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Abstract. We study the impacts of changes in international trade and domestic transport costs on the internal geography of countries in the presence of geographical asymmetries. To do so, we develop a two-country four-region model in which one country has a region that exhibits a 'geographical advantage' in terms of better access to the other country's markets. Our analysis reveals that, in equilibrium, the space-economies of the trading partners are interdependent and that agglomeration in one country reduces the occurrence of agglomeration in the other one, thus showing that physical geography suffices to build strong connections between the two space-economies. We also show that remoteness need not be a geographical disadvantage since a landlocked region may well be the location that attracts the larger share of firms. This is so when internal transport costs are high and, therefore, act as a barrier to competition from abroad.

Keywords: agglomeration; economic geography; international trade; trade and transport costs; locational advantage

JEL Classification: F12; F16; R12

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1 Introduction

The theoretical and practical merits of new economic geography (henceforth, NEG) have been heatedly debated in recent years by both economists and geographers. Yet, despite obvious shortcomings, we believe that NEG has allowed one to “combine old ingredients through a new recipe” in a way that has increased our understanding of some fundamental economic mechanisms explaining the formation of agglomerations. However, we also believe that one of the weakest points of NEG is geography itself. To a large extent, NEG has abstracted from geographical features proper in order to highlight the role of purely economic mechanisms in shaping the space-economy. While such a methodological approach is justified during the early development stages of the theory, the time has come to incorporate new and relevant geographical features into existing models. The aim of this paper is to contribute into this direction by considering the following two features.[6] First, we distinguish between different spatial scales, that is, *regions and countries*. In accord with armchair evidence, these scales are characterized by different impediments to the movement of both goods and factors. Second, we investigate the impact of *transportation gates*, defined as regions through which shipping to the international market must take place, on the spatial structure of the trading partners. In doing so, we want to account for the well-documented fact that regional differences in market access are large and seem to have a significant impact on the volume of trade and location decisions. For example, Limão and Venables (2001) find that the median landlocked country has less than 40% of the trade volume of the median coastal economy, thus showing that having such a geographical disadvantage reduces international trade flows significantly. Overman and Winters (2005) find that European integration has reoriented UK imports and exports in favor of ports located nearer to the continent, which points to an important role for market access in determining the geography of UK trade. Finally, Redding and Venables (2004) show that geographical disadvantage also maps into lower per capita income. They calculate that access to the coast and open trade policies increase per capita income by more than 20% and cutting a country’s distance from its trade partners by half increases its per capita income by around 25%.

In the same spirit, Gallup *et al.* (1999) argue that the location of economic agglomerations crucially depends on the accessibility to core markets

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[6] In the same vein, Behrens *et al.* (2004) have recently shown that measures of countries’ accessibility to international markets are crucial explanatory variables when it comes to correctly predict bilateral trade flows in manufacturing industries.

as well as on the degree of economic integration within countries. In their well-documented study, Gallup *et al.* highlight the fact that, when regions are characterized by a lack of proximity to core markets, population is concentrated in the interior rather than along the coast. For example, only 19% of the inhabitants of sub-Saharan Africa live within 100km of the coast, and this share does not increase significantly when we include population within 100km of ocean-navigable rivers. By contrast, population of Western Europe is heavily concentrated near coastal areas with about 89% of population living within 100km of the coast or ocean-navigable rivers. Although Eastern Europe and the former Soviet Union are not very far from the European core markets, the share of inhabitants near the coast (9% of population lives within 100km of the coast, or 55% if ocean-navigable rivers are included) is not high. However, the land area of Eastern Europe and the former Soviet Union represents 24 million square kilometers and only 3 million for Western Europe. This suggests that high domestic transport costs due to a large land area favor agglomeration in interior regions, whereas agglomeration is likely to take place in the region with a good access to the core markets once both international and domestic transport costs are sufficiently low.

To address the foregoing issues, we provide microeconomic foundations to the relationship between international trade costs, domestic transport costs and internal geography in the presence of a transportation gate. The key idea is that the remoteness of a region from foreign markets has two opposing effects. On the one hand, it makes imports and exports more costly, thus reducing the locational appeal of the region to firms and workers. On the other hand, it shelters the local market from foreign competition, thus increasing its locational appeal. This idea is embedded in a two-country four-region model with each country hosting two regions. We assume that one country features a region with preferential access to foreign markets ('gated country'), whereas in the other country both regions have the same international accessibility ('gate-less country'). Our main findings may be summarized as follows. First, compared with a situation without gate regions, the gate-less country is more likely to be agglomerated when its trade partner is gated. Stated differently, it is not a priori possible to assess whether the gated country is itself more likely to be agglomerated with or without a gate. This is because the gate favors agglomeration in the gate-less country, which in turn reduces the likelihood of agglomeration in the gated one. Accordingly, compared to a scenario without gate regions, whereas the gate fosters agglomeration in the gate-less country, it does not necessarily have the same effect in the gated country. This result reveals that *the presence of gated regions makes the economic geographies of coun-*

tries interdependent. In other words, the way the economic geography of a country is organized across its regions has a direct impact on the economic geography of the other country through the channels of international trade. For instance, the gated country is more likely to be agglomerated when its partner is dispersed.

Second, our model predicts that agglomeration in the gate region arises when the gated country is well integrated, whereas agglomeration in the landlocked region occurs when it is poorly integrated. This concurs with the observations made by Gallup *et al.* (1999) and discussed in the foregoing. It highlights that the impact of remoteness on the locational appeal of a region depends on the interplay between international trade barriers and intranational trade costs. Indeed, a transportation gate does not always attract industry because it acts as a channel through which competition from the other country affects domestic firms, which may offset any advantage in terms of foreign market access. That is, *remoteness need not be a locational disadvantage*. Note that geographical asymmetries and a richer spatial structure are crucial for our results because, in a symmetric setting, agglomeration arises only when transport costs are sufficiently low (Krugman 1991; Ottaviano *et al.*, 2002).

The remainder of the paper is organized as follows. Section 2 proposes a two-country four-region model and characterizes the market equilibrium for a given spatial structure. We show that changes in the interregional transport costs and in the international trade costs have quite different impacts on countries' internal organization in the benchmark case of a fully symmetric setting. In Section 3, we allow for the existence of a gated region, whence asymmetries in trade costs, and study its impact on the spatial organization of the two economies. Our model turns out to be useful for shedding some light on how increasing international integration of countries may affect their regional production structures. This is illustrated by a discussion of the impact of NAFTA on the space-economy of Mexico in the light of our model. Section 4 concludes.

Related literature. Some contributions have addressed the possible impact of a gate, or transportation hub, on the location of firms. First, in a setting with three equally-sized regions, Krugman (1993) shows numerically that the region with the geographical advantage attracts the largest share of firms. Fujita and Mori (1996) consider a two-region economy in which each region is represented by a straight line, while the two regions are connected by a bridge. They show that agglomeration may not occur at the hub when competition is sufficiently strong, very much as agglomeration may arise in the landlocked region in our model. In a Heckscher-Ohlin framework, Venables and Limão (2002) argue that remote regions may accommodate new firms because their remoteness is reflected in lower factor prices. Finally, Ago *et al.* (2006) develop a three-region model in which the central region has a geographical advantage. Using a CES-iceberg specification, they show that the central region always attracts more firms than the others, thus confirming Krugman (1993). Yet, using the quadratic-linear framework like ours, they also show that price competition may reverse this result in that the central region has a locational disadvantage. Likewise, a few papers distinguish between regions and countries as we do, and study how international trade affects the internal geography of countries in an otherwise symmetric setting. These include Krugman and Livas Elizondo (1996), Monfort and Nicolini (2000) and Behrens *et al.* (2005).

When compared to those contributions, the main distinctive feature of our model is the assumed configuration of trade costs: (i) international and intranational trade costs are independent, and (ii) the regions of one country have different trade costs to access the other country's regions. This allows us to study how different types of trade barriers and asymmetries in regional accessibility affect the distribution of economic activity.

