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Firm Heterogeneity and the Localization of Economic Activities

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Abstract

This paper examines how market access strategies, export and FDI, respond to changes in level of integration. Empirical evidence shows that both firm exports and multinational activity are affected by trade liberalization episode. To account for the strong positive correlation between export and FDI, we develop a general equilibrium model that features firm heterogeneity, trade and FDI with final and intermediate products. Different spatial networks are considered to quantify the effect of a preferential trade agreement (PTA) on supply mode decisions, for both partner and excluded countries. The model sheds new light on the mechanisms through which geography reshapes the concentration of economic activities inside and outside the PTA area.

JEL classification: F12; F15; F23; R12
Keywords: Heterogeneous firms; PTA; Spatial networks; Intrafirm trade

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1 Introduction

The effect of discriminatory trade policy on reorganization of production is an important issue in international trade. However, the question concerning how a trade policy event affects export and foreign direct investment (FDI) seems under-researched. The aim of this paper is to further enrich the analysis of symmetric as well as asymmetric trade liberalization on firm's organization of production. Combining intra-firm linkages with different structures of spatial networks, we investigate the impacts of deeper economic integration. The firm heterogeneity structure of the model is used to evaluate the impact of asymmetric trade integration on firms' location and organization of production. Our findings show that geographical differences milder the effect of discriminatory trade liberalization on the reorganization of modes supply strategy.

Preferential trade agreements (PTAs) allow countries to mutually grant preferential access on goods and services. PTA participation has accelerated over time and become more widespread; as of 2011 there are around 300 active agreements (WTO, 2011). PTAs serve different purposes, such as get access to larger markets or reach cheaper intermediate goods. In parallel to the increasing prominence of PTAs, there is also a growing concern about the fact that PTAs might hurt countries excluded from the agreements and thus hindering multilateral trade liberalization (see, for instance, Limao, 2007; Freund and Ornelas, 2010). PTA can in fact divert trade by substituting intra-bloc trade for trade from outside the group.

This paper enriches the exiting literature on heterogeneous firms by examining the mechanisms through which preferential trade liberalization affects firms' supply mode decisions in different spatial structures. Differently from previous studies, space is introduced as an exogenous variation that alters the effect of discriminatory liberalization. Moreover, we capture (via intra-firm trade) the complementarity relationship that can exist between trade and FDI.

Starting with the symmetric liberalization episode, we then move to the asymmetric liberalization one (PTA) and focus on two geographical settings. First, we consider different accessibility to foreign markets (physical distance and geographical features). Then, we analyse the case without cross-country differences in centrality. The way in which changes in tariffs affect the spatial equilibrium of export and FDI activities is crucially related to the characteristics of the transportation network. Export and FDI strategies are complement when they similarly react to a trade policy event, i.e. both trade and FDI flows increase after a reduction in trade costs. On the contrary, substitution is used to indicate when these activities move in opposite directions, i.e. proximity versus concentration hypothesis.[1]

In terms of findings, this model shows that geographical differences (such as physical distance) milder the effect of discriminatory trade liberalization in terms of relocation of modes supply strategy. In this set up, intra-firm trade is affected by additional costs linked to trade and geographical frictions. The implication of geographical frictions, which works as an additional dispersion, is that a reduction in trade barriers encourages both supply strategies within as well as outside the economically integrated area. This happens because the existence of geographical differences makes the country excluded from the PTA easier to reach when trade

[1] The proximity versus concentration hypothesis predicts that "firms are more likely to expand their production horizontally across borders the higher are the transport costs and trade barriers and the lower are investment barriers and the size of scale economies at the level at the plant level relative to the firm level" (Brainard, 1997).

barriers fall. The implication of intra-firm trade is that the relationship between export and FDI is affected. As a consequence of this, the canonical proximity *versus* concentration prediction changes. In particular, when countries signing the PTA are geographically remote, the complementarity relationship between export and FDI kicks in. This happens because, the fall in trade barriers reduces the cost related to intra-firm relative to export for a sufficiently productive firm, advantaging also the FDI strategy.

The literature on foreign direct investment and multinational corporations is vast.[2] Previous models of "horizontal" FDI, conceive foreign subsidiary's sales as increasing with distance. Horstmann and Markusen (1992), develop a model in which market structure is determined endogenously as the outcome of firms' plant location decisions. They incorporated multinational firms (MNFs) into a general equilibrium trade model where firms benefit from internalization due to increasing returns at the firm level. Brainard (1993) develop a model of MNFs by focusing on the location decisions proposing the so-called proximity versus concentration hypothesis, or scale versus proximity. This hypothesis highlights the trade-off between reducing trade costs by locating near customers and concentrating production in only one location (which gives rise to scale economies at the plant level).

More recently, Helpman, Melitz and Yeaple (2004) (hereafter HMY), build a multi-country, multi-sectoral general equilibrium model with firm heterogeneity to analyse firms' decision to serve foreign markets either through exports or local sales (FDI). In these models, firms are more likely to be engaged in foreign direct investment (FDI) activities when trade costs are high. For the same reason, horizontal FDI is not encouraged by a reduction in trade costs. On the contrary, when trade costs fall, scale economies can outweigh the benefit from locating near customers. In this case, export activities are more profitable. Hence, the proximity *versus* concentration hypothesis predicts that the fall in trade costs should reduce FDI and encourage exports.

Few empirical works address the role of regional economic integration on multinationals' location decision. Focusing on different types of regional integration, Blomström and Kokko (1997) study how PTA affects inward and outward FDI flows in the integrating region.[3] Baltagi et al. (2008) consider bilateral outward FDI stocks into Europe. Their findings indicate a relocation of FDI from other countries to PTA members. Chen (2009) shows that integrated areas attract MNFs activity when characterized by access to a large size of markets. Antras and Foley (2011) build on the work of HMY, but focusing only on MNFs, to analyse the behavior of U.S. MNFs as a consequence of the signing of the ASEAN FTA.

This paper contributes to the literature by investigating the role of a PTA in shaping the spatial distribution of firm's activity, highlighting the differences between export and FDI. The novelty of this analysis is to combine complex FDI together with export decisions inside a spatial network. To study how market access strategies respond to changes in level of integration, we propose a general equilibrium model that features firm heterogeneity, trade and FDI. Since both types of activities imply crossing the border, we assume that trade and geographical costs apply to exporting and FDI firms. Exporting firms export a finished good. Differently, foreign affiliates need to import a specific intermediate from their headquarters so

[2]See Barba-Navaretti and Venables (2004) for a survey on MNFs and empirical findings.

[3]They find that the U.S.-Canada Free Trade Agreement led to a reduction in intra-regional FDI to both the integrated area while it increased extra-regional FDI into Canada.

to sell *in loco* a finished good.

To keep the analysis simple, we consider the headquarter production of the intermediate input as given. This essential intermediate good must be produced in the home headquarter due, say, to issues of intellectual property protection, the need for highly specialised employees, or even overwhelming scale economies that makes production of the intermediate in a single plant the optimised outcome. We can think of this imported intermediate as knowledge transfer to the foreign affiliate. This knowledge transfer is a well established fact in the R&D literature. This transfer of intermediate goods will then create a strong positive correlation between trade and FDI. The diffusion of knowledge is at the heart of modern theories of growth and international trade. This paper borrows this concept of knowledge to characterize the relationship between headquarter and foreign affiliates. In this respect, it is also related to the model of knowledge transfer proposed by Yeaple and Keller (2012). In this study, the authors explain the labor market effects of offshoring in terms of the firms' ability to transfer knowledge abroad. The novelty of this paper stands in determining the spatial distribution of firm exports and multinational activity in the presence of complex MNFs strategy and different geography structures. As far as we know there are no other papers that look into how PTA affects the distribution of supply mode decisions.

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 characterizes its general equilibrium. Section 4 considers the effects of PTA on supply mode decisions considering different spatial networks. The last section concludes.

2 Theoretical Framework

To examine the implications of preferential trade agreements on supply strategies, we first propose a multi-country symmetric framework which accounts for both FDI and export mode decisions. Then we introduce the role of regional integration.

