International integration and regional inequalities: how important is national infrastructure?*

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Abstract

We investigate how international trade and trade policy possibly affect the regional distribution of economic activities within a country involved in a process of economic integration. Our analysis reveals that the impact of decreasing international trade costs on the spatial distribution of economic activities strongly depends on the structure of trade flows and the value of transport costs internal to the country. Whereas trade liberalization in developing countries with poor infrastructure and mostly autarkic regions may exacerbate spatial inequalities, countries with better infrastructure and larger volumes of interregional trade may experience a more balanced geographical development.

Keywords: trade liberalization; regional integration; transport costs; trade costs; economic geography.

JEL Classification: D11; F12; L13; R12.

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1 Introduction

The rapid globalization of the world economy and the resulting expansion in international trade are two of the most striking contemporary developments, affecting both the developed and the developing world. Given the economic and social importance of these two phenomena, it is fundamental to understand whether international trade and factor mobility might lead to a highly uneven distribution of the gains from trade, with only a handful of nations or regions reaping the benefits, while leaving the others aside in the economic development process. Although the possibility of economic divergence at a *large international scale* is a widely studied aspect of the globalization process (see, e.g., Krugman and Venables, 1995; Venables 1996; Venables and Puga, 1998), the *regional impacts* of economic integration *within* liberalizing countries have received only limited attention until now. Yet, such a neglect might be crucial because the effects of economic integration are likely to differ across regions within the same country, thus reshaping the economic landscape and possibly triggering social turmoils should the gains and losses be unevenly distributed. That such considerations are taken seriously by policy makers can, e.g., be seen in the European Union, where Article 130a of the Amsterdam Treaty of 1997 explicitly spells out a regional cohesion objective.

Despite its theoretical and practical importance, there are at present only few contributions dealing with the question of how international trade liberalization affects the spatial distribution of economic activities within a country involved in a process of international integration. This lack of studies is exacerbated by the fact that no clear picture emerges from the existing literature. Whereas Montfort and Nicolini (2000), Paluzie (2001), Monfort and van Ypersele (2003), and Crozet and Koenig Soubeyran (2004) all conclude that international trade liberalization is susceptible to increase regional inequalities within the liberalizing country, Krugman and Livas Elizondo (1996) and Behrens *et al.* (2003) show that this need not necessarily be the case.[1] What is even more troublesome, in our opinion, is that the results of the literature do not depend on the *value of transport costs within the liberalizing country itself.* Stated differently, developing countries with

[1] Both Montfort and Nicolini (2000), Montfort and van Ypersele (2003) and Behrens *et al.* (2003) develop two-country four-region models encapsulating two distinct geographical scales. They show that international trade liberalization affects the internal geographies of the countries and that these internal geographies are usually interdependent. Hence, there is *spatial correlation* in the sense that the countries' internal structures influence each other mutually through the channels of trade.

bad transportation infrastructure and more developed countries with good transportation infrastructure are affected in the same way. Yet, this conflicts with empirical evidence which shows that both transport costs within a country and transport costs for accessing world markets have a significant impact on the structure and intensity of trade (see, e.g., Limão and Venables, 1999; Henderson *et al.*, 2001). Further, there is ample evidence suggesting that increasing trade liberalization has exacerbated the regional inequalities in many developing countries, like Indonesia, Brazil and 19th century Spain (Tirado *et al.*, 2002), whereas several developed countries recently experience the gradual redispersion of their manufacturing industries (see Brülhart and Träger, 2004, for the EU; Holmes and Stevens, 2004, for the US).[2] Even *within developing countries*, the impacts of trade liberalization usually differ significantly between regions. As argued by Haddad *et al.* (2002), the Brazilian south and south-east (endowed with rather good infrastructure) actually experience a relative redispersion of their industry, whereas the north and north-east (endowed with rather poor infrastructure) experience a relative agglomeration. When combined with the increasing north-south polarization of Brazil (see, e.g., Haddad and Perobelli, 2003a and 2003b), these developments suggest that international and interregional integration affect countries in complex ways, depending among other things crucially on the quality of local transport infrastructure.

In the present paper, we develop an economic geography model of trade based on Ottaviano *et al.* (2002) which captures the main forces that explain whether increasing economic integration leads to a more even spatial distribution of economic activities or not. Three key characteristics stand out:[3] First, our model features 'weakly strategic' pricing in segmented markets. It therefore captures many *price effects* which, as recent works by Winters and Chang (2000), Chang and Winters (2002) and Lai and Trefler (2002) have shown, are fundamental to the understanding of the impacts of economic integration. Second, it captures some of the complex interactions between national transport infrastructure and international trade costs. More precisely, our model allows for *different structures of interregional trade flows*,

[2]As shown by Brülhart and Träger (2004), manufacturing has recently dispersed *topographically* in the EU. When the concentration of industrial sectors is measured with respect to overall employment, the results get reversed, thus explaining why there is no consensus in the empirical literature as well. It is our contention that the topographical definition of concentration is the relevant one for models of economic geography, since it explicitly takes into account the spatial dimension.

[3]As shown by Hayward (1995), the industrial structure of a region is another important characteristic that has to be taken into account. Because we focus on a single industry model, we do not investigate this issue any further.

which can be associated with different qualities of national transport infrastructure. This allows us to investigate more closely whether developing and developed countries are likely to be affected in the same way by a process of deepening economic integration. Third, and finally, since we are able to characterize the spatial evolution of the economy analytically, we do not require the use of numerical simulations as most of the existing literature does (see, e.g., Crozet and Koenig Soubeyran, 2004).

The remainder of the paper is organized as follows:

In Section 2, we present the model as an extension of Ottaviano *et al.* (2002) and Behrens (2004a, 2004b). We consider a country consisting of two regions which are trading with the rest of the world; depending on the quality of national infrastructure, i.e. the value of transport costs, the regions may also trade with each other.

In Section 3, we analyze the case in which the two regions of the liberalizing country are poorly integrated so that there is no interregional trade due to high transport costs. We show that international integration favors the emergence of regional inequalities in such a context, hence suggesting that *some degree of national integration is required if regional imbalances due to trade liberalization are to be avoided*.

In Section 4, we investigate the polar case in which the two regions are linked by good transport infrastructure so that there is bilateral interregional trade. In such a setting, the progressive opening of the economy to international trade leads to a more balanced regional development, because of the fiercer price competition within the country. Yet, we show that too much international integration is susceptible to lead to the break-down of interregional trade when transport costs within the country do not decrease sufficiently. This is because cheaper imported varieties displace more expensive nationally produced ones.

In Section 5, we then briefly discuss the case in which transport costs within the liberalizing country take intermediate values. We show that there is no easy way of predicting the spatial impacts of international integration in that case. Indeed, it may well lead again to regional divergence, because the structure of interregional trade within the country may become asymmetric. When taken together, these results show that transportation infrastructure plays a crucial role in determining whether economic integration leads to more or less spatial inequality within a country.

In Section 6, we relate our main findings to those in the existing literature and highlight in what respects they differ. We argue that the conflicting results are an unsuspected by-product of different modeling choices. We show, in particular, that the way in which we model transport costs is not neutral for the nature of the results we obtain.

Section 7 finally offers some conclusions and points towards future research directions.

2 The model

We consider an economy consisting of three 'regions', labeled H, F and R. Variables associated with each region will be subscripted accordingly. Regions H and F *belong to the same country*, whereas 'region' R stands for the rest of the world (henceforth, ROW). There are two production factors in the economy: geographically mobile manufacturing workers, who produce a differentiated good under monopolistic competition and increasing returns to scale; and immobile agricultural workers, who produce a homogeneous good under constant returns to scale and perfect competition. Denote by L (resp. by L_R) the mass of mobile, and by A (resp. by A_R), the mass of immobile workers in the country (resp. in the ROW). Without loss of generality, we assume that the rest of the world has no agricultural sector, i.e. $A_R = 0$. The immobile factor A is evenly split between the two regions H and F, each of which accommodates a mass $A/2$ of it. In accord with empirical evidence (e.g., SOPEMI, 1998) and a long-standing tradition in international trade theory, we assume that labor is *internationally immobile*. Hence, both L and L_R are considered as given and fixed. Yet, workers in the manufacturing sector are *mobile between regions H and F of the country* and $\lambda \in [0, 1]$ denotes the share of mobile factor located in region H.

Products in the manufacturing sector can be costlessly differentiated and we assume that there are no economies of scope. Hence, there is a one-to-one correspondence between firms and varieties. Denote by $N \equiv n_H + n_F + n_R$ (resp. by $N_C \equiv n_H + n_F$) the mass of firms, respectively of varieties, in the global economy (resp. in the country), where n_r is the mass of firms located in region $r = H, F, R$.

