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A Harmonization of First and Second Natures*

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Abstract

This paper investigates the joint impact of the first nature and the second nature forces on industry location. Towards this aim, we develop a two-region new economic geography model where local factor congestion and location advantages compete with demand linkages and product market crowding. In particular we study the case of absolute location advantage in a single industry model and the case of comparative advantages in a two-industry model. We characterize the structure of industries and discuss the possibilities of catastrophic changes, endogenous industrial asymmetries and specialization. We find that absolute location advantage are associated with a smooth agglomeration process and comparative advantages with a catastrophic process.

Keywords: dispersion, absolute location advantage, comparative advantage, industrial specialization

JEL classification: R10, R13, F12

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1 INTRODUCTION

Since the comparative advantage theory of Ricardo, Heckscher and Ohlin, it is widely believed that industries agglomerate because of access to cheaper resources. For instance, much of the U.S. aluminum production concentrates in the State of Washington where electric power is abundant and cheap, U.S. wine growers cluster in the State of California which is abundant in sun and soil, lumber suppliers locate close to the forest abundant State of Oregon, etc. In Europe, Crafts and Mulatu (2005) report that variations in factor endowments and factor intensity during the 19th century in the United Kingdom had a strong influence on location decisions. Meanwhile, many labor intensive industries like the textile and toy industries locate in less developed or emergent countries where unskilled labor is abundant and cheap.

On the other hand, recent studies find that industrial clustering and industrial specialization occur even without locational advantage (Krugman, 1991). In particular, the urban economic and economic geography literature investigate the possibility of endogenous spatial asymmetries that emerge in models with monopolistic competition, increasing returns and/or industry spillovers. Such models help to understand agglomeration processes taking place in regions like the Silicon Valley, Hollywood and Northern Italy by which firms gather in regions with no particular natural advantage (Porter, 1990; Saxenian 1994). This interpretation also allows to highlight the possible lock-in problems taking place in less developed regions lacking initial manufacturing bases (Krugman and Venables, 1995).

To our knowledge, Cronon (1991) called as 'first nature' the force by which firms locate according to local natural advantages and as 'second nature' the force by which firms locate according to an advantage stemming from the presence of other firms. Although most theoretical studies separately examine the first and second nature agglomerating processes, empirical studies tell us that the real world is a compound of both. For example, Kim (1995) and Brülhart and Trionfetti (2001) find that both first and second nature advantages are essential to determine the location in the U.S. and EU, respectively. For this reason, we propose a model that encompasses both types of advantages. Our main objective is to analyze how the properties of models of second nature advantages are altered when some industries benefit from first nature advantages. In particular, we investigate the impact of local factor advantages on the likelihood of endogenous asymmetries, catastrophic changes and hysteresis in the distribution of firms. In line with the 'new economic geography' literature, we want to provide information about the changes in trade pattern and firms distribution in a 'globalization' or 'trade integration' scenario where trade barriers decrease over time. To contrast to many contributions in 'new economic geography' that resort to numerical simulations and limit their study to subsets of equilibria, our side objective is to develop a model with good analytical tractability which allows us to characterize and study the full set of equilibria.

Our model extends Ottaviano et al. (2002) and Picard and Zeng (2005) to the case of multiple industries and local factor advantages. In each industry, manufacturing firms produce differentiated goods under increasing returns to scale and sell their products in two regions. Manufacturing firms are run by entrepreneurs (or skilled workers) who can freely move with their firm across regions. Manufacturing production requires the use of an immobile, local factor whose productivity differs across regions and whose returns are spent locally. Yet, local factors can also be employed in a traditional sector where traditional firms produce varieties of traditional goods at constant returns to scale. Local factors can be natural resources like land, minerals, energy; they can also be interpreted as human resources like immobile unskilled labor. Traditional activities may include agriculture, forestry, mine extraction, etc.

Our results can be summarized in two points. First, we investigate the role of absolute location advantage. Towards this aim we study a single industry that locate across two regions. Not surprisingly, we show that the distribution of firms is biased toward the advantaged region. Agglomeration stems from two distinct forces, demand linkages and locational advantages, which are complement and jointly dominate for intermediate values of trade costs. In addition, the presence of a local factor productivity advantage weakens the case for endogenous asymmetries and catastrophic changes. Indeed, as trade costs fall from high to small values, the distribution of firms remains on a continuous path: firms firstly disperse with a bias toward the advantaged region; they secondly smoothly agglomerate toward that region for intermediate trade costs and they finally re-disperse with the same bias when trade costs gets very small. This paper shows that the absence of catastrophic changes can be the result of absolute location advantages rather than agents' preference for their home land (Tabuchi and Thisse, 2002) or for manufacturing goods (Forslid and Ottaviano, 2003). Finally, we show in a welfare analysis that excess agglomeration occurs for large trade costs.

Second, we study the role of comparative advantages in a set-up with two industries. Many types of equilibria are possible: each industry may have its firms dispersed in every region; one industry may have its firms dispersed while the other may agglomerate in a region; both industries may agglomerate in the regions offering them a comparative advantage; and all industries may agglomerate in a single region. For small trade costs, comparative advantages induce regions to specialize in separate industries. For large trade costs, competition in the manufacturing product markets entices firms of every industry to disperse, with a bias toward the region offering them a comparative advantage. For intermediate trade costs, multiple equilibria may exist and the distribution of firms may follow very different paths as trade costs fall. In contrast to the single-industry model with absolute location advantage, this two-industry model with comparative advantage offers a case for endogenous asymmetries and catastrophic changes. Furthermore, we find that more industrialized regions may be less specialized and that, in some industries, firms may locate in opposition to comparative advantages. Hence, although some regions may offer more productive local factors to an industry, they may not succeed in becoming net exporter of the goods produced by that industry. Finally, in a more urban economic interpretation of the model, some equilibrium distributions of firms may represent endogenous urban hierarchies whereby one city supplies more varieties of each manufacturing good than the other (see Tabuchi and Thisse 2006). In a welfare analysis, we show that the socially optimal distributions of firms share most of the equilibrium properties. For given comparative advantages, firms specialize too much in the country offering them a comparative advantage. Agglomeration takes place for different values of trade costs.

Related literature: The present paper relates to the literature from a theoretical and an empirical viewpoint. From the theoretical viewpoint, the issue of first and second nature advantages has been studied in a small set of papers. In the regional science literature, our paper is closely related to Tabuchi and Thisse (2002). Those authors are the first who discuss a economic geography model with first nature advantages embedded in agents' heterogenous preferences for their (native) region. Those authors therefore analyze the conflict between the agglomeration force of demand linkage and the dispersion forces of product market crowding and local preferences. They find that as transport cost falls, firms smoothly agglomerate to one region and then smoothly re-disperse at small transport costs. Catastrophic changes in firms' distribution disappear. In the present paper, the first nature forces are embedded in the firms' production functions as, in each industry, inputs have heterogenous productivities in different locations. In some sense, our model can be considered as the dual approach of Tabuchi and Thisse (2002). However the conflict we analyze involves four forces: the two first nature forces caused by local factor congestion and local advantages and the two second nature forces caused by demand linkage and product market crowding. The first nature forces are different from Tabuchi and Thisse (2002). Although results are alike, they are rooted in different economic mechanisms. For instance, in the one-industry model with absolute location advantage (Section 4), firms smoothly agglomerate to one region and then smoothly re-disperse at small transport costs; catastrophic changes in firms' distribution disappear. Our model calls for the following distinctions between the two first nature forces. On the one hand, the re-dispersion effect stems from the local factor congestion but not from absolute location advantages. On the other hand, the absence of catastrophic changes stems from the presence of absolute location advantages but not from local factor congestion. To this respect, the roles of the first nature forces are more elaborated than in Tabuchi and Thisse (2002). Finally our results depart from those of the latter authors in a two industry set-up (Section 5) with comparative advantage. We indeed show that catastrophic changes do not disappear and that re-dispersion occurs within each industry for small enough comparative advantages and between industries otherwise.

Other theoretical contributions are mostly related to international trade issues. In this literature, first nature advantages are described by either the one-factor Ricardian model or the two-factor Heckscher-Ohlin model. Earlier contributions discuss footloose capital models where capital is spatially mobile and where the work force is spatially immobile but mobile across industries (Amiti, 1998; Venables, 1999; Ricci, 1999; Epifani 2005). Recent contributions assume one immobile productive factor (labor) only with firm heterogeneity (Bernard et al., 2007; Okubo, 2009). Such immobility assumptions do not allow for demand linkages that are caused by the relocation of the work force, which are worth more concern. To this respect, our paper (as well as Forslid and Wooton, 2003 and the Section 4 in Ricci, 1999) belongs to the regional economic literature, in the sense that skilled workers are mobile across regions. In addition, this small literature presents two difficulties. On the one hand, using CES preferences, those models rarely offer analytical results so that authors must often use numerical examples to highlight possible (unexpected) relationships between location advantages and agglomeration. By contrast, using assumptions similar to Ottaviano et al. (2002), our model offers better analytical tractability and confirms the suitability of Ottaviano et al.'s (2002) model for economic analysis. On the other hand, comparing the existing results in this literature appears to be difficult. Indeed, those papers make quite different assumptions about the type and number of industries that are subject to first nature advantages, about the nature of the dispersion forces and about the presence of a trade-free homogenous good.[1] Therefore, it is important to offer a study of first and second nature advantages in a unified framework that allows us to compare their respective roles on the spatial distribution of firms.

Our model revisits some results scattered in the literature. We stress the two following

[1] Indeed, there is one IRS industry in Forslid and Wooton (2003) and Epifani (2005), two IRS industries in Amiti (1998) and Ricci (1999) and K IRS industries in Venables (1999). Also, the dispersion force is due to labor immobility in the papers assuming footloose capital models whereas it assumed at the outset by a very ad hoc congestion function in Section 4 of Ricci (1999) or it results from heterogeneity of firms' fixed costs in Forslid and Wooton (2003). Finally, there is no trade-free homogenous good in Amiti (1998), Venables (1999), Forslid and Wooton (2003), whereas Ricci (1999) assumes such a good.

dissimilarities. First, assuming the mobility of workers across industries, Ricci (1999) finds a numerical example of *perverse relation* between comparative advantages and agglomeration. In this perverse relation, an increase in comparative advantage may reduce agglomeration or even reverse the agglomeration pattern. In contrast, assuming away the mobility of skilled workers across industries, our model excludes this perverse relation. Second, some authors have raised concerns about the indeterminacy of location equilibria in models with multiple industries. Venables (1999) then describes the Ricardian comparative advantages as a mechanism that allows to reduce (but not eliminate) this level of equilibrium indeterminacy. Epifani (2005) argues that embedding endowment-based comparative advantage might solve the indeterminacy and ambiguity. In contrast to those authors, we are able to apply the standard asymptotic stability condition at the firm level (rather than at the industry level as in Venables (1999)) and therefore waive the indeterminacy problem.

From the empirical viewpoint, there exist a significant research effort to disentangle the importance of second nature forces from first nature in the determination of trade and industry location. Results are mixed. Amongst others, Ellison and Glaeser (1997, 1999) show that more than 20% of observed geographic concentration can be explained by a small set of observable natural advantages such as abundance of electricity, gas, coal, cattle, skilled and unskilled workers. Craft and Mulatu (2005) show the significant impact of coal abundance in the location of industries during the 1871-1931 industrialization period in the UK and they highlight the dominating role of local factor endowment during the 19th century. Using a several-century data set, Davis and Weinstein (2002) confirm the dominant role of local factors in the concentration of Japanese economic activity while they report a substantial rise in the degree of spatial dispersion during the last century, which might be explained by increasing returns. Finally, Midelfart Knarvik et al. (2000) find empirical evidence of joint effects of economic geography linkages and comparative advantages in the case of EU between 1980 and 1994. Those authors claim to show that while production partly locates according to market access, it also locates according to local factor supplies. Midelfart Knarvik et al. (2002) further note the fact that EU regional industry portfolios increasingly became less similar in the period after 1980. Those authors infer that the fall in EU trade barriers in the 1980s resulted in smaller importance of market access so that local factor endowments had become more relevant determinants of industry location. Those last empirical results support our theoretical prediction that comparative advantages prevail for small trade costs. Yet, for intermediate trade costs, our two-industry model does not make any clear-cut prediction about the region where firms agglomerate: history matters. This might be a reason why comparative advantages and market access are empirically so hard to disentangle.

The paper is organized as follows. Section 2 presents the model and Section 3 explains the various specialization, agglomeration and dispersion forces. Section 4 discusses industrial location in a framework of one industry with absolute location advantage while Section 5 fully characterizes the industrial location patterns for the case of two industries with comparative advantage. Section 6 concludes.

2 THE MODEL

The model includes two sectors and two regions: home and foreign. In the first sector, called manufactures, firms produce under increasing returns to scale and sell their products under monopolistic competition. The manufacturing sector includes K industries (e.g., textile, automobile, IT and etc.), and each industry $k \in \{1, ..., K\}$ includes a continuum of indivisible firms $x \in [0, 1]$ each producing a differentiated variety $x \in [0, 1]$. The number of varieties in each industry is normalized to 1. Manufacturing firms can freely choose their location of production. Let $\lambda_k \in [0, 1]$ be the proportion of firms of industry k in the home region and $\lambda_k^* \equiv 1 - \lambda_k$ be the proportion in the foreign region. We superscript variables pertaining to the foreign region by an asterisk (*) and we expose economic relationships for the home region, symmetric relationships holding for the foreign region. In the second sector, called traditional sector, immobile firms produce at constant returns to scale and sell their products in perfectly competitive markets. This sector includes a traditional industry in each country, which may include for instance include agriculture, fishery, woodcraft, etc. Furthermore we will denote variables pertaining to the traditional industries by a prime symbol '.

