Three Essays on International Trade and Institutions

by

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To my parents. To my sons; Majd and Khaled, and my daughter Salma. To the one who without her this project could have not been accomplished, my wife Ahlam

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CHAPTER I

Introduction

This dissertation consists three distinct but related essays. The first essay addresses the effects of trade liberalization on firms' productivity. I endogenize firms' choices of production technology in what would be a standard Melitz model otherwise. The model is highly tractable and provides new insights about the relationship between firms' productivity and trade liberalization. Firms' responses to trade liberalization are heterogenous: exporters, on average, improve their level of technology adoption, whereas nonexporters downgrade their level of technology adoption. The degree to which exporters/nonexporters adjust their level of technology adoption depends on domestic market size, export destination market size, trade impediments, whether new exporter/nonexporter or old exporter/nonexporter, and model's parameters. In contrast to extant literature on endogenous production technology, the effects of trade liberalization are not limited to a specific subset of producers (mainly new exporters), but reach all existing firms. I also show that even with some firms adopting lower levels of production technology, gains from trade are larger relative to the standard Melitz' model.

The evolution of domestic institutions in the global economy is the subject of the second essay. Why does trade liberalization improve domestic institutions in some countries but not others? I incorporate contractual frictions in a two-country two-sector model of international trade with heterogeneous firms in which one sector produces homogenous goods and the other produces differentiated goods. Only the differentiated goods sector is subject to incomplete contracts. Countries are symmetric except for contracting institutional quality. Institutional quality is a source of comparative advantage: the country with better institutions exports the differentiated goods on net. In the differentiated goods sector, exporters, on average, benefit from domestic institutional reforms, whereas nonexporters' profits fall as institutions advance. The effect of institutional change on firms' profits is magnified as trade costs decline. To endogenize domestic institutions, I use the lobbying framework of Grossman and Helpman (1994), where subsets of exporters and nonexporters relate the group's monetary contribution to the domestic institutional quality. Reduction in trade costs deteriorates domestic contracting institutions if nonexporters are the predominant political group, which is more likely in countries with low initial domestic institutions. In addition, equilibrium domestic institutional quality is positively affected by the trade partner's institutional quality.

In the third essay (joint with Vanessa Alviarez), we study intra-firm trade and multinational production in the global economy. A salient empirical regularity of multinational production (MP) is that foreign affiliate sales are decreasing in trade costs. As a response, intra-firm trade, from parents to foreign affiliates, has been combined with standard models of *horizontal* MP to generate complementarities between trade and multinational activity that deliver gravity-style predictions for foreign affiliates' sales. However, intra-firm trade is not common across foreign affiliates but rather concentrated among a small set of large multinational firms (Ramondo et al., 2014). In addition, we document that not only firms in the upper-tail of the firm's size distribution, which are more likely to conduct intra-firm transactions, are subject to gravity forces; but also sales of relatively small foreign affiliates are significantly affected by geographical barriers. Two puzzles emerge: (i) why intra-firm trade is concentrated among the largest multinational firms? and (ii) what are the mechanisms that drive affiliates' sales in the lower tail of the distribution to obey gravity forces, even in the absence of intra-firm trade? In this paper we deliver a framework to explain theses two phenomenas. An affiliate's marginal cost is affected by the parent decision regarding the method of knowledge transfer. Exporting intermediate inputs embodying knowledge to an affiliate is subject to the standard iceberg-type trade costs and fixed costs of intra-firm trade. The costs of direct knowledge transfer are also increasing with geographical barriers but rises less than the costs of exporting intermediate inputs. Because of the fixed costs of intra-firm trade, only the most productive multinational firms choose to export to its affiliates. Moreover, the share of imported intermediate inputs to the affiliate's total costs is increasing with firm's productivity. We show that, in equilibrium and taking into account both the intensive and the extensive margins, foreign affiliates' sales for both the affiliates who import and do not import from parents suffer from gravity forces.

CHAPTER II

Trade and Technology Adoption

2.1 Introduction

The characteristics of firms have played a major role in the recent trade literature. On one hand, empirically, many studies show that exporters tend to be larger, more productive, and pay higher wages (Bernard and Jensen, 1999, 2004). Theoretically, Melitz (2003) has developed a new trade theory with heterogeneous firms and monopolistic competition where only the most productive firms choose to export.[1] On the other hand, several papers show that the decision to invest in productivity-enhancing activities and the decision to export are in fact complements.[2] That is, export market participation induces firms to invest more in productivity-enhancing activities and,

[1]Bernard et al. (2003) also deliver a heterogeneous-firm model under perfect competition where only the most productive firms export.

[2]For instance, Baldwin and Gu (2003, 2004, 2006) demonstrate that export participation for Canadian manufacturing plants is associated with plants' productivity growth. Van Biesebroeck (2005) shows that entry into exporter market increases exporters productivity advantage in nine African countries. De Loecker (2007) employs matched sampling techniques on Slovenian manufacturing firms operating between 1994–2000 to investigate the impact of export on a firm's productivity. He finds that exports increase a firm's productivity by 20 percent. Using a microlevel data for firms in Taiwanese electronic industry to investigate the impact of export participation on a firm's productivity, Aw et al. (2007, 2011) confirm the complementarity between export participation and R&D. Bustos (2011b) finds that, following a reduction in Brazilian tariffs, Argentinean exporters upgrade technology production. Lileeva and Trefler (2010) demonstrate that Canadian plants that were induced by the U.S. tariff cuts to export had higher adoption rates for advanced production technology. More supporting evidences on the impact of exporting on firm's productivity were also found by Isgut and Fernandes (2007) and Park et al. (2010).

hence, improves exporters' productivity.[3]

On average, 20 percent of the firms export, whereas the majority of the firms serve only the domestic market (Bernard and Jensen, 1999). How do nonexporters respond to trade liberalization? Will nonexporters adapt their level of production technology in response to reduction in trade impediments, or, conditional on surviving, will their characteristics remain unchanged? Is the exit option documented in the literature the only available tool for nonexporters? Does trade liberalization affect new exporters and old exporters alike? Is it the decision to export that matters, or where to export and how much to export when it comes to a firm's choice of production technology? Indeed, we have learned a great deal about firms' characteristics and how firms respond to trade liberalization, yet many aspects of the above questions remain unanswered or partially answered. In this paper, I try to fill this gap and provide a unified theoretical model that is applicable in addressing and answering these questions.

Moreover, the paper is motivated by the modeling limitations in the existing literature. The existing literature that models the linkages between exporting and firms' productivity is not as convincing as the self-selection modeling of productivity i.e., Melitz (2003). Most of the models impose binary choice of technology investment (high and low) and limit the impact of trade liberalization on firms' productivity to a subset of firms (for instance, new exporters, firms in the third quartile of the productivity distribution, and firms operating under low technology investment). Furthermore, the direction of the impact is forced to flow from a low level of technology investment to a high level of technology investment without addressing the possibility of downgrading (Bustos, 2011b; Atkeson and Burstein, 2010; Melitz and Costantini, 2007; Lileeva and Trefler, 2010; Yeaple, 2005). Finally, the relationship between in-

[3] The literature has emphasized on two main channels that link export participation to firms' productivity: (i) "learning- by- exporting" channel (Delgado et al., 2002), and (ii) market size channel: innovation (R&D) and market size are complements (Bustos, 2011b; Lileeva and Trefler, 2010; Caliendo and Rossi-Hansberg, 2012).

vestment in technology-enhancing activities and firms' productivity is exogenously specified and lacks the necessary microfoundations.

I provide a tractable model in which the direction of the impact of trade liberalization on firms' productivity, in principle, can go any direction, and more importantly, it reaches all surviving firms in the economy (nonexporters, new exporters, and old exporters). In so doing, new insights and testable implications are born out of the more flexible modeling: In response to reduction in variable trade cots, nonexporters downgrade their level of technology investment whereas exporters upgrade their level of technology investment. In other words, the gap between exporters' productivity and nonexporters' productivity increases. Yet unlike the related theoretical papers, the gap is widening not merely because of exporters adopting higher levels of technology but also because nonexporters downgrade the level of technology adopted. Old exporters and new exporters upgrade their technology investment disproportionately,[4] with new exporters experiencing large increases in productivity whereas old exporters productivity is almost unchanged. In response to reduction in fixed cost of trade (export), old exporters slightly downgrade technology adopted whereas nonexporters slightly adopt higher technology. New exporters, however, enjoy a sizable growth of production technology adopted and thus higher productivity.

Consistent with De Loecker (2007)'s empirical findings, firms' productivity responses to trade liberalization depend on domestic and export markets' characteristics. The larger the domestic market relative to the export market, the smaller the impact of trade liberalization on firms' decisions on production technology adoption. Moreover, exporters' productivity responses to trade are also positively associated with the number of export market destinations.

The implication of heterogeneous firms' productivity responses for the gains from

[4] Backus (2011) uses a quantile response model to show that changes in market size quasi–proportionately affects all firms regardless of their productivity percentile.

trade is important but understudied.[5] Gains from international trade are magnified by firms' decisions to exit, export and invest in productivity-enhancing activities.[6] To quantify the gains from international trade under the current framework, model's parameters are calibrated to match the stylized facts regarding firms' characteristics in the global economy. Relative to the counterfactual scenario in which firms' productivity is exogenous and invariant to trade costs, gains from trade openness are 50% to 100% higher even with some firms adopting lower level of technology in the open economy.

In a standard monopolistically competitive economy with heterogeneous firms and CES preferences, a firm chooses the number of intermediate inputs N and the amount of intermediate input each supplier provides (each supplier produces one intermediate input). The number of intermediate inputs N is our measure of production technology. Firms with higher N have more specialized production units (Grossman and Helpman, 1991). As in (Acemoglu et al., 2007), a firm's productivity is solely a function of technology adopted N, that is, the number of intermediate inputs used in producing the final good. Firms with higher N are more productive, and charge lower prices. The adoption of technology N conveys costs. Using more intermediate inputs requires sophisticated managerial skills and communication technology necessary to coordinate between the specialized production units. The cost of adopting technology N is firm specific where each firm learns its cost parameter after paying a sunk entry cost. The cost parameter draw represents a firm's ability to organize production process. Firms

[5] In fact, the implication of endogenous firms' productivity for the gains from trade is almost absent in the leading papers in this vein (e.g., Bustos, 2011b; Lileeva and Trefler, 2010). There are two important exceptions here: Atkeson and Burstein (2010) find that in a general equilibrium model where firms' decisions to export and innovate depend on trade costs, the impact of the changes in these decisions on welfare is largely offset by the firms' entry decision. Similar to the finding of the current paper, Caliendo and Rossi-Hansberg (2012) estimate that endogenous firms' productivity responses to trade liberalization increase the gains from trade by 41 percent relative to standard models.

[6] I also show that if there is no export fixed cost and hence all firms export, there will be no impact of trade liberalization on firms' investment in technology-enhancing activities (a result that is consistent with Eaton and Kortum, 2001; Atkeson and Burstein, 2010).

with lower cost draws are more efficient in organizing the process of the production and tend to be more specialized (higher N).

A firm chooses the number of intermediate inputs and the amount of each intermediate input to maximize its profits given the isoelastic demand it faces. The optimal production technology is increasing in the market size facing the firm and decreasing in cost draw. Consequently, in the closed economy, firms' technology, productivity, price, and profits are differentiated only because of the firm-specific draw. That is, the model is isomorphic to the Melitz model in the closed economy.

In an open economy, only the most productive firms choose to export due to the fixed cost of export. Exporters sell to both markets (domestic and foreign), whereas nonexporters only sell to the domestic market. Because a firm's choice of production technology depends on the market size facing the firm, trade liberalization magnifies the productivity gap between the most productive firms (who become exporters) and the least productive firms (nonexporters).

In addition, exporters choose a higher level of N relative to the autarky level since exporters' total sales to all destinations are larger than the autarky sales level.[7] This result resonates with the very old idea: profits/large markets enhance innovation. The larger the market is, the higher the level of specialization. Nonexporters, however, reduce N in response to trade liberalization. Simply put, international trade enhances competitiveness and lowers the aggregate price level via the entrance of foreign firms and a self selection effect; in effect, nonexporters respond in what seems counterintuitive at first look by lowering the level of N and charging higher prices. To see this, notice that the effective market size facing nonexporters is smaller relative to autarky; therefore, the resulting revenue from selling to the local market only is not sufficient to maintain the autarky level of production technology. As a result,

[7] This has to be the case for the free entry condition to be satisfied in the open economy. In contrast to the standard model with CES preferences, an exporter's domestic sales might be higher relative to autarky sales. Nevertheless, even with lower domestic sales after trade liberalization, aggregate exporters' sales are always higher than pretrade liberalization sales.

nonexporters reduce their expenditures on productivity-enhancing activities, charge higher prices, and target a smaller fraction of consumers.[8]

As in the standard trade model with monopolistic competition and CES preferences, the optimal price rule is to charge a constant markup over the marginal cost. Nonetheless, the marginal cost of a firm in the current framework is endogenous to export market participation. To be precise, a firm's marginal cost depends on a firm's productivity, which, in turn, is determined by the production technology adopted by a firm. In an open economy, firms decide simultaneously the level of production technology and whether to export, sell only to domestic market, or exist. Consequently, the production technology and the marginal cost are endogenous to export participation. Moreover, a positive correlation between the domestic market sales and the access to the export market is implied in the current model, as empirically documented by Eaton et al. (2011) and Lileeva and Trefler (2010).

The impact of trade on nonexporters seems to contradict the extant literature, where exposure to international markets increases the range of intermediate inputs used in the production of final products by enhancing the process of input creation and by facilitating the know-how technology spillover across borders/firms.[9] The current model is indeed silent about these important issues; instead, I focus on the heterogeneous firms' responses to the exposure to international trade where the cost of the adoption of technology N and/or the creation of new intermediates are held constant and unaffected by trade liberalization. Nevertheless, augmenting the model with these issues would not alter the main result of the paper: International trade affects firms' productivity disproportionately in favor of the initially more productive firms who become exporters in response to trade openness/liberalization.

This paper is related to recent literature on the impact of trade liberalization on

[8] I do not model marketing strategy here as in the study of Arkolakis (2010), but I leave this to future work.

[9] Grossman and Helpman (1991) is the classic treatment of the impact of trade on the process of innovation.

R&D and innovation by firms. Bustos (2011b) shows that a reduction in Brazilian tariffs induces Argentinean exporters to upgrade technology production, especially the firms on the upper middle of the size distribution. Using microdata of Slovenian manufacturing firms and controlling for exporting self-selection, De Loecker (2007) affirms that the productivity gap between exporters and nonexporters increases over time due to a " learning-by-exporting" mechanism. Importantly, De Loecker (2007) shows that the export market destination and the number of export destinations do affect productivity gains from exporting. His finding of positive correlation between the productivity gains and the number of export destinations is consistent with the model's prediction in this paper. Aw et al. (2011) develop and estimate a dynamic, structural model of exporting and R&D investment using data for Taiwanese manufacturing plants in the electronics products industry, where they confirm the complementarity between exporting and productivity-enhancing investments. In line with the current model, the return to exporting and R&D is increasing with initial productivity; thus, more productive firms self-select into both activities. Nevertheless, they model exporting and R&D investments as a binary decision; as a result, the model is unable to connect exporters' productivity gains to export destinations' characteristics and the possibility of downgrading.

The paper is also related to Lileeva and Trefler (2010), who find, by estimating a heterogeneous response model using the Local Average Treatment Effect Estimator (LATE), that Canadian plants that were induced by the U.S. tariff cuts to start exporting or export more had higher adoption rates for advanced production technology and engaged more in productivity-enhancing activities. Atkeson and Burstein (2010) and Melitz and Costantini (2007), in a dynamic environment, formalize the impact of trade liberalization on the firm's productivity and R&D investments. In a different vein, Verhoogen (2008) provides a simple theoretical framework to describe complementarity between exporting and product quality and uses Mexican data to empirically test the model's prediction. In addition to the aforementioned modeling issues, almost all of the papers above ignore the impact of trade liberalization on nonexporters both theoretically and empirically.

As indirect empirical support of the current model prediction, Bustos (2011a) finds that the least productive firms in Argentina downgrade skills in response to Brazilian' tariff reduction. Theoretically, Caliendo and Rossi-Hansberg (2012) is the most related paper to the current model. They show that an individual firm's response to trade openness is heterogenous depending on the firm's initial size and, in the case of exporters, on the export market size. Yet they deliver a decisive prediction at the aggregate level: In response to trade openness, on average, exporters enjoy higher productivity, whereas nonexporters' productivity fall. A firm's productivity is positively linked to the number of managerial layers (internal organization), which is a function of the market size faced by each firm. Because of the discrete nature of the number of layers, firms might not be producing at the minimum efficient scale (MES); therefore, the heterogenous responses to trade liberalization in their model stem from the firm's initial position relative to the MES. Overall, trade liberalization increases exporters' revenues and weakly increases the number of managerial layers and hence exporters' productivity. Nonexporters weakly decrease the number of managerial layers, leading to lower productivity, on average.

The rest of the paper is organized as follows. Section 2.2 describes the model. Section 3 describes the technology adoption in the closed economy. Section 2.4 studies a firm's production technology choices in the open economy. Section 2.5 presents a functional form for the cost function and solves for the model numerically. Section 6 concludes. All proofs and additional results can be found in Appendix 2.7 and Appendix 2.8

2.2 The Model

The world economy consists of two countries, D and F, where each country is endowed with fixed amounts of agents, L_D and L_F. Labor is the only factor of production. A representative agent in each country inelastically supplies one unit of labor. The total labor force for each country is also L_D and L_F.

2.2.1 Preferences

A representative consumer in country $i = D$, F maximizes utility derived from the consumption of goods from $H + 1$ sectors. Sector 0 provides a single homogenous good. Sectors $1 \ldots H$ are composites of differentiated goods. Each variety ω in sector $h = 1 \ldots H$, for all available varieties in the endogenous set Ω_h^i (to be determined), is produced by a unique producer who acts like a monopolist. A consumer's utility from the consumption of the homogenous good and the differentiated goods in country $i = D, F$ can be represented as follows:

$$U^i = Q_0^{\beta_0} \prod_{h=1}^{H} \left(\int_{\omega \in \Omega_h^i} q_h^d(\omega)^{\frac{\varepsilon_h - 1}{\varepsilon_h}} d\omega \right)^{(\frac{\varepsilon_h}{\varepsilon_h - 1})\beta_h} \tag{2.1}$$

$\beta_{h=1 \ldots H} \in (0, 1)$ is the fraction of a consumer's income spent on varieties of sector h, and $\beta_0 = 1 - \sum_{h=1}^{H} \beta_h$ is the fraction of income spent on the homogenous sector. $q_h^d(\omega)$ denotes the consumption of variety ω in sector h, and Q_0 represents the consumption of the good in the homogenous sector. $\varepsilon_h \in (1, \infty)$ is the elasticity of substitution between varieties in sector h.

2.2.2 Production

In the homogenous sector 0, there is a large number of price-taking firms producing the same good Q_0. The production of Q_0 features a linear technology in the only factor of production L, where a units of labor are required to produce one unit of Q_0.

$$Q_0 = \frac{1}{a_i} L_0 \qquad i = D, F$$

The production of variety ω in sector $h = 1 \ldots H$ depends on the level of technology adopted by the firm. Firms that endogenously choose to use a high range of intermediate inputs in the production process become more specialized and enjoy higher productivity. Consequently, the production technology of the firm is denoted by $N \in \mathbb{R}_+$, and for each $j \in [0\,,\, N]$, $X(j)$ is the quantity of intermediate input j. Given technology N, the production function of the firm is as follows (I suppress country indicator i for notational simplicity):

$$q_h(\omega) = N^{\kappa+1-\frac{1}{\alpha_h}} \left(\int_0^N X(j)^{\alpha_h} dj \right)^{\frac{1}{\alpha_h}} \qquad \alpha_h \in (0,1),\ \kappa > 0 \tag{2.2}$$

The function above is proposed by Benassy (1998) and used by Acemoglu et al. (2007). α_h determines the degree of complementarity between inputs. The elasticity of substitution between inputs $\frac{1}{1-\alpha_h}$ is always greater than 1. Benassy (1998) introduces $N^{\kappa+1-\frac{1}{\alpha_h}}$ in order to separate the elasticity of output with respect to the level of technology from the elasticity of substitution between inputs. To illustrate this point, suppose that $X(j) = X \, \forall j \in [0, N]$; hence, $q_h(\omega) = N^{\kappa+1} X$. Indeed, a firm's productivity is not a function of α_h, where productivity is defined as $\frac{q}{NX}$. The parameter κ determines the elasticity of productivity with respect to N. As in Acemoglu et al. (2007), there is a large number of profit maximizing suppliers, where every intermediate input is produced by one supplier.[10] It is worth noting that under this setting the measure of technology N is also a measure of the suppliers hired by a firm. The production technology of intermediate $X(j) \, \forall j \in [0, N]$ is identical to the

[10]Suppliers are still acting as price takers because, potentially, a final good producer could choose any supplier to produce that particular intermediate input.

production technology in sector 0: $X(j) = \frac{1}{a} L_j, \quad \forall j \in [0, N]$.

Adopting a technology N in sector h involves cost $C(N, \varphi)$ units of labor. Using a large number of intermediate inputs necessitates more advanced managerial skills and a sophisticated internal organization. That is, as the number of used intermediate inputs increases, a firm needs to acquire a higher level of managerial skills that enable it to organize the process of production efficiently. The cost parameter φ is a random variable drawn from a common cumulative distribution $G_h(\varphi)$, with associated probability density $g_h(\varphi)$ and $\frac{1}{\varphi} \in [1, \infty)$. In this setting, firms who receive high φ are less efficient in organizing the production process. The cost of adopting technology N in sector h, $C(N, \varphi)$, satisfies the following conditions for all sectors $h = 1 \ldots H$.

Assumption 1. *(i) For all $N \in \mathbb{R}_+$, $C(N, \varphi) = \varphi C(N)$.*

(ii) For all $N > 0$, $C(N)$ is twice continuously differentiable, with $C'(N) > 0$ and $C''(N) \geq 0$.

(iii) For all $N > 0$, $\frac{NC''(N)}{C'(N)} > \kappa(\varepsilon_h - 1) - 1$.

The first part of Assumption 1 tremendously simplifies the analysis.[11] The second part is standard and quite general. The third part, however, is specific to the firm's profit maximization problem in the current context to insure a finite and positive choice of N.[12]

2.3 Closed Economy

In this section, I characterize the technology adoption and the equilibrium in the closed economy.

[11]Alternatively, we can impose the more general condition $\partial C(N, \varphi)/\partial \varphi > 0$ for a given level of N.

[12]Please see the Appendix for detailed derivations of the third part of Assumption 1.

2.3.1 Technology Adoption in the Closed Economy

I will only consider sector h since the other sectors are analogous. For notational clarity, h subscript is dropped in the upcoming analysis. The price of the intermediate input $X(j), \forall \in j \in [0, N]$ is normalized to a; therefore, the equilibrium wage is equal to one.

A representative consumer maximizes her utility given by Equation (2.1) subject to the standard budget constraint: $\int_{\omega} p(\omega)q^d(\omega)d\omega = \beta R$. Here, $p(\omega)$ and $q^d(\omega) = q(\omega)$ are the price and quantity demanded of variety ω, respectively. R is the total expenditure on all varieties for all sectors $h = 0 \dots H$. The demand for variety ω is given by:

$$q^d(\omega) = Ap(\omega)^{-\varepsilon} \tag{2.3}$$

$A \equiv \frac{\beta R}{P^{1-\varepsilon}}$ is exogenous from firms' perspective and represents the market size. The aggregate price level in sector h is given by: $P = \left(\int_{\omega\in\Omega} p(\omega)^{1-\varepsilon}d\omega\right)^{\frac{1}{1-\varepsilon}}$.

Production in the differentiated goods sector: There is a continuum of firms each choosing to produce a different variety ω, where production technology is given by Equation (2.2). A firm learns its cost draw only after paying a sunk entry cost f^E units of labor. If a firm chooses to produce a positive amount of ω, it must pay a fixed cost f units of labor. Conditional on producing a positive amount of variety ω, a firm's profit maximization problem is calculated as follows:[13]

$$\max_{N,\{X(j)\}_j} \pi(N, X(j)) = p(\omega)q(\omega) - \left[\int_0^N aX(j)dj + \varphi C(N)\right] - f,$$

[13]Because we are assuming a continuum of firms, the effects of each firm's action on the aggregate variables is negligible; therefore, all firms take the aggregates as given. Moreover, we assume there is no strategic interaction between firms.

where $p(\omega)q(\omega) = q(\omega)^{\frac{\varepsilon-1}{\varepsilon}} A^{\frac{1}{\varepsilon}}$ and $q(\omega) = N^{\kappa+1-\frac{1}{\alpha}} \left(\int_0^N X(j)^\alpha dj\right)^{\frac{1}{\alpha}}$. Since the objective function above is jointly concave in $X(j)$ and the price of $X(j) = a \, \forall j$, the firm chooses the same level X for all intermediate inputs. Imposing $X(j) = X \, \forall j \in [0, N]$ and plugging in the constraints in the objective function, the maximization problem is then simplified to:

$$\max_{N,X} \pi(N, X) = N^{\frac{\varepsilon-1}{\varepsilon}(\kappa+1)} X^{\frac{\varepsilon-1}{\varepsilon}} A^{\frac{1}{\varepsilon}} - \{aNX + \varphi C(N) + f\} \tag{2.4}$$

By solving the first-order conditions of the profits maximization problem above, we obtain

$$\kappa \left(\frac{\varepsilon - 1}{\varepsilon}\right)^{\varepsilon} a^{1-\varepsilon} A (N^*)^{\kappa(\varepsilon-1)-1} = \varphi C'(N^*) \tag{2.5}$$

$$X^* = \frac{\varphi C'(N^*)}{a\kappa} \tag{2.6}$$

In the Appendix, I show that the second-order conditions are satisfied under Assumption 1. The first-order conditions (Equations (2.5) and (2.6)) can be solved recursively and yield a unique solution for N^* and X^*.

Proposition II.1. *Under Assumption 1, there exists a unique level of* $N^* > 0$, $X^* > 0$ *such that* N^*, X^* *satisfy*

$$\frac{\partial N^*}{\partial A} > 0, \qquad \frac{\partial X^*}{\partial A} \geq 0$$
$$\frac{\partial N^*}{\partial \alpha} = 0, \qquad \frac{\partial X^*}{\partial \alpha} = 0$$
$$\frac{\partial N^*}{\partial \varphi} < 0, \quad sign(\frac{\partial X^*}{\partial \varphi}) = sign(1 - \kappa(\varepsilon - 1))$$

Proof. In the appendix □

The level of technology N is increasing with the market size (A). This is a standard and a well-established result. Firms tend to have higher spending (investment) on productivity-enhancing activities (higher N) when facing large markets since the expected return from such investment is high enough to cover the investment cost. On the other hand, a firm selling to a small market is reluctant to spend aggressively on advanced technology because the return from such technology is not large enough to cover the high costs of adopting it. This is reminiscent of the old argument: Innovation is driven by profits. To be precise, it has been argued that the firm's profits ease the financial constraints on funding productivity-enhancing activities, leading to higher investment in R&D and productivity-enhancing activities. Conversely, the current model emphasizes on the return of productivity-enhancing activities across markets. The relationship between α and N is consistent with the result of Acemoglu et al. (2007): Under complete contracts, N is independent of α. The relationship between the level of technology adoption and the cost draw is fairly intuitive; firms with low draws choose higher N.

Although production technology N is decreasing with φ, the relationship between the total cost of adopting technology N, $\varphi C(N)$, and φ is ambiguous. Nevertheless, it is crucial to have a reasonable relationship between φ and total cost of technology adoption. Specifically, firms that receive low φ are expected to invest (spend) more on adopting more advanced technology.[14] In order to guarantee this relationship for any level of N, the cost function $C(N)$ has to satisfy the following assumption.

Assumption 2. *(i) For all $N > 0$, $C(N)$ is log- concave.*

(ii) For all $N > 0$, $N\left[\frac{C'(N)}{C(N)} - \frac{C''(N)}{C'(N)}\right] > 1 - \kappa(\varepsilon - 1)$.

Indeed, the first part of Assumption 2 restricts the set of convex cost functions we can use, but it is not a very restrictive assumption. Most of the standard cost

[14] Notice that I use the level of technology investment and the cost of adopting technology N interchangeably. That is, empirically, firms report their level of expenditures on R&D and/or productivity-enhancing activities, which often are seen as technology investments through the lens of econometricians. In the current model, the environment is static (I only consider steady-state equilibrium); hence, using both terminologies interchangeably shall not cause any confusion.

functions satisfy the log-concavity assumption. The second part of Assumption 2 is quite demanding; however, for most of the standard cost functions, it will hold as long as part 3 of Assumption 1 holds (for example, see Section **??**. In general, convex polynomial functions satisfy the assumption above).

Lemma II.1. *Define the total expenditure on technology investment measured in labor units by $\varphi C(N)$. Suppose that Assumption 1 and Assumption 2 hold, then the total expenditure on technology investment is decreasing with φ.*

$$\frac{\partial \varphi C(N)}{\partial \varphi} < 0$$

Proof. In the appendix □

Lemma II.2. *A firm's productivity level P^* defined by $\frac{q}{\int_0^N X(j)dj}$, which is equivalent to $\frac{q}{NX}$ if $X(j) = X$ is decreasing in φ.*

$$\frac{\partial P^*}{\partial \varphi} < 0$$

Proof. In the appendix □

Proposition II.2. *The profit function $\pi(N, X)$ is decreasing in φ:*

$$\frac{\partial \pi(N, X)}{\partial \varphi} < 0$$

Proof. In the appendix □

It is straightforward to see that the price charged by a firm is decreasing with N, whereas quantity supplied, total revenue, and profit are all increasing with N. Importantly, the ratio of two firms' levels of technology is solely a function of the ratio of their φ's.[15]

$$\frac{N(\varphi_1)}{N(\varphi_2)} = \vartheta_n\left(\frac{\varphi_1}{\varphi_2}\right) \qquad \vartheta_n'(\varphi) < 0$$

In the closed economy, the model is isomorphic to Melitz (2003), where firm's productivity is just a monotonic transformation in φ. That is, φ in the Melitz's model is replaced by $f(\varphi)$ in the current model ($f'(\varphi) < 0$); therefore, the model is solved accordingly.

2.3.2 Equilibrium in the Closed Economy

Consider the profit maximization problem of a firm with a given N.

$$\max_{p(\omega)} \pi(p,q) = p(\omega)q(\omega) - aNX - \overbrace{(\varphi C(N) + f)}^{\text{fixed cost}},$$

subject to $q(\omega) = Ap(\omega)^{-\varepsilon}$, and $X = \frac{q(\omega)}{N^{\kappa+1}}$.

The first-order condition of the above problem implies that a firm charges a price that is a constant markup over the marginal cost. The marginal cost for a given level of N and a, $MC(a,N)$, is defined by $\frac{\partial \frac{aNq}{N^{\kappa+1}}}{\partial q}$.

$$p(\omega) = \frac{\varepsilon}{\varepsilon - 1}\frac{a}{N^\kappa} \tag{2.7}$$

The price rule here is consistent with the standard monopolistic competition models with the CES preferences of Dixit and Stiglitz (1977). However, it is important to highlight the difference between the price rule in the current framework and in Melitz (2003). In contrast to Melitz (2003), the marginal cost in Equation (2.7) is endogenous; in particular, it depends on the chosen level of technology N, which in turn is given by Equation (2.5), that is, the marginal cost of a firm is endogenous to export participation. In a closed economy, nonetheless, the exogenous cost draw is

[15] In the Appendix I elaborate more on this point and show how we can use it to prove the existence of the equilibrium in both the closed and the open economies.

the only heterogeneous variable across firms (market size A is common to all firms in sector h); therefore, the choice of N and hence the marginal cost are distinct among firms who are serving the same sector h only because of the firm-specific cost draw φ (i,e., isomorphic to Melitz (2003)). A firm's revenue $r(\omega) = p(\omega)q(\omega)$ and profit, $\pi(\omega)$ are given as follows:

$$r(\omega) = A\left(\frac{\varepsilon}{\varepsilon - 1}\frac{a}{N^{\kappa}}\right)^{1-\varepsilon} \tag{2.8}$$

$$\pi(\omega) = \frac{1}{\varepsilon}r(\omega) - (\varphi C(N) + f) \tag{2.9}$$

Firms with the same cost draw behave symmetrically. In particular, they choose the same technology N, charge the same price, and supply the same quantity. I therefore index the firms from now on by N or φ interchangeably instead of ω.

Definition II.1. A steady-state equilibrium is characterized by constant masses of firms entering and producing, as well as, a stationary ex post distribution cost parameter φ among producing firms such that goods and labor markets clear.

Firms pay a fixed cost of production f^E in order to discover φ. After observing their draws, firms decide to operate or exit the market. Existing firms face a constant and exogenous probability of death δ each period. Let M^E denote the total mass of firms that enter in a given period. M is the mass of firms operating in equilibrium. The value of a firm operating in the market is:

$$V(\varphi) = \max\left\{0, \sum_{t=0}^{\infty}(1-\delta)^t \pi(N(\varphi))\right\} = \max\left\{0, \frac{\pi(N(\varphi))}{\delta}\right\} \tag{2.10}$$

$\pi(N)$ is given by Equation (2.9). The ex post φ's distribution $\mu(\varphi)$ is a truncation of the ex ante φ's distribution, $g(\varphi)$, at the zero profit.

$$\mu(\varphi) = \begin{cases} \frac{g(\varphi)}{G(\varphi_D)}, & \text{if } \varphi < \varphi_D \\ 0, & \text{otherwise} \end{cases}$$

where φ_D is the zero-profit cutoff (ZPC) draw: $\varphi_D; \pi(N(\varphi_D) = 0$. A ZPC can be written as

$$\frac{1}{\varepsilon} r(N(\varphi_D) = f + \varphi_D C(N(\varphi_D)) \tag{2.11}$$

A free entry condition (FEC) drives the expected value of the firm to 0. That is,

$$\int_0^{\varphi_D} \pi(N(\varphi))g(\varphi)d\varphi = \delta f^E \tag{2.12}$$

In order for the mass of operating firms M to be constant, the mass of new producers has to be equal to the mass of firms that die every period: $G(\varphi_D)M^E = \delta M$. In this setting, M^E represents the mass of potential entrants. Labor market clearing is given by:

$$\beta L = \frac{M}{G(\varphi_D)} \left[\delta F^E + \int_0^{\varphi_D} \left(f + \frac{aq(N(\varphi))}{N(\varphi)^\kappa} + \ell(C(N(\varphi), \varphi)) \right) dG(\varphi) \right] \tag{2.13}$$

Goods market clearing is

$$R = L \tag{2.14}$$

$\ell(C(N(\varphi), \varphi)) = \ell(\varphi C(N(\varphi)))$ is the cost of adopting technology N measured in the units of labor. For simplicity, I assume that $\ell(\varphi C(N)) = \varphi C(N)$. Hence, the total cost of adopting technology N measured in the units of labor is $w\varphi C(N(\varphi))$.

Proposition II.3. *There exists a unique steady-state equilibrium that satisfies* (2.11), (2.12), (2.13), (2.14), *and the constant mass of firms condition* $G(\varphi_D)M^E = \delta M$

Proof. In the appendix □

Proposition II.4. *The ZPC φ_D is independent of L as well as the market size A. The number of operating firms in the equilibrium and the welfare measured by the inverse of the price level, nevertheless, are increasing with L.*

Proof. In the appendix □

2.4 Open Economy

The world economy consists of two countries, D and F with identical preferences and production technology in all sectors but different labor force size, $L_D \neq L_F$. Firms from country $i = D, F$ that export to country $i' \neq i$ pay a one time fixed cost of exporting $f_{i'i}$. In addition, shipping goods from country i to i' is costly. In particular, firms in country $i \in \{D, F\}$ need to ship $\tau_{i'i} > 1$ units of variety ω in order for one unit of variety ω to arrive at country $i' \in \{D, F\}$. The homogenous good Q_0 is freely traded and is used as the numeraire. Its price is set equal to a. If country i produces Q_0 in the open economy, the wage in country i is 1. I assume that the share of expenditures on Q_0, β_0, and L_i $i \in \{D, F\}$ are large enough so that both countries continue to produce the homogenous good in the open economy.[16] I also assume that there is no trade in intermediate goods; only final goods are traded. Preferences in country $i \in \{D, F\}$ are as follows

$$U^i = Q_0^{\beta_0} \prod_{h=1}^{H} \left(\int_{\omega \in \Omega_h^{i*}} q_h(\omega)^{\frac{\varepsilon_h - 1}{\varepsilon_h}} d\omega \right)^{(\frac{\varepsilon_h}{\varepsilon_h - 1})\beta_h} \tag{2.15}$$

$\Omega_h^{i*} = \Omega_h^{ii} \bigcup \Omega_h^{ii'}$ is the set of all available varieties in sector h in country i, which is a composite of all domestically produced varieties and imported varieties from country

[16]The assumption is made for simplification purposes. Relaxing this assumption would not alter the main results of the paper because the model's mechanisms depend on the real wages in both countries not on the nominal wages. In response to trade liberalization, real wages increase in the model with or without the outside sector.

i'. Again, in the upcoming analysis, I consider only the equilibrium outcome for sector $h = 1 \dots H$ (sector's subscript is suppressed for notational clarity).

