extension of the approach developed by Ottaviano *et al.* (2002) to the richer spatial economy depicted above. Production takes place in two sectors, a perfectly competitive sector and a monopolistically competitive one. The former employs only unskilled labor, which is immobile both between and within countries, whereas the latter employs only skilled labor, which is immobile between countries but mobile within them. The fact that we build on Ottaviano *et al.* (2002) separates us from the standard Dixit-Stiglitz-Krugman (henceforth, DSK) framework (Fujita *et al.*, 1999). This allows us to uncover effects that are ruled out by the restrictive assumptions of such framework. In particular, new insights stem from two *direct competition effects*: (i) local prices decrease with the number of local producers, in accordance with the theory of industrial organization, and (ii) lower transport or trade costs lead to lower prices, as suggested by Hotelling (1929, p.50) for whom "merchants would do well, instead of organizing improvement clubs and booster associations to better the road, to make transportation as difficult as possible." These two effects do not appear in the DSK framework. Yet, as shown by Lai and Trefler (2002), they seem to be crucial for measuring the impact of trade liberalization.

In Section 3, we show that lowering international trade costs may lead to the dispersion of skilled labor within each country, while reducing interregional transport costs is likely to foster its agglomeration, starting with the country having the lower initial level of transport costs. Accordingly, inserting a country in a network of international exchanges yields a richer set of conditions for agglomeration to arise than in the case of an isolated country. In particular, *common changes in internal and external barriers to goods mobility may have very different impacts on the spatial structure of different countries.* Most interestingly, our findings seem to agree with some of the conclusions obtained by Head and Mayer (2003) in their survey of the empirics of agglomeration and trade: "these results point to the empirical relevance of agglomeration forces operating through forward linkages, but these forces are likely to stay very localized, *unable to generate core-periphery patterns in Europe at a large geographical level* at least as long as labor remains so sensitive to migration costs" (emphasis in the original).[3]

[3] Our findings also agree with the empirical analyses conducted by Davis and Weinstein (1998, 1999) for OECD countries and for Japanese prefectures, respectively.

Section 4 presents the implications of our analysis for the evolution of the terms of trade as barriers to goods mobility change. Although the terms of trade are central to international trade, their evolution is too stylized within the DSK framework. The reason being that, since the equilibrium prices are given by a constant mark-up over marginal costs, those prices depend neither on the spatial distribution of firms, nor on the values of transport and trade costs. Because of the dominance of the DSK approach in new trade theory, most recent empirical applications have focused on trade volumes and market shares rather than on prices. Yet, as argued by Winters and Chang (2000, p.365), such applications are not entirely satisfactory because "economically they reflect the mercantilist fallacy by equating increases in welfare with giving away more goods!". The direct competition effects borrowed from Ottaviano *et al.* (2002) allow us to undertake a detailed investigation of how the terms of trade change both with the value of trade *and* with the value of transport costs of the trading partners.[4]

The gains from building on Ottaviano *et al.* (2002) are also reaped in sections 5 and 6, where we perform a welfare analysis that would be especially cumbersome within the DSK framework. We show that, although the internal structure of a country does not directly depend on the way the other country is organized, *geography matters for the level of welfare within each country as well as for the global welfare level.* This happens because both the nature and the intensity of trade change with the geography of the trading partners. In particular, our framework appears to be especially well suited to separately assess the impacts of falling international trade costs and of falling interregional transport costs.

Two key results stand out. First, as in Brander and Krugman (1983), there can be reciprocal dumping so that a decrease in international trade costs is not always beneficial to both parties. Specifically, we show that a higher degree of integration leads to a reduction in welfare when trade costs are high. By contrast, integration becomes beneficial when trade costs have fallen below some threshold value. This differs from what happens within the DSK framework, in which, due to constant mark-ups, falling trade costs always improve the welfare levels in both countries.

Second, we show that each country has always an incentive to reduce its own interregional transport costs. However, such reduction is always harmful to the other country. The reason is that, by improving its own

[4] Recent works in international trade theory have put more emphasis on the terms of trade and on issues of strategic pricing in segmented markets. Yet, those approaches are rare and remain essentially in the spirit of oligopolistic partial equilibrium models (see, e.g., Winters and Chang, 2000; Chang and Winters, 2002).

transportation infrastructure, a country makes its domestic market more competitive and, therefore, reduces the operating profits of foreign firms as well as the wages they pay to their workers. Hence, there is a *negative transport externality* that manifests itself through the channel of trade. Moreover, when both countries strive to reduce their internal transport costs, they may end up both better off or worse off, depending on their spatial structure. Specifically, when agglomeration prevails in both countries, their joint reduction of transport costs is always beneficial to each country. On the contrary, *when both countries have a dispersed economic landscape, they may end up being trapped into a prisoner's dilemma*.

Finally, in section 6, we introduce an additional realistic feature of international trade costs that is generally neglected by trade theory: *density economies* in transportation at the international level. It is well documented that shipping costs are lower on routes processing large volumes of freight and/or linked to hubs because specialized services and large scale infrastructure can be developed.[5] For example, Mori and Nishikimi (2002) observe that transport costs from Japan to a non hub-port in Southeast Asia are approximately 23% higher than to a hub-port in the same region. The magnitude of these figures clearly reveals the importance of density economies along some routes that may lie at the origin of some observed agglomeration phenomena. We account for density economies by assuming that international trade costs depend negatively on the degree of agglomeration within countries. We show that *in the presence of density economies the internal geographies of the two countries are linked*. Section 7 concludes.

Related literature. There are only few contributions related to the main issues motivating the present paper. Though sharing with our set-up the central role of interregional migration as the driver of agglomeration, they all use the DSK framework and fall short of complete analytical solutions. In a two-country three-region setting involving congestion costs as a dispersion force, Krugman and Livas Elizondo (1996) as well as Fujita *et al.* (1999, ch.18) argue that lower international trade costs foster dispersion in the country opening to trade. Paluzie (2001) as well as Crozet and Koening-Soubeyran (2002) obtain the opposite result in a setting in which the dispersion force is given by partially immobile demand: trade openness fosters agglomeration. Such different results stem from the fact that changes in trade costs do not affect the dispersion force in Krugman and Li-

[5]See Braeutigam *et al.* (1982) for an empirical study of rail transportation, Caves *et al.* (1984) as well as Brueckner *et al.* (1992) for the case of airline transportation, which all show the prevalence of density economies in the corresponding sectors.

vas Elizondo (1996), whereas they do in Paluzie (2001) as well as in Crozet and Koening-Soubeyran (2002). In a two-country four-region setting, Monfort and Nicolini (2000) show through simulations that international trade liberalization between countries leads to more agglomeration within each country.

2 The model

The economy consists of two countries, labeled $r = H, F$, each having two regions, labeled $i = 1, 2$. When needed, variables associated with each country and each region will be subscripted accordingly.[6]

There are two production factors, skilled and unskilled workers. In order to abstract from comparative advantage, both countries have the same endowments and we denote by L the mass of skilled and by A the mass of unskilled workers in each country. Each worker works and consumes in the same region. Unskilled workers are immobile and evenly split between regions so that each region accommodates a mass $A/2$ of them. Skilled workers are *mobile within* but *immobile between countries* and we denote by $\lambda_r \in [0, 1]$ their share in region 1 of country r. This means that the mass of skilled workers living in country r is constant but that its interregional distribution is endogenous. Note that the relative immobility of unskilled with respect to skilled workers fits empirical observation, whereas the international immobility of all workers fits a long-standing tradition in trade theory.

Production takes place in two sectors. The 'traditional' sector supplies a homogenous good under perfect competition using unskilled labor as the only input of a constant-returns technology. The unit input requirement is set to one by choice of units. In the 'modern' sector monopolistically competitive firms offer a mass N of varieties of a horizontally differentiated good employing both factors under increasing returns to scale. There is a one-to-one correspondence between firms and varieties so that N is also the mass of available varieties. Specifically, the firm producing variety v incurs a fixed cost of $\phi > 0$ units of skilled labor and $m\, q(v)$ units of unskilled labor to produce the quantity $q(v)$.