Each region is endowed with local, immobile factors which differ across regions and which are owned by local residents. To capture the idea of Ricardian advantages, we assume that local factors differ across space in productivity but not in quantity. At the same time, to concentrate on the issue of location advantages in the manufacturing sector we assume away productivity differences in the traditional sector. Hence, we assume that each region hosts A immobile individuals who each own a unit of local factor. On the one hand, the local factor can be used at unit productivity in the traditional sector in any region. On the other hand, the local factor can be used in the manufacturing sector as a fixed input whose productivity differs across regions and industries.[2] More precisely, each manufacturing firm in industry k requires ϕ_k and ϕ_k^* units of local factor to produce in the domestic and foreign regions, where $\phi_k \neq \phi_k^*$. As in Ottaviano

[2] In our model, Ricardian comparative advantage is slightly different from the traditional one, which is based on the constant-return to scale technology and one factor of production.

et al. (2002), manufacturing firms are assumed to use no variable input.[3]

Each manufacturing firm is run by a mobile entrepreneur who locally spends his income. Entrepreneurs may be seen as skilled workers who are able to operate the manufacturing firms. As in Krugman (1981), we assume that entrepreneurs and/or skilled workers are immobile across industries. The basic reason for this is that some special training is required to become an entrepreneur and/or a skilled worker in a specific industry and different skills are required for different industries. Therefore, changing a profession is very costly. Since the mass of entrepreneurs in each industry is 1, the total number of owners of local factors and entrepreneurs is equal to $M \equiv 2A + K$. When the entrepreneurs are skilled workers, this number represents the total number of workers in the economy. Entrepreneurs and owners of local factors are also consumers whose preferences are defined as follows.

Consumers: Individuals consume three types of goods: manufacturing goods, traditional goods and a homogenous good used as a numéraire. In this text, we follow Baldwin et al.'s (2003) notation by denoting variables related to imported varieties by an upper bar ($^{-}$). Then, as in Ottaviano et al. (2002) and Picard and Zeng (2005), we assume that each domestic consumer is endowed with the following additive, quadratic utility function

$$\begin{aligned} U =& \alpha \sum_{k=1}^{K} \left(\int_{\Omega_k} q_k(x)dx + \int_{\bar{\Omega}_k} \bar{q}_k(x)dx \right) - \frac{\beta-\gamma}{2} \sum_{k=1}^{K} \left(\int_{\Omega_k} [q_k(x)]^2 dx + \int_{\bar{\Omega}_k} [\bar{q}_k(x)]^2 dx \right) \\ & - \frac{\gamma}{2} \sum_{k=1}^{K} \left(\int_{\Omega_k} q_k(x)dx + \int_{\bar{\Omega}_k} \bar{q}_k(x)dx \right)^2 + \left(q' - \frac{1}{2} q'^2 \right) + \left(\overline{q}' - \frac{1}{2} \overline{q}'^2 \right) + q_0, \end{aligned} \tag{1}$$

where $q_k(x)$ is his individual consumption of domestic manufacturing variety x in industry k, $\bar{q}_k(x)$ is the consumption of manufacturing variety x imported in the domestic region, and Ω_k and $\bar{\Omega}_k$ are the sets of local and imported manufacturing varieties. The masses of firms in those sets Ω_k and $\bar{\Omega}_k$ are naturally equal to λ_k and $1 - \lambda_k$. The parameter α measures the intensity of preference for manufacturing products and the difference $\beta - \gamma > 0$ is a proxy for the consumer's preference toward product variety of manufacturing goods. The variables (q', $\overline{q}'$) denote the consumptions of two 'traditional' varieties that are perfectly differentiated and respectively produced by a constant returns to scale sector in the domestic and foreign regions. As it will become clear later, those local traditional sectors are needed to obtain a non trivial outcome in the market for local factors.[4] Meanwhile, q_0 is the consumption of the homogenous

[3]In Ottaviano et al. (2002), manufacturing firms may use the numéraire good q_o as a variable input. This amounts to rescale the intercept α/β of firms' demand functions.

[4]To focus on the location of the manufacturing sector, we have simplified the sub-utility for the traditional

good that is used as numéraire good. In contrast to manufacturing and traditional goods, this good is not produced but given as endowment to consumers. The above utility function degenerates to that of Ottaviano et al. (2002) when there exists only one manufacturing industry ($K = 1$) and when the two traditional goods are absent.

Consumers maximize their utility with respect to their budget constraint. Let (p_k, q_k) be the consumer price and individual consumption of a manufacturing variety produced at home by industry k and let $(\overline{p}_k, \overline{q}_k)$ be the consumer price and quantity of imported variety. Let $(p', \overline{p}')$ denote the price of the local and imported traditional varieties. The budget constraint writes as

$$\sum_{k=1}^{K} \left(\int_{\Omega_k} p_k(x) q_k(x) dx + \int_{\overline{\Omega}_k} \overline{p}(x) \overline{q}_k(x) dx \right) + p'q' + \overline{p}'\overline{q}' + q_0 = w + \widetilde{q}_0,$$

where w is the consumer's earnings and $\widetilde{q}_0$ is her endowment in numéraire. Using symmetry between varieties and assuming sufficiently large endowment in numéraire $\widetilde{q}_0$ as in Ottaviano et al. (2002), we get the following individual demand functions for manufacturing varieties:

$$q_k = a - (b + c)p_k + cP_k \quad \text{and} \quad \overline{q}_k = a - (b + c)\overline{p}_k + cP_k, \tag{2}$$

where

$$a = \frac{\alpha}{\beta}, \ b = \frac{1}{\beta}, \ c = \frac{\gamma}{(\beta - \gamma)\beta},$$

and where q_k and p_k are the demand of and price paid by a home consumer for a manufacturing variety produced by a home firm belonging to industry k and where

$$P_k = \lambda_k p_k + (1 - \lambda_k)\overline{p}_k$$

is the domestic price index for the goods produced by industry k.

Similarly we can get the individual demand for varieties of the traditional sector. In each region, the same traditional variety has the same price. Let $(p', \overline{p}')$ be the consumer price of a traditional variety produced in the domestic and imported from the foreign region. Then individual demands are simply given by

$$q' = 1 - p' \text{ and } \overline{q}' = 1 - \overline{p}'. \tag{3}$$

Individual consumption of the domestic traditional variety is identical across regions.

varieties to its minimal form. A more general utility function with imperfect substitute varieties is developed in Picard and Zeng (2006).

Manufacturing firms: The total demand for a variety produced by a manufacturing firm consists of the aggregate demand of individuals located in both regions. Since each entrepreneur follows his manufacturing firm, the number of domestic consumers is equal to $A + \lambda K$ where $\lambda \equiv \sum_{k=1}^{K} \lambda_k / K$ measures the proportion of entrepreneurs locating at home. Therefore, a home entrepreneur in industry k earns a wage equal to

$$w_k = p_k q_k (A + \lambda K) + (\overline{p}_k^* - \tau)\overline{q}_k^* [A + (1 - \lambda)K] - \phi_k w',$$

where the two first terms represents his sales in the local and foreign markets and the last term her cost for domestic local factors. In this expression, $\overline{q}_k^*$ the individual demand for this exported variety (i.e. the import purchased by a foreign consumer) and $\overline{p}_k^*$ is its export price; w' is the price of the domestic local factor. As in Ottaviano et al. (2002) and Picard and Zeng (2005), the trade cost τ is paid in numéraire.

Each home entrepreneur chooses his domestic and export prices $(p_k, \overline{p}_k^*)$ taking other firms' prices as given. His optimal prices are given by

$$p_k = \frac{2a + \tau c(1 - \lambda_k)}{2(2b + c)} \quad \text{and} \quad \overline{p}_k^* = p_k^* + \frac{\tau}{2},$$

whereas his wage w writes as

$$w_k = (b + c)\{(p_k)^2 (A + \lambda K) + (\overline{p}_k^* - \tau)^2 [A + (1 - \lambda)K]\} - \phi_k w' \tag{4}$$

Traditional firms: In each region, a traditional sector uses a constant returns to scale technology to produce one variety of a traditional good. Traditional goods differ according to regions' endowments of local factors. For instance, regions endowed with land and sun may specialize in the production of fruits and wine, those endowed with forests in woodcraft, etc. We assume that local factors are used at unit productivity in the traditional sector. Also, as usual in the economic geography literature, we assume that traditional varieties are traded at zero cost. As a consequence, the price of the domestic traditional good in both regions is equal to the price of the domestic local factor, $w' = p'$. The individual demands of domestic and foreign consumers are therefore equal to:

$$q' = \overline{q}'^* = 1 - p' = 1 - w'.$$

The total demand for the domestic traditional good is thus equal to $q'M$ (that is, $q'(2A + K)$). The supply of this good is equal to the number of units of local factor that are not used by manufacturing firms. When demand equals supply we get:

$$q'M = A - \sum_{k=1}^{K} \lambda_k \phi_k.$$

We have similar equality for the foreign region. Then the local factor prices are determined as follows.

$$w' = 1 - \frac{1}{M}\left(A - \sum_{k=1}^{K} \lambda_k \phi_k\right), \quad w'^* = 1 - \frac{1}{M}\left(A - \sum_{k=1}^{K} (1-\lambda_k) \phi_k^*\right). \tag{5}$$

The domestic factor price increases with larger local factor usage by domestic manufacturing firms. From the last expression, it is clear that domestic and foreign factor prices move in opposite directions when firms relocate from one region to the other. Also, note that because local factors are used to produce traditional goods that are perfectly differentiated, factor prices cannot be expected to be equal. As a result, each domestic owner of a local factor gets an earning w equal to the price of this factor w'.

Restrictions: In this paper we restrict our analysis to the situation in which consumers always purchase a positive amount of every manufacturing and traditional variety. Hence, we impose $q_k > 0, \overline{q}_k > 0$, $q' > 0$ and $w' > 0$ for any $k = 1, \cdots, K$ and any $\lambda_k \in [0,1]$. Specifically, we impose the following restrictions:

$$\tau < \tau^{\text{trade}} \equiv \frac{2a}{2b+c} \quad \text{and} \quad A > \max\left\{\sum_{k=1}^{K} \phi_k, \sum_{k=1}^{K} \phi_k^*\right\} \tag{6}$$

The first part of (6) guarantees that the demand of manufacturing exports is large enough to compensate for their trade cost. The second part implies that the supplies of local factors are sufficiently large so that some local factor is always used by the traditional sector. Note finally that because $M > A$, we have $w' > 0$ from (5).

3 AGGLOMERATION AND DISPERSION FORCES

In this section we present the agglomeration and dispersion forces generated by the entrepreneurs who decide the location of firms. We first derive the entrepreneurs' indirect utility and we then discuss the impact of firms' distribution on entrepreneurs incentive to locate in a region. We then define the equilibrium and stability concept that we use in the subsequent sections.

Entrepreneurs' location incentives: The indirect utility of an entrepreneur obtains by plugging his optimal consumption levels (2) and (3) into the utility function (1). Similarly to Ottaviano et al. (2002), the indirect utility of entrepreneurs employed in industry k can be broken down into their consumption surplus S and S' from manufactured and traditional goods, their wages w_k and their initial numéraire endowments $\widetilde{q}_0$:

$$V_k = \sum_{l=1}^{K} S_l + S' + w_k + \widetilde{q}_0.$$

Remember that we denote variables pertaining to the foreign region by an asterisk (*), those pertaining to the traditional sector by an apostrophe ($'$) and those related to imports by an upper bar ($^-$). Entrepreneurs' incentives to move between regions are given by their utility differential:

$$\Delta V_k \equiv V_k - V_k^* = \sum_{l=1}^{K} (S_l - S_l^*) + S' - S'^* + (w_k - w_k^*). \tag{7}$$

Note that the term $S' - S'^*$ in (7) is zero because the access to traditional varieties is the same in every region. Therefore relocation incentives do not depend directly on the traditional sector. Nevertheless, this sector generates a dispersion and agglomeration force in the economy which we now describe in more detail.

One can compute that consumption surplus from manufactured goods is equal to

$$\begin{aligned} S_k = & \frac{a^2}{2b} - a[\lambda_k p_k + (1-\lambda_k)\overline{p}_k] - \frac{c}{2}[\lambda_k p_k + (1-\lambda_k)\overline{p}_k]^2 \\ & + \frac{(b+c)}{2}[\lambda_k p_k^2 + (1-\lambda_k)\overline{p}_k^2] \end{aligned}$$

and that the surplus differential for all manufactures is equal to

$$\sum_{l=1}^{K} (S_l - S_l^*) = \frac{(2a - \tau b)\,(b+c)^2}{(2b+c)^2} \tau \sum_{l=1}^{K} \left(\lambda_l - \frac{1}{2} \right)$$

Obviously, the coefficient in this expression is positive because $2a > \tau b$ by the restriction (6). An increase in the number of firms in a region increases the surplus from consumption for all consumers of that region. As more firms agglomerate, consumers benefit from a larger number of varieties and smaller prices. This is an agglomeration force.