2.4.1 Technology Adoption in the Open Economy

The profit maximization problem for nonexporters in country i is identical to the closed economy, except that they face a different market size, $A_{i*} \equiv \frac{\beta L_i}{P_{i*}^{1-\varepsilon}}$, where

$$P_{i*} = \left[\int_{\omega \in \Omega^{i*}} p(\omega)^{1-\varepsilon} d\omega \right]^{\frac{1}{1-\varepsilon}} \tag{2.16}$$

As a result, the nonexporter's optimal choices of N_{ii} and X_{ii} are given as follows:

$$\kappa \left(\frac{\varepsilon - 1}{\varepsilon} \right)^{\varepsilon} a^{1-\varepsilon} A_{i*} N_{ii}^{\kappa(\varepsilon-1)-1} = \varphi C'(N_{ii}) \tag{2.17}$$

$$X_{ii} = \frac{\varphi C'(N_{ii})}{a\kappa} \tag{2.18}$$

Now consider the profit maximization problem for a country i exporter:

$$\max_{N,X} \pi(N, X) = p_{ii}(\omega) q_{ii}(\omega) + p_{i'i}(\omega) q_{i'i}(\omega) - \left[\int_0^N aX(j)dj + \varphi C(N) + f_i + f_{i'i} \right],$$

where $p_{ii(\omega)} q_{ii}(\omega) = q_{ii}^{\frac{\varepsilon-1}{\varepsilon}} A_{i*}^{\frac{1}{\varepsilon}}$, $p_{i'i}(\omega) q_{i'i}(\omega) = q_{i'i}^{\frac{\varepsilon-1}{\varepsilon}} A_{i'*}^{\frac{1}{\varepsilon}}$, and $q_{ii} + \tau_{i'i} q_{i'i} = q = N^{\kappa+1} X$.

$r_{i'i}(\omega) = p_{i'i}(\omega) q_{i'i}(\omega)$ is the value of exports of a firm that resides in country i to country i' net of the transportation cost. The exporter profit maximization problem is simplified to[17]

[17] Too see this, consider the profit maximization problem for an exporter given a constant level of N

$$\max_{q_{ii}, q_{i'i}} q_{ii}^{\frac{\varepsilon-1}{\varepsilon}} A_i^{\frac{1}{\varepsilon}} + q_{i'i}^{\frac{\varepsilon-1}{\varepsilon}} A_{i'}^{\frac{1}{\varepsilon}} - \frac{aq}{N^\kappa} - (\varphi C(N) + f_{ii} + f_{i'i})$$

subject to $q_{ii} + \tau q_{i'i} = q$. From the first-order conditions, $q_{ii} = \left(\frac{\varepsilon}{\varepsilon-1} a/N^\kappa \right)^{-\varepsilon} A_i$ and $q_{i'i} = \left(\frac{\varepsilon}{\varepsilon-1} \tau a/N^\kappa \right)^{-\varepsilon} A_{i'}$. The prices are given by $p_{ii} = \frac{\varepsilon}{\varepsilon-1} a/N^\kappa$ and $p_{i'i} = \tau p_{ii}$. Substitute for the

$$\max_{N,X} \pi(N,X) = N^{\frac{\varepsilon-1}{\varepsilon}(\kappa+1)} X^{\frac{\varepsilon-1}{\varepsilon}} \mathcal{A}^{\frac{1}{\varepsilon}} - aNX - \varphi C(N) - (f_i + f_{i'i}) \tag{2.19}$$

The first-order conditions of the above problem yield the following optimal choices of the level of technology and the amount of each intermediate N_e, X_e:

$$\kappa \left(\frac{\varepsilon-1}{\varepsilon}\right)^{\varepsilon} a^{1-\varepsilon} \mathcal{A}_i N_e^{\kappa(\varepsilon-1)-1} = \varphi C'(N_e) \tag{2.20}$$

$$X_e = \frac{\varphi C'(N_e)}{a\kappa} \tag{2.21}$$

Here $\mathcal{A}_i \equiv A_i + \tau_{i'i}^{1-\varepsilon} A_{i'}$ is the total (domestic and foreign) market size that faces an exporter from country i. The elasticity of substitution ε controls the importance of trade impediments for trade flows. Indeed, propositions (1)–(4) apply to the technology adoption in the open economy. Two points are worth mentioning, however: (1) the level of technology N is decreasing in transportation cost τ since $\mathcal{A}$ is decreasing in τ and increasing in the export market size $A_{i'}$, and (2) the differences in N across exporters depend only on the cost parameter φ. Nevertheless, the ratio of exporter's technology to nonexporter's technology is now determined by both the ratio of their costs parameter and the ratio of market sizes faced by each firm,

$$\frac{N(\varphi_1)^{EXP}}{N(\varphi_2)^{NEXP}} = \vartheta_a \left(\frac{\mathcal{A}}{A}\right) \vartheta_n \left(\frac{\varphi_1}{\varphi_2}\right), \qquad \vartheta_a'(.) > 0. \tag{2.22}$$

prices and quantities in the profit function to get the reduced form function as a function of N:

$$N(.) = arg \max_N \pi(N) =$$

$$\left(\frac{\varepsilon}{\varepsilon-1} a/N^{\kappa}\right)^{1-\varepsilon} \left[A_i + \tau^{1-\varepsilon} A_{i'}\right] - a^{1-\varepsilon} \left(\frac{\varepsilon}{\varepsilon-1} a/N^{\kappa}\right)^{-\varepsilon} \left[A_i + \tau^{1-\varepsilon} A_{i'}\right] / N^{\kappa} - \varphi C(N) - f_{ii} - f_{i'i}$$

f.o.c. and some algebra,

$$\kappa \left(\frac{\varepsilon-1}{\varepsilon}\right)^{\varepsilon} a^{1-\varepsilon} \mathcal{A}_i N^{\kappa(\varepsilon-1)-1} = \varphi C'(N)$$

$\frac{\mathcal{A}_i}{A_{i*}} = 1 + \tau^{1-\varepsilon}\frac{A_{i'i*}}{A_{i*}}$ is increasing with the export destination market size $A_{i'i*}$ and decreasing in the domestic market size A_{i*} and the transportation cost $\tau_{i'i}$. As a result, the ratio of the level of technology adopted by an exporter to that of nonexporter is increasing with the size of export market destination and decreasing with τ and the domestic market size A_{i*}.[18] Equation (2.22) is of great interest theoretically and empirically. The equation generates a clear-cut prediction about the effects of trade openness/liberalization on the level of technology adopted by exporters relative to nonexporters. That is, trade liberalization magnifies the productivity differences between exporters and nonexporters. Interestingly, the magnitude of the magnification depends on the ratio of the export destination market size to the domestic market size. Moreover, in a multicountry model, the size of the export destination market is also increasing with the number of the markets. This said, the ratio of an exporter's level of technology to a nonexporter's level of technology is also magnified by the number of export destinations. Unless we solve for the steady state equilibrium in the open economy, nothing can be said about firms' level of technology posttrade liberalization relative to their level of technology in autarky.

2.4.2 Equilibrium in the Open Economy

To solve for the steady-state equilibrium in the open economy, I use the same technique I used in the closed economy; namely, I start with the reduced-form description of the economy for a given level of N and then from there proceed to solve for the steady-state equilibrium. In so doing, I provide a comparable model with the standard Melitz's model, and more importantly, I develop a tractable framework for the analysis of the impact of trade liberalization on firms' productivity.

As in the closed economy, a nonexporter with fixed N_{ii} sets $p_{ii} = \frac{\varepsilon}{\varepsilon-1}\frac{a}{N_{ii}^{\kappa}}$ and

[18] In the symmetric country case, the ratio is reduced to $\vartheta_a((1+\tau^{1-\varepsilon}))\vartheta_n(\frac{\varphi_1}{\varphi_2})$; therefore, the ratio is magnified by a constant multiple that is greater than 1.

generates a revenue and a profit of $r_{ii} = A_{i*}\left(\frac{\varepsilon}{\varepsilon-1}\frac{a}{N_{ii}^{\kappa}}\right)^{1-\varepsilon}$ and $\pi_{ii} = \frac{1}{\varepsilon}r_{ii} - (\varphi C(N_{ii}) + f_{ii})$. Similarly, an exporter's quantities supplied in both markets, the prices charged in the domestic and foreign markets, the total revenues, and the profits are given by:[19]

$$
\begin{aligned}
q_T^e &\equiv q_{ii}^e + \tau_{i'i}q_{i'i}^e = N_e^{\kappa+1}X \\
p_{ii}^e &= \frac{\varepsilon}{\varepsilon-1}\frac{a}{N_e}, \qquad p_{i'i}^e = \tau_{i'i}p_{ii}^e \\
r_T^e &\equiv r_{ii}^e + r_{i'i}^e = \left(A_{i*} + \tau_{i'i}^{1-\varepsilon}A_{i'*}\right)\left(\frac{\varepsilon}{\varepsilon-1}\frac{a}{N_e^{\kappa}}\right)^{1-\varepsilon} \\
\pi_T^e &\equiv \pi_{ii}^e + \pi_{i'i}^e = \frac{1}{\varepsilon}r_T - [\varphi C(N_e) + f_i + f_{i'i}]
\end{aligned}
$$

Again, the price charged by an exporter in both markets is standard and consistent with the standard monopolistic competition models with CES preferences: the price is a constant markup over the marginal cost. In contrast to the standard model, the marginal cost is an endogenous variable via the choice of N. Moreover, markets are not separable as in the standard model. The decision to export affects the choice of N and, hence, the marginal cost, price, and sales in the domestic market. This result is also presented by Caliendo and Rossi-Hansberg (2012). The result is also consistent with the empirical documentation Eaton et al. (2011) about French firms. They find that average sales in domestic market rises with selling to more markets. The model above naturally leads to a positive relationship between exporting sales and domestic market sales.

As in the closed economy, the steady-state equilibrium in the open economy is characterized by the free entry; the ZPC, the export cutoff, labor and goods market clearing; constant masses of firms entering, producing, and exporting; stationary ex post distributions of φ among producing and exporting firms; and balanced trade.

[19] Note that $\tau_{i'i}q_{i'i}^e$ is the total amount that is shipped from i to i' and $q_{i'i}$ is the amount consumed by consumers in i'.

The ZPC is derived from

$$\pi_{ii}(\varphi_i) = 0 \tag{2.23}$$

An export cutoff condition is written as follows:[20]

$$\pi_T(\varphi_{i'i}) = \max\{0, \pi_{ii}(\varphi_{i'i})\} \tag{2.24}$$

A free entry condition in the open economy is expressed as follows:

$$\int_{\varphi_{i'i}}^{\varphi_i} \pi_{ii}(\varphi)g(\varphi)d\varphi + \int_0^{\varphi_{i'i}} \pi_T(\varphi)g(\varphi)d\varphi = \delta f^E \tag{2.25}$$

Labor market clears:

$$\beta L = \frac{M_i}{G(\varphi_{ii})}\left\{\delta f^E + \int_0^{\varphi_{ii}} (f + \frac{aq(N(\varphi))}{N(\varphi)^\kappa} + \ell(C(N(\varphi),\varphi)))dG(\varphi) + \int_0^{\varphi_{i'i}} f_{i'i}\, dG(\varphi)\right\} \tag{2.26}$$

The goods' market clearing:

$$R_i = L_i, \qquad i \in \{D, F\} \tag{2.27}$$

When countries are symmetric (i.e., $L_D = L_F$) the trade balance $M_{i'i}\int_0^{\varphi_{i'i}} r_{i'i}(\varphi)\frac{g(\varphi)}{G(\varphi_{i'i})}d\varphi = M_{ii'}\int_0^{\varphi_{ii'}} r_{ii'}(\varphi)\frac{g(\varphi)}{G(\varphi_{ii'})}d\varphi$ is guaranteed by Equations (2.27),(2.26), and (2.25). Here $M_{i'i}$ denotes the mass of country i exporters to country i'. For asymmetric countries, it is well known that the country with larger labor force exports the differentiated goods in net and imports the homogenous good.[21] In the steady-state equilibrium, the masses of exporters and producers (M_i) given the exogenous death probability δ are constant, that is, $G(\varphi_i)M_i^E = \delta M_i = \delta(M_{ii} + M_{i'i})$. M_{ii} is the mass of firms that

[20] $f_{i'i}$ is assumed to be large enough such that only the most productive firms export and the fraction of exporters, $G(\varphi_{i'i})$ is less than the fraction of nonexporters.

[21] In order for both countries to produce the outside sector in the asymmetric countries setting, we impose a lower bound on trade costs $\tau(\frac{L_i}{L_j})$, which is increasing in its argument.

only produce and sell in the domestic market.

Proposition II.5. *There exists unique* $\{\varphi_{i'i}, M_i, M_{i'i}, P_i\}$ *that satisfy the equilibrium conditions (Equations*(2.23)-(2.27)*) and the constant masses of exporting and producing firms as well as a stationary ex post* φ *distribution. Moreover, the ZPC in the open economy,* $(\varphi_i)^{open}$*, is lower than the ZPC in the closed economy,* $(\varphi_i)^{closed}$.

Proof. In the appendix □

The proof of Proposition II.5 is analogous to the proof in the closed economy. I show that the aggregates can be summarized by a weighted average cost draw $\tilde{\varphi}$, where the new weighted average is taken for all available varieties in the economy (i.e., local producers and exporters and the other country exporters). As a result, the ZPC can be written as the relationship between the average profits (for both exporters and nonexporters) and the weighted average cost draw. The FEC is still the same as before: $Pr(\varphi < \varphi_i)\bar{\pi} = \delta f^E$. Again, $\bar{\pi}$ is the average profit for both exporters and nonexporters conditional on successful entry. I also show that $\varphi_{i'i} = f_\varphi(\varphi_i)$; that is, the exporting cutoff is solely a function of the ZPC.

Proposition II.6. *Trade openness increases the welfare in both countries measured by* $P_i^{-1}\, i \in \{D, F\}$.

Proof. In the appendix □

Proposition II.7. *Nonexporters adopt a lower level of technology* N *in response to trade openness, whereas exporters adopt a higher level of* N *compared with the autarky level.*

Proof. In the appendix □

If there is no fixed cost associated with export, $f_x = 0$, all firms export, and the impact of trade openness is isomorphic to increasing the labor size in the closed economy. As a result, A remains unchanged as well as the choice of N by any existing firm.[22] On the other hand, if $f_X > 0$, only a subset of firms export. Nonexporters will adopt lower level of technology because the market size L is constant and the new aggregate price level is lower than the pretrade aggregate price level. In order for the FEC to be satisfied, exporters adopt a higher level of technology as the decrease in aggregate price level is more than offset by the boost in export market revenues.

The model in the open economy is able to generate one of the most prominent features of the Melitz (2003) model and the monopolistic competition models with heterogenous firms[23]; namely, trade liberalization forces the least productive firms to exit the markets and the most productive firms to self-select to export. Nevertheless, in the present model, the self-selection impact is not the only force that affects the aggregate productivity in the economy. Surviving firms also alter their levels of production technology in response to trade openness. That is, trade affects average productivity by forcing the least productive firms to exit the market and by reallocating the resources to more productive firms (i.e., Meltiz's effect), and by inducing the surviving firms to optimally change their levels of production technology and hence productivity.

Gains from trade are assured by Proposition II.6. A very important and vital question in the recent trade literature is the order of magnitude of gains from trade across the predominant trade models.[24] I carry this exercise and compare the gains from trade in the current model when a firm's productivity is endogenous and respon-

[22]Eaton and Kortum (2001) and Atkeson and Burstein (2010) also show that if all firms export, no firm will improve its product quality/production technology.

[23]For example, Chaney (2008); Arkolakis (2010); Arkolakis et al. (2008).

[24]In Eaton and Kortum (2002); Krugman (1980); Melitz (2003) a firm's productivity is constant and unaffected by trade openness. The gains from trade in these models emanate from different channels: resource reallocation toward the comparative advantage sectors (Eaton and Kortum, 2002 as well as factor proportions models), economies of scale and the love for variety (as in Krugman, 1980), and the creative destruction and inter-firm resource reallocation as in Melitz (2003). Interestingly, Arkolakis et al. (2012) show that gains from trade across a wide range of trade models depend on two sufficient statistics: the elasticity of imports with respect to trade impediments and the share of expenditure on domestic goods.

sive to trade liberalization with the gains from trade when the production technology N and the firm's productivity is given by the autarky level in the open economy. The following proposition summarizes the order of magnitude of the gains from trade under the endogenous production technology setting presented in the current model relative to the gains from trade when production technology N is unaffected by trade liberalization.

Proposition II.8. *The gains from trade under endogenous production technology N specified in the current model are larger than the gains from trade when production technology N is constant.*

Proof. In the appendix □

A firm that had survived trade openness in the Melitz's model might not be able to do so in the present model. Firms are confronting much tougher competition relative to the standard Melitz (2003): in addition to the competition coming from foreign exporters, trade openness enhances domestic exporters productivity, leading them to charge lower prices and sell more in the domestic markets. Overall, the forces of creative destruction are magnified on both the extensive and the intensive margins, which, in turn, enlarges the gains from trade.

2.5 Illustrative Examples

In this section, specific functional forms for the technology cost function are provided. Although analytical solution is available in some cases with simple functional forms of the cost of technology, we have to resort to numerical analysis with more complicated cost functions. Even with the simplest cost function I can think of, comparing the gains from trade between models with exogenous productivity and models featuring endogenous technology necessitates the use of numerical methods. Thus, the parameters are calibrated such that the model matches some of the stylized facts regarding the firm's characteristics in the global economy. I simulate the model and calculate a firm's production technology choice under a wide range of settings. The comparative statics analysis is also provided. Moreover, I provide quantitative assessments of the gains from trade and compare it with the no-technology-upgrading scenario.

2.5.1 Example One: Symmetric Countries and Linear Cost of Technology Adoption

The simplest cost function that satisfies Assumption 1 and Assumption 2 is the linear function: $C(N) = N$. In this case, $1 - \kappa(\varepsilon - 1)$ has to be greater than zero, and X is therefore increasing with φ. The first-order conditions Equations (2.5) and (2.6) are then given by:

$$N^* = \Psi A^{\frac{1}{1-\kappa(\varepsilon-1)}} \varphi^{\frac{1}{\kappa(\varepsilon-1)-1}}, \qquad X^* = \frac{\varphi}{a\kappa}$$

Ψ is constant. The exact forms of all constants are provided in Appendix 2.8.

We cannot proceed without parameterizing the distribution of the cost parameter φ. Complying with the literature, I assume that φ^{-1} with the support $[1, \infty)$ is drawn from a Pareto distribution with the shape parameter θ.[25] Using this distribution in the FEC, integrating and substituting for the value of φ_i from the ZPC yield the solution for the ZPC, φ_i, in terms of the model's parameters:

$$\varphi_i = \left[\frac{\delta f^E}{f_i} \lambda \right]^{\frac{1}{\theta}}, \qquad i \in \{D, F\}$$

[25] The cumulative distribution function of a Pareto random variable X with the shape parameter θ is given by: $F(X) = Pr(x < X) = 1 - (\frac{b}{X})^{\theta}$, for $x \in [b, \infty)$ and $b > 0$. Hence, $G(\varphi) = \varphi^{\theta}$ for $\varphi \in (0, 1]$. In order to guarantee the existence of a finite mean we also assume that $\theta > \frac{\kappa(\varepsilon-1)}{1-\kappa(\varepsilon-1)}$. The Pareto distribution assumption provides a good fit for firm level data. Specifically, it is a good approximation of the upper tail of the distribution of firm sizes (Axtell, 2001; Luttmer, 2007; di Giovanni and Levchenko, 2013).

λ is constant. To solve for the number of operating firms, $M_i \in \{D, F\}$, I use the labor market clearing condition Equation(2.13),

$$M^E = \frac{L}{f^E}\frac{1}{\varepsilon}\frac{\kappa(\varepsilon-1)}{\theta}, \qquad M_i = \frac{G(\varphi_i)}{\delta}M^E.$$

Consequently, the aggregate price level P_i, the market size A, and the production technology cutoff N_i are derived.

The characterization of the equilibrium in the closed economy is complete. I turn now to the equilibrium in the open economy. A nonexporter's maximization problem is similar to the closed economy, whereas an exporter with φ draw solves Equation(2.19). The levels of technology N for a nonexporter and an exporter, respectively, are calculated as follows:

$$N^* = \Psi A^{\frac{1}{1-\kappa(\varepsilon-1)}}\varphi^{\frac{1}{\kappa(\varepsilon-1)-1}}, \qquad X^* = \frac{\varphi}{a\kappa}$$

$$N_e^* = B(\tau)N^*(\varphi), \qquad X^* = \frac{\varphi}{a\kappa}$$

$B(\tau)$ is constant for a given τ. The ZPC φ_i, the exporting cutoff φ_X and the number of operating firms M_i in the open economy, respectively, are given as follows:

$$\varphi_i = \left[\frac{\delta f^E}{\frac{f}{\lambda} + \Lambda^\theta \frac{f_X}{\lambda}}\right]^{\frac{1}{\theta}}, \quad \varphi_X = \Lambda\varphi_i, \quad M^E = \frac{L}{f^E}\frac{1}{\varepsilon}\frac{\kappa(\varepsilon-1)}{\theta}, \quad M_i = \frac{G(\varphi_i)}{\delta}M^E$$

Λ is constant. The characterization of the equilibrium in the open economy is complete, where A and the production technology cutoff N^* are derived from the aggregate price level.

2.5.2 Calibration and Simulation

In order to solve the model numerically, I calibrate the model's parameters : $\{\varepsilon, \kappa, a, \theta, f^E, f_i, f_x, \tau, \delta\}$. I solve the model by having firms draw their cost parameter from a Pareto distribution. Given the cutoffs and the price level derived in the previous example, the choice of technology N by each firm in the closed and the open economies can be obtained. Without loss of generality, the size of labor force L, the wage w, and the fixed cost of producing f_i are normalized to one. Parameter κ determines the elasticity of productivity with respect to technology level N is set to 0.25 as in Acemoglu et al. (2007). The elasticity of substitution $\varepsilon = 3.8$ is taken from Bernard et al. (2007). In fact, Anderson and van Wincoop (2004) report available estimates of ε to be in the range of 3 to 10. Given the choice of κ and the restriction imposed by the linear cost function, $(1 - \kappa(\varepsilon - 1)) > 0$, we are bounded to set ε less than 5. I use the approach of di Giovanni and Levchenko (2013) and di Giovanni et al. (2011) to show that a firm's sales follow a power law with exponent equal to $\frac{1-\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)}\theta$. In the data, firm sales follow a power law with exponent close to 1. I use 1.06 (Axtell, 2001); hence, $\theta = 1.06\frac{\kappa(\varepsilon-1)}{1-\kappa(\varepsilon-1)}$ (see Appendix 2.9). The benchmark of variable trade costs τ is set to 1.3 (Ghironi and Melitz, 2005). The exogenous exit rate δ is set to 0.1 (Ghironi and Melitz, 2005; Caliendo and Rossi-Hansberg, 2012). The fixed cost of exporting f_X is calibrated such that only 21 percent of the surviving firms export (Bernard et al., 2003). Finally, as in Ghironi and Melitz (2005), as long as f/f_X is constant, the choice of f^E does not affect the relative responses of firms' technology (or the relative response of any variable) to trade liberalization; thus, without loss of generality, it is considered as a free variable.

In our baseline economy, as we can see in Figures (2.1) and (2.2), in response to trade openness, the most productive firms self-select into selling in both markets (they become exporters), adopt higher N, and hence experience higher productivity. In contrast, low productivity firms sell only to the domestic market and downgrade their level of production technology N; as a result, their productivity falls. The impact of trade liberalization on a firm's productivity is heterogenous. Exporting increases a firm's productivity by almost 3.5% for all firms that induced to export, whereas nonexporters' productivity falls by almost 25% (see Figure (2.3)).

Firms' profits take the usual shape as in the standard Melitz's model (Figure (2.4)). Nonexporters generate lower profits in the open economy relative to the closed economy as well as the least productive exporters. The most productive exporters earn higher profits relative to closed economy profits. Unlike profits, all exporters generate higher revenues, employ more workers, and adopt higher N relative to the closed economy. As shown above, the level of N adopted by a firm is related to the effective market size A facing it. The effective market size A decreases[26] as we liberalize the economy, which severely inflicts firms who only sell to the domestic market. Although exporters suffer from lower sales revenue in the domestic market, they are more than offset by the sales revenues from the export destination market. Yet because of the gigantic reduction in the domestic market size, their relative productivity would not increase as much as the reduction in nonexporters' relative productivity.

2.5.3 Example Two: Symmetric countries, Strictly Convex Cost of Technology Adoption and Fixed Cost of Adjustment

In this example, the cost function of Example 1 is generalized such that the new cost function of technology adoption is strictly convex: $C(N) = \frac{1}{\phi}N^{\phi}$, $\phi > 1$. It is straightforward to check that both Assumption 1 and Assumption 2 are satisfied with the restriction: $\phi - \kappa(\varepsilon - 1) > 0$. In a closed economy, a firm chooses its production technology $N(\varphi)$ and X by solving the maximization problem Equation (2.4) with the above cost of technology adoption. Unlike Example 1, in this example, in addition to the recurrent variable cost of adopting technology N, $C(N)$, changing a firm's initial technology incurs a fixed cost of adjustment. In other words, a firm

[26] Note that the decrease of A is necessary to have gains from trade, where the size of the gains depends on the size of the reduction in A.

that adopts a new level of technology for whatsoever reason needs to pay the variable costs associated with adopting technology N, $C(N)$ and a fixed cost of adjustment, which is independent of N. In our context, the cost of adopting technology N' in the open economy can be written as follows;

$$C(N') = \frac{1}{\phi}(N')^{\phi} + c\mathbb{I}\{N' \neq N\}, \tag{2.28}$$

where $\mathbb{I}$ is an indicator function that takes a value of 1 if a firm adjusts its production technology in the open economy and 0 otherwise. Parameter c refers to the fixed cost of adjustment measured in units of labor.

2.5.3.1 No Adjustment Cost $c = 0$

First, I characterize technology adoption in this economy and the aggregate equilibrium variables when $c = 0$. In this case, Example 2 is isomorphic to Example 1 qualitatively (see Figure (2.5)). However, the level of technology adoption for every firm is lower when the parameter that governs the cost function convexity $\phi > 1$ is larger. Intuitively, the cost of adopting technology N is higher with strictly convex function, and therefore, the optimal value of N is lower for any cost parameter draw. The equilibrium with this cost function is fully characterized in Appendix 2.8.

2.5.3.2 No Technology Upgrading/Downgrading

I turn now to study industry equilibrium and general equilibrium when the firm's technology N is constant and given by the optimal choice in autarky. That is, I set the fixed cost of adjustment $c = \infty$. In the open economy, the model is transformed to the standard Melitz's model with the technology of production given by $q = N^{\kappa}(NX)$. This setting is of vital importance since it allows us to assess the magnitude of gains from trade when firm productivity is endogenous to trade liberalization relative to the gains from trade when the firm's productivity is invariant to trade liberalization (i.e., gains from trade when $c = 0$ versus gains from trade when $c = \infty$).

At the beginning of each period, the dying firms are exactly offset by the new entrants who have to adopt the production technology, N, at the beginning of the period before observing the state of the economy in that period. For simplicity, I assume that firms are unable to anticipate their export status and trade liberalization to be a surprise. In effect, all firms will start the period with a production technology that reflects the optimal choice in the previous period (here in autarky) and have to pay the fixed cost of adjustment if they decide to change production technology afterward. Indeed, this will shut down the dynamic process of technology adoption[27] and greatly simplify the calculations of the open economy aggregate equilibrium variables; nevertheless, the main purpose of this exercise (gains from trade under endogenous technology relative to gains from trade under fixed technology of production) is preserved and still meaningful (for details, see Appendix 2.8).

Allowing the production technology to be endogenous to trade liberalization almost doubles the gains from trade. The intuition behind this large increase in gains from trade is as follows: when production technology and hence firm's productivity are endogenous to trade liberalization, the forces of creative destruction are intensified and become more salient. In a sense, the zero profit cutoff, φ_i, is pushed down further, which induces more firms to exit the market relative to a fixed productivity economy. Exporting is more profitable under endogenous productivity. In addition to the usual revenue gains from exporting, exporters enjoy higher productivity, which enhances both the domestic and the export sales.[28] That is, the opportunity cost

[27]Otherwise, firms should consider the expected export status in the open economy when they choose production technology N.

[28]Notice that the ratio of exporting firms is constant and given by 21 percent under both exogenous and endogenous productivity setting, which translates to lower exporting cutoff under the endogenous productivity setting. If I were to leave the level of fixed cost of exporting f_x constant as given by the benchmark value, almost no firm finds it optimal to export under exogenous production technology setting.

of not being an exporter increases when productivity is endogenous to trade relative to the exogenous firm's productivity setting. On the other hand, the marginal nonexporters who had survived trade liberalization under constant production technology will ultimately not survive the stiff competition in the world economy with endogenous productivity.

In summary, in addition to the effect of the entrance of foreign exporters to the domestic market, most productive domestic firms self-select to exporting activities, which makes them more productive firms with lower prices in the domestic market. This will significantly push the aggregate price level down, which, in turn, increases the cost of production by increasing the real wage in the economy. As a result, fewer and fewer firms are able to survive this economy relative to the one with exogenous productivity, and therefore, the increase in weighted average productivity is significantly higher.

2.5.3.3 Finite and Positive Cost of Adjustment

When the cost of adjustment is positive, but not prohibitive, only a subset of firms adjust their level of production technology in response to trade openness. If the gains in profits from upgrading/downgrading N relative to maintaining the autarky level of N are larger than the fixed cost of adjustment, firms choose to upgrade/downgrade. Alternatively, firms will refrain from adjusting their production technology if the benefit from doing so is less than the fixed cost of adjustment. In what follows, I assume that only firms who choose to upgrade are entitled to both variable costs and fixed cost of adjustment $c \in \mathbb{R}_{++}/\infty$, whereas downgraders are subject to variable costs only. That is, the cost of adopting technology N' is expressed by;

$$C(N') = \frac{1}{\phi}(N')^{\phi} + c\mathbb{I}\{N' > N\}$$

Let N^* be the optimal choice of production technology for firms who decide to adjust their level of technology in an open economy and N is the optimal production technology for firms who do not adjust ($N = N_{autarky}$). The level of technology for φ-firm is;

$$N^{open}(\varphi) = \begin{cases} N^*(\varphi), & \text{if } \pi(N^*(\varphi)) - \pi(N(\varphi)) > c, \\ N, & \text{otherwise} \end{cases}$$

$$N^*(\varphi) = \Psi_\phi \left(\frac{A_{open}}{\varphi}\right)^{\frac{1}{\phi-\kappa(\varepsilon-1)}}, \quad N(\varphi) = \Psi_\phi \left(\frac{A_{autarky}}{\varphi}\right)^{\frac{1}{\phi-\kappa(\varepsilon-1)}}$$

Ψ_ϕ is constant. Indeed, all nonexporters choose to downgrade in this setting since there is no fixed cost of downgrading, and by construction, $\pi(N^*(\varphi)) - \pi(N(\varphi)) > 0$ for any $\varphi \in (0, 1]$. On the other hand, not all exporters choose to upgrade their production technology. For sufficiently high c, only the most productive exporters adjust(remember, all exporters are new exporters when we move from autarky to the open economy). To see this, consider the loss function, $\Delta(\varphi) \equiv \pi(N(\varphi)) - \pi(N^*(\varphi)) < 0$. It is straightforward to show that $\Delta(\varphi)$ is increasing in φ. The most productive exporters (low φ) suffer more from sticking to the old production technology relative to the least productive exporters. In fact, $\Delta(\varphi)$ is monotonically increasing in φ, and therefore, for an appropriate value of c, there exists an adjusting cutoff $\varphi_X^{adjust} < \varphi_X$ such that all exporters with $\varphi < \varphi_X^{adjust}$ choose $N^*(\varphi)$. Exporters with $\varphi > \varphi_X^{adjust}$ choose $N(\varphi)$. Consequently, producing and exporting cutoffs can be found in the same way similar to Example 1, and the adjusting cutoff is figured out by the indifference between exporting using old technology and exporting using the updated technology: $\Delta + c = 0$. Similar analysis applies when nonexporters are subject to the fixed cost of adjustment.

As in Bustos (2011b), not all exporters find it profitable to upgrade; in particular, the marginal exporter continues to use the autarky production technology. In fact, if the cost of adopting technology N' is represented by Equation (2.28) for $N' \in (0, \bar{N}]$, where $\bar{N}$ is the maximum available level of technology[29] and for sufficiently high c, the model predictions completely coincide with those in Bustos (2011b): (1) the non-exporters' production technology is constant and invariant to trade liberalization, (2) the marginal exporter chooses not to upgrade, and (3) medium productivity exporters upgrade, and the most productive firms with $N(\varphi) = \bar{N}$ continue to use the same production technology.

2.5.4 Example Three: Asymmetric Countries

It is well known that the level of effective market size A and the ZPC are invariant to labor force size L under CES preferences, which is in a stark contrast with the empirical facts where many scholars have documented positive and significant relationship between market size and average productivity. Melitz and Ottaviano (2008) adopt a linear demand system in what would be a standard Melitz's model otherwise, to capture the impact of market size on aggregate productivity. The question is whether the firms' choice of production technology under this framework, which features endogenous markup, is similar to the constant markup framework. I do not attempt to do this here and leave this to future work[30] The purpose of this example is to show how exporters and nonexporters operating in markets with different sizes respond to trade liberalization, and thus, I choose to differentiate between markets not by choosing different labor force sizes. Instead, I differentiate the level of entry cost f^E across markets. Larger f^E is manifested in larger effective market size A and higher zero profit cutoff.[31] I solve the model numerically (for details, see Appendix2.8).

[29] We assume that $\bar{N}$is small enough; specifically, there exists φ_N such that $N(\varphi) = \bar{N}$ for all $\varphi < \varphi_N$.

[30] The complications arise here form the fact that firms will not pass all of a cost differential to consumers. By adopting a higher level of N, a firm's cost of production decreases. However, the reduction in cost will not be completely reflected in proportional reduction in price since a firm will be able to charge a higher markup.

[31] Again, we shall not confuse the usual view of market size, which ultimately lowers the ZPC as in Melitz and Ottaviano (2008), with the effective market size A in the current model.

Again, in both countries, exporters adopt higher levels of production technology in the open economy relative to the closed economy, while nonexporters downgrade N. The percentage increase in exporters' productivity in the small country is larger than the percentage increase in productivity for large country exporters. On the other hand, the small country nonexporters' productivity falls disproportionally more than the large country nonexporters' productivity (see Figures (2.13) and (2.14)).

2.5.5 Comparative Statics

The comparative statics analysis is carried out by changing the variable costs of trade and the fixed costs of trade separately. In the first exercise, I vary the level of variable costs of trade τ and leave all other parameters constant, including the fixed cost of trade f_x. In response to a variable cost of trade reduction from 1.3 to 1.2, in symmetric countries with $C(N) = N$, nonexporters experience 6.2% loss in their productivity, whereas old exporters' productivity increases by 0.12%. New exporters (firms that are induced to export because of this reduction in τ) enjoy a significant boost in their productivity: 38.79%. Similar patterns arise when variable trade costs are pushed further down to 1 (see Figures (2.6) and (2.7)). On the other hand, if variable costs of trade increase from 1.3 to 1.5, nonexporters (before and after increase in τ) enjoy an increase in their productivity by 26.6%, whereas exporters' productivity falls by 0.54%. New nonexporters, i.e., those who used to be exporters at the old level of τ but find it optimal not to export under the new level of τ, lose 21% of their productivity.

In our second thought experiment, I change the value of fixed cost of exporting while leaving all other parameters constant, including the variable cost of trade. To my knowledge, no previous paper has studied the impact of the fixed cost of exporting on a firm's productivity. We are able to do so here because of the richness of the model we have introduced. In particular, the general equilibrium effects on a firm's productivity are derived in a tractable way that facilities the comparative static analysis regarding the change in any model's parameter in interest. Disentangling the source of trade liberalization into variable and fixed costs of trade yields very interesting results. Surprisingly, when fixed cost of trade falls, old exporters and nonexporters adopt lower levels of production technology relative to the trading equilibrium with higher fixed costs of exporting. New exporters who find it optimal to start exporting as fixed cost of exporting declines experience a large increase in productivity. As the fixed cost of exporting increases, exporters and old nonexporters, in fact, enjoy a modest increase in productivity, whereas the new nonexporters who cannot make it anymore to the export market because of the high fixed cost of exporting suffer a sizable decrease in productivity.

