Spatial Networks and Heterogeneous Firms*

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Abstract

This paper examines the discriminatory nature of PTA in a framework where trade policy affects both exporting firms as well as MNFs. This will generate implication on the supply strategy of firms. Considering different spatial networks, we quantify the effect of PTA on supply mode decisions, for both partner and excluded countries. Combining PTA and spatial networks allows us to disentangle the effects of different level of integration in encouraging some market access strategies instead of others.

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1 Introduction

The effect of discriminatory trade frictions on re-organization of production in a firm heterogeneity set up is an important issue in international trade. The aim of this paper is to fill the gap in theoretical and empirical trade research by focusing on the link between trade barriers and firm's organization of production. Using different structures of spatial networks, we investigate the positive and normative impacts of deeper international integration. Firm heterogeneity will allow us to evaluate the impact of different levels of trade integration on firms' location and organization of production.

PTA generates two types of discriminations. The first type of discrimination is characterized by the well-known diversion effect *vis-à-vis* the third country (both for export and FDI activities). The second type of discrimination alters the supply strategy in member countries as well as in the excluded one (thus it alters the distribution of firm's activity). We will show that PTA always produces both types of discriminations but the extent is depending of the spatial networks considered. Thus, the interaction between PTA and accessibility to foreign markets will deliver different scenarios for the reorganization of supply strategy.

Markusen and Horstmann (1992) developed 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) followed a similar line of research by focusing on the location decisions proposing the so-called proximity versus concentration hypothesis, or scale versus proximity.[1] 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). In these models, firms are more likely to be engaged in foreign direct investment (FDI) activities when trade costs are high. Thus, foreign subsidiary's sales increase with distance. 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.

Comparing this theory with the empirical evidence on FDI, we discover that the spatial distribution of affiliates is much richer than the scale-versus-proximity would predict. In fact, despite the reduction in transport costs across countries, there has been a consistent growth of FDI inflows. The data shows that multinational enterprises account for a very significant fraction of world trade flows; and trade in intermediate inputs between divisions of the same firm constitutes an important portion of these flows (Hanson, Mataloni and Slaughter, 2001). Alfaro and Charlton (2007), using a new firm level data set, establish that vertical FDI (subsidiaries which provide inputs to their parent firms) is larger than commonly thought,

[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).

even within developed countries.[2] This result is in line with Bernard, Jensen and Schott (2007), as they find that the proportion of intra-firm trade is higher between rich countries than between rich and poor countries.

Moreover, Buch, Kleinert, Lipponer and Toubal (2005), Carr, Markusen, and Maskus (2001) and Mayer and Head (2004) show that including distance as a proxy for trade costs negatively affects affiliate sales: a reduction in trade costs coincide with FDI growth[3]. Other empirical studies depart from the classical bilateral FDI assumption and introduce an element which takes into account spatial interdependence in foreign direct investment. Blonigen, Davies, Waddell and Naughton (2007) and Baltagi, Egger and Pfaffermayr (2006) attempt to test empirically the complex integration strategies of multinationals by considering the role of third countries as a determinant of FDI. They all find significative and positive third country effects.

This data shows a broad range of strategies that multinational enterprises can undertake, highlighting the fact that the classical distinction between horizontal and vertical FDI is not accounting for all the facts. Trade and taxes are important policies which can affect the mix of affiliate strategies. Also distance, not only geographical but also cultural, plays an important role in the strategy choices of the multinational enterprises.

We propose to study how market access strategy (export vs. FDI share by sector and by destination country) and welfare respond to changes to changes in level of integration. We introduce variations by firms by markets as a new element with respect to the existing literature where variations are by market (homogeneous firm) or by firm in a single market (Helpman, Melitz and Yeaple, 2004). In this model we will have firms switching type from FDI to export (or vice versa) in relation to distance: there will not be a one to one correspondence between firm type and characteristics. This model changes the usual MNF pattern by introducing non-monotonic relationships between affiliate sales and distance. As far as we know there are no other papers that look into how PTA affects the distribution of supply mode decisions.