By (4), entrepreneurs' wage differential is equal to

$$w_k - w_k^* = \frac{b+c}{2b+c}(2a - \tau b)\tau \sum_{l=1}^{K} \left(\lambda_l - \frac{1}{2} \right) \tag{8}$$

$$-\frac{c(b+c)}{2(2b+c)}\tau^2 M\left(\lambda_k-\frac{1}{2}\right)-(\phi_k w'-\phi_k^* w'^*)$$

The first term embeds the *demand linkage* by which firms' revenues and entrepreneurs' wages are larger in the region where firms agglomerate. This is the second nature agglomeration force. It increases with the aggregate size of entrepreneur's population in region home. The second term represents the negative effect of *product market crowding* in the manufacturing industry k. When firms belonging to this industry agglomerate in a region, they face tougher competition which decreases prices and entrepreneurs' wages in the industry. This dispersion force increases with larger trade cost τ and total population M. The last term denotes the rent differential that entrepreneurs leave to the owners of local factors. When the local factor consists of (unskilled) labor, this represents the (unskilled) workers' wage. One computes that

$$\begin{aligned}(\phi_k w'-\phi_k^* w'^*) =&\frac{M-A}{M}(\phi_k-\phi_k^*)+\frac{1}{2M}\left(\phi\phi_k-\phi^*\phi_k^*\right)\\&+\frac{1}{M}\sum_{l=1}^{K}\left(\lambda_l-\frac{1}{2}\right)\left(\phi_l\phi_k^*+\phi_k\phi_l^*\right)\\&+\frac{1}{M}\sum_{l=1}^{K}\left(\lambda_l-\frac{1}{2}\right)\left(\phi_l-\phi_l^*\right)\left(\phi_k-\phi_k^*\right),\end{aligned}$$

where $\phi\equiv\sum_{k=1}^{K}\phi_k$ and $\phi^*\equiv\sum_{k=1}^{K}\phi_k^*$. The coefficient in the first term is positive under (6). This formula embeds several effects that we describe here. The first two terms represent a *constant bias towards the region with location advantages*. For the sake of the explanation, first suppose that comparative advantages are equally distributed so that $\phi=\phi^*$. Then, the first two terms are negative if the domestic region has an absolute location advantage in industry k: $\phi_k<\phi_k^*$. So, local factor rents are smaller and entrepreneurs earn more in the domestic region. When location advantages are not equally distributed so that $\phi\neq\phi^*$, the direction of the bias also depends on the global location advantage of a region: the bias toward the home region indeed increases when the ratio ϕ/ϕ^* decreases. This happens for instance when the home region is more productive in every industry.

The third term in the above expression represents a *dispersion force* generated by the *use of immobile, local factors*. Entrepreneurs do not like to locate in a same region because they are likely to exhaust the local factor supply and to raise the rents to the owners of local factors. By dispersing they get access to a larger supply of factors and they obtain smaller factor prices. This dispersion force is readily observed in the absence of location advantages ($\phi_l=\phi_l^*=\phi_k=\phi_k^*$). Then, the above expression increases when firms agglomerate in the domestic region. As the demand for the local factor rises, local factor rents increase and entrepreneurs earn less.

The last term translates the *Ricardian force* resulting for the *gains from comparative advantages.* It is indeed observed through the relocation of industries with similar location advantages when the term $(\phi_l-\phi_l^*)(\phi_k-\phi_k^*)$ is positive. In this case, the last term is positive when $\lambda_l > 1/2$ and industry k is encouraged to relocate its firms to the foreign region, thereby decreasing the last term of (8) the wage differential.

Observe that all components of entrepreneurs' utility differential (7) are linear functions of λ_k $(\forall k)$. Some lines of computation show that this utility differential can be rewritten as follows:

$$\Delta V_k = -\Phi_k + \sum_{l=1}^{K} \delta_{kl} \left(\lambda_l - \frac{1}{2} \right), \tag{9}$$

where

$$\begin{aligned} \Phi_k =& \frac{1}{2M} \left(\phi \phi_k - \phi^* \phi_k^* \right) + \frac{M-A}{M} (\phi_k - \phi_k^*), \\ \delta_{kl} =& \digamma_{kl}(\tau) - \frac{1}{M} \left[(\phi_k - \phi_k^*)(\phi_l - \phi_l^*) + (\phi_k \phi_l^* + \phi_k^* \phi_l) \right], \end{aligned}$$

and where

$$\digamma_{kl}(\tau) = \begin{cases} \digamma(\tau) \equiv \frac{(b+c)(3b+2c)}{(2b+c)^2}(2a-b\tau)\tau - \frac{c(b+c)M}{2(2b+c)}\tau^2 & \text{if} \quad k=l \\ \Gamma(\tau) \equiv \frac{(b+c)(3b+2c)}{(2b+c)^2}(2a-b\tau)\tau & \text{if} \quad k \neq l. \end{cases} \tag{10}$$

Note that $\Gamma(\tau) > \digamma(\tau)$ and that $\digamma$ and Γ are concave in τ. Moreover, under the restriction (6), $\Gamma(\tau)$ is positive and always strictly increasing. Meanwhile, $\digamma(\tau)$ strictly increases at $\tau = 0$, attains a maximum at $\tau = 2a(3b+2c)/(6b^2+4bc+2bcM+c^2M)$ and decreases for larger τ.

Location Equilibrium: In accordance to the literature we define the equilibrium to be a distribution of firms in each industry such that factors and goods markets clear and such that no entrepreneur is enticed to relocate. That is, an equilibrium is a vector $\boldsymbol{\lambda}^E = \left(\lambda_1^E, ..., \lambda_K^E\right)$ that fulfills one of these three conditions: (i) $\Delta V_k = 0$ if $\lambda_k^E \in (0,1)$, (ii) $\Delta V_k \geq 0$ if $\lambda_k^E = 1$ or (iii) $\Delta V_k \leq 0$ if $\lambda_k^E = 0$. Furthermore, an equilibrium distribution of firms is asymptotically stable if any small deviation from the equilibrium distribution leads back to the equilibrium distribution according to the following dynamics of entrepreneurs:

$$\frac{d\lambda_k}{dt} = \Delta V_k, \quad k = 1, \ldots, K.$$

Particularly, an interior distribution of firms will be stable if domestic entrepreneurs' utility falls as they agglomerate more at home. Conversely a distribution of firms will be unstable if entrepreneurs' utility increases as they locate further in that region. In the case of a single industry $K = 1$, the stability of the above dynamics impose that the entrepreneurs' utility differential is negatively sloped ($\delta_{11} < 0$). As a consequence, a marginal shift of the domestic entrepreneurial population above the equilibrium makes the utility differential negative, which entices entrepreneurs to leave the domestic region and revert back to the equilibrium. In the case of multiple industries $K > 1$, the stability condition impose a constraint on sign of the eigenvalues of the matrix (δ_{kl}). This amounts to impose that any combination of marginal shifts of domestic entrepreneurial populations will make the utility differential negative and will entice entrepreneurs to revert back to the equilibrium. See Tabuchi and Zeng (2004) for detail.

4 SINGLE INDUSTRY AND ABSOLUTE LOCATION ADVANTAGE

In this section we discuss the benchmark case of one industry that has an absolute location advantage in the domestic region. We show that whereas location advantages increase the likelihood of agglomeration, small changes in trade barriers are not necessarily associated with catastrophic and irreversible changes in firm locations.[5]

Specifically, we assume $K = 1$ and $\boldsymbol{\lambda} = \lambda_1$ and without loss of generality we set

$$\phi_1 = \varphi(1-\theta) \text{ and } \phi_1^* = \varphi(1+\theta), \tag{11}$$

where the parameter $\theta \in (0,1)$ measures the absolute location advantage of the home region and the parameter $\varphi > 0$ the firms' average local factor requirement. The characterization of the location equilibrium requires to study the function

$$\Delta V(\lambda) = \Phi + \left(\lambda - \frac{1}{2}\right)\delta, \tag{12}$$

where $\delta \equiv F(\tau) - \Psi$, $F(\tau)$ is defined in (10) and

$$\Psi \equiv \frac{2}{M}\varphi^2\left(1+\theta^2\right) > 0 \tag{13}$$

[5]In this paper, location asymmetries result from local advantages in factor supplies. They may also stem from transport advantages as discussed in Behrens et al. (2006).

$$\Phi \equiv \frac{2}{M}\varphi\theta\left(\varphi + M - A\right) > 0. \tag{14}$$

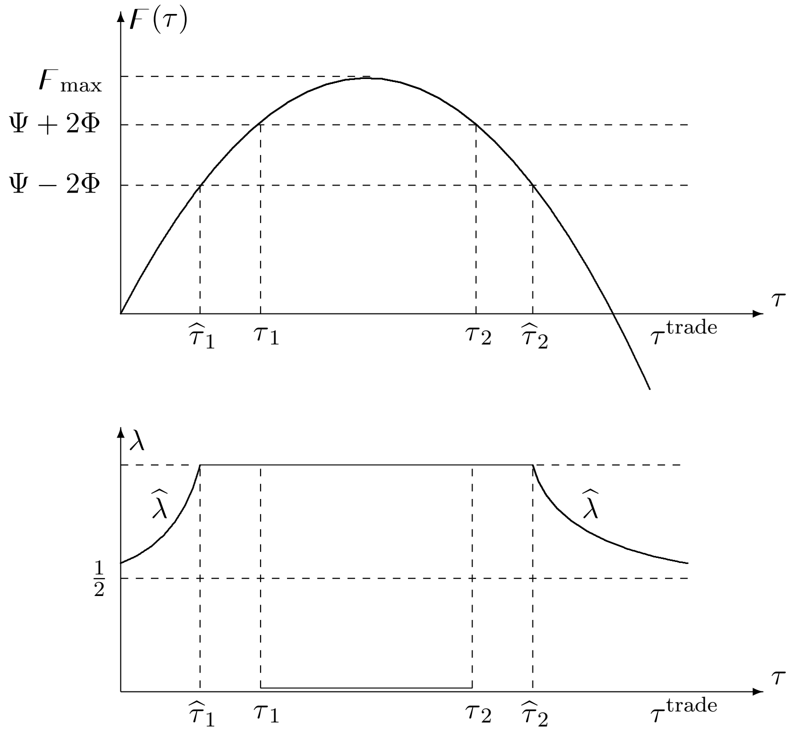


Figure 1: Single industry location

We are now equipped to characterize the spatial industry distributions as follows. First, when all entrepreneurs agglomerate in the domestic region, they must have larger utility at home so that $\Delta V(1) \geq 0$ if and only if $F(\tau) \geq \Psi - 2\Phi$. This argument is illustrated in the top panel of Figure 1 that displays the concave function $F(\tau)$. Full agglomeration takes place for any trade costs such that this function is above $\Psi - 2\Phi$. That is, for $\tau \in [\widehat{\tau}_1, \widehat{\tau}_2]$. Second, when all entrepreneurs agglomerate in the foreign region, they must get a smaller utility at home so that $\Delta V(0) \leq 0$ if and only if $F(\tau) \geq \Psi + 2\Phi$. From Figure 1, this situation occurs for any trade costs $\tau \in [\tau_1, \tau_2]$, which is a subset of $[\widehat{\tau}_1, \widehat{\tau}_2]$. Finally, entrepreneurs can be indifferent between the two regions, so that $\Delta V(\lambda) = 0$. The solution of this interval gives the interior equilibrium

$$\widehat{\lambda} \equiv \frac{1}{2} - \frac{\Phi}{\delta}.$$

Given our stability criterion, this equilibrium is stable if and only if the slope of ΔV is negative, which requires that $\delta < 0$. As a consequence, one can show that this interior solution $\widehat{\lambda}$ is larger than 1/2 and smaller than 1 if and only if $\delta < -2\Phi$, which is equivalent to $F(\tau) < \Psi - 2\Phi$. That is, if $\tau \in [0, \widehat{\tau}_1) \cup (\widehat{\tau}_2, \tau^{\text{trade}})$. The bottom panel of Figure 1 displays the stable equilibrium distribution of firms as a function of τ. We have proved the following Proposition:

Proposition 1 *(Single industry equilibrium) There exist three possible configurations for stable equilibrium distributions λ^E:*
(i) $\lambda^E = 0, 1$ if $F(\tau) \geq \Psi + 2\Phi$, or, equivalently, $\tau \in [\tau_1, \tau_2]$;
(ii) $\lambda^E = 1$ if $\Psi - 2\Phi \leq F(\tau) < \Psi + 2\Phi$, or, equivalently, $\tau \in [\widehat{\tau}_1, \tau_1) \cup (\tau_2, \widehat{\tau}_2]$;
(iii) $\lambda^E = \widehat{\lambda} \in (0, 1)$ if $F(\tau) < \Psi - 2\Phi$, or, equivalently, $\tau \in [0, \widehat{\tau}_1) \cup (\widehat{\tau}_2, \tau^{trade})$.

Proposition 1 allows us to clarify the impact of trade costs on agglomeration and dispersion. Note that this model is equivalent to Ottaviano et al. (2002) when $\varphi = \theta = 0$ and to Picard and Zeng (2005) when $\varphi > 0$ and $\theta = 0$ in their particular case of zero trade cost in traditional sector. In those models, the equilibrium distribution of firms is determined by a stability condition that is related to the slope of the entrepreneurs' utility differential, that is, to the value of δ in expression (13). When $\delta > 0$, the demand linkage dominates: the relocation of a small mass of entrepreneurs in a region raises their consumption surplus in that region more than it reduces their wages and it thus attracts the other entrepreneurs. This process is cumulative and agglomeration occurs.