Another interesting experiment is to have a zero fixed cost of exporting (i.e., Krugman (1980)). In this case, all surviving firms will sell to both markets domestic and foreign. As anticipated by the model, a firm's productivity is constant under this scenario. That is, if the fixed cost of exporting drops from trade prohibitive level ($f_X = \infty$) to zero and, hence, all surviving firms export, the impact of this kind of trade liberalization is isomorphic to an increase in the size of labor force, which, as is well known, does not affect the effective market size A when preferences are presented by CES. In Figures (2.8) and (2.9), it shown how firms respond to changing the fixed cost of exporting. For instance, the left graph of Figure (2.9) demonstrates the firms' productivity responses to a 50% reduction in fixed export cost: old exporters and old nonexporters decrease their productivity by 1%. The new exporters' productivity increases by almost 35%. The right figure depicts the firms' productivity in an open economy with zero fixed cost relative to firm' productivity in autarky. Trade in this case is welfare improving but has no impact on firms' productivity.

Our analysis of the impact of variable costs of trade on a firm's productivity and technology adoption resonates the findings of Lileeva and Trefler (2010). As discussed above, once we introduce fixed cost of adjustment and bound the level of production technology from above, the results will be similar to those of Bustos (2011b), where the impact of trade liberalization on the firm's productivity is stronger on the firms that are in the third quartile of the firm size distribution. Nevertheless, the model presented here diverges from Bustos (2011b) by introducing the differentiated impacts of trade liberalization on new exporters' and old exporters' technology adoption. The impact of trade liberalization via reductions in variable costs of trade is to some degree consistent with Caliendo and Rossi-Hansberg (2012). Exporters' heterogeneous responses in their model and the Lileeva and Trefler (2010)'s negative selection can be easily produced in the current model by imposing an upper boundary on the production technology $\bar{N}$. As a result, firms already using $\bar{N}$ are invariant to trade openness. Firms faraway from $\bar{N}$ experience higher percentage change in productivity in response to trade liberalization.

The gap between an exporter and a nonexporter is governed by Equation (2.22). In Figures (2.10) (2.11),(2.12), (2.13) and (2.14), it is shown how the productivity gap between an exporter and a nonexporter varies as variable costs of trade τ change, confirming the analytical analysis (i.e., Equation (2.22)). The gap is decreasing in τ in both countries and is larger in the small country for any level of τ. Moreover, the productivity gap is more sensitive to τ in the small country, in the sense that it expands much faster in the small country relative to the big country as τ decreases. Interestingly, the productivity gap increases at an increasing rate as τ falls in the small country, whereas it increases at a decreasing rate in the large country as τ falls.

2.6 Conclusion

I present a tractable model that introduces the choice of technology investment by firms into the standard Melitz's model. Trade openness, indeed, increases aggregate productivity not only because of the Melitz self selection effect but also because firms adjust, optimally, their choice of technology adoption and hence their productivity. The model exploits the old idea of the affinity between market size and innovation in a tractable way: ceteris paribus, nonexporters downgrade production technology whereas exporters upgrade. Different trade costs (variable vs. fixed export cost) impact firms' productivity differently. Moreover, lowering trade variable costs seems to have a very small impact on old exporters' productivity but a large impact on new exporters' productivity. The relative export market size to domestic market size is indispensable in understanding the magnitude of trade impact on a firm's productivity.

The implication of the model is also striking regarding the gains from trade: The gains from trade are larger relative to the standard Melitz's model as a consequence of tougher competition, which makes it even harder for the least productive firms to survive. In this economy, the forces of creative destruction are magnified on both the extensive andt he intensive margins.

2.7 Appendix A: Proofs

Second-Order Conditions of the Profit Maximization:

The solution to the maximization problem is unique if the matrix of the second-order condition evaluated at the optimal level of N and X is negative definite.

$$\Gamma = \begin{pmatrix} \frac{\partial^2 \pi}{\partial X^2} & \frac{\partial^2 \pi}{\partial N \partial X} \\ \frac{\partial^2 \pi}{\partial N \partial X} & \frac{\partial^2 \pi}{\partial N^2} \end{pmatrix} = \begin{pmatrix} \frac{-1}{\varepsilon} a^2 \kappa \frac{N}{\varphi C'(N)} & a\left[\frac{\varepsilon-1}{\varepsilon}(\kappa+1)-1\right] \\ a\left[\frac{\varepsilon-1}{\varepsilon}(\kappa+1)-1\right] & \frac{1}{N}(\frac{\varepsilon-1}{\varepsilon}(\kappa+1)-1)\varphi C'(N)\frac{1+\kappa}{\kappa} - \varphi C''(N) \end{pmatrix} < 0$$

Γ is negative definite if the diagonal elements are negative and the determinant is positive. The first diagonal element is negative since the first derivative of the cost function is positive. The second diagonal element is negative if $\frac{N}{C''(N)}C'(N) >$

$(\frac{\varepsilon-1}{\varepsilon}(\kappa+1)-1)\frac{\kappa+1}{\kappa}$. The determinant is negative if $\frac{NC''(N)}{C'(N)} > \kappa(\varepsilon-1)-1$. If $\kappa(\varepsilon-1)-1<0$, the second diagonal element and the determinant are both negative. If $\kappa(\varepsilon-1)-1>0$, then Assumption 1 implies that both the determinant and the second diagonal element are negative because the condition for negative determinant implies that the second diagonal element is negative.

Proof of Proposition II.1. Define $F(.) = \kappa\left(\frac{\varepsilon-1}{\varepsilon}\right)^{\varepsilon} a^{1-\varepsilon} A N^{\kappa(\varepsilon-1)-1} - \varphi C'(N) = 0$. By implicit theorem,

$$\begin{aligned}\frac{\partial N}{\partial A} &= -\frac{\partial F/\partial A}{\partial F/\partial N}\\ &= \frac{-\kappa\left(\frac{\varepsilon-1}{\varepsilon}\right)^{\varepsilon} a^{1-\varepsilon} N^{\kappa(\varepsilon-1)-1}}{(\kappa(\varepsilon-1)-1)\kappa\left(\frac{\varepsilon-1}{\varepsilon}\right)^{\varepsilon} a^{1-\varepsilon} A N^{\kappa(\varepsilon-1)-2} - \varphi C''(N)}\end{aligned}$$

The numerator is always negative. The sign of the dominator is given by the sign of $\kappa(\varepsilon-1)-1-\frac{NC''(N)}{C'(N)}$, which is negative (see Assumption 1). Hence , N is increasing in A. Similarly,

$$\frac{\partial N}{\partial \varphi} = \frac{C'(N)}{(\kappa(\varepsilon-1)-1)\kappa\left(\frac{\varepsilon-1}{\varepsilon}\right)^{\varepsilon} a^{1-\varepsilon} A N^{\kappa(\varepsilon-1)-2} - \varphi C''(N)} < 0$$

And, $\frac{\partial X}{\partial A} = \frac{\partial X \partial N}{\partial N \partial A} > 0$.

$$sign(\frac{\partial X}{\partial \varphi}) = sign((\kappa(\varepsilon-1)-1)N^{\kappa(\varepsilon-1)-2}\frac{\partial N}{\partial \varphi}) = -sign(\kappa(\varepsilon-1)-1)$$

Proof of Lemma II.1.

$$\varphi C'(N) = \kappa\left(\frac{\varepsilon-1}{\varepsilon}\right)^{\varepsilon} a^{1-\varepsilon} A N^{\kappa(\varepsilon-1)-1} \qquad \text{by (2.5)}$$
$$\varphi C(N) = \frac{C(N)}{C'(N)} N^{\kappa(\varepsilon-1)-1} C_1 \qquad C_1 > 0 \, \text{is constant}$$
$$\frac{\partial \varphi C(N)}{\partial \varphi} = C_1 \frac{\partial (N^{\kappa(\varepsilon-1)-1} \frac{C(N)}{C'(N)})}{\partial N} \frac{\partial N}{\partial \varphi}$$

The derivative above is negative if and only if $\frac{\partial \frac{C(N)}{C'(N)} N^{\kappa(\varepsilon-1)-1}}{\partial N} > 0$. With some algebraic manipulation, we can show that this term is positive if $N\left[\frac{C'(N)}{C(N)} - \frac{C''}{C'(N)}\right] > 1-\kappa(\varepsilon-1)$.

Proof of Lemma II.2. Notice that the productivity P can be written as, $P^* = N^\kappa$. Hence, $\frac{\partial P^*}{\partial \varphi} = \kappa N^{\kappa-1}\frac{\partial N}{\partial \varphi} < 0$.

Proof of Proposition II.2. Assume that the level of technology N is fixed. We want to find the level of X that maximizes (2.4). That is , $X(N, A, .) = arg\max_X \pi(N_{constant}, X)$, which is a function of N, but not φ. Define the reduced-form profit function as

$$\pi(N) = N^{\frac{\varepsilon-1}{\varepsilon}(\kappa+1)} X(N, A, .)^{\frac{\varepsilon-1}{\varepsilon}} A^{\frac{1}{\varepsilon}} - \{aNX(N, A, .) + \varphi C(N) + f\} \tag{2.29}$$
$$= \phi(N, A, \varepsilon, \kappa, a) - \varphi C(N) - f \tag{2.30}$$

The optimal value of N that is derived in (2.5) can also be calculated as $N(A, \varphi, .) = arg\max_N \pi(N)$. Define $v(N)$ such that

$$v(N) \equiv \pi(N(A, \varphi, .)) = \phi(N(A, \varphi, .), A, a, \varepsilon, \kappa) - \varphi C(N(A, \varphi, .)) \tag{2.31}$$

By envelope theorem,

$$\frac{\partial v(N)}{\partial \varphi} = -C(N) < 0.$$

Proof of Proposition II.3. Notice that the ratio of any two firms' output, technology, revenues and variable profits, s= $\frac{1}{\varepsilon}r - \varphi C(N)$, depend only on the ratio of the cost shocks φ:

$$\frac{q(\varphi_1)}{q(\varphi_2)} = \vartheta_q\left(\frac{\varphi_1}{\varphi_2}\right) \qquad \frac{r(\varphi_1)}{r(\varphi_2)} = \vartheta_r\left(\frac{\varphi_1}{\varphi_2}\right)$$
$$\frac{N(\varphi_1)}{N(\varphi_2)} = \vartheta_n\left(\frac{\varphi_1}{\varphi_2}\right) \qquad \frac{s(\varphi_1)}{s(\varphi_2)} = \vartheta_s\left(\frac{\varphi_1}{\varphi_2}\right)$$

Where $\vartheta_i\, i \in \{q, n, s, r\}$ is decreasing with φ. As in Melitz (2003), the aggregate variables can be defined by the weighted average cost draws $\tilde{\varphi}$. Specifically,

$$\begin{aligned} P &= M^{\frac{1}{1-\varepsilon}}\left(\int_0^{\varphi_D} p(\varphi)^{1-\varepsilon}\mu(\varphi)d\varphi\right)^{\frac{1}{1-\varepsilon}} \\ &= M^{\frac{1}{1-\varepsilon}}p(\tilde{\varphi}(\varphi_D)) \end{aligned}$$

$$\tilde{\varphi}(\varphi_D) = \left(\int_0^{\varphi_D} N(\varphi)^{\kappa(\varepsilon-1)}\frac{g(\varphi)}{G(\varphi_D)}d\varphi\right)^{\frac{1}{\varepsilon-1}}$$

We also can write the revenue, the variable profits, and the net profits in terms of $\tilde{\varphi}$:

$$\begin{aligned} R &= M\int_0^{\varphi_D} r(\varphi)\mu(\varphi)d\varphi = Mr(\tilde{\varphi}) \\ S &= M\int_0^{\varphi_D} s(\varphi)\mu(\varphi)d\varphi = Ms(\tilde{\varphi}) \\ \Pi &= M\int_0^{\varphi_D} \pi(\varphi)\mu(\varphi)d\varphi = M(s(\tilde{\varphi}) - f) \\ &= M\pi(\tilde{\varphi}) \end{aligned}$$

Let $\bar{\pi} = \pi(\tilde{\varphi})$

$$\begin{aligned}\bar{\pi} &= s(\tilde{\varphi}) - f \\ &= s(\varphi_D)\vartheta_s(\frac{\tilde{\varphi}}{\varphi_D}) - f = f\vartheta_s(\frac{\tilde{\varphi}}{\varphi_D}) - f \\ &= fk(\varphi)\end{aligned}$$

Where, $k(\varphi) = \vartheta_s(\frac{\tilde{\varphi}(\varphi)}{\varphi}) - 1$. A FEC is given by:

$$\begin{aligned}G(\varphi_D)\int_0^{\varphi_D} \pi(\varphi)\mu(\varphi)d\varphi = \delta f^E \\ \bar{\pi} = \frac{\delta f^E}{G(\varphi_D)}\end{aligned}$$

Combine ZPC and FEC together:

$$fj(\varphi) = \delta f^E$$

Here $j(\varphi) = G(\varphi)k(\varphi)$. In the space of (π, φ) we need to show that (FEC) is decreasing in φ, while (ZPC) is increasing, and they intersect at a unique point by showing that $j(\varphi)$ is increasing in φ with $lim_{\varphi\to 0}j(\varphi) = 0$ and $Lim_{\varphi\to\infty}j(\varphi) = \infty$. Indeed, the problem is similar to Melitz (2003); hence, the proof is complete.

Proof of Proposition II.4. Notice that $\tilde{\varphi}(\varphi_D)$ is only a function of φ_D. Thus, φ that satisfies (ZPC) and (FEC) simultaneously is only a function of the exogenous parameters. For the second part of the proposition (i,e., A is independent of L), notice that the price level $P = M^{\frac{1}{1-\varepsilon}}p(\tilde{\varphi})$ depends on A. In particular, $p(\tilde{\varphi}) = \frac{\varepsilon}{\varepsilon-1}\frac{a}{\tilde{\varphi}}N^{-1}(A)^{-\kappa}$. Since labor is the only factor of production, we impost that $L =$

$R = M\int_0^{\varphi_D} r(\varphi)\mu(\varphi)d\varphi = Mr(\tilde{\varphi})$. The explicit formula of $r(\tilde{\varphi})$ is given as follows:

$$r(\tilde{\varphi}) = A^{1-\varepsilon}N^{-1}(A)^{\kappa(\varepsilon-1)}(\frac{\varepsilon}{\varepsilon-1}a)^{1-\varepsilon}(\tilde{\varphi}(\varphi_D))^{\varepsilon-1}$$

Hence,

$$A = \frac{r(\tilde{\varphi})}{p(\tilde{\varphi})^{1-\varepsilon}} = \vartheta_a(A, \text{exogenous parameters})$$

As shown above, the number of operating firms M can be calculated from the income-expenditure identity: $R = L$.

$$M = \frac{L}{r(\tilde{\varphi})} = \vartheta_m(L, A, \tilde{\varphi}) \equiv \frac{L}{\vartheta_m(A, \tilde{\varphi}, \text{parameters})}$$

Since A and $\tilde{\varphi}$ are only functions of the exogenous parameters, M is a function of the model's parameters and L. Indeed, M is increasing with L. The positive effect of L on the welfare $\mathbb{W} = M^{\frac{1}{\varepsilon-1}}p(\tilde{\varphi})^{-1}$ follows from the relationship between M and L.

Proof of Proposition II.5. The proof is analogous to the proof in the closed economy with some modification. First, without loss of generality, I only consider the proof for the symmetric countries case. The proof of asymmetric countries is similar but is more computationally involved. I start with the price index in the open economy and show that, as in the closed economy, we can write it in term of a weighted average cost parameter φ. In fact, I will express all aggregates in the economy in terms of this weighted average.

$$P_i = \left\{ M_i \int_0^{\varphi_i} p_{ii}(\varphi)^{1-\varepsilon}\mu_i(\varphi)d\varphi + M_{ii'}\int_0^{\varphi_{ii'}} p_{ii'}(\varphi)^{1-\varepsilon}\mu_{ii'}d\varphi \right\}^{\frac{1}{1-\varepsilon}}$$

By symmetry, $M_{i'i} = M_{ii'} = M_x$ and $\varphi_{ii'} = \varphi_{i'i} = \varphi_x$. Hence,

$$\begin{aligned}
P_i = \{M_{ii} \int_{\varphi_x}^{\varphi_i} p_{ii}(\varphi)^{1-\varepsilon}\mu_{ii}(\varphi)d\varphi + \\
M_x \int_0^{\varphi_x} p_{ii}(\varphi)^{1-\varepsilon}\mu_x(\varphi)d\varphi + \\
M_x \int_0^{\varphi_x} (\tau p_{ii}(\varphi))^{1-\varepsilon}\mu_x(\varphi)d\varphi\}^{\frac{1}{1-\varepsilon}} \\
= \left\{M_{ii}p(\tilde{\varphi}_i(\varphi_i, \varphi_x))^{1-\varepsilon} + (1+\tau^{1-\varepsilon})M_x p^e(\tilde{\varphi}_x(\varphi_x))^{1-\varepsilon}\right\}^{\frac{1}{1-\varepsilon}}
\end{aligned}$$

where,

$$\begin{aligned}
\tilde{\varphi}_i &= \left(\int_{\varphi_x}^{\varphi_i} N(\varphi)^{\kappa(\varepsilon-1)}\mu_{ii}(\varphi)d\varphi\right)^{\frac{1}{\varepsilon-1}} \\
\tilde{\varphi}_x &= \left(\int_0^{\varphi_x} N(\varphi)^{\kappa(\varepsilon-1)}\mu_x(\varphi)d\varphi\right)^{\frac{1}{\varepsilon-1}}. \\
p(\tilde{\varphi}_i) &= \frac{\varepsilon}{\varepsilon-1} a N^{-1}(A,.)^{-\kappa}\frac{1}{\tilde{\varphi}_i} \\
p^e(\tilde{\varphi}_x) &= \frac{\varepsilon}{\varepsilon-1} a N^{-1}(A(1+\tau^{1-\varepsilon}))^{-\kappa}\frac{1}{\tilde{\varphi}_x} = G_\tau(\tau)p(\tilde{\varphi}_x)
\end{aligned}$$

$G_\tau(\tau) = N^{-1}((1+\tau^{1-\varepsilon})^{-\kappa} < 1$, $G_\tau(\infty) = 1$ and $\tau = 1 = arg \max_\tau G_\tau(\tau)$. Then the price level can be written as follows:

$$\begin{aligned}
P_i &= \left\{M_{ii}p(\tilde{\varphi}_i)^{1-\varepsilon} + (1+\tau^{1-\varepsilon})G_\tau(\tau)M_x p(\tilde{\varphi}_x)^{1-\varepsilon}\right\}^{\frac{1}{1-\varepsilon}} \\
&= M_t^{\frac{1}{1-\varepsilon}} p(\tilde{\varphi}_t)
\end{aligned}$$

M_t is the mass of all available varieties in country i: $M_t = M_{ii} + 2M_x = M_i + M_x$. The weighted average cost draw of all firms competing in country i is given by $\tilde{\varphi}_t$,

$$\tilde{\varphi}_t = \left\{\frac{1}{M_t}\left(M_{ii}\tilde{\varphi}_i^{\varepsilon-1} + (1+\tau^{1-\varepsilon})G_\tau(\tau)M_x\tilde{\varphi}_x^{\varepsilon-1}\right)\right\}^{\frac{1}{\varepsilon-1}}$$

Again, the total revenue $R = M_i \int_0^{\varphi_i} r(\varphi)\mu_i d\varphi$ can be written as a function of $\tilde{\varphi}_t$.

That is,

$$R = M_t r(\tilde{\varphi}_t)$$

Similarly,

$$\begin{aligned}\Pi &= M_{ii}\pi_{ii}(\tilde{\varphi}_i) + M_x \pi_T(\tilde{\varphi}_x) \\ &= M_t \pi(\tilde{\varphi}_t)\end{aligned}$$

In the previous derivations, I exploit the fact that the ratio of two exporters' output, revenues, variable profits, and technology is solely a function of the ratio of their cost draw and equals to the ratio of two non-exporters' output, revenues, variable profits, and technology with the same draws as exporters. Indeed, the ratio of an exporter's production technology to a nonexporter' production technology is determined by Equation (2.22). The next step is to show that φ_x is a function of φ_i and the model's exogenous parameters. As a result, $\tilde{\varphi}_t$ is going to be a function of φ_i and the exogenous parameters.[32] To show that $\varphi_x(\varphi_i)$, note that $s_{ii}(\varphi_i) = f_i$, $s^e(\varphi_x) = s_{ii}(\varphi_x) + f_x$ and $\frac{s^e(\varphi)}{s_{ii}(\varphi)} = d(\tau) > 1$.[33] Consequently,

$$\begin{aligned}s^e(\varphi_x) &= f\vartheta_s(\frac{\varphi_x}{\varphi_i}) + f_x \\ s^e(\varphi_i)\vartheta_s(\frac{\varphi_x}{\varphi_i}) &= f\vartheta_s(\frac{\varphi_x}{\varphi_i}) + f_x \\ s_{ii}(\varphi_i)d\vartheta_s(\frac{\varphi_x}{\varphi_i}) &= f\vartheta_s(\frac{\varphi_x}{\varphi_i}) + f_x \\ \varphi_x &= \vartheta_s^{-1}\left(\frac{f_x}{f(d(\tau)-1)}\right)\varphi_i\end{aligned}$$

[32] Again, the effective market size A is given by the exogenous parameters.

[33] $d(\tau)$ is constant for a given level of τ and $d'(\tau) < 0$. As τ goes to infinity, d converges to one. Also, note that $s^e(.)$ is linked to s_{ii} by the following relation: $s^{ee}(\varphi_x) = \frac{1}{\varepsilon}\overbrace{(1+\tau^{1-\varepsilon})G_\tau(\tau)^{\varepsilon-1}r_{ii}(\varphi_x)}^{r^e(\varphi_x)} - \varphi_x \overbrace{C(G_\tau(\tau))C(N(\varphi_x))}^{C^e(N(\varphi_x))}$.

From the Equation above, it is straightforward to see that φ_x is increasing by one-to-one in φ_i. Similar to the closed economy proof, I define $\bar{\pi}$ to be the average profits conditional on successful entry and rewrite the (ZPC) as a function of $\bar{\pi}$. Formally,

$$\begin{aligned}\bar{\pi} &= p_{ii}\pi_{ii}(\tilde{\varphi}_i) + p_x\pi(\tilde{\varphi}_x) \\ &= p_{ii}fk(\varphi_i) + p_x f k_x(\varphi_i) + p_x f_x k(\varphi_x)\end{aligned}$$

$p_{ii} = \frac{G(\varphi_i)-G(\varphi_x)}{G(\varphi_i)}$ is the probability of only selling to the domestic market conditional on successful entry. $p_x = \frac{G(\varphi_x)}{G(\varphi_i}$ is the probability of selling to both markets conditional on successful entry. $k(\varphi_j) = \vartheta_s(\frac{\tilde{\varphi}_j}{\varphi_j})$ and $k_x(\varphi_j) = \vartheta_s(\frac{\tilde{\varphi}_x}{\varphi_j}) - 1$. The ZPC can be simplified more as follows:

$$\bar{\pi} = fk(\varphi_i) + p_x f_x k(\varphi_x) + p_x f(k_x(\varphi_i) - k(\varphi_i)) \tag{2.32}$$

Since we impose that f_x is large enough such that the fraction of exporters is less than the fraction nonexporters, $\tilde{\varphi}_x < \tilde{\varphi}_i$, and thus $p_x f(k_x(\varphi_i) - k(\varphi_i)) > 0$. The FEC is given by:

$$\bar{\pi} = \frac{\delta f^E}{G(\varphi_i)}$$

Again, in the space of (π, φ), there exists a unique φ_i that simultaneously solves ZPC and FEC. Formally, in the space (π, φ), we need to find φ that satisfies the following equation:

$$\delta f^E = fj(\varphi) = f_x j(\varphi_x(\varphi)) + G(\varphi_x(\varphi))f(k_x(\varphi) - k(\varphi))$$

The problem is similar to the closed economy, given that the second term is increasing in φ as well as the last term. To show that $\varphi_i^{open} < \varphi_i^{closed}$, note that in the space of (π, φ), the FEC remains unchanged compared with the closed economy: In equilibrium, the expected value of future profits must equal the suck entry cost f^E. On the other hand, ZPC shifts up since the first term is similar to the one in the closed economy, while the second and the third terms are positive and increasing in φ. In other words, trade openness, as expected, increases the ex ante expected profits per firm.

Proof of Proposition II.6. The proof is proceeded by contradiction. Assume that $f_x = 0$; hence, all firms export. Indeed if this is the case, A is constant, and therefore, the technology choices and the prices remain constant for all firms. Moreover, the ZPC is unchanged relative to the closed economy. Consequently, the trade openness impact is isomorphic to doubling the labor size in the closed economy. Now assume that $f_x > 0$ and only some firms export. If the resulting aggregate price level is higher relative to the autarky aggregate price level, all surviving firms choose a higher level of N and charge lower prices. However, if this is the case, the ZPC in the open economy must be higher than the ZPC in autarky, which means larger mass of producing domestic firms. If the number of firms producing in the open economy relative to the number of producing firms in the closed economy is greater than one and all firms charge lower prices relative to the closed economy, the resulting aggregate price level must be lower than the closed economy aggregate price level (contradiction) . Similar argument can be made when the price level in the open economy equals the price level in the closed economy. In conclusion, the aggregate price level in the open economy must be less than the aggregate price level in the closed economy.

Proof of Proposition II.7. The first part follows immediately from Proposition II.6. The second part is true if $\mathcal{A} > A_{close}$. In case of symmetric countries (without loss of generality), $\mathcal{A} = A_\tau + \tau^{1-\varepsilon} A_\tau$. I denote the level of A in the open economy for a given level of τ by A_τ. First, notice that $\lim_{\tau \to \infty} \mathcal{A} = A_{close}$. Hence, to show that

$\mathcal{A} > A_{close}$, it is sufficient to show that $\mathcal{A}$ is decreasing in τ,

$$\frac{\partial \mathcal{A}}{\partial \tau} = \frac{\partial A_\tau}{\partial \tau}(1 + \tau^{1-\varepsilon}) + (1-\varepsilon)\tau^{-\varepsilon} A_\tau.$$

The first argument of the right-hand side of the equation above is positive, while the second one is negative. We need to show that the first argument is less than the second. Notice that A_τ depends on the ZPC φ_i, and therefore, A_τ is connected to τ through φ_i. As we have shown above, the properties of FE C and ZPC in the current model are identical to the ones in Melitz (2003) and, consequently, his result that an exporter's revenues in the open economy (domestic sales r^D and export sales r^X) are strictly greater than its revenues in a closed economy: $r_{close}(\varphi) < r^D_{open}(\varphi) + r^X_{open}(\varphi)$ also holds here, which is equivalent to $\mathcal{A} > A_{close}$. In fact, the strict inequality is larger in the current model. To show that an exporter's production technology is increasing in f_x conditional on being an exporter, it is sufficient to show that $\frac{\partial (1+\tau^{1-\varepsilon}) A_{(\tau, f_x)}}{\partial f_x} > 0$, which is indeed the case since $A_{(\tau, f_x)}$ is increasing with f_x and $\lim_{f_x \to 0} A_{(\tau, f_x)} = A_{close}$.

Proof of Proposition II.8 The proof simply follows by noting that the expected profits conditional on successful entry $\bar{\pi}$ when N is endogenous is higher than $\bar{\pi}$ when N is constant. In particular, the last term in (2.32) equals zero when N is constant.

2.8 Appendix B: Examples and Simulations

2.8.1 Example One

By solving the firm's maximization problem in the closed economy (i.e., Equation (2.4)), the level of technology N adopted by a firm with φ productivity (φ-firm) is,

$$N^* = \Psi A^{\frac{1}{1-\kappa(\varepsilon-1)}} \varphi^{\frac{1}{\kappa(\varepsilon-1)-1}}, \qquad X^* = \frac{\varphi}{a\kappa} \tag{2.33}$$

$\Psi \equiv \left(\frac{a^{\varepsilon-1}}{\kappa}\right)^{\frac{1}{\kappa(\varepsilon-1)-1}} \left(\frac{\varepsilon}{\varepsilon-1}\right)^{\frac{\varepsilon}{\kappa(\varepsilon-1)-1}}$. The ZPC in the closed economy is,

$$\varphi_i^{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-1}} \Theta(A) = f, \qquad i \in \{D, F\} \tag{2.34}$$

where $\Theta(A) \equiv \frac{1-\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)} \Psi A^{\frac{1}{1-\kappa(\varepsilon-1)}}$. Using the Pareto distribution in the FEC, integrating and substituting for the value of φ_i from the ZPC yield the solution of φ_i in terms of the model's parameters:

$$\varphi_i = \left[\frac{\delta f^E}{f_i} \lambda\right]^{\frac{1}{\theta}}, \qquad i \in \{D, F\} \tag{2.35}$$

$\lambda \equiv \frac{\theta + \frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-1}}{\frac{\kappa(\varepsilon-1)}{1-\kappa(\varepsilon-1)}}$. To solve for M, I use the labor market clearing condition Equation (2.13). First, note that a firm that receives a shock φ_1 chooses $X^* = \frac{\varphi_1}{a\kappa} = \frac{1}{a} L_x$; hence, the amount of labor used to produce X^*, L_x, is given by $\frac{\varphi_1}{\kappa}$. The labor requirement that is used in production by φ_1-firm is given by $\frac{aq(\varphi_1)}{N(\varphi_1)^\kappa} = N(\varphi_1) L_x = \frac{1}{\kappa} \Psi A^{\frac{1}{1-\kappa(\varepsilon-1)}} \varphi_1^{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-1}}$. In addition, the firm's expenditures on technology investment are measured in units of labor requirement, which is given by $\ell(C_L(C(\varphi_1))) = \varphi_1 N(\varphi_1) = \Psi A^{\frac{1}{1-\kappa(\varepsilon-1)}} \varphi_1^{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-1}}$. Given the total labor demand by each firm, we can solve the market clearing condition and find M as a function of the model's parameters:

$$M^E = \frac{L}{f^E} \frac{1}{1 + \Psi_1} \tag{2.36}$$

$$M = \frac{G(\varphi_D)}{\delta} M^E \tag{2.37}$$

$\Psi_1 \equiv \frac{\overbrace{\theta + \frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-1}}^{\lambda}}{\frac{\kappa(\varepsilon-1)}{1-\kappa(\varepsilon-1)}} + \theta\frac{1+\kappa}{\kappa}$. The price level is immediately derived from φ_D and M^E. That is,

$$P^{1-\varepsilon} = M\int_0^{\varphi_i} p(\varphi)^{1-\varepsilon}\mu(\varphi)d\varphi$$
$$= \frac{M^E}{\delta}\int_0^{\varphi_i}\left(\frac{\varepsilon}{\varepsilon-1}\frac{a}{N(\varphi)^\kappa}\right)^{1-\varepsilon} dG(\varphi)$$
$$= \frac{M^E}{\delta}\theta\left(\frac{\varepsilon}{\varepsilon-1}a\right)^{1-\varepsilon}\Psi^{\kappa(\varepsilon-1)}\left(\frac{L}{P^{1-\varepsilon}}\right)^{\frac{\kappa(\varepsilon-1)}{1-\kappa(\varepsilon-1)}}\int_0^{\varphi_i}\varphi^{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-1}+\theta-1}d\varphi$$
$$P^{\frac{1-\varepsilon}{1-\kappa(\varepsilon-1)}} = \frac{\theta}{\delta}M^E\left(\frac{\varepsilon}{\varepsilon-1}a\right)^{1-\varepsilon}\Psi^{\kappa(\varepsilon-1)}L^{\frac{\kappa(\varepsilon-1)}{1-\kappa(\varepsilon-1)}}\frac{\varphi_i^{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-1}+\theta}}{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-1}+\theta}$$
$$P =$$
$$L^{\frac{1}{1-\varepsilon}}\left\{\frac{1}{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-1}+\theta}\frac{\theta}{1+\Psi_1}\left(\frac{\varepsilon a}{\varepsilon-1}\right)^{1-\varepsilon}\Psi^{\kappa(\varepsilon-1)}\left(\delta f^E\right)^{\frac{\kappa(\varepsilon-1)}{(\kappa(\varepsilon-1)-1)\theta}}\left(\frac{\lambda}{f_i}\right)^{\frac{\kappa(\varepsilon-1)}{(\kappa(\varepsilon-1)-1)\theta}+1}\right\}^{\frac{1-\kappa(\varepsilon-1)}{1-\varepsilon}}$$

Hence,

$$A = \left\{\frac{1}{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-1}+\theta}\frac{\theta}{1+\Psi_1}\left(\frac{\varepsilon a}{\varepsilon-1}\right)^{1-\varepsilon}\Psi^{\kappa(\varepsilon-1)}\left(\delta f^E\right)^{\frac{\kappa(\varepsilon-1)}{(\kappa(\varepsilon-1)-1)\theta}}\left(\frac{\lambda}{f_i}\right)^{\frac{\kappa(\varepsilon-1)}{(\kappa(\varepsilon-1)-1)\theta}+1}\right\}^{\kappa(\varepsilon-1)-1} \tag{2.38}$$

The ZPC is calculated as follows:

$$N_i(\varphi_i) = \Psi^{1-\kappa(\varepsilon-1)}\left[\frac{\delta f^E}{f}\lambda\right]^{\frac{1}{\theta(\kappa(\varepsilon-1)-1)}}$$
$$\left\{\frac{1}{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-1}+\theta}\frac{\theta}{1+\Psi_1}\left(\frac{\varepsilon a}{\varepsilon-1}\right)^{1-\varepsilon}\left(\delta f^E\right)^{\frac{\kappa(\varepsilon-1)}{(\kappa(\varepsilon-1)-1)\theta}}\left(\frac{\lambda}{f_i}\right)^{\frac{\kappa(\varepsilon-1)}{(\kappa(\varepsilon-1)-1)\theta}+1}\right\}^{-1}$$

The characterization of the equilibrium in the closed economy is complete. I turn now to the equilibrium in the open economy. The φ-nonexporter's maximization problem is similar to the closed economy, whereas the φ-exporter solves Equation (2.19). The levels of technology

N for nonexporter and exporter, respectively, are:

$$N^*(\varphi) = \Psi A^{\frac{1}{1-\kappa(\varepsilon-1)}} \varphi^{\frac{1}{\kappa(\varepsilon-1)-1}}, \qquad X^* = \frac{\varphi}{a\kappa} \tag{2.39}$$

$$N_e^*(\varphi) = \Psi \left(A(1+\tau^{1-\varepsilon})\right)^{\frac{1}{1-\kappa(\varepsilon-1)}} \varphi^{\frac{1}{\kappa(\varepsilon-1)-1}}, \qquad X^* = \frac{\varphi}{a\kappa} \tag{2.40}$$

$$N_e^*(\varphi) = B(\tau)N^*(\varphi) \tag{2.41}$$

$B(\tau) \equiv \left(1+\tau^{1-\varepsilon}\right)^{\frac{1}{1-\kappa(\varepsilon-1)}} > 1$. From the ZPC:

$$\varphi_i^{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-1}} \Theta(A) = f_i\,, \qquad i \in \{D, F\} \tag{2.42}$$

The FEC is given by (2.25).

$$\int_{\varphi_X}^{\varphi_i} \pi_{ii}(\varphi)g(\varphi)d\varphi + \int_0^{\varphi_X} \pi_T(\varphi)g(\varphi)d\varphi = \delta f^E \tag{2.43}$$

$$\int_{\varphi_X}^{\varphi_i} \left[\frac{1}{\varepsilon} A \left(\frac{\varepsilon a}{\varepsilon-1}\right)^{1-\varepsilon} N(\varphi)^{\kappa(\varepsilon-1)} - \varphi N(\varphi) - f_i\right] dG(\varphi)$$
$$+ \int_0^{\varphi_X} \left[B(\tau)\frac{1}{\varepsilon} A \left(\frac{\varepsilon a}{\varepsilon-1}\right)^{1-\varepsilon} N(\varphi)^{\kappa(\varepsilon-1)} - B(\tau)\varphi N(\varphi) - f_i - f_X\right] dG(\varphi) = \delta f^E$$

$$\frac{\theta}{\lambda_1}\Theta(A)\left[\varphi_i^{\lambda_1} - \varphi_X^{\lambda_1} + B(\tau)\varphi_X^{\lambda_1}\right] - \varphi_i^{\theta} f_i - \varphi_X^{\theta} f_X = \delta f^E \tag{2.44}$$

where, $\lambda_1 \equiv \theta + \frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-1}$. In order to solve for the ZPC from the FEC, we need to write φ_X as a function of φ_i.[34]

$$\varphi_X = \Lambda \varphi_i \tag{2.45}$$

where $\Lambda \equiv \left(\frac{f_X}{f_i(B(\tau)-1)}\right)^{\frac{\kappa(\varepsilon-1)-1}{\kappa(\varepsilon-1)}} < 1$.[35] Substitute for φ_X in FEC,

[34] The derivation simply follows by noting that $s^e(\varphi)/s_{ii}(\varphi) = B(\tau)$, $s(\varphi_1)/s(\varphi_2) = (\frac{\varphi_1}{\varphi_2})^{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-1}}$, and $s_{ii}(\varphi_i) = f_i$. See the Appendix 2.7 for details.