2.1 Preferences

Consumers in each country share the same preferences over two final goods: a homogeneous good, h, and a differentiated good, x. We assume a two-tier preference with Cobb-Douglas in the upper tier and CES in the lower tier. A fraction of income, β, is spent on the differentiated good, $c(v)$, and the rest $(1-\beta)$ is spent on the homogeneous good, h. The utility function is

$$U = h^{(1-\beta)} \left[\int_{v \in V} c(v)^{(\sigma-1)/\sigma} dv \right]^{\frac{\sigma\beta}{\sigma-1}} \tag{1}$$

where $\sigma > 1$ represents the elasticity of substitution between any two products within the group and V is the set of available varieties.

2.2 Supply

There are N potentially asymmetric countries. We denote the geographical distance between markets with d. In this framework we have two final goods, two intermediate goods and one factor. Each country is endowed with labour, L, which is supplied inelastically.

There are two sectors, one homogeneous and one differentiated. The homogeneous sector produces a homogeneous good, h, with constant returns to scale and perfect competition. In this sector the technology is simple. We choose units of h such that one unit of labour is required per unit of output. Therefore, the unit cost function is w, where w is the wage rate for labour. This unit cost function represents marginal and average costs. In the homogeneous sector, competition ensures price equal marginal costs, $p_h = w$. It is convenient to choose good h as the numeraire, so that $p_h = 1$; hence, the pricing condition becomes: $1 = w$. Assuming the nations are large enough, it is easy to show that homogeneous good h is produced in every country. Since it is freely traded on international markets, the cost of producing it is equal in every country, so wages are equalized. The differentiated sector produces a continuum of horizontally differentiated varieties, $x(v)$, from two intermediate goods (or tasks), y_1 and y_2. Both y_1 and y_2 are produced with one unit of labour. The particular production structure of foreign affiliates requires intermediate y_1 to be made by the headquarter, due to technological appropriability issues. Each variety is then supplied by a Dixit-Stiglitz monopolistically competitive firm which produces under increasing returns to scale which arise from a fixed cost.

We consider three modes of supply in the x-sector; firms which sell only domestically (D-mode); firms who export (X-mode), and firms who supply the foreign market via FDI (M-mode). Hence, when a firm decides to serve the foreign market, it chooses whether to export domestically produced goods or to produce in foreign via affiliate production. Differently from the HMY set up, in this paper geographical distance plays a crucial role in characterizing intra-firm trade.[4] More specifically, the fact that foreign affiliates need to import y_1 from their home headquarters plays an important role. If a firm chooses to supply the foreign market via local sales of its affiliates, these affiliates must import the intermediate good y_1 from the home nation. Since the M-mode does not entirely avoid trade costs, export and FDI activities can here become complements: trade liberalization increases both types of mode of supply.

Entering the x sector involves a fixed variety-development cost f_I.[5] Subsequently, each entrant draws a labour per unit output coefficient (called a) from a cumulative density function $G(a)$ that is common to every country. The support of the continuous random variable a is $0 \leq a \leq a_0$. Upon drawing its own parameter a, each firm decides to exit (if it has a low productivity draw), or to produce. In this case, the firm must face additional fixed costs linked to the mode of supply chosen. If it chooses to produce for its own domestic market, it pays the additional fixed market entry cost, f_D. If the firm chooses to export, it bears the additional costs f_X of meeting different market specific standards (e.g. the cost of creating a distribution network in a new country). Finally, if the firm chooses to serve foreign markets through FDI, it incurs in the fixed cost of creating a distribution network as well as building up new capacities in the foreign country, f_M.

As mentioned, the homogeneous sector is not subject to trade costs, but the differentiated sector is subject to iceberg costs proportional to distance.[6] More precisely, in the X-mode case, the entire final good is subject to iceberg costs, while with M-mode only the intermediate good y_1 is subject to iceberg costs. Selling one unit in the d destination market, would require

[4] In HMY the export versus MNFs choice is affected by the classical scale versus proximity trade-off.

[5] The subscript I stands for innovation.

[6] Trade costs are broadly defined to include different kind of impediments: trade barriers, geographical and cultural differences etc.

shipment from the origin country o of $d_{od}\tau_{od} \geq 1$ units for the exporting firms and $(d_{od}\tau_{od})^{\eta}$ for the FDI firms, where d_{od} represents the transport barriers, τ_{od} represents the iceberg trade cost (or non-transport barriers) and η the share of intermediate good used in final production. Since FDI is affected by trade costs, its marginal cost increases with transport and tariff costs.

2.3 Intermediate Results

2.3.1 Demand

Given preferences across varieties have the standard CES form, the demand function is,

$$x_o(v) = A_o p_o(v)^{-\sigma} \quad \text{where } A_o \equiv \frac{\beta E_i}{P_o^{1-\sigma}}$$

where we set o for origin and d for destination. Thus, $x_o(v)$ represents the consumption of typical variety v, A_o is the demand shifter and finally $p_o(v)$ is the consumer price index of variety v. A_o is exogenous from the perspective of the firm and composed by the aggregate level of spending on the differentiated good in the origin country, βE_o divided by the CES price index, $P_o^{1-\sigma}$. The inverse demand function is given by

$$p_o(v) = A_o^{\frac{1}{\sigma}} x_o(v)^{-\frac{1}{\sigma}} \tag{2}$$

2.3.2 Organization and Product Variety

Given that f_I has been paid, the output of every variety is described by a Cobb-Douglas function of the intermediate goods,

$$x_o(v) = \frac{1}{a(v)} \left(\frac{y_1}{\eta}\right)^{\eta} \left(\frac{y_2}{1-\eta}\right)^{1-\eta}, \, 0 < \eta < 1 \tag{3}$$

where $1/a(v)$ represents the firm specific productivity parameter and η is the Cobb-Douglas cost share of y_1, common across all nations. When trade is possible, firms that produce decide whether to supply a particular market and how, i.e. via export or FDI strategies. This depends on their own productivity and on the distance between the origin and the destination country. As mentioned before, the marginal costs for the exporting firms is higher than the one for the FDI firms.

Since y_1 and y_2 are produced with L whose wage is unity, the marginal costs, mc_{Do} , for local production in every origin country is the following,

$$mc_{Do} = a(v)$$

The marginal cost for exporting to the destination market is linear in $d\tau$,

$$mc_{X,od} = a(v)\, d_{od}\tau_{od}$$

where d_{od} and τ_{od} represent distance and trade cost respectively between origin and destination countries. Finally, the marginal cost for supplying the destination market via local sales of foreign affiliates is concave in $d\tau$,

$$mc_{M,od} = a(v)(d_{od}\tau_{od})^{\eta}$$

Note that in this last marginal cost distance matters but only in relation to cost share, η, of the intermediate good y_1 used in the production of the final good. Using the mark up, $\sigma/(\sigma-1)$, we can easily derive the price for each particular mode of supply decisions.[7]

2.3.3 Mode of Supply Decisions

The mode of supply decision choice involves the comparison of profit levels taking into account the various fixed and variable trade costs. A firm can decide to: (i) not supply a market, (ii) supply it via exports, or (iii) supply it via local sales of foreign affiliates. Of course, the local market is supplied by local sales, if the firm is active (iv).

Firm's productivity determines the optimal mode of supply. As described above, four cases are relevant.

Case (i). If the firm decides not supply a market and exits, the operating profits are zero.

Case (ii). If the firm decides to supply a market via exports, the profits from exporting to a market d-steps are linearly decreasing in d and τ,

$$\pi_{X,od} = [p_{X,od}(v) - a(v)d_{od}\tau_{od}]x_{od}(v) - f_X \tag{4}$$

where $x_{od}(v)$ represents the quantity exported to country d.

Case (iii). If the firm decides to supply a market via FDI, the profits realized by a subsidiary located in the destination market depend on the interaction between d and τ,

$$\pi_{M,od} = [p_{M,od}(v) - a(v)(d_{od}\tau_{od})^{\eta}]x_{od}(v)_M - f_M \tag{5}$$

where $(d_{od}\tau_{od})^{\eta}$ is the distance and trade costs associated with the intermediate good, y_1, imported from the home country and $x_{od}(v)_M$ is the quantity supplied by the foreign subsidiary in country d.