We assume, for simplicity, that trading the homogenous good is costless.[4] This makes this good a suitable choice for the numéraire. The differentiated good can be traded at no cost within each region, whereas trading varieties of the differentiated good across regions is costly. More precisely, we assume that there is a unit *transport cost* $\tau > 0$ for shipping any variety between regions H and F of the country, whereas shipping any variety to or from the ROW entails a unit *trade cost* $t > 0$. Both transport and trade costs are

[4]It is of interest to note that most of the NEG literature overlooks the existence of agricultural transport costs (see, e.g., Fujita *et al.*, 1999).

incurred by the firm in terms of the numéraire. Whereas transport costs τ essentially reflect the quality of national infrastructure, trade costs t include all impediments to trade, i.e. international transport costs, tariffs, and non-tariff barriers. Note that we assume that regions H and F can access world markets at equal costs. Stated differently, international trade involves no *gate effects* in our setting. Allowing for such effects would bias the results in favor of the region having the better access to world markets (see, e.g., Crozet and Koenig Soubeyran, 2004).

Each worker in the economy supplies inelastically one unit of labor and is endowed with $\bar{q}_0 > 0$ units of the numéraire. The initial endowment $\bar{q}_0$ 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 and a consumer in region $r = H, F, R$ solves the following consumption problem:

$$\mathcal{P}\begin{cases} \max\limits_{q_0;\, q_r(i),\, i\in[0,N]} & \alpha \displaystyle\int_0^N q_r(i)\mathrm{d}i - \frac{\beta-\gamma}{2}\int_0^N q_r(i)^2\mathrm{d}i - \frac{\gamma}{2}\left(\int_0^N q_r(i)\mathrm{d}i\right)^2 + q_0 \\ & \text{s.t.} \displaystyle\int_0^N p_r(i)q_r(i)\mathrm{d}i + q_0 = w + \bar{q}_0 \end{cases}$$

where $\alpha > 0$ and $\beta > \gamma > 0$ are parameters. Define $\sigma \equiv \beta - \gamma$ for notational convenience. The parameter σ is then an inverse indicator of the elasticity of substitution between any two varieties of the differentiated good (see Ottaviano *et al.*, 2002).

As can be readily verified, the consumer problem $\mathcal{P}$ yields linear demand functions

$$q_r^*(i) = a - (b + cN)p_r(i) + cP_r, \tag{1}$$

where a, b and c are positive coefficients given by

$$a \equiv \frac{\alpha}{\sigma + N\gamma}, \quad b \equiv \frac{1}{\sigma + N\gamma} \quad \text{and} \quad c \equiv \frac{\gamma}{\sigma(\sigma + N\gamma)} \tag{2}$$

and

$$P_r \equiv \int_0^N p_r(i)\mathrm{d}i \tag{3}$$

is the aggregate price index of the differentiated industry in region r. Clearly, $\bar{P}_r = P_r/N$ can then be interpreted as the average price of the manufacturing products in region $r = H, F, R$. As can be seen from (1), demand $q_r^*(i)$ for variety i drops below zero once its price $p_r(i)$ exceeds some *reservation price*

$$\tilde{p}_r(i) \equiv \frac{a + cP_r}{b + cN}.$$

As shown by Behrens (2004a, 2004b), in order to obtain a meaningful specification for all possible prices, we can focus on the positive part of the demand only. The demand functions (1) can hence be expressed as

$$q_r^*(i) = \big[a - (b + cN)p_r(i) + cP_r\big]^+, \tag{4}$$

where $[\cdot]^+$ denotes the positive part.

In what follows, we assume that firms differ only by the particular variety they sell and by the region they are located in. We may hence drop the firm index i. Each firm in the manufacturing sector has a fixed input requirement of $\phi > 0$ units of mobile and mq units of immobile labor to produce the quantity q. Without loss of generality, we may set $m = 0$ because this amounts to rescaling firms' demand intercepts (Ottaviano *et al.*, 2002). Under these assumptions, labor market clearing in each region implies that

$$n_H = \frac{\lambda L}{\phi}, \;\; n_F = \frac{(1-\lambda)L}{\phi} \quad \text{and} \quad n_R = \frac{L_R}{\phi}. \tag{5}$$

Denote by w_r the manufacturing wage rate in region r and by p_{rs} the price a firm established in region r charges in region s. In accord with empirical evidence (see, e.g., Greenhut, 1981; Head and Mayer, 2000; Haskel and Wolf, 2001), we assume that markets are *segmented* so that firms are free to set a price particular to each market they sell their output in. In what follows, we denote by $M_r = A/2 + \phi n_r$ the market size of region $r = H, F$ and by $M_R = \phi n_R$ that of the ROW.

As shown in Appendix A, when analyzing the spatial structure of the country we can disregard the exports to the rest of the world of firms in region H and region F, which greatly simplifies the algebraic developments. This is because (i) markets are segmented, so that market conditions in the ROW do not depend on the spatial structure of the country; and (ii) all firms in the country have the same access to world markets, which implies that there are no locational differences in export revenues depending on the precise region firms are located in. Stated differently, export revenues do not influence the location decisions of firms within the country, since these revenues *are not region specific.*[5] Hence, without loss of generality we assume that $q_{HR}^* = q_{FR}^* = 0$. Note that this assumption does *not imply that firms do not export to the rest of the world*, it just states that we may abstract from these exports.

[5]Such a result no longer holds when the two regions have a different access to the world market. It is also of interest to note that, given the quasi-linear specification, total market size does not affect firms' incentives to agglomerate in our model, which explains why we can normalize exports to zero.

Using the above notation and neglecting export revenues, the profit of a firm located in region $r = H, F$ is given by

$$\pi_r = M_r p_{rr} q_{rr}^* + M_s (p_{rs} - \tau) q_{rs}^* - \phi w_r, \qquad s \neq r. \tag{6}$$

Because of the monopolistically competitive market structure with a continuum of firms, each firm accurately neglects its impact upon, and hence reactions from, other firms and takes the price index (3) as given. Depending on the value of the transport costs the profit-maximizing prices are then as follows:

$$p_{rr} = \frac{a + cP_r}{2(b + cN)} = \tfrac{1}{2}\tilde{p}_r \tag{7}$$

and

$$p_{rs} = \begin{cases} \frac{1}{2}(\tilde{p}_s + \tau_{rs}) & \text{if} \quad \tau_{rs} < \tilde{p}_s \\ \tilde{p}_s & \text{if} \quad \tau_{rs} \geq \tilde{p}_s \end{cases}, \; r \neq s, \tag{8}$$

where

$$\tau_{rs} = \begin{cases} \tau & \text{if} \quad r, s = H, F, \quad r \neq s \\ t & \text{if} \quad r = H, F, \; s = R \;\text{ or }\; r = R, \; s = H, F. \end{cases}$$

Using the symmetry between firms, the aggregate price index (3) in region r can thus be expressed as

$$P_r = n_r p_{rr}(P_r) + n_s p_{sr}(P_r) + n_t p_{tr}(P_r), \quad s \neq r \neq t. \tag{9}$$

The *price equilibrium* is then determined as follows: each firm sets its optimal price, taking aggregate market conditions P_r as given, yet, when taken together, aggregate market conditions P_r must be consistent with individual prices.[6] Plugging expressions (7) and (8) into (9), we can solve for the price equilibrium. Yet, because the expressions of the profit-maximizing prices depend on the structure of regional and international trade, three cases have to be distinguished: (i) transport costs within the country are very high, i.e. $\tau \geq \tilde{p}_s$ for $s = H, F$ and for all values of $\lambda \in [0, 1]$, so that interregional trade never occurs; (ii) transport costs within the country are sufficiently low, i.e. $\tau < \tilde{p}_s$ for $s = H, F$ and for all values of $\lambda \in [0, 1]$, so that interregional trade always occurs; and (iii) transport costs τ within the country take intermediate values, so that the occurence of interregional trade *depends on the spatial distribution* λ *of the industrial sector* within the country. For simplicity, the first case can be associated with developing countries characterized by bad

[6] Notice that firm behavior remains 'weakly strategical' in this model, contrary to the CES framework usually used in the literature (see, e.g., Fujita *et al.*, 1999; Fujita and Thisse, 2002).

infrastructure and low volumes of interregional trade, whereas the second case can be associated with developed countries characterized by good infrastructure and large volumes of interregional trade. The third case then covers the broad spectrum in between the two 'extreme cases'.[7]