All goods can be shipped across countries and regions. They are, how-

[6] Note that our setting may also be interpreted as describing two regional blocks, each formed by two relatively well integrated countries in terms of factor mobility (e.g. Belgium and Luxembourg). In such a context, our paper would allow one to study the impact of regionalism and of multilateralism.

ever, subject to different shipping costs. On the one hand, all shipments of the homogenous good are free. This makes that good the natural choice for the numéraire, which implies that in equilibrium the unskilled wage is equal to one everywhere. On the other hand, both international and interregional shipments of the differentiated varieties are costly. Specifically, international shipments face the same cost per unit shipped of $\tau > 0$ units of the numéraire regardless of the regions of origin and destination. This assumption implies that any region of a country has the same access to each region of the other country. Stated differently, no region offers a comparative advantage in trading on the foreign markets, thus implying that *international trade involves no gate effect*. By contrast, interregional shipments may face different costs: shipping one unit within country $r = H, F$ requires $t_r > 0$ units of the numéraire. For the ease of exposition, henceforth we refer to the international cost τ as the *trade cost* and to the interregional cost t_r as the *transport cost* of country $r = H, F$. Conceptually, the difference between the two shipping costs is the following. Since, for our purpose, the standard distinction between tariff and non-tariff barriers is not critical, the cost τ includes all impediments to trade, such as shipping costs per se, but also tariff and non-tariff barriers to trade, different product standards, difficulty of communication, and cultural differences.

Differently, t_r stands for the sole costs of shipping the differentiated product between the two regions of the same country r. Clearly, our model boils down to a standard trade model when $t_H = t_F = 0$.

Each worker is endowed with one unit of labor and $\overline{q}_0 > 0$ units of the numéraire. The initial endowment $\overline{q}_0$ is supposed to be large enough for her consumption of the numéraire to be strictly positive at the market outcome. All workers have the same quadratic utility. A typical resident of region i in country r solves the following consumption problem:

$$\begin{cases} \max\limits_{q_{ri}(v),\, v\in[0,N]} \alpha \int_0^N q_{ri}(v)dv - \frac{\beta-\gamma}{2}\int_0^N q_{ri}(v)^2 dv - \frac{\gamma}{2}\left[\int_0^N q_{ri}(v)dv\right]^2 + q_0 \\ \text{s.t.} \int_0^N p_{ri}(v)q_{ri}(v)dv + q_0 = y_{ri} + \overline{q}_0 \end{cases}$$

where $\alpha > 0$, $\beta > \gamma > 0$ are parameters, $p_{ri}(v)$ is the consumer price of variety v in region i of country r and y_{ri} is the resident's income which depends on her skilled or unskilled status.

It is readily verified that solving the consumption problem yields the individual demand functions given by

$$
\begin{aligned}
q_{rij}(v) &= a-(b+cN)p_{rij}(v)+cP_{rj} \\
q_{rsi}(v) &= a-(b+cN)p_{rsi}(v)+cP_{si}
\end{aligned}
\tag{1}
$$

with

$$
a \equiv \frac{\alpha}{\beta+(N-1)\gamma}, \quad b \equiv \frac{1}{\beta+(N-1)\gamma}, \quad c \equiv \frac{\gamma}{(\beta-\gamma)[\beta+(N-1)\gamma]}
$$

In expression (1), $p_{rij}(v)$ is the price a firm located in region i of country r charges to consumers in region j of the same country r, whereas p_{rsi} is the price a firm located in country r charges in region i of the other country $s \neq r$. Note that there is no need to mention the region of origin in country r because all firms located in this country have the same access to region i of country s. Analogously, $q_{rij}(v)$ is the output of a firm located in region i of country r demanded by a consumer in region j of the same country r, whereas $q_{rsi}(v)$ is the output of a firm located in country r demanded by a customer in region i of the other country $s \neq r$. Finally,

$$
P_{rj} = \int_0^N p_{rj}(v)dv \tag{2}
$$

is the price index (i.e., N times the average price) of varieties in region j of country r.

Since demands are linear and the unskilled wage is equal to one everywhere, for notational convenience we can set $m = 0$ without loss of generality as this amounts to rescaling all firms' demands intercepts. Then, skilled labor market clearing in each region implies:

$$
n_{r1} = \frac{\lambda_r L}{\phi} \quad n_{r2} = \frac{(1-\lambda_r)L}{\phi} \quad n = n_{r1}+n_{r2} = \frac{L}{\phi} \quad N = 2n \tag{3}
$$

where n_{ri} is the mass of modern firms in region i of country r.

Product and labor markets are *segmented* and entry as well as exit are free. The first assumption means that each firm is free to set a price specific to the region and the country in which it sells its output. The second assumption means that skilled wages are determined by the zero-profit condition implied by free entry and exit of firms in each region. More precisely, the equilibrium wages of the skilled are determined by a bidding process in which firms compete for workers by offering higher wages until no firm can profitably enter or exit the market. Let w_{ri} be the skilled wage rate prevailing in region i of country r.

Therefore, as firms bear all trade and transport costs, a firm located in region 1 of country H maximizes profits given by:

$$\pi_{H1} = p_{H11}q_{H11}\left[\frac{A}{2}+\lambda_H L\right]+(p_{H12}-t_H)q_{H12}\left[\frac{A}{2}+(1-\lambda_H)L\right] + (p_{HF1}-\tau)q_{HF1}\left[\frac{A}{2}+\lambda_F L\right]+(p_{HF2}-\tau)q_{HF2}\left[\frac{A}{2}+(1-\lambda_F)L\right]-\phi w_{H1}$$

Firms located in other regions solve symmetric maximization problems.

Throughout this paper, we focus on the meaningful case in which costs are sufficiently low for interregional and international trade to be bilateral, regardless of the (interior) firm distributions λ_H and λ_F. Assuming that both t_r and τ are sufficiently low (details are given below), the profit-maximizing prices are as follows:
(i) intraregional prices

$$p_{rii} = \frac{1}{2}\frac{a+cP_{ri}}{b+cN} \tag{4}$$

(ii) interregional prices

$$p_{rij} = p_{rjj}+\frac{t_r}{2}, \qquad i \neq j \tag{5}$$

(iii) international prices

$$p_{rsi} = p_{sii}+\frac{\tau}{2}, \qquad r \neq s. \tag{6}$$

As stated above, the profit-maximizing price that country s-firms set in region i of country r does not depend on the region of country s in which the firm is located; this is because all firms in country s have the same access to each region of country r.

Note that the price a firm sets in a region depends on the price index P_{ri} of this region, which depends itself on the prices set by *all* other firms. Because there is a continuum of firms, each firm is negligible and chooses its optimal price, taking aggregate market conditions as given. However, put together these aggregate market conditions must be consistent with firms' optimal pricing decisions. Hence, the (Nash) equilibrium price index $P^{\star}_{ri}$ must satisfy the following equilibrium condition:

$$P^*_{ri} = n_{ri}p_{rii}(P^*_{ri}) + n_{rj}p_{rji}(P^*_{ri}) + n\,p_{sri}(P^*_{ri}) \tag{7}$$

Under the assumption of bilateral trade between countries and regions, the equilibrium price indices can be found by solving (7) for P^*_{ri} after using (4), (5) and (6). This yields:

$$P^*_{ri} = \frac{2an + (b+2cn)(n_{rj}t_r + n\tau)}{2(b+cn)} \qquad r = H, F \quad \text{and} \quad i = 1, 2. \tag{8}$$

Note that all these equilibrium price indices depend on the average trade costs $n_{rj}t_r + n\tau$ incurred in supplying region i of country r. As expected, the price index decreases with the mass of local firms (Krugman, 1991; Fujita *et al.*, 1999). Substituting (8) into (4) gives the equilibrium intraregional prices:

$$p^*_{rii} = \frac{2a + c(n_{rj}t_r + n\tau)}{4(b+cn)}, \quad r = H, F \tag{9}$$

which can then be used to recover the equilibrium interregional and international prices from (5) and (6) respectively.

The expressions of the equilibrium prices reveal the crucial difference between the chosen model of monopolistic competition and the DSK framework. In particular, unlike what could be obtained with the DSK model, each of these equilibrium prices decreases with the number of firms located in the corresponding regions (n_{ri}, n_{rj} and n_{si}), thus showing the existence of a true competition effect consistent with the industrial organization literature. Hence, firms "weakly" interact in our setting. Clearly, prices also depend positively on transport and trade costs, thus accounting for infranational and international competition. Note, finally, that country r's firms export prices decrease as the market of country s becomes more integrated (i.e. as t_s decreases), showing that prices are 'strategic complements' in our model. This result is consistent with recent estimates obtained by Chang and Winters (2002).