Case (iv). If the market under consideration is the firm's home market, the profits from undertaking D-mode supply are

$$\pi_{Do}(v) = [p_{Do}(v) - a(v)]x(v)_o - f_D \tag{6}$$

where $x(v)_o$ represents the quantity supplied in the domestic market.

Using the intermediate results from consumers and firms optimization problems we calculate the operating profit for the three modes of supplying a market.[8] The profit from serving the domestic market is a function of the demand shifter and the constant mark-up,

$$\pi^*_{Do}(a, A, \eta) = A_o a^{1-\sigma}\frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{(1-\sigma)} - f_D$$

[7] See appendix A for details of the cost minimization problem.

[8] The operating profit equations are indicated with stars.

where A_o and η are industry (and so country) specific. Using $B_o = \frac{A_o}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{(1-\sigma)}$ we obtain:

$$\pi^*_{Do}(a, A, \eta) = B_o a^{1-\sigma} - f_D \tag{7}$$

If a firm chooses the X-mode for a given foreign market, then its equilibrium net operating profit on sales in that market is

$$\pi^*_{X,od}(a, A, \eta) = B_d \left(d_{od}\tau_{od}a\right)^{1-\sigma} - f_X \tag{8}$$

where $B_d = \frac{A_d}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{(1-\sigma)}$. If a firm chooses the M-mode for a given foreign market, then the equilibrium net operating profit it would earn is

$$\pi^*_{M,od}(a, A, \eta) = B_d a^{1-\sigma}\left[\left(d_{od}\tau_{od}\right)^{\eta}\right]^{1-\sigma} - f_M \tag{9}$$

To focus on the central case, we set parameters so to get the same ranking as in HMY when there are only two nations. Namely, firms with sufficiently high productivity will supply the foreign market at all, with the most productive supplying it via FDI rather than exports. In this way our model is in line with the HMY empirical findings. Hence, the regularity condition we need is,

$$f_D < \left(d_{od}\tau_{od}\right)^{(\sigma-1)} f_X < \left(d_{od}\tau_{od}\right)^{\eta(\sigma-1)} f_M$$

2.4 Equilibrium Conditions

The Cutoff Conditions

Firms choose the optimal supply mode for each market. To relate this choice to firms' marginal costs we define a threshold marginal cost, $a(v)$, for each destination and for each mode of supply. Using the equilibrium operating profit of serving the domestic market from (7), we derive the domestic cutoff condition,

$$a_{Do} = \left(\frac{f_D}{B_o}\right)^{\frac{1}{1-\sigma}} \tag{10}$$

That is, firms with $a(v)$ below a_D will find it optimal to supply their local market; firms with $a(v) > a_{Do}$ will expect negative profits and exit the industry.

The choice in foreign markets is more complex. The net operating profits of supplying the foreign market d-steps away rise under both modes of supply. Firms with $a_{X,od} < a(v) < a_{Do}$ have positive operating profits from sales in the domestic market, but they lose money if they choose to supply foreign markets. Using the net operating profit from exporting (8), we can derive the X-mode cutoff,

$$a_{X,od} = \left(\frac{f_X}{B_d\left(d_{od}\tau_{od}\right)^{1-\sigma}}\right)^{\frac{1}{1-\sigma}} \tag{11}$$

Only firms with $a(v) \leq a_{X,od}$ will consider export to the d market.

Notice that at $a(v) = a_{X,od}$ exporting yields a higher net operating profit then FDI. This ordering switches, however, for firms with $a(v) \leq a_{M,od}$, where this is defined as the $a(v)$ where:

$$a_{M,od} = \left(\frac{f_M - f_X}{B_d \left[(d_{od}\tau_{od})^{\eta(1-\sigma)} - (d_{od}\tau_{od})^{1-\sigma} \right]} \right)^{\frac{1}{1-\sigma}} \tag{12}$$

This M-mode cutoff is obtained by equating the operating profits from doing FDI, (9), with the operating profit from doing export, (8). This is because by construction, a firm chooses to supply market d via FDI if and only if the FDI strategy is more profitable than the export strategy, i.e. if this holds:

$$\pi_{M,od} - \pi_{X,od} \geq f_M - f_X$$

which can be rewritten as,

$$B_d a_{M,od}^{1-\sigma} \left[(d_{od}\tau_{od})^{\eta(1-\sigma)} - (d_{od}\tau_{od})^{1-\sigma} \right] = f_M - f_X$$

Notice that if $a(v) \leq a_{M,od}$, M-mode supply yields a higher net operating profit.

This set up is initially used to briefly explore the properties of the symmetric equilibrium. Then it will be our point of departure to evaluate the role of different spatial networks on preferential trade agreements.

3 General Equilibrium in the Symmetric Case

This section presents general equilibrium results for the perfectly symmetric case, $o = d$.[9] Using the expression in (32) inside the domestic cutoff condition (10), we find the equilibrium number of varieties (and so the number of all firms competing in that country) consumed in a typical nation:

$$n^* = \frac{(b-1)\beta E}{\sigma b f_D [1 + T^{1-b} \sum_{d=1}^{N-1} (\phi_{od}\gamma_{od})^b + V^{1-b} \sum_{d=1}^{N-1} [(\phi_{od}\gamma_{od})^\eta - \phi_{od}\gamma_{od}]^b]} \tag{13}$$

where $b = \frac{k}{\sigma-1}$; $\phi_{od} = \tau_{od}^{1-\sigma}$; $\gamma_{od} = (d_{od})^{1-\sigma}$; $T = f_X/f_D$ and $V = (f_M - f_X)/f_D$.

We set $\Omega = T^{1-b} \sum_{d=1}^{N-1} (\phi_{od}\gamma_{od})^b$, and, $\Psi = V^{1-b} \sum_{d=1}^{N-1} [(\phi_{od}\gamma_{od})^\eta - \phi_{od}\gamma_{od}]^b$. Where the parameters Ψ and Ω summarize the impact of the two types of trade barriers on exports and on FDI activities. More specifically, Ω represents the combined effect of higher fixed and variable costs on the export strategy. While Ψ measures the relative fixed and variable costs of FDI strategy. Using Ψ and Ω, the expression for n^* could be then simplified to:

$$n^* = \frac{(b-1)\beta E}{\sigma b f_D [1 + \Omega + \Psi]} \tag{14}$$

The equilibrium number of firms described by (14) represents the actual number of survivors in each country, which decreases with Ψ and Ω, hence it decreases with higher fixed and variable costs. Using the free entry condition in (33), and the cutoff conditions in (10)-(12), we get

[9] Appendix B provides further details on free entry and price index for the symmetric case.

explicit closed form solutions for a_D, $a_{X,od}$, and $a_{M,od}$. In particular,

$$a^*_{Do} = a_0 \left[\frac{(b-1)f_I}{(f_D(1+\Psi+\Omega))} \right]^{\frac{1}{k}} \tag{15}$$

Using (17) inside the ratio between (11) and (10) we find:[10]

$$a^*_{X,od} = a_0 \left[\frac{(b-1)f_I}{f_X(1+\Psi+\Omega)} \left(\phi_{od}\gamma_{od}\right)^b T^{1-b} \right]^{\frac{1}{k}} \tag{16}$$

Finally, using (17) inside the ratio between (12) and (10) we obtain the equilibrium cutoff for the M-mode is:

$$a^*_{M,od} = a_0 \left[\frac{(b-1)f_I}{(1+\Psi+\Omega)} \left[(\phi_{od}\gamma_{od})^\eta - (\phi_{od}\gamma_{od})\right]^b \frac{V^{1-b}}{f_M - f_X} \right]^{\frac{1}{k}} \tag{17}$$

Comparative statics on equations (16)-(17), points out an interesting result. A reduction in trade costs, everything else constant, decreases the marginal cost of exporting as well as the marginal cost of FDI. More specifically, while the the ratios of the fixed costs stay the same, the marginal cost of exporting decreases more than the marginal cost of FDI (this latter decreases $\eta < 1$ times the reduction in trade costs). What allows FDI to become more or less attractive is strictly related to the spatial network considered and to the share of imported input in production. In the following sections we show how increased exposure to trade generates the entry of new exporters as well as new FDI firms if non-transport frictions are very high. This result thus confirms a complementarity relationship between export and FDI.