After solving for the price equilibrium, the equilibrium wages in the manufacturing industry of the country are determined as usual in a perfect labor market by the zero-profit condition. Hence, there are no pure profits so that all operating profits are absorbed by the wage bill, which implies that

$$w_r^* = \frac{M_r q_{rr}^* p_{rr}^* + M_s q_{rs}^* (p_{rs}^* - \tau)}{\phi}, \qquad s \neq r. \tag{10}$$

Using the symmetry between firms, the indirect utility in region $r = H, F$ can be finally expressed as follows:

$$\begin{aligned} V_r^* &= \alpha\big(n_r q_{rr}^* + n_s q_{sr}^* + n_R q_{Rr}^*\big) - \frac{\sigma}{2}\big(n_r q_{rr}^{*2} + n_s q_{sr}^{*2} + n_R q_{Rr}^{*2}\big) \\ & -\frac{\gamma}{2}\big(n_r q_{rr}^* + n_s q_{sr}^* + n_R q_{Rr}^*\big)^2 \\ & +\big[w_r^\star - n_r p_{rr}^* q_{rr}^* - n_s p_{sr}^* q_{sr}^* - n_R p_{Rr}^* q_{Rr}^*\big] + \bar{\phi}_0, \end{aligned} \tag{11}$$

where the last two terms correspond to the consumption of the numéraire. In what follows, we assume that mobile workers migrate from low to high utility regions. Hence, the equation of motion can be easily described with the help of the *indirect utility differential* between regions H and F, which is given by

$$\Delta V^*(\lambda) \equiv V_H^*(\lambda) - V_F^*(\lambda). \tag{12}$$

A *spatial equilibrium* is such that product and labor markets clear at the equilibrium prices and wages, while no mobile worker has an incentive to change his current location. Formally, a spatial equilibrium arises at $\lambda \in (0,1)$ when $\Delta V^*(\lambda) = 0$, or at $\lambda = 0$ if $\Delta V^*(0) \leq 0$, or at $\lambda = 1$ if $\Delta V^*(1) \geq 0$. Such an equilibrium always exists because V^* is a continuous function of λ (Ginsburgh *et al.*, 1985, Proposition 1). An interior equilibrium is *stable* if and only if the slope of the indirect utility differential (12) is negative in a neighborhood of the equilibrium, whereas the two agglomerated equilibria are always stable whenever they exist.

[7] Note that the 'closed economy versions' of cases (i) to (iii) have been respectively analyzed by Behrens (2004a), Ottaviano *et al.* (2002), and Behrens (2004b). We develop the 'open economy' counterparts in sections 3 to 5 of this paper.

3 International trade liberalization when regions are poorly integrated

In this section, we investigate how international trade liberalization possibly affects the equilibrium distribution of firms in a country characterized by poor transport infrastructure and no interregional trade. To do so, we make the following two assumptions. First, interregional transport costs τ are sufficiently high so that no interregional trade occurs between regions H and F for all spatial distributions λ of firms. Albeit strong, this particular assumption captures the idea that poor national infrastructure and little interregional integration within a country are important obstacles to trade (see, e.g., Limão and Venables, 1999).[8] Second, we assume that international trade costs t are sufficiently low such that the ROW always sells to both region H and F for all spatial distributions λ of firms. Stated differently, the country is a priori always open to international trade. The precise conditions for these assumptions to hold will be derived below.

Using expressions (7), (8) and (9) with $\tau_{rs} \geq \tilde{p}_s$, the equilibrium price indices are given by

$$P_r^* = \frac{a(N + n_s) + n_R(b + cN)t}{2b + c(n_r + n_R)}, \qquad s \neq r. \tag{13}$$

Substituting the equilibrium price index (13) into (7) and (8) finally yields the following equilibrium prices:[9]

$$p_{rr}^* = \frac{2a + cn_R t}{2[2b + c(n_r + n_R)]} \quad \text{and} \quad p_{Rr}^* = p_{rr}^* + \frac{t}{2}, \quad r = H, F, \tag{14}$$

which, using (4), yields the equilibrium demands

$$q_{rr}^* = (b + cN)p_{rr}^* \quad \text{and} \quad q_{Rr}^* = \frac{(b + cN)[2a - (2b + cn_r)t]}{2[2b + c(n_r + n_R)]}, \quad r = H, F. \tag{15}$$

Note that, by assumption, $q_{HF}^* = q_{FH}^* = 0$, because there is no interregional trade between regions H and F. Note also that the equilibrium prices (14)

[8] A more realistic specification would be to assume that $\tau_{rs} = \tau + T$ and $\tau_{rr} = T$ for $r, s = H, F$, where τ are interregional transport costs and T are transaction costs related to the institutional framework. Provided that T is low enough, such that there is trade within each region, the qualitative results are the same as in our model. We hence opt for the analytically simpler specification.

[9] Because of regional autarky, the interregional prices p_{rs}^*, with $r \neq s$, are of no importance. Hence, we do not derive them explicitly.

are increasing with respect to trade costs t, which shows that trade liberalization erodes the monopoly profits of firms in the country through fiercer price competition by making imports more competitive. Finally, one should note that p_{rr}^* is decreasing with respect to the local mass n_r of firms, hence revealing the presence of a *direct competition effect* in the local market (Fujita *et al.*, 1999, call this the price index effect). This implies that the region with the larger industry share imports goods cheaper from the ROW, because local prices of substitute varieties are lower. All these results are in accordance with what is know in international trade and spatial pricing theory (see, e.g., Winters and Chang, 2000; Fujita and Thisse, 2002).

Under which conditions on the costs (τ, t) is a trade structure with regional autarky and imports from the rest of the world sustainable? Using expression (8), there are no exports from region F to region H if

$$\tau \geq \tilde{p}_H(\lambda, t), \quad \tilde{p}_H(\lambda, t) \equiv \frac{2a + cn_R t}{2b + c[\lambda N_C + n_R]}, \tag{16}$$

where $\tilde{p}_H$ is the consumer reservation price in region H. Similarily, there are no exports from region H to region F if

$$\tau \geq \tilde{p}_F(\lambda, t), \quad \tilde{p}_F(\lambda, t) \equiv \frac{2a + cn_R t}{2b + c[(1-\lambda) N_C + n_R]}. \tag{17}$$

In order for interregional trade not to occur no matter the spatial distribution of the industry, both conditions must simultaneously hold for all values of $\lambda \in [0, 1]$.[10] This yields the unique condition

$$\tau \geq \tau_{\text{notrade}}(t) \equiv \frac{2a + cn_R t}{2b + cn_R}. \tag{18}$$

Note that τ_{notrade} is decreasing with respect to trade costs t. Stated differently, the lower is t, the more likely condition (18) is to hold. This shows that when national infrastructure is poorly developed, *increasing international integration may well lead to a break-down of interregional trade* within

[10] We assume that there is no re-export from the ROW to regions in the country. Stated differently, when there is no interregional trade between H and F, firms cannot tranship via the rest of the world. A sufficient condition for this is that $\tau < 2t$. Combining this condition with (18), yields the sufficient condition

$$\frac{2a}{4b + cn_R} < t < \frac{2a}{2b + c(n_H + n_F)},$$

which always holds when the country is 'small' when compared with the ROW (i.e. when n_R is large when compared with $n_H + n_F$).

the liberalizing country, because cheaper imported varieties displace more expensive national ones. To the best of our knowledge, this effect has been overlooked in the literature until now. For ROW firms to always profitably export to regions H and F, both

$$t \leq \frac{2a}{2b + c\lambda N_C} \quad \text{and} \quad t \leq \frac{2a}{2b + c(1-\lambda)N_C}$$

must hold. Hence, firms in the ROW export to regions H and F no matter the value of $\lambda \in [0,1]$ if and only if

$$t \leq t_{\text{trade}} \equiv \frac{2a}{2b + c(n_H + n_F)}. \tag{19}$$

Note that, since $t < a/b$ in order for $q_{Rs} > 0$ to hold, condition (18) implies that $\tau > t$ in this case. Stated differently, interregional transport costs are larger than international trade costs. Although this is a strong assumption, the lack of data does not easily allow to assert whether shipping goods internationally to coastal regions of some developing countries is not cheaper than transporting goods from the coast to the more landlocked regions. Indeed, Elbadawi *et al.* (2001) find for a sample of Sub-Saharan countries that domestic transport costs have an even stronger influence on trade than international trade costs. Further, if we assume that τ also includes a more broadly defined transaction cost component, it is likely that its value for developing countries is quite large (see, e.g., Bussolo and Whalley, 2003, for the case of India).[11]