2 The model

The economy consists of two countries (or regional blocks), labeled $i = H, F$, each having two regions, labeled $r = 1, 2$. When needed, variables associated with each country and each region will be subscripted accordingly. There are two production factors, skilled and unskilled labor, supplied by skilled and unskilled workers respectively. Each individual works and consumes in the region she is established in and supplies inelastically one unit of labor. Unskilled workers are immobile between both regions and countries, whereas skilled workers are *mobile within* but *immobile between countries*. This assumption aims at capturing the fairly well-documented fact that, at least in developed countries, unskilled workers tend to be less mobile than skilled workers, whereas all kinds of labor are relatively immobile at the international level because of strong regulations (SOPEMI, 1998; Faini *et al.*, 1999).[7]

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[7] Migration of unskilled (and often landless) rural labor is an important factor in explaining the formation of large agglomerations in developing countries. In our setting, we consider the unskilled as being small rural land-owners who are immobile. Note also that some immobile workers are needed for dispersion to possibly occur in this type of model.

To control for the impact of endowment differences, we assume that both countries have the same masses L and A of skilled and unskilled workers. The unskilled are evenly split between regions so that each accommodates a mass $A/2$ of them. We further denote by $0 \leq \lambda_i \leq 1$ the (endogenously determined) share of skilled workers located in region 1 of country i.

There are two production sectors. The traditional sector supplies a homogeneous good under perfect competition using unskilled labor as the only input of a constant-return 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. Specifically, to produce a quantity $q(v)$ of any variety requires $mq(v) \geq 0$ units of unskilled and $\phi > 0$ units of skilled labor. Without loss of generality, we set $m = 0$ in what follows. As our preferences generate linear demand functions (see (2) below), setting $m = 0$ amounts to rescaling firms' demand intercepts (Ottaviano *et al.*, 2002). Since there are no economies of scope and returns to scale are increasing at the plant level, there is a one-to-one correspondence between firms and varieties, so that N also stands for the mass of modern firms. Given the technology in the modern sector, skilled labor market clearing in each country $i = H, F$ implies:

$$n_{i1} = \frac{\lambda_i L}{\phi} \qquad n_{i2} = \frac{(1-\lambda_i)L}{\phi} \qquad n = n_{i1} + n_{i2} = \frac{L}{\phi} \qquad N = 2n \tag{1}$$

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

All goods can be shipped across countries and regions. They do, however, incur different unit trade costs. On the one hand, the homogeneous good is freely tradable at zero costs. 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 transactions between region r of country i and region s of country j incur a unit trade cost of $\tau(ir, js) > 0$, whereas shipping one unit between the two regions within the same country i costs $t_i > 0$. All transport and trade costs are expressed in units of the numéraire, and we assume that $\tau(ir, js) = \tau(js, ir)$, i.e., that international trade costs between any pair of regions are symmetric.

Each worker is endowed with not only one unit of labor but also $\overline{q}_0 > 0$ 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 quasi-linear utility with quadratic subutility. A typical resident of region i in country r solves the following consumption problem:

$$\max_{q_{ir}(v),\,\forall v\in[0,N]} \alpha\int_0^N q_{ir}(v)\mathrm{d}v - \frac{\beta-\gamma}{2}\int_0^N [q_{ir}(v)]^2\mathrm{d}v - \frac{\gamma}{2}\left[\int_0^N q_{ir}(v)\mathrm{d}v\right]^2 + q_0$$
$$\text{s.t.} \quad \int_0^N p_{ir}(v)q_{ir}(v)\mathrm{d}v + q_0 = y_{ir} + \overline{q}_0$$

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

Since in equilibrium all varieties with the same regions of origin and destination will share the same prices and sales, in what follows we drop the variety index v to simplify notation. Let $q_{js,ir}$ denote the output of a firm located in region s of country j demanded by a consumer in region r of country i. It is readily verified that the individual demand functions are given by

$$q_{js,ir} = a - (b + cN)p_{js,ir} + cP_{ir} \tag{2}$$

where

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

and where $p_{js,ir}$ is the price a firm located in region s of country j charges to consumers in region r of country i. Finally,

$$P_{ir} = \sum_{j=H,F}\sum_{s=1,2} n_{js}p_{js,ir} \tag{3}$$

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

We assume that product markets are *segmented* and that labor markets are *local*. 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.[8] The

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[8] Whereas there is a vast amount of empirical evidence suggesting that international markets are segmented (Engel and Rogers, 1996; Haskel and Wolf, 2001), one might think of national markets as being more integrated in that firms would be mill pricers. While this is true to some extent, even within fairly well-integrated regional blocks, such as the EU or Canada/US, border effects remain strong (Head and Mayer, 2000; Engel and Rogers, 1996). Even more surprising, spatial price discrimination and border effects are pervasive *within* major industrialized countries (Greenhut, 1981). Wolf (2000) estimates a gravity equation for inter-state trade in the US. Even after correcting for remoteness of the US states, he finds that the home-bias dummy enters positively and is highly significant: *ceteris paribus* a state trades on average 4.39 times more with itself than with other US states.

second assumption means that no commuting takes place so that workers are employed only in the region of residence. For skilled workers this implies that their wages may differ across regions and we denote by w_{ir} the skilled wage rate prevailing in region r of country i. Note, however, that, as already mentioned, local labor markets do not prevent the equalization of unskilled wages as this is driven by free trade in the traditional good.

As firms bear all trade and transport costs, a firm located in region r of country i maximizes profits given by:

$$\begin{aligned}\pi_{ir} \quad = \quad & M_{ir}p_{ir,ir}q_{ir,ir} + M_{is}(p_{ir,is} - t_i)q_{ir,is} \\ & + M_{jr}[p_{ir,jr} - \tau(ir,jr)]q_{ir,jr} + M_{js}[p_{ir,js} - \tau(ir,js)]q_{ir,js} - \phi w_{ir}\end{aligned} \tag{4}$$

with $i \neq j, r \neq s$, and where

$$M_{i1} = \frac{A}{2} + \lambda_i L \qquad \text{and} \qquad M_{i2} = \frac{A}{2} + (1 - \lambda_i)L$$

are the masses of consumers of the regions of country i.

2.1 The market outcome

Throughout the 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. The precise conditions for this to hold are established below as (11) and (12). Assuming that all t_r and $\tau(ri, sj)$ are sufficiently low, the profit-maximizing prices are as follows:

(i) intraregional prices

$$p_{ir,ir} = \frac{a + cP_{ir}}{2(b + cN)} \tag{5}$$

(ii) interregional prices

$$p_{ir,is} = p_{ir,ir} + \frac{t_i}{2} \qquad r \neq s \tag{6}$$

(iii) international prices

$$p_{ir,js} = p_{js,js} + \frac{\tau(ir,js)}{2} \qquad i \neq j. \tag{7}$$

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.

Specifically, because there is a continuum of firms, each firm is negligible and chooses its optimal price, taking aggregate market conditions as given. At the same time, these aggregate market conditions must be consistent with firms' optimal pricing decisions. Hence, the (Nash) equilibrium price index P_{ir}^* must satisfy the following fixed point equilibrium condition:

$$P_{ir}^* = n_{ir}p_{ir,ir}(P_{ir}^*) + n_{is}p_{is,ir}(P_{ir}^*) + n_{jr}p_{jr,ir}(P_{ir}^*) + n_{js}p_{js,ir}(P_{ir}^*). \tag{8}$$

Under the assumption of bilateral trade between countries and regions, the equilibrium price indices can be found by solving (8) for P_{ir}^* after using expressions (5)–(7). This yields:

$$P_{ir}^* = \frac{2an + (b + 2cn)\left[n_{is}t_i + n_{jr}\tau(jr, ir) + n_{js}\tau(js, ir)\right]}{2(b + cn)} \tag{9}$$

for $i = H, F$ and $r = 1, 2$. Accordingly, the equilibrium price index in region r of country i depends on the average cost $n_{is}t_i + n_{jr}\tau(jr, ir) + n_{js}\tau(js, ir)$ firms incur in supplying that region. As expected, the price index decreases with the mass of local firms, since these firms can supply the local market at zero costs. Substituting (9) into (5) gives the equilibrium intraregional prices:

$$p_{ir,ir}^* = \frac{2a + c\left[n_{is}t_i + n_{jr}\tau(jr, ir) + n_{js}\tau(js, ir)\right]}{4(b + cn)} \qquad i = H, F \tag{10}$$

which can then be used to recover the equilibrium interregional and international prices from (6) and (7), respectively.