Our model is closely related to Melitz (2003) and Helpman, Melitz and Yeaple (2004), hereafter HMY. Melitz (2003) added two crucial elements to the new trade theory. The first is the fixed market entry costs that a potential entrant has to pay. The second is heterogeneity in firms' productivity. By introducing firm heterogeneity in the Krugman (1980) model, he observed how an increase in trade exposure leads to a reallocation of firms toward the more efficient, without necessarily inducing an increase in the productive efficiency of individual firms.[4] In line with Melitz (2003), HMY built a multi-country, multi-sectoral general equilibrium model with the intent to analyze the decision of heterogeneous firms to serve foreign markets either through exports or local sales (FDI). Similar to Melitz (2003), they work with heterogeneous firms, identical nations, a single factor, but with more sectors. They find that at the (sectoral) aggregate level, the ratio of FDI to export sales should be higher in indus-

[2]This result depends on the level of disaggregation they considered.

[3]This seems to be confirmed in the EU, where under the single market situation a reduction in trade costs has been achieved.

[4]This result is partially contradicted by Baldwin and Nicoud (2007), where they pointed out that "although freer trade improves industry productivity in a level sense, it harms it in a growth sense".

tries with higher productivity dispersion. Their results rely on the assumption of perfectly symmetric countries and on the absence of asymmetries in trade costs or in fixed costs. As a consequence, a firm that exports to one single country will also export to every other country. This could limit our comprehension of reality, where usually a firm chooses a mixture of supply modes.

Building on Melitz (2003) and HMY, this paper considers the role of distance on the decision of whether and how a firm chooses to serve a foreign market. Using within-sector heterogeneity and identical countries we assume that trade costs (which depends on both trade openness and distance) apply to both exports and FDI because both involve transportation (the first of a finished good, the second of an intermediate good).In keeping with the strong positive correlation between trade and FDI, we assume that an essential intermediate good must be produced at home 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. In the model, we take the home production of the intermediate as a given.

We chose a model which uses the heterogeneous firms approach because it allows us to model some aspects of international modes of supply that until now have only been studied empirically. More precisely, the heterogeneous firms approach serves three purposes: to explain patterns of productivity differences between multinationals, exporters and national firms, to dull the knife-edge result in which homogeneous firms all choose the same (or are indifferent between) supply modes, and more importantly to introduce different supply modes in different destination markets for each firm. Despite the gain in terms of a more succinct and transparent framework, the homogeneous firms approach would not have allowed keep the consistency between the model and firm level data.

Likewise, the model can also be viewed as an enrichment of the cornerstone models with firm heterogeneity. Firstly, we give a role to spatial networks by introducing trade costs in the MNF's activity. Secondly, we exploit the multicountry dimension to analyze how discriminatory trade liberalization affects differently the supply mode decisions in partner and excluded countries.

This 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. Section 5 we characterize the equilibrium of the model according to different level of intra-firm trade. The last section concludes.

2 Theoretical Framework

To examine the implications of preferential trade agreements on supply strategies, we propose a multi-country framework which accounts for both FDI and export mode decisions. For this purpose, we will use as a benchmark the model by Helpman, Melitz and Yeaple (2004).

2.1 Preferences

Consumers in each country share the same preferences over two final goods: a homogeneous good, z, 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, z. The utility function is

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

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 identical countries. We denote the distance between markets with "d". This implies that distance between markets rises by steps of 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, z, with constant returns to scale and perfect competition. In this sector the technology is simple. We choose units of z such that one unit of labour is required per unit of output. Thus, 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, $p_z = w$. It is convenient to choose good z as the numeraire, so that $p_z = 1$; hence, the pricing condition will become: $1 = w$. Assuming the nations are large enough, it is easy to show that homogeneous good z 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, but y_1 can only be made at home, due to technological appropriability issues. Each variety is 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.

As in Helpman, Melitz and Yeaple (2004), this choice is affected by the classical scale versus proximity trade-off. Nevertheless, in our model, geographical distance plays also a role in characterizing intra-firm trade. Since y_1 can only be made at home plays an important role. If a firm chooses to supply the foreign market via local sales of its affiliates, the affiliate must import the intermediate good y_1 from the home nation. This implies that the M-mode does not entirely avoid trade costs.