In the present model, agglomeration is the result of four competing forces: demand linkages, product market crowding, location advantages and local factor congestion. For trade costs within the interval $[\tau_1, \tau_2]$, demand linkages here dominate the three other forces so that agglomeration can take place in any region. The location of a large group of entrepreneurs in one region creates a demand that is sufficiently large to entice other entrepreneurs to co-locate in that region whatever the intensity of competition, location disadvantages or local factor congestion. For trade costs in the interval $[\widehat{\tau}_1, \tau_1) \cup (\tau_2, \widehat{\tau}_2]$, demand linkages are weaker but combine with location advantages to make the domestic region more attractive. Agglomeration can occur only in the region with an absolute location advantage. So, *demand linkages and absolute location advantages are not supplementary but complementary forces.* For trade costs in the interval $(\widehat{\tau}_2, \tau^{\text{trade}})$, product market crowding dominates demand linkages. Entrepreneurs tends to disperse to avoid the negative effect of competition on their earnings. The absolute location advantage favors the domestic region. Finally, for trade costs in the interval $[0, \widehat{\tau}_1)$, demand linkages and product market crowding effects vanish so that the dominating forces are the local factor congestion and the absolute location advantage. Re-dispersion takes place because entrepreneurs earn less from a better access to consumers than the cost caused by higher local factor price in the larger region. The latter 're-dispersion' process at small trade costs has been already highlighted in the literature (see Tabuchi, 1998; Puga, 1999; Tabuchi and Thisse, 2002; and Picard and Zeng, 2006).

The above results can be discussed in terms of Cronon's (1991) terminology where location advantages and local factor congestion are 'first nature' forces whereas demand linkages and product market crowding are 'second nature' forces. As seen above, the first nature forces dominates only for small trade costs $\tau \in [0, \widehat{\tau}_1)$ because market access and product market crowding offer second order benefit and cost to entrepreneurs. First nature and second nature also act as complementary forces for trade costs $\tau \in [\widehat{\tau}_1, \tau_1) \cup (\tau_2, \widehat{\tau}_2]$. Demand linkages must be complemented by absolute location advantages to entice agglomeration. Second nature forces dominate only for intermediate trade costs $\tau \in [\tau_1, \tau_2]$ where demand linkages are stronger and large trade costs $\tau \in (\widehat{\tau}_2, \tau^{\text{trade}})$ where product market crowding dominates.

We now present the properties of the equilibrium distributions of firms with respect to the factor requirements, absolute location advantages and trade costs.

4.1 The effect of trade integration

We discuss the 'globalization' or 'trade integration' process where trade costs τ fall from large to small values. Let us take again the example described in Figure 1 where the equilibrium distribution $\widehat{\lambda}$ of firms is shown in the bottom panel. Suppose firstly that τ decreases from τ^{trade} to $\widehat{\tau}_2$. Since the interior distribution of firms $\widehat{\lambda}$ is a continuous function of τ, it continuously increases and reaches the point of full agglomeration in the home region at $\tau = \widehat{\tau}_2$. Thus, as trade costs decrease, firms smoothly shift from asymmetric dispersion to full agglomeration in the region with absolute location advantages. There is no catastrophic agglomeration process. Suppose then that trade costs further decrease in the range $[\widehat{\tau}_1, \widehat{\tau}_2]$. Then firms remain agglomerated in the home region. Suppose finally that trade costs further fall in the range $[0, \widehat{\tau}_1]$. Then firms smoothly shift from agglomeration to asymmetric dispersion.

In this paper, *the absence of catastrophic changes in the location pattern stems from the presence of absolute location advantages;* it does however not stem from the presence of local factor congestion. To clarify this idea, it is easy to show that catastrophic changes emerge in the absence of absolute location advantage even though there exists local factor congestion. Indeed, when $\theta = 0$ but $\varphi > 0$ so that $\Phi = 0$ but $\Psi = \frac{2}{M}\varphi^2 > 0$, the entrepreneurs' location incentives write as $\Delta V = (\lambda - \frac{1}{2})\delta = (\lambda - \frac{1}{2}) \left[F(\tau) - \frac{2}{M}\varphi^2\right]$, which has two roots τ_1 and τ_2.

Therefore, a symmetric equilibrium ($\lambda = 1/2$) emerges for small trade costs ($\tau \leq \tau_1$) and large trade costs ($\tau \geq \tau_2$) and full agglomeration ($\lambda \in \{0, 1\}$) for intermediate values of trade costs ($\tau_1 \leq \tau \leq \tau_2$). Hence, when trade cost falls from large to small values, the firms firstly disperse, then catastrophically agglomerate at $\tau = \tau_2$ and finally catastrophically re-disperse at $\tau = \tau_1$. Hence catastrophic changes occurs when absolute location advantages vanish despite the existence of local factor congestion (which is consistent with Picard and Zeng (2005)).

As a consequence, this model of absolute location advantages qualifies Krugman's (1991) or Ottaviano et al.'s (2002) ideas of endogenous asymmetries and catastrophic agglomeration in the distribution of firms that happens in the 'globalization' or 'trade integration' process. In such a scenario, if firms are initially located in the region offering absolute location advantages, they agglomerate in a smooth way and within that region. Therefore small absolute location advantages eliminate the possibility of catastrophic changes and of irreversible agglomeration processes. Our result also puts Davis and Weinstein's (2002) contribution in perspective. These authors indeed show that Japanese cities consistently returned to their original positions in the city ranking after the Allied bombing in 1945. As a consequence they conclude that the 'theory of location fundamentals' is more relevant than the theory of increasing returns. Increasing returns are indeed expected to yield stronger randomness in the city ranking as they give rise to endogenous asymmetries. However, the present model shows that the recovery of Japanese cities is not inconsistent with the theory of increasing returns. The present model predicts that firms resume production in their former city provided that very small locational advantages are preserved after the bombing. The theories of location fundamentals and increasing returns are here complementary but not supplementary.

4.2 Absolute location advantage and factor requirement

It is interesting to study how Proposition 1 relates to the parameters associated to absolute location advantages, namely, the domestic absolute location advantage θ and the average local factor requirement φ. The sizes of the sets $[\tau_1, \tau_2]$ and $[\widehat{\tau}_1, \widehat{\tau}_2]$ depend on how the boundaries $\Psi + 2\Phi$ and $\Psi - 2\Phi$ are positioned compared to the maximum value of $\digamma(\tau)$, i.e. $\digamma_{\max} = \max_\tau \digamma(\tau)$. One computes that

$$\Psi + 2\Phi = \frac{2}{M}\left(\varphi^2(\theta+1)^2 + 2\varphi\theta(M-A)\right),$$
$$\Psi - 2\Phi = \frac{2}{M}\left(\varphi^2(\theta-1)^2 - 2\varphi\theta(M-A)\right).$$

Let the threshold functions $\varphi_+(\theta)$, $\varphi_-(\theta)$ and $\varphi_o(\theta)$ solve the equalities $\Psi + 2\Phi = \digamma_{\max}$,

$\Psi - 2\Phi = \digamma_{\max}$ and $\Psi - 2\Phi = 0$. Those threshold functions are depicted in the left panel of Figure 2. It can readily be shown that $\varphi_+(\theta) \le \varphi_-(\theta)$ and $\varphi_o(\theta) < \varphi_-(\theta)$ and that $\varphi'_+(\theta) < 0$, $\varphi'_-(\theta) > 0$ and $\varphi'_o(\theta) > 0$. This description allows us to characterize the following five location patterns, which are depicted in the right panel of Figure 2.

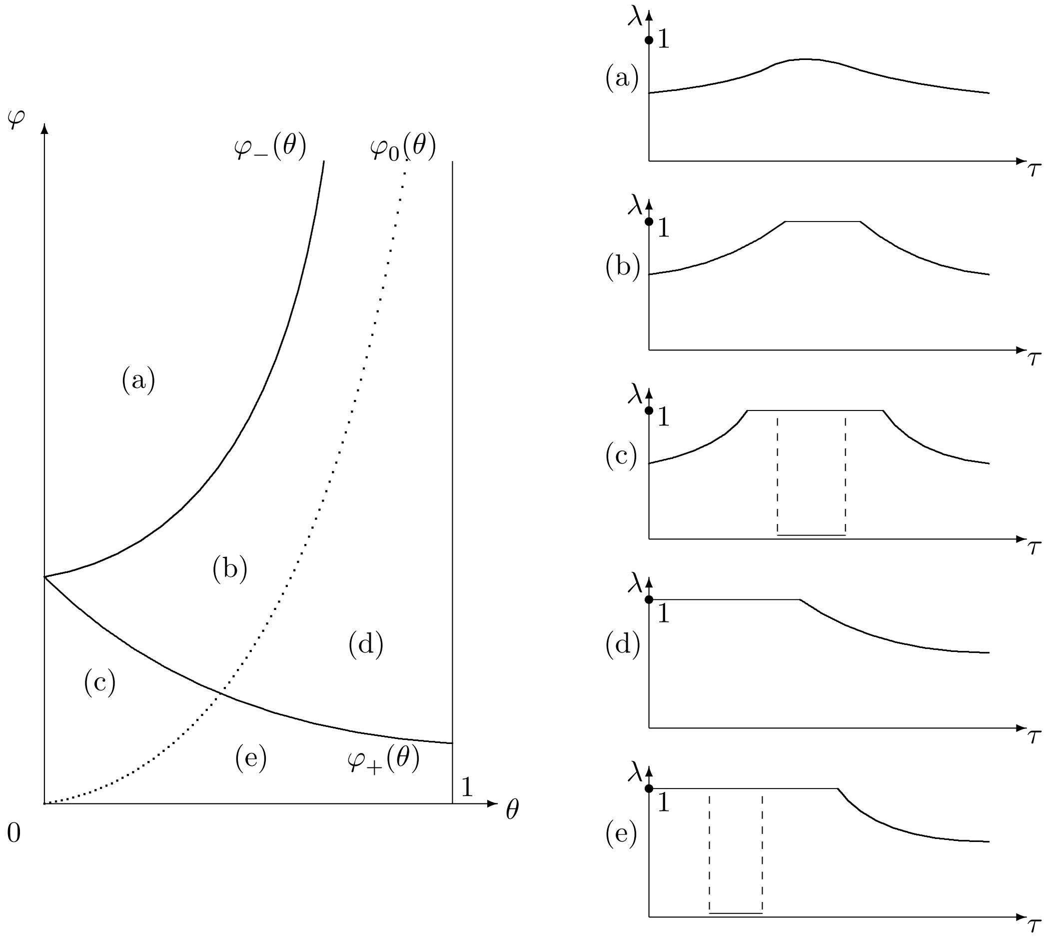


Figure 2: Industry location patterns with respect to θ and φ

(a) For large enough φ but small enough θ (so that $\varphi > \varphi_-(\theta)$), one gets $\Psi + 2\Phi > \Psi - 2\Phi > \digamma_{\max}$ so that both intervals $[\tau_1, \tau_2]$ and $[\widehat{\tau}_1, \widehat{\tau}_2]$ are empty. There then exists no value of trade costs for which firms fully agglomerate in any region. The industry disperses with a bias towards the home region. Local factor requirements are so strong that neither demand linkages nor absolute location advantages are sufficient to support full agglomeration.

(b) For large enough φ and intermediate θ (so that $\varphi_-(\theta) > \varphi > \max\{\varphi_+(\theta), \varphi_o(\theta)\}$), one gets $\Psi + 2\Phi > \digamma_{\max} > \Psi - 2\Phi > 0$ so that the interval $[\widehat{\tau}_1, \widehat{\tau}_2]$ becomes nonempty whereas

$[\tau_1, \tau_2]$ remains empty. There then exists no value of trade costs for which the industry agglomerates in the (foreign) region with the locational disadvantage; the industry agglomerates in the home region for $\tau \in [\hat{\tau}_1, \hat{\tau}_2]$. Such a situation occurs because local factor requirements are either unequal or large enough so that locational advantages dominate demand linkages.

(c) For small θ and φ (so that $\varphi_+(\theta) > \varphi > \varphi_o(\theta)$), one gets $\digamma_{\max} > \Psi + 2\Phi > \Psi - 2\Phi > 0$ so that both intervals $[\hat{\tau}_1, \hat{\tau}_2]$ and $[\tau_1, \tau_2]$ are nonempty. An example of this configuration is shown in Figure 1. In this case, any effect may dominate according to the value of trade costs.

(d) For large enough φ and θ (so that $\varphi_o(\theta) > \varphi > \varphi_+(\theta)$), one can get $\Psi + 2\Phi > \digamma_{\max} > 0 > \Psi - 2\Phi$. The last inequality implies that $\hat{\tau}_1 = 0$. Therefore firms fully agglomerate in the region with the absolute location advantage if $\tau \in [0, \hat{\tau}_2]$. There exists no value of trade costs for which the industry fully agglomerates in the region with the locational disadvantage. There does not exist any redispersion for low trade costs because the absolute location advantage dominates the effect of local factor crowding.