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

$$t_i \leq t_{ir}^{trade} \equiv \frac{2a + c\left[n_{jr}\tau(jr, ir) + n_{js}\tau(js, ir)\right]}{2(b + cn)} \qquad i = H, F \tag{11}$$

must hold for interregional trade in each country to take place, regardless of the firm distributions λ_i. Observe that lower values of $\tau(jr, ir)$ and $\tau(js, ir)$ lead to a decrease in the threshold value of interregional trade costs t_i for which there is interregional trade. Hence, *lower international trade costs may lead to a break down of internal trade when the regional markets of a country are poorly integrated*, especially when some regions have a good access to the international marketplace. 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

$$\tau(js, ir) \leq \frac{2a + c[n_{is}t_i + n_{jr}\tau(jr, ir)]}{2(b + cn) - cn_{js}} \tag{12}$$

must hold for firms in region s of country j to profitable export to region r of country i. As can be seen from (12), the feasibility of international trade depends on the value of interregional transport costs, on the access of suppliers in the other region, and on the spatial distribution of industry *within* each country. This is because lower interregional transport costs and the agglomeration of firms exacerbate price competition in local markets, thus making penetration by outside firms more difficult. To avoid a proliferation of subcases, in what follows we focus on situations in which international trade occurs for all distributions of firms within countries. The most stringent case arises when $n_{jr} = n_{is} = 0$ and $n_{js} = n$ so that we assume throughout this paper that

$$\tau \leq \tau_{trade} \equiv \frac{2a}{2b + cn} \tag{13}$$

holds. When condition (13) holds, firms export from region s of country j to region r of country $i \neq j$ regardless of the spatial structure of the economy and regardless of the countries and regions under consideration.

Substituting the equilibrium prices (6), (7) and (10) into the individual demands (2), the equilibrium consumption levels are given by

$$q^*_{ir,ir} = a - (b + cN)p^*_{ir,ir} + cP^*_{ir} = (b + cN)p^*_{ir,ir} \tag{14}$$

for shipments within the same region. They are given by

$$q^*_{is,ir} = q^*_{ir,ir} - \frac{(b + cN)t_i}{2} \tag{15}$$

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

$$q^*_{js,ir} = q^*_{ir,ir} - \frac{(b + cN)\tau(js, ir)}{2} \tag{16}$$

for shipments between regions belonging to different countries ($i \neq j$). One can easily check that these quantities are always positive when conditions (11) and (13) hold.

Regarding local labor markets, 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. As a result, all operating profits are absorbed by the wage bill. Therefore, in equilibrium the skilled wage rate in region r of country i satisfies the condition $\pi_{ir}(w^*_{ir}) = 0$. Using (4), (6)–(10) and (14)–(16), the equilibrium wages can be easily calculated as follows:

$$\begin{aligned} w^*_{ir} &= \frac{b+cN}{\phi}\left[M_{ir}(p^*_{ir,ir})^2 + M_{is}\left(p^*_{is,is} - \frac{t_i}{2}\right)^2\right] \qquad (17) \\ &+ \frac{b+cN}{\phi}\left[M_{jr}\left(p^*_{jr,jr} - \frac{\tau(ir,jr)}{2}\right)^2 + M_{js}\left(p^*_{js,js} - \frac{\tau(ir,js)}{2}\right)^2\right]. \end{aligned}$$

The *market equilibrium* associated with a given spatial distribution of skilled workers in each country is then fully characterized by (6), (7), (10) and (17).

The skilled workers are mobile between regions and migrate between them to exploit differences in indirect utility levels. As shown by Ottaviano *et al.* (2002), the indirect utility in region i of country r may be expressed as follows:

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

where

$$\begin{aligned} S^*_{ir} &= \frac{a^2N}{2b} - a\left[n_{ir}p^*_{ir,ir} + n_{is}p^*_{is,ir} + n_{jr}p^*_{jr,ir} + n_{js}p^*_{js,ir}\right] \qquad (18) \\ &+\frac{b+cN}{2}\left[n_{ir}(p^*_{ir,ir})^2 + n_{is}(p^*_{is,ir})^2 + n_{jr}(p^*_{jr,ir})^2 + n_{js}(p^*_{js,ir})^2\right] \\ &-\frac{c}{2}(n_{ir}p^*_{ir,ir} + n_{is}p^*_{is,ir} + n_{jr}p^*_{jr,ir} + n_{js}p^*_{js,ir})^2 \end{aligned}$$

is the individual consumer surplus evaluated at the market equilibrium. The *indirect utility differential* between the two regions of country $i = H, F$ is then defined as follows:

$$\Delta V^*_i(\lambda_i, \lambda_j) \equiv V^*_{i1}(\lambda_i, \lambda_j) - V^*_{i2}(\lambda_i, \lambda_j). \qquad (19)$$

For any given value of λ_j, a national equilibrium $\lambda^*_i(\lambda_j)$ in country i is such that no skilled worker in i has an incentive to change location, conditional upon the fact that the product markets clear at the equilibrium prices (6), (7) and (10) and that labor markets clear at the equilibrium wages (17). Formally, a *national equilibrium* arises at:

- $\lambda^*_i \in (0,1)$ when $\Delta V^*_i(\lambda^*_i(\lambda_j), \lambda_j) = 0$,
- $\lambda^*_i = 0$ if $\Delta V^*_i(0, \lambda_j) \leq 0$,
- $\lambda^*_i = 1$ if $\Delta V^*_i(1, \lambda_j) \geq 0$.

Such an equilibrium always exists because V_i^* is a continuous function of λ_i and λ_j (Ginsburgh *et al.*, 1985, Proposition 1). An interior national equilibrium is stable if and only if the slope of the indirect utility differential (19) is negative in a neighborhood of the equilibrium, whereas full agglomeration is always stable whenever it exists.

We then define a *global equilibrium* as a distribution $(\lambda_i^*, \lambda_j^*)$ such that λ_i^* is a national equilibrium associated with λ_j^* for each country. Formally, such an equilibrium satisfies the following conditions:

$$\lambda_i^* = \lambda_i^*(\lambda_j^*) \qquad \text{and} \qquad \lambda_j^* = \lambda_j^*(\lambda_i^*).$$

A global equilibrium $(\lambda_i^*, \lambda_j^*)$ is stable if, for each country i, λ_i^* is a stable national equilibrium corresponding to λ_j^* with $j \neq i$.

Note that, because the geographies of the two countries are now interdependent, the existence of a global equilibrium is a less straightforward issue than in 'standard' NEG models. This is because changes in λ_i^* induce a *spatial externality* to country $j \neq i$. In general, without some regularity conditions we may have either no global equilibrium or multiple global equilibria. Below we discuss existence and uniqueness in our specific setting.

2.2 The benchmark case: geographical symmetry

Let us start with the benchmark case of geographical symmetry, which rests on Behrens *et al.* (2005): $\tau(js, ir) = \tau$ for $r, s = 1, 2$ and $i \neq j$. Stated differently, each region has the same access to all international markets.