[35] To guarantee that only the most productive firms export i.e., $\Lambda < 1$, f_x must be greater than $f_i(B(\tau)-1)$.

$$\varphi_i = \left[\frac{\delta f^E}{\frac{f}{\lambda} + \Lambda^\theta \frac{f_X}{\lambda}}\right]^{\frac{1}{\theta}} < \left[\frac{\delta f^E}{f_i/\lambda}\right]^{\frac{1}{\theta}} \tag{2.46}$$

Again, I solve for the equilibrium numbers of producing and exporting firms by solving the labor market clearing conditions:

$$M^E f^E + \frac{M^E}{\delta} \int_0^{\varphi_X} \left(f_i + f_X + \frac{aq_e(N_e(\varphi))}{N_e(\varphi)^\kappa} + \ell(C(N_e(\varphi),\varphi))\right) dG(\varphi)$$

$$+ \frac{M^E}{\delta} \int_{\varphi_X}^{\varphi_i} \left(f + \frac{aq(N(\varphi))}{N(\varphi)^\kappa} + \ell(C(N(\varphi),\varphi))\right) dG(\varphi) = L$$

$$M^E f^E + \frac{M^E}{\delta}\left[\frac{\theta}{\lambda_1}\Psi A^{\frac{1}{1-\kappa(\varepsilon-1)}} \frac{1+\kappa}{\kappa}\left(B(\tau)\varphi_X^{\lambda_1} - \varphi_X^{\lambda_1} + \varphi_i^{\lambda_1}\right) + \varphi_X^\theta f_X + \varphi_i^\theta f_i\right] = L \tag{2.47}$$

Substituting for $\varphi_X = \Lambda\varphi_i$ and manipulating, we get

$$M^E = \frac{L}{f^E}\frac{1}{1+\Psi_2} \tag{2.48}$$

Here $\Psi_2 \equiv \frac{c_2((B(\tau)-1)\Lambda^{\lambda_1}+1)+1+\Lambda^\theta f_X/f_i}{1/\lambda + \frac{1}{\lambda}\Lambda^\theta f_X/f_i}$ and $c_2 \equiv \frac{\theta}{\lambda_1}\frac{\kappa(\varepsilon-1)}{1-\kappa(\varepsilon-1)}\frac{1+\kappa}{\kappa}$. Further simplification of Ψ_2 yields, as expected under the Pareto distribution assumption, $\Psi_2 = \Psi_1$.

$$P_i = \left\{\frac{M^E}{\delta}\left(\int_{\varphi_X}^{\varphi_i} p(\varphi)^{1-\varepsilon} dG(\varphi) + (1+\tau^{1-\varepsilon})\int_0^{\varphi_X} p_x^{1-\varepsilon}(\varphi) dG(\varphi)\right)\right\}^{\frac{1}{1-\varepsilon}} \tag{2.49}$$

$$P_i^{\frac{1-\varepsilon}{1-k(\varepsilon-1)}} = \frac{\theta}{\lambda_1\delta}\left(\frac{\varepsilon a}{\varepsilon-1}\right)^{1-\varepsilon} \Psi^{\kappa(\varepsilon-1)} L^{\frac{\kappa(\varepsilon-1)}{1-\kappa(\varepsilon-1)}} M^E \left\{1 - \Lambda^{\lambda_1} + B(\tau)\Lambda^{\lambda_1}\right\}\varphi_i^{\lambda_1} \tag{2.50}$$

Where $p(\varphi)$ is the price charged by nonexporters and $p_x(\varphi)$ is the exporter's price charged in the domestic market. substituting for M^E and φ_i, we obtain the following:

$$P_i = L^{\frac{1}{1-\varepsilon}}$$

$$\left\{\frac{1}{\lambda_1}\frac{\theta}{1+\Psi_2}\left(\frac{\varepsilon a}{\varepsilon-1}\right)^{1-\varepsilon}\Psi^{\kappa(\varepsilon-1)}\left(\delta f^E\right)^{\frac{\kappa(\varepsilon-1)}{(\kappa(\varepsilon-1)-1)\theta}}\left(1+\Lambda^{\lambda_1}(B(\tau)-1)\right)\left(\frac{1}{\frac{f_i}{\lambda}+\frac{\Lambda^\theta f_X}{f_i}}\right)^{\frac{\lambda_1}{\theta}}\right\}^{\frac{1-\kappa(\varepsilon-1)}{1-\varepsilon}}$$

The characterization of the equilibrium in the open economy is complete, where A and the production technology cutoff N^* are immediately derived from the aggregate price level.

$$A =$$

$$\left\{ \frac{1}{\lambda_1} \frac{\theta}{1+\Psi_2} \left(\frac{\varepsilon a}{\varepsilon - 1} \right)^{1-\varepsilon} \Psi^{\kappa(\varepsilon-1)} \left(\delta f^E\right)^{\frac{\kappa(\varepsilon-1)}{(\kappa(\varepsilon-1)-1)\theta}} \left(1 + \Lambda^{\lambda_1}(B(\tau)-1)\right) \left(\frac{1}{\frac{f_i}{\lambda} + \frac{\Lambda^\theta f_X}{f_i}} \right)^{\frac{\lambda_1}{\theta}} \right\}^{\kappa(\varepsilon-1)-1}$$

2.8.2 Example Two

When $c = 0$, $C(N) = \frac{1}{\phi} N^\phi$. In the closed economy, the technology adoption by the φ-firm,

$$N(\varphi) = \Psi_\phi \left(\frac{A}{\varphi} \right)^{\frac{1}{\phi - \kappa(\varepsilon-1)}} \qquad X = \frac{\varphi N^{\phi-1}}{a\kappa}. \tag{2.51}$$

$\Psi_\phi \equiv \left(\frac{a^{\varepsilon-1}}{\kappa} \right)^{\frac{1}{\kappa(\varepsilon-1)-\phi}} \left(\frac{\varepsilon}{\varepsilon-1} \right)^{\frac{\varepsilon}{\kappa(\varepsilon-1)-\phi}}$. The (ZPC) in the closed economy is,

$$\varphi_i^{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-\phi}} \Theta_\phi(A) = f, \qquad i \in \{D, F\} \tag{2.52}$$

$\Theta_\phi(A) \equiv \frac{\phi-\kappa(\varepsilon-1)}{\phi\kappa(\varepsilon-1)} \Psi_\phi^\phi A^{\frac{\phi}{\phi-\kappa(\varepsilon-1)}}$. Using the Pareto distribution in the FEC, integrating and substituting for the value of φ_i from the ZPC yield the solution of φ_i in terms of the model's parameters:

$$\varphi_i = \left[\frac{\delta f^E}{f_i} \lambda_\phi \right]^{\frac{1}{\theta}}, \qquad i \in \{D, F\} \tag{2.53}$$

$\lambda_\phi \equiv \frac{\theta + \frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-\phi}}{\frac{\kappa(\varepsilon-1)}{\phi-\kappa(\varepsilon-1)}}$. Notice that $M = \frac{L}{\bar{r}}$, and $\bar{r} = \int_0^{\varphi_i} r(\varphi) \frac{dG(\varphi)}{G(\varphi_i}$ is the expected revenue conditional on a successful entry. Using this relationship,

$$M^E = \frac{L}{f^E} \frac{1}{(1+\Psi_1)\phi}. \tag{2.54}$$

Notice that $1+\Psi = \theta\frac{\varepsilon}{\kappa(\varepsilon-1)}$. The aggregate price level is given by:

$$P =$$

$$L^{\frac{1}{1-\varepsilon}} \left\{ \frac{1}{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-\phi}+\theta} \frac{\theta}{\phi(1+\Psi_1)} \left(\frac{\varepsilon a}{\varepsilon-1}\right)^{1-\varepsilon} \Psi_{\phi}^{\kappa(\varepsilon-1)} \left(\delta f^E\right)^{\frac{\kappa(\varepsilon-1)}{(\kappa(\varepsilon-1)-\phi)\theta}} \left(\frac{\lambda_\phi}{f_i}\right)^{\frac{\kappa(\varepsilon-1)}{(\kappa(\varepsilon-1)-\phi)\theta}+1} \right\}^{\frac{\phi-\kappa(\varepsilon-1)}{\phi(1-\varepsilon)}}$$

We follow similar steps as in Example One to find the technology adoption level by firms.

$$N^*(\varphi) = \Psi_\phi \left(\frac{A}{\varphi}\right)^{\frac{1}{\phi-\kappa(\varepsilon-1)}}, \qquad X^* = \frac{\varphi N^{\phi-1}}{a\kappa} \tag{2.55}$$

$$N_e^*(\varphi) = \Psi_\phi \left(A(1+\tau^{1-\varepsilon})\right)^{\frac{1}{\phi-\kappa(\varepsilon-1)}} \varphi^{\frac{1}{\kappa(\varepsilon-1)-1}}, \qquad X^* = \frac{\varphi N^{\phi-1}}{a\kappa} \tag{2.56}$$

We can also show that the export cutoff $\varphi_X = \Lambda_\phi \varphi_i$. Here $\Lambda_\phi \equiv \left(\frac{f_X}{f_i(B_\phi(\tau)-1)}\right)^{\frac{\kappa(\varepsilon-1)-\phi}{\kappa(\varepsilon-1)}} < 1$, and $B_\phi(\tau) \equiv \left(1+\tau^{1-\varepsilon}\right)^{\frac{\phi}{\phi-\kappa(\varepsilon-1)}} > 1$. Consequently,

$$\varphi_i = \left[\frac{\delta f^E}{\frac{f}{\lambda_\phi} + \Lambda_\phi^\theta \frac{f_X}{\lambda_\phi}}\right]^{\frac{1}{\theta}} < \left[\frac{\delta f^E}{f_i/\lambda_\phi}\right]^{\frac{1}{\theta}} \tag{2.57}$$

The aggregate price level is

$$P_i = L^{\frac{1}{1-\varepsilon}} \{ \frac{1}{\lambda_{1\phi}} \frac{\theta}{\phi(1+\Psi_1)} \left(\frac{\varepsilon a}{\varepsilon-1}\right)^{1-\varepsilon} \Psi_\phi^{\kappa(\varepsilon-1)} \left(\delta f^E\right)^{\frac{\kappa(\varepsilon-1)}{(\kappa(\varepsilon-1)-\phi)\theta}}$$
$$\left(1+\Lambda_\phi^{\lambda_{1\phi}}(B_\phi(\tau)-1)\right) \left(\frac{1}{\frac{f_i}{\lambda_\phi} + \frac{\Lambda_\phi^\theta f_X}{f_i}}\right)^{\frac{\lambda_{1\phi}}{\theta}} \}^{\frac{\phi-\kappa(\varepsilon-1)}{\phi(1-\varepsilon})}$$

$\lambda_{1\phi} \equiv \theta + \frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-\phi}$. We can simply find the market size A in the closed and the open economies from the zero-profit condition once we solve for the ZPC.

No technology upgrading/downgrading. Here I assume that c is large enough such that no firm finds it optimal to change its production technology chosen in autarky. The whole goal of this exercise is to asses the gains from trade under the endogenous technology setting versus the gains from trade under the standard models of trade with heterogeneous firms and CES preferences. I proceed as follows. First, I characterize the equilibrium in the closed and the open economies as in Example 2 with $C(N) = \frac{1}{\phi}N^{\phi}$. Our approach and results are exactly as shown above. The welfare $\mathbf{W} = \frac{w}{P}$ in the closed and the open economies are derived consequently. Next, we envision a world economy where every firm maintains its production technology adopted in the closed economy because adjustment costs are prohibitive. The ZPC in the open economy therefore is given by;

$$\frac{1}{\varepsilon}r(N(\varphi_i)) - \overbrace{\varphi_i C(N(\varphi_i))}^{\text{fixed in open economy}} = f_i \tag{2.58}$$

Substitute for $r(.)$ and N in terms of φ and simplify, we get

$$\Psi_{\phi}^{\phi} A_{close}^{\frac{\phi}{\phi-\kappa(\varepsilon-1)}} \left[\frac{A_{open}}{A_{close}} \frac{1}{\kappa(\varepsilon-1)} - \frac{1}{\phi}\right] \varphi_i^{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-\phi}} = f_i \tag{2.59}$$

The cost of adopting technology N is fixed from a firm perspective once it has been chosen. Furthermore, in the open economy, since no firm exports without selling to the domestic market, I comply with the literature and assume that both the fixed cost of producing f and the fixed cost of technology adoption $C(N)$ are paid from the domestic sales and, hence, irrelevant to the export decision whenever a firm's productivity is invariant to trade status. The exporting cutoff φ_X is pinned down in the standard way here: a firm chooses to export if the export sales net of variable costs cover the fixed cost of exporting.

$$r^x(N(\varphi_x) - \tau aNX - f_x = 0 \tag{2.60}$$

$$\frac{1}{\varepsilon}\tau^{1-\varepsilon} r(N(\varphi_x)) = f_x. \tag{2.61}$$

$$\frac{1}{\varepsilon}\tau^{1-\varepsilon} A_{open} \left(\frac{\varepsilon a}{\varepsilon-1}\right)^{1-\varepsilon} \Psi_{\phi}^{\kappa*(\varepsilon-1)} A_{close}^{\frac{\kappa*(\varepsilon-1)}{\phi-\kappa(\varepsilon-1)}} \varphi_X^{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-\phi}} = f_x. \tag{2.62}$$

where $r^x(.)$ denotes revenues in export destination market, and $r(.)$ denotes gross sales in domestic market. FEC is,

$$\int_0^{\varphi_i} \pi^D(\varphi)dG(\varphi) + \int_0^{\varphi_D} \pi^X(\varphi)dG(\varphi) = \delta f^E \tag{2.63}$$

$$\left(\frac{\theta}{\lambda_{1\phi}} - 1\right)\left[f_i\varphi_i^{\theta} + f_x\varphi_X^{\theta}\right] = \delta f^E. \tag{2.64}$$

$\pi^D(.)$ and $\pi^X(.)$ are profits in domestic and export markets, respectively. Apparently, there are no closed form solutions for the three equations above, thus, I resort to numerical solution. From the ZPC and the export cutoff equation, I write ZPC and export cutoffs in terms of the market size in the open economy and the model's parameters (note that the market size in the closed economy is given). After plugging the values of producing and exporting cutoffs in FEC, we end up with one equation and one endogenous variable A_{open}. The value of all model's parameters are given in our calibration from Example One. However, the value of the fixed cost of exporting we obtained above to ensure that only 21% of firms export will be problematic in the current setting. With endogenous technology, the cost of adopting technology N is paid by sales from both markets since an exporter maximizes the joint profits in both markets, and therefore, the level of N is directly connected to export decision. In the current setting, nonetheless, the markets are completely separable and, importantly, the cost of technology adoption is irrelevant to exporting decision. In fact, no acceptable numerical solution can be found when using the value of f_x we had in the previous example. Two methods are implemented to solve this problem. In the first method, for the given values of f_x, I characterize the equilibrium for every value of f_x and calculate the ratio of correspondent exporters to the total number of surviving firms. Among those equilibria, I choose the one with exporters' fraction that satisfies the 21% condition and use it to compare the gains from trade under the two scenarios. In the second method, I impose $\frac{G(\varphi_X)}{G(\varphi_i)} = 21\%$. Again, there is no closed formula here to construct the proper restrictions on the related parameters' value. As a result, I add this condition to free entry condition and solve simultaneously for both A_{open} and f_x. Once market size A_{open} is obtained, it is straightforward to compare the gains from trade under constant technology with the gains from trade with endogenous technology. One might concern that, given the fact that some parameters (in particular, f_x) under the two scenarios are not the same, we might end up comparing orange with apple. I argue that, although it is a legitimate criticism, it does not disturb our comparison. In contrast, the results we obtain provide the minimum impact of endogenous technology on gains from trade because the calibrated values of f_x in constant productivity environment estimated by either method are always less than the ones we obtained under endogenous productivity.

2.8.3 Example Three: Asymmetric Countries

I characterize the equilibrium in the case of asymmetric countries with $C(N) = \frac{1}{\phi}N^{\phi}$ and $c = 0$. The closed economy aggregate equilibrium variables and the firm's production technology are solved for each country $i \in \{D, F\}$ as shown above. The open economy aggregate variables are obtained numerically by solving the following equations simultaneously (Note all parameters are common in both countries except f^E):

$$\Theta(A_i)\varphi_i^{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-\phi}} = f \qquad \text{ZPC} \tag{2.65}$$

$$\left[\Theta(\mathcal{A}_i) - \Theta(A_i)\right]\varphi_{ji}^{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-\phi}} = f_x \quad i,\, j \in \{D,\, F\} \qquad \text{Export} \tag{2.66}$$

$$\frac{1}{\lambda_{1\phi}}\Theta(A_i)\left(\varphi_i^{\lambda_{1\phi}} - \varphi_{ji}^{\lambda_{1\phi}}\right) - \left(\varphi_i^{\theta} - \varphi_{ji}^{\theta}\right)f + \frac{\theta}{\lambda_{1\phi}}\Theta(\mathcal{A}_i)\varphi_{ji}^{\lambda_{1\phi}} - \varphi_{ji}^{\theta}(f + f_x) = \delta f_i^E \qquad \text{FEC} \tag{2.67}$$

$\lambda_{1\phi}$ and $\Theta(.)$ are defined as above, and $\mathcal{A}_i = A_i + \tau^{1-\varepsilon}A_j$.

2.9 Appendix C: The Distribution of Firm Sales in Zipf's Law

In the data, the distribution of firm size follows a power law with an exponent close to 1. That is, the firm's sales, s, are therefore distributed according to

$$Pr(s > S) = cS^{-\zeta}, \qquad \zeta \approx 1. \tag{2.68}$$

In the current model (with $C(N) = \frac{1}{\phi}N^{\phi}$, and $c = 0$), φ-firm sales, s, can be written as follows:

$$s(\varphi) = r(\varphi) = p(\varphi)q(\varphi) = A\left(\frac{\varepsilon}{\varepsilon-1}\frac{a}{N^{\kappa}}\right)^{1-\varepsilon} \tag{2.69}$$

$$= A^{\frac{\phi}{\phi-\kappa(\varepsilon-1)}}\Psi_{\phi}^{\kappa(\varepsilon-1)}\varphi^{\frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-\phi}} \tag{2.70}$$

$$= \Gamma\varphi^{\eta} \tag{2.71}$$

where $\Gamma \equiv A^{\frac{\phi}{\phi-\kappa(\varepsilon-1)}}\Psi_{\phi}^{\kappa(\varepsilon-1)}$ and $\eta \equiv \frac{\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)-\phi}$. The distribution of firm sales in the current model, then, obtained as follows:

$$Pr(s > S) = Pr(\Gamma\varphi^{\eta} > S) \tag{2.72}$$

$$= Pr((\frac{1}{\varphi})^{-\eta} > \frac{S}{\Gamma}) \tag{2.73}$$

$$= \left(\frac{S}{\Gamma}\right)^{\frac{\theta}{\eta}} \tag{2.74}$$

$$= cS^{-\zeta} \tag{2.75}$$

$c \equiv \Gamma^{-\theta\eta}$ and $\zeta \equiv \theta(\frac{\phi-\kappa(\varepsilon-1)}{\kappa(\varepsilon-1)})$.

Figure 2.1: Technology Adoption: Example One

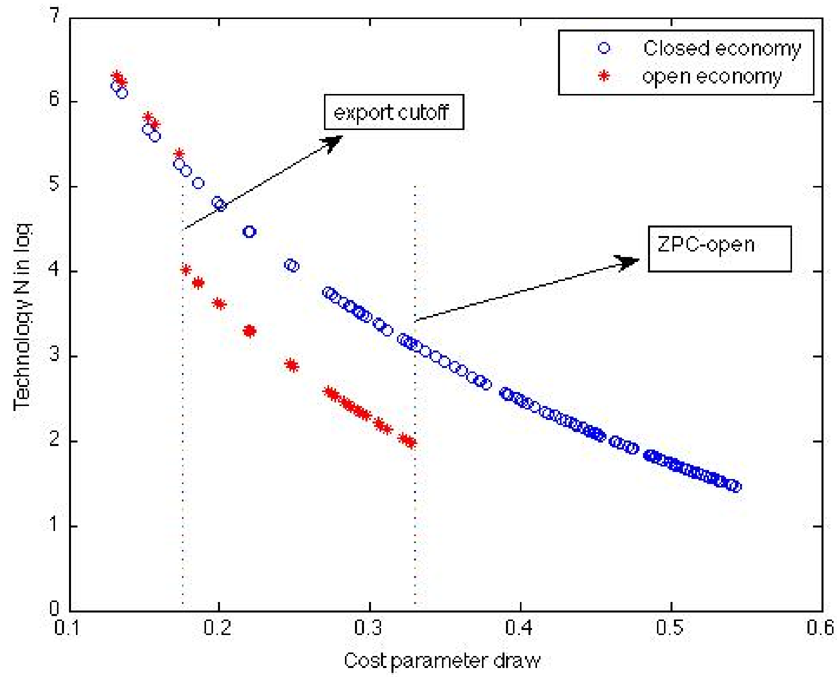


Figure 2.2: Firm Productivity N^{κ} in the Open and Closed Economies: Example One

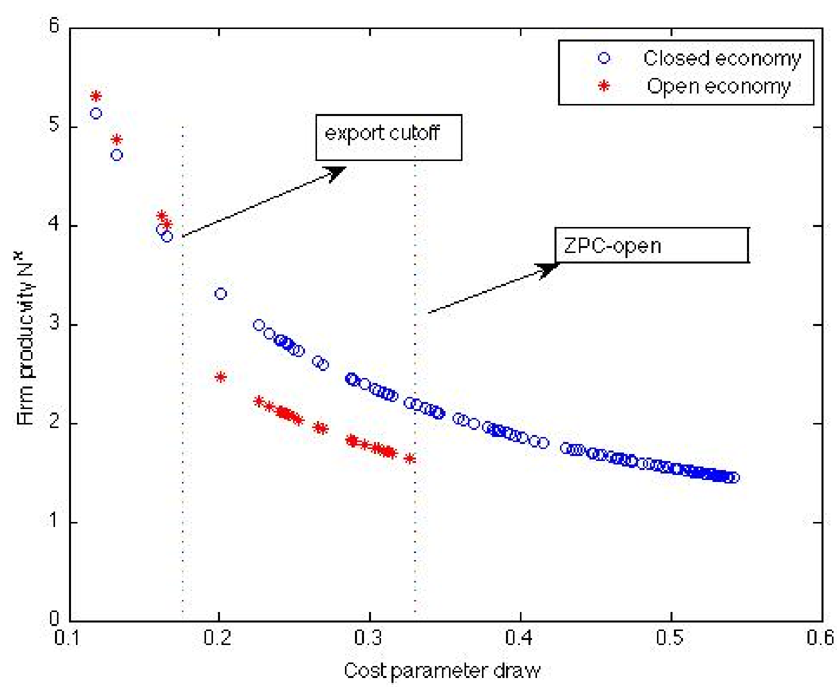


Figure 2.3: Relative Productivity: Example One

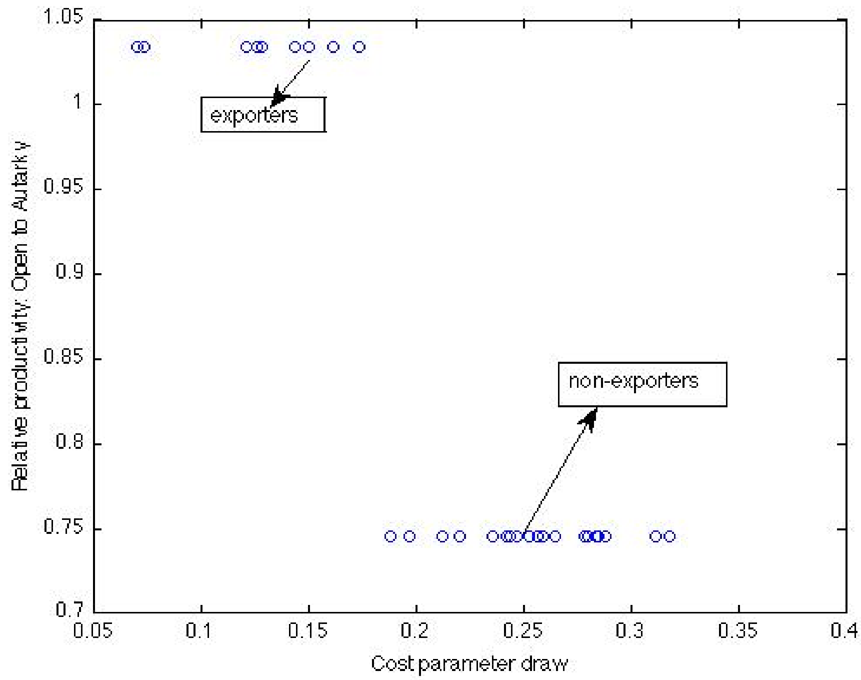


Figure 2.4: Firms Net Profits in the Open and Closed Economies: Example One

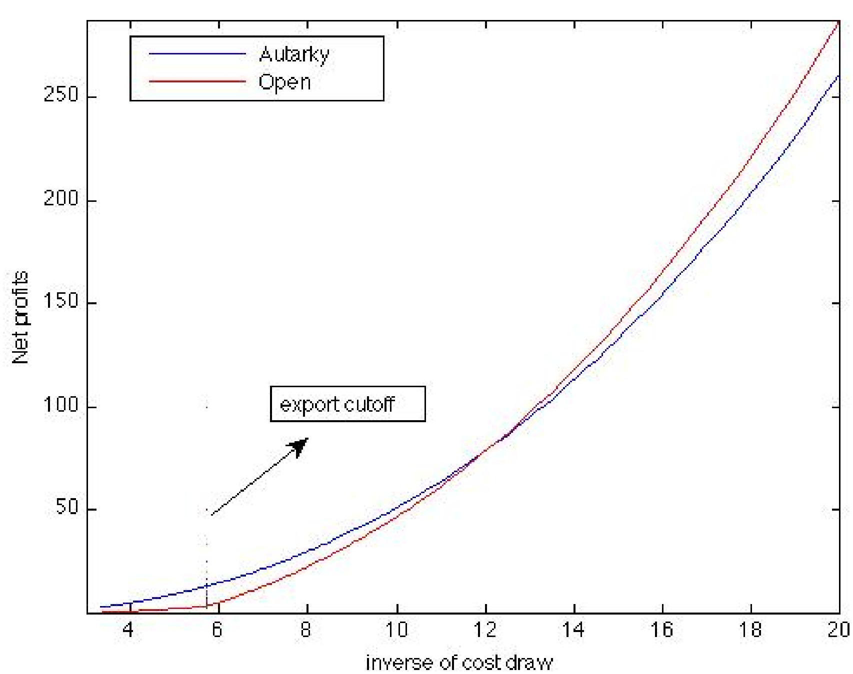


Figure 2.5: Example Two with $\phi = 1.25$ and No Adjustment cost $c = 0$

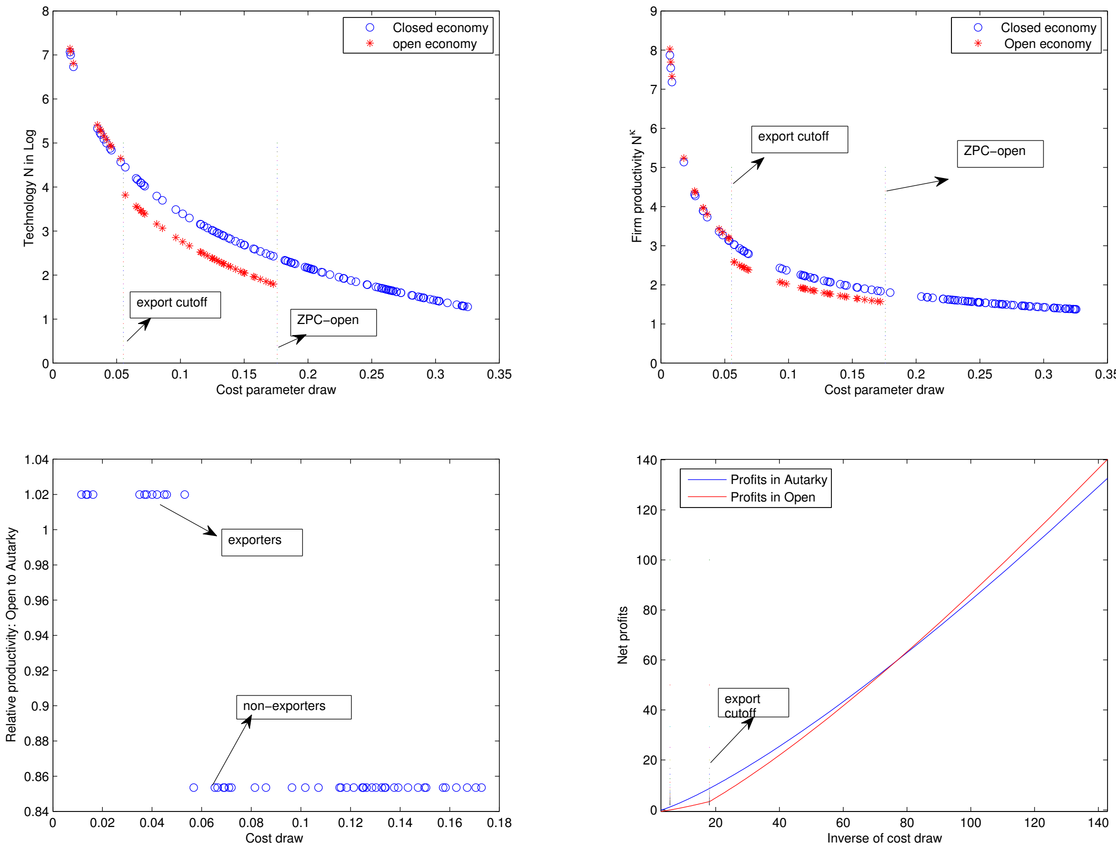


Figure 2.6: Firms Productivity: Reduction in Variable Trade Costs τ from 1.3 to 1.2

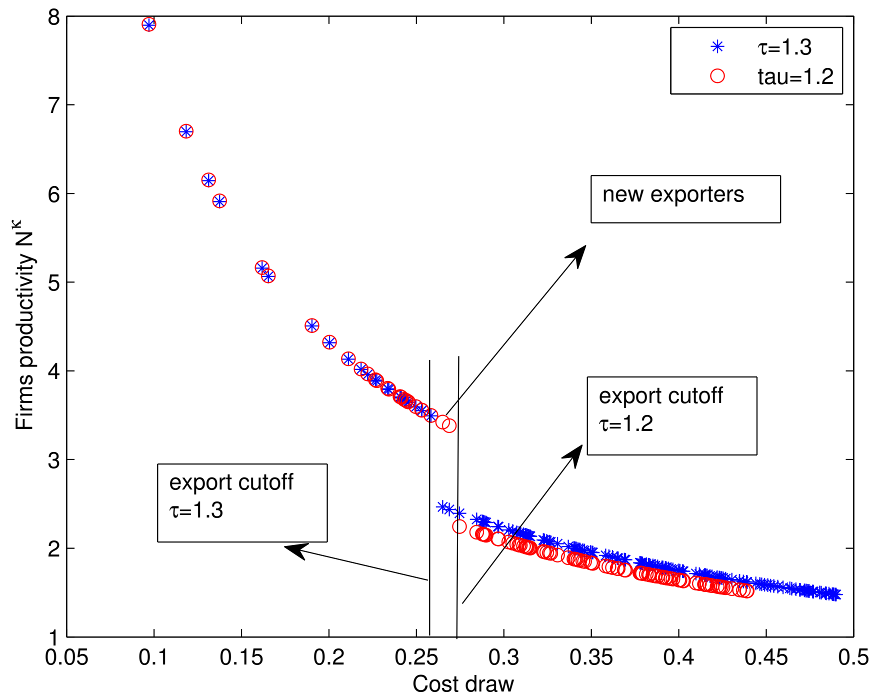


Figure 2.7: Trade Liberalization Impacts on a Firm's Productivity: Variable Trade Costs τ

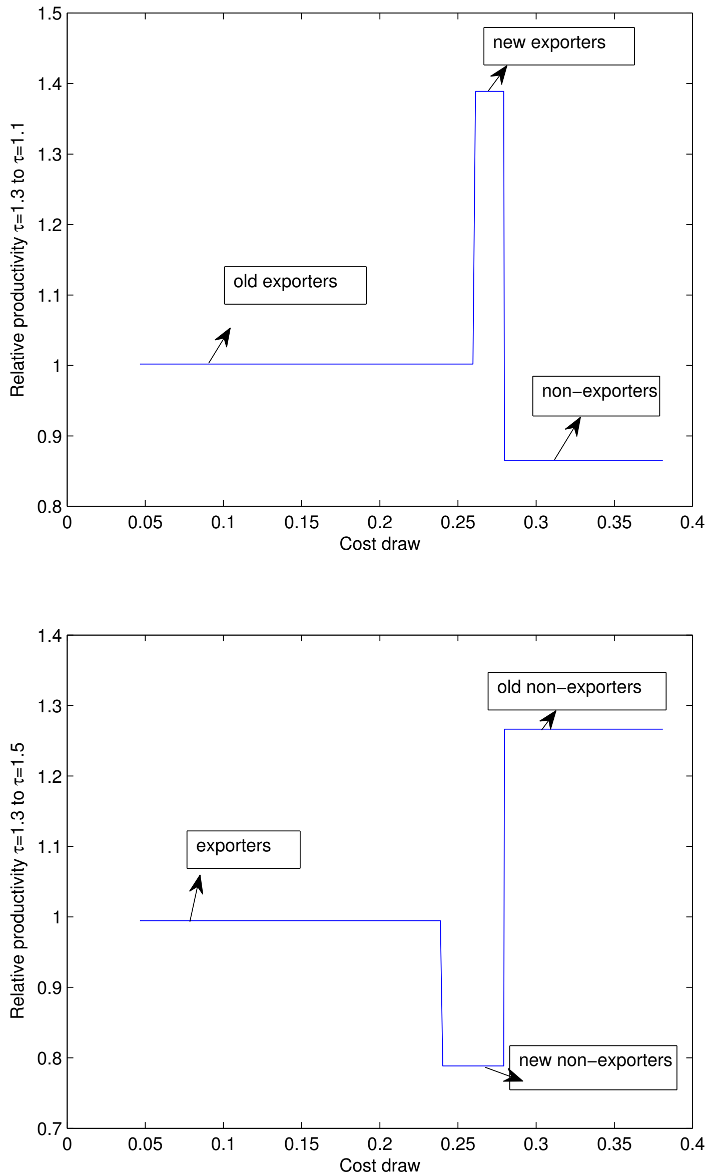


Figure 2.8: The Impact of Fixed Cost of Exporting on a Firms' Productivity

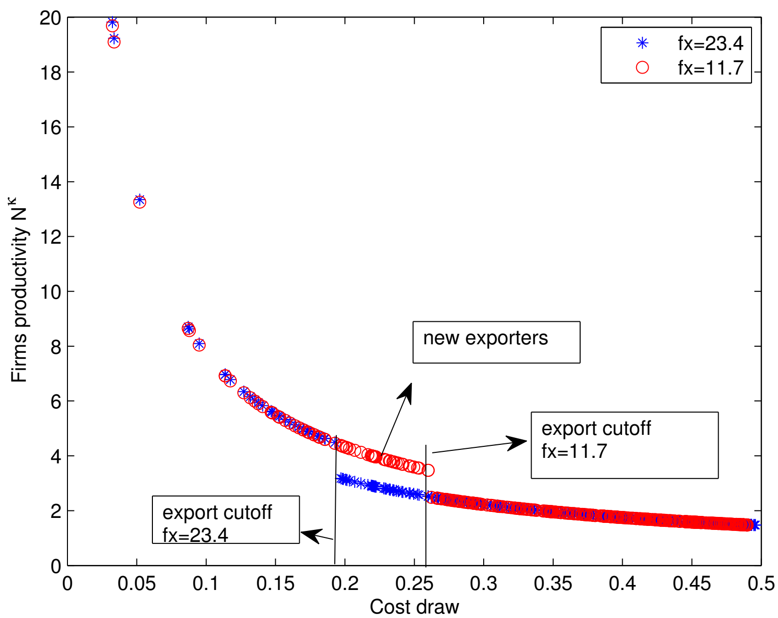


Figure 2.9: Trade Liberalization Impacts on a Firm's Productivity: Fixed Cost of Trade

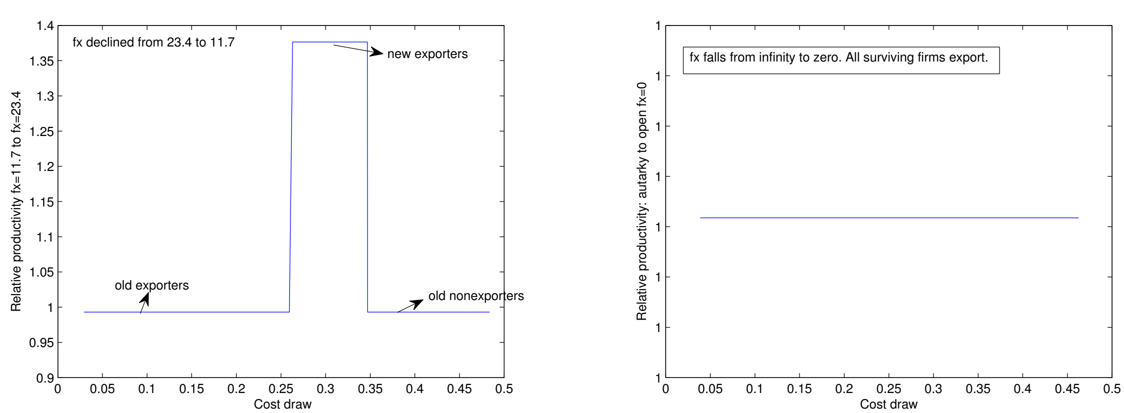
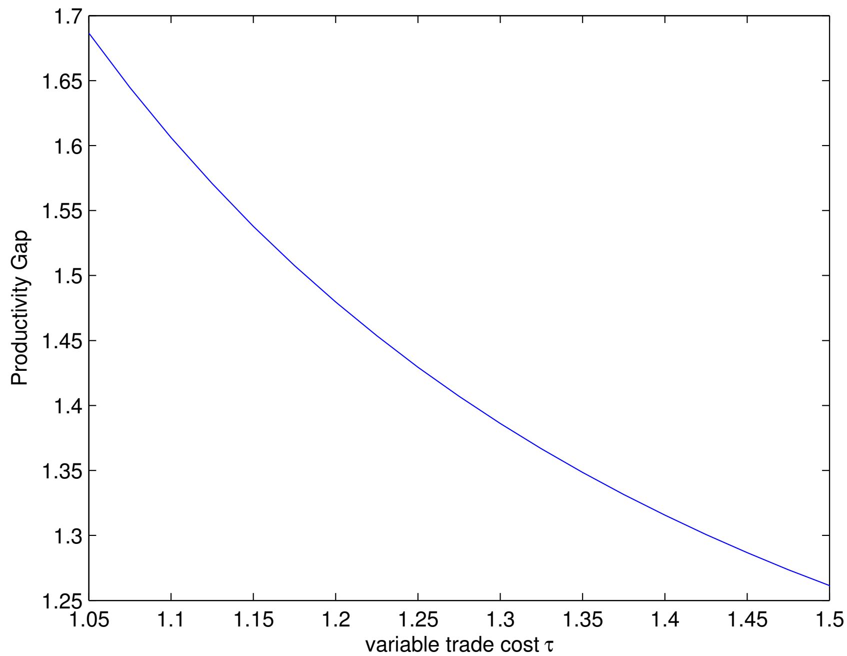


Figure 2.10: Productivity Gap between an Exporter and a Nonexporter: Symmetric Countries



Note: All remaining parameters are as in the baseline calibration, including the fixed cost of trade f_x. The cost of technology adoption is given by the functional form in Example One. In case of symmetric countryies, the normalized productivity gap is given by $(1+\tau^{1-\varepsilon})^{\frac{1}{1-\kappa(\varepsilon-1)}}$, which is indeed decreasing with τ. The gap is between an exporter who continues to be an exporter for all values of τ above and a nonexporter who also continues to be a nonexporter for all values of τ above. The normalization rules out productivity differences from cost draws.