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 (this happens 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 (for example, 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 j market, would require shipment from the origin country of $d_{ij}\tau_{ij} \geq 1$ units for the exporting sector and $(d_{ij}\tau_{ij})^{\eta}$ for the FDI sector, where τ_{ij} represents the iceberg trade cost 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,

$$x_i(v) = A_i p_i(v)^{-\sigma} \quad \text{where } A \equiv \frac{\beta E_i}{P^{1-\sigma}}$$

where i indicates the country, $x_i(v)$ represents the consumption of typical variety v, A_i is the demand shifter and finally $p_i(v)$ is the consumer price index of variety v. A_i is exogenous from the perspective of the firm and composed by the aggregate level of spending on the differentiated good in country i, βE^i divided by the CES price index, $P^{1-\sigma}$. Country symmetry allows us to drop the country subscript. The inverse demand function is given by

$$p(v) = A^{\frac{1}{\sigma}} x(v)^{-\frac{1}{\sigma}} \tag{2}$$

[5] The subscript I stands for innovation.

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

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,

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

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 will depend on their own productivity and on the distance between the origin and the destination country. As mentioned before, the marginal costs in the exporting sector will be higher than the one in the FDI sector. Thus, distance will also play a role in the consumer price.

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

$$mc_D = a(v)$$

where country symmetry allows us to drop the country subscript.[7] The marginal cost for exporting to a market that is d-steps away is linear in $d_{ij}\tau_{ij}$,

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

where d_{ij} and τ_{ij} represent distance and trade cost respectively. Finally, the marginal cost for supplying the d market via local sales of foreign affiliates is concave in $d_{ij}\tau_{ij}$,

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

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.

2.3.3 Mode of Supply Decisions

The mode of supply decision choice will involve 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 will determine 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

[7] See appendix A1 for details of the cost minimization problem.

to a market d-steps are linearly decreasing in d_{ij} and τ_{ij},

$$\pi_{X,ij} = \left[p_X(v) - a(v)\, d_{ij}\tau_{ij}\right] x(v)_X - f_X \tag{4}$$

where $x(v)_X$ represents the quantity exported.

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

$$\pi_{M,ij} = \left[p_M(v) - a(v)\left(d_{ij}\tau_{ij}\right)^{\eta}\right] x(v)_M - f_M \tag{5}$$

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

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

$$\pi_{Di}(v) = \left[p_D(v) - a(v)\right] x(v)_D - f_D \tag{6}$$

where $x(v)_D$ 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,

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

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

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

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

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

If a firm chooses the M-mode for a given foreign market, then the equilibrium net operating profit it would earn is

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

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

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

condition we need is,

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

To clarify the set up we deal with, Figure 1 presents the profit functions discussed in the text above.

Figure 1: Profits and Foreign Markets j and k

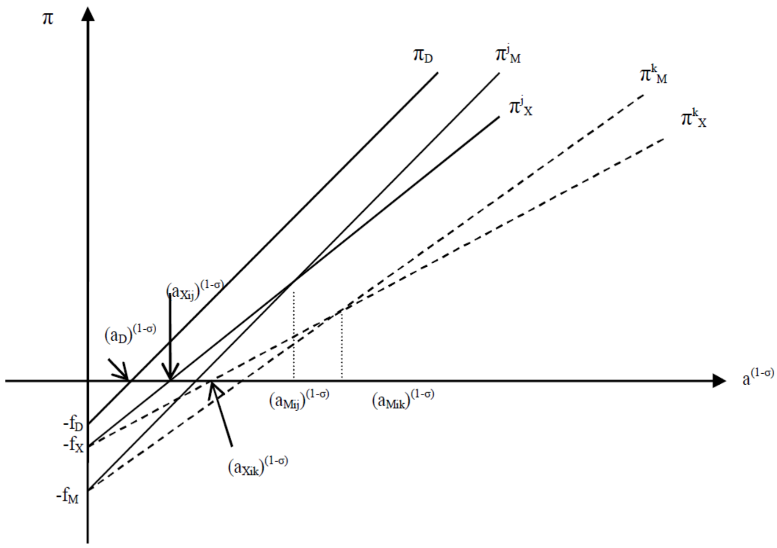

Figure 1 shows how distance affects the modes of supply. On the horizontal axis we have $a^{1-\sigma}$; since $\sigma > 1$, this variable can be used as a firm-level productivity index. All the profits described in (7), (8) and (9) are increasing functions of $a^{1-\sigma}$. The diagram plots π_D, π_X^j and π_M^j which are the operating profits for a firm supplying a market locally (π_D), exporting to market j $\left(\pi_X^j\right)$ and supplying via M-mode $\left(\pi_M^j\right)$. Independently of the type of activity, the more productive is a firm, the more profits it will make. The profit function π_X^j is flatter than π_D and π_M^j due to trade costs. Vertical intercepts of both exports and FDI are lower due to higher fixed costs. Figure 1 also plots the profits for a firm reaching market k via export, π_X^k, and FDI, π_M^k. Consider π_M^k. Its slope is flatter than π_M^j while its vertical intercept is unchanged. In the supply mode via FDI only a part of the intermediate goods incurs in trade costs, this makes π_M^j steeper than π_X^j. This condition is preserved for any further increase in distance: π_M^k is also steeper than π_X^k.