Using (6), (7), (10), (14)–(16) and (17), some cumbersome calculations yield

$$\Delta V_i^*(\lambda_i) = \frac{n(b+2cn)t_i}{4\phi(b+cn)^2}\left(\lambda_i - \frac{1}{2}\right)(-\varepsilon_1 t_i + \varepsilon_2 + \varepsilon_3\tau), \tag{20}$$

where

$$\begin{aligned} \varepsilon_1 &\equiv 5c^2n^2\phi + 12bcn + 2c^2nA + 6b^2\phi + 2bcA > 0 && (21)\\ \varepsilon_2 &\equiv 4a\phi(3b+4cn) > 0 && (22)\\ \varepsilon_3 &\equiv 2cn\phi(2b+3cn) > 0 && (23) \end{aligned}$$

are bundles of parameters independent of transport and trade costs.

It follows immediately from (20) that $\lambda_i = 1/2$ is always a national equilibrium within each country. Since the indirect utility differential is linear with respect to λ_i, the stability of this equilibrium depends on the sign of $-\varepsilon_1 t_i + \varepsilon_2 + \varepsilon_3\tau$. When this expression is negative, dispersion is the unique stable global equilibrium in country i; when it is positive, the dispersed equilibrium is unstable so that agglomeration of all skilled workers of country i 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. This particular result depends on the specific assumptions made, namely that all regions in each country have the same access to the international market place.

As the indirect utility differential in a country depends only upon its internal distribution of economic activities, a national equilibrium is also a global equilibrium. As argued previously, agglomeration is a national equilibrium in country i if and only if $-\varepsilon_1 t_i + \varepsilon_2 + \varepsilon_3 \tau \geq 0$, which means that

$$t_i \leq t^*(\tau) \equiv \frac{\varepsilon_2 + \varepsilon_3 \tau}{\varepsilon_1} \tag{24}$$

or, alternatively,

$$\tau \geq \tau^*(t_i) \equiv \frac{\varepsilon_1 t_i - \varepsilon_2}{\varepsilon_3} \tag{25}$$

is a necessary and sufficient condition. This leads to the following result.

Proposition 1 *Assume that no country has a gated region. Then, the internal geographies of countries are independent and agglomeration is a stable national equilibrium in country i if and only if*

$$t_i \leq t^*(\tau)$$

or, equivalently, if and only if

$$\tau \geq \tau^*(t_i).$$

Observe that, for both the agglomerated and dispersed configurations to arise as a global equilibrium when transport and/or trade costs vary, it must be that $\tau^*(t_i) < \tau_{trade}$ and $t^*(\tau) < t_{trade}(\tau)$.

Because ε_1 is positive, for a given τ agglomeration within country i is more likely to be a stable national equilibrium when the transport costs in this country are low. This concurs with the main result of economic geography in which agglomeration arises when trading across places becomes less expensive (Krugman, 1991; 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_i such that $\tau^*(t_i) > 0$, agglomeration within a country is more likely to be a stable national equilibrium when trade costs are high. Everything else equal, *domestic firms react to more international competition by relaxing intranational competition* *through dispersion.* This finding seems to be in accord with recent empirical results presented by Brülhart and Traeger (2005). Indeed, these authors show that, over the 1975–2000 period, manufacturing jobs have moved from regions with high employment densities towards regions with low employment densities, thus becoming geographically more dispersed. Furthermore, this relocation of manufacturing employment has been dominated by intra-country shifts in the 1990s.[9]

3 Geographical asymmetry: the case of a gated region

In this section, we study the impact of an *exogenously given gated region* on the global equilibrium of the two countries. More precisely, we assume that region 1 of country H accesses the two regional markets of country F at the same unit trade cost τ, whereas shipping the differentiated good from region 2 of country H to any region of country F is more expensive as it requires going through region 1 of country H (which is hence an export gate).[10] This implies that firms located in region 2 of country H incur a unit trade cost equal to $t_H + \tau > \tau$ in order to export their varieties. We find it reasonable to assume that region 1 of country H is also an import gate in the sense that shipping varieties from any region of country F to region 2 of country H requires going through region 1 of country H. Hence, the unit trade costs of country F's firms when shipping to region 2 of country H are also given by $t_H + \tau > \tau$. Region 1 of country H is called a *gate*, whereas region 2 is said to be *landlocked.* Given our assumption on trade costs, we have:

$$\begin{aligned} \tau(H2, F1) &= \tau(H2, F2) = \tau + t_H \\ \tau(H1, F1) &= \tau(H1, F2) = \tau. \end{aligned} \tag{26}$$

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[9] Focussing on an index of *relative concentration*, Brülhart and Traeger (2005) show that the manufacturing sector has become *more concentrated* over the 1975–2000 period. However, this is because the manufacturing sector is "slowly becoming more geographically concentrated relative to the spatial spread of total employment" (Brülhart and Traeger, 2005, p.617), whereas manufacturing is "becoming significantly less concentrated relative to physical space (decreasing 'topographic concentration')" (op. cit., p.597). Hence, in geographical terms there is *dispersion* of the manufacturing industry.

[10] We disregard the case of a gated region in each country because the gains from this additional analysis in terms of results-to-maths ratio are very low. On the one hand, even when we assume that intranational transport costs are identical in both countries, the formal analysis is very heavy. On the other hand, it is straighforward to check that $\lambda_H = \lambda_F = 0$ when transport costs are high enough and $\lambda_H = \lambda_F = 1$ when transport costs are low enough, as in the model with a single gate.

This means that region 2 of country H has a priori a *geographical disadvantage* in terms of remoteness from international markets, because, given (7), it faces higher transport costs that make foreign market penetration more difficult for its products and increases prices for imports from the foreign country. When taken together, these two aspects could render this landlocked region less attractive to both firms and consumers. Yet, region 2 is also more sheltered from international competition than the gated region, which can attenuate, or even reverse, that geographical disadvantage.

3.1 Some preliminary results

Using (6), (7), (10) and (26), it is readily verified that the equilibrium intraregional prices are as follows:

$$\begin{aligned} p^*_{H1,H1} &= \frac{2a + c(n_{H2}t_H + n\tau)}{4(b+cn)} \\ p^*_{F1,F1} &= \frac{2a + c(n_{F2}t_F + n_{H2}t_H + n\tau)}{4(b+cn)} \\ p^*_{H2,H2} &= \frac{2a + c[(n_{H1}+n)t_H + n\tau]}{4(b+cn)} \\ p^*_{F2,F2} &= \frac{2a + c(n_{F1}t_F + n_{H2}t_H + n\tau)}{4(b+cn)} \end{aligned}$$

The analysis of the prices confirms that the landlocked region 2 in country H enjoys the highest degree of protection from foreign competition since $\partial p^*_{H2,H2}/\partial n > \partial p^*_{H1,H1}/\partial n > 0$. In addition, intraregional prices in country F depend on the internal transport costs and the spatial organization of production in country H. In other words, operating profits from local sales in the gate-less country F are affected by the location choices of skilled workers in country H, the reason being that firms in country F bear an additional transport cost to serve the landlocked region. Obviously, when the number of firms established in this region (i.e., n_{H2}) decreases, the impact of transport costs in country H on intraregional prices in country F declines. Put differently, intraregional prices in country H do not depend on the spatial organization of production in country F. We will see, however, that this is not the case for the equilibrium distribution of skilled workers λ^*_H.

Some straightforward, but cumbersome, calculations that use (6), (7), (10), (17) and (26), show that the indirect utility differentials (19) in the two countries can be expressed as follows:

$$\Delta V_F^*(\lambda_H, \lambda_F) = \frac{t_F(b+2cn)n}{8\phi(b+cn)^2}\left(\lambda_F - \frac{1}{2}\right)\{-\varepsilon_1 t_F + \varepsilon_2 + \varepsilon_3[t_H(1-\lambda_H)+\tau]\} \tag{27}$$

and

$$\Delta V_H^*(\lambda_H, \lambda_F) = \frac{t_H(b+2cn)}{8\phi(b+cn)^2}\left[C_1\lambda_H + C_2\lambda_F(1-\lambda_F) + C_3\right] \tag{28}$$

where ε_1, ε_2 and ε_3 are given by (21), (22) and (23), and where

$$\begin{aligned}
C_1 &\equiv 2n[-\varepsilon_1 + 3\phi(b+cn)^2]t_H + n\varepsilon_2 + n\varepsilon_3\tau \\
C_2 &\equiv 4\phi n^2 c(b+cn)t_F > 0 \\
C_3 &\equiv (b+cn)[ncAt_F - 2bAt_H - 2(ncA + 2bA + 3\phi nb + 3c\phi n^2)\tau + 4aA]
\end{aligned}$$

are bundles of parameters, which depend on transport and trade costs. Note that the coefficient of t_H in C_1 (i.e., $-\varepsilon_1 + 3\phi(b+cn)^2$) is negative.