(e) For large θ but small φ (so that $\varphi < \min\{\varphi_+(\theta), \varphi_o(\theta)\}$), one gets $\digamma_{\max} > \Psi + 2\Phi > 0 > \Psi - 2\Phi$. The last inequality also implies that $\hat{\tau}_1 = 0$. So, there does not exist any redispersion for low trade costs because of the strong absolute location advantage. As a result, firms agglomerate in any region for $\tau \in [\tau_1, \tau_2]$ and only in the region with the absolute location advantage if $\tau \in [0, \hat{\tau}_2] \backslash [\tau_1, \tau_2]$.

To sum up, Figure 2 shows that demand linkages dominates for small local factor requirements φ, the effect of product market crowding dominate for large local factor requirements φ and absolute location advantage dominates for large absolute location advantage θ.

4.3 Welfare analysis

In this section, we investigate whether the spatial equilibrium induces excess agglomeration or excess dispersion. Towards this aim we compare the equilibrium distribution with the distribution chosen by a social planner that maximizes the total surplus of the whole economy. We assume that this social planner is able to allocate the entrepreneurs and their firms but that she is unable to set the product prices. The planner maximizes the following total welfare function:

$$\mathcal{W}(\boldsymbol{\lambda}) = \left(A + \sum_{k=1}^{K} \lambda_k\right)\left(\sum_{k=1}^{K} S_k + S'\right) + Aw' + \sum_{k=1}^{K} \lambda_k w_k$$
$$+ \left[A + \sum_{k=1}^{K}(1-\lambda_k)\right]\left(\sum_{k=1}^{K} S_k^* + S'^*\right) + Aw'^* + \sum_{k=1}^{K}(1-\lambda_k)w_k^* + \text{constant}. \qquad (15)$$

which includes the consumption surpluses, the local factor returns to local factor owners and the entrepreneurs' earnings in each region. In our model, this welfare function is a quadratic concave function of λ_k.

In the case of one industry, the labor requirement ϕ_1 and ϕ_1^* are specified by (11) and the firms' distribution is given by λ. The welfare function simplifies to

$$\mathcal{W}(\lambda) = \frac{\delta^0}{2}\left(\lambda - \frac{1}{2}\right)^2 + \Phi\left(\lambda - \frac{1}{2}\right) + \text{constant},$$

where

$$\delta^o = \digamma^o(\tau) - \Psi,$$
$$\digamma^o(\tau) = \frac{2(b+c)(3b+c)}{(2b+c)^2}(2a - b\tau)\tau - \frac{c(b+c)(3c+8b)M}{4(2b+c)^2}\tau^2, \qquad (16)$$

where $\Psi > 0$ and $\Phi > 0$ are defined by (13) and (14), respectively and where $\digamma^o(\tau)$ is a concave function of τ. As for $\digamma(\tau)$, we use $\widehat{\tau}_1^o$, $\widehat{\tau}_2^o$ to denote the two roots of $\digamma^o(\tau) = \Psi - 2\Phi$. Differentiating the welfare function with respect to λ, we obtain the social optimum condition

$$\mathcal{W}'(\lambda) = \Phi + \left(\lambda - \frac{1}{2}\right)\delta^o = 0. \qquad (17)$$

Note that the condition (17) is identical to equilibrium condition (12) except that function $\digamma^o(\tau)$ replaces function $\digamma(\tau)$. Hence, the social optimal distribution have properties that are similar to the equilibrium one. Let $\widehat{\lambda}^o \equiv 1/2 - \Phi/\delta^o$ be the root of (17).

Proposition 2 *(Single industry optimum) There exist two possible configurations for the socially optimal distributions* λ^o*:*
(i) $\lambda^o = 1$ *if* $\digamma^o(\tau) \geq \Psi - 2\Phi$*, or, equivalently,* $\tau \in [\widehat{\tau}_1^o, \widehat{\tau}_2^o]$*;*
(ii) $\lambda^o = \widehat{\lambda}^o$ *if* $\digamma^o(\tau) < \Psi - 2\Phi$*, or, equivalently,* $\tau \in [0, \widehat{\tau}_1^o) \cup (\widehat{\tau}_2^o, \tau^{trade})$*.*

Proof: If $\digamma^o(\tau) > \Psi$, then $\delta^0 > 0$ holds so that $\mathcal{W}(\lambda)$ is convex and is maximized at $\lambda^o = 1$

(because $\mathcal{W}(1) - \mathcal{W}(0) = \Phi > 0$). If $\Psi - 2\Phi \leq \digamma^o(\tau) \leq \Psi$, then we have $-2\Phi < \delta^o \leq 0$, which implies that $\mathcal{W}'(\lambda) \geq \mathcal{W}'(1) \geq 0$ for all λ and therefore $\lambda^o = 1$. Finally, when $\digamma^o(\tau) < \Psi - 2\Phi$, we have $\delta^o < 0$ and $\widehat{\lambda}^o \in (0, 1)$. Therefore, the interior point $\widehat{\lambda}^o$ is the maximizer. □

The social planner balances the first nature' forces generated by absolute location advantages and local factor congestion with the second nature' forces created by demand linkages and product market crowding. As in the equilibrium, the first nature forces dominate only for small trade costs because market access and product market crowding bring only second order benefits and costs to the consumers and entrepreneurs. The second nature forces dominate for intermediate trade costs where demand linkages are stronger. They also dominate for larger trade costs because of stronger product market crowding.

Proposition 2 shows that the impacts of the absolute location advantages on the social optimum are very similar to those of the equilibrium. The main difference with the equilibrium is that the social planner never finds it optimal to have entrepreneur agglomerating in the disadvantaged region. The planner avoids inefficient lock-in effect into the disadvantaged region.

Does the spatial equilibrium imply excess agglomeration or excess dispersion? The equilibrium and the optimum distribution differ only by the functions $\digamma^o(\tau)$ and $\digamma(\tau)$. From the above discussion we can readily infer that there will be excess agglomeration if $\digamma^o(\tau) \leq \digamma(\tau)$ and excess dispersion otherwise. Since

$$\digamma^o(\tau) - \digamma(\tau) = \frac{(b+c)\tau}{4(2b+c)^2}[24ab - \tau(12b^2 + 4bcM + c^2M)]$$

is negative if and only if

$$\tau \geq \tau^o \equiv \frac{24ab}{12b^2 + 4bcM + c^2M},$$

there is excess agglomeration for $\tau \geq \tau^o$ and excess dispersion otherwise. In contrast to the equilibrium thresholds $(\widehat{\tau}_1, \widehat{\tau}_2)$, the social optimal threshold τ^o is independent of the use of local factors and the absolute location advantages. This is because the first nature forces are conveyed through perfectly competitive traditional sectors and do not call for correction by the social planner. By contrast, the second nature forces call for a correction of entrepreneurs' location decisions. The inefficiency in firms' location stems from the fact the entrepreneurs do not internalize the effect of their location decisions on consumer surplus. For small trade costs, they agglomerate to individually benefit from demand linkages and comparative advantages and do not consider the welfare of consumers in the deserted region. For large trade costs, they disperse in both regions to individually avoid competition and do not consider the possible savings in trade cost and local factor use when they agglomerate in the advantaged region.

5 TWO INDUSTRIES AND COMPARATIVE ADVANTAGES

The theory of comparative advantage involves at least two industries with different location advantages. Yet few papers in economic geography offer a complete analytical characterization of the distributions of firms in economies that include many industries. Venables (1999) and Fujita et al. (1999) are able to characterize the equilibrium configurations in a many-industry model under the assumption of industry indivisibility; Tabuchi and Thisse (2006) assume zero trade cost in one industry to derive equilibrium properties in a two-industry model. To our knowledge, we here offer a first full characterization of (divisible) industry location with comparative advantages and non-zero trade barriers. This section firstly describes the nature of comparative advantages, secondly discusses the location incentives of entrepreneurs and the associated agglomeration and dispersion forces. We then characterize the location equilibria and finally relate them to the issues of regional specialization and trade integration.

To focus on the comparative advantage, we analyze the case of two industries ($K = 2$) without absolute location advantage in the whole manufacturing sector:

$$\phi_1 = \phi_2^* = \varphi(1-\theta), \quad \phi_2 = \phi_1^* = \varphi(1+\theta), \tag{18}$$

where $\varphi > 0$ and $\theta \in (0,1)$ are two constants. Hence, the parameter θ measures the comparative advantage that the home region gives to industry $k = 1$ as well as the comparative advantage that the foreign region gives to industry $k = 2$. The parameter φ measures the firms' average productivity.[6] Furthermore, we compute

$$\begin{aligned} &\Phi_k = (-1)^k \Phi \quad \text{where} \quad \Phi \equiv \frac{2}{M}\theta\varphi\left(\varphi + M - A\right) > 0, \\ &\delta_{11} = \delta_{22} = \Gamma(\tau) - \frac{2}{M}\varphi^2\left(\theta^2+1\right), \\ &\delta_{12} = \delta_{21} = \Gamma(\tau) + \frac{2}{M}\varphi^2(\theta^2-1), \end{aligned} \tag{19}$$

where M is now equal to $2A+2$. Note finally, that the second part of (6) is simplified as

$$A > 2\varphi, \tag{20}$$

[6]Indeed, the parameter φ measures the average productivity of firms within countries ($\varphi = (\phi_1+\phi_2)/2 = (\phi_2^*+\phi_2^*)/2$) and across countries ($\varphi = (\phi_1+\phi_1^*)/2 = (\phi_2+\phi_2^*)/2$).

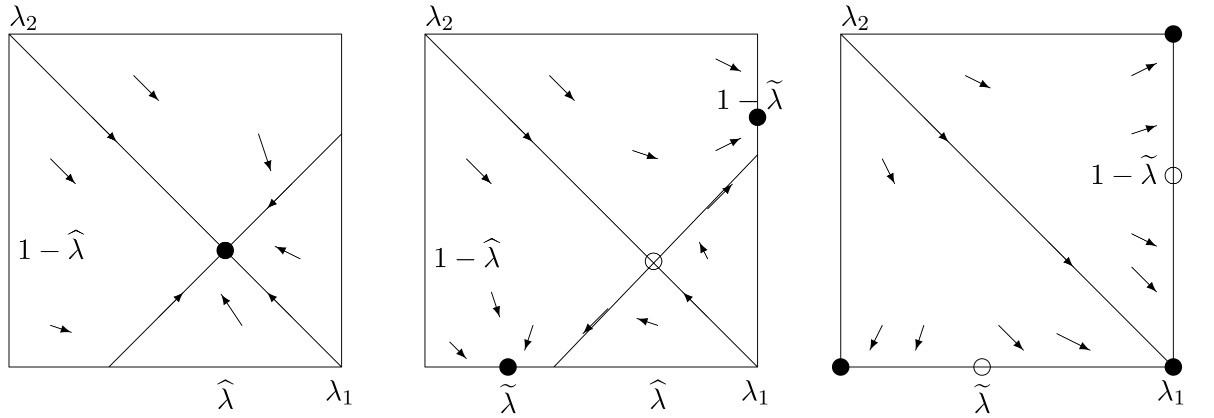
which is satisfied for large enough sizes of immobile population A.

5.1 Entrepreneurs' location incentives

Location equilibria are determined by the system

$$\frac{d\lambda_k}{dt} = \Delta V_k, \quad \lambda_k \in [0,1], \quad k = 1,2$$

that expresses entrepreneurs' relocation process according to their location incentives ΔV_k, $k = 1,2$. Figure 3 presents three examples[7] of entrepreneurs' location incentives. The small arrows in each panel depict the vectors $(\Delta V_1, \Delta V_2)$ for various distributions of firms $\boldsymbol{\lambda} = (\lambda_1, \lambda_2)$. Stable equilibria are represented by black dots whereas unstable equilibria are denoted by white dots.



$\rho_1 < 0, \quad \rho_2 < 0$ $\qquad$ $\rho_1 \in (0, 2\Phi), \ \rho_2 \in (-2\Phi, 0)$ $\qquad$ $\rho_1 > 2\Phi, \ \rho_2 < -2\Phi$

Figure 3: Location incentives $(\Delta V_1, \Delta V_2)$

The stability properties of this system are determined by the eigenvalues of the matrix (δ_{kl}) which are computed as it follows:

$$\begin{aligned} \rho_1 &= \delta_{11} + \delta_{12} = \digamma(\tau) + \Gamma(\tau) - \frac{4}{M}\varphi^2 \\ \rho_2 &= \delta_{11} - \delta_{12} = -\frac{c(b+c)M}{2(2b+c)}\tau^2 - \frac{4}{M}\varphi^2\theta^2, \end{aligned} \tag{21}$$

where ρ_2 is always negative. A candidate equilibrium distribution is given by the solution of the

[7]Figure 3 is constructed with parameters values equal to $a = b = c = \phi = 1$ and $A = 6$. Furthermore, $(\theta, \tau) = (0.10, 0.60)$ in the left hand panel, $(\theta, \tau) = (0.10, 0.50)$ in the center panel and $(\theta, \tau) = (0.08, 0.25)$ in the right hand panel.

system of equations $\Delta V_k = 0$, $k = 1, 2$, which is equal to $\boldsymbol{\lambda} = (\widehat{\lambda}, 1 - \widehat{\lambda})$ where

$$\widehat{\lambda} = \frac{1}{2} - \frac{\Phi}{\rho_2} = \frac{1}{2} + \frac{2\theta\varphi\left(\varphi + M - A\right)}{|\rho_2| M} > \frac{1}{2} \tag{22}$$

This solution corresponds obviously to the unique equilibrium if all eigenvalues are negative and if it is an interior solution. That is, if $\rho_1 < 0$ and $\widehat{\lambda} < 1$. This case is shown in the left hand panel of Figure 3 where entrepreneurs' incentives point in the direction of the distribution $(\widehat{\lambda}, 1 - \widehat{\lambda})$. If the eigenvalue ρ_1 is positive, the system $d\lambda_k/dt = \Delta V_k$ is unstable and entrepreneurs are enticed to agglomerate in some region. When ρ_1 is positive but not too large, entrepreneurs in one industry agglomerate whereas those in the other industry disperse. This case is shown in the central panel of Figure 3 where entrepreneurs' incentives point in the direction of the two distributions $(\widetilde{\lambda}, 0)$ and $(1, 1 - \widetilde{\lambda})$ where

$$\widetilde{\lambda} = \frac{-2\Phi + \delta_{11} + \delta_{12}}{2\delta_{11}} \tag{23}$$

When ρ_1 is large enough, entrepreneurs may agglomerate in a single region or in separate regions. As shown in the right hand panel of Figure 3, there then exist three possible equilibrium distributions $(0, 0), (1, 0)$ and $(1, 1)$.