Result 1: *Trade liberalization forces the least productive firms to exit, generates the entrance of new firms into the export markets while discourages FDI activity. Export and FDI activities are substitute activities for sufficiently low transport frictions, i.e. low d_{od}.*

Proof. See Appendix C. ■

These results are obtained assuming a perfectly symmetric scenario. Despite the existence of N countries, we are not yet considering how the spatial structure is affecting the supply mode decisions within the same firm and across countries.
To precisely characterize the relationship between export and FDI and to give a role to third countries, we need to consider specific geographical frameworks. Therefore, the next sections examine the relationship between export and FDI while accounting for third country effects. Discriminatory trade policy (PTAs) as well as specific geographical frameworks, will thus be the focus of the following analysis.

4 Spatial Networks and Preferential Trade Agreements

To give a role to discriminatory trade policy, we need to go beyond the two country location. In what follows, we establish the role of a PTA in shaping the spatial distribution of firm's

[10] Intra-country transport frictions are assumed to be zero.

activity, while allowing for different geography structures.

In a two country model, the relative position of each one of the countries is irrelevant. But when more countries are considered, and trade costs are not symmetric, accounting for their relative position becomes crucial. We thus assume that the world is composed by three economies. In this set up, we analyse how different spatial networks interact with asymmetric liberalization (PTA) in determining the volume and the extent of firms' supply strategy.

Two types of spatial networks are considered. The first representation relies on the Euclidean distance between different countries located on a line segment. Then to eliminate cross country differences in centrality, we consider a spatial network in which countries are evenly spaced around a circle so that shipping between any two locations takes place through the center. These two structures allows us to analyse how changes in trade frictions affect countries' distribution of economic strategy accounting for the level of dispersion of firms productivity-draws.

Our three countries framework is composed by i, j and z countries. With respect to the symmetric situation explored in section 3, we now solve for a new equilibrium in which a PTA exists between country i and j. The PTA takes as usual the form of a reduction in trade costs between two countries while excluding the third one. Since transport and non-transport frictions are considered country pair symmetric, the PTA implies a reduction in τ_{ij} as well as τ_{ji}, all else equal. Starting from this new equilibrium, we consider the effects of further integration between i and j, in the two possible types of spatial networks. Comparative statics on equilibrium cutoffs is provided in appendices E to G.

4.1 General Equilibrium in the Asymmetric Case

In what follows we propose the benchmark case for spatial networks analysis, i.e. preferential trade liberalization without assuming any particular spatial network. Notice that symmetry is preserved between country i and j. This implies that the new model to be solved has eight cutoffs, two free entry conditions and two price indices. We then evaluate the PTA according to the different spatial structures.

Free Entry

In order to characterize the general equilibrium results for the asymmetric case, we specify the two free entry conditions and the two price indices. The free entry condition for firms in country z is defined as follows:

$$\int_{0}^{a_{D\_z}} \Pi_D^o dG(a) + 2\int_{a_{M\_zi}}^{a_{X\_zi}} \Pi_X^d dG(a) + 2\int_{0}^{a_{M\_zi}} \Pi_M^d dG(a) \ = f_I \tag{18}$$

where z and i are respectively the origin and the destination country (notice that $i = j$).

The free entry condition for firms in country $i = j$ can be defined as:

$$\int_{0}^{a_{D\_i}} \Pi_D^o dG(a) + \int_{a_{M\_ij}}^{a_{X\_ij}} \Pi_X^d dG(a) + \int_{a_{M\_iz}}^{a_{X\_iz}} \Pi_X^d dG(a) + \int_{0}^{a_{M\_ij}} \Pi_M^d dG(a) + \int_{0}^{a_{M\_iz}} \Pi_M^d dG(a) \ = f_I \tag{19}$$

Note that the cutoff a_{M_ij} as well as a_{M_zi} represent the threshold marginal costs for FDI firms; while a_{X_ij} as well as a_{X_zi} represent the threshold marginal costs for exporting firms.[11]

Price Index

The price index of the final good in country z is defined as:

$$P_z^{1-\sigma} = \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \Bigg[n_z \int_0^{a_{D\_z}} a^{1-\sigma} dG(a/a_{D\_z}) + $$

$$+ 2n_i \left(\phi_{iz}\gamma_{iz} \int_{aM\_iz}^{a_{X\_iz}} a^{1-\sigma} dG(a/a_{D\_i}) + (\phi_{iz}\gamma_{iz})^{\eta} \int_0^{a_{M\_iz}} a^{1-\sigma} dG(a/a_{D\_i}) \right) \Bigg] \tag{20}$$

The price index for the final good in country $i = j$ is:

$$P_i^{1-\sigma} = \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} \Bigg[n_i \Bigg(\int_0^{a_{D\_i}} a^{1-\sigma} dG(a/a_{D\_i}) + \phi_{ij}\gamma_{ij} \int_{aM\_ij}^{a_{X\_ij}} a^{1-\sigma} dG(a/a_{D\_i}) + (\phi_{ij}\gamma_{ij})^{\eta} \int_0^{a_{M\_ij}} a^{1-\sigma} dG(a/a_{D\_i})) \Bigg)$$

$$+ n_z \Bigg(\phi_{iz}\gamma_{iz} \int_{aM\_iz}^{a_{X\_iz}} a^{1-\sigma} dG(a/a_{D\_i}) + (\phi_{iz}\gamma_{iz})^{\eta} \int_0^{a_{M\_iz}} a^{1-\sigma} dG(a/a_{D\_i}) \Bigg) \Bigg] \tag{21}$$

Comparative Statics for Asymmetric Case

In this part we provide comparative statics for the general asymmetric case where no particular spatial network is assumed. More specifically, we study the cutoffs behaviour in case of deeper asymmetric trade liberalization, i.e. increase in ϕ_{ij}. Our set up considers countries i and j as perfectly symmetric and different from country z in terms of trade integration. The system to be solved involves eighteen equations (fifteen cutoffs and the number of firms in each country). However, due to the symmetry between i and j, the system has eight cutoffs and two number of firms. To simplify notation, we study the effect of a change in ϕ_{ij} on equilibrium cutoffs using a general terminology such as o for origin and d for destination.

Let's start with the domestic cutoff:

$$\frac{\partial a_{Do}}{\partial \phi_{ij}} = \frac{\partial}{\partial \phi_{ij}} \left(\frac{f_D}{B_o}\right)^{\frac{1}{1-\sigma}} \tag{22}$$

The sign of this derivative depends on the behavior of the demand level in each of the origin country, B_o. Notice that B_i and B_z are obtained from the solution of the system between equations (18) and (19).[12] Since B_i is decreasing with ϕ_{ij}, the derivative is unambiguously negative for country i. Countries i and j experience an increase in the average productivity.[13] Differently, since B_z is increasing, the derivative is unambiguously positive for country z domestic cutoff.

[11] Appendix D provides the free entry conditions solved assuming the Pareto distribution (equations (38) and (39)).

[12] See Appendix D for further details.

[13] B_i $(= B_j)$ is decreasing because the price index in the countries belonging to the integrated area is decreasing.

Comparative statics on the exporting cutoff implies:

$$\frac{\partial a_{Xod}}{\partial \phi_{ij}} = \frac{\partial}{\partial \phi_{ij}} \left(\frac{f_X}{B_d \left(\phi_{od}\gamma_{od}\right)} \right)^{\frac{1}{1-\sigma}} \tag{23}$$

the sign of this derivative depends on the two terms in the denominator, B_d and $(\phi_{od}\gamma_{od})$. We established that as a consequence of integration between i and j, B_z is increasing in the excluded country, while $B_{i=j}$ is decreasing in those countries belonging to the PTA. Thus, in the integrated area, the export cutoffs, a_{Xij} and a_{Xiz}, are increasing due to the reduction in trade costs. On the contrary, deeper integration between i and j decreases the export cutoff required for z-firms to export in the integrated area: a_{Xzi} decreases due to the exclusion effect. Marginal cost of export is thus increasing for firms in the integrated area, while it decreases for firms in the excluded area.