In the remainder of this section we assume that conditions (18) and (19) hold. Substituting (14) and (15) into (10), the equilibrium wage in region $r = H, F$ is given by

$$w_r^* = \left(\frac{A}{2} + \phi n_r\right) \frac{(b + cN)[2a + cn_R t]^2}{4\phi[2b + c(n_r + n_R)]^2}. \tag{20}$$

Further, substituting (14), (15) and (20) into (11), and recalling that only the intraregional quantities q_{rr}^* are non-zero, yields, after some longer rear-

[11] Anderson and van Wincoop (2004) estimate that the average ad valorem equivalent of trade costs for industrialized countries amounts to 170%. Of these, transport costs, border frictions, and internal costs of distribution (which are related to our τ) amount to 21%, 44% and 55% respectively. Figures for developing countries are higher, thus suggesting that the assumption $\tau > t$ is not totally off the mark.

rangements, the indirect utility

$$\begin{aligned} V_r^*(\lambda) &= \frac{b+cN}{8[2b+c(n_r(\lambda)+n_R)]^2}\Bigg\{4\left(\frac{a}{b}\big[n_r(\lambda)+n_R\big]-n_Rt\right) \\ &\quad\times\big[4ab+ac(n_r(\lambda)+n_R)+bcn_Rt\big]+\left(\frac{A}{\phi}-n_r(\lambda)\right)(2a+cn_Rt)^2 \\ &\quad-n_R\big[2a-(2b+cn_r(\lambda))t\big]\big[6a+(2b+4cn_R+cn_r(\lambda))t\big]\Bigg\}, \quad (21) \end{aligned}$$

with $n_H = \lambda L/\phi$ and $n_F = (1-\lambda)L/\phi$. Using (21) to evaluate the indirect utility differential (12), we get:

$$\Delta V^*(\lambda) = (2\lambda-1)\frac{(b+cN)N_C(2a+cn_Rt)}{8[2b+c(N_R+(1-\lambda)N_C)]^2[2b+c(N_R+\lambda N_C)]^2}p(\lambda), \quad (22)$$

where $p(\lambda)$ is a second order polynomial with respect to λ whose expression is given in Appendix B. Expression (22) shows that the symmetric distribution $\lambda = 1/2$ is always a spatial equilibrium. Yet, this equilibrium may be unstable for some ranges of parameter values, in which case at least some agglomeration must occur. In order to investigate the impact of an international trade liberalization on the internal geography of the country, we evaluate the sign of the derivative of the indirect utility differential (12) at the symmetric equilibrium $\lambda = 1/2$. Some longer, yet standard, calculations show that

$$\left.\frac{\partial(\Delta V^*)}{\partial\lambda}\right|_{\lambda=1/2} \geq 0 \quad \Leftrightarrow \quad p(1/2) \geq 0 \quad \Leftrightarrow \quad C_1t + C_2 \geq 0, \quad (23)$$

where

$$\begin{aligned} C_1 &\equiv 2c\left[\big(A_b - A\big) + \frac{5}{2}\phi n_R - \frac{\phi}{2c}\big(4b + cN_C + 2cn_R\big)\right]n_R \\ C_2 &\equiv 4a\left[\big(A_b - A\big) + \frac{5}{2}\phi n_R\right] \end{aligned}$$

and where

$$A_b \equiv \frac{12b\phi + cN_C\phi}{4c} \quad (24)$$

is the *break-point of the closed economy under regional autarky* (see Behrens, 2004a). When condition (23) holds, the symmetric configuration is unstable, so that either full or partial agglomeration of firms into one of the two regions is a stable spatial equilibrium. Stated differently, in that case the economy exhibits regional inequalities in the spatial distribution of population and employment, even in the absence of interregional trade. It is also of particular interest to note that, because varieties produced in the country are not shipped across regions, the larger region offers a larger choice of consumption goods. This captures the empirical fact that in many developing countries most goods (and nearly all services) are available in larger urban areas only, whereas consumers in the country-side are usually left with very little to choose from. This, in turn, creates a significant *consumption bias*, which further exacerbates already existing inequalities by inducing consumer migration.

Some closer inspection of (23) reveals that three cases must be distinguished, which are summarized by the following proposition.

Proposition 1 *Consider a two-region country with prohibitively high interregional transport costs, i.e.* $\tau \geq \tau_{\text{notrade}}$.

(i) If

$$(A_b - A) + \frac{5}{2}\phi n_R \leq 0 \tag{25}$$

then dispersion is the only stable equilibrium with international trade for all values of trade costs t.

(ii) If

$$(A_b - A) + \frac{5}{2}\phi n_R - \frac{\phi}{2c}[4b + cN_C + 2cn_R] \geq 0$$

then (full or partial) agglomeration is a stable equilibrium with international trade for all values of trade costs t.

(iii) If

$$(A_b - A) + \frac{5}{2}\phi n_R - \frac{\phi}{2c}[4b + cN_C + 2cn_R] < 0 < (A_b - A) + \frac{5}{2}\phi n_R$$

then there exists a unique value, given by

$$t^* = \frac{2a}{n_R}\frac{2(A_b - A) + 5\phi n_R}{\phi[4b + cN_C + 2cn_R] - 2c(A_b - A) - 5c\phi n_R} > 0, \tag{26}$$

such that (full or partial) agglomeration is a stable equilibrium for all $t \leq t^*$, *whereas dispersion is the only stable equilibrium for all* $t > t^*$.

Proof. Because t is positive, the first two cases are obvious since they imply that expression (23) is either always positive or always negative. In these cases, the nature of the spatial equilibrium is the same for all values of trade costs t and corresponds either to dispersion or to (full or partial) agglomeration of economic activities. Case three is also obvious since the equation $C_1 t + C_2 = 0$ with $t \geq 0$ is linear and has a unique solution, given by (26), when $C_1 \leq 0$ and $C_2 \geq 0$. Note, finally, that the case $C_1 \geq 0$ and $C_2 \leq 0$ is impossible and can hence be ruled out. ■

Proposition 1 shows that international trade liberalization may well exacerbate regional inequalities within a liberalizing country endowed with poor transport infrastructure, because (full or partial) agglomeration is more likely to be the equilibrium outcome when trade costs t decrease. Some straightforward analysis shows that t^* is decreasing with respect to c, which implies that stronger product differentiation leads to earlier regional 'symmetry breaking'. Further, condition (25) is more likely to hold if the mass of immobile factor in the country is large when compared to the mass of firms in the rest of the world and if the degree of scale economies ϕ is not too large.[12] Condition (25) can be interpreted in terms of *relative size effects*. When A is large so that $A_b - A < 0$, dispersion prevails if the economy is closed. Because the second term in expression (25) is positive, we see that the opening of the economy to international trade (i.e. $n_R > 0$) weakens the centrifugal force created by the immobile population. This concurrs with Montfort and Nicolini (2000, p. 303), who state that "openness to trade works against convergence as the international integration process exacerbates the agglomeration forces at work within countries". In the presence of international trade, dispersion no longer weakens price competition sufficiently, since *local price competition is exacerbated by foreign competitors*. Hence, the centripetal forces generated by the large market come to dominate, which explains why agglomeration is more likely to arise.

The results established in this section might explain why the Brazilian macro regions 'North' and 'North-East' currently experience some relative spatial polarization, with increasing concentration of population and industry in the three states of Bahia, Pernambuco and Cearà. Indeed, as shown by Haddad and Perobelli (2003a,b) the North and North-East do not display significant commercial interactions among their states, most of which are more strongly linked to the economic cores in the 'South' and 'South-East'. This is partly driven by the fact that infrastructure in the North is poor when compared to the one in the South. Hence, the Brazilian economy experiences a process of regional divergence at two different geographical scales: (i) the increasing polarization between the North and the South, driven by

[12] These results are in accordance with the ones established in alternative models (see, e.g., Montfort and Nicolini, 2000; Paluzie, 2001; Montfort and van Ypersele, 2003; Crozet and Koenig Soubeyran, 2004).

market size effects, industrial linkages and consumption bias; and (ii) the increasing polarization *within* the North, possibly driven by increasing international trade liberalization (Mercosur, GATT) when combined with a poorly developed transportation network.

4 International trade liberalization when regions are well integrated

In this section, we analyze the impacts of international trade liberalization on countries endowed with good national infrastructure and characterized by large volumes of interregional trade. Contrary to the previous section, we now assume that transport costs τ are sufficiently low so that all firms in the country always serve both region H and F for all distributions $\lambda \in [0, 1]$. We further continue to assume that international trade costs t are sufficiently low so that the ROW always sells to both region H and F for all spatial distributions λ of firms. The precise conditions for these assumptions to hold will be derived below.