We are now equipped to determine the conditions on τ and t_r for trade to occur between any two regions at these equilibrium prices. Starting with interregional transport costs, it is easy to check that

$$t_r \leq t_{trade}(\tau) \equiv \frac{2a + cn\tau}{2(b+cn)}, \qquad r = H, F \tag{10}$$

must hold for interregional trade in each country to take place, regardless of the firm distributions λ_r.[7] Observe that a lower τ leads to a decrease in the

[7] This condition also ensures that interregional prices net of transport costs remain positive.

threshold value of interregional trade costs t_r for which there is interregional trade. Hence, *lower trade costs in the international marketplace may lead to a break down of internal trade when the regional markets of a country are poorly integrated.* This is because cheaper imported varieties will displace more expensive nationally produced ones.

As to international trade costs, it is readily verified that the condition

$$\tau \leq \tau_{trade} \equiv \frac{2a}{2b + cn} \tag{11}$$

must hold for trade between countries to arise. The value τ_{trade} does not depend on national transport costs because international trade costs are not region-specific. We assume from now on that both conditions (10) and (11) are always satisfied.

Substituting the equilibrium prices (5), (6) and (9) into the individual demands (1), the equilibrium consumption levels are given by

$$q^*_{rii} = a - (b + cN)p^*_{rii} + cP^*_{ri} = (b + cN)p^*_{rii} \tag{12}$$

for shipments within the same region. They are given by

$$q^*_{rij} = q^*_{rjj} - \frac{(b + cN)t_r}{2} \tag{13}$$

for shipments between different regions of the same country ($i \neq j$) and by

$$q^\star_{rsi} = q^\star_{sii} - \frac{(b + cN)\tau}{2} \tag{14}$$

for shipments between regions belonging to different countries ($r \neq s$).

As discussed above, the equilibrium wages of the skilled are determined by a bidding process in which all operating profits are absorbed by the wage bill. Therefore, in equilibrium the skilled wage rate in region i of country r satisfies $\pi_{ri} = 0$. This wage is determined by a *national component* that depends on the distribution λ_r of firms in country r, as well as by an *export component* that depends on the distribution λ_s of firms in the other country. This property of separability will be of fundamental importance in the subsequent equilibrium analysis. Let us write the equilibrium wage as follows:

$$w^*_{ri} = \frac{1}{\phi}[D_r(\lambda_r) + E_r(\lambda_s)] \tag{15}$$

where by (3)

$$D_r(\lambda_r) = \left(\frac{A}{2} + \phi n_{ri}\right) p^*_{rii} q^*_{rii} + \left(\frac{A}{2} + \phi n_{rj}\right) (p^*_{rij} - t_r) q^*_{rij}$$

is the revenue from domestic sales of a firm located in country r, whereas

$$E_r(\lambda_s) = \left(\frac{A}{2} + \phi n_{si}\right) (p^*_{rsi} - \tau) q^*_{rsi} + \left(\frac{A}{2} + \phi n_{sj}\right) (p^*_{rsj} - \tau) q^*_{rsj}$$

stands for its export revenue from foreign sales.

Substituting the equilibrium prices as well as the equilibrium quantities (12) – (14) into (15) finally yields

$$\begin{aligned} w^*_{ri} &= \frac{1}{\phi}\left[\left(\frac{A}{2} + \phi n_{ri}\right)(p^*_{rii})^2 + \left(\frac{A}{2} + \phi n_{rj}\right)\left(p^*_{rjj} - \frac{t_r}{2}\right)^2\right] \\ &\quad + \frac{1}{\phi}\left[\left(\frac{A}{2} + \phi n_{si}\right)\left(p^*_{rsi} - \frac{\tau}{2}\right)^2 + \left(\frac{A}{2} + \phi n_{sj}\right)\left(p^*_{rsj} - \frac{\tau}{2}\right)^2\right]. \end{aligned} \tag{16}$$

3 Interregional and international equilibrium

We first evaluate the indirect utilities of the skilled workers in regions 1 and 2 of country $r = H, F$ at the equilibrium prices and wages. As shown by Ottaviano *et al.* (2002), the indirect utility in region i of country r may be expressed as follows:

$$V^*_{ri} = S^*_{ri} + w^*_{ri} + \overline{q}_0$$

where

$$\begin{aligned} S^*_{ri} &= \frac{a^2 N}{2b} - a\big(n_{ri} p^*_{rii} + n_{rj} p^*_{rji} + n_s p^*_{sri}\big) \\ &\quad + \frac{b + cN}{2}\left[n_{ri}(p^*_{rii})^2 + n_{rj}(p^*_{rji})^2 + n_s(p^*_{sri})^2\right] \\ &\quad - \frac{c}{2}\big(n_{ri} p^*_{rii} + n_{rj} p^*_{rji} + n_s p^*_{sri}\big)^2 \end{aligned} \tag{17}$$

is the individual consumer surplus evaluated at the market outcome. The indirect utility differential between the two regions of country $r = H, F$ is then defined by

$$\Delta V^*_r(\lambda_r) \equiv V^*_{r1}(\lambda_r) - V^*_{r2}(\lambda_r) \tag{18}$$

which depends only upon the distribution λ_r in country r. This stems from the fact that, as shown by (15), the equilibrium wage w^*_{ri} prevailing in region

i of country r is given by the sum of two terms, $D_r(\lambda_r)$ and $E_r(\lambda_s)$, which are respectively independent of λ_s and of λ_r. As a result, $E_r(\lambda_s)$ cancels out in the indirect utility differential $\Delta V_r^{\star}$, which becomes a function of the distribution λ_r only. As will be shown in section 6, this property no longer holds once we allow for economies of density in transportation.

A spatial equilibrium is such that, in each country, no skilled worker has an incentive to change location, conditional upon the fact that the product markets clear at the equilibrium prices (5), (6) and (9) and the labor markets at the equilibrium wages (16). Formally, a *spatial equilibrium* arises at $\lambda_r \in (0,1)$ when $\Delta V_r^*(\lambda_r) = 0$, or at $\lambda_r = 0$ if $\Delta V_r^*(0) \leq 0$, or at $\lambda_r = 1$ if $\Delta V_r^*(1) \geq 0$. Such an equilibrium always exists because $V_r^{\star}$ is a continuous function of λ_r (Ginsburgh *et al.*, 1985). An interior equilibrium is stable if and only if the slope of the indirect utility differential (18) is negative in a neighborhood of the equilibrium, whereas the two agglomerated equilibria are always stable whenever they exist.

Using expressions (5), (6) and (9), (12) – (14) and (16), some cumbersome calculations yield

$$\Delta V_r^*(\lambda_r) = \frac{n(b+2cn)t_r}{4\phi(b+cn)^2}\left(\lambda_r - \frac{1}{2}\right)(\varepsilon_1 t_r + \varepsilon_2 + \varepsilon_3 \tau) \tag{19}$$

where

$$\varepsilon_1 \equiv -(5c^2n^2\phi + 12bcn + 2c^2nA + 6b^2\phi + 2bcA) < 0 \tag{20}$$

$$\varepsilon_2 \equiv 4a\phi(3b + 4cn) > 0 \tag{21}$$

$$\varepsilon_3 \equiv 2cn\phi(2b + 3cn) > 0 \tag{22}$$

are constants depending on the structural parameters of the economy.

It follows immediately from (19) that $\lambda_r = 1/2$ is always an equilibrium within each country. Since the indirect utility differential is linear with respect to λ_r, the stability of this equilibrium depends on the sign of $\varepsilon_1 t_r + \varepsilon_2 + \varepsilon_3 \tau$. When this expression is negative, dispersion is the unique stable spatial equilibrium in country r; when it is positive, the dispersed equilibrium is unstable so that agglomeration of all skilled workers of country r is the only stable equilibrium. This implies that *the economic geography of a country depends on its transport costs as well as on trade costs, but not on the transport costs of the other country.* Of course, this result depends on the specific assumptions made. The first key-assumption is that all firms in a country have the same access to the regional markets of the other country.[8] However, it must be kept in mind that relaxing this assumption would bias the results in favor of the region having a better access to the foreign markets (see, e.g. Crozet and Koenig-Soubeyran, 2002). Our second critical assumption is that international markets are segmented. Indeed, assuming that interregional markets are integrated (i.e., firms must charge the same mill price to all its customers living in the same country) would not affect the foregoing property. By contrast, the geography of country r would depend on transport costs in country s if the international markets were integrated, but there is little empirical evidence that this is so (see, e.g. Head and Mayer, 2000).