Figure 2.11: Exporter's productivity: Symmetric Countries

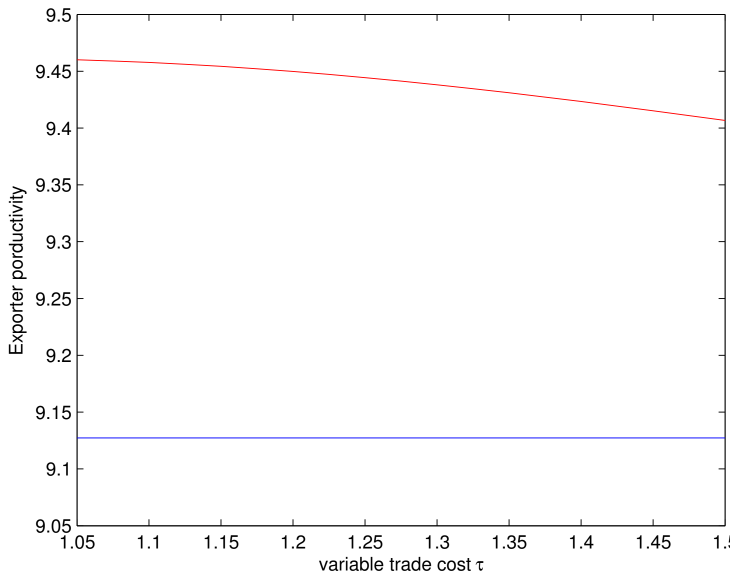
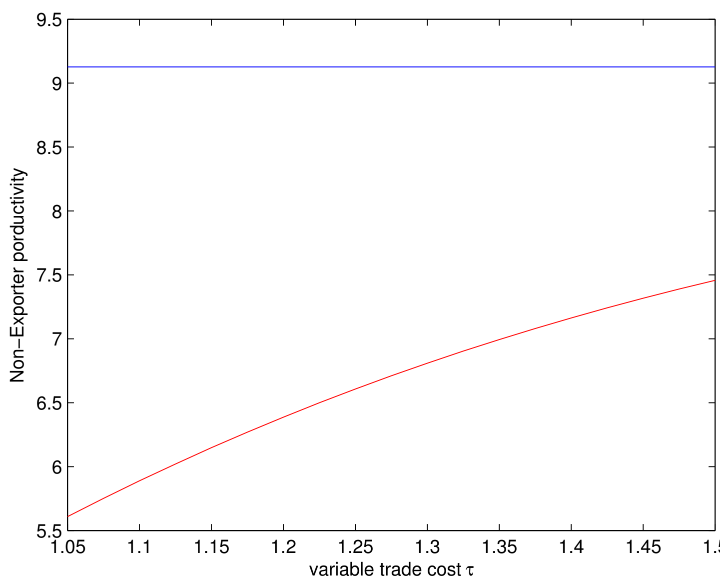
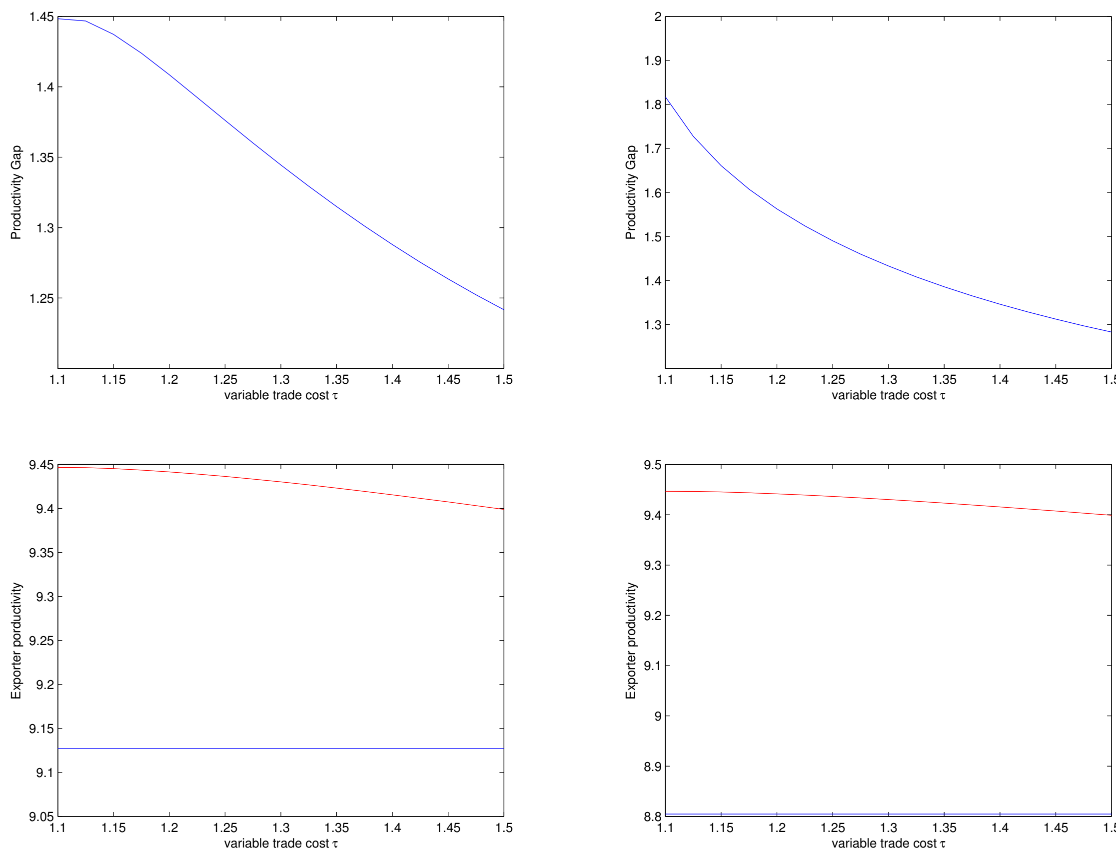


Figure 2.12: Nonexporter's Productivity: Symmetric Countries



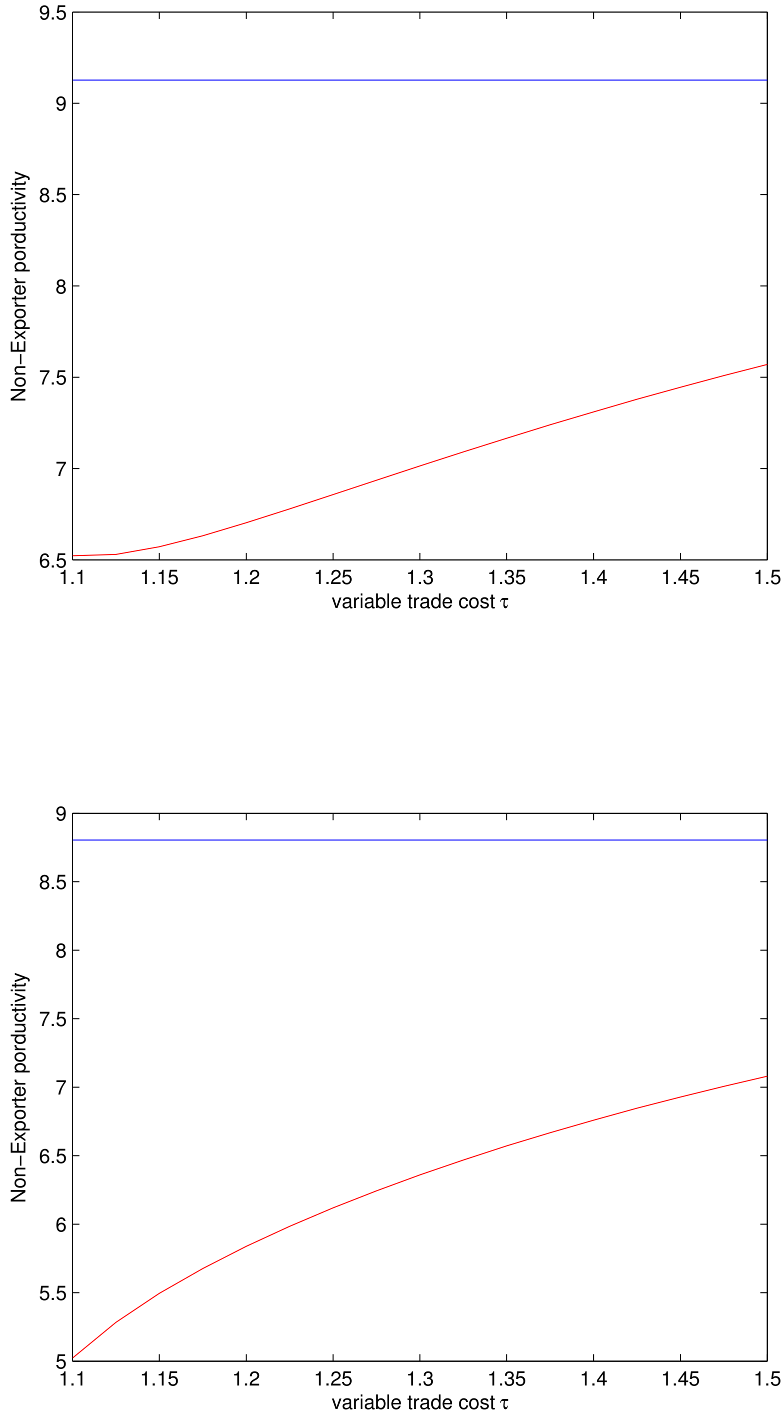
Note: The figures above show the productivity of one single exporter/nonexporter who continues to be an exporter/nonexporter for any $\tau \in [1.05\,1.5]$. The blue line shows the firm's productivity in the closed economy.

Figure 2.13: Productivity Gap between an Exporter and a Nonexporter: Asymmetric Countries



Note: The top left and the bottom left figures show the productivity gap between an exporter and a nonexporter, and an exporter's productivity in the large country, respectively. The top and the bottom right figures show the productivity gap between an exporter and a nonexporter, and an exporter's productivity in the small country. The blue line in the lower figures denotes an exporter's productivity in the closed economy. Notice that, in contrast to symmetric countries case, I cannot allow τ to be lower than 1.1 in the current example. In fact, for any $\tau \in [1, 1.1)$, the ZPC in the small country is lower than the exporting cutoff. The gap is larger in the small country and the small country exporters' productivity in the open economy relative to autarky is higher than the large country exporters' relative productivity. In absolute values, the average exporter/nonexporter in the large country enjoys higher productivity.

Figure 2.14: Nonexporter Productivity: Asymmetric Countries



Note: The top figure shows a nonexporter's productivity who resides in the large country. The bottom figure shows a nonexporter's productivity in the small country

CHAPTER III

Contracting Institutions and International Trade: The Political Economy of Institutions in the Global Economy

3.1 Introduction

Since the influential work of Levchenko (2007), numerous papers have documented the importance of domestic institutions as a source of countries' comparative advantage.[1] Nonetheless, small but growing literature is emphasizing on the impact of international trade on domestic institutions.[2] A common theme across these studies is that trade openness pro-

[1] A notable paper here is Nunn (2007) who provides a decisive empirical evidence on the role of contracting institutions as a source of comparative advantage (for an excellent review of the literature, see Nunn and Trefler, 2013). In fact, domestic institutions not only impact the comparative advantage of countries, but also affect the volume of trade and trade policy as well. For instance, Morrow et al. (1998); Mansfield et al. (2000), and Decker and Lim (2009) show that good institutions (either in the form of democratic regimes or contracting institutions) favor trade. Anderson and Marcouiller (2002) empirically demonstrate that low-quality institutions reduce trade, as insecurity raises the price of traded goods. de Groot et al. (2004), and Yu (2010) present a gravity equation augmented with institutional quality/democracy and find it has a positive effect on trade flows.

[2] See, for example (Levchenko, 2013; Eichengreen and Leblang, 2008; Acemoglu et al., 2005). Broadly, the endogenity problem between domestic institutions and economic performance is indeed

found affects the evolution of domestic institutions. Yet the literature has not settled on whether trade liberalization improves domestic institutions and if so under what conditions.

This paper addresses the impact of trade liberalization on contracting institutions.[3] As documented by many researchers, the effect of domestic institutions on economic growth and economic performance cannot be overemphasized. If the quality of domestic institutions is affected by trade openness, then the gains from trade go beyond what the standard models of trade propose. Anecdotes from historical studies suggest that trade openness might deteriorate or improve domestic institutions, however. Trade alters the political power of the contested groups in the society by enriching specific groups in the economy who in turn might affect the domestic institutional change. For instance, the Atlantic triangle trade enriched the Caribbean plantation elite who exploited their new economic power to exclude workers from the political sphere.[4] Overall, the empirical results are inconclusive, with some studies finding positive impact of trade openness on institutional quality (Acemoglu et al., 2005; López-Córdova and Meissner, 2005; Rudra, 2005; Subramanian et al., 2007; Levchenko, 2013), others finding negative impact of trade (Li and Reuveny, 2003; Segura-Cayuela, 2006; Engerman and Sokoloff, 1997, 2002; Yu, 2007; Woodward, 1999), and still others finding no clear impact of globalization on broad democratic institutions (Nicolini and Paccagnini, 2011; Rodrik et al., 2004; Rigobon and Rodrik, 2005).

The present study provides a unified theoretical framework of international trade with heterogeneous firms and contractual frictions. This framework has three main features. First, institutions are a source of comparative advantage. Second, institutional change has stark distributional consequence across firms within sectors. Third, the domestic institu-

well recognized in both the economic and the political economy literature (North, 1973, 1990; Acemoglu et al., 2001; Rodrik, 2008; Rodrik et al., 2004; Olson, 1982; Ostrom, 1990; de Mesquita et al., 2005; Acemoglu and Robinson, 2006; Przeworski, 2000)

[3]Contracting institutions refer to the rules and regulations that govern and organize private contracts between economic agents. Differences in contracting institutions across countries are substantial; for example, the cost of enforcing a simple commercial debt contract is over 440 percent of income per capita and requires a process lasting, on average, 495 days in the Dominican Republic, whereas in New Zealand, it costs less than 12 percent of income per capita and requires only 50 days (Acemoglu and Johnson, 2005). World Bank Doing Business Contract Enforcement Indicator and Worldwide Governance Indicators, and the indicator of institutional quality developed by Djankov et al. (2003) are examples of empirical measures (proxies) of contracting institutions.

[4]The Atlantic triangle trade refers to the Atlantic three-corner trade: Europe, Africa, and the New World.

tions are endogenously determined in a political economy equilibrium. The advantage of this framework is that it reconciles the main lessons from the historical studies of the impact of trade on domestic institutions. First, whether trade improves or deteriorates the domestic institutions is significantly determined by the initial domestic institutions. Second, it is the special interest groups that initiate and shape the direction of domestic institutional change.

To my knowledge, this is the first model that incorporates institutional frictions to international trade model with heterogeneous firms and monopolistic competition where institutions themselves are a source of comparative advantage and therefore play a key role in shaping the patterns of trade.[5] The tractability of the model enables me to obtain a rich set of predictions and propositions. Some of these predictions are empirically supported in the literature but lack theoretical justification, whereas others are novel and enhance our understanding of the role of contracting institutional imperfections in the global economy.

The property rights model of Grossman and Hart (1986) is the cornerstone of modeling institutional frictions in the current model. In particular, the environment is one of the partial institutional imperfections as in Acemoglu et al. (2007) (see model's details below). The advantage of adopting this approach of modeling institutional frictions, in contrast to the transaction cost approach (Coase-Williamson), is that "the space of contracts and the

[5]Levchenko (2007) provides a model of institutional comparative advantage in an H-O framework. Acemoglu et al. (2007) present a model of institutional imperfection in the closed economy and show the distortionary impact of institutional friction on technology adoption and consequently firms' productivity. In an open economy, institutions are a source of comparative advantage. In contrast to their framework, production technology is constant here, yet institutional differences across countries are a source of comparative advantage. Moreover, the current model is more tractable in analyzing patterns of trade and the impact of the interaction of trade impediments with institutional quality in shaping trade patterns and gains from trade. Antras and Helpman (2004, 2008); Antras (Forthcoming), and Antras and Chor (2013) propose a theoretical framework of institutional frictions in the global economy, but they are mostly interested in firm organization and offshoring. Do and Levchenko (2009) develop a model that embeds institutions in the Melitz' s model, where institutions are modeled as fixed production cost. That is, institutional reforms in their model can be understood as deregulations (specifically, improving the doing business environment by reducing the costs of starting a business). The current paper deals with contracting institutions measured by rule of law and contract enforcement. Stefanadis (2010) shows how trade impacts institutions by changing the aggregate allocation of talent between production and appropriation. The main mechanism in his model is that, under a new trade theory framework, trade changes the composition of domestic varieties relative to total varieties. Hence, overall product variety becomes less sensitive to domestic manufacturing activity. The preopenness institutions determine whether trade enhances or hinders domestic institutions.

nature of ex-post negotiations between parties are independent of the ownership structure decision at period zero" Antras (Forthcoming). As a result, the holdup problem persists even with vertical integration. Accordingly, the results of the present paper are qualitatively robust and invariant to different ownership structures. The Melitz model is augmented with a modified version of the partially imperfect contracts framework of Acemoglu et al. (2007), and the general equilibrium is accordingly solved.

The world economy consists of two symmetric countries except for contracting institutional quality, and two sectors. The first sector produces homogenous goods under perfect competition and complete contracts. The other sector produces differentiated products under monopolistic competition and subject to incomplete contracts. The specification of firms' entry, exit, and export in the differentiated products sector is similar to Melitz (2003)'s model.

Institutional quality in this setting will be a source of comparative advantage in the open economy. In particular, institutional frictions impact the share of intra-industry trade in a manner consistent with comparative advantage and factor proportion theories. A country with superior contacting institutions exports differentiated products on net and imports homogenous goods. In addition, economic welfare and gains from trade are increasing in domestic institutional quality.[6]

How do firms' preferences over institutions evolve in response to trade liberalization? Consequently how does trade liberalization facilitate institutional reforms or hinder them? Institutional reforms redistribute resources across firms, and as a result, firms' profits also change in response to changes in institutional quality. Specifically, on the one hand, advancing contracting institutions proportionately improves all domestic firms' productivity. Firms charge lower prices and generate more revenues and profits. On the other hand, as domestic institutions improve, the domestic market becomes more competitive, reducing firms' profits from selling in the domestic market. The latter effect outweighs the former, resulting in

[6]These results are remarkably similar to those of Helpman and Itskhoki (2010) who study the interaction between labor market frictions and international trade. Although the two studies deal with different frictions and adopting completely different modeling approaches, both deliver very similar results regarding the patterns of trade, gains of trade and country-interdependence.

lower profits in the domestic market as domestic institutions improve. Nonetheless, profits from exporting to the foreign market increase as domestic institutions improve since the foreign market competitiveness does not increase with domestic institutional quality. To satisfy the free entry condition, exporters' aggregate profits in both markets (domestic and foreign) increase as domestic institutions improve. Moreover, institutional reform induces the least productive firms to exit the market and the most productive nonexporters to start exporting.

Interestingly, the distribution of firm-preferences over institutional reforms depends on country's relative institutional quality. In a country with inferior institutions, both the ratios of exporters to nonexporters and export sales to domestic sales are low relative to the country with superior institutions. Consequently, the fraction of firms that support/oppose institutional reforms varies across countries. Overall, for a given level of trade openness, the opposition to reforms is much more intensified in a country with inferior institutions, and the fraction of firms that support reforms is small and weak compared with a country with superior institutions. In other words, countries with weak institutions are more susceptible to the political pressures from the domestic losers from institutional reforms. The analysis is consistent with many papers in this vein. For instance, Segura-Cayuela (2006) proposes a model of trade and inefficient institutions in which trade liberalization in economies with weak institutions might lead to worse economic policies and institutions.[7]

Lower trade costs not only impact the relative power of exporters and nonexporters, but also magnify the distributional consequences of domestic institutional reforms. To see this, as trade costs fall, the ex-ante expected profits significantly increase in institutional

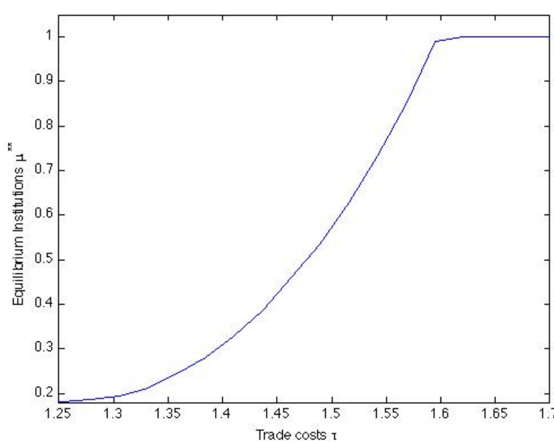
[7]Inefficient institutions refer to the ability of the elite (autocrats) to expropriate from the nonelite. Trade openness reduces the distortionary effects of expropriating institutions on elite-owned sector's profits by making the elite sectors rely less on nonelite sectors, thus increasing the elite's ability to extract. A similar argument is made by Bourguignon and Verdier (2005). In their model, physical and human capital are complements. In the societies initially dominated by the oligarchic capitalist elite and incomplete financial markets, trade liberalization might act as disincentive for investment in human capital (less education subsidy), consolidating less democratic institutions and less egalitarian economy. Stefanadis (2010) provides a theoretical model where international trade leads to institutional deterioration in predator-friendly economies, whereas in producer-friendly economies, trade improves institutions. Acemoglu et al. (2005) argue that the Atlantic trade between 1500 and 1850 had improved institutions in countries with initially advanced institutions. In a different vein, Franzese and Mosher (2002) argue that trade strengthens domestic institutions (networks) regardless of their efficiency.

quality (since exporting is more profitable), leading more firms to enter the market. That is, for low trade costs, as domestic institutional quality improves, the greater the profit loss in the domestic market and the larger the exporting profits. In fact, in the closed economy, firms' profits are invariant to domestic institutional qualityincrease in firm's productivity is completely offset by the increase of the domestic market competitiveness. In effect, firms are expecting to engage more in political activities tailored to influence the domestic institutions as trade costs decrease.

To demonstrate the impact of lowering trade costs on the domestic contracting institutions, the "Protection for sale" lobbying framework of Grossman and Helpman (1994) is employed to endogenize contracting institutions. There are two lobbyist groups in the economy: a subset of nonexporters and a subset of exporters. Each group proposes a menu of offers that relates prospective monetary contribution to the level of contracting institutions to maximize the group's joint economic welfare. The incumbent government takes the offers as given and chooses domestic institutional quality to maximize a weighted sum of aggregate social welfare and total contribution.

The take-home message is summarized in Figure 3.1. In this example, only nonexporters

Figure 3.1: Impact of Trade on the Political Equilibrium of Institutional Quality



are assumed to lobby (see Section 3.6 for more details on the political economy model and the parameters used to produce the figure). Given that the losers from institutional reforms dominate the political economy in the country, the endogenous contracting institutional qualities that emerge as the solution to the political economy decrease as the economy becomes more and more open. In this scenario, trade liberalization worsens contracting institutions in the country.

The example underscores the importance of the political economy mechanism and the distribution of the political power in the economy in determining the impact of trade liberalization on the domestic institutions, a feature that is shared with many papers in this subject. For instance, in Stefanadis (2010), a crucial determinant of the effect of trade openness on institutions and the distribution of talent is the political economy setting of a country. Whether the politically dominant group in the economy is the producer or the predator determines how domestic institutions respond to trade openness. In contrast to the related literature and consistent with the recent trade models with heterogeneous firms, the emphasis in the current paper is on firms' responses to institutional reforms.

An interesting feature of the model is its implication of country interdependence. First, an improvement in a country's own institutions enhances its welfare but hinders its trade partner's welfare, *all else equal*. This intriguing result emanates from the fall in trade partner's competitiveness as domestic institutions advance, which outweighs the effect of term of trade improvement. The result contradicts the impact of unilateral trade liberalization where lowering import tariff unilaterally increases the partner's economic welfare but hurts the domestic economic welfare because of what is known in the literature as the home market effect.[8] Second, its is shown that the endogenous contracting institutions that emerge as the equilibrium solution to the political economy game, for any given level of trade openness, are increasing with the trade partner's institutional quality.

The rest of the paper is organized as follows. Section 3.2 provides the theoretical model of trade and contracting institutions. Section 3.3 studies the interaction between trade impediments and contractual frictions in shaping patterns of trade and the gains from trade, and the differential impacts of trade liberalization on countries with different institutional settings. Distributive consequences of institutional reforms and firm-preferences over insti-

[8]See, for example, Krugman (1980); Melitz and Ottaviano (2008). Recently, Demidova and Rodriguez-Clare (2013) demonstrate that the home market effect disappears when dispensing with the outside sector.

tutions in the open economy are the subject of Section 3.4. Section 3.5 provides a numerical example and conducts comparative statics analysis. Section 3.6 presents the political economy framework. Section 3.7 concludes. Detailed derivations and proofs can be found in the Appendix.

3.2 The Model

The interaction between contracting institutions and trade impediments is studied through a two-sector two-country model of international trade in which one sector produces a perfectly competitive homogenous products under perfect contracts and the other produces differentiated products subject to partially imperfect contracts. Countries (H and F indexed by i, j) are identical except for contractual friction. Each country is populated by a unit measure of consumers/workers (or, simply, a representative consumer). Labor the only factor of production is available in inelastic supply L. That is, the representative consumer is endowed with L units of labor, which she supplies inelastically.

In the differentiated products sector, the specification of firm exit, entry, and export is similar to that of Melitz (2003). A firm needs to pay a sunk entry cost f^E units of labor to learn its productivity φ drawn from a known cumulative distribution $G(\varphi)$. In addition, a firm incurs a fixed production cost f units of labor. Exporters are subject to a fixed export cost f_x units of labor, and shipping goods across boarders is subject to iceberg transport cost. In order for one unit of a variety to arrive in country j, a firm in country i has to ship $\tau_{ji} > 1$ units of its variety.[9] A firm decides to produce (export) if domestic (export) sales are large enough to cover fixed production (export) cost.

3.2.1 Note on Contracting Institutions

Contracting institutions are modeled with the Grossman-Hart-Moore property rights approach, which was adopted by Acemoglu et al. (2007). In particular, each monopolist in

[9]In what follows, the first subscript refers to the destination country and the second subscript denotes the source country. Conveniently, τ_{ii} is normalized to 1.

the differentiated products sector with a unique productivity draw φ uses a CES composite of N intermediate inputs to produce the final differentiated good. Similar to Acemoglu et al. (2007), each intermediate input is produced by a perfectly competitive firm/supplier. A supplier needs to undertake relationship-specific investments in a unit measure of symmetric activities with constant marginal cost c units of labor to produce the intermediate input. A fraction of these activities $\mu \in [0, 1]$ is verifiable and thus contractable ex-ante. The remaining activities $1 - \mu$ are nonverifiable and hence noncontractable ex-ante. μ is the measure of contracting institutional quality that varies across countries. The quality of intermediate input produced and the final good producer's profits depend on the relationship-specific investments made by the supplier.

As a result, a final good producer designs a contract stipulating an investment level in contractable activities and an upfront payment (can be positive or negative) but does not specify the investment levels in the remaining activities. Suppliers choose their investment levels in noncontractable activities in anticipation of ex-post distribution in revenue (determined by Shapley value as the solution to multilateral bargaining) and may decide to withhold their service in these activities from the firm.

The equilibrium solution is found by characterizing the symmetric Subgame Perfect Nash Equilibrium (SSPE). As is well known, a holdup problem emerges, and there will be underinvestment in noncontractable and contractable activities. After solving the SSPE, the firm's profit function is similar to the standard profit function in Melitz (2003). Institutional friction reduces proportionately gross variable profits in both domestic and foreign markets. That is, a change in institutions is similar to a proportional change in the productivity of the country's firms. In a simple two-sector framework where, by assumption, one sector is not subject to institutional friction, contracting institutions can be simply modeled by scaling up a firm's draw in the differentiated products sector by a constant that represents a country's institutional quality, i.e., country-specific productivity that is common to all domestic firms. However, in a more realistic setup where all sectors in a country are subject to the same institutional quality, the approach of modeling contracting institutions adopted in this paper is crucial to determine a country's comparative advantage sectors. In particular, a superior institutional quality country will have comparative advantage in institution-intensive sectors (in other words, sectors where contracting institutions are very important). The elasticity of substitution between intermediate inputs determines the importance of institutions in each sector in our framework. For instance, a sector with high elasticity of substitution between inputs (high $\alpha < 1$ see below) is not severely affected by contractual frictions.

3.2.1.1 Intermediate Input Production and Contract Design

The economy is endowed with a large number of perfectly competitive suppliers with zero outside option. The production of $X(j)$ requires a unit measure of relationship-specific investment in activity i, $x(i, j)\, \forall j \in [0, N]$, with constant marginal cost c_x. The production function of intermediate inputs is Cobb-Douglas and symmetric in the activities.

$$X(j) = exp\left(\int_0^1 lnx(i, j)di\right). \tag{3.1}$$

Contracts are incomplete: A fraction $\mu < 1$ is ex-ante contractable, whereas $1 - \mu$ of the relationship-specific activity is noncontractable. The timing of the events is as follows (see Acemoglu et al., 2007, p. 922):

- A firm (final good producer)[10] pays f^E and discovers its productivity φ.
- The φ-firm offers a contract $[[x_c(i, j)]_{i=0}^{\mu}, d(j)]$ for every intermediate input $j \in N$, where $x_c(i, j)$ is an investment level in the contractable activity and $d(j)$ is the upfront payment.
- Potential suppliers decide whether to apply for the contracts. Then the firm chooses N suppliers, one for each intermediate input j.[11]
- All suppliers $j \in N$ simultaneously choose investment level $x(i, j)$. In the contractable activities $i \in [0, \mu]$, they are bound by the specified amounts in the contract: $x(i, j) =$

[10]I refer to final good producers as firms and intermediate input producers as suppliers.

[11]One might be tempted to think that a supplier might refuse to apply to a firm with low productivity and prefer to wait for a better match. This is not the case under this framework, however. As shown in the Appendix, firms are undifferentiated in the eyes of suppliers since every surviving firm designs an optimal contract that leaves all suppliers with zero quasi-rent.

$x_c(i,j)\, for\, i \in [0,\mu]\, \forall j$.

- The suppliers and the firm bargain over the division of revenue. Suppliers can withhold their services in noncontractable activities at this stage.

- A firm decides whether to exit, or to sell to the domestic market or to both markets. Revenue is distributed according to the bargaining agreement.

The along-the-equilibrium path behavior in the SSPE can be presented as $\{\tilde{x}_c, \tilde{x}_n, \tilde{d}\}$ such that for every $j \in [0,N]$ the upfront payment $d(j) = \tilde{d}$, and the investment levels are $x(i,j) = \tilde{x}_x$ for $i \in [0,\mu]$ and $x(i,j) = \tilde{x}_n$ for $i \in (\mu, 1]$. The SSPE is characterized by backward induction. In particular, for every final good producer and for the given production technology and demand (see below), a final producer revenue function will be a function of x_c and x_n, $R(x_c, x_n, .)$. This revenue is distributed among the suppliers and the firm according to Shapley values. As a result, a firm maximizes its Shapley value net of variable costs subject to the suppliers' participation constraints and the incentive compatibility constraints (Acemoglu et al., 2007, p. 922). The formal treatment of contracting institutions and the solution concepts are relegated to the Appendix.

3.2.2 Preferences and Demand

Consumers' preferences between the homogenous product, q_0, and the real consumption index of differentiated product, Q, are represented by the quasi-linear utility function,[12]

$$U = q_0 + \frac{1}{\eta} Q^{\eta}, \tag{3.2}$$

$$Q = \left[\int_{\omega \in \Omega} q(\omega)^{\beta} \right]^{\frac{1}{\beta}}, \quad 0 < \eta < \beta < 1, \tag{3.3}$$

where $q(\omega)$ denotes the consumption of variety ω, and Ω is the set of varieties available for consumption. β controls the elasticity of substitution between varieties. The restriction $\eta < \beta$ ensures that varieties are better substitutes for each other than for the outside sector q_0. In what follows, I assume that income is large enough such that the consumption of q_0

[12]This quasi-linear utility function is taken from Helpman and Itskhoki (2010).

is always positive. The price of q_0 in both countries is normalized to one. The numeraire is produced under perfectly competitive conditions with constant return to scale in both countries and is freely traded; hence, wages (w_i) in both countries are pinned down by the numeraire sector.

It is easy to verify that economic welfare is directly linked to Q. If total expenditure in the economy is constant (which it is since labor supply size (L) and wages are constant, and aggregate profits net of sunk entry cost equal zero), higher Q is manifested in higher welfare. The above-mentioned utility function implies that a consumer with spending $E = wL$ chooses $Q = P^{-1/(1-\eta)}$ and $q_0 = E - P.Q > 0$. Here, $P = \left[\int_{\omega\in\Omega} p(\omega)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}$ is the aggregate price index in the differentiated goods sector, $\varepsilon = \frac{1}{1-\beta}$ denotes the elasticity of substitution between varieties, and $p(\omega)$ is the price of variety $\omega \in \Omega$. The demand for variety ω is standard and given by

$$q^d(\omega) = Q^{-\frac{\beta-\eta}{1-\beta}} p(\omega)^{-\frac{1}{1-\beta}} \tag{3.4}$$

Therefore, the indirect utility $\mathbb{V}$ is given by[13]

$$\mathbb{V} = E + \frac{1-\eta}{\eta} Q^{\eta}. \tag{3.5}$$

3.2.3 Production and Market Structure

Homogenous sector. Linear production technology in labor: one unit of labor is required to produce one unit of the homogenous product. L_0: $q_0 = L_0$. Since the environment is one of incomplete specialization and zero trade cost in the homogenous sector, the wage $w_i = 1$.
Differentiated sector. Since the productivity draw φ is firm specific and each firm produces one unique variety ω, firms are with φ instead of ω. The final good production is given by

$$q(\varphi) = \varphi N^{1-\frac{1}{\alpha}} \left[\int_0^N X(j)^{\alpha} dj\right]^{\frac{1}{\alpha}}, \tag{3.6}$$

[13]Notice that total expenditure in the differentiated products sector $PQ = Q^{\eta} = P^{-\frac{\eta}{1-\eta}}$.