Using expressions (7), (8) and (9) with $\tau_{rs} < \tilde{p}_s$, the equilibrium price indices are given by

$$P_r^* = \frac{aN + (b + cN)\left[n_s\tau + n_R t\right]}{2b + cN}. \tag{27}$$

As can be seen from (27), the price index in region $r = H, F$ depends on the weighted average $\bar{\tau}_r \equiv n_s\tau + n_R t$ of international trade and interregional transport costs. The larger these costs, the larger the price index. Under which conditions on the costs (τ, t) is a trade structure with interregional trade and imports from the ROW sustainable? As can be seen from expressions (7) and (8), transport costs τ must be sufficiently low such that

$$\tau < \min_{r=H,F} \left\{ \frac{a + cP_r^*}{b + cN} \right\}$$

holds. Some calculations, using (27), show that there is interregional trade between regions H and F for all values of $\lambda \in [0, 1]$ if and only if

$$\tau < \tau_{\text{trade}}(t) \equiv \frac{2a + cn_R t}{2b + c(N_C + n_R)}. \tag{28}$$

It is readily verified that $\tau_{\text{trade}} < \tau_{\text{notrade}}$ for all parameter values. Note that τ_{trade} is decreasing with respect to trade costs t. Stated differently, the lower is t, the more unlikely condition (28) is to hold. This is again due to the fact that cheaper imported varieties displace more expensive national ones, hence possibly leading to a break-down of interregional trade within the liberalizing country when its transport infrastructure is not sufficiently developed. The conditions for imports from the ROW to be positive are again given by (19), as derived in the previous section. In the remainder of this section, we assume that conditions (28) and (19) hold. Substituting (27) into (7) and (8), the equilibrium prices are given by

$$p_{rr}^* = \frac{1}{2}\frac{2a + c\left[n_s\tau + n_R t\right]}{2b + cN} \quad \text{and} \quad p_{rs}^* = p_{ss}^* + \frac{\tau}{2}, \qquad r \neq s \tag{29}$$

within the country, whereas the import prices from the ROW to region $r = H, F$ can be expressed as

$$p_{Rr}^* = p_{rr}^* + \frac{t}{2}\cdot \tag{30}$$

It is of interest to notice that

$$0 < \frac{\partial p_{Rr}^*}{\partial \tau} < \frac{\partial p_{sr}^*}{\partial \tau} < 1,$$

which implies that any decrease in τ twists the 'terms of trade' in favor of national firms. Stated differently, the better the home market is integrated, the more difficult it is to sell from outside (i.e. we have a 'fortress effect'). These results are in accordance with empirical estimates by Chang and Winters (2002), who have shown that Brazil's accession to Mercosur has significantly eroded the terms of trade of non-member trading partners in favor of member trading partners.

Plugging expressions (27) and (29) into expression (4), we get the national demands

$$q_{rr}^* = (b + cN)p_{rr}^* \quad \text{and} \quad q_{rs}^* = q_{ss}^* - \frac{b + cN}{2}\tau, \qquad r \neq s, \tag{31}$$

as well as the import demands

$$q_{Rr}^* = q_{rr}^* - \frac{b + cN}{2}t, \qquad r = H, F. \tag{32}$$

Evaluating the equilibrium wage (10) at the market equilibrium yields

$$w_r^* = \frac{1}{\phi}\left[\left(\frac{A}{2} + \phi n_r\right)q_{rr}^* p_{rr}^* + \left(\frac{A}{2} + \phi n_s\right)q_{rs}^*(p_{rs}^* - \tau)\right]. \tag{33}$$

Substituting expressions (31)-(33) into (11), the indirect utility in region $r = H, F$ can then be expressed as follows:

$$\begin{aligned} V_r^*(\lambda) &= \frac{a(b+cN)}{b}\left(Np_{rr}^* - n_s\frac{\tau}{2} - n_R\frac{t}{2}\right) - \frac{b+cN}{2}\left[n_r p_{rr}^{*2}\right. \\ &\left. + n_s\left(p_{rr}^* - \frac{\tau}{2}\right)^2 + n_R\left(p_{rr}^* - \frac{t}{2}\right)^2\right] - \frac{c(b+cN)}{2b}\left(Np_{rr}^*\right. \\ &\left. - n_s\frac{\tau}{2} - n_R\frac{t}{2}\right)^2 + \frac{b+cN}{\phi}\left[\left(\frac{A}{2} + \phi n_r\right)p_{rr}^{*2}\right. \\ &\left. + \left(\frac{A}{2} + \phi n_s\right)\left(p_{ss}^* - \frac{\tau}{2}\right)^2\right] - (b+cN)\left[n_r p_{rr}^{*2}\right. \\ &\left. - n_s\left(p_{rr}^* - \frac{\tau}{2}\right)\left(p_{rr}^* + \frac{\tau}{2}\right) - n_R\left(p_{rr}^* - \frac{t}{2}\right)\left(p_{rr}^* + \frac{t}{2}\right)\right], \end{aligned}$$

where n_r and n_s are functions of λ. This allows us to derived the equilibrium expression for the indirect utility differential (12) between regions H and F. Substituting the equilibrium prices (29) into the previous expression, some tedious but standard calculations finally yield

$$\Delta V^*(\lambda) = \tau\frac{(b+cN)N_C}{4\phi[2b+cN]^2}\left(\lambda - \frac{1}{2}\right)\left[C_1 t + C_2 + C_3\tau\right], \tag{34}$$

where C_1, C_2 and C_3 are constants given by

$$\begin{aligned} C_1 &\equiv 2n_R c\phi(3cN + 4b) > 0 \\ C_2 &\equiv 4a\phi(6b + 4cN) > 0 \\ C_3 &\equiv -12\phi b^2 - \phi c^2 N(3N - N_C) - 2Ac^2N - 4bAc - 12\phi bcN < 0. \end{aligned}$$

As in Ottaviano *et al.* (2002), the indirect utility differential is a linear function of λ, so that either dispersion or full agglomeration is the only spatial equilibrium. As can be seen from expression (34), $\lambda = 1/2$ is always a spatial equilibrium which can be stable or unstable, depending on the sign of $C_1 t + C_2 + C_3\tau$. If $C_1 t + C_2 + C_3\tau > 0$ (resp. < 0), full agglomeration of all firms in one of the two regions (resp. dispersion of firms across the regions) is the only stable equilibrium.[13] Because C_1 is positive, whereas C_3 is negative, we have the following result.

Proposition 2 *Consider a two-region country with low transport costs, i.e. $\tau < \tau_{\text{trade}}$, so that there is interregional trade for all values of λ.*

[13]Note that when $C_1 t + C_2 + C_3\tau = 0$, any configuration is a spatial equilibrium. In what follows, we disregard this special case because it is not likely to occur.

(i) When trade costs t decrease, dispersion of economic activities can be sustained as an equilibrium for a larger range of parameter values.

(ii) When transport costs τ decrease, agglomeration of economic activities can be sustained as an equilibrium for a larger range of parameter values.

Proposition 2 clearly shows that international integration (i.e. a decrease in t) fosters a more even spatial distribution of economic activities, whereas interregional integration (i.e. a decrease in τ) fosters the emergence of regional inequalities. The second result is in line with what is known in 'new' economic geography (see, e.g., Krugman, 1991; Fujita *et al.*, 1999), whereas the first result conflicts with the prediction of the literature that a deepening international integration is susceptible to exacerbate regional inequalities (see, e.g., Montfort and Nicolini, 2000). Proposition 2 hence shows that *it is not generally possible to make any prediction as to the spatial evolution of a country involved in a process of joint international and interregional integration.* This invites us to be very careful when trying to assess the possible impacts of regional development policies involving both reductions in national transport and international trade costs.

The results established in this section might explain why the Brazilian macro regions 'South' and 'South-East' currently experience some redispersion of industry. Indeed, as argued by Haddad and Perobelli (2003a,b) the metropolitan areas of São Paulo and Rio de Janeiro are loosing industry in favor of neighboring regions like Minas Gerais and Santa Catarina. Although significant land rent differentials are obviously important in explaining this movement of decongestion, the deepening international trade liberalization, when combined with the good transport infrastructure of the South, might also constitute a factor favoring such an evolution.

5 International trade liberalization when interregional market access may get asymmetric

Until now, we have only focused on the two 'extreme cases' in which the structure of interregional trade within the liberalizing country is independent of the industry distribution λ. As argued in sections 3 and 4, this is the case when interregional transport costs τ are either very high (i.e., $\tau \geq \tau_{\text{notrade}}$) or very low (i.e., $\tau \leq \tau_{\text{trade}}$). In this section, we briefly discuss what takes place for intermediate values of τ, when the structure of trade between the two regions must be *endogenously determined.* Since the analysis gets more involved, we do not attempt to fully characterize all possible cases and develop, instead, two small examples that illustrate what is going on.