As the indirect utility differential in a country depends only upon its internal distribution of economic activities, a spatial equilibrium in the global economy consists of two independent spatial equilibria (one for each country). As argued previously, agglomeration is a spatial equilibrium in country r if and only if $\varepsilon_1 t_r + \varepsilon_2 + \varepsilon_3 \tau \geq 0$, which means that

$$t_r \leq \frac{\varepsilon_2 + \varepsilon_3 \tau}{-\varepsilon_1} \tag{23}$$

or, alternatively,

$$\tau \geq \frac{-\varepsilon_1 t_r + \varepsilon_2}{\varepsilon_3} \tag{24}$$

yields a necessary and sufficient condition for agglomeration in country r to be a stable spatial equilibrium (recall that ε_1 is negative).

This leads to the following result.

Proposition 1 *Agglomeration is a stable spatial equilibrium in country r if and only if*

$$t_r \leq t^*(\tau) \equiv \frac{2\phi[2a(3b + 4cn) + 2cn\phi(2b + 3cn)\tau]}{5c^2n^2\phi + 6b\phi(b + 2cn) + 2cA(b + cn)}$$

or, equivalently, if and only if

$$\tau \geq \tau^*(t_r) \equiv \frac{[5c^2n^2\phi + 6b\phi(b + 2cn) + 2cA(b + cn)]t_r - 4a\phi(3b + 4cn)}{2cn\phi(2b + 3cn)}.$$

Observe that, for both the agglomerated and dispersed configurations to arise as a spatial equilibrium when transport and/or trade costs vary,

[8] This includes the standard assumption that marginal labor requirements are constant.

it must be that $\tau^*(t_r) < \tau_{trade}$ and $t^*(\tau) < t_{trade}(\tau)$. Because $\varepsilon_2 > 0$, when $\tau = 0$ the latter inequality holds provided that $\varepsilon_1 t_{trade}(0) + \varepsilon_2 < 0$. By continuity, the two configurations will then emerge as equilibria in the vicinity of $\tau = 0$. Because the absolute value of ε_1 rises with A, $\varepsilon_1 t_{trade}(0) + \varepsilon_2 < 0$ holds if and only if A exceeds some threshold value that we denote $\overline{A}$. In particular, some simple calculations show that $\overline{A}$ is larger than $3L$; hence we assume throughout that $A > \bar{A} > 3L$. This reflects the idea that immobile activities represent the larger share of the economy. Note also that $t^*(\tau)$ always exceeds some threshold $T > 0$ when τ is arbitrarily small, whereas $\tau^*(t_r)$ equals 0 as soon as t_r is smaller than T while being strictly positive.

The two inequalities identified in the foregoing proposition can be viewed as being dual to the extent that each yields a necessary and sufficient condition to be imposed on transport or on trade costs for agglomeration to arise in a country, each condition depending on the other parameter. Because ε_1 is negative, *for a given* τ *agglomeration within country* r *is more likely to be a stable equilibrium when the transport costs in this country are low.* Everything else being equal, more infranational competition leads domestic firms to cluster because they have a larger market (recall that the spatial distribution of consumers within each country is endogenous), which in turn makes the penetration by the foreign firms tougher. This concurs with the main result of economic geography in which agglomeration arises when trading across places becomes less expensive (Krugman, 1991; Fujita *et al.*, 1999; Ottaviano *et al.,* 2002). The novelty is that here the occurrence of agglomeration is lowered, namely $t^*(\tau)$ decreases, as trade costs keep falling.

Because ε_3 is positive, *for a given* t_r *such that* $\tau^*(t_r) > 0$*, agglomeration within a country is more likely to be a stable equilibrium when trade costs are high.* Everything else equal, domestic firms react to more international competition by relaxing infranational competition through dispersion. This agrees with what we know in spatial competition where the spatial distribution of consumers between countries is exogenous (d'Aspremont *et al.*, 1979). In this case, liberalizing trade would foster dispersion within each country, thus providing a rationale for the empirical results of Ades and Glaeser (1995) mentioned in the introduction. Among other things, Proposition 1 shows how trade impediments may affect the economic geography of countries involved in the integration process.

As $\tau^*(t_r)$ increases with t_r, it also follows from Proposition 1 that the country with the lower transport costs is agglomerated for a larger range of trade costs. This result suggests that *lowering transport costs inside a* *country involved in a process of international integration could well trigger more regional imbalance within this country*, unless the global economy has reached a fairly high level of integration. Our model thus provides a possible explanation for the empirical results obtained by de la Fuente and Vives (1995) regarding the impact of the entry of Spain and Portugal on their internal economic geography. Furthermore, it is well known that EU regional policies mainly focus on financing transport infrastructure in lagging regions. Our results suggest that such a policy may fail to produce the expected results because its impact critically depends on the degree of international integration as well as on the degree of national integration, both of which are likely to significantly vary across countries within the EU.

4 The terms of trade

As usual in both theoretical and applied trade theory, we define *the (international) terms of trade of region i in country r as the ratio of its export unit value index to its import unit value index* (Dornbusch *et al.*, 1977; United Nations, 1977).[9] The unit value index is defined as the ratio of total value (of imports or exports) to total quantity (of imports or exports). Hence, the export unit value index of region $i = 1, 2$ in country $r = H, F$, evaluated at the market equilibrium, is given by

$$\text{euv}_{ri} = \frac{(A/2 + \phi n_{s1})q^*_{rs1}p^*_{rs1} + (A/2 + \phi n_{s2})q^*_{rs2}p^*_{rs2}}{(A/2 + \phi n_{s1})q^*_{rs1} + (A/2 + \phi n_{s2})q^*_{rs2}} = \theta_{s1}p^*_{rs1} + \theta_{s2}p^*_{rs2} \tag{25}$$

where θ_{sj} is the share of exports of region i of country r to region j of country s, with $\theta_{s1} + \theta_{s2} = 1$. Because region i of country r imports all varieties produced in country s at the same price $p^\star_{sri}$, the import unit value index is simply given by

$$\text{iuv}_{ri} = p^*_{sri}. \tag{26}$$

Hence, the terms of trade of region i of country r are given by

$$\rho_{ri} \equiv \frac{\text{euv}_{\text{ri}}}{\text{iuv}_{\text{ri}}} = \frac{\theta_{s1}p^*_{rs1} + \theta_{s2}p^*_{rs2}}{p^*_{sri}}. \tag{27}$$

How do the terms of trade change with respect to transport and trade costs? Since the general analysis with asymmetric firm distributions turns

[9] In order to remain within the standard framework of international trade theory, in this index we do not take into account the interregional "imports".

out to be too complex, we focus exclusively on the symmetric setting in which both countries are dispersed. Albeit particular, our setting allows us to uncover several interesting results. Some cumbersome calculations reveal that

$$\left.\frac{\partial \rho_{ri}}{\partial \tau}\right|_{\lambda_r=\lambda_s=1/2} = \frac{2cn(2b+3cn)(t_r - t_s)}{(4a + cnt_r + 6\tau cn + 4\tau b)^2}. \tag{28}$$

Condition (28) shows that, when the two countries are dispersed, *international integration shifts the terms of trade in favor of the more integrated country.* More precisely, when $t_r < t_s$, a decrease in τ raises ρ_{r1} and ρ_{r2} but both ρ_{s1} and ρ_{s2} decrease; the two regions of the same country are equally affected. This result shows that the transport costs of the trading partners have a direct impact on the terms of trade, even when the two countries have the same size and the same spatial structure.