We now consider comparative statics on equilibrium cutoff for firms accessing the d-market via FDI,

$$\frac{\partial a_{Mod}}{\partial \phi_{ij}} = \frac{\partial}{\partial \phi_{ij}} \left(\frac{f_M - f_X}{B_d \left[\left(\phi_{od}\gamma_{od}\right)^{\eta} - \phi_{od}\gamma_{od} \right]} \right)^{\frac{1}{1-\sigma}} \tag{24}$$

The sign of this derivative depends on the behaviour of B_d and $[(\phi_{od}\gamma_{od})^{\eta} - \phi_{od}\gamma_{od}]$. We have seen, the reaction of B_d with respect to ϕ_{ij} depends on the destination country considered. As before, the derivative of the second term, $[(\phi_{od}\gamma_{od})^{\eta} - \phi_{od}\gamma_{od}]$, becomes relevant for establishing the sign of (24) only when we consider the FDI cutoff for firms in countries belonging to the PTA. In this case, the result can be ambiguous since it depends on what happens to the derivative of the denominator. It is easy to verify that $\eta\gamma_{ij}^{\eta-1}\phi^{\eta-1} < 1$ holds for sufficiently low transport and non-transport frictions. This result implies that the derivative of the denominator is the sum of two negative terms. Therefore, the sign of the overall derivative of (24) is negative. This result is always true when we analyze PTA effect by eliminating cross country differences in centrality.[14] In this case, the FDI cutoff of PTA countries is decreasing. It is possible to prove that when country z is geographically included, as in case B, $\eta\gamma_{ij}^{\eta-1}\phi^{\eta-1}$ is larger than one: when transportation barriers between i and j are sufficiently high, the FDI cutoff of firms in the PTA countries is increasing in ϕ_{ij}.[15] Differently, there are no ambiguities for the FDI cutoff required for z-firms to open overseas affiliates in the integrated area: it is unambiguously decreasing.

Complementarity between export and FDI relies on similar reaction of export and FDI cutoffs to further degrees of integration. Thus, if the sign of equation (24) is positive, export and FDI activities are complement for firms in the PTA. The behaviour of cutoffs generates implication on number of firms as well as on the intensity of their activities.[16] The complexity of analytical results for the asymmetric case, requires to solve the model numerically so to show graphically the behaviour of our key variables. Notice that due to the asymmetries assumed, getting analytical results is a problem. Nevertheless, we follow the standard literature in economic geography to deal with asymmetries.[17] The model can in fact be solved numerically

[14] This case will be examined in Section 4.2.

[15] This because in the derivative of equation (24), the part where $\eta\gamma_{ij}^{\eta-1}\phi^{\eta-1}$ enters is always bigger than the other one.

[16] The proofs in Appendices G to H, focus on numbers of firms. It is straightforward to derive similar results for volume of activities.

[17] See Fujita et al. (1999) and Baldwin et al. (2003).

and these numerical results can be presented graphically. The results suggest that the behavior of the three country model is different to that of the two-country model. The three country model allows us to give a role to economic geography and to consider special cases which deliver different patterns in terms of organization of firms' supply strategy. Analysis of the cutoff, number of firms, export and FDI flows will be provided for the different spatial networks.

The main result is that the existence of geographical differences milder the effect of discriminatory trade liberalization on the reorganization of modes supply strategy. Thus, on the one side, when geography is important, the integrated area experiences relatively less concentration of economic activities, such as trade and FDI. On the other side, these economic activities move out of the third country and concentrate exclusively within the PTA area when cross country differences in centrality are eliminated.

4.2 Impact of changes in tariff frictions: triangle

This section considers different accessibility to foreign markets, i.e. $d_{od} \neq d$. In a three country setup, we evaluate declining non-transport frictions between countries i and j, while keeping fixed frictions involving country z. We consider a PTA between countries i and j to characterize how changes in bilateral non-transport frictions, τ_{ij}, affect countries' equilibrium distribution of activity. To give a role to transport frictions, we consider a linear representation of the spatial network. A preferential trade liberalization event is here combined with different accessibility to foreign markets, i.e. $d_{od} \neq d$. Note that shipping from i to j (when i and j are adjacent) costs $\tau_{ij} \times d_{ij}$, whereas shipping to a third z-country costs $\tau_{iz} \times d_{iz}$, with $d_{ij} \neq d_{iz}$.

This section distinguishes between two cases, A and B, according to the geographical position of country z with respect to i.[18] Since our interest is to show the impact of preferential liberalization on the localization of firms' activities, the comparative statics conducted in the following sections will be related to changes in the number of exporting and FDI firms in the integrated region as well as in the excluded country.

Case A: Country z is geographically isolated, i.e. $d_{ij} < d_{iz} = d_{jz}$.
This section considers the effect of a PTA when country-z is not only excluded from the economic integration but also geographically disadvantaged. Starting from a benchmark equilibrium in which country-z is geographically isolated and excluded from the PTA, we consider the effects of increasing level of integration between i and j, i.e. reduction in τ_{ij}. Due to the geographical exclusion of country z, the FDI cutoff for firms belonging to the PTA area is characterized by a non monotonic behavior with respect to an increase in ϕ_{ij}. [19]

The number of active firms is decreasing in both the integrated area and in country z. For low level of integration, the number of i- and j- exporters and overseas affiliate increases after the PTA both in the integrated area and in the excluded country. Nevertheless, for higher levels of trade integration the increase in the number of overseas affiliate within the integrated area, turns into a decline.[20] In this scenario, further integration between i and j encourages exporters at the expenses of FDI activity. Despite the reduction in τ_{ij}, FDI activity remains

[18] Due to the high parameterization of the model, we cannot provide closed form solutions. Each of the following results will thus rely on numerical examples where specific parameter values are assigned.

[19] Appendix E provides a graphical analysis.

[20] This result is linked to the non monotonic behavior of a_{Mij}.

so expensive, that only the export activity is prompt. The opposite result is true for country z: the number of z-firms that can enter as exporters and foreign affiliates in the integrated area, unambiguously declines after PTA.

Result 2. *Different accessibility to foreign markets reinforces the substitution between supply mode decisions, export and FDI, in the integrated area. Moreover, the geographical exclusion of country z encourages firms in i and j to increase their activity within as well as outside the integrated area. Further integration among PTA members, reduces the number of z-firms engaging in export and FDI in the integrated area.*

Proof. See Appendix E. ■

Case B: Country z is geographically integrated, i.e. $d_{iz} < d_{ij} = d_{jz}$
This section considers the effect of a PTA when country-z is excluded from the economic integration but enjoys a better geographically location. When transportation or/and non transportation barriers are sufficiently high, the FDI cutoff for PTA-firms is unambiguously decreasing in ϕ_{ij}.[21]

All the results stay the same as in case A, but for the marginal cost of FDI. More precisely, due to larger trasportation barriers between countries in the integrated area, the FDI strategy undertaken by those firms in the PTA area, can take advantage from the trade liberalization event. Indeed, the number of i and j overseas affiliates is here unambiguously increasing for any level of trade integration.

Due to the location disadvantage between i and j, the reduction in τ_{ij} engenders a positive effect for both types of economic activities, exports and FDI. The compound effect of accessibility and trade costs mitigates the role of intermediates which characterize the additional cost due to intra-firm trade. FDI and export activities in the integrated area become complement. In line with Chen (2009), the model finds that the integrated areas attract MNFs activity when characterized by access to a large size of markets.