Before discussing the different possibilities, we need to determine how the structure of interregional trade may change with the value of trade costs t and the firm distribution λ. As shown by expressions (16) and (17), interregional trade from region F to region H occurs if and only if

$$\tau < \tilde{p}_H(\lambda, t) \equiv \frac{2a + cn_R t}{2b + c[\lambda N_C + n_R]}, \tag{35}$$

whereas interregional trade from region H to region F occurs if and only if

$$\tau < \tilde{p}_F(\lambda, t) \equiv \frac{2a + cn_R t}{2b + c[(1-\lambda) N_C + n_R]}. \tag{36}$$

By construction, τ_{trade} (resp. τ_{notrade}) is the smallest (resp. the largest) value of the right-hand sides of (35) and (36) for $\lambda \in [0, 1]$. As can be seen from expressions (18), (28), (35) and (36), for intermediate values of transport costs $\tau \in [\tau_{\text{trade}}, \tau_{\text{notrade}}]$, the precise structure of interregional trade depends on the firm distribution λ and on international trade costs t, which makes the analysis more involved.

In what follows, we assume the following parameter values: $\alpha = 1$, $\beta = 1$, $\gamma = 0.6$, $L = 2$, $\phi = 1$, $n_R = 2.2$. Further, we consider two special, yet meaningful, cases: (i) we assume that the initial values of (τ, t) and $A = 32$ are such that there is interregional trade associated with a *fully agglomerated equilibrium* $\lambda^* = 1$; and (ii) we assume that the initial values of (τ, t) and $A = 64$ are such that there is interregional trade associated with a *dispersed equilibrium* $\lambda^* = 1/2$. Figures 1 and 2 depict these two cases.

Insert figures 1 and 2 about here.

As can be seen from both figures, for any given value of interregional transport costs τ, decreasing international trade costs make the occurrence of regional autarky more likely, whereas bilateral trade becomes less likely. This is because of the pro-competitive effects of international trade, which decrease national prices and, therefore, make interregional trade globally less profitable.

Let us begin with case (i). As can be seen from expressions (35) and (36), $\tilde{p}_H = \tau_{\text{trade}}$ and $\tilde{p}_F = \tau_{\text{notrade}}$. Hence, as depicted in Figure 1, the two thresholds τ_{trade} and τ_{notrade} partition the (τ, t) space into three subsets: the subset Ω_1 associated with regional autarky for all values of λ; the shaded subset Ω_3 associated with bilateral trade for all values of λ; and the subset Ω_2, associated with an asymmetric trade pattern in which firms in the large region H can profitably export to the small (high price) region F, whereas firms in the small region F cannot profitably export to the large (low price) region H. We have further depicted in figures 1 and 2 the critical value

$$\tau^* \equiv \frac{C_1 t + C_2}{-C_3} \tag{37}$$

at which we switch from full agglomeration to dispersion.

Assume that we start from a high initial value of international trade costs $t \approx t_{\text{trade}}$. [14] For interregional trade to be bilateral, $\tau < \tau_{\text{trade}}$ must hold. This leaves us hence with five possible trajectories, depending on the initial value of transport costs τ:

(a) $\tau \in [\tau_1, \tau_{\text{trade}}]$: As t gradually decreases, we first switch to unilateral trade from H to F as we enter the subset Ω_2. When this happens, full agglomeration remains the unique stable equilibrium. For very low values of t, we finally enter the subset Ω_1, associated with regional autarky. Given the chosen parameter values, one can verify with the help of (25) that dispersion is the only stable equilibrium. Hence, the spatial structure of the economy experiences a catastrophic change from full agglomeration to dispersion.[15]

(b) $\tau \in [\tau_2, \tau_1]$: As t gradually decreases, we switch to unilateral trade from H to F as we enter the subset Ω_2. Full agglomeration is then always stable for all values of t. Stated differently, in this case *decreasing international trade costs have no impact on the spatial structure of the country.*

(c) $\tau \in [\tau_3, \tau_2]$: Starting from full agglomeration, a decrease in t first triggers the dispersion of the industry as we cross the threshold τ^*. Note, however, that the pattern of trade remains bilateral in this case. As we switch to $\lambda^* = 1/2$, further decreases in trade costs have no more impact on the spatial structure, since the structure of trade cannot become asymmetric anymore when firms are symmetrically distributed.

(d) $\tau \in [\tau_4, \tau_3]$: Everything works as in case (c), expect that the structure of trade remains always bilateral.

(e) $\tau \in [0, \tau_4]$: In this case, national transport costs are so low that the industry is always fully agglomerated for all values of international trade costs t.

This first example shows that *even when the structure of trade may change, decreasing trade costs do not lead to more agglomeration.* Indeed,

[14] A complete analysis of how the spatial structure of the industry changes when the value of interregional transport costs τ decreases can be found in Ottaviano *et al.* (2002) and Behrens (2004a, 2004b). We therefore restrict our analysis to changes in international trade costs in this paper.

[15] It is readily verified that this case is only possible when $\tau_{\text{notrade}}(0) < \tau_{\text{trade}}(t_{\text{trade}})$, i.e. when $n_R > N_C$. This assumption seems plausible to us.

in the 'worst case' the industry is agglomerated and simply remains so. Further, we see that the phenomenon is highly non-linear for the intermediate cases, since slight changes in the value of τ can lead to very different equilibrium trajectories as t gradually decreases.

Consider now case (ii). As can be seen from (35) and (36), when $\lambda^* = 1/2$ we have $\tilde{p}_H = \tilde{p}_F \equiv \tilde{p}$. Hence, as depicted in Figure 2, the subset Ω_2 in which trade is asymmetric disappears. In that case, the threshold $\tilde{p}$ partitions (τ, t)-space into two subsets: the subset Ω_1 associated with regional autarky for all values of λ; and the shaded subset Ω_3 associated with bilateral trade for all values of λ. Assume again that initially $t \approx t_{\text{trade}}$. For the structure of interregional trade to be bilateral, it is necessary that $\tau < \tilde{p}$. Figure 2 then shows that there are two possible cases:

(a) $\tau \in [\tau_1, \tilde{p}]$: In this case, interregional trade remains first bilateral as t decreases. When we then cross the threshold $\tilde{p}$, interregional trade breaks down because of the strong international competition. The new structure of trade is that of regional autarky. Given the parameter values, (25) shows that dispersion remains the unique stable equilibrium.

(b) $\tau \in [\tau_3, \tau_1]$: In this case, trade remains always bilateral and dispersion is the only spatial equilibrium.

This second example shows, once more, that international integration does not lead to an increase in the degree of spatial concentration within the liberalizing country, even when changes in the structure of trade are taken into account.

We believe that these two examples suffice to show that the relationship between decreasing international trade costs and the spatial organization of the economy is quite involved once possible changes in the structure of interregional trade are taken into account. To keep the analysis tractable, we have voluntarily disregarded the setting in which *there is a joint international and interregional integration process*. As shown by figures 1 and 2, things may then become highly non-linear, with possibly multiple reversals in the process of agglomeration and dispersion. This suggests that one cannot hope for a simple and monotonous relationship between a joint process of international and interregional integration and the spatial structure of the economy. The complete characterization of all equilibrium trajectories under asymmetric trade, though difficult, hence deserves some further investigation in the future.

6 Does the way we model trade costs matter?

As shown in sections 3 to 5, international trade liberalization is likely to have different impacts on the internal geography of a liberalizing country, depending crucially on the quality of its interregional transport infrastructure. We have been able to derive clear results in the two cases in which the internal structure of trade does not depend on the spatial distribution λ of the industry. Whereas decreases in t may trigger a process of agglomeration when $\tau > \tau_{\text{notrade}}$, it may actually trigger a process of dispersion when $\tau < \tau_{\text{trade}}$.