Furthermore, we have

$$\left.\frac{\partial \rho_{ri}}{\partial t_s}\right|_{\lambda_r=\lambda_s=1/2} = \frac{cn}{(4a + cnt_r + 6\tau cn + 4\tau b)} > 0 \tag{29}$$

as well as

$$\left.\frac{\partial \rho_{ri}}{\partial t_r}\right|_{\lambda_r=\lambda_s=1/2} = -cn\frac{4a + cnt_s + 6\tau cn + 4\tau b}{(4a + cnt_r + 6\tau cn + 4\tau b)^2} < 0. \tag{30}$$

Conditions (29) and (30) show that each country has an incentive to decrease its transport costs in order to twist the terms of trade in its favor. Because the terms of trade are directly linked to welfare (Winters and Chang, 2000), each country also has an incentive to twist the terms of trade in order to improve its welfare. That such a "competitive" behavior can make everybody worse off is shown in section 6. One can further see that

$$\left.\frac{\partial \rho_{ri}}{\partial t_s}\right|_{\lambda_r=\lambda_s=1/2} \gtreqless -\left.\frac{\partial \rho_{ri}}{\partial t_r}\right|_{\lambda_r=\lambda_s=1/2} \quad \text{iff} \quad t_r \gtreqless t_s. \tag{31}$$

This shows that *when both countries simultaneously decrease their transport costs by the same amount*, the initially better integrated country enhances the terms of trade of its regions.

The foregoing discussion may be summarized as follows.

Proposition 2 *When both countries are dispersed, a decrease in international trade costs shifts the terms of trade in favor of the country with lower interregional transport costs. Moreover, if transport costs fall within one* *country only, its terms of trade improve; if they fall equiproportionately in both countries, the terms of trade move in favor of the country with lower initial transport costs.*

This result suggests that the future expansion of the EU to ten new member countries is not likely to leave the terms of trade unchanged. Indeed, as shown previously, international integration could well lead to a deterioration of the terms of trade of the new entrants, characterized by less developed infrastructures than those of the EU-92 members. As shown by Baldwin *et al.* (2003) similar conclusion are also reached within the DSK framework, which reveals their robustness. Notice, however, that under DSK assumptions the movements of the terms of trade would be driven by changing θ's only. Here they also stem from changing prices as trade and transport costs affect firms' mark-ups.

5 Trade costs and welfare

Our framework allows for a precise study of the welfare impact of the various parameters expressing the freeness of exchange across regions and countries. For simplicity, in analyzing such impacts, we neglect both the proceeds that governments obtain through tariffs on imports and the infrastructure costs they must incur to make interregional transportation cheaper. Notice, however, that assuming that reductions in trade and/or transport costs require the use of resources would reinforce our results.

Individual utilities being quasi-linear, the total welfare W_r in country r may be defined as the sum of consumer surpluses and wages across regions:

$$\begin{aligned} W_r(\lambda_r, \lambda_s) &= \lambda_r L[S_{r1}(\lambda_r) + w_{r1}(\lambda_r, \lambda_s)] + (1-\lambda_r)L[S_{r2}(\lambda_r) + w_{r2}(\lambda_r, \lambda_s)] \\ &\quad + \frac{A}{2}[S_{r1}(\lambda_r) + S_{r2}(\lambda_r) + 2] \end{aligned}$$

where S_{ri}, as defined by (17), is the consumer surplus in region $i = 1, 2$ of country $r = H, F$ (recall that unskilled wages are equal to unity).

First, differentiating this expression with respect to τ yields

$$\frac{\partial W_r}{\partial \tau} = \frac{b + 2cn}{16(b + cn)} (\kappa_1 t_r + \kappa_2 t_s + \kappa_3 \tau + \kappa_4)$$

where

$$\begin{aligned}\kappa_1(\lambda_r) &\equiv 2(b+cn)[4cn^2\phi\lambda_r(\lambda_r-1)-cnA]<0\\ \kappa_2(\lambda_s) &\equiv 4cn^2(b+cn)\phi\lambda_s(\lambda_s-1)-cnA(2b+cn)<0\\ \kappa_3 &\equiv 2(6b^2+8bcn+3c^2n^2)(\phi n+A)>0\\ \kappa_4 &\equiv -2a(3b+2cn)(n\phi+A)<0\end{aligned}$$

Therefore, we have

$$\frac{\partial W_r}{\partial \tau} \gtreqqless 0 \quad \text{if and only if} \quad \tau \gtreqqless \widehat{\tau}_r(\lambda_r)$$

where

$$\widehat{\tau}_r(\lambda_r,\lambda_s) \equiv \frac{-\kappa_1(\lambda_r)t_r-\kappa_2(\lambda_s)t_s-\kappa_4}{\kappa_3} < \tau_{trade}$$

for all admissible values of λ_r and t_r.

In general, we have $\widehat{\tau}_r(\lambda_r,\lambda_s) \neq \widehat{\tau}_s(\lambda_r,\lambda_s)$. Without loss of generality, we may assume that $t_r \leq t_s$ so that we have $\widehat{\tau}_r(\lambda_r,\lambda_s) \leq \widehat{\tau}_s(\lambda_r,\lambda_s)$ for all spatial equilibria. When τ starts decreasing from τ_{trade}, our results then show that *lowering trade costs makes each country worse off when these costs are sufficiently high*, i.e. when $\tau > \widehat{\tau}_s(\lambda_r,\lambda_s)$. Then, as τ falls below $\widehat{\tau}_s(\lambda_r,\lambda_s)$, there is a first reversal in that the welfare starts increasing in country s, whereas it keeps decreasing in r. Finally, when τ is sufficiently low ($\tau < \widehat{\tau}_r(\lambda_r,\lambda_s)$), the welfare level rises in both countries when trade costs decrease further. In the limit case where $t_H = t_F$, the foregoing sequence involves only two steps, namely a decrease and then an increase in the welfare of each country. These results show that integrating two economies leads to a $\cup$-shaped relationship between national welfare and trade costs. *Stated differently, the benefits of integration come after its costs.*

To sum-up, we have:

Proposition 3 *When trade costs gradually decrease, the global economy goes through three phases: (i) the level of welfare in each country decreases; (ii) the less integrated country enjoys a welfare improvement whereas the welfare of the other country keeps falling; and (iii) both countries are better off.*

This result stems from the fact that firms absorb part of the shipping costs so that there is too much trade going on. This is reminiscent of the inefficiency of 'dumping' pointed out by Brander and Krugman (1983): lower trade costs may reduce welfare when they remain sufficiently high because the resource waste due to dumping offsets the gains from tougher competition. Here, the same line of reasoning applies due to freight absorption as equilibrium prices (5), (6) and (9) make clear. Since no freight is absorbed by firms facing CES demands and iceberg trade costs, the above proposition would not hold in the DSK framework of Fujita *et al.* (1999).

6 Transport costs and welfare

Consider now a gradual decrease in transport costs in, say, country r. As the welfare impact may vary across countries, it is useful to distinguish between the *national* and the *global effects* of lower t_r.

6.1 National welfare

Some tedious but standard calculations show that, regardless of the equilibrium configuration in either country, we have:

$$\frac{\partial W_r}{\partial t_r} < 0 \qquad r = H, F$$

Hence, *the welfare of country r always increases when its transport costs are lowered*. This shows that the resource waste effect is always more than offset by the pro-competitive effect as the latter is amplified by a 'home market effect' (Krugman, 1980): domestic firms increase their market shares at the expense of foreign firms.

Consider now the impact on country $s \neq r$. Because a decrease in t_r, by exacerbating the degree of price competition in country r, affects adversely the export prices of the firms located in country $s \neq r$ and because this effect is the only one that impacts on the welfare of this country, we immediately have

$$\frac{\partial W_s}{\partial t_r} > 0 \qquad r = H, F \quad \text{and} \quad s \neq r$$

In words, we see that a country is always worse off when the foreign country improves upon the quality of its transportation infrastructure. Put differently, we have something like a "fortress effect" in that accessing the increasingly integrated market becomes more and more difficult (see, e.g. Head and Mayer, 2000, for the European case). In the case of country s the resource waste effect more than offsets the pro-competitive effect as it is now the former that is supported by the 'home market effect'. This result is reminiscent of the ones obtained in the context of preferential trading agreements, where it is shown that even if external tariffs (τ in our case) are unchanged, nonmember countries to the agreement are likely to suffer from regional integration (see, e.g. Chang and Winters, 2002, for estimates of those effects).