In this model, the eigenvalues ρ_1 and ρ_2 are two measures for the forces towards 'region industrial concentration' and 'regional specialization'. The home 'industrial concentration' can here be defined by the ratio of domestic manufacturing firms: $\eta \equiv (\lambda_1 + \lambda_2)/2$. In the absence of industry concentration one has that $\eta = 1/2$ whereas one obtains that $\eta = 1$ in the case of full agglomeration of all industries in the same region. Similarly to Ricci (1999), we can define regional specialization as a relative concept that compares the home specialization in the industry $k = 1$ for which it offers a comparative advantage to specialization in the other industry $k = 2$. That is, the home regional specialization can be defined as $\lambda_1 - \lambda_2$. In the absence of regional specialization one obviously has that $\lambda_1 - \lambda_2 = 0$. Hence, in Figure 3, a rise in industrial concentration that makes industrial specialization unchanged implies a move on a 45° line either to the North-East or to the South-West. By contrast, a rise in industrial specialization that keeps industrial concentration constant implies a move on a -45° line to the South-West. The directions 45° and -45° are related to our analysis by the fact that they correspond to the eigenvectors $(1, 1)$ and $(-1, 1)$ associated to the eigenvalues ρ_1 and ρ_2. Therefore, a more positive eigenvalue ρ_1 is related to a stronger force towards region industrial concentration whereas a negative eigenvalue ρ_1 is related to a force against it. By (21), there will exist forces toward region industrial concentration for intermediate values of trade cost τ when demand linkages dominate product market crowding effects (large $F(\tau) + \Gamma(\tau)$). The forces against region industrial concentration will prevail otherwise. Similarly, a more negative eigenvalue ρ_2 reflects to a stronger force toward regional specialization. Firms will then tend to locate more according to their comparative advantages, which by (21) will happen for larger θ.

The full characterization of location equilibria depends on the eigenvalues (ρ_1, ρ_2) and is presented in Appendix 1. The nature and the properties of location equilibria are nevertheless better discussed in terms of trade costs τ and comparative advantages θ as displayed in Figure 4. Roughly speaking, the second nature forces (demand linkages and product market crowding) fall for smaller trade costs τ and the first nature forces weaken for smaller comparative advantages θ. Let us consider three different levels of comparative advantages θ. First, when comparative advantages are sufficiently important, first nature dominates for sufficiently low trade costs. As the reader can see in the top of Figure 4, as trade costs diminish, entrepreneurs tend to disperse less and less (configuration (i)). At some point one industry agglomerate in the region that provides them with a comparative advantage (configuration (ii)). Finally, each industry agglomerates in the country offering them a comparative advantage (configuration (iv)). Second, when comparative advantages take intermediate values, industries can reach any of the above configurations (i), (ii) and (iv) plus a configuration (v) that mixes full agglomeration in both regions or in any single region. In this configuration (v) demand linkages are so important that agglomeration can take place in any region. Third, when comparative advantages are very weak, the effect of product market crowding dominates for high trade costs whereas demand linkages dominates for low trade costs. As the reader can see in the bottom of Figure 4, as trade costs diminish, entrepreneurs tend to disperse less and less (configuration (i)), then to agglomerate in one of the two regions (configuration (iii)). For further reduction in trade costs, demand linkages diminish and local congestion forces become relatively more important so that a first industry re-disperses (configuration (ii)) before the second industry (configuration (i)). For even smaller trade costs, demand linkages and product market crowding vanish so that the only forces in presence are local congestion and comparative advantages. The two industries then re-disperse by agglomerating in the region offering them any location advantage (configuration (iv)). Note that configurations (i) and (iv) imply a single equilibrium whereas the other configurations imply two or three equilibria. We formalize those results in the following proposition, which become clearer with the help Figure 4.

Proposition 3 *There exist five thresholds* $(\tau_1, \tau_2, \tau_3, \tau_4, \tau_5)$ *such that:*
(i) each industry disperses ($\boldsymbol{\lambda}^E = (\widehat{\lambda}, 1 - \widehat{\lambda})$ *either for large* $\tau \geq \tau_5$, *or for* $\tau < \tau_1$ *and small*

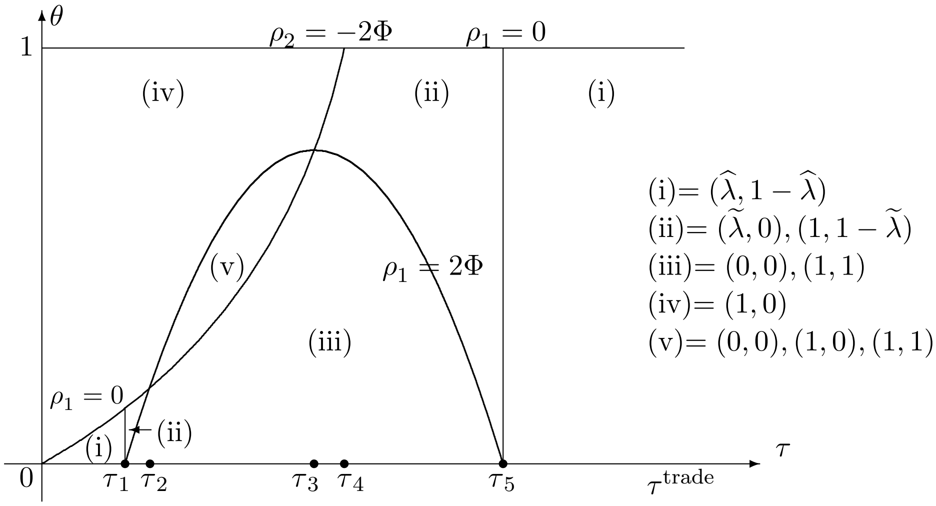


Figure 4: Industry location with respect to τ and θ

enough θ;
(ii) one industry agglomerates in one region where the other disperses ($\boldsymbol{\lambda}^E \in \{(\widetilde{\lambda}, 0), (1, 1-\widetilde{\lambda})\}$) either for $\tau \in [\tau_3, \tau_5]$ and large enough θ, or for $\tau \in [\tau_1, \tau_2]$ and small θ;
(iii) all industries agglomerate in the same region ($\boldsymbol{\lambda}^E \in \{(0,0), (1,1)\}$) for $\tau \in [\tau_1, \tau_5]$ and small enough θ;
(iv) industries agglomerate according to their comparative advantages ($\boldsymbol{\lambda}^E = (1,0)$) for $\tau \in [0, \tau_4]$ and large enough θ;
(v) industries agglomerate either according to their comparative advantages or agglomerate in any same region for $\tau \in [\tau_2, \tau_3]$ and intermediate θ.

The proof is in Appendix A. We now turn to the issue of regional specialization and globalization.

5.2 Regional specialization and comparative advantages

Does a region specialize in the industry to which it offers a comparative advantage as predicted by Ricardo? We here show that regions never specialize in opposition to their comparative advantages. Towards this aim, we here focus on the definition of regional specialization as the share of the advantaged industry in the whole manufacturing sector in a specific region. So, let $s \equiv 2\lambda_1/(\lambda_1+\lambda_2)-1$ be the specialization index for the domestic region and $s^* \equiv 2\lambda_2^*/(\lambda_1^*+\lambda_2^*)-1$ for the foreign region. We naturally have that $s = 0$ in the absence of regional specialization

($\lambda_k = 1/2$) and $s = 1$ in the case of full specialization ($\lambda_1 = 1$, $\lambda_2 = 0$). Under this definition, the following proposition shows that regions never specialize in opposition to their comparative advantages. However, they face different degrees of specialization in the configuration (ii) where $s > s^*$ holds for $(\widetilde{\lambda}, 0)$ while $s < s^*$ holds for $(1, 1 - \widetilde{\lambda})$. In this equilibrium configuration, while one region hosts all firms of the industry to which it offers a comparative advantage, it also hosts a share of the other industry. In contrast, the other region hosts a share of the sole industry to which it offers a comparative advantage. Hence, the former region is fully specialized whereas the latter region is less specialized because it hosts firms of both industries. Therefore, the less industrialized region is more specialized while the more industrialized one is less specialized. The intuition is that the more industrialized region yields more consumption surplus which compensates for the entrepreneurs' loss from not exploiting comparative advantages. In contrast to Ricci (1999), we are here able to provide an analytical characterization of this effect which occurs if and only if $0 < \rho_1 < 2\Phi$ and $\rho_2 < -2\Phi$. This requires *intermediate values of trade costs and strong enough comparative advantages.* We summarize those results in the following proposition.

Proposition 4 (Regional specialization) *A region always hosts more firms of the industry for which it offers a comparative advantage. A marginal increase of comparative advantages* θ *never reduces regional specialization.*

Proof: See Appendix 1. □

The above result contrasts to Ricci's (1999, p. 372) result in which the degree of specialization cannot be unambiguously signed. Since his model is not analytically solvable, Ricci uses a numerical example showing the so-called *perverse relation* that an increase in comparative advantage reduces specialization. Our result shows that the perverse relation might result from the assumption that the skilled workers are mobile across industries. As a result, the size of an industry changes with the agglomeration effect of the other industry.

5.3 The process of trade integration

We are also equipped to study the impact of trade costs on the location of firms and industries. In this section we focus on the possibility that, as trade cost falls, some firms agglomerate in opposition to the comparative advantage offered by their host region.

First, we ask the question about whether firms agglomerate more in the region offering comparative advantages. The answer depends on whether we consider configuration (i) or configuration (ii). In configuration (i) it can readily be shown that $\widehat{\lambda}$ increases with smaller τ. Smaller trade costs τ reduce the dispersion of firms because firms are less able to avoid the competition within their own industry by locating apart. Hence, in the first equilibrium configuration, *firms more intensively concentrate according to the comparative advantages as trade costs fall*; this happens for instance when trade costs are large. This can been seen in Figure[8] 5, in which the number of firms in domestic region H, λ_1, increases as trade costs fall in configuration (i).

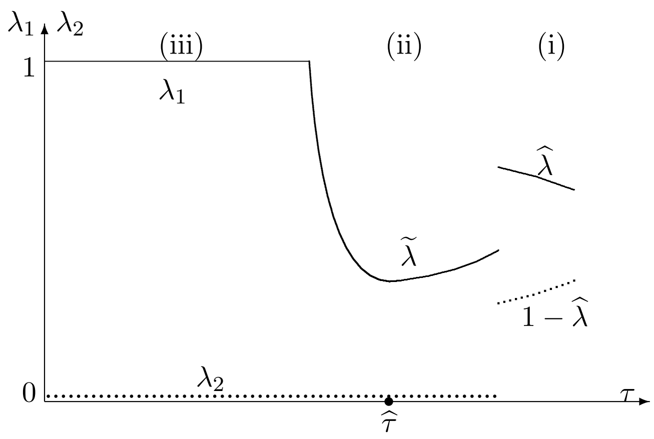


Figure 5: Industry location with respect to τ (Dotted lines are for industry 2)

In configuration (ii), one can show that the function $\widetilde{\lambda}$ may increase or decrease as τ falls within the relevant interval of trade costs. As shown in Figure 5, there may exist a value of trade cost $\widehat{\tau}$ such that $\widetilde{\lambda}$ decreases in τ for $\tau < \widehat{\tau}$ and increases otherwise. Therefore, if $\tau < \widehat{\tau}$, firms more intensively concentrate according to the comparative advantages as trade costs fall. However, if $\tau > \widehat{\tau}$, *the firms in one industry agglomerate in the region offering a comparative advantage* whereas *the firms in the other industry may increasingly locate in opposition to comparative advantages when τ decreases.*

It is also interesting to study the two types of transitions in the scenario presented in Figure 5. First, note that the transitions between equilibria of configurations (i) and (ii) are discontinuous and that they imply that *when trade costs fall, some industry discontinuously relocates in the region that does not offer a comparative advantage*! To see this, note that it can readily be checked that $\widetilde{\lambda} < \widehat{\lambda}$ if and only if $\widehat{\lambda} < 1$. Consider then the transition from $\boldsymbol{\lambda}^E = (\widehat{\lambda}, 1 - \widehat{\lambda})$ to $\boldsymbol{\lambda}^E \in (\widetilde{\lambda}, 0)$ as shown in Figure 5. In this case, industry 2 agglomerates in the foreign region while industry 1 also concentrates further in the foreign region although the latter offers no comparative advantage to this industry. The same argument holds for the transition from

[8]Figure 5 is constructed with parameters $a = b = c = \phi = 1$, $A = 6$ (the same in Figure 3) and $\theta = .21$.