The first result, though derived in a setting without interregional trade, is largely in accord with the main findings of the literature based on the Dixit-Stiglitz-Iceberg framework (see, e.g., Montfort and Nicolini, 2000; Paluzie, 2001; Montfort and van Ypersele, 2003; Crozet and Koenig Soubeyran, 2004). The second, though derived in a setting featuring interregional trade, is not. We think that these qualitative differences are largely driven by differences in modeling choices for trade costs: additive trade costs with segmented markets versus multiplicative trade costs with integrated markets.[16] In the Dixit-Stiglitz-Iceberg model, trade costs take the 'iceberg' form and are, therefore, de facto equivalent to an ad valorem tariff. This specific modeling choice is made because alternative specifications of transportation costs are not compatible with the constant demand elasticity that simplifies significantly the developments in the Dixit-Stiglitz model. Yet, as argued recently by Fujita and Thisse (2002, p. 306), the constant demand elasticity "conflicts with research in spatial pricing theory in which demand elasticity varies with distance [...] although the iceberg cost is able to capture the fact that shipping is resource-consuming, such a modeling strategy implies that any increase in the mill price is accompanied with a proportional increase in transport costs, which often seems unrealistic". Clearly, "this is enough to cast doubt on the generality of the results derived under the iceberg assumption" (Fujita and Thisse, 2002, p. 347).

To see how the modeling choice influences the results, let $\tau_I \geq 1$ stand for the interregional transport costs in the Dixit-Stiglitz-Iceberg model. Hence, for one unit of any variety to arrive in the destination region, τ_I units have to be dispatched from the region of origin. The delivered price in region $s \neq r$ is then given by $p_{rs} = \tau p_{rr}$. The *share of transport costs in the delivered price* $(p_{rs} - p_{rr})/p_{rs} = (\tau - 1)/\tau$ is thus independent of the mill

[16]See Ago *et al.* (2004) for another study highlighting differences between the Dixit-Stiglitz-Iceberg and the quadratic model.

price. Stated differently, it is always equally profitable to ship the good between both regions, no matter the value of the mill price.

In the quadratic setting with linear trade costs and interregional trade, the delivered price in region $s \neq r$ is given by $p_{rs} = p_{ss} + \tau/2$. In the absence of transport costs, the firm sells its variety at the 'mill price' p_{ss} in the foreign market. Hence, the share of transport costs in delivered prices is now given by $(p_{rs} - p_{ss})/p_{rs} = \tau/(2p_{ss} + \tau)$. Clearly, when p_{ss} decreases, whereas interregional trade costs τ remain the same (there is no reason for them to vary simultaneously), firms' profit margins on interregional business are gradually wiped out. It is well known that such mechanisms play an important role in explaining the location behavior of many industries. As argued by Henderson *et al.* (2001), quite modest changes in prices (due to increasing liberalization or rapidly changing supply and demand conditions) can completely wipe out profit margins in industries in which imported intermediate inputs account for a large share of total value-added.

To see how this difference in the evolution of the share of transport costs in delivered prices may explain the diverging results, consider the following thought experiment. Assume we are in a "Dixit-Stiglitz-Iceberg world" and that the industry is dispersed. Hence, $p_{HH} = p_{FF}$ by symmetry. As t progressively decreases, price competition in both regions gets fiercer, leading to a decrease in the equilibrium prices p_{HH} and p_{FF} (see Montfort and Nicolini, 2000). Therefore, delivered prices decrease but, as argued above, the share of transport costs in these prices remains constant. Stated differently, international trade liberalization has no impact on the relative profitability of firms' interregional business in the country. Yet, increasing price competition due to imports decreases the initial advantage firms enjoyed from being spatially separated. Hence, the market size effect comes to dominate, which leads firms to agglomerate in the larger region. Assume next that we are in a "quadratic world with additive trade costs" and that the initial equilibrium is one of full agglomeration in, say, region H. As t decreases, so do p_{HH} and p_{FF}. Yet, contrary to the previous case, *the share of transport costs in delivered prices now increases*. Hence, it becomes relatively less profitable for firms in the large region to ship goods to the small one, because their profit margins are eroded. To put this differently, everything works as if *internal transport costs had actually increased*. At the same time, firms in the large region suffer from fiercer price competition due to imports, and, since profit margins on interregional trade decrease, this competition is even stronger than in the small region. Firms may therefore find it profitable to relax competition in the large region by relocating to the small one and increasing their profit margins on local sales.

Assume, finally, that we are in the quadratic setting *without interregional trade*. As shown by (7) and (8) in Section 2, $p_{rs} = 2p_{ss}$, which implies that the share of trade costs in interregional prices is now given by $(p_{rs} - p_{ss})/p_{rs} = 1/2$. Hence, just as in the Dixit-Stiglitz-Iceberg setting, this share is constant and does not depend on the value of the mill price.[17] Not surprisingly, international trade liberalization hence leads to increasing regional divergence, for exactly the same reasons as those discussed previously.

We believe these results suffice to show that conclusions on regional convergence or divergence due to international trade liberalization should be drawn carefully, because they may change with the way transport and trade costs are actually modeled. Since additive transport costs have the nature of non-tariff barriers or specific tariffs, whereas iceberg transport costs have the nature of ad valorem tariffs, our results further suggest that decreasing trade costs can have very different impacts on the spatial distribution of economic activities, depending on whether they are of an ad valorem nature or not. There may thus be room to choose a way of liberalizing trade that is compatible with regional development objectives.

7 Conclusions

As shown in this paper, the quality of the transportation infrastructure of a country involved in a process of international integration is of fundamental importance in determining whether regional inequalities are likely to widen or to narrow over time. Indeed, both transport and trade costs influence significantly the equilibrium prices and wages, hence providing firms and mobile workers with incentives to agglomerate in, or to disperse across, the space-economy. Quite surprisingly, the various impacts of international and interregional integration on prices have been largely overlooked in economic geography until now.

We have argued that countries with poor infrastructure involved in a process of international integration are likely to experience regional divergence. Hence, some interregional integration seems to be a prerequisite for a balanced spatial development avoiding the emergence of strong regional inequalities. Yet, providing better infrastructure without a simultaneous international integration is susceptible to lead to the same result when workers are mobile across regions. This is especially the case for developing countries, where workers seek better living standards and, therefore, react strongly to

[17] The particular value of 1/2 is due to the quadratic utility specification.

wage differentials. Governments of developing countries involved in a process of economic integration hence walk a thin line. *Providing too little or too much infrastructure both triggers regional divergence.* What is hence needed is 'just enough' infrastructure, combined with a progressive opening to international trade.

We have finally shown that differences in the nature of trade impediments have a direct impact on the spatial distribution of economic activities. Hence, the choice of the appropriate instrument for trade liberalization is important if regional imbalances are to be avoided. When taken together, our results suggest that *international trade policy and the development of national transportation infrastructure definitely require some coordination.* Indeed, when decision-making takes place within various hierarchical instances, e.g. investments in infrastructure at the local government level and trade policy at the national government level, a lack of coordination and the choice of the "wrong instrument" may well lead to the failure of development policies and possibly suboptimal results downstream.

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Appendix A: Zero normalization of export revenues

In this appendix, we justify our normalization of exports. Assume that firms export to the rest of the world. In that case, the profit (6) must be replaced with

$$\pi_r = \underbrace{M_r q^*_{rr} p^*_{rr} + M_s q^*_{rs}(p^*_{rs} - \tau)}_{\text{national revenue } r} + \underbrace{M_R q^*_{rR}(p^*_{rR} - t)}_{\text{export revenue } r} - \phi w_r, \qquad s \neq r$$

in region r and by

$$\pi_s = \underbrace{M_s q^*_{ss} p^*_{ss} + M_r q^*_{sr}(p^*_{sr} - \tau)}_{\text{national revenue } s} + \underbrace{M_R q^*_{sR}(p^*_{sR} - t)}_{\text{export revenue } s} - \phi w_s, \qquad r \neq s$$

in region s of the country. Maximizing profits with respect to p_{rR} and p_{sR}, and using the same approach as in sections 2 and 3, it is readily verified that the equilibrium price index in the ROW is given by

$$P^*_R = \frac{aN + (b + cN)N_C t}{2b + cN},$$

which yields the equilibrium prices

$$p^*_{RR} = \frac{2a + cN_C t}{2(2b + cN)}, \qquad p^*_{HR} = p^*_{RR} + \frac{t}{2} \qquad \text{and} \qquad p^*_{FR} = p^*_{RR} + \frac{t}{2}.$$

Since $N_C = L/\phi$ is a constant, these prices are *independent of the internal spatial structure* λ *and the transport costs* τ *of the country.* Note further that, due to market segmentation, all equilibrium prices in regions H and F of the country remain unchanged. Export demands from the rest of the world for varieties produced in the country are then given by

$$q^*_{HR} = q^*_{FR} = \frac{(b + cN)[2a - (2b + cn_R)t]}{2(2b + cN)},$$

which are also independent of λ.[18] All other national demands remain unchanged. As a consequence, we have

$$X \equiv M_R q^*_{rR}(p^*_{rR} - t) = M_R q^*_{sR}(p^*_{sR} - t).$$

Using the zero-profit condition, the new equilibrium wages are given by

$$w^*_r = \frac{M_r q^*_{rr} p^*_{rr} + M_s q^*_{rs}(p^*_{rs} - \tau)}{\phi} + \frac{X}{\phi}$$

in region $r = H, F$, which are equal to the equilibrium wages (10) plus the additional export revenues.[19] Since all prices and quantities in regions H and F of the country remain the same, the only change in the indirect utility differential (12) is due to the change in the equilibrium wages w^*_H and w^*_F.