A first conclusion therefore emerges: *each country has an unambiguous incentive to decrease its transport costs but this affects adversely the foreign country.* The reason is rent shifting which leads to a potential conflict of interests between countries. With respect to the DSK approach, in our model the beneficial effects of rent shifting are amplified by the pro-competitive effect.

6.2 Global welfare

The analysis of the impact of a change in t_r on global welfare is more convoluted as the total effect varies with the internal geography of the trading partners. Therefore, for simplicity, we restrict ourselves to two particular cases: (i) transport costs t_r vary whereas t_s is kept constant and we evaluate the effect for $t_H = t_F = t$, and (ii) transport costs are the same in both countries $t_H = t_F = t$ and we evaluate the effect of a variation in t (which now corresponds to a *joint equiproportionate* variation of t_H and t_F).

Let

$$\Omega_r(\lambda_r, \lambda_s) \equiv \frac{\partial W_r}{\partial t_r} + \frac{\partial W_s}{\partial t_r} \qquad \text{with } s \neq r \tag{32}$$

so that the evolution of $W_r + W_s$ is given by the sign of $\Omega_r(\lambda_r, \lambda_s)$. When $\Omega_r(\lambda_r, \lambda_s) < 0$ (resp. $\Omega_r(\lambda_r, \lambda_s) > 0$), the global welfare rises (resp. falls) when transport costs in country r decrease. Interestingly enough, we will see that the sign of $\Omega_r(\lambda_r, \lambda_s)$ varies with the value of t and, therefore, with the internal geography of countries H and F. Because of symmetry, only two spatial patterns may arise in equilibrium, namely the two economies are dispersed ($\lambda_H = \lambda_F = 1/2$) or agglomerated (without loss of generality, $\lambda_H = \lambda_F = 1$).

(i) Consider first the case in which dispersion prevails in either country, that is, $t > t^\star$. We then have

$$\Omega_r(1/2, 1/2) = \frac{n(L+A)(b+cn)}{16(2b+cn)^2}\,(\delta_1 t + \delta_2 + \delta_3 \tau)$$

where

$$\begin{aligned} \delta_1 &\equiv 12b^2 + 20bcn + 9c^2n^2 > 0 \quad \delta_2 \equiv -4a(3b+2cn) < 0 \\ \delta_3 &\equiv 2cn(4b+3cn) < 0 \end{aligned}$$

Let

$$\widetilde{t}_d(\tau) \equiv -\frac{\delta_2 + \delta_3\tau}{\delta_1} > 0$$

be the solution to $\delta_1 t + \delta_2 + \delta_3\tau = 0$ with respect to t. Then, we have $\Omega_r(1/2, 1/2) > 0$ (resp. $\Omega_r(1/2, 1/2) < 0$) if and only if $t > \widetilde{t}_d$ (resp. $t < \widetilde{t}_d$).

In the appendix, we show that the global welfare impact of a unilateral decrease in transport costs depends on the initial value of these costs. Specifically, *global welfare decreases when* $t > \widetilde{t}_d > t^\star(\tau)$ *and increases when* $\widetilde{t}_d > t > t^*(\tau)$. This occurs when trade costs are high or the mass of unskilled workers is large. Further, *when both trade costs are low and the mass of unskilled is small, decreasing transport costs within a country is always inefficient.*

(ii) We now come to the case in which $t < t^*(\tau)$ so that agglomeration prevails in the two national economies. The analysis is similar to the one above but the results are more clear-cut. We must now evaluate the sign of

$$\Omega_r(1, 1) = \frac{n(b + 2cn)A}{16(b + cn)^2} (\eta_1 t + \eta_2 + \eta_3\tau)$$

where

$$\begin{aligned} \eta_1 &\equiv 6b^2 + 8bcn + 3c^2n^2 > 0 \quad \eta_2 \equiv -cn(4b + 3cn) < 0 \\ \eta_3 &\equiv -2a(3b + 2cn) < 0 \end{aligned}$$

Let $\widetilde{t}_a$ be the solution of $\eta_1 t + \eta_2 + \eta_3\tau = 0$ with respect to t, namely

$$\widetilde{t}_a \equiv -\frac{\eta_2 + \eta_3\tau}{\eta_1} > 0$$

Clearly, $\Omega_r(1, 1) < 0$ (resp. $\Omega_r(1, 1) > 0$) if and only if $t > \widetilde{t}_a$ (resp. $t < \widetilde{t}_a$). To rank $\widetilde{t}_a$ and $t^*(\tau)$, we set $\Delta_a \equiv \widetilde{t}_a - t^*(\tau)$. Again, $\widetilde{t}_a$ is independent of A whereas $t^*(\tau)$ is a decreasing function of A, so that Δ_a is an increasing function of A. Because $\Delta_a(\overline{A}) > 0$, Δ_a is positive for all $A > \overline{A}$, thus implying that $\Omega_r(1, 1)$ is always positive. In words, when the two countries are agglomerated, any reduction of transport costs by one country is always beneficial to this country and to the global economy. Also, the two countries are never trapped into a prisoner's dilemma.

Our analysis may be summarized as follows.

Proposition 4 *Assume that both countries have the same transport costs. When both trade costs are sufficiently low and the mass of unskilled workers is small enough, a unilateral decrease of its transport costs by one country is* *socially undesirable as long as* $t > t^*(\tau)$ *and becomes desirable for* $t < t^*(\tau)$. *In the remaining cases, it is undesirable for* $t > \widetilde{t}_d$ *and desirable for* $t < \widetilde{t}_d$.

Once more we find that, differently from the DSK framework, for high trade costs the resource waste effect dominates the pro-competitive effect, provided shipping costs are relatively large.

6.3 Should transportation policies be coordinated?

As our setting is symmetric, we also have

$$\left.\frac{\partial W_s}{\partial t_r}\right|_{t_r=t_s} = \left.\frac{\partial W_r}{\partial t_s}\right|_{t_r=t_s} \qquad \text{with } s \neq r \tag{33}$$

and, thus, substituting (33) into (32) shows that

$$\Omega_r(\lambda_r, \lambda_s) \equiv \left.\frac{\partial W_r}{\partial t_r}\right|_{t_r=t_s} + \left.\frac{\partial W_r}{\partial t_s}\right|_{t_r=t_s} \qquad \text{with } s \neq r$$

also measures the impact on the welfare of country r of a simultaneous and identical variation of t_r and t_s.

We know that each country has incentives to improve its welfare by decreasing its own transport costs. However, when both countries simultaneously decrease their transport costs, we may reinterpret the results of the foregoing section as follows. First, when $t > \widetilde{t}_d$ regardless of the values of A and τ, each country ends up being worse off because the negative effect inflicted by the other is dominant. Put differently, the two countries are in a *prisoner's dilemma situation*. This unsuspected result can be established only in a setting involving several countries because the direct effects of improving national transport infrastructure are always positive. It also uncovers a case in which international cooperation in choosing a transportation policy is desirable.[10]

Second, as in the foregoing, when $t < \widetilde{t}_d$ both countries are better off except when both trade costs are low and the mass of unskilled is small, which implies that the welfare of each country can still decrease. All of this shows that *uncoordinated transport policies may have diverging consequences on the welfare level of each country according to the initial level of the corresponding costs.*

[10] That result is reminiscent of the one highlighted in the debate on unilateral versus multilateral trade agreements. Indeed, it is argued that multilateral negociations (e.g., the GATT) allow countries to escape from a potential 'terms-of-trade driven' prisoner's dilemma that could arise from multiple unilateral agreements (Bagwell and Staiger, 1998 and 1999).

7 Density economies in transportation

So far, we have assumed that trade costs are independent of the spatial distribution of firms within the two countries. Yet, as argued in the introduction, it is a well-established fact that international transport costs are lower on routes processing larger volumes of freight. In this section, we assume that trade costs τ are affected by the spatial distribution of firms in the two countries as observed in reality. We see this as a forceful example of the validity of Ohlin's claim as quoted above: "*international trade theory cannot be understood except in relation to and as part of the general location theory*" (Ohlin, 1968, p. 97).