Inspecting (27) reveals immediately that $\lambda_F = 1/2$ is always a national equilibrium in country F. Its stability depends on the sign of $-\varepsilon_1 t_F + \varepsilon_2 + \varepsilon_3[t_H(1-\lambda_H)+\tau]$. When this last expression is negative, dispersion is a stable equilibrium, whereas agglomeration is a stable equilibrium should it be positive. As $\varepsilon_k > 0$ for $k = 1, 2, 3$, it is clear that, for given transport costs t_H and t_F and trade costs τ, *agglomeration in country F is more likely to be a stable national equilibrium when country H's firms are agglomerated in the landlocked region* ($\lambda_H = 0$). Symmetrically, dispersion is more likely to be a stable national equilibrium in country F when country H's firms agglomerate in the gated region ($\lambda_H = 1$). This can be understood as follows. When country H's firms agglomerate in region 2, international competition in country F gets milder because country H's firms must incur larger trade costs in exporting to country F. Hence, everything works as if international trade costs were higher, which thus fosters agglomeration in country F. Clearly, the opposite holds when firms agglomerate in the gated region.

Expression (27) also reveals that, for a given distribution λ_H, *agglomeration in country F is more likely to be a stable national equilibrium when transport costs within country H are sufficiently high.* Furthermore, this effect is stronger the smaller is λ_H, as agglomeration in the landlocked region of country H renders competition in country F weaker. Finally, note that decreasing t_F always favors agglomeration in country F, which is the standard result of new economic geography (Krugman, 1991; Ottaviano *et al.*, 2002).

While ΔV_F^* depends in a simple way on the distributions λ_H and λ_F, this no longer holds true for ΔV_H^*. Indeed, as shown by (28), $\lambda_H = 1/2$ is almost never a national equilibrium. This is due to the fact that country H's regions are now asymmetric in terms of their access to the international market. Because $C_2 > 0$ and because $\lambda_F(1-\lambda_F)$ is minimal when $\lambda_F = 1/2$, dispersion in country F increases the degree of agglomeration in country H. In addition, it is easy to check that $\partial \Delta V_H^* / \partial t_F > 0$ regardless of the spatial configuration in country F. In other words, *falling transport costs in country F favor the agglomeration of activities in the landlocked region of country H.* Although a marginal change in t_F does not affect the surplus and the revenue from domestic sales in country H, a fall in t_F modifies the revenue from foreign sales. More precisely, the fall in the revenue from foreign sales is higher in the landlocked region than in the gated region.

Regarding the global equilibrium of the two countries, the following result is proven in Appendix A.

Proposition 2 *Assume that region* 1 *of country H is a gate. A stable global equilibrium $(\lambda_H^*, \lambda_F^*)$ exists for all admissible parameter values of the model.*

3.2 International integration, transport costs, and the location of economic activities

Although the analysis of the global equilibrium is more involved in the presence of a gated region than when there is no such gate, clear-cut analytical results can be derived. This is because, as shown by (27), a stable global equilibrium in country F involves either agglomeration or dispersion, so that we can restrict ourselves to these two cases only.[11]

Case 1. Consider, first, the case in which country F is agglomerated ($\lambda_F^* = 1$). This configuration is stable provided that

$$\lambda_H^* < 1 + \frac{-\varepsilon_1 t_F + \varepsilon_2}{\varepsilon_3 t_H} + \frac{\tau}{t_H}. \tag{29}$$

When $\tau \geq \tau^*(t_F)$, where $\tau^*(t_F)$ is defined by (25), the right hand side of (29) exceeds 1, which implies that agglomeration in F is stable regardless of

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[11] We deliberately rule out the zero measure case in which

$$\lambda_H^* = 1 + \frac{-\varepsilon_1 t_F + \varepsilon_2}{\varepsilon_3 t_H} + \frac{\tau}{t_H}$$

and in which every spatial configuration would be an equilibrium in country F.

the value of λ_H. In this case, internal agglomeration forces in country F are strong enough to dominate any effect stemming from the spatial externality generated by country H.

Observe also that (29) may be rewritten as follows:

$$-\varepsilon_1 t_F + \varepsilon_2 + \varepsilon_3 \tau > (\lambda_H^* - 1)\varepsilon_3 t_H \tag{30}$$

which is less stringent than in the no-gate case because $\varepsilon_3 > 0$. This shows that *the existence of a gate in country H makes agglomeration in country F more likely.* This is especially so when internal transport costs t_H are large, or when the gated region hosts a small mass of firms, or both.

When there is agglomeration in country F, the indirect utility differential in country H boils down to

$$\Delta V_H^*(\lambda_H, 1) = \frac{t_H(b + 2cn)}{8\phi(b + cn)^2}(C_1\lambda_H + C_3).$$

Hence, $(\lambda_H^*, \lambda_F^*) = (1, 1)$ is a stable global equilibrium if and only if $C_1 + C_3 > 0$. Some straightforward calculations then show that

$$C_1 + C_3 > 0 \quad \iff \quad t_H < \bar{t}_H^1 \equiv \frac{\zeta_1 t_F - \zeta_2 \tau + \zeta_3}{\zeta_4} \tag{31}$$

where $\zeta_k > 0$ $(k = 1, 2, 3, 4)$ are four bundles of parameters that are independent of t_H, t_F and τ (see Appendix B). Similarly, $(\lambda_H^*, \lambda_F^*) = (0, 1)$ is a stable global equilibrium if and only if $C_3 < 0$. It is easy to see that

$$C_3 < 0 \quad \iff \quad t_H > \bar{t}_H^0 \equiv \frac{\zeta_1 t_F - \overline{\zeta}_2 \tau + \overline{\zeta}_3}{\overline{\zeta}_4} \tag{32}$$

where $\overline{\zeta}_{k'} > 0$ $(k' = 2, 3, 4)$ are three bundles of parameters that are again independent of t_H, t_F and τ (see Appendix B).

Using conditions (31) and (32), it is readily verified that there is a unique global equilibrium whenever $\bar{t}_H^1 < \bar{t}_H^0$, a condition equivalent to

$$\tau > \frac{(\zeta_1\overline{\zeta}_4 - \zeta_4\zeta_1)t_F + (\zeta_3\overline{\zeta}_4 - \zeta_4\overline{\zeta}_3)}{\zeta_2\overline{\zeta}_4 - \zeta_4\overline{\zeta}_2} \equiv \overline{\tau} > 0. \tag{33}$$

The last inequality comes from $\zeta_1\overline{\zeta}_4 - \zeta_4\zeta_1 > 0$, $\zeta_3\overline{\zeta}_4 - \zeta_4\overline{\zeta}_3 > 0$ and $\zeta_2\overline{\zeta}_4 - \zeta_4\overline{\zeta}_2 > 0$. Hence, we may conclude that a unique equilibrium is more likely when trade costs are high enough and when internal transport costs in country F reach low values. When condition (33) does not hold and when $t_H \in (\overline{t}_H^1, \overline{t}_H^0)$, there are multiple stable global equilibria, involving full agglomeration in either the gated or the landlocked region.