Thus, there exist different productivity levels at which a firm is indifferent between supply modes; these productivity levels change with geographical distance as well as level of trade costs. The cutoff productivity level at which operating profits from domestic sales equal zero is $a_D^{1-\sigma}$. The productivity levels at which exporters and FDI just break even are generically $a_{X,id}^{1-\sigma}$ and $a_{M,id}^{1-\sigma}$. Greater distance will modify these cutoffs. For any given market, say market j, $a_{Xij}^{1-\sigma} < a_{Mij}^{1-\sigma}$. Similarly in market k: $a_{X,ik}^{1-\sigma} < a_{M,ik}^{1-\sigma}$.

These conditions are ensured by the regularity condition. If $a_{X,id}^{1-\sigma}$ rises with the distance of the market "d", we cannot say the same for $a_{M,id}^{1-\sigma}$. In fact, $a_{M,id}^{1-\sigma}$ has an ambiguous behaviour with respect to distance (or larger trade costs), which depends on the freeness of trade. We cannot *a priori* rank the thresholds for X versus M, nor for M at different distances. More precisely, Figure 1 holds for sufficiently high freeness of trade and distance.

2.4 Equilibrium Conditions

We now turn to formal statements of the thresholds illustrate in Figure 1.

The Cutoff Conditions

Firms will 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,

$$a_D = \left(\frac{f_D}{B}\right)^{\frac{1}{1-\sigma}} \tag{10}$$

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

The choice in foreign markets is more complex so we will structure the discussion with the help of Figure 1. As we see from the figure, the net operating profits of supplying the foreign market d-steps away rise under both modes of supply. Firms with $a_{X,ij} < a(v) < a_D$ 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,

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

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

Notice from Figure 1 that at $a(v) = a_{X,ij}$ exporting yields a higher net operating profit then FDI. This ordering switches, however, for firms with $a(v) \leq a_{M,ij}$, where this is defined as the $a(v)$ where:

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

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 will choose to supply market j via FDI if and only if the FDI strategy is more profitable than the export strategy, i.e. if this holds:

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

which can be rewritten as,

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

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

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, $E(\pi) - f_I$. This condition holds for all type of firms. The cumulative density function is $G(a)$, with support: $[0, ..., a_0]$, where for simplicity we can set $a_0 = 1$. The free entry condition can be defined as:

$$\int_0^{a_D} \pi_D dG(a) + \sum_{j=1}^{N-1}\{\int_{a_{M,ij}}^{a_{X,ij}} \pi_{X,ij} dG(a) + \int_0^{a_{M,ij}} \pi_{M,ij} dG(a)\} = f_I \tag{13}$$

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

$$\int_0^{a_D}[\left(\frac{\sigma}{\sigma-1}\right)^{(1-\sigma)}\frac{\beta E a^{1-\sigma}}{P^{1-\sigma}\sigma} - f_D]dG(a) + \sum_{j=1}^{N-1}\{\int_{a_{M,ij}}^{a_{X,ij}}[\left(\frac{\sigma}{\sigma-1}\right)^{(1-\sigma)}\frac{\phi_{ij}\gamma_{ij}a^{1-\sigma}\beta E}{P^{1-\sigma}\sigma} - f_X]dG(a) + \tag{14}$$

$$\int_0^{a_{M,ij}}[\left(\frac{\sigma}{\sigma-1}\right)^{(1-\sigma)}\frac{(\phi_{ij}\gamma_{ij})^{\eta}\beta E a^{1-\sigma}}{P^{1-\sigma}\sigma} - f_M]dG(a)\} = f_I \tag{15}$$

where $\phi_{ij} = \tau_{ij}^{1-\sigma}$ is freeness of trade, $\gamma_{ij} = d_{ij}^{1-\sigma}$ and d_{ij} is the parameter that takes into consideration the different country locations; finally $P^{1-\sigma}$ is a weighted average of the marginal costs 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:

$$P^{1-\sigma} = \left(\frac{\sigma}{\sigma-1}\right)^{(1-\sigma)} n \int_0^{a_D} a^{1-\sigma} dG(a/a_D) + \tag{16}$$

$$\left(\frac{\sigma}{\sigma-1}\right)^{(1-\sigma)} n \sum_{j=1}^{N-1} \left[\int_0^{a_{M,ij}} [\phi_{ij}\gamma_{ij}]^{\eta} a^{1-\sigma} dG(a/a_D) + \int_{a_{M,ij}}^{a_{X,ij}} \phi_{ij}\gamma_{ij} a^{1-\sigma} dG(a/a_D) \right] \tag{17}$$

where n represents the measure of varieties available in the country. Notice that using (17) in (15) will make disappear 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:

$$G(a) = \left(\frac{a}{a_0}\right)^k \tag{18}$$

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 will offer a price only if they have at least a productivity of $1/a_D$. Hence, the cumulative distribution is defined on a support $[0, ..., a_D]$. Solving for the price index we will obtain:

$$P^{1-\sigma} = \frac{n}{1-\frac{1}{b}} a_D^{1-\sigma} \left[1 + T^{1-b} \sum_{j=1}^{N-1} (\phi_{ij}\gamma_{ij})^b + V^{1-b} \sum_{j=1}^{N-1} [(\phi_{ij}\gamma_{ij})^{\eta} - \phi_{ij}\gamma_{ij}]^b \right] \tag{19}$$

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

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

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

$$+ \sum_{j=1}^{N-1} \int_{a_{M,ij}}^{a_{X,ij}} (a^{1-\sigma} (\phi_{ij}\gamma_{ij}) - f_X) dG(a)] = f_I \tag{20}$$

We can now use (19), (20), and (10)-(12) to obtain closed form solutions.

3 General Equilibrium

In order to analyze the main implications of our model, we exploit the fact that all fixed coefficients are the same in every country and that the distribution function is the same. However, the existence of N countries located evenly around a circular trade route introduces a role for distance in generating heterogeneity in the supply mode decisions within the same firm. Using the expression in (19) inside the domestic cutoff condition (10), we find the equilibrium number of varieties (and so the number of surviving firms) consumed in a typical nation:

$$n^* = \frac{(b-1)\beta E}{\sigma b f_D [1 + T^{1-b} \sum_{j=1}^{N-1} (\phi_{ij}\gamma_{ij})^b + V_d^{1-b} \sum_{j=1}^{N-1} [(\phi_{ij}\gamma_{ij})^\eta - \phi_{ij}\gamma_{ij}]^b]} \tag{21}$$

We define $\Omega = T^{1-b} \sum_{j=1}^{N-1} (\phi_{ij}\gamma_{ij})^b$, and, on the other hand, $\Psi = V^{1-b} \sum_{j=1}^{N-1} [(\phi_{ij}\gamma_{ij})^\eta - \phi_{ij}\gamma_{ij}]^b$. Where Ψ and Ω could be considered as parameters that summarize the impact of the two types of trade barriers on exports and FDI activities. In particular, Ω represents the combined effect of higher fixed costs and variable distance costs on the export strategy. While Ψ measures the role of the difference in these costs when choosing between a FDI strategy and an export strategy. Using Ψ and Ω, the expression for n^* could be then simplified to:

$$n^* = \frac{(b-1)\beta E}{\sigma b f_D [1 + \Omega + \Psi]} \tag{22}$$

The equilibrium number of firms described by (22) represents the actual number of survivors in each country, which decreases with Ψ and Ω, hence it decreases with higher fixed and variable distance costs. Using the free entry condition in (20), and the cutoff conditions in (10)-(12), we get explicit closed form solutions for a_D, $a_{X,ij}$, and $a_{M,ij}$. In particular,

$$a_D^* = a_0 \left[\frac{(b-1) f_I}{(f_D(1 + \Psi + \Omega))} \right]^{\frac{1}{k}} \tag{23}$$

Using (25) inside the ratio between (11) and (10) we find:

$$a_{X,ij}^* = a_0 \left[\frac{(b-1) f_I}{f_X(1 + \Psi + \Omega)} (\phi_{ij}\gamma_{ij})^b T^{1-b} \right]^{\frac{1}{k}} \tag{24}$$

Finally, using (25) inside the ratio between (12) and (10) we obtain the equilibrium cutoff for the M-mode is:

$$a_{M,d}^* = a_0 \left[\frac{(b-1) f_I}{(1 + \Psi + \Omega)} [(\phi_{ij}\gamma_{ij})^\eta - (\phi_{ij}\gamma_{ij})]^b \frac{V_d^{1-b}}{f_M - f_X} \right]^{\frac{1}{k}} \tag{25}$$

The index d inside these expressions is related to the geographical distance between the origin and a specific destination country.