More precisely, we assume that

$$\tau(\lambda_H, \lambda_F) = \tau[1 - \xi(\lambda_H + \lambda_F - 1)] \tag{34}$$

where $\xi \in [0, 1]$ is an indicator of the degree of density economies in transportation and $\tau \leq \tau_{trade}$. Without loss of generality, we assume that region 1 is the larger region in each country: $\lambda_H \geq 1/2$ and $\lambda_F \geq 1/2$. Clearly, when both countries are dispersed ($\lambda_H = \lambda_F = 1/2$), we have $\tau(\lambda_H, \lambda_F) = \tau$, while international trade costs drop to $(1 - \xi)\tau$, which can be interpreted as the incompressible component of trade costs, when both countries are agglomerated. For $\xi = 0$, there are no economies of transport density and we fall back on the case covered in section 3.

Although we have no empirical evidence to support the explicit functional form (34), the idea is that a higher degree of agglomeration within each country is accompanied by the development of specific transportation infrastructures that make the impediments to trade between countries weaker. Equally important is the fact that (34) is sufficient to break the separability property between the two countries' internal geographies.

Indeed, using (19) the indirect utility differential becomes:

$$\Delta V_r^*(\lambda_r, \lambda_s) = \frac{n(b + 2cn)t_r}{4\phi(b + cn)^2} \left(\lambda_r - \frac{1}{2}\right) \left[\varepsilon_1 t_r + \varepsilon_2 + \varepsilon_3 \tau(\lambda_r, \lambda_s)\right] \tag{35}$$

where ε_1, ε_2 and ε_3 are given by (20), (21) and (22), respectively. It is worth noting that, differently from (19), (35) now depends on the entire distribution (λ_H, λ_F) through the international trade cost $\tau(\lambda_r, \lambda_s)$. Among other things, as just anticipated, this implies that *there is interdependence between the internal geographies of the two countries.*

The definition of a spatial equilibrium being the same as in the foregoing, it follows from (35) that $\lambda_r = 1/2$ remains an equilibrium for country

$r = H, F$. Because $\varepsilon_1 t_r + \varepsilon_2 + \varepsilon_3 \tau(\lambda_r, \lambda_s)$ depends on the spatial distribution of firms in the two countries, we might observe richer spatial patterns. The various stable equilibria are now described by and classified into five categories.

(i) *Full dispersion* with $\lambda_H^* = \lambda_F^* = 1/2$ is a stable equilibrium if and only if

$$\varepsilon_1 t_r + \varepsilon_2 + \varepsilon_3 \tau \leq 0 \quad \text{and} \quad \varepsilon_1 t_s + \varepsilon_2 + \varepsilon_3 \tau \leq 0.$$

It is readily verified that this is the case if and only if

$$t_r \geq \frac{\varepsilon_3 \tau + \varepsilon_2}{-\varepsilon_1} \equiv t^b(\tau) \tag{36}$$

holds for $r = H, F$. As expected, this shows that dispersion is a spatial equilibrium if and only if transport costs in both countries are sufficiently high. Here, $t^b(\tau)$ is called the *unconditional sustain point*. Note that $t^b(\tau) \equiv t^*(\tau)$, where $t^*(\tau)$ is given by (23) in section 3.

(ii) *Full agglomeration* with $\lambda_H^* = \lambda_F^* = 1$ is a stable equilibrium if and only if

$$\varepsilon_1 t_r + \varepsilon_2 + \varepsilon_3 \tau(1 - \xi) \geq 0 \quad \text{and} \quad \varepsilon_1 t_s + \varepsilon_2 + \varepsilon_3 \tau(1 - \xi) \geq 0.$$

Some straightforward calculations show that this is the case if and only if

$$t_r \leq t^s(\tau) \equiv \frac{\varepsilon_3 (1 - \xi)\tau + \varepsilon_2}{-\varepsilon_1} \tag{37}$$

holds for $r = H, F$. Hence, as expected, full agglomeration is a spatial equilibrium if and only if transport costs in both countries are sufficiently low. Here, $t^s(\tau)$ is defined as the *unconditional sustain point.*

The adjective 'unconditional' in defining $t^b(\tau)$ and $t^s(\tau)$ is used because the distribution of firms within country r, say, is driven by internal forces only and is independent of the distribution λ_s prevailing in the other country. It is straightforward to show that $t^s(\tau) < t^b(\tau)$ for all values of τ:

$$t^b(\tau) - t^s(\tau) = \frac{\varepsilon_3}{-\varepsilon_1} \xi \tau \geq 0.$$

This shows that the gap between the unconditional break and sustain points widens with the degree of density economies ξ as well as with the value of trade costs τ. Thus, *the higher the density economies and the larger the values of international trade costs, the more interdependent the geographies of* *the trading partners.*[11] Because $t^b > t^s$, there now exist additional equilibria, which are not covered by cases (i) and (ii). They are as follows.

(iii) A *mixed equilibrium* with $\lambda_r^* = 1$ and $\lambda_s^* = 1/2$ is a stable spatial equilibrium if and only if

$$\varepsilon_1 t_r + \varepsilon_2 + \varepsilon_3 \tau \left(1 - \frac{\xi}{2}\right) \geq 0 \quad \text{and} \quad \varepsilon_1 t_s + \varepsilon_2 + \varepsilon_3 \tau \left(1 - \frac{\xi}{2}\right) \leq 0.$$

Hence,

$$t_r \leq t^c(\tau) \quad \text{and} \quad t_s \geq t^c(\tau) \tag{38}$$

must hold, where

$$t^c(\tau) \equiv \frac{\varepsilon_3 \tau \left(1 - \frac{\xi}{2}\right) + \varepsilon_2}{-\varepsilon_1}$$

is the conditional break-sustain point at which the equilibrium pattern of a country changes *conditionally upon the geographical structure of the other.* Clearly, we have $t^s(\tau) < t^c(\tau) < t^b(\tau)$.[12]

Somewhat unexpectedly, we will see that there is a whole range of parameter values for which there exist stable equilibria such that one of the two countries is partially agglomerated.[13] This comes as a surprise because such equilibria never arise in comparable one country models of economic geography (Krugman, 1991; Fujita *et al.*, 1999; Ottaviano *et al.*, 2002).

(iv) An *interior equilibrium* with $\lambda_r^* = 1$ and $\lambda_s^* \in (1/2, 1)$ is a stable equilibrium if and only if

$$\varepsilon_1 t_r + \varepsilon_2 + \varepsilon_3 \tau (1 - \xi \lambda_s^*) \geq 0 \quad \text{and} \quad \varepsilon_1 t_s + \varepsilon_2 + \varepsilon_3 \tau (1 - \xi \lambda_s^*) = 0.$$

Some simple calculations show that

[11] When there are no density economies in transportation (i.e. when $\xi = 0$), the unconditional break and sustain points coincide and we fall back on the case covered in section 3.

[12] Note that mixed equilibria also arise in the two country-four region DSK setting without density economies used by Montfort and Nicolini (2000). However, in such a framework analytical solutions are not available for this special case and the qualitative analysis turns out to be intractable.

[13] One can easily check that there is no stable interior equilibrium such that both countries are simultaneously partially agglomerated.

$$\lambda_s^* = \frac{\varepsilon_1 t_s + \varepsilon_2}{\varepsilon_3 \tau \xi} + \frac{1}{\xi}$$

and that the condition for agglomeration in country r holds at $\lambda_s^\star$ when $t_r \leq t_s$. Furthermore, the interior equilibrium $\lambda_s^\star$ in country s is stable when

$$t_s < t^c(\tau)$$

and it belongs to $(1/2, 1)$ if and only if

$$t^s(\tau) < t_s < t^c(\tau) \tag{39}$$

which implies the previous inequality.

(v) An *interior equilibrium* with $\lambda_r^* = 1/2$ and $\lambda_s^* \in (1/2, 1)$ is a stable equilibrium if and only if

$$\varepsilon_1 t_r + \varepsilon_2 + \varepsilon_3 \tau [1 - \xi(\lambda_s^* - 1/2)] \leq 0 \quad \text{and} \quad \varepsilon_1 t_s + \varepsilon_2 + \varepsilon_3 \tau (1 - \xi \lambda_s^*) = 0. \tag{40}$$

Some simple calculations show that

$$\lambda_s^* = \frac{\varepsilon_1 t_s + \varepsilon_2}{\varepsilon_3 \tau \xi} + \frac{1}{\xi} + \frac{1}{2}$$

which belongs to $(1/2, 1)$ if and only if

$$t^c(\tau) < t_s < t^b(\tau). \tag{41}$$

Further, dispersion in country r is stable at $\lambda_s^\star$ if and only if $t_r \geq t_s$, while the stability condition for s is given by

$$t_s < t^b(\tau)$$

which is satisfied when (41) holds.