Conditions (31) and (32) show that agglomeration in the gated region is a national equilibrium when transport costs t_H are low, whereas agglomeration in the landlocked region is an equilibrium when transport costs t_H are high. As these two conditions are not mutually exclusive, for intermediate values of t_H, there is multiplicity of equilibria in that both agglomeration in the gated and landlocked regions are stable equilibria. Note, however, that agglomeration in the gated region is more likely when country F is poorly integrated, or when trade costs are low, or both. Indeed, when country F is poorly integrated, price competition in this country is mild, which increases the relative importance of this market for country H's firms (a larger share of operating profits is generated in country F). Similarly, when trade costs τ are low, the access to the international market is made easy, thus implying that exports are a major determinant of the profitability of domestic firms. Even though price competition is stronger, firms agglomerate in the gated region in order to secure themselves better access to all markets. Stated differently, *the gated region hosts the whole industry because market access considerations dominate the competition effect.*

Finally, $\lambda_H^* = C_3/(-C_1)$ is an interior equilibrium if and only if $C_3 > 0$ and $C_1 + C_3 < 0$ (or, equivalently, $\overline{t}_H^0 > t_H > \overline{t}_H^1$). Under this condition, this outcome is always stable since C_1 is necessarily negative. Some simple calculations reveal that C_3 (resp., $-C_1$) decreases (resp., increases) with t_H. In other words, *the economy moves gradually from agglomeration in the landlocked region to agglomeration in the gated region when transport infrastructure in country H improves.*

We may summarize our results as follows.

Proposition 3 *Assume that region 1 of country H is a gate. When the foreign country F is agglomerated, country H is such that (i) $\lambda_H^* = 1$ if and only if*

$$t_H < \frac{\zeta_1 t_F - \zeta_2 \tau + \zeta_3}{\zeta_4}$$

(ii) $\lambda_H^* = 0$ if and only if

$$t_H > \frac{\zeta_1 t_F - \overline{\zeta}_2 \tau + \overline{\zeta}_3}{\overline{\zeta}_4}$$

and (iii) $\lambda_H^* \in (0,1)$ if and only if the foregoing inequalities do not hold.

This proposition, illustrated in Figure 1, is sufficient to show that the introduction of very basic geographical features suffices to yield a much richer set of possible patterns than standard NEG models.

Insert Figure 1 about here.

Case 2. Assume now that country F is dispersed ($\lambda_F^* = 1/2$). This configuration is stable provided that

$$\lambda_H^* > 1 + \frac{-\varepsilon_1 t_F + \varepsilon_2}{\varepsilon_3 t_H} + \frac{\tau}{t_H}. \tag{34}$$

As shown by (20), the corresponding condition when there is no gate is given by $\varepsilon_1 t_F + \varepsilon_2 + \varepsilon_3 \tau < 0$. When this last condition is met, the right hand side of (34) is smaller than 1, which shows that dispersion may be feasible for some values of λ_H. Condition (34) may be rewritten as follows:

$$-\varepsilon_1 t_F + \varepsilon_2 + \varepsilon_3 \tau < (\lambda_H - 1)\varepsilon_3 t_H \tag{35}$$

which is more stringent than in the no-gate setting because $\varepsilon_3 > 0$.

Let $\widehat{C}_3 \equiv C_2/4 + C_3 > C_3$. When $\lambda_F^* = 1/2$, the indirect utility differential in country H reduces to

$$\Delta V_H^*(\lambda_H, 1/2) = \frac{t_H(b + 2cn)}{8\phi(b + cn)^2}\left(C_1 \lambda_H + \widehat{C}_3\right).$$

Hence, agglomeration with $(\lambda_H^*, \lambda_F^*) = (1, 1/2)$ is a stable global equilibrium in country H when

$$C_1 + \widehat{C}_3 > C_1 + C_3 > 0. \tag{36}$$

As can be seen from the first inequality in (36), *agglomeration in the gated region is more likely when country F is dispersed than when it is agglomerated*. Indeed, when firms are dispersed in country F, its domestic markets are less competitive, which increases country F's importance in country H's firm profits. This in turn attracts more firms to the gated region because it offers a better access to country F. Some straightforward calculations show that

$$C_1 + \widehat{C}_3 > 0 \quad \Longleftrightarrow \quad t_H < \frac{\xi_1 t_F - \zeta_2 \tau + \zeta_3}{\zeta_4} \tag{37}$$

where $\xi_1 \equiv \zeta_1 + cn^2\phi(b + cn)$. Clearly, (37) may be interpreted in the same way as condition (31). Agglomeration in the landlocked region, i.e. $(\lambda_H^*, \lambda_F^*) = (0, 1/2)$, is a global equilibrium if and only if

$$\widehat{C}_3 < 0 \quad \Longleftrightarrow \quad t_H > \frac{\xi_1 t_F - \overline{\zeta}_2 \tau + \overline{\zeta}_3}{\overline{\zeta}_4}. \tag{38}$$

Again, (38) may be interpreted in the same way as condition (32). Note that, as in the case of agglomeration in country F, multiple global equilibria may arise for intermediate values of the transport costs t_H.

Finally, a stable interior equilibrium arises at $\lambda_H^* = -\widehat{C}_3/C_1$ if and only if $\widehat{C}_3 > 0$ and $C_1 + \widehat{C}_3 < 0$. Because $\widehat{C}_3 > C_3$, such an equilibrium is more likely to arise when country F is dispersed than when it is agglomerated.

To sum up:

Proposition 4 *Assume that region* 1 *of country* H *is a gate. When the foreign country* F *is dispersed, country* H *is such that (i)* $\lambda_H^* = 1$ *if and only if*

$$t_H < \frac{\xi_1 t_F - \zeta_2 \tau + \zeta_3}{\zeta_4}$$

(ii) $\lambda_H^* = 0$ *if and only if*

$$t_H > \frac{\xi_1 t_F - \overline{\zeta}_2 \tau + \overline{\zeta}_3}{\overline{\zeta}_4}$$

and (iii) $\lambda_H^* \in (0, 1)$ *if and only if the foregoing inequalities do not hold.*

This proposition, which is the counterpart of Proposition 3, shows again that all possible configurations may emerge as a stable global equilibrium in country H when country F is dispersed.

3.3 NAFTA and the economic geography of Mexico

We show below that the foregoing model allows us to replicate the observed changes in the spatial structure of Mexico during the last decades. Recall that, from the 1950s until the mid-1980s, Mexico's economy was largely closed to international trade as the consequence of a restrictive import-substituting industrialization policy. From the mid-1980s on, a rapid policy of trade liberalization was implemented, which opened the Mexican market to increased quantities of imports from the rest of the world, especially the United States. As highlighted by Krugman and Livas Elizondo (1996) and Hanson (1998), this rapid trade liberalization was accompanied by a significant shift of Mexican manufacturing employment from the region of Mexico City towards the US border. According to the data presented in Hanson (1998, p.428), the share of the north and the border regions in total manufacturing employment rose from 26.2% to 37.31%, whereas the share of the center and of the Mexico City region dropped from 69.92% to 56.94%.

Stated differently, the Mexican episode of trade liberalization was accompanied by a significant redispersion of manufacturing activities towards the US-Mexican border: “trade reform has coincided with sectorial and spatial employment shifts in Mexico” (Hanson, 1998, p.427). Note that, although Krugman and Livas Elizondo (1996) explain why trade liberalization implied a fall in the degree of agglomeration in Mexico, they do not provide theoretical foundations for the growth in the north and the border regions at the expense of Mexico City.