[18] It is then readily verified that firms in the country can profitably export to the ROW when

$$t \leq \frac{2a}{2b + cn_R} \tag{38}$$

holds. Note that this condition applies to all cases covered in sections 3 to 5. This is due to the fact that (38) *does not depend on the internal geography of the country.* Clearly, this result depends on our modeling framework (see, e.g., Crozet and Koenig Soubeyran, 2004, for an alternative approach). Indeed, we could expect that in reality a larger agglomeration of firms gives rise to the development of infrastructure and transportation services which allow firms located in the larger region to access the external market more easily and at lower cost (as in, e.g., Behrens *et al.*, 2003). Such considerations are at the heart of the theories of hubs and economies of transport density, in which it is argued that an increase in the mass of local firms decreases costs of accessing foreign markets, since demand for transport services leads to the development of trunk routes and large scale infrastructures.

[19] When firms in the country are able to export to the ROW, equilibrium profits and wages in regions H and F increase. Yet, they increase by the same amount in both regions and have, therefore, no impact on location choices.

Since both wages change by the same amount X/ϕ, their difference remains unchanged, which shows that (12) is not modified in the presence of positive exports. We may thus normalize X (or, equivalently, q^*_{HR} and q^*_{FR}) to zero without loss of generality.

Appendix B: Expression of the polynomial

The polynomial p can be expressed as follows:

$$p(\lambda) = c^2 N_C^2 (2a - cn_R t)\lambda(1-\lambda) + K,$$

where K is given by

$$\begin{aligned} K &= 24ab^2 + 2ac^2 N_C n_r + 2ac^2 n_R^2 + 8abc(N_C + 2n_R) + 4b^2 cn_R t \\ &\quad - c^3 n_R^2 t(N_C + n_R) + \frac{c(4b + cN_C + 2cn_R)(2a + cn_R t)(2n_R\phi - A)}{\phi}. \end{aligned}$$

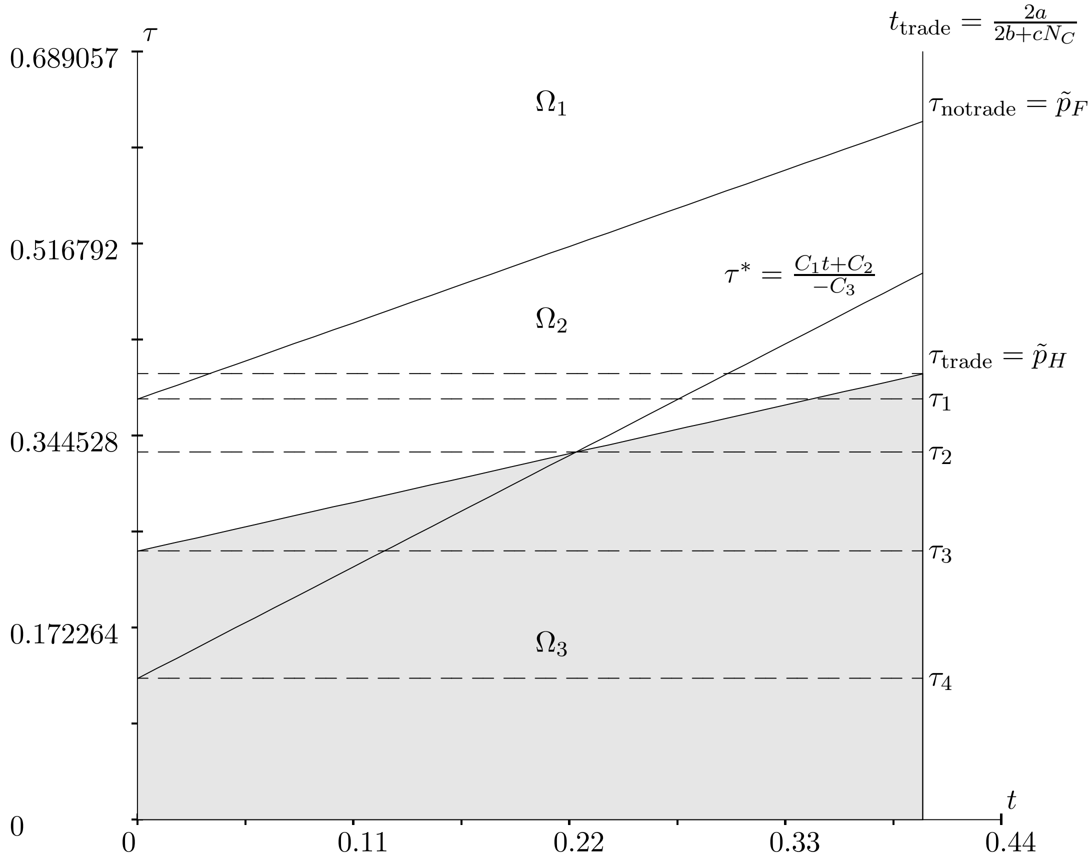

Figure 1: Trade structures and thresholds when $\lambda^* = 1$

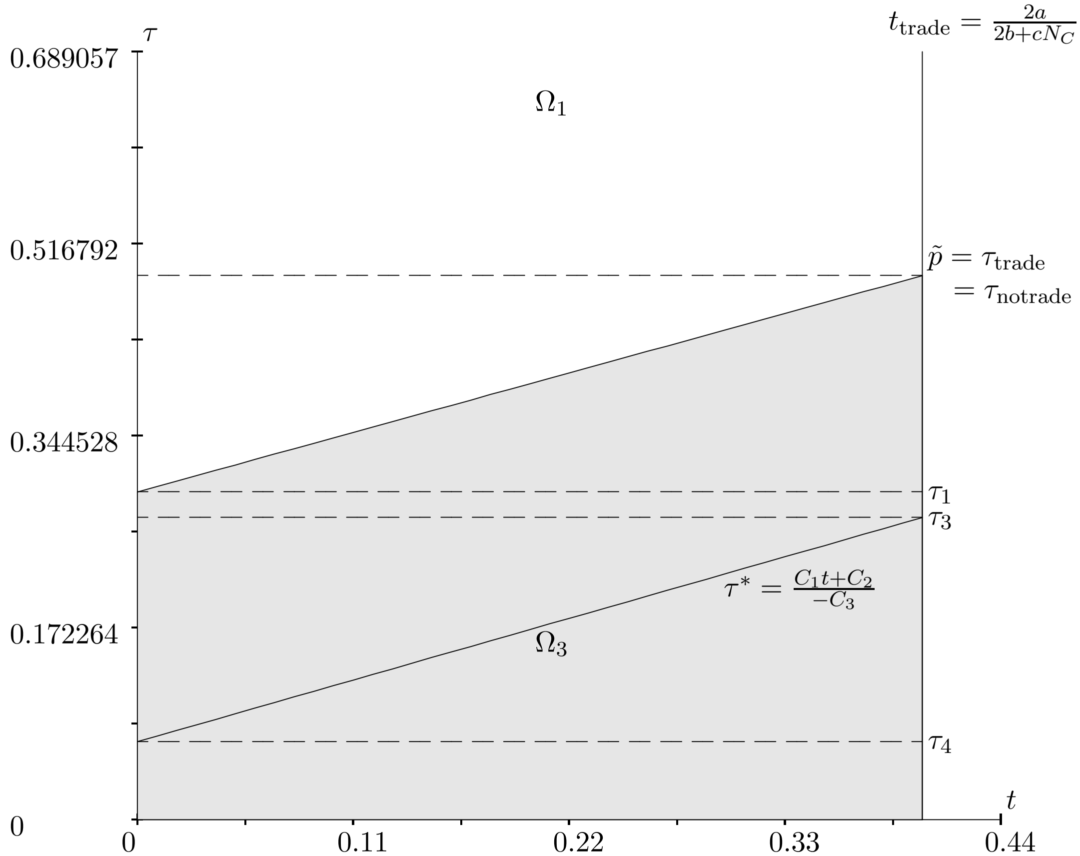

Figure 2: Trade structures and thresholds when $\lambda^* = 1/2$