It is readily verified that (36)-(41) together with the associated conditions cover the whole set of possible values for t_r and t_s. Cases (iv) and (v) clearly show that, *when transport costs take intermediate values, the more integrated country is more agglomerated whereas the less integrated country is more dispersed.* This can be seen from figure 1, where all couples (λ_r, λ_s) below (resp. above) the diagonal correspond to equilibria where country r is more (resp. less) agglomerated than country s. It is then easily verified that the interior equilibria $\lambda_s^\star$ vary continuously between 1/2 and 1 as transport costs evolve (see figure 1). Therefore, *there is no catastrophic transition from agglomeration to dispersion.*

Insert figure 1 about here

In section 3, the independence between the two internal geographies eliminates the intermediate cases (iii) – (v), which shows that *agglomeration (or dispersion) within a country may be induced by the geography of the other country through the channel of trade.* In other words, even though there is a priori no internal reason for dispersion, say, to arise in a country, this configuration may well arise because of the internal structure of the trading partner. Indeed, as shown by figure 1, there is a range of transport cost values $t_r \in [t^s, t^b]$ for which *country r would be agglomerated if there were no economies of density, while country r is either dispersed or only partially agglomerated in the presence of density economies.*

This is best explained as follows. If transport costs in country r take intermediate values (between t^s and t^b), the agglomeration forces generated within country r are sufficiently strong to sustain agglomeration in the absence of density economies. Yet, in the presence of such economies, firms in country r do not agglomerate since this decreases trade costs and, therefore, significantly increases the impact of foreign competitors in country r. Only if country-s transport costs are sufficiently large (whence country s is dispersed) will firms in country r partially agglomerate, since the better access to the less competitive external markets makes up for the stronger import competition. Hence, somewhat paradoxically, *economies of density in transportation may favor a more even spatial distribution within countries, while the distribution between countries gets more asymmetric.* Of course, this result crucially hinges on the assumption that no region has a comparative advantage in accessing the foreign markets.

Finally, we have seen that there is a range of values of transport costs for which both countries would be agglomerated without the presence of density economies in transportation, whereas at most one of them is (fully) agglomerated in the presence of such economies. Because the welfare in country r increases as its transport costs decrease (see section 5.2), there is a potential conflict of interests in that only one country develops a core region whereas both would like to have one. Yet, as also argued in section 5.2, decreasing transport costs in both countries are not necessarily beneficial to them. Hence, the presence of density economies in transportation might well prevent such an undesirable situation to arise.

8 Concluding remarks

We have presented a model that shows how changes in the transportability of commodities as well as in the mobility of factors *between and within* countries affect the location of economic activities, the distribution of factors, the geography of demand and, therefore, the pattern of trade as well as welfare.

Our key result is that lower intranational transport costs foster regional divergence when international trade costs are high enough, whereas lower international trade costs promote regional convergence when intranational transport costs are high enough. This clearly shows that, *when production factors have different degrees of mobility at different spatial scales of analysis, international and interregional integration play important, yet distinct, roles in explaining the evolution of economic geography within a country.* In particular, no general conclusion can be reached on the impact of a simultaneous international and interregional integration on regional imbalances when internal transport and international trade costs are not too different. Accordingly, the eastern enlargement of the EU, when coupled with infrastructural improvements in the lagging regions of new member countries, might well have very different effects on those countries' economic geography depending on their internal integration and their relative distance from the old members.

Whereas our results concerning *interregional* integration agree with what is known in economic geography, our results concerning *international* integration do not. In particular, they conflict with those obtained in comparable models featuring partially immobile demand as dispersion force (Montfort and Nicolini, 2000; Crozet and Koenig-Soubeyran, 2002). These studies argue that international trade liberalization fosters regional polarization within countries. How can we explain such different results? The answer lies in an unsuspected by-product of different modeling strategies. While the cited contributions use the DSK framework with CES demands and iceberg costs of transportation, we use instead linear demands and linear costs of transportation. Consequently, trade and transport costs affect prices multiplicatively in the above references, whereas they affect prices additively in our model. In other words, while trade and transport costs are proportional to prices in the DSK setting, their shares in prices vary with the level of prices in ours. The main message of economic geography is that the internal geography of a 'country' depends on the level of its transport costs. This in turn affects the intensity of competition and the level of prices in the space-economy under consideration. When trade costs are additive, there is no feedback effect from prices to trade costs, but trade costs are affected when they are multiplicative. This clearly shows that *the way trade and transport costs are modeled is not neutral for the nature of the results.*

Under this respect, it is worth noting that iceberg costs have more the nature of an ad valorem tariff than that of a standard shipping cost or that of a nontariff barrier, which are not directly related to the value of traded goods. Consequently, if trade liberalization consists mainly in the removal of either tariff barriers or nontariff barriers, its impact on the internal geography of countries may be different. This finding shows that there is great need for more 'realistic' trade cost specifications, where both the additive and the multiplicative components are accounted for. It also suggests that, on the one hand, increasing regional polarization within the EU could well be driven by improvements in member-states' infrastructures combined with the decrease of ad valorem tariff barriers whereas, on the other hand, actual improvements in infrastructures at the EU level would be insufficient to favor a more balanced regional development. These various effects have been overlooked in the literature, where all the impediments to trade are typically collapsed into a single parameter affecting prices in the same way. Such a simplifying approach could explain why different authors obtain contrasted results about the impact of a growing economic integration. In a way, our claim is reminiscent of the distinction between ad valorem and per unit commodity taxes whose impacts on the market outcome are known to be very different (see, e.g. Anderson *et al.*, 2001).

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Appendix: welfare impact of a unilateral decrease in transport costs

To determine the sign of $\Omega_r(1/2, 1/2)$, we have to rank $\widetilde{t}_d$ and t^*. Set $\Delta_d \equiv \widetilde{t}_d - t^*$. As $\widetilde{t}_d$ is independent of A whereas t^* is a decreasing function of A, Δ_d is an increasing function of A. To determine the sign of Δ_d, we evaluate Δ_d at the lowest admissible value of A, which is given by the threshold $\overline{A}$ defined in section 3. It is then readily verified that $\Delta_d(\overline{A}) > 0$ if and only if $\tau \in (\widetilde{\tau}, \tau_{trade})$ where

$$\widetilde{\tau} \equiv \frac{2acn(3b + 4cn)}{24b^3 + 72b^2cn + 70bc^2n^2 + 21c^3n^3} < \tau_{trade}$$

in which case $\Delta_d > 0$ for all values of $A > \overline{A}$. Hence, $\Omega_r(1/2, 1/2) > 0$ as long as $t > \widetilde{t}_d$, thus implying that *both countries are worse off when one country unilaterally cuts its own transport costs from high values.* By contrast, when $t \in (t^*, \widetilde{t}_d)$, we obtain $\Omega_r(1/2, 1/2) < 0$ in which case the domestic country gains more than the foreign country loses.

It remains to describe what happens when $\tau < \widetilde{\tau}$, that is, when $\Delta_d(\overline{A}) \leq 0$. In this case, $\widetilde{A}$ exists such that $\Delta_d(A) > 0$ (resp. $\Delta_d(A) < 0$) when $A > \widetilde{A}$ (resp. $A < \widetilde{A}$), where

$$\widetilde{A} \equiv \frac{\phi}{c} \frac{9a(2b^2 + 21bcn + 13c^2n^2) + (5bc^2n^2 + 6c^3n^3)\tau}{3(2ab + 2cn) + (4cbn + 3c^2n^2)\tau} > \overline{A}$$

When $\tau < \widetilde{\tau}$, two cases may arise when $A > \widetilde{A}$. In the former one, $\Omega_r(1/2, 1/2) > 0$ as long as $t > \widetilde{t}_d$ and negative otherwise. In the latter case, we always have $A < \widetilde{A}$ and $\Omega_r(1/2, 1/2) > 0$ because $\widetilde{t}_d < t^*$. In other words, a decrease in one country's transport costs is always globally efficient when the mass of unskilled is not too large.