We now show that our model is able to account for the three factors put forward in Hanson’s empirical analysis (1998) of the Mexican case: (i) transport costs, which make firms locate in regions with good access to foreign markets; (ii) backward and forward linkages, which make firms locate close to buyers and sellers; and (iii) agglomeration economies, which reinforce historically locked-in patterns of industry location.[12]

It is reasonable to assume that Mexico is the gated country H, whereas the US is the gate-less country F because a very large fraction of its economic activity is located along the East and West coasts. Assume, further, that Mexico has a relatively high value of internal transport costs t_H, whereas internal transport costs t_F for the US are much lower. Finally, without loss of generality, we assume that country F is initially dispersed, i.e., $\lambda_F^* = 1/2$.[13] Rewriting Proposition 4, we know that $\lambda_H^* = 1$ when

$$\tau < \widehat{\tau}^1 \equiv \frac{\xi_1 t_F - \zeta_4 t_H + \zeta_3}{\zeta_2} \tag{39}$$

while $\lambda_H^* = 0$ when

$$\tau > \widehat{\tau}^0 \equiv \frac{\xi_1 t_F - \overline{\zeta}_4 t_H + \overline{\zeta}_3}{\overline{\zeta}_2}. \tag{40}$$

Analogously to condition (33), we have a unique global equilibrium when $\widehat{\tau}^0 > \widehat{\tau}^1$. This is equivalent to the condition

$$t_H > \widehat{t}_H \equiv \frac{(\overline{\zeta}_2 \xi_1 - \xi_1 \zeta_2) t_F + (\overline{\zeta}_2 \zeta_3 - \overline{\zeta}_3 \zeta_2)}{\zeta_4 \overline{\zeta}_2 - \overline{\zeta}_4 \zeta_2} > 0. \tag{41}$$

When this condition does not hold, we have multiple equilibria and full agglomeration into either of the two regions of country H is a stable equilibrium. These results are summarized in Figure 2.

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[12] Of course, since our model features no input-output linkages, the supplier driven forward linkages do not apply to our setting.

[13] This assumption is not crucial for our qualitative results. See Appendix C for the case where $\lambda_F^* = 1$.

Insert Figure 2 about here.

To begin with, assume that t_H is sufficiently large such that (41) holds, which is more likely to arise when t_F is low and τ large. This is because the market of country F is sufficiently integrated and difficult to access from abroad, which makes penetration more difficult and, therefore, reduces its relative importance for country F's firms. When (41) holds, it is easy to choose admissible parameter values such that full agglomeration in the landlocked region 2 of country H is the unique stable equilibrium. Even though access to foreign markets is worse from the landlocked region, agglomeration in this region may be sustained once it has been established there. Historically, this setting may be seen as corresponding to the period preceding Mexican trade liberalization, when the region of Mexico City was the economic centre of the country, concentrating nearly one half of all manufacturing employment (Hanson, 1998).

Assume, next, that trade is progressively liberalized, as was the case from the mid-1980s on. As τ gradually decreases, country H progressively experiences a relative dispersion of its economic activities towards the gated region. More precisely, two different cases may arise. If, on the one hand, t_H is sufficiently large, such that $\widehat{\tau}^0 > \widehat{\tau}^1$, then dispersion takes place gradually. In particular, for all values of τ such that $\widehat{\tau}^0 > \tau > \widehat{\tau}^1$, there is a unique stable interior equilibrium and λ_H^* varies smoothly from 0 to 1 as τ decreases. This illustrates the progressive growth of the gated region at the expense of the industrial core, as trade becomes freer. Yet, history has endowed the core with sufficient inertia for dispersion to occur gradually. If, on the other hand, t_H is low such that $\widehat{\tau}^1 > \widehat{\tau}^0$, the economy remains agglomerated in the landlocked region until $\tau < \widehat{\tau}^0$, from which point on there is a rapid change in the spatial structure with the gated region becoming the new core of the economy. We see this second scenario more as a theoretical possibility. Indeed, even when rapid spatial changes do occur in the real world, there is much more locational inertia so that the modifications can hardly be described as being 'catastrophic'.

4 Conclusions

Most NEG models expunge geography by confining themselves to 'double-point economies', i.e. scenarios in which alternative locations are two dimensionless points. A first step ahead is to consider 'quadruple-point economies', which is the minimum requirement to talk about the internal geographies of two countries. This setup reveals the complex evolution of the economic landscape due to interactions between international trade barriers and interregional transport infrastructures in the presence of internal migration. Complexity stems from 'international externalities', which are channeled through trade and render the internal geographies of countries intertwined.

An interesting case of such an international externality arises in the presence of gated regions, i.e., regions through which imports to and exports from countries have to go. With two countries, one with a gate region ('gated country') and the other without any gate region ('gate-less country'), three main results stand out. First, compared with a situation with no gate regions, the gate-less country is more likely to be agglomerated when its trade partner is gated. Yet, it is not a priori possible to assess whether the gated country is itself more likely to be agglomerated with or without a gate. This is because the gate favors agglomeration in the gate-less country, which in turn reduces the likelihood of agglomeration in the gated country. Thus, whereas the gate fosters agglomeration in the gate-less country, agglomeration in the gated country does not necessarily take place. Second, the gated country is more likely to be agglomerated when its partner is dispersed. Third, and last, agglomeration in the gate region arises when the gated country is well integrated, whereas agglomeration in the landlocked region occurs when it is poorly integrated.

While we have used these predictions to shed light on the geography of Mexico after NAFTA, it is tempting to apply them to other regional agreement, such as the European Union or Mercosur. For example, the construction of major land transport infrastructure is one of the main tools used by the European Commission to integrate new members. Our analysis suggests that EU decision-makers would be well inspired to pay more attention to the possible implications of their policies on the internal geography of the new and old members.

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Appendix A: Proof of Proposition 2

Assume, without loss of generality because country F is symmetric and ΔV_F^* is linear in λ_F, that $\lambda_F \geq 1/2$. Using (27) and (28), we can show that

$$\begin{aligned} \frac{\partial(\Delta V_H^*)}{\partial \lambda_F} &= (1-2\lambda_F)\frac{t_H(b+2cn)}{8\phi(b+cn)^2}C_2 \leq 0 & (42) \\ \frac{\partial(\Delta V_F^*)}{\partial \lambda_H} &= (1-2\lambda_F)\frac{nt_F(b+2cn)}{16\phi(b+cn)^2}\varepsilon_3 t_H \leq 0 & (43) \end{aligned}$$

because $\varepsilon_3 > 0$ and $C_2 > 0$. Since ΔV_r^* is a continuous and differentiable function of λ_r, a stable national equilibrium always exists in each country $r = H, F$ for any given value of λ_s.

Let λ_H^0 and λ_F^0 be the given initial values and let $\lambda_H^1(\lambda_F^0)$ be a corresponding stable national equilibrium in country H. Given $\lambda_H^1(\lambda_F^0)$, we can then find a stable national equilibrium $\lambda_F^1(\lambda_H^1)$ in country F. Clearly, the existence of a stable global equilibrium implies that the two sequences $\{\lambda_H^t\}$ and $\{\lambda_F^t\}$ converge. To show it, note that at any period t, three possibilities may arise:

- If $\lambda_H^t(\lambda_F^{t-1}) = \lambda_H^{t-1}$, the process terminates and $(\lambda_H^t, \lambda_F^{t-1})$ is a stable global equilibrium.
- If $\lambda_H^t(\lambda_F^{t-1}) > \lambda_H^{t-1}$, we know from (43) that ΔV_F^* shifts down at every point of the interval $[1/2, 1]$. Because ΔV_F^* is linear in λ_F, it follows that $\lambda_F^t(\lambda_H^t) \leq \lambda_F^{t-1}$ must hold. Given from (42), this shifts ΔV_H^* upward at every point of the interval $[0, 1]$, so that $\lambda_H^{t+1}(\lambda_F^t) \geq \lambda_H^t$ must hold. The period t being arbitrary, the two sequences $\{\lambda_H^t\}$ and $\{\lambda_F^t\}$ are monotonic. Convergence then follows because $\lambda_H \in [0, 1]$ and $\lambda_F \in [1/2, 1]$ are compact sets.
- If $\lambda_H^t(\lambda_F^{t-1}) < \lambda_H^{t-1}$, the proof is analogous to that in the previous case.

Hence, a stable global equilibrium exists for all parameter values of the model.