Differently to HMY, these cutoffs change in relation to the geographical location of the destination country. Indeed, equations (23)-(25) change in relation to the number of countries belonging to this trade bloc and more importantly, (24) and (25) change with respect to the destination country we consider to reach. Since countries are evenly spaced along the circular trade route, the above equations are the same for whatever country we pick to be the origin country.

4 Supply Modes Decisions and PTA

In this section, to keep the analysis tractable, we assume that the world is composed by three identical economies. We will analyze how different spatial networks affect aggregate flows as well as firms' supply strategy across trading countries.[9] This is particularly interesting when considering the role of trade agreement on the spatial distribution of firm's activity.

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. In this paper two types of spatial networks are considered. The first representation relies on the Euclidean distance between different countries located on a line segment.[10]

To eliminate cross country differences in centrality, we then 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. Within these two structures, we will analyze how changes in trade frictions affect countries' distribution of economic strategy (by sector) accounting for the level of dispersion of firms productivity-draws. We also consider the welfare implications of further degree of integration.

Different accessibility to foreign markets magnifies the effect of PTA on MNFs activity (when the latter is characterized by intra-firm relationship). By strengthening the reaction of local sales (via a magnification of the intensive and extensive margin of FDI), PTA leads to a higher predicted trade elasticity of local sales of foreign affiliates than in existing models of exports and FDI. This effect changes depending on the spatial network considered.

In sub-section 4.1, preferential trade agreement episode will be explored considering different accessibility to foreign markets (physical distance and geographical features). Differently, in sub-section 4.2, the same PTA episode will be explored considering no cross-country differences in centrality.[11] Thus, the way in which changes in non-transport frictions will affect our spatial equilibrium will also depend on the characteristics of the transportation network. Denoting with d_{ij} the cost of transport barriers, which work similarly to the iceberg fixed

[9] The spatial networks will allow for differences in centrality.

[10] The model proposed in Section 2 develops a multi-country set-up. Nevertheless here, to keep the analysis as simple as possible, we provide comparative statics using a three countries example.

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

cost, we thus subsequently analyze two cases: $d_{ij} \neq d$ and $d_{ij} = d$.

PTA generates two types of discriminations. The first type of discrimination is characterized by the well-known diversion effect *vis-à-vis* the third country (both for export and FDI activities). The second type of discrimination alters the supply strategy in member countries as well as in the excluded one (thus it alters the distribution of firm's activity). We will show that PTA always produces both types of discriminations but the extent is depending of the spatial networks considered. Thus, the interaction between PTA and accessibility to foreign markets will deliver different scenarios for the reorganization of supply strategy.

4.1 Impact of changes in non-transport frictions: triangle

We now focus on the impact of changes in trade costs on the distribution of economic activity. We consider preferential trade agreements to explain how changes in bilateral non-transport frictions (i.e., τ_{ij}) affect countries.[12] To give a role to transport frictions, we consider a linear representation of the spatial network. Trade liberalization event is thus combined with different accessibility to foreign markets, i.e. $d_{ij} \neq d$. Note that shipping from i to j (when i and j are adjacent) costs $\tau_{ij} * d_{ij}$, whereas shipping to a third country, z, costs $\tau_{iz} * d_{iz}$.

Considering different accessibility to foreign markets, i.e. $d_{ij} \neq d$, we work with three countries, i, j and z, to evaluate declining non-transport frictions between countries i and j, while keeping fixed the frictions involving country z. In a model with heterogeneous firms and intra-firm trade, member countries i and j, gain better reciprocal access to their markets, which in turns positively affects each supply strategies only if accessibility does not play a relevant role. In this scenario, the larger is the accessibility issue, the more PTA should encourage intra-firm trade and export among member countries. Conversely, PTA should divert both export and intra-firm trade from the excluded country. This diversion might induce a reshape in production strategy in the excluded country: towards HFDI or subcontracted activities.