$\boldsymbol{\lambda}^E = (\widehat{\lambda}, 1 - \widehat{\lambda})$ to $\boldsymbol{\lambda}^E \in (1 - \widetilde{\lambda}, 1)$.

Second, the transitions between the equilibrium configurations (ii) and (iv) are continuous. This readily follows from Lemma 6 of Appendix 1. As trade cost falls, firms smoothly agglomerate. Yet, because $\widetilde{\lambda}$ may increase or decrease in τ, firms do not necessarily agglomerate according to the comparative advantages associated to their industry.

Figure 5 presents a possible sequence of location equilibria that occurs in the 'globalization' or 'trade integration' scenario where trade cost falls. Similar to the case of one industry, the whole manufacturing sector disperses for large τ, agglomerates for intermediate τ and re-disperses for small τ. However, the re-dispersion patterns are richer. It occurs within industries for small comparative advantages and then occurs between industries.

As it can be seen from Figure 4, there obviously exist many other sequences of location equilibria. Hence, *globalization implies a large variety of firms' location patterns.* The richness of equilibrium structures in a two-region two-industry model contrasts with the standard results obtained in the two-region one-industry models discussed in the literature and in Section 4.

We summarize this discussion in the following proposition.

Proposition 5 (Globalization or trade integration) *Suppose that trade costs fall. Then, in equilibrium configuration (i), industries smoothly relocate according to their comparative advantages. In equilibrium configuration (ii), an industry may smoothly relocate in opposition to its comparative advantage. At the transitions between equilibrium configurations (i) and (ii), both industries discontinuously relocate, one of them relocating in opposition to its comparative advantage.*

5.4 Welfare analysis

In this section, we investigate whether the spatial equilibrium induces excess agglomeration or excess dispersion in the case of two industries with comparative advantages. Towards this aim we compare the equilibrium distribution with the distribution chosen by a social planner that maximizes the total surplus of the whole economy, $\mathcal{W}$, as defined by (15). As before, the social planner is again able to allocate the entrepreneurs and their firms but that she is unable to set the product prices. Under assumption (18), expression (15) is simplified as

$$\mathcal{W}(\lambda_1, \lambda_2) = \frac{1}{2} \sum_{k=1}^{2} \sum_{k=1}^{2} \delta^o_{kl} \big(\lambda_k - \frac{1}{2}\big)\big(\lambda_l - \frac{1}{2}\big) + \sum_{k=1}^{2} \Phi_k \big(\lambda_k - \frac{1}{2}\big) + \text{constant},$$

where

$$\delta_{11}^o = \delta_{22}^o = \digamma^o(\tau) - \frac{2}{M}\varphi^2(\theta^2+1),$$
$$\delta_{12}^o = \delta_{21}^o = \Gamma^o(\tau) + \frac{2}{M}\varphi^2(\theta^2-1),$$
$$\Gamma^o(\tau) = \frac{2(b+c)(3b+c)}{(2b+c)^2}\tau(2a-b\tau),$$

while $\digamma^o(\tau)$ and Φ_k have been previously defined in (16) and (19). The marginal changes in the social planner welfare objective are given by

$$\frac{\partial \mathcal{W}}{\partial \lambda_k} = -\Phi_k + \sum_{l=1}^{2} \delta_{kl}^o\left(\lambda_l - \frac{1}{2}\right), \quad k = 1, 2.$$

These expressions are similar to the incentives of the entrepreneurs (9) except that the functions $\digamma^o(\tau)$ and $\Gamma^o(\tau)$ here replace $\digamma(\tau)$ and $\Gamma(\tau)$. Hence, the social optimal distribution of firms shares some of the properties of the equilibrium. Those properties are given by the eigenvalues of the matrix (δ_{ij}^o)

$$\rho_1^o = \delta_{11}^o + \delta_{12}^o = \digamma^o(\tau) + \Gamma^o(\tau) - \frac{4}{M}\varphi^2,$$
$$\rho_2^o = \delta_{11}^o - \delta_{12}^o = -\frac{c(8b+3c)(b+c)}{4(2b+c)^2}M\tau^2 - \frac{4}{M}\varphi^2\theta^2.$$

Define

$$\widehat{\lambda}^o = \frac{1}{2} - \frac{\Phi}{\rho_2^o}, \quad \widetilde{\lambda}^o = \frac{-2\Phi + \delta_{11}^o + \delta_{12}^o}{2\delta_{11}^o}. \tag{24}$$

As in the analysis of Proposition 3, we can obtain the optimal configurations with respect to θ and τ. The result is shown in Figure 6, and formally given as Lemma 7 in Appendix 1.

As shown in Figures 4 and 6, the optimal distribution of firms never includes configuration (v). In this configuration, firms could lock themselves into a same region or into different regions according to their comparative advantages. The planner avoids lock-in effects in wrong places. She allocates the industries in the same locale only if demand linkages dominate and in different locales only if comparative advantages dominate.

A further comparison between the optimum and equilibrium distribution of firms requires to study the relationship between $(\delta_{ij})$and $(\delta_{ij}^o)$and their respective eigenvalues. It is easy to check that $0 > \rho_2 > \rho_2^o$. As a result, from (24), we get that $\widehat{\lambda} > \widehat{\lambda}^o$. In other words, *there exists excessive specialization in the equilibrium configuration (i) where no industries fully agglomerate.*

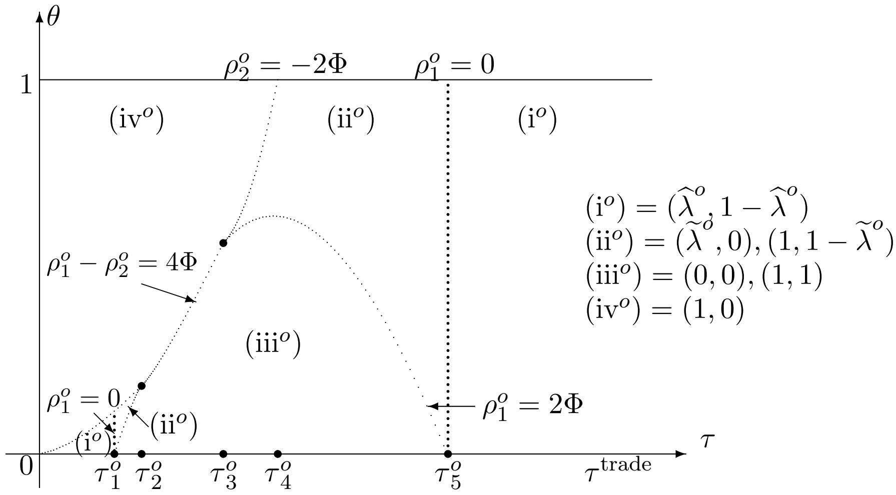


Figure 6: Welfare configurations in the case of two industries

As shown in Figures 4 and 6, such a configuration occurs for large enough trade costs. The intuition goes as it follows. Although entrepreneurs want to disperse to avoid competition, they also have an incentive to agglomerate in the region offering them a comparative advantage. However, when the entrepreneurs and their firms agglomerate in such a way, consumers have access to baskets of goods with unbalanced diversity. They indeed have a closer access to more products of one industry but to less products of the other. Because their preferences display decreasing love for variety for the goods of each manufacturing industry, consumers prefer to have access to baskets of goods that have more balanced diversity. However, because entrepreneurs do not internalize the consumer loss of such unbalanced diversity, they tend to excessively agglomerate in the region that offers them a comparative advantage, which implies excessive specialization.

It is worth noting that, as trade costs fall and reach τ_5^o, the optimal industry distribution changes from configuration (i) where no industry agglomerates to configuration (ii) where one industry agglomerates. Such a change is encountered in the equilibrium structure. By contrast, the present configuration shift results from the planner's choice. The latter indeed balances the welfare cost of a bad access to product markets by the immobile individuals with the benefit of a close access by the mobile entrepreneurs who agglomerate under configuration (ii). In this model, the latter welfare cost gets weaker at smaller trade costs and the planner chooses to agglomerate the mobile work force of some industry if $\tau < \tau_5^o$. More technically, the welfare objective $\mathcal{W}$ shifts from a concave to a saddle surface as the positive definitiveness of the matrix (δ_{ij}^o) - determined by the sign of $\rho_1^o \rho_2^o$ which is equal to the opposite sign of the first eigenvalue,

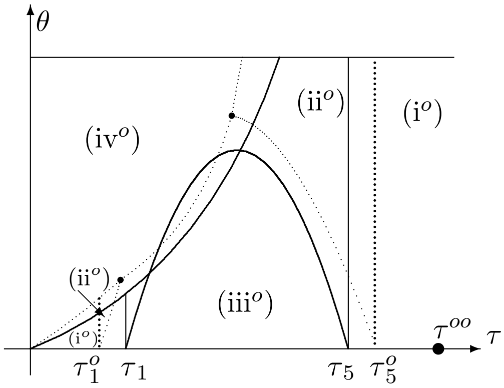
$(-\rho_1^o)$ changes at $\tau = \tau_5^o$. In this welfare exercise, the utilitarian planner is able to redistribute the gains from agglomeration to the immobile individuals located in the less industrialized region.

We finally discuss how the optimal configurations compare with the equilibrium ones. Note that $\rho_1^o(\tau) \geq \rho_1(\tau)$ holds if and only if $\tau \leq \tau^{oo}$ where

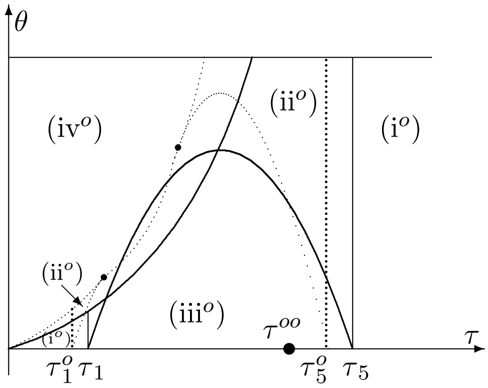
$$\tau^{oo} = \frac{48ab}{24b^2 + 4bcM + c^2M}.$$

The relationship between the sets of parameters supporting various equilibrium and optimum configurations depends on the threshold τ^{oo}. As for the threshold τ^o discussed in Section 4.3, the threshold τ^{oo} does not depend on the parameters determining local factor congestion and comparative advantages. This is again because the first nature forces are conveyed through perfectly competitive traditional sectors and do not call for correction by the social planner. The threshold τ^{oo} however increases with larger demand parameter a and smaller mass of immobile individuals $(M - 2)$. Hence, this threshold is likely to be large under the conditions where the planner favors a better product market access for the mobile entrepreneurs: that is, when entrepreneurs are numerous compared to the immobile individuals and when they have high demand for their own manufacturing products. As a result, τ_5 is likely to be lower than τ^{oo} and $\rho_1^o(\tau_5) \geq \rho_1(\tau_5)$. Such a situation is presented in the left panel of Figure 7, that displays the optimal configurations with dotted lines and equilibrium ones with solid lines. When we compare the equilibrium to the optimum, we observe the following points: the set of parameters supporting configurations (i) shrinks to the East; the set supporting configuration (ii) moves to the North-East whereas the set supporting equilibrium configuration (iii) expands to the North. As market access is the prevalent force in configuration (iii), it is natural to observe the expansion of this configuration when the planner implements its optimum.

Finally, the right panel of Figure 7 presents the situation where entrepreneurs are few compared to the immobile individuals and when they have low demand for their own products. The threshold τ^{oo} is then likely to be small and the planner likely to favor product market access by immobile individuals. As a result, τ_5 is likely to be smaller than τ^{oo} and $\rho_1^o(\tau_5) < \rho_1(\tau_5)$. From the right panel of Figure 7, we observe the following points: the set of parameters supporting configurations (i) expands to the West allowing for a more symmetric distribution of firms; the set supporting configuration (ii) moves to the North-West whereas the set supporting equilibrium configuration (iii) expands again to the North. The main message from this case is that the planner prefers more industry symmetry for high trade costs but still favors more agglomeration for intermediate trade costs where demand linkages are important.



(a) $\rho_1^o(\tau^{oo}) = \rho_1(\tau^{oo}) < 0$



(b) $\rho_1^o(\tau^{oo}) = \rho_1(\tau^{oo}) > 0$

Figure 7: Welfare and equilibrium of two industries

6 CONCLUSION

In this paper we have developed a two-region model that embeds both the monopolistic competition and the comparative advantages through regions' differences in local factor productivities. The model incorporates four forces: demand linkages, product market crowding, local factor congestion and comparative advantages. Our main conclusion is that the latter forces play a dominant role for small and large values of trade costs. For small trade costs, demand linkages and product market crowding have second effects so that comparative advantages dominate. For large trade costs demand linkages are dominated by product market crowding so that firms do not agglomerate. Firms then disperse with some bias toward the region offering either an absolute location advantage in the case of single industry or a comparative advantage in the case of two industries. For intermediate trade costs, demand linkages dominate and entice firms in several or all industries to agglomerate. Regions may not specialize in the industries to which they offer comparative advantages and trade pattern may be opposite to the one expected under Ricardian comparative advantages. In our view, our results reconcile theory with the empirical literature that qualifies the importance of increasing returns to scale in trade compared to natural advantages. It also gives theoretical support for the recent growing discrepancies between EU regions' portfolios of industries.