$N \in R_+$ is the number of intermediates (exogenous and nontraded), $X(j)$ denotes the demand for intermediate j, and α controls the elasticity of substitution between intermediates.[14]

A country i firm's revenue function can be written as follows[15]

$$R_i = q(\varphi)^{\beta} \left[Q_i^{-\frac{\beta-\eta}{1-\beta}} + \mathbb{1}_{ji}(\varphi) \tau^{\frac{-\beta}{1-\beta}} Q_j^{-\frac{\beta-\eta}{1-\beta}} \right]^{1-\beta}. \tag{3.7}$$

The indicator variable $\mathbb{1}_{ji}(\varphi)$ equals one if the firm exports and zero otherwise. In the Appendix, I show that the SSPE of contracts design under incomplete contracts yields to the following reduced-form profit function for a firm:

$$\pi_i(\varphi) = \pi_{ii}(\varphi) + \mathbb{1}_{ji}(\Theta)\pi_{ji}(\varphi), \quad \text{total profit=domestic +export} \tag{3.8}$$

$$\pi_{ii}(\varphi) = (1-\beta)\Theta Z(\mu_i) Q_i^{\frac{-(\beta-\eta)}{1-\beta}} - f, \quad \text{domestic profit} \tag{3.9}$$

$$\pi_{ji}(\varphi) = (1-\beta)\Theta Z(\mu_i) \tau_{ji}^{\frac{-\beta}{1-\beta}} Q_j^{\frac{-(\beta-\eta)}{1-\beta}} - fx, \quad \text{export profit} \tag{3.10}$$

$Z(.,\mu) \equiv \beta^{\frac{\beta\mu}{1-\beta}} (\alpha(1-\gamma))^{\frac{\beta(1-\mu)}{1-\beta}} \left[\frac{1-\alpha(1-\mu)(1-\gamma)}{1-\beta(1-\mu)}\right]^{\frac{1-\beta(1-\mu)}{1-\beta}} c_x^{\frac{-\beta}{1-\beta}}$,$\Theta \equiv \varphi^{\frac{\beta}{1-\beta}}$, and $\gamma \equiv \frac{\alpha}{\alpha+\beta}$.

Lemma III.1. *$Z(.,\mu)$ denoting a measure of "derived efficiency" is increasing in μ*

At this point, the firm's profit function in the current framework model is very similar to the Melitz (2003) model where the first term in domestic and export profit functions represents variable profits in the domestic and the foreign markets, respectively. An improvement in institutional quality in country i leads to proportional increase in the productivity of all country i's firms. Under a complete contracts environment ($\mu = 1$), the model is isomorphic

[14] All results derived below hold when N is normalized to one, i.e., one input instead of many intermediate inputs. In fact, N has no effect on firm's profits, zero profit cutoff, exporting cutoff, and aggregate variables. Nevertheless, I choose to present the production function as in (3.6) for the sake of generality.

[15] To see this, the price charged by country i firm in country j $p_{ji}(\varphi) = \tau p_{ii}(\varphi)$, where $p_{ii}(\varphi)$ denotes the domestic firm price in the domestic market. Total revenue R is given by $p_{ii}q_{ii}^d + p_{ji}q_{ji}^d$, q_{ii}^d is the domestic demand given by (3.4), and $q_{ji}^d = \tau Q_j^{-\frac{\beta-\eta}{1-\beta}} p_{ji}(\varphi)^{\frac{-1}{1-\beta}}$ is the total amount shipped by a country i exporter to country j. Then, $\frac{q_{ji}}{q_{ii}} = \tau^{\frac{-\beta}{1-\beta}} \left[\frac{Q_j}{Q_i}\right]^{-\frac{\beta-\eta}{1-\beta}}$. Use this with $q(\varphi) = q_{ii} + q_{ji}$ to obtain the revenue function.

to Melitz (2003) with $Z = \beta^{\frac{\beta}{1-\beta}} c_x^{\frac{-\beta}{1-\beta}}$.[16] The profit functions (3.8), (3.9), and (3.10) imply that a firm chooses not to exit the domestic market and sell a positive amount of its variety if and only if $\pi_{ii}(\Theta) \geq 0$. Similarly, a firm will export if and only if $\pi_{ji} \geq 0$ ($\mathbb{1}_{ji}(\Theta) = 1$ for $\Theta \in \{\Theta \in R_{++} : \pi_{ji}(\Theta) \geq 0\}$ and zero otherwise). Indeed, both domestic and export profit functions are continuous and increasing in Θ; therefore, the zero profit cutoff (ZPC) and the export cutoff are given by;

$$\pi_{ii}(\Theta_{ii}) = 0 : \quad \to \Theta_{ii} = \frac{1}{1-\beta} \frac{f}{Z(\mu_i)} Q_i^{\frac{\beta-\eta}{1-\beta}} \tag{3.11}$$

$$\pi_{ji}(\Theta_{ji}) = 0 : \quad \to \Theta_{ji} = \frac{1}{1-\beta} \frac{f_x}{Z(\mu_i)} \tau^{\frac{\beta}{1-\beta}} Q_j^{\frac{\beta-\eta}{1-\beta}} \tag{3.12}$$

As it is standard, $\Theta_{ji} > \Theta_{ii} > \Theta_{min}$, where Θ_{min} is the lowest productivity level in the support of the distribution $G(\Theta)$. This order of cutoffs ensures that the most productive firms export, firms with medium productivity only serve the domestic market, and the least productive firms exit.[17]

3.2.3.1 Equilibrium

The industry equilibrium in the long run can be characterized by the above-mentioned cutoffs and the free entry condition. In equilibrium, free entry drives a firm's ex-ante expected profits net of sunk entry cost to zero.

$$\int_{\Theta_{ii}}^{+\infty} \pi_{ii}(\Theta) dG(\Theta) + \int_{\Theta_{ji}}^{+\infty} \pi_{ji}(\Theta) dG(\Theta) = f^E. \tag{3.13}$$

[16] Notice that variable profit $v\pi = (1-\beta)Z(\mu_i)Q_i^{\frac{-(\beta-\eta)}{1-\beta}}$, as in the standard monopolistic competition models with CES preferences, is proportional to a firm's revenue; $v\pi = (1-\beta)\left[\frac{1-\alpha(1-\mu)(1-\gamma)}{1-\beta(1-\mu)}\right] R(Q,Z)$. When $\mu = 1$ (i.e., complete contracts), the model collapses to the standard Melitz model with $v\pi = (1-\beta)R$.

[17] Notice that in the case of symmetric countries, $\Theta_{ji} > \Theta_{ii}$ if $f_x > \tau^{\frac{-\beta}{1-\beta}} f$. In the current model, imposing $f_x > f$ is sufficient to guarantee that $\Theta_{ji} > \Theta_{ii}$. The second inequality is true whenever the ZPC in the closed economy is greater than Θ_{min}, which necessitates $\int_{\Theta_{ii}}^{\infty} \Theta dG(\Theta) > \Theta_{min}(1+f^E/f)$.

Equivalently, the free entry condition can be be expressed by

$$f\int_{\Theta_{ii}}^{+\infty}\left(\frac{\Theta}{\Theta_{ii}}-1\right)dG(\Theta)+f_x\int_{\Theta_{ji}}^{+\infty}\left(\frac{\Theta}{\Theta_{ji}}-1\right)dG(\Theta)=f^E \quad \text{for } i\,j\in\{H,F\} \tag{3.14}$$

There are two free entry equations (one for each country) and four cutoffs $\{\Theta_{HH},\Theta_{FF},\Theta_{FH},\Theta_{HF}\}$. Using ZPC (3.11), I can express Θ_{ji} in term of Θ_{jj}. Specifically,

$$\frac{\Theta_{ji}}{\Theta_{jj}}=\frac{f_x\tau^{\frac{\beta}{1-\beta}}}{f}\frac{Z(\mu_j)}{Z(\mu_i)}. \tag{3.15}$$

Then, the four cutoffs (as a function of exogenous variables) are uniquely pinned down by (3.14) and (3.15). It is easily verified that the equilibrium, which is characterized by $\{\Theta_{HH},\Theta_{FF},\Theta_{FH},\Theta_{HF}\}$, exists and is unique. Interestingly, the cutoffs do not depend on the levels of institutional quality, but only on its ratio. The equilibrium real consumption index Q_i, then, is derived from the ZPC.[18]

3.3 Contracting Institutions, Trade Barriers, Trade Patterns and Welfare

In this section, I study the impact of differences in institutional quality on trade partners. Specifically, the interaction between institutional quality and trade impediments shapes patterns of trade and welfare gains from trade are examined. This is an important question because it enhances our comprehension of trade policy differences across countries. The same trade policy might have different distributional consequences and welfare gains (losses) when applied to countries with different political and economic institutions, legal

[18] Notice that in autarky, the free entry condition is given by;

$$f\int_{\Theta_{ii}}^{+\infty}\left(\frac{\Theta}{\Theta_{ii}}-1\right)dG(\Theta)=f^E.$$

Hence, $\Theta_{ii}^{autarky}$ is not a function of contracting institutions. Notice the similarity between the current model and Helpman and Itskhoki (2010). In their model, labor market friction (Diamond-Mortensen-Pissarides-type friction) reduces productivity of all firms in the country and the cutoffs depend on labor market friction only in the open economy.

institutions, judiciary systems, and contracting institutions. The aim is to have a simple framework that is capable of delivering testable and intuitive predictions about the patterns of trade, the gains from trade, and the distributional consequences for simultaneous changes in both trade impediments and institutional quality. The vast majority of the extant literature on trade policy does not account for the differentiated impact of changing trade barriers on countries with different institutional frictions assuming exogenous institutions with a vague role in the economy. Likewise, the literature that deals with institutions in the global economy rules out endogenous trade policy.

The current framework is simple yet sophisticated enough to address questions such as the following: How does institutional reform in one country affect its trade partner? Does trade liberalization affect countries with different legal institutions differently? Are countries with similar institutions more likely to engage in free trade? To this end, I derive the impact of simultaneous changes in both trade barriers and institutional quality on zero-profit cutoffs and exporting cutoffs. By totally differentiating Equations (3.14) and (3.15), the following is obtained

$$\widehat{\Theta}_i = \frac{\delta_{ji}}{\Delta}\left[(\delta_{ij}+\delta_{jj})\left(\widehat{Z(\mu_i)}-\widehat{Z(\mu_j)}\right)-\frac{\beta}{1-\beta}(\delta_{jj}-\delta_{ij})\,\hat{\tau}\right], \tag{3.16}$$

$$\widehat{\Theta}_{ji} = \frac{\delta_{ii}}{\Delta}\left[-(\delta_{ij}+\delta_{jj})\left(\widehat{Z(\mu_i)}-\widehat{Z(\mu_j)}\right)+\frac{\beta}{1-\beta}(\delta_{jj}-\delta_{ij})\,\hat{\tau}\right], \tag{3.17}$$

here, $\delta_{ii} \equiv \frac{f}{\Theta_{ii}}\int_{\Theta_{ii}}^{+\infty}\Theta dG(\Theta)$, $\delta_{ji} \equiv \frac{f_x}{\Theta_{ji}}\int_{\Theta_{ji}}^{+\infty}\Theta dG(\Theta)$, $\Delta \equiv (\delta_{ii}\delta_{jj}-\delta_{ji}\delta_{ij})$, and $\hat{x}$ stands for $\frac{\partial x}{x}$

The average variable profits conditional on successful entry in the domestic market i and in the foreign market j are given by δ_{ii} and δ_{ji}, respectively.[19] To assess the impact of changes in contracting institutions and trade impediments on the real consumption index Q_i and hence economic welfare, the ZPC Equation (3.11) and Equation (3.16) are used to

[19] It can be shown that the average sales per entering firm in the domestic and the foreign markets are given by; $\delta_{ii}/(1-\beta)\phi$ and $\delta_{ji}/(1-\beta)\phi$, where $\phi \equiv \left[\frac{1-\alpha(1-\mu)(1-\gamma)}{1-\beta(1-\mu)}\right]$.

obtain the following:

$$\frac{\beta-\eta}{1-\beta}\hat{Q}_i = \frac{1}{\Delta}\left[\delta_{jj}\left(\delta_{ii}+\delta_{ji}\right)\widehat{Z(\mu_i)} - \delta_{ji}\left(\delta_{ij}+\delta_{jj}\right)\widehat{Z(\mu_j)} - \frac{\beta}{1-\beta}\delta_{ji}\left(\delta_{jj}-\delta_{ij}\right)\hat{\tau}\right]. \quad (3.18)$$

Before proceeding further, a couple of useful and technical lemmas are introduced to facilitate the analysis of the impact of contracting institutions and trade impediments in the global economy.

Lemma III.2. *if $\mu_H > \mu_F$, then $\Theta_H > \Theta_F$ and $\Theta_{FH} < \Theta_{HF}$.*

Lemma III.3. *Let $\mu_H > \mu_F$. Then $Q_H > Q_F$.*

Lemma III.2 states that in the country with better institutions, exporting requires lower productivity relative to the country with bad institutions. Nonetheless, surviving the domestic market in the country with better institutions is much harder than in the country with inferior institutions. The intuition is, since the ex-ante expected profit from exporting is higher in the country with good institutions, the ex-ante domestic expected profit in the country with better institutional quality has to be lower than the inferior institutions country to satisfy the free entry condition. Lemma III.3 points out that countries with better institutions enjoy a higher real consumption index and thus a higher economic welfare.

Lemma III.4. *Trade liberalization (lower τ) increases the zero profit cutoff in both countries and decreases export cutoff in both countries.*

Lemma III.4 states that the effect of trade liberalization in the current model is equivalent to the standard Melitz model. That is, trade liberalization induces interfirm resource reallocation with more resources devoted to more productive firms. The next lemma is a technical one that corresponds to the assumption of incomplete specialization.

Lemma III.5. *In equilibrium with incomplete specialization, expected domestic variable profits per entering firm are larger than expected export variable profits per entering firms in both countries: $\delta_{ii} > \delta_{ji}$ for $i\,j \in \{H, F\}$. Furthermore, if $\mu_H > \mu_F$, then $\delta_{HH} < \delta_{FF}$ and $\delta_{FH} > \delta_{FH}$.*

Lemma III.5 is a product of the assumption of incomplete specialization. The lemma is crucial to the paper's results derived below. The next proposition summarizes the impact of institutional quality on the pattern of trades.

Proposition III.1. *Let $\mu_H > \mu_F$. Then, country H exports differentiated products on net and imports homogenous goods. Moreover, the share of intraindustry trade is decreasing in* $\frac{Z(\mu_H)}{Z(\mu_F)}$.

As documented by Levchenko (2007) and Nunn (2007), institutions are a source of comparative advantage. However, institutions in the current framework affect the share of intraindustry trade.[20]

Proposition III.2. *An improvement in contracting institutions in country H enhances country H's economic welfare and harms its trade partner's economic welfare. Nonetheless, a simultaneous proportional improvement in institutions in both countries increases welfare in both countries.*

In contrast to Levchenko (2007) and, broadly, pure comparative advantage models where shocks transmit across countries through fluctuations in terms of trade, the decrease in competitiveness in the trade partner as a result of domestic institutional improvements hinders foreign (trade partner) firms' entrance and hence severely reduces domestically produced varieties in the foreign market. The increase of import varieties and improvement in terms of trade in the foreign country is outweighed by the reduction in competitiveness and therefore economic welfare falls. This result might be overturned once the outside sector assumption is dispensed such that reforms in one country might be welfare-enhancing in both countries. This, in fact, resonates with the analysis of home market effects and unilateral trade liberalization.

Proposition III.3. *Both countries gain from trade. However, the welfare in the country with better institutions rises proportionately more.*

[20] In Levchenko (2007), firms operate under perfect competition, and countries completely specialize according to comparative advantage; hence, intraindustry trade is absent in his model.

Proposition III.3 is interesting for two reasons. First, in contrast to a pure comparative advantage model with institutional distortions, gains from trade are assured for both countries.[21] Second, it is consistent with the discussion regarding the impact of domestic institutions on the gains from trade openness: countries with better domestic institutions can potentially benefit more from trade openness Rodrik (2008).

Overall, the results in this section resonate with those of Helpman and Itskhoki (2010), with contractual frictions replacing labor market rigidities in their model.

3.4 Firm-Preferences over Institutions in the Global Economy

The model thus far provides enough structure and insight to infer firm-preferences over institutions. I will extensively use the impact of change in institutions on zero profit cutoff, export cutoff, and real consumption expenditure to infer firm-preferences over institutions in the open economy.

3.4.1 Domestic Institutions reforms

First, I the effects of changes in domestic institutions on firm's domestic and export profits are analyzed (trade partner's institutions and trade costs are held constant $\hat{\tau} = \widehat{Z(\mu_j)} = 0$). By using Equations (3.16) and (3.18), it is direct to show that the change in the variable domestic profits $v_{ii}(\Theta) = \pi_{ii}(\Theta) - f$ is

$$\begin{aligned} \widehat{v_{ii}(\Theta)} &= -\frac{\beta-\eta}{1-\beta}\hat{Q}_i + \widehat{Z(\mu_i)} \\ &= \widehat{Z(\mu_h)}\left[1 - \frac{\delta_{jj}(\delta_{ii}+\delta_{ji})}{\Delta}\right] = \begin{cases} < 0 & \text{if } \hat{Z} > 0 \\ > 0 & \text{if } \hat{Z} < 0 \end{cases} \end{aligned} \quad (3.19)$$

[21] For example, Levchenko (2007) shows that the South (the country with inferior institutions) might lose from trade, whereas the North's gains are guaranteed. In a broader sense, Helpman and Krugman (1987) argue that gains from trade might not materialize in economies with nonconvexities and distortions.

Ceteris paribus, advancing contracting institutions in country i, lowers variable profits in domestic markets for all firms. The intuition is that gains in profits resulting from higher derived efficiency (higher $Z(\mu_i)$) is more than offset by losses from increased competition (higher Q). Similarly, the proportional change in export variable profits in response to domestic institutional change, all else constant, is given by

$$\begin{aligned} \widehat{v_{ji}(\Theta)} &= -\frac{\beta-\eta}{1-\beta}\hat{Q}_j + \widehat{Z(\mu_j)} \\ &= \widehat{Z(\mu_i)}\left[1+\frac{\delta_{ij}(\delta_{ji}+\delta_{ii})}{\Delta}\right] = \begin{cases} >0 & \text{if } \hat{Z}>0 \\ <0 & \text{if } \hat{Z}<0. \end{cases} \end{aligned} \tag{3.20}$$

In contrast to variable profits in the domestic market, export variable profits are increasing in domestic institutional quality. In fact, this can be seen from Proposition III.2, which states that improvement in domestic institutions harms the trade partner, i.e., lower Q_j. Export profits increase not only because firm's productivity has increased, but also because the foreign market is more profitable.

To completely characterize the impact of institutional reforms on firms' profitability, firms are divided into three groups: (i) nonexporters who remain nonexporters or exit the market post reforms; (ii) nonexporters who become exporters in response to institutional reforms, and (iii) exporters who continue to export. The impact of institutions change on firms belonging to group 1 is immediately inferred from (3.19): nonexporters' profits decline (increase) as domestic contracting institutions improve (deteriorate). In other words, nonexporters who anticipate to continue being nonexporters will oppose institutional reforms. Firms in groups 2 and 3 preferences over institutional reforms are scrutinized.

Proposition III.4. *Nonexporters who continue to be nonexporters post-reform, oppose institutional reforms.*

Assuming that firms are owned by consumers, the negative impact of institutional reforms on nonexporter's income (profits) outweighs the increase in indirect utility due to higher Q; as a result, indirect utility of this particular individual declines as institutions advance.

Firms in Group 2: nonexporters who become exporters in response to institutional reforms. From Equation (3.17), institutional reforms decrease the export cutoff; hence, firms with $\varphi \in [\Theta_{ji}^{post}, \Theta_{ji}^{pre}]$ belong to group 2, where Θ_{ji}^{post} represents export cutoff under new institutional quality and Θ_{ji}^{pre} is the pre-reform export cutoff. In other words, those are the firms who were induced to export by institutional reforms. Firms in this group enjoy higher profits if profits generated from exporting outweigh profit lost in the domestic market. Indeed, the marginal exporter under the new institutional arrangement is worse off relative to pre-reform. But, then, the question is whether some nonexporters who become exporters in response to institutional reforms benefit from these reforms. Overall, for any initial institutional quality level, a productivity cutoff exists $\Theta_{ji}^{support} > \Theta_{ji}^{post}$ such that all firms with productivity above it enjoy higher profits when institutional quality improves. Consequently, some firms in group 2 benefit from reforms if and only if $\Theta_{ji}^{support} < \Theta_{ji}^{pre}$.

Proposition III.5. *Nonexporters who become exporters post-reforms i.e., firms with $\Theta \in [\Theta_{ji}^{post}, \Theta_{ji}^{pre}]$ are divided between reform proponents and opponents . In particular, all firms with $\Theta \in [\Theta_{ji}^{post}, \Theta_{ji}^{support}]$ oppose reforms, whereas firms with $\Theta \in [\Theta_{ji}^{support}, \Theta_{ji}^{pre}]$ endorse reforms.*

Group 3: exporters-exporters. Firms who export pre and post reforms (i.e., firms with productivity $\Theta > \Theta_{ji}^{pre}$) will be affected by institutional reforms through changes in both domestic and export profits. As shown above domestic profits decline for all firms, whereas export profits increase for firms belonging to this group. The proportional change in total variable profit for an exporter is given by

$$\widehat{v(\Theta)} = \widehat{v_{ii}(\Theta)}\frac{v_{ii}(\Theta)}{v(\Theta)} + \widehat{v_{ji}(\Theta)}\frac{v_{ji}(\Theta)}{v(\Theta)} \tag{3.21}$$

Free entry condition (3.14), and Equation (3.19) guarantee that the change in an exporter's total variable profits (domestic and export) is positive in the case of institutional reforms. Otherwise, the free entry condition will be violated. Therefore, exporters-exporters will always support institutional reforms since they enjoy higher gross and net profits.

Summary III.1. For any initial values of μ_H, μ_F, and τ, a productivity cutoff exists in country $i \in \{H, F\}$, $\Theta_{ji}^{support}$ such that all firms with productivity above it experience an increase in their profits as institutional quality improves, whereas the profits of all firms with productivity below it decline.

3.4.2 Trade Liberalization

The distributional impact of trade policy (here modeled as different levels of τ) is similar to the trade policy literature under the framework of new new trade policy. Most exporters benefit from trade liberalization, whereas nonexporters lose. In this section, on the one hand, I address the differentiated impacts of lowering trade barriers on countries with different institutional environments. On the other hand, I analyze the distributional impact of institutional reforms and thus firms' preferences over these reforms under different levels of trade openness.

3.4.2.1 Differentiated Impacts of Trade Liberalization

On the aggregate level, Proposition III.3 states that both countries gain from trade. The gains from trade are not evenly distributed across trade partners, however. Countries with relatively superior institutions gain more from trade.

Another interesting comparison is the distributions of winners and losers from lowering trade barriers across countries with different institutions. As pointed out above, the fraction of firms that export in a country with relatively worse institutions is less than the fraction of exporters in a country with relatively better institutions. As a result, the fraction of winners (losers) in country with relatively inferior institutions is lower (higher) than a country with relatively superior institutions. An office-seeker politician who is concerned about getting reelected is perhaps more susceptible to protectionists' pressure in a country with weak institutional quality and, importantly, places more political weight on anti-free trade groups relative to a country with higher institutional quality.

3.4.2.2 Distributive Consequences of Institutions and Trade Liberalization

Institutional reforms redistribute income and reallocate resources across sectors and across firms within sectors. In autarky, however, institutional reforms will only trigger sectoral resource reallocation, whereas per firm's profit is invariant to reforms. The intuition here is that, in the long-run equilibrium, the impact of institutional reforms on a firm's productivity is completely offset by the change in real consumption index Q, leaving firm's profits and zero profit cutoff unchanged. To be precise, in the closed economy, institutional reforms scale a firm's productivity up. Firms, on average, are more productive and larger relative to the pre-reforms. Ex-ante expected profits from entry decline, leading to fewer mass of potential entrants. The impact of more productive firms on the real consumption index is mitigated by less entrants, slightly increasing the real consumption index.

In the open economy, the story becomes more interesting since institutional reforms trigger both inter and intraindustry resource reallocation. As shown above, in the differentiated goods sector, exporters' sales, employment, size, and profits increase, whereas nonexporters shrink in response to institutional reforms. The main issue here, however, is investigating the impact of trade liberalization (lower trade barriers τ) on the magnitude of the distributional effects of institutional reforms. By addressing this issue, the hope is to understand how firms' preferences evolve during episodes of trade liberalization and thus the likelihood of institutional reforms in response to trade liberalization. The change in nonexorters' variable profits in response to institutional reforms in the home country is given by (3.19). The magnitude of the change in nonexporters' profits is determined by $\left[1 - \frac{\delta_{jj}(\delta_{ii}+\delta_{ji})}{\Delta}\right]$. Similarly the term $\left[1 + \frac{\delta_{jj}(\delta_{ii}+\delta_{ji})}{\Delta}\right]$ determines the magnitude of the change of exporters' profits in response to institutional change. The next proposition summarizes the impact of lowering trade costs on the distributional effects of domestic institutions.

Proposition III.6. *The distributional effect of institutional reforms is magnified as trade costs decrease. Nonexporters' variable profits more proportionately decrease in the more open economy relative to the less open economy as institutional quality improves. By con-*

trast, exporters' aggregate profits more proportionately rise in the more open economy relative to the less open economy as institutional quality improves.

Intuitively, for low trade costs, improvement in domestic institutions not only makes domestic firms more productive, but also increases the ex-ante expected profits (since exporting is more profitable now), inducing more firms to pay the sunk entry cost. The domestic market becomes very competitive (larger number of firms and more productive firms) severely inflicting nonexporters' profits. Conversely, for export profits, the complementarity between institutional quality and lower trade costs makes exporting much more profitable, increasing exporters' aggregate profits.

3.4.3 Country Interdependence: Reforms in Trade Partner Institutions

One of the most intriguing results in the paper is in fact related to the impact of institutional reforms on trade partner's economic welfare (recall Proposition III.2). That is, an improvement in own institutions raises own economic welfare but harms the trade partner's economic welfare. Consequently, institutional reforms in country j would have distributional effects on country i firms. To see this, notice that the proportional change in country i's domestic variable profits as country j's institutional quality changes is (all else equal)

$$\widehat{v_{ii}(\Theta)} = \widehat{Z(\mu_j)}\frac{\delta_{ji}(\delta_{ij}+\delta_{jj})}{\Delta} = \begin{cases} > 0 & \text{if } \hat{Z} > 0 \\ < 0 & \text{if } \hat{Z} < 0. \end{cases} \tag{3.22}$$

The change of country i's exporters variable profits is given by

$$\widehat{v_{ji}(\Theta)} = -\widehat{Z(\mu_j)}\frac{\delta_{ii}(\delta_{jj}+\delta_{ij})}{\Delta} = \begin{cases} < 0 & \text{if } \hat{Z} > 0 \\ > 0 & \text{if } \hat{Z} < 0. \end{cases} \tag{3.23}$$

Moreover, to satisfy the free entry condition in country i, country i exporters' aggregate profits fall in response to institutional reforms in country j. Clearly, the qualitative effect of country j's institutional reforms on country i firms is the opposite of the impact of country i's institutional reforms on country i firms.

3.5 Pareto Distribution: Numerical Example

For the numerical illustration of the main mechanisms of the model and for the purpose of conducting comparative static analysis, a Pareto distribution assumption of productivity draws is used:

$$G(\Theta) = 1 - \left(\frac{\Theta_{min}}{\Theta}\right)^{\kappa}, \quad \text{for}\, \Theta > \Theta_{min} \quad \text{and}\, \kappa > 2.$$

The shape parameter κ controls the dispersion of the random variable Θ, with higher values of κ representing less dispersion. The numerical restriction that κ is greater than two ensures finite variance of the productivity distribution. To ease notation, Θ_{min} is normalized to 1. As is well known, the Pareto distribution is not only analytically convenient, but also approximates the right tale of the empirical distribution of firm's size reasonably well. By providing a functional form of productivity draws, the model's main predictions can be confirmed and, importantly, a comparative static analysis can be conducted to compare the distributional consequences of institutional reforms across different levels of trade openness and across different initial institutional qualities in both countries. The solution to the model under Pareto distribution yields to the following zero-profits cutoffs, export cutoffs, and real consumption indexes:

$$\Theta_{ii} = \left(\frac{f}{(\kappa-1)f^E}\right)^{\frac{1}{\kappa}} \left[\frac{1 - \left(\frac{Z(\mu_i)}{Z(\mu_j)}\right)^{\kappa} \tau^{\frac{-\kappa\beta}{1-\beta}} \left(\frac{f_x}{f}\right)^{-\kappa+1}}{1 - \tau^{\frac{-2\kappa\beta}{1-\beta}} \left(\frac{f_x}{f}\right)^{2(-\kappa+1)}}\right]^{\frac{-1}{\kappa}} \qquad i,\, j \in \{H, F\}$$

$$\Theta_{ji} = \tau^{\frac{\beta}{1-\beta}} \frac{Z(\mu_j)}{Z(\mu_i)} \left(\frac{f}{(\kappa-1)f^E}\right)^{\frac{1}{\kappa}} \frac{f_x}{f} \left[\frac{1 - \left(\frac{Z(\mu_j)}{Z(\mu_i)}\right)^{\kappa} \tau^{\frac{-\kappa\beta}{1-\beta}} \left(\frac{f_x}{f}\right)^{-\kappa+1}}{1 - \tau^{\frac{-2\kappa\beta}{1-\beta}} \left(\frac{f_x}{f}\right)^{2(-\kappa+1)}}\right]^{\frac{-1}{\kappa}} \qquad i,\, j \in \{H, F\}$$

$$Q_i^{\frac{\beta-\eta}{1-\beta}} = (1-\beta) f^{\frac{1-\kappa}{\kappa}} Z(\mu_i) \left((\kappa-1)f^E\right)^{\frac{-1}{\kappa}} \left[\frac{1 - \left(\frac{Z(\mu_i)}{Z(\mu_j)}\right)^{\kappa} \tau^{\frac{-\kappa\beta}{1-\beta}} \left(\frac{f_x}{f}\right)^{-\kappa+1}}{1 - \tau^{\frac{-2\kappa\beta}{1-\beta}} \left(\frac{f_x}{f}\right)^{2(-\kappa+1)}}\right]^{\frac{-1}{\kappa}} \qquad i,\, j \in \{H, F\}$$

The number of potential entrants in country $i \in \{H, F\}$ is given by:

$$M_i = (1-\beta)\phi_i \frac{\kappa - 1}{\kappa} \frac{f\Theta_{jj}^{-\kappa} Q_i^{\eta} - f_x \Theta_{ij}^{-\kappa} Q_j^{\eta}}{f^2 \Theta_{ii}^{-\kappa}\Theta_{jj}^{-\kappa} - f_x^2 \Theta_{ij}^{-\kappa}\Theta_{ji}^{-\kappa}} \qquad i,\, j \in \{H, F\} \tag{3.24}$$

$$\phi_i \equiv \left[\frac{1-\alpha(1-\mu_i)(1-\gamma)}{1-\beta(1-\mu_i)}\right] \qquad i \in \{H, F\}$$

Parameter Restrictions: Empirically, (i) the most productive firms export, whereas medium productive firms only serve the domestic market, and (ii) the least productive firms exit the market as trade barriers decline. To ensure that these empirical regularities in the current model the following is required: $\Theta_{ii} < \Theta_{ji}$ and $\Theta_{ii} > 1$. In equilibrium, $\Theta_{ji} > \Theta_{ii}$ if the model's parameters satisfy the following inequality:

$$\frac{f}{f+f_x}\left(\tau^{\frac{\beta}{1-\beta}} \frac{f_x}{f}\right)^{\kappa} + \frac{f_x}{f+f_x}\left(\tau^{\frac{\beta}{1-\beta}} \frac{f_x}{f}\right)^{-\kappa} > \max\left\{\frac{Z(\mu_i)}{Z(\mu_j)}, \frac{Z(\mu_j)}{Z(\mu_i)}\right\}$$

The conditions on the model's parameters for empirical regularity $\Theta_{ii} > 1$ to hold in equilibrium are $\lim_{\tau\to\infty} \Theta_{ii}(\tau) = \left(\frac{f}{(\kappa-1)f^E}\right)^{\frac{1}{\kappa}} > 1$, which is true if $\kappa < 1 + \frac{f}{f^E}$. Finally, the environment is one of the incomplete specializations if and only if $M_i > 0 \quad i \in \{H, F\}$. Therefore, the conditions on the parameters for incomplete specialization can be written as follows:

$$f\Theta_{jj}^{-\kappa} Q_i^{\eta} > f_x \Theta_{ij}^{-\kappa} Q_j^{\eta}$$

Notice that the condition should be checked only for the country with relatively low institutional quality (F is the country with relatively low institutional quality). That is:

$$\left(\frac{\Theta_{FH}}{\Theta_{HH}}\right)^{\kappa} \left(\frac{Q_F}{Q_H}\right)^{\eta} > \frac{f_x}{f}$$

Figure 3.2 shows the minimum values of trade costs τ given different values of relative institutional quality between country H and country F measured by the ratio of derived efficiency between the two countries for incomplete specialization to hold in the equilibrium ($M_F > 0$). The value of μ_H is set to one, where $\mu_F \in [0, 1]$. In $(\frac{Z(1)}{Z(\mu_F)}, \tau)$ space, the complete specialization schedule ($M_F = 0$) is represented by the upward sloping line: that is, given $\mu_H = 1$, for any μ_{F*}, $\exists \tau^*$ such that for any $\tau > \tau^*$ the number of potential entrants is strictly positive in both countries. The complete specialization set is given by $\{(\frac{Z(1)}{Z(\mu_{F*})}, \tau^*) : \tau \leq \tau^*, M_F = 0\}$. Intuitively, τ^* is increasing in $\frac{Z(1)}{Z(\mu_F)}$, i.e., decreasing in μ_F. As we can see in the Figure, the condition of incomplete specialization is relatively easy to satisfy: for relatively similar countries, almost any value of $\tau > 1$ satisfies the condition for incomplete specialization.[22]

Figure 3.2: Parameter Restriction: Incomplete Specialization

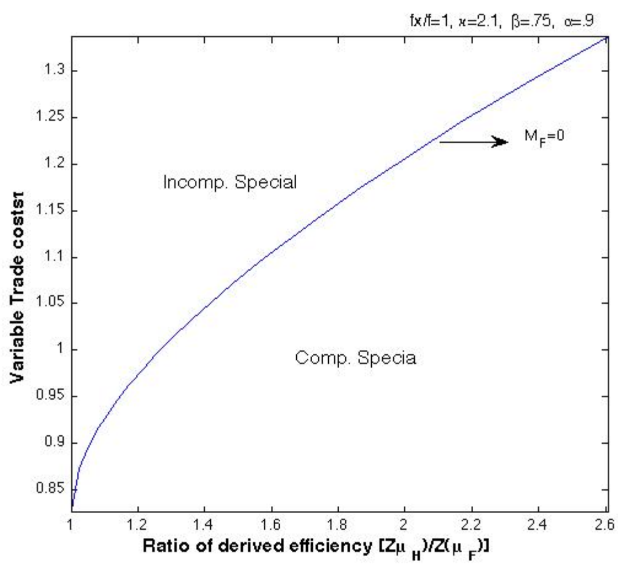


Figure 3.3 depicts the net aggregate profits in country F and country H. As predicted by the analytical analysis of the model, nonexporters in the relatively low institutional quality country (here country F) enjoy higher domestic profits, whereas exporters in country H are larger and more profitable than exporters in country F. Moreover, the export cutoff in country H is lower than its counterpart in country F, whereas the zero-profit cutoff in country F is lower (not shown in the figure). Exporting is more prevalent in country H with a larger number of exporters and a higher average sales per exporter.

Next, the influence of institutional reforms on firms' profitability is demonstrated. The exercise is done for a fixed level of trade variable cost $\tau = 1.3$. In this experiment, con-

[22]Also notice that $\Theta_{HH} > 0$ if and only if $\left(\frac{Z(\mu_i)}{Z(\mu_j)}\right)^{\kappa} \tau^{\frac{-\kappa\beta}{1-\beta}} \left(\frac{f_x}{f}\right)^{-\kappa+1} < 1$. However, this condition is implied by the conditions for incomplete specialization.

tracting institution in country H is constant and given by $\mu_F = .8$. The level of contracting institutions in country F is in the interval $[.3, 1]$. As institutional quality advances in country F, it turns from a country with relatively low institutions to the country with superior institutions. Figure 3.4 and Figure 3.5 show country F a nonexporter's profits and an exporter's profits as a function of contracting institutions in country F. As contracting institutions improve in country F, an always nonexporter's profits decline and an always exporter's profits increase. Indeed, the relationship between profits and contracting institutions is not affected by a country's relative contracting institutions.