Proposition (for triangle): For the excluded country, discrimination in the mode of supply strategy is larger the larger is firms' heterogeneity, the lower is intra-firm trade and the more important is different accessibility to markets. Proof.

4.2 Impact of changes in non-transport frictions: circle

We consider now countries evenly spaced around a circle so that shipping between any two locations takes place through the center. Exploiting the multi-country set up, we investigate how changes in tariffs via PTA agreements affect industry location in a set up with heterogeneous firms.

The effects of a PTA between i and j are similar to those described in 4.1 but milder due to the absence of different accessibility to markets. **To be continued...**

[12] In our model no need to introduce a condition to avoid arbitrage, we assume the existence of Rules of Origin such as: when delivered to country j a good is certified as *made in country i* and thus faces trade costs τ_{ij} only if a substantial part of its value added is generated in i.

4.3 Discussion

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 (more specifically the MNFs activity can increase, as well as trade, between countries member of the agreement). Thus we should expect PTA policy to have a stronger impact on firms' organization of production in countries with large firms' heterogeneity. It should be noted, however, that firms in the country excluded from the PTA, will face a tougher foreign environment (discrimination effect against country z): entering foreign market is relatively more difficult for z-firms.

PTA as usual has discriminatory effects which are less important when countries are more similar in terms of locations. In cases in which countries strongly differs in terms of locations (borders or language differences), the discriminatory effect can damage not only the excluded country, but also some activity in the PTA countries. PTA will play a stronger role in reshaping firms' organization of production (generating benefits and costs according to the type of firm considered) the larger is heterogeneity in productivity and if countries differ in location and trade relationships. This negative externality paid by the excluded country, z, is an additional costs imposed by PTA. When differences exist at too many level (transportations, level of heterogeneity within a country), there seems to exist additional arguments against PTA policy. A milder trade policy, such as multilateral trade policy, could at least eliminate the effects on the excluded country.

5 The Role of Intra-Firm Trade

In this Section we analyze the equilibrium results according to low and high level of intra-firm trade. **To be continued...**

6 Conclusion

This paper makes four contributions to the existing literature. First, we enrich the spatial pattern of FDI, so that it depends on firm characteristics. This generates a more complex outcome than the standard Markusen model. Second, by introducing heterogeneity by firms by markets we highlight a process through which one firm may supply some markets via FDI and others via exports. Third, we shed light on the effects of discriminatory trade liberalization in different geographical space. Preliminary evidence on the effects of PTA seems to confirm the role of geographical distance in characterizing the reorganization of mode of supply.

In this paper we consciously avoided the literature on export platform FDI, since we did not allow for the possibility of re-export from a foreign affiliate. However, stepping slightly outside the model, when distance increases, some firms stop building foreign affiliates abroad and start to undertake export as a foreign market access strategy. This export activity might be cheaper if it takes place between the last foreign country where it has been built the foreign affiliate and the new destination country. This latter case would imply an export platform strategy, where the foreign affiliate firm located in country j sells in that foreign market j, and also in third markets through export.

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7 Appendix

A1. 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:

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

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

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

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

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

$$\begin{aligned} TC_{M,j} &= y_1^* d\tau + y_2^* + f(d) + f_M \\ &= x(v)\, a(d\tau)^{\eta} + f(d) + f_M \end{aligned} \tag{26}$$

Using (26) inside (6) it is possible to derive an expression for the multinational equilibrium profits, which depends only on the final output $x(v)$:

$$\pi_{M,d}(a, A, \eta) = A^{i\frac{1}{\sigma}} x(v)^{\frac{\sigma-1}{\sigma}} - x(v)\, a(d\tau)^{\eta} - f(d) - f_M \tag{27}$$

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

$$x(v)^* = \frac{A^i \left(\frac{\sigma-1}{\sigma}\right)^{\sigma}}{\left(a(d\tau)^{\eta}\right)^{\sigma}} \tag{28}$$

Equations (27) and (28) refers to this specific multinational framework; the problem above can be solved for each different type of firm. More generically, the final good producer will choose the supply mode that maximizes $\pi_k^*(a, A, \eta)$ where $k = M$, X or D. For this reason, final good producers organize the production so as to minimize both variable and fixed costs.

A2. ?