Appendix B: Expressions of ζ_k and $\overline{\zeta}_{k'}$

The bundles of parameters of Section 3.3 are given as follows:

$$\begin{aligned}
\zeta_1 &\equiv cnA(b+cn) \\
\zeta_2 &\equiv 2A(b+cn)(2b+cn) + 2bn\phi(3b+4cn) \\
\zeta_3 &\equiv 4aA(b+cn) + 4an\phi(3b+4cn) \\
\zeta_4 &\equiv 2A(b+cn)(b+2cn) + 2n\phi(3b^2+6bcn+2c^2n^2) \\
\overline{\zeta}_2 &\equiv 2A(b+cn)(2b+cn) + 6n\phi(b+2cn)^2 \\
\overline{\zeta}_3 &\equiv 4aA(b+cn) \\
\overline{\zeta}_4 &\equiv 2A(b+cn)
\end{aligned}$$

Appendix C: Illustration with $\lambda_F^* = 1$

Assume that $\lambda_F^* = 1$. From Proposition 3, $\lambda_H^* = 1$ when

$$\tau < \overline{\tau}^1 \equiv \frac{\zeta_1 t_F - \zeta_4 t_H + \zeta_3}{\zeta_2}$$

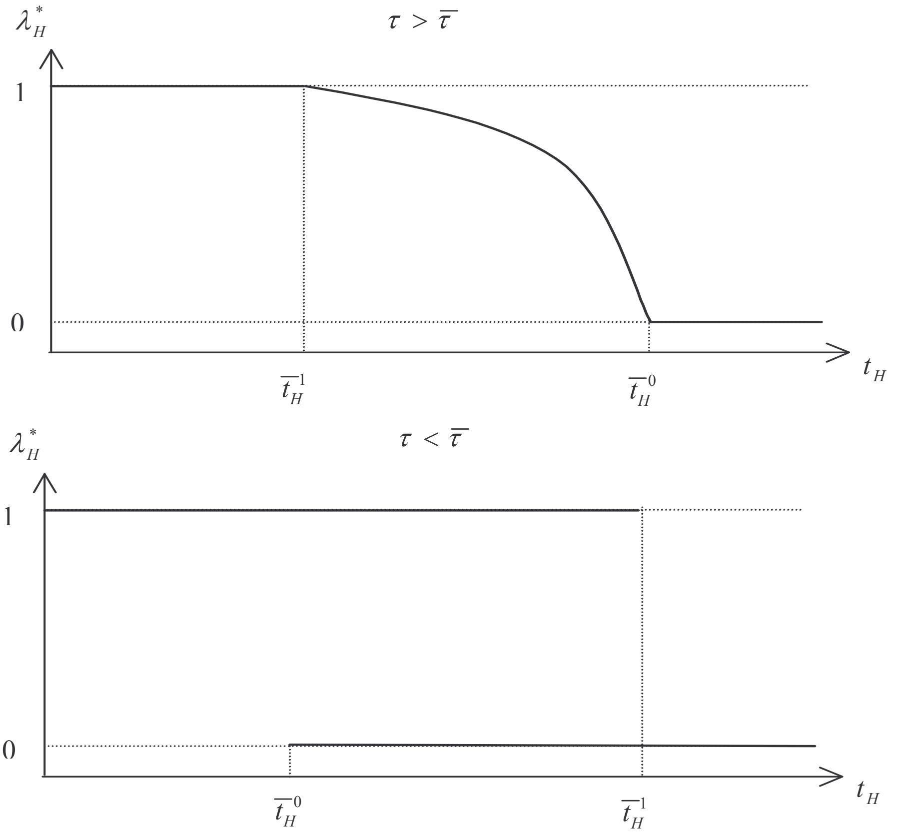
while $\lambda_H^* = 0$ when

$$\tau > \overline{\tau}^0 \equiv \frac{\zeta_1 t_F - \overline{\zeta}_4 t_H + \overline{\zeta}_3}{\overline{\zeta}_2}$$

Notice that $\overline{\tau}^0 > \overline{\tau}^1$ when

$$t_H > \bar{t}_H \equiv \frac{(\overline{\zeta}_2 \zeta_1 - \zeta_1 \zeta_2) t_F + (\overline{\zeta}_2 \zeta_3 - \overline{\zeta}_3 \zeta_2)}{\zeta_4 \overline{\zeta}_2 - \overline{\zeta}_4 \zeta_2} > 0$$

where $\overline{\zeta}_2 \zeta_1 - \zeta_1 \zeta_2 > 0$, $\overline{\zeta}_2 \zeta_3 - \overline{\zeta}_3 \zeta_2 > 0$ and $\overline{\zeta}_2 \zeta_3 - \overline{\zeta}_3 \zeta_2 > 0$. In that case, the agglomerated equilibrium is unique, whereas there are multiple equilibria in the opposite case. All interpretations are the same as in Section 5.


$\tau > \overline{\tau}$

$\tau < \overline{\tau}$

Figure 1.

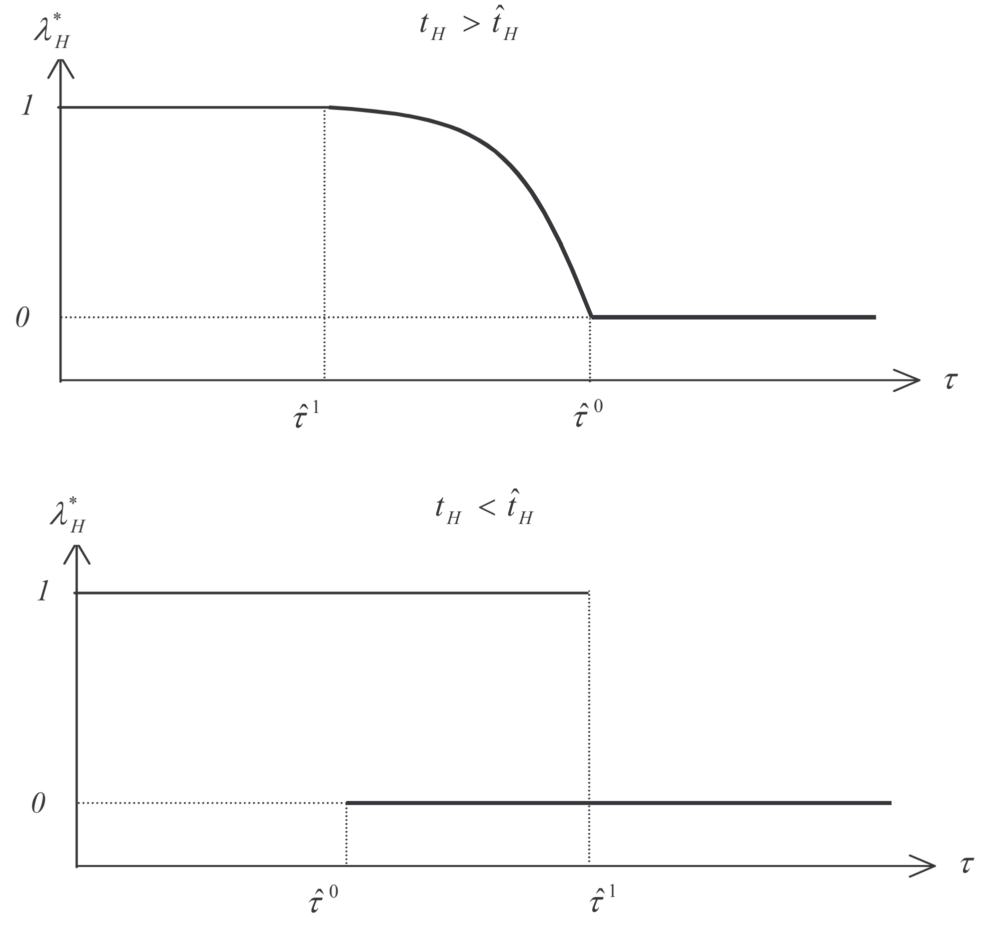

λ_H^*
$t_H > \hat{t}_H$
1
0
τ
$\hat{\tau}^1$
$\hat{\tau}^0$
λ_H^*
$t_H < \hat{t}_H$
1
0
τ
$\hat{\tau}^0$
$\hat{\tau}^1$

Figure 2.

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