The impact of trade liberalization on the distributional consequences of institutional reforms is depicted in Figure 3.6. The figure shows the impact of institutional reforms in country F (institutional quality has increased from 0.4 to 0.5, whereas the institutions level in country H is constant at 0.8) for different levels of trade openness (measured by τ). The top left figure shows an always nonexporter's profits in response to institutional reforms. The net profits for this particular nonexporters decline as institutional quality improves for any level of openness (the green line that represents the profits under new institutional quality is always below the blue line, which represents profits under pre-reforms institutional quality). Interestingly, the decline in a nonexporter's profits is increasing with trade openness. For instance, a nonexporter's profits fall by almost 1.2% when $\tau = 1.2$ and by .5% when $\tau = 1.5$. Likewise, an exporter's profits increase by almost 4% when $\tau = 1.2$ and almost by 2% for $\tau = 1.4$ (bottom figures). That is, the distributional consequences of institutional reforms are magnified in the open economy when institutions are a source of comparative advantage across countries.

The experiment in Figure 3.6 is repeated in Figure 3.7, but for different levels of the country H's institutional qualities ($\mu_H = 0.3$, 0.5, and 1.0). The goal of this example is to explore the impact of the trade partner's institutional quality on the distributional effects of domestic institutional reforms. Indeed, qualitatively, all results in the previous example hold here. Nonetheless, improving the country F's institutional quality from 0.4 to 0.5 has a stronger impact on firms' profits as contracting institutions in county H decrease. The intuition is the following: country F's real consumption Q_F is decreasing in country

H's institutional quality; meanwhile, the impact of country F's institutional change on Q_F decreases as Q_F increases. As a result, the decrease in domestic profits resulting from domestic institutional reforms is more severe when the trade partner's institutional quality is low since a small improvement in domestic institutions has a sizable impact on the real consumption index Q_F and thus the domestic profits. The same logic applies to export profits.

3.6 Political Economy of Endogenous Institutions

Institutional reforms in the open economy generate salient distributional consequences; therefore, firms, as discussed above, possess strong preferences over these reforms. Firms who might lose or gain from these reforms will naturally engage in some sort of political actions to influence the level of institutional quality in the economy. As in the standard endogenous trade policy literature, this section demonstrates how the current framework can be combined with the lobbying model of Grossman and Helpman (1994) to endogenize contracting institutions in the global economy.

The original paper of Grossman and Helpman (1994) studies the endogenous trade policy (tariff) in the global economy. Nevertheless, Grossman and Helpman (2001) demonstrate the generality of the framework by using it in other contexts. Levchenko (2013) uses the lobbying game of Grossman and Helpman to study contracting institutions in the open economy under the H-O trade framework.[23]

3.6.1 Lobbying Game

As in Grossman and Helpman (1994), a policy maker is subject to special interest groups' pressure. Domestic firms are divided into two groups: nonexporters and exporters: $o \in \mathcal{O} = \{NE, EX\}$. Each lobbyist group proposes a menu of offers $C(\mu)$ that relates prospective monetary contribution to the level of contracting institutions chosen by the incumbent government. The government chooses the level of institutions $\mu \in [0, 1]$ to maximize a

[23]See also Abel-Koch (2013).

weighted sum of aggregate social welfare and total contributions.

$$G(\mu) = \lambda W(\mu) + \sum_{o \in \mathcal{O}} \mathbb{1}_o C_o(\mu) \tag{3.25}$$

$0 \leq \lambda < \infty$ denotes the social welfare weight. The higher λ is, the more benevolent the incumbent government is. The indicator function $\mathbb{1}_o$ takes a value of one if a subset of the firms belonging to that particular group has overcome the collective action problem and formed a lobbyist group and zero otherwise.[24] $W(\mu)$ is the aggregate welfare and given by[25]

$$W(\mu) = L\left(1 + S(Q(\mu))\right) \tag{3.26}$$

$S(Q(\mu)) \equiv \frac{1-\eta}{\eta} Q^{\eta}$ represents the consumer surplus in the economy, which is increasing in Q and μ. The objective function of each lobby is to maximize the joint welfare of its members net of political contribution,

$$G_o(\mu) = W_o(\mu) - C_o(\mu) \tag{3.27}$$
$$W_o(\mu) = \gamma_o L(1 + S(Q(\mu))) + \Pi_o(\mu)$$

Firms are owned by workers with $\gamma_o \equiv \frac{H_o}{L}$ representing the fraction of labor force that owns firms in group o. The aggregate profits of firms in group o are denoted by Π_o.

3.6.2 Lobbying Firms and Endogenous Entry

The potential number of entrants is a function of institutional quality in the economy and the anticipated pre-entry partition of firms varies with μ. Whether firms are allowed to lobby pre-entry or whether firms that expect to move from one group to another, as the level of institutional quality changes, engage in lobbying will impact the equilibrium

[24] Here, we assume that lobbyist groups and the participant firms are exogenously given. For endogenous formulation of lobbyist firms, see Bombardini (2008).

[25] In this section, I changed the model setup slightly. In particular, I assume that each country is endowed with L measure of workers with each worker inelastically supplies one unite of labor.

outcome of the political economy game and greatly complicate the analysis both analytically and numerically. Instead, strong conditions are imposed on firms that participate in the lobbying game. First, firms engage in lobbying only after they pay the sunk entry cost. Second, given trade costs τ and trade partner's institutions, only firms with a productivity level such that they choose never to export and never to exit the market at any level of domestic contracting institutions $\mu \in [0, 1]$ (always survival and nonexporters) are allowed to lobby in the nonexporters' group. It is important to mention that this subset of firms is not representing and lobbying for the aggregate nonexporters' welfare taking into account the impact of their political actions on the number of potential nonexporting firms in the economy. Rather, their concern is only about the joint profits of lobbying firms, where, at the lobbying stage of the game, the set of lobbying firms is given and unaffected by the level of contracting institutions. Likewise, only firms that export for any level of μ are allowed to lobby in the exporters' group.

The first condition is not very restrictive. Realistically, only established firms engage in political activities. The second condition is mainly for tractability and simplicity. Without it, it might be almost impossible to characterize all possible equilibrium outcomes. The implication of these conditions, in contrast to the scenario where lobbying firms maximize the joint profits of all firms in that group taking into account the impact of institutions on the measure of firms in the group, is that aggregate nonexporters' profits might increase with institutions, whears average profits per nonexporter is always decreasing. As a result, lobbying firms end up lobbying for a suboptimal institutional quality level from each lobbyist's perspective (see formal analysis below).

3.6.3 Timing and Political Equilibrium of the Lobbying Game

I modify the timing of the events slightly by adding lobbying to the economy. That is, after a firm pays f^E and discovers its productivity Θ, it engages in lobbying for group $o \in \mathcal{O}$ if and only if Θ satisfies the conditions for lobbying in the previous subsection: for nonexporters' group $\Theta \in [\Theta_{ii}(\mu = 1), \Theta_{ji}(\mu = 1)]$, and $\Theta \in [\Theta_{ji}(\mu = 0), \infty)$ for exporters. The remaining events are exactly the same as before. The timing of the lobbying game is as follows. lobbying firms in groups $o \in \mathcal{O}$ simultaneously and noncoopperatively offer a contribution for each feasible level of $\mu \in [0, 1]$, $C_o(\mu)$, to maximize its welfare net of contribution $G_o(\mu)$. The incumbent government takes the contribution schedule as given and chooses the level of μ that maximizes it objective function $G(\mu)$. The government implements the chosen level of μ and receives the corresponding contribution with probability of one.

Definition III.1. (Grossman and Helpman, 1994). An equilibrium is a set of contribution functions $\{C_o^*(\mu)\}$ one for each group $o \in \mathcal{O}$ such that each one maximizes the joint welfare of the group's member (lobbying members) net of contribution given the schedules set by the other groups and the anticipated political optimization by the government, and an institutional quality level μ^* that maximizes the government's objective, taking the contribution schedules as given.

Proposition III.7. *(Bernheim and Whinston, 1986). $\{C_o^*(\mu), \mu^*\}$ for $o \in \mathcal{O}$ is a Subgame Perfect Nash Equilibrium of the lobbying game if and only if*

(i) *$C_o^*(\mu)$ is feasible for all $o \in \mathcal{O}$*

(ii) *μ^* maximizes $\lambda W(\mu) + \sum_{o \in \mathcal{O}} \mathbb{1}_o C_o^*(\mu)$ on $\mu \in [0, 1]$*

(iii) *μ^* maximizes $\lambda W(\mu) + \sum_{o \in \mathcal{O}} \mathbb{1}_o C_o^*(\mu) + W_o(\mu) - C_o^*(\mu)$ for every $o \in \mathcal{O}$ and $\mu \in [0, 1]$*

(iv) *for every $o \in \mathcal{O}$, there exists an $\mu_o^* \in [0, 1]$ that maximizes $\lambda W(\mu) + \sum_{o \in \mathcal{O}} \mathbb{1}_o C_o^*(\mu)$ on $\mu \in [0, 1]$ such that $C_o^*(\mu_o) = 0$*

Condition (i) restricts the contribution of any lobby to be nonnegative and no greater than the aggregate income available to the lobby's members. Condition (ii) is straightforward; a government maximizes its weighted sum of aggregate welfare and total contributions. Condition (iii) implies that for every lobby o, the equilibrium level of contracting institutions μ^* maximizes the joint welfare of that lobby and the government, given the contribution schedules offered by other lobbies. The last condition states that the contribution of lobby o is just enough such that the government is indifferent between implementing the equilibrium institutions level μ^* and the policy it would have chosen without lobby o contribution.[26]

Since many contribution schedules might satisfy Proposition III.7, we restrict our attention to the equilibrium under a truthful contribution schedule, which reflects the true preferences of the lobby everywhere. Formally, the truthful contribution schedule of lobby o takes the form of

$$C_o^T(\mu, B_o) = \max\left[0, W_o(z) - B_o\right] \tag{3.28}$$

For some, $B_o \geq 0$. The equilibrium level of contracting institutions μ^* under a truthful contribution schedule, Truthful Nash Equilibria (TNE), has a compelling property. The equilibrium contracting institutions μ^* satisfies

$$\mu^* = arg \max_{\mu \in [0,1]} \left[\lambda W(\mu) + \sum_{o \in \mathcal{O}} \mathbb{1}_o W_o(\mu)\right] \tag{3.29}$$

The incumbent government ends up maximizing a social welfare function that places larger weights on lobbies. Specifically, a lobbyist group gets a weight of $1+\lambda$, while a non-lobbyist group gets a weight of λ.[27] If only exporters lobby (i.e., $\mathbb{1}_{EX} = 1, \mathbb{1}_{NX} = 0$), the political equilibrium is to set institutional quality at the highest possible level, which is one in our context. To see this, notice that when only exporters lobby, the government chooses μ to maximize $L(\lambda + \gamma_{EX})(1 + S(Q(\mu))) + \Pi_{EX}$. It is straightforward to verify that both the consumer surplus and the exporters' aggregate profits are increasing in $\mu \in [0, 1]$.[28] Another trivial case is when no group lobbies (i.e., $\mathbb{1}_{NX} = \mathbb{1}_{EX} = 0$). Here, again $\mu^* =$

[26] For a detailed discussion of the proposition and its conditions, please see Grossman and Helpman (1994).

[27] As shown in Grossman and Helpman (1994), the amount of contribution of lobby o is large enough to make the government indifference between choosing μ^{-o} and choosing μ^*, where $\mu^{-o} = arg \max \sum_{\substack{o' \in \mathcal{O} \\ o' \neq o}} C_{o'}^T(\mu, B_{o'}) + \lambda W(\mu)$ denotes the equilibrium institutions level that would emerge from political maximization of the government if lobby o contributions were zero. Hence, the truthful contributions of lobby o can be found from the following equation

$$\sum_{\substack{o' \in \mathcal{O} \\ o' \neq o}} \mathbb{1}_{o'} C_{o'}^T(\mu^{-o}, B_{o'}) + \lambda W(\mu^{-o}) = \sum_{o \in \mathcal{O}} \mathbb{1}_o C_o^T(\mu, B_o) + \lambda W(\mu) \quad \text{for all}\, o \in \mathcal{O}$$

[28] Notice that $\Pi_{EX} = \int_{\Theta \in EX(\Theta)} (\pi_{ii}(\Theta) + \pi_{ji}(\Theta)) d\Theta$, which is increasing in μ in order for the free entry condition to be satisfied.

$arg\max_{\mu\in[0,1]}(\lambda W(\mu)) = 1.$

Result III.1. Trade liberalization bolsters domestic contracting institutions if exporters, who export institutions-intensive goods, are the political dominant group in the economy.

It is useful at this point to contrast this result with the historical studies investigating the 17th and 19th century Atlantic three-corner trade, which emphasized the importance of the initial conditions manifested in a country's initial comparative advantage in understanding the impact of trade on domestic institutions. Trade is institutions-enhancing if a country specializes in highly institutions-dependent goods, but it hinders domestic institutions if a country's comparative advantage is based on non institutional factors. In the current model with two sectors (homogenous and differentiated), trade advances domestic institutions, conditional on exporters being the dominant group, since institutions are the only source of comparative advantage.

However, the model can be extended to incorporate these historical observations by introducing a second differentiated sector that is less dependent on contracting institutions than the original sector. In effect, trade might deteriorate domestic institutions if a country's initial comparative advantage is in the less institutions-dependent sector.[29] The mechanism that links trade to domestic institutional change in the current model is different from those in the historical studies, underscoring the impact of trade on the distribution of political and economic power across special interest groups. Here trade reinforces the distributional consequence of trade and, as a result, impacts domestic institutions, even with the political power of economic groups held constant.[30]

We are particularly interested in the case where only nonexporters engage in lobbying activities. The main goal of this exercise is to demonstrate the impact of trade liberalization

[29]Levchenko (2013) finds similar results, emphasizing the role of a country's initial comparative advantage.

[30]In fact, both mechanisms are presented in the current model: trade reinforces the distributional consequences of institutions and concentrates wealth in the hand of specific groups. Levchenko (2013) proposes a contractual frictions framework embedded in H-O trade model where trade alters the rent-seeking (generated from institutional frictions) group's preferences from anti institutional reforms to pro institutional reforms: In an open economy, rents can be captured only if a country continues to produce the institutionally dependent sector, requiring higher institutional quality than the trade partner's institutional quality (conditional on sharing a relatively similar production technology with the trade partner).

on domestic institutions when some domestic economic losers from institutional reforms are the ones who dominate the political economy. Consider an incumbent government who chooses μ to maximize its objective function given by (3.25)

$$\begin{aligned}&\max_{\mu\in[0,1]} \lambda L(1+S(Q(\mu)))+L\gamma_{NX}(1+S(Q))+\Pi_{NX}\\&=\max_{\mu\in[0,1]} L(\lambda+\gamma_{NX})(1+\frac{1-\eta}{\eta}Q^{\eta}(\mu))+\Pi_{NX}\end{aligned}$$

Our assumption about lobbying firms states that only firms with productivity in $NE(\Theta)\equiv[\Theta_{ii}(\bar{\mu}),\Theta_{ji}(\bar{\mu})]$, with $\bar{\mu}\leq 1$ denoting the maximum feasible value of μ in country i, participate in lobbying. Given this, we can write the lobbying firms' aggregate profits as $\Pi_{NX}=\int_{\Theta\in NE(\Theta)}\pi_{ii}(\Theta)d\Theta$. Since Θ is a random variable drawn from a Pareto distribution, then, equivalently, we can write the aggregate profits of the lobbying firms as $\Pi_{NX}=M(\mu)\int_{\Theta_{ii}(\bar{\mu})}^{\Theta_{ji}(\bar{\mu})}\pi_{ii}(\Theta)dG(\Theta)$. The problem of this last term is that the number of potential entrants is endogenous to the level of contracting institutions μ, and problematically, per-firm profits are not necessarily increasing with the aggregate profits Π_{NX}. Lobbying and its outcome under this framework are, to some degree, meaningless. It is not clear why existing firms would lobby to maximize the joint profits of all of its members, including the potential entrants who might hurt the existing firms.

The first condition about lobbying firms is of great use here; specifically, only firms that pay the sunk cost of entry and discover its productivity engage in political activities. At the lobbying stage, the firm's productivity is known. The boundaries of the set of lobbying firms are predetermined, and the lobbying firms' joint profits are the sum of the profits of all firms who belong to the lobbying set $NE(\Theta)$, where the number of entrants M is taken as given. That is, $\Pi_{NX}=\int_{\Theta\in NE(\Theta)}\pi_{ii}(\Theta)d\Theta=M\int_{\Theta\in NE(\Theta)}\pi_{ii}(\Theta)dG(\Theta)$.

The country i government's maximization problem, given country j's institutional quality and trade barriers (country subscript is omitted if no confusion is caused), is[31]

$$\max_{\mu\in[0,1]}(\lambda+\gamma_{NX})(1+\frac{1-\eta}{\eta}Q^{\eta}(\mu))+M\int_{\Theta\in NE(\Theta)}\left((1-\beta)\Theta Z(\mu)Q^{-\frac{\beta-\eta}{1-\beta}}(\mu)-f\right)dG(\Theta) \tag{3.30}$$

Given the Pareto assumption,

$$\max_{\mu\in[0,1]}(\lambda+\gamma_{NX})(1+\frac{1-\eta}{\eta}Q^{\eta}(\mu))+M\frac{\kappa}{\kappa-1}(1-\beta)Z((\mu)Q^{-\frac{\beta-\eta}{1-\beta}}(\mu)\Psi-f\Psi_1, \tag{3.31}$$

where $\Psi\equiv\Theta_{ii}(1)^{1-\kappa}-\Theta_{ji}(1)^{1-\kappa}>0$, $\Psi_1=\Theta_{ii}(1)^{-\kappa}-\Theta_{ji}(1)^{-\kappa}>0$ and M are constant and not a function of μ.

The first term of the equation above is increasing with μ, whereas the second term, which represents a nonexporter's expected profits, is decreasing with μ. As a result, for a plausible range of parameters values (especially, λ and η), the optimal value of contracting institutions μ^* is indeed less than one. Trivially, the level of optimal institutional quality under the lobbying game is increasing in the social welfare weight, denoted by λ. If the incumbent government places larger and larger weights on the aggregate social welfare relative to the weight on lobbies monetary contribution (in extreme case $\lambda\to\infty$), the chosen institutional quality gets closer to one. The parameter η controls the elasticity of substitution between the outside sector and the differentiated sector. The higher η the larger the marginal change in social welfare (the first term in the equation above) in response to the change in institutional quality μ and the lower the derivative of nonexporters' profits (the second term in the equation above) with respect to μ will be. As η gets closer to β, the impact of institutional reforms on nonexporters' profits gets smaller, while the social welfare's response to these reforms is magnified; as a result, the level of institutional quality that maximizes (3.31) goes up. The next lemma summarizes the linkages between the optimal chosen level of institutional quality and some of the major parameters in the model.

Lemma III.6. *The institutional quality that emerges as the solution to the lobbying game*

[31]Notice that since in this section each country is endowed with L workers and each worker inelastically supplies one unit of labor, the domestic and the export profits are L times its counterparts in the previous sections: $\pi_{ii}(\Theta)=L$ times domestic profits given by (3.9).

given by (3.31) *is decreasing in the elasticity between the real consumption index* Q *and institutional quality* μ, $\zeta_{Q,\mu}$. *Moreover, the government chooses a higher level of* μ *for higher levels of the social welfare weight* λ *and for a higher fraction of consumers/voters who own the lobbying firms* α_{NX}. *However, The chosen institutional quality falls with the size of the set that determines the lobbying firms,* $NE(\Theta)$. *Finally,* μ^* *is decreasing with* M.

If lower institutional quality impacts nonexporter's profits greatly (high $\zeta_{Q,\mu}$), the institutional quality that emerges from the lobbying game is lower relative to the case where the contracting institutions have a small impact on the nonexporters' profit. Indeed, for higher $\zeta_{Q,\mu}$, the distortional effect of μ on the economic welfare is higher, with the owner of firms (consumers) demanding higher μ. This last effect is outweighed by the impact of μ on firms' profits. The impacts of λ and α_{NX} are straightforward and logical, as discussed in Grossman and Helpman (2001). Nonetheless, the impact of the boundaries of the set that determines the lobbying firms in our economy is unique to the current framework, which features lobbying with free entry. Indeed, for a given measure of entrants M, the larger the range of the lobbying set, the larger the ex-post lobbying firms' profits and consequently the lower the level of equilibrium μ.

Although the set of lobbying firms is exogenously given in the current framework, the importance of the set of lobbying firms cannot be overemphasized. Realistically, the set of lobbying firms is correlated with economic and political institutional arrangements (the term here, unlike how it's used in the previous sections and almost everywhere in the paper, refers to the broader definition of *institutional setting*: legal institutions: rule of rule and contracting institutions; political institutions: electoral system and political parties; and informal institutions: culture, bureaucracy, and clientelism). In societies where bribes and/or lobbying are conceived as the best way to do business, more firms get involved in lobbying (legal or illegal), and as a result, the endogenous contacting institutional quality is expected to be correlated with other aspects of formal and informal institutional settings. This said, in the current framework, the main point is not to explain contracting institutions differences across countries; rather I try to illuminate the channels and mechanisms in which trade liberalization and initial institutions impact domestic contracting institutions.

Obviously, M is an endogenous variable and depends on institutional quality. The solution of the lobbying game (i.e., 3.31) yields an optimal institutional quality for every M, $\mu^*(M)$. The mass of potential entrants M that clears the market, for any given μ, is pinned down by Equation (3.24). Formally, the problem of finding M that is consistent with market clearing and political economy solutions is equivalent to finding the fixed point of $M = g(\mu^*(M))$, where g represents the functional relationship between M and μ as in equation (3.24). Precisely,

$$M_i = (1-\beta)\phi_i(\mu^*(M))\frac{\kappa-1}{\kappa}\frac{f\Theta_{jj}(\mu^*(M_i))^{-\kappa}Q_i(\mu^*(M_i))^{\eta} - f_x\Theta_{ij}(\mu^*(M_i))^{-\kappa}Q_j(\mu^*(M_i))^{\eta}}{f^2\Theta_{ii}(\mu^*(M_i))^{-\kappa}\Theta_{jj}(\mu^*(M_i))^{-\kappa} - f_x^2\Theta_{ij}(\mu^*(M_i))^{-\kappa}\Theta_{ji}(\mu^*(M_i))^{-\kappa}} \tag{3.32}$$

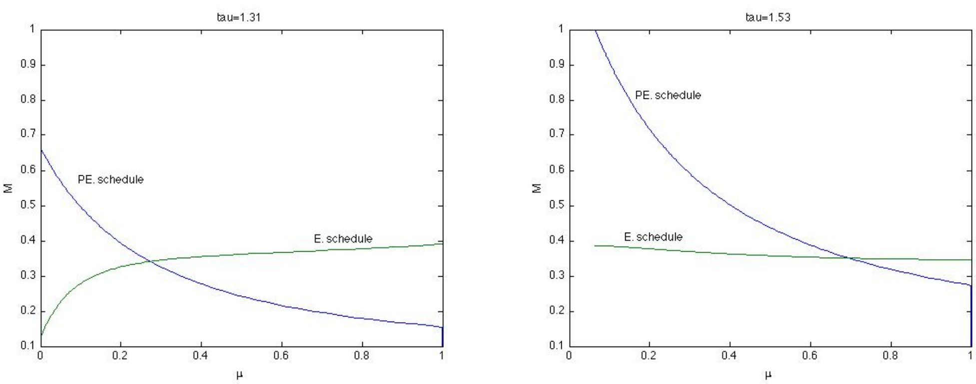
$$\mu^*(M_i) = arg\max_{\mu}(\lambda+\gamma_{NX})(1+\frac{1-\eta}{\eta}Q^{\eta}(\mu)) + M_i\frac{\kappa}{\kappa-1}(1-\beta)Z((\mu)Q^{-\frac{\beta-\eta}{1-\beta}}(\mu)\Psi - f\Psi_1 \tag{3.33}$$

We need to show that the M that satisfies equation (3.32) exists and is unique. A trivial case is when $\mu^*(M) \in \{0, 1\}$ (i.e., there is no interior solution for the lobbying problem and the chosen institutional quality is either 0 or 1 regardless of M). In this case, $M \in \{M(0), M(1)\}$. The existence of the political economy when $\mu^*(M) \in [0, 1]$ is described below.

Claim III.1. Given the model's parameters, trade partner institutions μ_j, and $\tau \in [\tau^{min}, \tau^{max}]$, there exists a unique pair of $\{\mu_i^{**} \in [0, 1], M^{**}\}$ that satisfies (3.32) and (3.33).

The formal proof is relegated to the Appendix. To give an idea about the proof and the mechanism of the model, consider the political economy schedule $\mu^*(M)$, which according to Lemma III.6 is strictly decreasing in M for $\mu^*(M) \in [0, 1]$. Then there exists M^{max} and M^{min} such that for any $M > M^{max}$, $\mu^*(M) = 0$, and $\mu^*(M) = 1$ for $M < M^{min}$. Equation (3.24) delivers the mass of entrants M as a function of μ such that the markets clear. Let call this relationship the economic schedule, $\mu^E(M)$ (i.e., for every M there is μ that clears the markets). The analysis of the economic schedule is more involved and complicated than the political economy schedule. In particular, it changes sign depending on the level of trade costs, τ. Fortunately, it exhibits consistent patterns: for low τ, M is strictly increasing in μ, decreasing when τ is high enough. The existence of the equilibrium commands two sufficient conditions; (i) the political economy schedule starts above the economy schedule (e.g., $M^*(0) > M^E(0)$), and (ii) the economic schedule ends above the political economy schedule as μ approaches 1. When the economic schedule is strictly increasing or decreasing and the equilibrium exists, it is also unique. Theoretically, multiple equilibria are only possible in the medium ranges of τ. Our simulation shows that for wide range of the model's parameters, the equilibrium is always unique. Figure 3.8 provides examples of the political economy schedule and the economic schedule under our preferred parameter values[32] when trade partner institutions $\mu_j = .5$ and $\tau \in \{1.31, 1.53\}$.

Figure 3.8: Political Economy Equilibrium



Result III.2. Let μ^{**} be the political economy equilibrium where both schedules intersect. Then μ^{**} is increasing in λ, α_{NX}, and η but decreasing in $NE(\Theta)$.

Relying on Lemma III.6, the political economy schedule shifts up as λ and/or α_{NX} increase, whereas the economic schedule is invariant to these parameters. As a result, μ^{**} increases. On the other hand, an increase in the size of $NE(\Theta)$ shifts the political economy schedule down but leaves the economic schedule unchanged, causing μ^{**} to fall. The impact of η on μ^{**} is more complicated: a fall in η shifts both the political economy and the economic schedules up, with the magnitude of the economic schedule shift dominating the shift in the political economy schedule, leading to higher μ^{**}.

[32] $\eta = .5, \alpha = .9, \beta = .75, \kappa = 2.1, f_x/f = 2.1, f^E = .5, \lambda = .025$, and $\alpha_{NX} = .01$.

Our primary interest is, given the trade partner institutions, the impact of trade liberalization (lower τ) on the political economy equilibrium of domestic institutions. Unfortunately, a closed form solution of the political equilibrium institutions μ^{**} that solves (3.32) and (3.33) is not applicable. I resort to numerical analysis to recover μ^{**}. I start with an initial guess of the potential mass of entrants $M_{\{0\}} > 0$ and find $\mu^{*}(M_{\{0\}})$ by solving equation (3.31) numerically. Second, $\mu^{*}(M_{\{0\}})$ is used to find $M^{E}(\mu^{*}(M_{\{0\}})$, which clears the market (i.e., equation (3.24)). Third, if $|M^{E}(\mu^{*}(M_{\{0\}}) - M_{\{0\}}| < \epsilon$, stop; otherwise iterate until convergence. Finally, given our equilibrium domestic institutions, I calculate the mass of potential entrants in the other country M_j. If $M_j \leq 0$, then μ^{**} leads to complete specialization, and the incomplete specialization equilibrium does not exist.

The political economy equilibrium of institutional quality μ^{**} versus trade impediments τ is depicted in Figure 3.9. Evidently, μ^{**} is increasing in τ. If contracting institutions are a source of comparative advantage and if losers from institutional reforms dominate the political institutions, the incumbent government, who maximizes the weighted sum of aggregate social welfare and political contribution, chooses a lower level of institutional quality as trade impediments fall. The result could simply be comprehended from the fact that lowering τ reinforces the role of contracting institutions as a source of comparative advantage and therefor amplifies the distributional consequences of institutional reforms. Nonexporters, the only lobby group and the losers from institutional reforms, are more devoted to preventing or mitigating institutional reforms in the more open economy since they are severely inflicted by institutional reforms. Technically, higher trade costs τ lead to upward shift in the political economy schedule. The economic schedule is also affected by changes in τ. Starting from low τ, the schedule is upward sloping. As τ increases, the economic schedule rotates clockwise, becoming flatter, and, as τ continues to increase, it becomes downward sloping.[33] Overall, the upward shift in political economy as τ increases dominates the clockwise rotation in the economic schedule.

[33]Trade costs impact the economic schedule only if $\mu_i \neq \mu_j$. This is a well known result; under symmetric country and Pareto assumption, the mass of potential entrants is invariant to trade costs. As τ increases, causing the economic schedule to rotate clockwise, all schedules intersect at the point where $\mu_i = \mu_j$.

In autarky, the role of contracting institutions as a source of comparative advantage and their distributional consequences are ceased. Exporters and nonexporters are better off as institutions advance. In fact, as shown in Figure 3.9, the equilibrium institutional quality is set to the highest level when τ is high enough, but not autarky. By contrast, when trade barriers are relatively low, the optimal chosen level of contracting institutions is the lowest.

Result III.3. The equilibrium institutional quality μ^{**} is increasing in trade impediments τ, ceteris paribus.

The impact of trade partner's institutions on the political equilibrium of the lobbying game in the domestic economy is shown in Figure 3.10. First, notice that the qualitative impact of trade partner's institutions on the equilibrium domestic institutions is similar for different values of trade variable costs: the political equilibrium of domestic institutional quality is increasing with the trade partner's institutional quality for any level of τ. This is a very interesting result, which basically interrelates domestic institutions to the trade partner's institutions. Not only do the domestic political and economic conditions matter when it comes to domestic policies and institutional reforms, but trade partners' characteristics are also paramount as the domestic context. Simply put, global context does matter. Important implications both empirically and theoretically emerge as a result. For instance, an empirical model that tests the impact of trade openness on the domestic institutional quality without controlling for trade partner's relevant conditions might be misspecified.

Result III.4. Countries are interdependent. Trade with countries with superior institutions foster domestic institutional quality.

But the question then is why commerces with countries that exhibit advanced institutions spur the domestic institutions or, as in here, mitigate nonexporters' oppositions to domestic institutional reforms. Technically, the result emanates from the impact of trade partner's institutional quality on domestic real consumption index Q and from the diminishing effect of domestic institutions on domestic real consumption index Q. To be precise, the impact of domestic institutional reforms on aggregate welfare relative to its impact on nonexporters' profits increases as trade partners' institutional quality increases. In effect, the equilibrium domestic institutional quality rises with trade partner's institutions.

3.6.4 Trade and the Relative Power of Special Interest Groups

As noted by Nunn and Trefler (2013), institutional change is possible only if it is supported by the powerful special interest groups. Existent literature on trade and domestic institutional change emphasizes on the role of trade in enriching these powerful special interest groups, which, in turn, leads to profound institutional changes. Here, I provide a brief discussion to demonstrate how trade changes the relative power of special interest contenders. Assuming that both exporters and nonexporters lobby, the incumbent government maximization problem can be written as

$$\max_{\mu\in[0,1]}(\lambda+\alpha_{NX}+\alpha_{EX})(1+S(Q))+\Pi_{NX}+\Pi_{EX}$$
$$=\max_{\mu\in[0,1]}(\lambda+\alpha_{NX}+\alpha_{EX})(1+S(Q))+M\left[\int_{\Theta\in NE(\Theta)}\pi_{ii}(\Theta)dG(\Theta)+\int_{\Theta\in EX(\Theta)}\pi_{i}(\Theta)dG(\Theta)\right]$$

As before, $\pi_{ii}(\Theta)$ (domestic profits) are decreasing in μ, and $\pi_i(\Theta) = \pi_{ii}(\Theta) + \pi_{ji}(\Theta)$ (domestic and export profits) are increasing in μ. The sets of lobbying firms ($NE(\Theta)$ and $EX(\Theta)$) are also a function of trade costs. Specifically, lower trade costs enlarge the set of lobbying firms in the exporters group and shrink the set of lobbying firms in the nonexporters group. From Lemma III.6, we know that the chosen level of μ^* is decreasing in $NE(\Theta)$, and by the same reasoning, it is easy to show that μ^* is increasing in $EX(\Theta)$. In effect, even when the distributional consequences of institutions are held constant, trade liberalization makes exporters more powerful, changing the equilibrium of the lobbying game.[34]

[34] One might be concerned that our results in the previous section are emanating from the impact of trade on the set of lobbying firms. This is not the case, however. Our results in the previous section are robust to the scenario where the set of lobbying firms is invariant to trade costs. Indeed, both mechanisms are present in Figure 3.9.

3.7 Conclusion

I embed contractual frictions (modeled as in Grossman and Hart, 1986) in a two-country two-sector trade model that features monopolistic competition (MC), increasing returns to scale (IRS) and heterogeneous firms (HF). The first sector produces homogenous products under standard assumptions and complete contracts, whereas the second sector produces differentiated products under MC, IRS, HF and is subject to contractual frictions. In this environment, I show that institutions are a sources of comparative advantage; specifically, a country with relatively better institutions exports the differentiated products in net and imports the homogenous good. Both countries gain from trade, but a country with better institutions gains more. Furthermore, similar countries (in terms of institutional quality) have a larger volume of intraindustry trade.

Institutional reforms have stark distributional consequences in the global economy. The nature of the redistributive consequences of institutions is novel and unexplored. Institutional reforms redistribute resources across sectors and across firms within sectors. I carefully characterize firms' preferences over institutional reforms in the open economy for all operating firms. I show that there exists a productivity cutoff where all firms below are reforms' opponents, while firms above are proponents of institutional reforms. One of the main contributions of the paper is the analysis of the impact of trade liberalization on the distributional consequence of institutional reforms. Trade reinforces the redistributive effects of institutions.

Domestic institutional quality is not necessarily positively associated with trade liberalization. The paper emphasizes contextual analysis to understand the responses of the domestic institutional quality to lowering trade costs. Initial institutional arrangements, political organizations, and the structure of political influences are crucial elements in the analysis of endogenous contracting institutions in the global economy. The general result is that trade, most likely, reinforces the predominant initial institutions. Moreover, countries are interdependent, in a sense, institutional reform in one country improves its welfare, but it decreases trade partner's. Nevertheless, commerces with high institutional quality partner advance domestic institutions.

3.8 Appendix A: Incomplete Contracts and SSPE

In this appendix, I provide the derivation of the reduced-form profit (3.8). In order to find the reduced-form profit function for a firm, we need to solve for the SSPE using backward induction. The timing of the game is as mentioned in the text. First, notice that a firm's revenue function is given by (I drop firm identifier script for notational simplicity)[35]

$$R = q^{\beta}\bar{Q}^{1-\beta}, \qquad q = \varphi N^{1-\frac{1}{\alpha}}\left[\int_0^N X(j)^{\alpha}dj\right]^{\frac{1}{\alpha}}$$

$$X(j) = exp\left(\int_0^1 lnx(i,j)di\right), \qquad x(i,j) = \begin{cases} x_c, \text{ for } i \in [0,\mu] \\ x_n, \text{ for } i \in (\mu, 1] \end{cases}$$

Here, $\bar{Q} \equiv \left[Q_i^{-\frac{\beta-\eta}{1-\beta}} + \mathbb{1}_{ji}(\varphi)\tau^{\frac{-\beta}{1-\beta}}Q_j^{-\frac{\beta-\eta}{1-\beta}}\right]$. Then, using the above equations we write the revenue function in terms of x_c and x_n.

$$R = \varphi^{\beta}N^{\beta}\left[[x_c^{\mu}x_n^{1-\mu}\right]^{\beta}\bar{Q}^{1-\beta} \tag{3.34}$$

This revenue is distributed among suppliers and the firm according to the Shapley value. Let $s_x(x_c, x_n)$ denote the Shapley value of a representative supplier and $s_q(x_c, x_n)$ denote the Shapley value of the firm. Then $s_q(x_c, x_n) + Ns_x(x_c, x_n) = R$. Rolling back to the stage before bargaining, all suppliers know exactly the amount of investment in contractable activities since these are specified explicitly in the contract (notice here that $x(i,j) = x_{c,j}$ for $i \leq \mu$ since these activities enter the intermediate production function symmetrically and all have the same marginal cost). Since the investment level in noncontractible activities cannot be specified in the contract, all supplier j chooses $x_n(j)$ simultaneously and nonco-

[35]The derivations, notations, and the description of the incomplete contracts follow closely Acemoglu et al. (2007). If fact, some definitions/sentences are taken without modification/slightly modified from Acemoglu et al. (2007).

operatively. Given the investment level in all noncontractible activities by all supplier other than j, $x_n(-j)$, supplier j chooses $x_n(j)$ to maximize her Shapley value net of the costs associated with investment in $x_n(j)$: $x_n(j) = arg\max_{x_n(j)} s_x[x_c, x_n(-j), x_n(j)] - (1-\mu)c_x x_n(j)$. As we deal with symmetric equilibrium, $x_n(-j) = x_n = x_n(j)$; thus the optimal value of $x_n(j)$ is each supplier's best response:

$$x_n \in arg\max_{x_n(j)} s_x[x_x, x_n, x_n(j)] - (1-\mu)c_x x_n(j). \tag{3.35}$$

This is the supplier incentive compatibility constraint with imposing symmetric equilibrium (let $B(x_n)$ be the best response of player j to x_n, then we need $x_n \in B(x_n)$).