Result 3. *Further trade integration among PTA members characterized by important geographical barriers, results in fostering both export and FDI activity within and outside that integrated region. FDI and exports become complement.*

Proof. See Appendix F. ■

4.3 Impact of changes in tariff frictions: circle

To eliminate cross country differences in centrality, we consider a spatial network in which the three countries are evenly spaced around a circle so that shipping between any two locations takes place through the center, i.e. $d_{od} = d$. Abstracting from transport frictions, we again consider a PTA between countries i and j to explain how changes in bilateral non-transport frictions, affect countries' equilibrium distribution of activity. The absence of transport differences, changes the supply patterns in the integrating block.

[21] See appendix E for comparative statics on a_{Mij}.

Comparative statics on equilibrium cutoffs reveals that the FDI strategy undertaken from those firms in the PTA area, is discouraged as a consequence of discriminatory trade liberalization. In this framework, where we eliminated cross country differences in centrality, the way in which number of firms are affected changes.

Deeper integration implies a decline in the number of overseas affiliate within the integrated area and an increase of exporting firms. Similarly to case A, further integration between i and j encourages exporters at the expenses of FDI activity. Fostering the substitutability result. Differently from both cases A and B, the PTA reduces the number of i- and j- exporters and overseas affiliate entering the excluded country. The absence of country differences in centrality, reduces the overall number of foreign suppliers entering country z.

On the other side, the number of active firms in country z is increasing. The PTA signed between country i and j makes more firms to survive in the excluded country. This result is driven by the concentration of economic activities in the integrated area, which reduces the competitive pressures in country z. This results in more inefficient firms surviving in country z. As before, the number of z-firms entering the PTA area as exporters and foreign affiliates is unambiguously reduced.[22]

Result 4. *Further integration makes export and FDI activities among PTA members perfect substitutes. The absence of different accessibility to foreign markets deepens the concentration of economic activities in the integrated area. In country z both activities, export and FDI, are discouraged as a consequence of deeper PTA integration.*

Proof. See Appendix G. ■

The less sensitive FDI activity is to trade barriers, the more likely is that FDI and export activities behave as substitute, i.e. confirming the proximity versus concentration hypothesis. In this scenario, a PTA between countries i and j forces the least productive FDI firms to move out of their fierce competitive integrated markets. The substitutability between FDI and exports activities in partner countries is re-established, due to the smaller role played by transport barriers in the FDI variable costs with respect to export variable cost.

Some of these results are in line with Melitz (2003): trade liberalization, between i and j, allows previously non-exporting firms to become exporters in their respective markets. However, the existence of intra-firm trade as well as spatial networks, change the classical framework. Complementarity or substitution effect between FDI and export strategies, generates different results. Complementarity results in reducing the concentration of economic activities into the integrated region. The opposite is true in case of substitution.

4.4 Discussion

Discriminatory trade liberalization modify the reorganization of modes supply strategy in the two areas. After integration, the new economic block experiences tougher competition. This results in shrinking the excluded country's economic activity, which is excluded from larger economic integration. In the excluded country, firms are forced to become more productive in both mode of supply strategies, export and FDI. Differently, the integrating block enjoys the

[22] Due to the high parameterization of the model, we cannot provide closed form solutions. The following result will thus rely on numerical example where specific parameter values are assigned.

entry of new exporting firms. The results for multinationals are more complex and depend on the spatial network considered.

The dispersion of firms productivity draws plays an interesting role. Indeed, larger degrees of heterogeneity (k low) are connected with a tougher environment in particular for MNFs activity. *Vice versa*, the smaller is the extent of firms' heterogeneity, the milder is the effect of PTA on MNFs activity. Firms in the country excluded from the PTA face a tougher foreign environment: entering foreign market becomes relatively more difficult for z-firms.

The discriminatory effect of a PTA in terms of concentration of economic activities seems to be more important when countries are more similar in terms of locations: in this case the integrated area becomes the core. Conversely, when countries strongly differ in terms of locations (borders or language differences), the effect of redirecting economic activities outside the excluded country is reduced. When differences exist at too many level (transportation, level of heterogeneity within a country), the core outcome is less likely.

This set up allow us to say something in terms of export platform. In section 4.1 we considered a discriminatory trade policy with different accessibility to foreign markets, i.e. $d_{od} \neq d$. As we also found in section 4.2, the number of z-firms exporting or doing FDI declines. Nevertheless, it is not difficult to prove that when different accessibility to foreign markets are considered, and more specifically when z is geographically excluded, as in case A, z-firms consider to use an export platform strategy: open a foreign affiliate in i and from there export to country j enjoying reduced trade costs. The export activity is cheaper if it takes place inside the integrated region. This effect means that the number of z-exporting firms is declining faster than the number of z-firms opening a foreign affiliate.[23]

5 Conclusion

This paper investigates the impact of international trade agreements on firms' organizational choices across countries. The PTA episode is considered in two geographical settings. First, we consider different accessibility to foreign markets (physical distance and geographical features). Then, we analyse the case without cross-country differences in centrality.

The model makes three contributions to the existing literature. First, we enrich the spatial pattern of FDI, so that it depends on firm characteristics and intra-firm trade. This generates a more complex outcome than the standard model. Second, by introducing heterogeneity by firms, we characterize the concentration of economic activities in each specific spatial network considered. Third, we shed light on the effects of discriminatory trade liberalization in different spatial networks.

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A Cost Minimization Problem

In order to find the equilibrium operating profits, we solve the minimization problem of the firm. For example, the cost minimization problem for foreign affiliates:

$$\min_{y_1,y_2,\lambda} L = y_1 d\tau + y_2 + \lambda \left[x\left(v\right) - \frac{1}{a}\left(\frac{y_1}{\eta}\right)^{\eta}\left(\frac{y_2}{1-\eta}\right)^{1-\eta} \right]$$

where the Lagrangian multiplier λ represents the marginal cost of production. The Hicksian factor demands are:

$$y_1^* = x\left(v\right) a\eta \left(\frac{1}{d\tau}\right)^{1-\eta}$$

$$y_2^* = x\left(v\right) a \left(1-\eta\right)\left(d\tau\right)^{\eta}$$

Using the Hicksian demands, we can write the total cost of a subsidiary as a function of the final output, $x\left(v\right)$:

$$TC_{M,d} = y_1^* d\tau + y_2^* + f(d) + f_M$$

$$TC_{M,d} = x\left(v\right) a\left(d\tau\right)^{\eta} + f(d) + f_M \tag{25}$$

Using (25) inside (6) it is possible to derive an expression for the multinational equilibrium profits, which depends only on the final output $x\left(v\right)$:

$$\pi_{M,d}(a, A, \eta) = A^{\frac{1}{\sigma}} x\left(v\right)^{\frac{\sigma-1}{\sigma}} - x\left(v\right) a\left(d\tau\right)^{\eta} - f_M \tag{26}$$

hence the optimal output for the affiliate located in the foreign country is:

$$x\left(v\right)^* = \frac{A\left(\frac{\sigma-1}{\sigma}\right)^{\sigma}}{\left(a\left(d\tau\right)^{\eta}\right)^{\sigma}} \tag{27}$$

Equations (26) and (27) refers to this specific multinational framework; the problem above can be solved for each different type of firm. More generically, the final good producer chooses the supply mode that maximizes $\pi^*(a, A, \eta)$ where $k = M$, X or D. For this reason, final good producers organize the production so as to minimize both variable and fixed costs.

B Free Entry and Price Index for Symmetric Case

Free Entry

It is possible to describe the equilibrium which characterizes this economy. In order to do so, we need to specify some other equilibrium equations, namely the free entry condition and the price index.