Nevertheless, our theoretical analysis is based on some simplifying assumptions. For example, the industries are assumed to be of the same size and local factors have no impact on variable inputs. Furthermore, the absolute location advantages and the comparative advantages are here examined separately in a single industry model and in a two-industry model. The study of a model breaking those assumptions turns out to be much more difficult. However, some additional analytical and numerical works have shown that our main results remain qualitatively valid.

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APPENDIX 1: FULL CHARACTERIZATION OF EQUILIBRIA

We prove the following equivalent conclusion, which is supported by Figure 6. We explain the construction of Figure 4 and Proposition 3.

Lemma 6 *(i) If $\rho_1 < 0$ and $\rho_2 < -2\Phi$, then $(\widehat{\lambda}, 1-\widehat{\lambda})$ is the only stable equilibrium, where $\bar{\lambda}$ is given by (22);*
(ii) If $0 < \rho_1 < 2\Phi$ and $\rho_2 < -2\Phi$, then $(\widetilde{\lambda}, 0)$ and $(1, 1-\widetilde{\lambda})$ are the only stable equilibria, where $\widetilde{\lambda}$ is given by (23);
(iii) If $\rho_1 > 2\Phi$ and $\rho_2 < -2\Phi$, then $(1,1)$ and $(0,0)$ are the only stable equilibria;
(iv) If $\rho_1 < 2\Phi$ and $\rho_2 > -2\Phi$, then $(1,0)$ is the only stable equilibria;
(v) If $\rho_1 > 2\Phi$ and $\rho_2 > -2\Phi$, then $(0,0)$, $(1,1)$ and $(1,0)$ are the only stable equilibria.

Proof: (i) Since $\rho_1 < 0$ and $\rho_2 < 0$, the only candidate of interior equilibrium $(\widehat{\lambda}, 1-\widehat{\lambda})$ is stable if $\widehat{\lambda} \in (0,1)$. The later is ensured by the fact that $\rho_2 < -2\Phi$. On the other hand, due to the linearity of our dynamic system, other (corner) equilibria are not stable when the interior equilibrium $(\widehat{\lambda}, 1-\widehat{\lambda})$ is stable.

(ii) Since $0 < \rho_1 < 2\Phi$ and $\rho_2 < -2\Phi$, we have $\delta^{11} = (\rho_1 + \rho_2)/2 < 0$. Therefore $\widetilde{\lambda}$ of (23) is in $(0,1)$. Furthermore, equilibria $(\widetilde{\lambda}, 0)$ and $(1, 1-\widetilde{\lambda})$ are stable because $\delta^{22} = \delta^{11} < 0$. On the other hand, there is no stable interior equilibrium because $\rho_1 > 0$. Furthermore, other (corner)

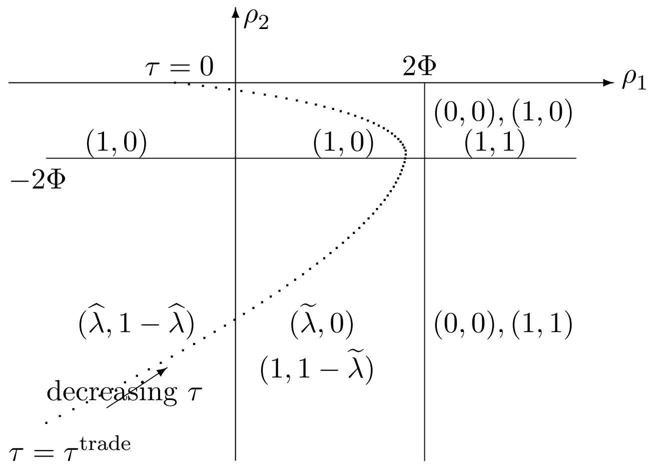

Figure 8: Industry location with respect to ρ_1 and ρ_2

equilibria are not stable when the equilibria $(\widetilde{\lambda}, 0)$ and $(1, 1-\widetilde{\lambda})$ are stable due to the linearity of our dynamic system.

(iii) Since $\rho_1 > 2\Phi > 0$, there is no stable interior equilibrium. Furthermore, since $\rho_1 > 2\Phi > 0$ and $\rho_2 < -2\Phi$, we have $\widetilde{\lambda} > 1$ if $\delta^{11} > 0$ and $\widetilde{\lambda} < 0$ if $\delta^{11} < 0$. Therefore, there is no equilibrium configuration of $(\widetilde{\lambda}, 0)$ or $(1, 1-\widetilde{\lambda})$. Now, we check other possible corner equilibria. Both $(1,0)$ and $(0,1)$ are not stable because $\rho_2 < -2\Phi$. On the other hand, both $(1,1)$ and $(0,0)$ are stable because $\rho_1 > 2\Phi$.

(iv) Since $\rho_2 > -2\Phi$, it holds that $\widehat{\lambda} > 1$. Therefore, there is no interior equilibrium. If $\delta^{11} > 0$, then $\widetilde{\lambda} < 0$ due to $\rho_1 < 2\Phi$. If $\delta^{11} < 0$, then $\widetilde{\lambda} > 1$ due to $\rho_2 > 2\Phi$. Therefore, there is no equilibrium configuration of $(\widetilde{\lambda}, 0)$ or $(1, 1-\widetilde{\lambda})$ where $\widetilde{\lambda} \in (0,1)$. Distribution $(1,1)$ and $(0,0)$ are not equilibrium because $\rho_1 < 2\Phi$. Distribution $(0,1)$ is not stable because $\rho_2 < 0 < 2\Phi$. Finally, distribution $(1,0)$ is a stable equilibrium because $\rho_2 > -2\Phi$.

(v) Since $\rho_1 > 2\Phi$ and $\rho_2 > -2\Phi$, it holds that $\widehat{\lambda} > 1$ and $\widetilde{\lambda} < 0$. Therefore, there is no equilibrium configuration of $(\widehat{\lambda}, 1-\widehat{\lambda})$, $(\widetilde{\lambda}, 0)$ or $(1, 1-\widetilde{\lambda})$. Distribution $(0,1)$ is not stable because $\rho_2 < 0 < 2\Phi$. Distribution $(1,0)$ is a stable equilibrium because $\rho_2 > -2\Phi$, distributions $(0,0)$ and $(1,1)$ are stable equilibria because $\rho_1 > 2\Phi$. □

Construction of Figure 4 and Proposition 3: We here justify the mapping of the equilibrium structure as a function of (ρ_1, ρ_2), as presented in Lemma 6 and Figure 8, into a function of (τ, θ). Note that the locus of $\rho_1 = 0$ is independent of τ and is displayed by two vertical lines in Figure 3. Because the function $\rho_1 - 2\Phi$ is linear in θ and quadratic in τ, the locus of $\rho_1 = 2\Phi$

represents a concave parabola. Because $\rho_2 + 2\Phi$ is the sum of quadratic function in τ and in θ, the locus of $\rho_2 = -2\Phi$ is displayed as (a piece of) an ellipsis. It is trivial to check that the loci of $\rho_1 = 2\Phi$ and $\rho_2 = -2\Phi$ cross at two interior points so that we have two areas for (i) and two areas for (ii).These arguments justify Figure 4 and formalizes Proposition 3.

Proof of Proposition 4:

Since $\widehat{\lambda} > 1 - \widehat{\lambda}$, $\widetilde{\lambda} > 0$ and $1 > 1 - \widetilde{\lambda}$ are true, we know that a region always hosts more firms of the industry for which it offers a comparative advantage.

To prove the second half, we note that

$$\begin{aligned}\frac{\partial(\widehat{\lambda} - \frac{1}{2})}{\partial\theta} &= -\frac{1}{\rho_2^2}\left(\frac{\partial\Phi}{\partial\theta}\rho_2 - \Phi\frac{\partial\rho_2}{\partial\theta}\right) > \frac{2\Phi}{\rho_2^2}\left(\frac{\partial\Phi}{\partial\theta} + \frac{1}{2}\frac{\partial\rho_2}{\partial\theta}\right)\\ &= \frac{4\varphi\Phi}{M\rho_2^2}[M - A - (2\theta - 1)\varphi] > 0, \qquad (25)\\ \frac{d\widetilde{\lambda}}{d\theta} &= -\frac{1}{\delta_{11}}\left(\frac{\partial\Phi}{\partial\theta} + \widetilde{\lambda}\frac{\partial\delta_{11}}{\partial\theta}\right) = -\frac{2\varphi}{\delta_{11}M}[M - A + (1 - 2\theta\widetilde{\lambda})\varphi] > 0, \qquad (26)\end{aligned}$$

where the inequality of (25) is from the fact of $M > A + 2\varphi$ due to (20), and the inequality of (26) is from the fact that $\delta_{11} = (\rho_1 + \rho_2)/2 < 0$ holds for equilibrium configuration (ii) and inequality $M > A + 2\varphi$. Therefore,

$$\frac{\partial s}{\partial\theta} = 2\frac{\frac{\partial\lambda_1}{\partial\theta}\lambda_2 - \lambda_1\frac{\partial\lambda_2}{\partial\theta}}{(\lambda_1 + \lambda_2)^2}$$

is positive for equilibrium configurations (i) and (ii). For other configurations, $\partial s/\partial\theta = 0$ holds. □

Lemma 7 *(i^o) If $\rho_1^o < 0$ and $\rho_2^o < -2\Phi$, then $(\widehat{\lambda}^o, 1 - \widehat{\lambda}^o)$ is the only maximizer, where $\bar{\lambda}^o$ is given by (24);*
(ii^o) If $0 < \rho_1^o < 2\Phi$ and $\rho_2^o < -2\Phi$, then $(\widetilde{\lambda}^o, 0)$ and $(1, 1 - \widetilde{\lambda}^o)$ are the only maximizers, where $\widetilde{\lambda}^o$ is given by (24);
(iii^o) If $\rho_1^o > 2\Phi$ and $\rho_2^o < \rho_1^o - 4\Phi$, then $(1, 1)$ and $(0, 0)$ are the only maximizers;
(iv^o) If $\rho_2^o > -2\Phi$ and $\rho_1^o < \rho_2^o + 4\Phi$, then $(1, 0)$ is the only maximizer.

Proof: (i^o) Since $\rho_1^o < 0$ and $\rho_2^o < 0$, the welfare function is concave. The candidate $(\widehat{\lambda}^o, 1 - \widehat{\lambda}^o)$ is a maximizer if $\widehat{\lambda}^o \in (0, 1)$. The later is ensured by the fact that $\rho_2^o < -2\Phi$. Furthermore, due to the concavity, other (corner) equilibria are not stable when the interior equilibrium $(\widehat{\lambda}^o, 1 - \widehat{\lambda}^o)$ is stable.

(ii^o) Since $0 < \rho_1^o < 2\Phi$ and $\rho^o < -2\Phi$, we have $\delta_{11}^o = (\rho_1^o + \rho_2^o)/2 < 0$. Therefore $\widetilde{\lambda}^o$ of (23) is in $(0, 1)$. Furthermore, distribution $(\widetilde{\lambda}^o, 0)$ and $(1, 1 - \widetilde{\lambda}^o)$ are maximizers because $\delta_{22}^o = \delta_{11}^o < 0$. On the other hand, there is no interior maximizers because $\rho_1^o > 0$. Furthermore, other (corner) distributions are not maximizers when $(\widetilde{\lambda}^o, 0)$ and $(1, 1 - \widetilde{\lambda}^o)$ are maximizers due to the concavity with respect to λ_1 and λ_2.

(iii^o) Since $\rho_1^o > 2\Phi > 0$, there is no interior maximizer. Furthermore, we have $\widetilde{\lambda}^o < 0$ if $\delta_{11}^o < 0$. Therefore, there is no maximizer of configuration $(\widetilde{\lambda}^o, 0)$. Similar argument show that there is no maximizer of configuration $(1, 1 - \widetilde{\lambda}^o)$. Now, we check other possible corner distributions. It follows that

$$\mathcal{W}(1, 1) = \mathcal{W}(0, 0) > \mathcal{W}(1, 0) > \mathcal{W}(0, 1).$$

Therefore, $(1, 1)$ and $(0, 0)$ are the only maximizers.

(iv^o) Since $\rho_2^o > -2\Phi$, it holds that $\widetilde{\lambda}^o > 1$. Therefore, there is no interior maximizer. If $\delta_{11}^o < 0$, then $\widetilde{\lambda}^o > 1$ due to $\rho_2^o > 2\Phi$. Therefore, there is no maximizer of configuration $(\widetilde{\lambda}^o, 0)$. Similar argument show that there is no maximizer of configuration $(1, 1 - \widetilde{\lambda}^o)$ where $\widetilde{\lambda}^o \in (0, 1)$. Finally, It follows that

$$\mathcal{W}(1, 0) > \max\{\mathcal{W}(1, 0), \mathcal{W}(0, 1), \mathcal{W}(0, 0)\}.$$

Therefore, $(1, 0)$ is the only maximizers.

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