Free entry ensures equality between the expected operating profits of a potential entrant and the entry cost, $E\left(\pi\right) - f_I$. This condition holds for all type of firms. The cumulative density function is $G(a)$, with support: $[0, ..., a_0]$. The free entry condition can be defined as:

$$\int_0^{a_D} \pi_D dG(a) + \sum_{j=1}^{N-1} \{ \int_{a_{M,od}}^{a_{X,od}} \pi_{X,od} dG(a) + \int_0^{a_{M,od}} \pi_{M,od} dG(a) \} = f_I \tag{28}$$

Using the profit conditions (7)-(9), we obtain:

$$\int_0^{a_D}[\left(\frac{\sigma}{\sigma-1}\right)^{(1-\sigma)}\frac{\beta E a^{1-\sigma}}{P^{1-\sigma}\sigma}-f_D]dG(a)+\sum_{j=1}^{N-1}\{\int_{a_{M,od}}^{a_{X,od}}[\left(\frac{\sigma}{\sigma-1}\right)^{(1-\sigma)}\frac{\phi_{od}\gamma_{od}a^{1-\sigma}\beta E}{P^{1-\sigma}\sigma}-f_X]dG(a)+$$

$$\int_0^{a_{M,od}}[\left(\frac{\sigma}{\sigma-1}\right)^{(1-\sigma)}\frac{(\phi_{od}\gamma_{od})^{\eta}\beta E a^{1-\sigma}}{P^{1-\sigma}\sigma}-f_M]dG(a)\} = f_I \tag{29}$$

where $\phi_{od}=\tau_{od}^{1-\sigma}$ is freeness of trade, $\gamma_{od}=d_{od}^{1-\sigma}$ and d_{od} is the parameter that takes into consideration the different country locations; finally $P^{1-\sigma}$ is a weighted average of the marginal costs corrected for markups of all firms active in the market. Let's spend some more words on this term, $P^{1-\sigma}$.

In every country this weighted average, $P^{1-\sigma}$, is characterized by all the brands offered in that particular country. Brands offered by domestic firms, for which the consumer price is $a\sigma/(\sigma-1)$; brands offered by foreign exporters, for which the consumer price is $a\sigma d\tau/(\sigma-1)$; and finally, brands supplied by foreign subsidiaries, with consumer price $a\sigma(\tau d)^{\eta}/(\sigma-1)$. Therefore:

$$P^{1-\sigma}=\left(\frac{\sigma}{\sigma-1}\right)^{(1-\sigma)}n\int_0^{a_D}a^{1-\sigma}dG(a/a_D)+$$

$$\left(\frac{\sigma}{\sigma-1}\right)^{(1-\sigma)}n\sum_{j=1}^{N-1}\left[\int_0^{a_{M,od}}[\phi_{od}\gamma_{od}]^{\eta}a^{1-\sigma}dG(a/a_D)+\int_{a_{M,od}}^{a_{X,od}}\phi_{od}\gamma_{od}a^{1-\sigma}dG(a/a_D)\right] \tag{30}$$

where n represents the measure of varieties available in the country. Notice that using (30) in (29) cancels out the term $\left(\frac{\sigma}{\sigma-1}\right)^{(1-\sigma)}$.

Parameterization: Pareto Distribution

The fact that the free entry condition and the price index depend on the probability distribution implies that in order to have explicit solutions for this model, we need to assume a particular functional form for G(a). Following the empirical literature on firm size distribution (see Axtell 2001 and HMY), we use as an approximation the Pareto distribution. The cumulative distribution function of a Pareto random variable a is:

$$G(a)=\left(\frac{a}{a_0}\right)^k \tag{31}$$

where k and a_0 are the shape and scale parameter, respectively. Note that k=1 implies a uniform distribution on $[0,a_0]$. The shape parameter k represents the dispersion of cost draws. An increase in k would imply a reduction in the dispersion of firm productivity-draws. Hence, the higher is k the smaller is the amount of heterogeneity. We can now use this Pareto distribution to derive the price index and the free entry condition.

As we said, firms offer a price only if they have at least a productivity of $1/a_D$. Hence, the cumulative distribution is defined on a support $[0,...,a_D]$. We can now solve the symmetric price index to obtain:

$$P^{1-\sigma} = \left(\frac{\sigma}{\sigma-1}\right)^{(1-\sigma)} \frac{n}{1-\frac{1}{b}} a_D^{1-\sigma} \left[1 + T^{1-b} \sum_{j=1}^{N-1} (\phi_{od}\gamma_{od})^b + V^{1-b} \sum_{j=1}^{N-1} \left[(\phi_{od}\gamma_{od})^\eta - \phi_{od}\gamma_{od}\right]^b\right] \tag{32}$$

where $b = \frac{k}{\sigma-1}$; $\phi_{od} = \tau_{od}^{1-\sigma}$; $\gamma_{od} = (d_{od})^{1-\sigma}$; $T = f_X/f_D$ and $V = (f_M - f_X)/f_D$. In order for the integral to converge we assume that $b > 1$.

Rewriting now the free entry condition using the Pareto distribution we obtain:

$$\frac{E}{\sigma P^{1-\sigma}}[\int_0^{a_D} (a^{1-\sigma} - f_D)dG(a) + \sum_{j=1}^{N-1} \int_0^{a_{M,od}} (a^{1-\sigma} (\phi_{od}\gamma_{od})^\eta - (f_M)dG(a)+$$

$$+\sum_{j=1}^{N-1} \int_{a_{M,od}}^{a_{X,od}} (a^{1-\sigma} (\phi_{od}\gamma_{od}) - f_X)dG(a)] = f_I \tag{33}$$

We can now use (32), (33), and (10)-(12) to obtain the closed form solutions in section 3.

C Proof of Result 1

In a perfectly symmetric set up, with two countries o and d, differentiating (17) with respect to ϕ_{od} gives:

$$\frac{\partial a_{Mod}}{\partial \phi_{od}} = \frac{\partial}{\partial \phi_{od}} a_0 \left[\frac{(b-1)f_I}{(1+\Psi+\Omega)} \left[(\phi_{od}\gamma_{od})^\eta - (\phi_{od}\gamma_{od})\right]^b \frac{V^{1-b}}{f_M - f_X}\right]^{\frac{1}{k}} \tag{34}$$

The sign of this derivative is ambiguous and depends on the two terms where ϕ_{od} is entering, such as in Ψ, Ω and the square bracket. Therefore, the sign of (34) is determined by the sign of

$$\frac{\partial}{\partial \phi_{od}} \frac{\left[(\phi_{od}\gamma_{od})^\eta - (\phi_{od}\gamma_{od})\right]^b}{(1+\Psi+\Omega)} \tag{35}$$

Substitutability between export and FDI exists if the following condition holds:

$$\frac{\partial a_{Mod}}{\partial \phi_{od}} < 0 \Longleftrightarrow \frac{\partial}{\partial \phi_{od}} \frac{\left[(\phi_{od}\gamma_{od})^\eta - (\phi_{od}\gamma_{od})\right]^b}{(1+\Psi+\Omega)} < 0 \tag{36}$$

The condition above, which ensures substitution, holds when

$$\frac{\partial \left[(\phi_{od}\gamma_{od})^\eta - (\phi_{od}\gamma_{od})\right]^b}{\partial \phi_{od}} < 0 \Longleftrightarrow \eta(\phi_{od}\gamma_{od})^{\eta-1} < 1 \tag{37}$$

Notice that equation (37) is true for sufficiently low transport frictions. Thus, low transport frictions ensure substitutability between export and FDI.

D Free Entry and Price Index for Asymmetric Case

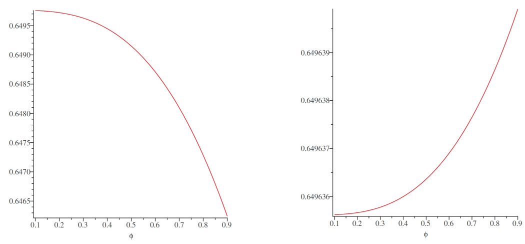
Section 4 investigate the effects of PTA with different spatial networks. This section considers country i and j as perfectly symmetric and different from country z, to analyze the effect of a PTA between i and j. The price index is thus identical in countries i and j. The same for their free entry conditions and cutoffs. To solve the model, we rewrite the free entry for country i $(=j)$ using the cutoffs and the Pareto distribution, such as:[24]

$$\frac{1}{b-1}\left[f_D^{1-b}B_i^b + (f_M - f_X)^{1-b}\left[(B_{j=i}((\phi_{ij}\gamma_{ij})^\eta - \phi_{ij}\gamma_{ij}))^b + (B_z((\phi_{iz}\gamma_{iz})^\eta - \phi_{iz}\gamma_{iz}))^b\right]\right.$$
$$\left. + f_X^{1-b}\left[(\phi_{ij}B_{j=i})^b + (\phi_{iz}B_z)^b\right]\right] = f_I \quad (38)$$

Similarly, the free entry in country z can be obtained:

$$\frac{1}{b-1}\left[f_D^{1-b}B_z^b + 2(f_M - f_X)^{1-b}(B_{i=j}((\phi_{zi}\gamma_{zi})^\eta - \phi_{zi}\gamma_{zi}))^b + 2f_X^{1-b}\left(\phi_{zi}B_{i=j}\right)^b\right] = f_I \quad (39)$$

This system of two equations, (38) and (39), can be solved for B_i and B_z to obtain closed form solutions for the eight cutoffs.[25] Solving numerically the B's allow us to characterize their evolution with respect to deeper integration between countries i and j. We get,



(a) B_i (b) B_z

where the parameters values are: $\sigma = 2$, $\beta = 3$, $f_I = 0.061$, $k = 3$, $E = 100$, $\beta = 0.4$, $\eta = 0.4$. Values for the fixed costs are chosen so to satisfy the ranking condition. Notice that these graphical results hold for every spatial network considered.

E Proof of Result 2 (Case A)

In what follows, we provide graphical results to establish the impact of a preferential trade agreement between countries i and j when country-z is not only excluded from the economic integration but also geographically disadvantaged. The following comparative statics assume parameter values such that: $d_{ij} = 2$, $d_{iz} = d_{jz} = 5$, $\phi_{iz} = \phi_{jz} = 0.3$, $\sigma = 2$, $\beta = 3$, $f_I = 0.061$, $k = 3$, $E = 100$, $\beta = 0.4$, $\eta = 0.4$.

The equilibrium number of exporting firms used for the comparative statics is:

$$n_{X,od} = n_{Do}\int_{a_{M,od}}^{a_{X,od}} dG(a/a_{Do}) \quad (40)$$

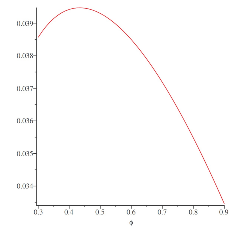
[24]Symmetry between country i and j implies that B_i=B_j.

[25]Even though analytical solutions for B_i and B_z can be computed, comparative statics with respect to ϕ_{ij} is difficult to interpret. For this reason we rely on numerical solutions.

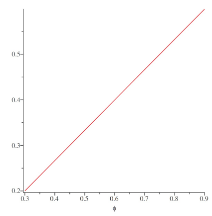
The equilibrium number of foreign affiliates is given by:

$$n_{M,od} = n_{Do} \int_{0}^{a_{M,od}} dG(a/a_{Do}) \tag{41}$$

Using equations (40) and (41), we show the graphical implications on the number of firms of the non monotonic FDI cutoffs within the integrated area:

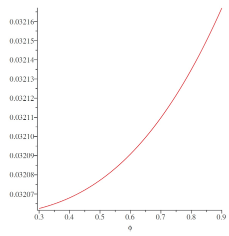


(c) n_{Mij}

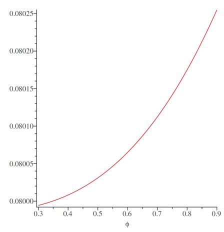


(d) n_{Xij}

The geographical exclusion of country z boosts economic activities of PTA-firms within and outside the integrated area,



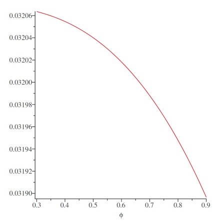
(e) n_{Miz}



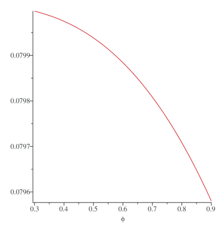
(f) n_{Xiz}

The number of exporting and affiliates activities that enters in country z from i and j is increasing. The reduced concentration of economic activities in the integrated area is captured by the fact that both n_{Xiz} and n_{Miz} are increasing as well as n_{Mij} and n_{Xij}.

The opposite is true for firms in country z:



(g) n_{Mzi}

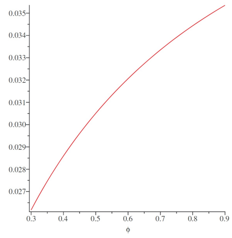


(h) n_{Xzi}

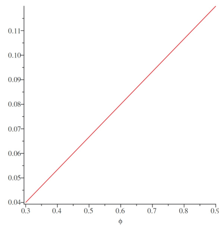
F Proof of Result 3 (Case B)

In what follows, we provide graphical results to establish the impact of a preferential trade agreement between countries i and j when country-z enjoys a better geographical location. The following comparative statics assume parameter values such that: $d_{ij} = d_{jz} = 10$, $d_{iz} = 2$, $\phi_{iz} = \phi_{jz} = 0.3$, $\sigma = 2$, $\beta = 3$, $f_I = 0.061$, $k = 3$, $E = 100$, $\beta = 0.4$, $\eta = 0.4$.

Case B differs with respect to Case A because now there is no ambiguity concerning the reaction of a_{Mij}: export and FDI are complementarity in the integrated area. Thus using equations (40) and (41) we get:



(i) n_{Mij}



(j) n_{Xij}

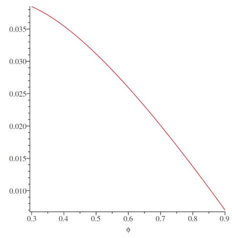
Economic activities of PTA-firms is boosted also outside the integrated area. Thus, the number of exporting and affiliates activities that enters in country z from i and j is increasing. As for Proposition 2, the reduction in concentration of economic activities in the integrated area is captured by the fact that both n_{Xiz} and n_{Miz} are increasing as well as n_{Mij} and n_{Xij}. Differently from case A, here this result is independent on the level of integration, ϕ_{ij}.

As in case A, the number of exporting and affiliates activities from country z are both decreasing.

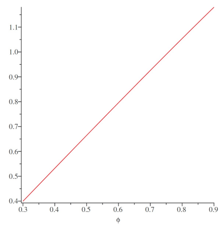
G Proof of Result 4

In what follows, we abstract from transport frictions to explore graphically the impact of a preferential trade agreement between countries i and j. The following comparative statics assume parameter values such that: $d_{ij} = d_{jz} = d_{iz} = 1$, $\phi_{iz} = \phi_{jz} = 0.3$, $\sigma = 2$, $\beta = 3$, $f_I = 0.061$, $k = 3$, $E = 100$, $\beta = 0.4$, $\eta = 0.4$.

Using equations (40) and (41), we can show the graphical results for the behavior of the number of firms linked to the existence of neat substitutability between export and FDI in the integrated area:

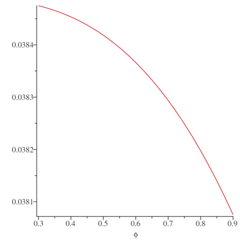


(k) n_{Mij}

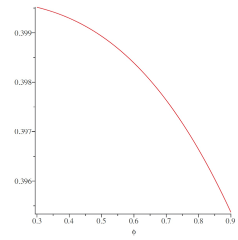


(l) n_{Xij}

Only export activities of PTA-firms is boosted in the integrated area. Differently, the number of exporting and affiliates activities that enters in country z from i and j is decreasing:



(m) n_{Miz}



(n) n_{Xiz}

The absence of different accessibility to foreign markets, deepens the concentration of export activities in the integrated area. This result is captured by the fact that while n_{Xiz} and n_{Miz} are decreasing, n_{Xij} is increasing. The smaller role played by distance, generates substitution between export and FDI in the PTA region, thus n_{Mij} is decreasing. Similarly to the previous cases, the number of exporting and affiliates activities from country z are both decreasing.

The result is different from cases A and B: relocation here occurs exclusively within the integrated area.