Moving one step backward in the game tree, suppliers accept the offered contract if and only if they expect to receive at least their outside option (normalized to zero here). Thus, the participation constraint for a supplier is

$$s_x(x_c, x_n) + d \geq \mu c_x x_c + (1-\mu)c_x x_n, \quad x_n \text{ satisfies (3.35)} \tag{3.36}$$

That is, every supplier is expecting her Shapley value and upfront payment d to cover the cost of investment in contractible and noncontractible activities. If the firm were to choose a contract (x_c, d) such that the participation constraint does not satisfy, the pool of suppliers who accepts to engage in a production relationship with the firm is simply empty. The firm designs a contract (x_c, d) to maximize its profit:

$$\max_{x_c, x_n, d} s_q(x_c, x_n) - Nd \tag{3.37}$$

$$s.t \quad x_n \in arg\max_{x_n(j)} s_x[x_x, x_n, x_n(j)] - (1-\mu)c_x x_n(j)$$

$$s_x(x_c, x_n) + d \geq \mu c_x x_c + (1-\mu)c_x x_n$$

The participation constraint is satisfied with equality; otherwise, the firm could reduce d without violating the incentive compatibility constraint and thus increases its profits. Substitute out d from the firm's objective function, and by using the equality in the participation constraint, the firm's problem is simplified to

$$\max_{x_c, x_n} \overbrace{s_q(x_c, x_n) + N s_x(x_c, x_n)}^{=R} - \mu c_x x_c + (1-\mu) c_x x_n, \text{subject to (3.35)} \tag{3.38}$$

To solve for x_n one needs to fine the explicit formula of the supplier Shapley value, which we turn to in the next subsection.

3.8.1 Shapley Value

In the above setting, the complication of calculating Shapley values arises because of the continuum number of suppliers: $i \in (0, N]$. When the number of players is finite, the Shapley value of player j is the average of her marginal contributions to all feasible coalitions that consist of players ordered below her for all feasible permutations. That is, with a firm (player 0) and M suppliers, let $g = \{g(0), ...g(M)\}$ be a permutation of $0, 1, \ldots M$, and let $z_g^j = \{j' | g(j) > g(j')\}$ be the set of players ordered below j in the permutation g. Denote the value of the coalition consisting of any subset of $M+1$ players by v, such that $v : G \to \mathbb{R}$, where G is the set of all feasible permutations. Then the Shapley value of a player j is given by

$$s_j = \frac{1}{(M+1)!} \sum_{g \in G} [v(z_g^j \cup j) - v(z_g^j)] \tag{3.39}$$

Acemoglu et al. (2007) derive the asymptotic Shapley value, which is defined as the limit of the solution of (3.39) as the number of player goes to infinity.[36] I borrow the less formal method to derive the Shapley value with continuum players from Acemoglu et al. (2007). In particular, notice that the final producer is essential to have a positive output. Let, $m(j, n)$ denote the marginal contribution of supplier j with a coalition formed from the final good producer and a measure of n suppliers all ordered below j. The Shapley value of j is the average of her marginal contributions to coalitions that consist of players ordered below here in all feasible orderings conditional of having the final good producer ordered below j. That is, for any coalition size $n < N$, with probability $1 - \frac{n}{N}$, the final producer is not in

[36] Formal treatments, detailed derivations and proofs can be found in Acemoglu et al. (2007).

the coalition, and therefore the marginal contribution of $j \in n$ is zero. Averaging over all possible equally-likely ordering of the players, the Shapley value can be written as

$$\bar{s}_x[N, x_c, x_n(-j), x_n(j)] = \frac{1}{N}\int_0^N \frac{n}{N} m(j,n)dn$$
$$m(i,j) = \bar{Q}^{1-\beta}\left[\frac{x_n(j)}{x_n(-j)}\right]^{(1-\mu)\alpha} x_c^{\beta\mu} x_n(-j)^{\beta(1-\mu)} N^{\beta-1} n^{(\beta-\alpha)\alpha}$$

Solving the previous equations yields

$$s_x[x_c, x_n(-j), x_n(j)] = (1-\gamma)\varphi^\beta \bar{Q}^{1-\beta}\left[\frac{x_n(j)}{x_n(-j)}\right]^{(1-\mu)\alpha} x_c^{\beta\mu} x_n(-j)^{\beta(1-\mu)} N^{\beta-1} \quad (3.40)$$

Notice that under symmetric equilibrium $x_n(-j) = x_n(j) = x_n$, the Shapley value produces a simple division rule:

$$s_x[x_c, x_n, x_n] = (1-\gamma)\varphi^\beta N^{\beta-1}\left[x_c^\mu x_n^{1-\mu}\right]^\beta = (1-\gamma)\frac{R}{N}. \quad (3.41)$$

Hence,

$$s_q[x_c, x_n, x_n] = \gamma R, \quad \gamma \equiv \frac{\alpha}{\alpha+\beta} \quad (3.42)$$

To obtain SSPE, we find x_n that satisfies incentive compatibility constraint (3.35) using (3.40):

$$x_n = arg \max_{x_n(j)} (1-\gamma)\varphi^\beta \bar{Q}^{1-\beta}\left[\frac{x_n(j)}{x_n(-j)}\right]^{(1-\mu)\alpha} x_c^{\beta\mu} x_n(-j)^{\beta(1-\mu)} N^{\beta-1} = x_n(x_c)$$

The firm's profit optimization problem is then given by

$$\max_{x_c} R(x_c, x_n(x_c)) - N[\mu c_c x_c + (1-\mu)c_x x_n(x_c)] \quad (3.43)$$

The solution to the above problem delivers the reduced-form profit functions (3.9) and (3.10).

3.9 Appendix B: Proofs

Proof of Lemma III.1

Proof. We show that $\log(Z)$ is increasing in μ.

$$\frac{\partial \log(Z)}{\partial \mu} = \frac{\beta}{1-\beta}\left[\log(\beta) - \log(\alpha(1-\gamma))\right] + \frac{(1-\beta(1-\mu))\alpha(1-\gamma) - \beta[1-\alpha(1-\mu)(1-\gamma)]}{(1-\beta)(1-\alpha(1-\mu)(1-\gamma))}$$
$$+\frac{\beta}{1-\beta}\log\left(\frac{1-\alpha(1-\mu)(1-\gamma)}{1-\beta(1-\mu)}\right)$$

The second derivative is given by

$$\frac{\partial^2 Z}{\partial \mu^2} = (\alpha(1-\gamma)-\beta)\beta\left[\frac{-\alpha}{((1-\beta)(1-\alpha(1-\mu)(1-\gamma)))^2} + \frac{1}{(1-\beta)(1-\alpha(1-\mu)(1-\gamma))}\right] < 0$$

The inequality emerges since $\alpha(1-\gamma)-\beta) < 0$. As a result, for $\mu \in [0,1]$ the first derivative of Z with respect to μ reaches its minimum at $\mu = 1$, where $\frac{\partial Z}{\partial \mu}|_{\mu=1} > 0$. Hence, $Z(\mu)$ is increasing in $\mu \in [0,1]$. □

Proof of Lemma III.2

Proof. By construction, we have $\Theta_{ii} < \Theta_{ji}$ for $i,\ j \in \{H, F\}$. Hence,

$$\frac{\delta_{ii}}{\delta_{ji}} = \frac{f}{f_x}\frac{\Theta_{ji}}{\Theta_{ii}}\frac{\int_{\Theta_{ii}}^{\infty}\Theta dG(\Theta)}{\int_{\Theta_{ji}}^{\infty}\Theta dG(\Theta)} > \frac{f}{f_x}\frac{\Theta_{ji}}{\Theta_{ii}} \rightarrow \frac{\delta_{ii}}{\delta_{ji}} > \tau^{\frac{\beta}{1-\beta}}\frac{Z(\mu_j)}{Z(\mu_i)} \text{ by (3.15)}$$
$$\text{Thus,}\quad \frac{\delta_{jj}}{\delta_{ij}}\frac{\delta_{ii}}{\delta_{ji}} > \tau^{\frac{2\beta}{1-\beta}} > 1 \rightarrow \Delta \equiv (\delta_{ii}\delta_{jj} - \delta_{ji}\delta_{ij}) > 0.$$

Assume that $\mu_i = \mu_j$ (i.e., symmetric countries): $\Theta_{ii} = \Theta_{jj}$ and $\Theta_{ji} = \Theta_{ij}$. Now let $\widehat{Z(\mu_i)} > \widehat{Z(\mu_j)} \rightarrow Z(\mu_i) > Z(\mu_j)$. From (3.16) and (3.17), and the fact that $\Delta > 0$, it is direct to show $\Theta_{ii} > \Theta_{jj}$ and $\Theta_{ji} < \Theta_{ij}$. □

Proof of Lemma III.3

Proof. The proof follows immediately from Lemma III.2, Lemma III.1, and the ZPC Equation (3.11): That is, $\left(\frac{Q_H}{Q_F}\right)^{\frac{\beta-\eta}{1-\beta}} = \frac{\Theta_{HH}Z(\mu_H)}{\Theta_{FF}Z(\mu_F)} > 1$ if $\mu_H > \mu_F$. □

Proof of Lemma III.5

Proof. The incomplete specialization condition is satisfied if and only if $M_i > 0\, i \in \{H, F\}$. Total expenditure in the differentiated sector in country i is equal to $PQ = Q^\eta$, which is also equal to the domestic firms' total sales in the domestic market i and the aggregate foreign firms' sales in the domestic market:

$$Q_i^\eta = R_{ii} + R_{ji} = M_i \frac{\delta_{ii}}{(1-\beta)\phi_i} + M_j \frac{\delta_{ij}}{(1-\beta)\phi_j} \quad i \in \{H, F\} \tag{3.44}$$

Solving the two equations above yields

$$M_i = \phi_i \frac{1-\beta}{\Delta} \left[\delta_{jj} Q_i^\eta - \delta_{ij} Q_j^\eta\right], \tag{3.45}$$

here, $\phi_i = \left[\frac{1-\alpha(1-\mu_i)(1-\gamma)}{1-\beta(1-\mu_i)}\right]$.

The incomplete specialization condition is satisfied if and only if $\left(\frac{Q_H}{Q_F}\right)^\eta > \frac{\delta_{HF}}{\delta_{FF}}$ and $\left(\frac{Q_F}{Q_H}\right)^\eta > \frac{\delta_{FH}}{\delta_{HH}}$. Hence, $\frac{\delta_{HH}}{\delta_{FH}} > \left(\frac{Q_H}{Q_F}\right)^\eta > 1 \to \delta_{HH} > \delta_{FH}$. A similar argument applies to country F, $\delta_{FF} > \delta_{HF}$. Lemma III.2 implies $\delta_{HH} < \delta_{FF}$ and $\delta_{FH} > \delta_{HF}$ since δ_{ij} is decreasing in Θ_{ij} for $i, j \in \{H,\, F\}$ □

Proof of Lemma III.4

Proof. The proof follows immediately from (3.16), (3.17), $\Delta > 0$, and Lemma III.5. □

Lemma III.7. *The adjusted number of entrants $\bar{M}_i \equiv \frac{M_i}{\phi_i}$ is strictly increasing in μ_i*

Proof of Lemma III.7

Proof. Consider the expenditure-revenue identity (3.44). Now, let $\hat{\mu}_i > 0$ and $\hat{\mu}_j = 0$. Then from the analysis above, Q_i increases, and δ_{ii} and δ_{ij} decrease. The identity is satisfied if and only if (i) $\bar{M}_i$ and $\bar{M}_j$ increase, (ii) $\bar{M}_i$ decreases while $\bar{M}_j$ increases, and (iii) $\bar{M}_i$ increases and $\bar{M}_j$ decreases. To prove the lemma, it is sufficient to show that $\bar{M}_j$ increases in μ_i only if $\bar{M}_i$ is increasing in μ_i. Therefore, case (ii) is ruled out and $\bar{M}_i$ is indeed increasing in μ_i. By equation (3.45) and given that Q_i, and δ_{jj} are increasing in μ_i, whereas Q_j, δ_{ii}, and δ_{ij} are decreasing in μ_i, the result follows. □

Proof of Proposition III.1

Proof. Let $X_{ji} = M_i \int_{\Theta_{ji}}^{\infty} R_{ji}(\Theta) dG(\Theta)$ be the value of aggregate exports in the differentiated sector of country i to country j. Equivalently, X_{ji} can be written as

$$X_{ji} = \frac{M_i}{\phi_i} \frac{\delta_{ji}}{(1-\beta)}$$

If $\mu_H > \mu_F$, then by Lemma III.5, Lemma III.3, and equation (3.45), $\frac{M_H}{\phi_H} > \frac{M_F}{\phi_F}$ and $\delta_{FH} > \delta_{HF}$. Hence, $X_{FH} > X_{HF}$. Assuming balanced trade, the total volume of trade between the two countries is $2X_{FH} > X_{FH} + X_{HF}$. That is, country F exports the homogenous good. The share of intra-industry trade $\frac{X_{HF}}{X_{FH}} = \frac{M_F/\phi_F}{M_H/\phi_H} \frac{\delta_{HF}}{\delta_{FH}}$, by using (3.45) and (3.18), is indeed decreasing in $\frac{Z(\mu_H)}{Z(\mu_F)}$. □

Proof of Proposition III.2

Proof. Equation (3.18) and $\Delta > 0$. □

Proof of Proposition III.3

Proof. The proposition is immediately implied by (3.18) and Lemma III.5. □

Proof of Proposition III.4

Proof. If nonexporters only care about their profits, then the proof is derived in the text (see equation (3.19)). In the case where the owners of the nonexporting firms are consumers; hence, they take into consideration the impact of institutional reforms on both their real income and their consumer surplus $S(Q)$ a representative nonexporter's welfare can by written as $W(\mu) = (1 + S(Q(\mu))) + \pi(\mu)$. This function is decreasing in μ for a plausible range of parameters (see Political Economy section). □

Proof of Proposition III.5

Proof. The marginal exporter (i.e., with productivity $\Theta = \Theta_{ji}^{post}$) is indeed worse off in the post reform, while An exporter-exporter (i.e., with productivity $\Theta \geq \Theta_{ji}^{pre}$) is better off. Since $\pi(\Theta)$ is continuous and increasing in Θ, the existence of $\Theta_{ji}^{support}$ is guaranteed. □

Proof of Proposition III.6

Proof. : We need to show that $\left[1 - \frac{\delta_{jj}(\delta_{ii}+\delta_{ji})}{\Delta}\right]$ is decreasing with τ. The proof follows immediately by noting that δ_{ii} (δ_{ji}) increases (decreases) with τ (in order to satisfy the free entry condition) and $\delta_{ii} > \delta_{ji}$. □

Proof of Lemma III.6

Proof. First, let's rewrite the maximization problem (3.31) such that the government is choosing the level of derived efficiency Z instead of μ. This is completely legitimate since μ enters the objective function only through Z and Z is strictly increasing in $\mu \in [0, 1]$; thus the equilibrium level of institutional quality μ^* can be recovered by taking the inverse of Z^*, that is, $\mu^* = Z^*(\mu)^{-1}$. From the fist-order condition,

$$\frac{1}{Z^*} = \frac{MB_2}{B_1} Q^{-\beta\frac{1-\eta}{1-\beta}} \left[\frac{\beta - \eta}{1 - \beta} - \frac{1}{\zeta_{Q,Z}}\right], \tag{3.46}$$

where, $B_1 \equiv (\lambda + \alpha_{NX})(1 - \eta) > 0$, $B_2 \equiv (1 - \beta)\frac{\kappa}{\kappa-1}\Psi > 0$, and $\zeta_{Q,Z} = \frac{\partial Q}{\partial Z}\frac{Z}{Q} > \frac{1-\beta}{\beta-\eta}$ denotes the elasticity between Q and Z. The equilibrium derived efficiency Z^* is increasing in B_1 and therefore in λ and α_{NX} but is decreasing in B_2, which is increasing in $NE(\Theta)$ via $\Psi \equiv \Theta_{ii}(1)^{1-\kappa} - \Theta_{ji}(1)^{1-\kappa}$. Similarly, Z^* falls with $\bar{M}$ and $\zeta_{Q,Z}$.[37] □

Proof of Claim III.1

Proof. For technical easiness, instead of dealing with M, let's define $\bar{M} \equiv \frac{M}{\phi}$. Lobbying firms take $\bar{M}$ as given instead of M, and we replace M with $\bar{M}$ in the economic schedule.[38] Indeed, the political economy schedule $\mu^*(\bar{M})$ is still strictly decreasing in $\bar{M}$ (see Lemma III.6 and its proof above). Rewrite the political economy schedule as $\bar{M}^{PE}(\mu)$, which is strictly decreasing in μ. The economic schedule $\bar{M}^E(\mu)$ is strictly increasing in μ. This can easily be derived from equation (3.24) since Θ_{jj}, Q_j, and Θ_{ji} are decreasing in μ_i, whereas Θ_{ii}, Q_i, and Θ_{ji} are increasing. To complete the proof, we need to show that $\bar{M}^{PE}(\mu = 0) >$

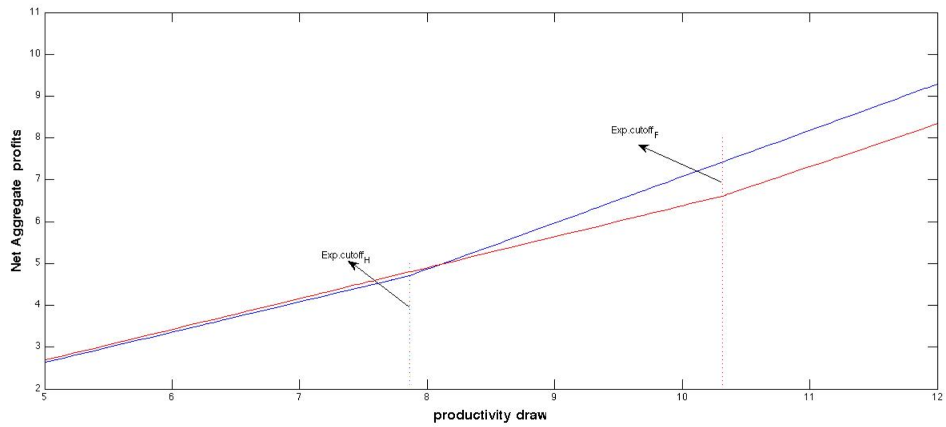
[37] $\zeta_{Q,Z} = \frac{1-\beta}{\beta-\eta}[1 + \vartheta(\tau)] > \frac{1-\beta}{\beta-\eta}$, and $\vartheta(\tau) \equiv \frac{Z^\kappa \tau^{\frac{-\kappa\beta}{1-\beta}} \left(\frac{f_x}{f}\right)^{1-\kappa}}{1 - Z^\kappa \tau^{\frac{-\kappa\beta}{1-\beta}} \left(\frac{f_x}{f}\right)^{1-\kappa}}$.

[38] This trick buys us tractability without altering our basic analysis, results, and proofs.

$\bar{M}^E(\mu = 0)$ and $\bar{M}^{PE}(\mu = 1) < \bar{M}^E(\mu = 1)$. Heuristically, let's assume that $\lim_{\mu \to 0} Z(\mu) = 0$,[39] then with some tedious algebra it is shown that $\lim_{\mu \to 0} \bar{M}^{PE}(\mu) \to \infty$. Moreover, $\lim_{\mu \to 0} \bar{M}^E(\mu) \to 0$. In fact, it goes to $-\infty$ but we always assume $M \geq 0$. Both schedules and $Z(\mu)$ are continuous in μ and for the purpose of our proof in β. Thus, there exists β such that $\lim_{\mu \to 0} Z(\mu) = \epsilon > 0$; hence, $\bar{M}$ is slightly greater than zero (i.e., incomplete condition is satisfied), and $\bar{M}^{PE}(\mu = 0) > \bar{M}^E(\mu = 0)$. To show that $\bar{M}^{PE}(\mu = 1) < \bar{M}^E(\mu = 1)$, without loss of generality, let's assume symmetric country ($\mu_i = \mu_j = 1$); then it can be shown that $\bar{M}^E = (1 - \beta)Q_i^\eta[f^E + \frac{\kappa}{\kappa-1}(f\Theta_{ii}^{1-\kappa} - \Theta_{ji}^{1-\kappa})]$ and $\bar{M}^{PE}$ is directly derived from the first-order condition equation (3.46). As τ approaches infinity, $\bar{M}$ goes to zero and is strictly less than $\bar{M}^E$. Again, both schedules are continuous in τ; therefore, there exists $\tau^{min} < \infty$ such that for every $\tau > \tau^{min}$, $\bar{M}^E > \bar{M}^{PE}$. Our numerical simulations show that a wide range of the models' parameters and trade costs satisfy the conditions under which the political equilibrium exists. In fact, once incomplete specialization conditions are satisfied, political equilibrium solutions always exist, including the corner solutions. Having $\bar{M}^{**}$ and $\mu^{**}(\bar{M}^{**})$ at hand, recovering M^{**} and μ^{**} is straightforward. Thus μ^{**} and M^{**} exist and are unique, since existence is a sufficient condition for uniqueness in the current framework. □

[39] This will be true if β is very close to one.

Figure 3.3: Net Aggregate Profits



The red line is for country F, while the blue line is for country H. The following Parameter values are used in this figure: $\mu_H = .8$, $\mu_F = .6$, $\tau = 1.3$, $\frac{f}{f_x} = 3$, $\kappa = 2.1$, $\beta = .75\,\eta = .5$, $f^E = .5$, and $\alpha = .9$.

Figure 3.4: A Nonexporter's Profits

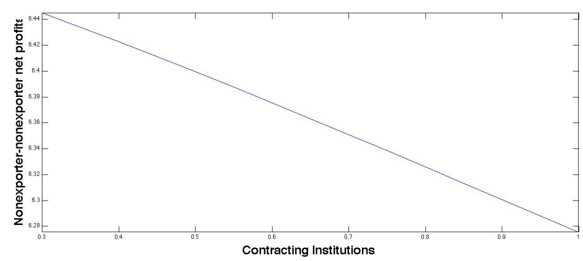


Figure 3.5: An exporter's profits

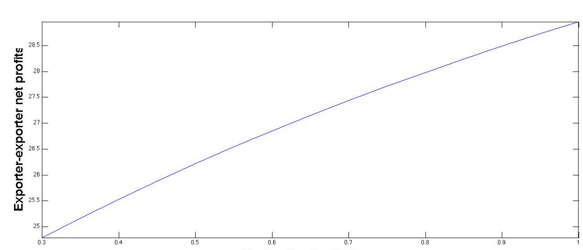
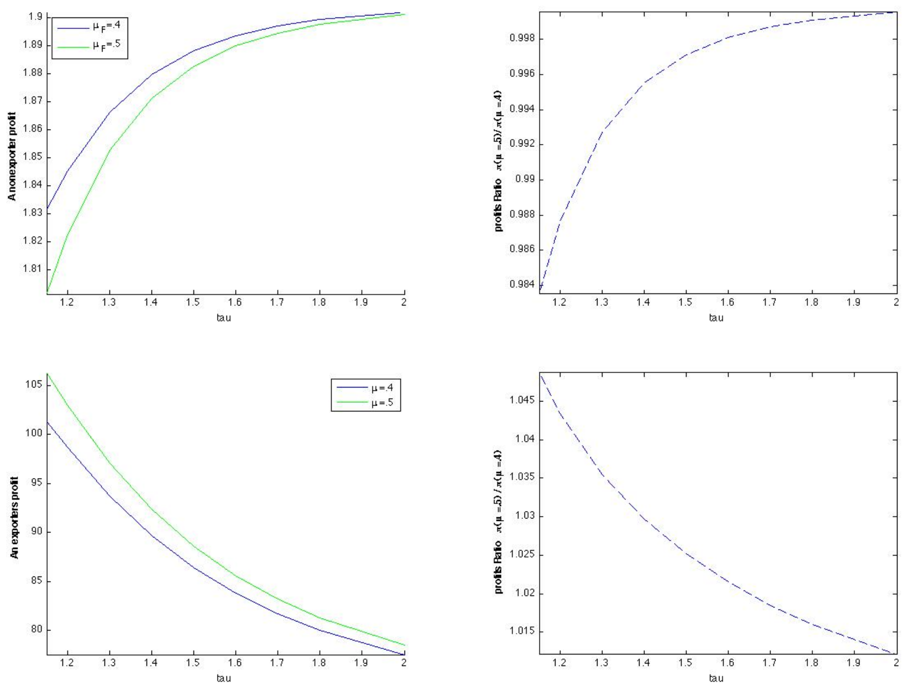


Figure 3.6: The Distributional Consequences of Inst. Reforms in the Global Economy



The figures are for country F. The institutional level of Country H is fixed at $\mu_H = .8$.

Figure 3.7: The Impact of Trade Partner Inst. on the Distributional Consequences of Domestic Inst. Reforms

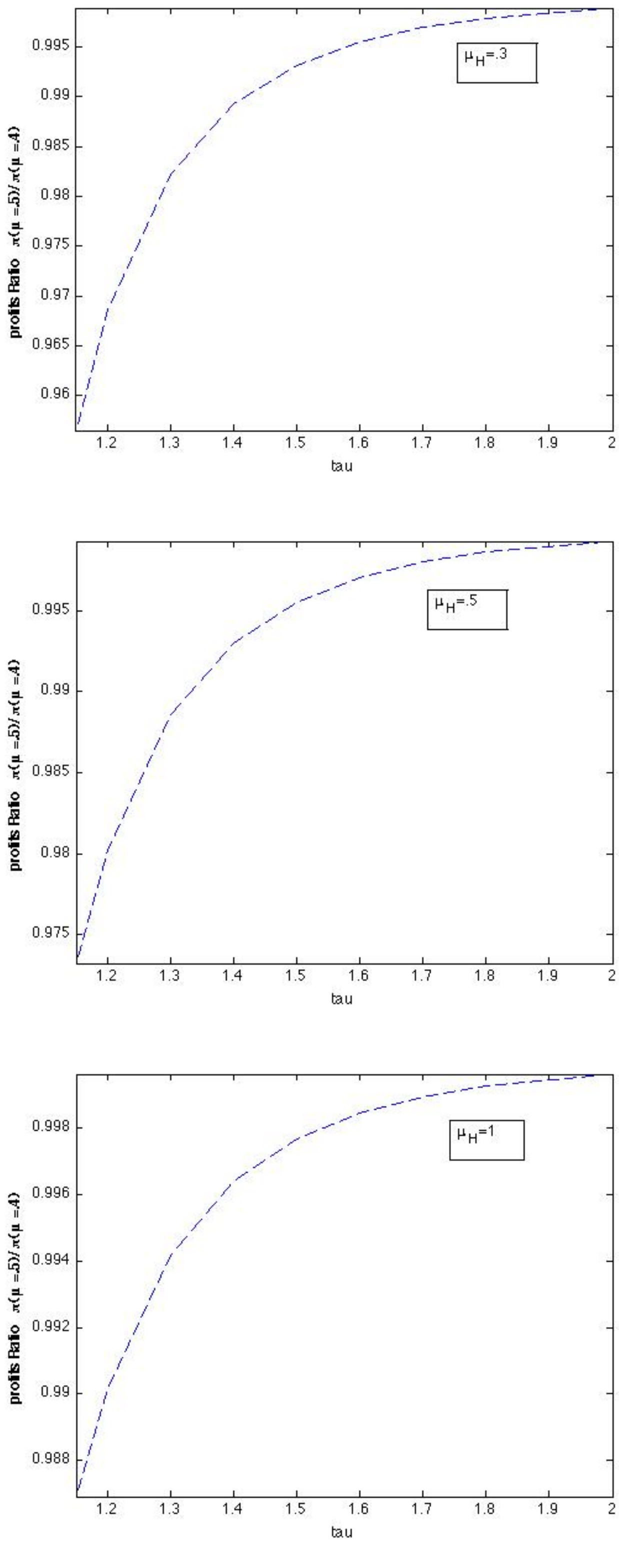
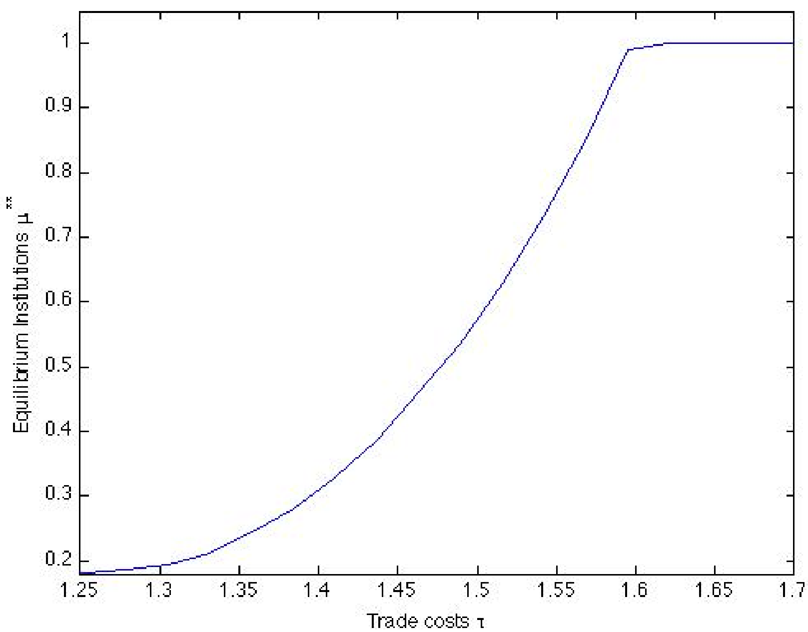
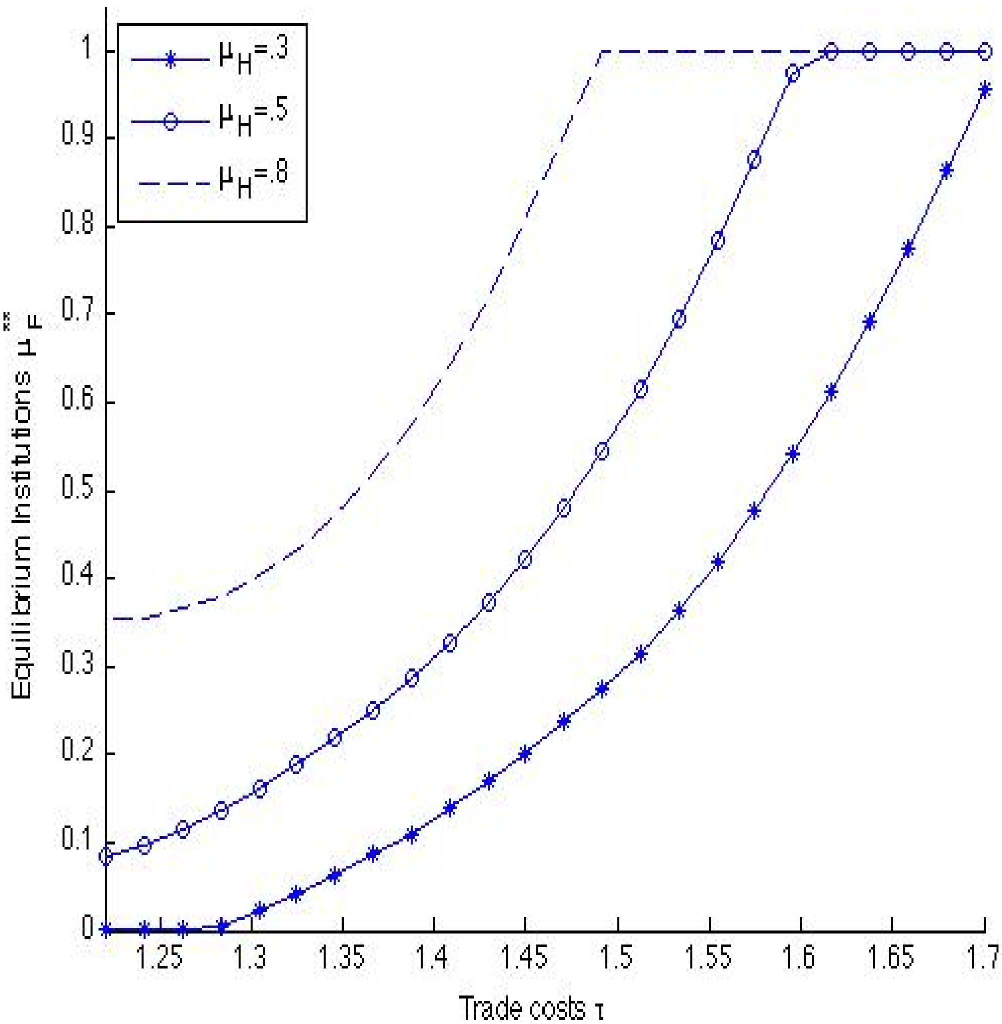


Figure 3.9: Equilibrium Institutional Quality



The figure shows the political economy equilibrium of contracting institutions μ^{**} as a function of τ. The parameter values used to generate this figure are $\beta = .75, \alpha = .9, \eta = .5, f_x/f = 2, f^E = .5, \kappa = 2.1, \mu_j = .5, \lambda = .025$, and $\alpha_{NX} = .01$.

Figure 3.10: Trade Partner's Impact on Political Equilibrium Domestic Institutions



The parameters values used to generate this figure are: $\beta = .75, \alpha = .9, \eta = .5, f_x/f = 2, f^E = .5, \kappa = 2.1, \lambda = .025$, and $\alpha_{NX} = .01$.

CHAPTER IV

Multinational Production and Intra-firm Trade

4.1 Introduction

The proximity-concentration tradeoff constitutes the basis of one of the most important theories of multinational production.[1] In a stark contrast with the prediction of the workhorse monopolistic competition model of trade and foreign direct investment, several new empirical papers document that total foreign affiliates' sales are subject to gravity-style forces akin to those observed for aggregate exports (Yeaple, 2009; Keller and Yeaple, 2013; Irarrazabal et al., 2013). That is, rather than overcome the transportation costs associated to exports,

[1]There are two main competing international trade theories that aim to explain the behavior of multinational corporations. The first of these theories is based on the so call *horizontal* multinational production, under which the primary motive for expanding operations overseas is to satisfy foreign final consumers. Under this theoretical approach the multinational firm faces a concentration-proximity tradeoff. On the one hand, firms that choose to produce at home market and sell internationally through exports, while taking advantage of the economies of scale of concentrating operations in one location face higher marginal cost of selling to foreign markets because of the associated transportation cost. On the other hand, the firm could take advantage of the proximity to foreign markets when it sets operations abroad and saves the transportation cost associated to exports (Brainard, 1997; Markusen, 2004). The second theory is based on the *vertical* multinational activity, under which the primary motive of setting operations abroad is to take advantage of price differences of factors of production across countries, to produce intermediate inputs at a lower cost. These inputs could be sell back to the parent company or to a third affiliate in another country to advance further stages of the production process (Helpman, 1984).

multinational sales also decrease with remoteness and other geographical variables.

A natural explanation for the observed patterns of bilateral foreign affiliate sales is the existence of trade in intermediate inputs across countries within the boundaries of the firmintra-firm trade. The usage of intermediate inputs produced by the parent introduces a source of complementarities between trade and multinational production, given that in order to produce overseas, foreign affiliates have to import intermediate inputs from their home market.

Intra-firm trade is an important component of U.S. international trade. In particular, exports of manufacturing goods from U.S. parents to their cross border network of affiliates account for 20 percent of U.S. exports; and intra-firm imports by foreign controlled U.S. affiliates from their foreign parent groups have generally accounted for 20-25 percent of total U.S. imports. Thus, to bridge the theory of horizontal multinational activity with the new empirical facts, new models have incorporated intra-firm transactions in the workhorse framework of trade and foreign direct investment (FDI) (Helpman et al., 2004. HMY, henceforth).

A striking feature of intra-firm trade is its pronounced heterogeneity across firms; not only at the aggregate level, but also at the sector-destination country level. In particular, using a detailed data from the Bureau of Economics Analysis, Ramondo et al. (2014) have documented that intra-firm trade is concentrated among a small number of large affiliates and it only represents a very small fraction of their input and their total sales. For example, in 2004, the median manufacturing affiliate received none of its inputs from their parent firm,[2] and sold 91 percent of its production to unrelated parties, mostly in the host country.[3]

[2]Of course, this does not rule out the possibility that an affiliate is importing intermediate inputs from another affiliate who is part of the international production chain. Unfortunately, such flows are not recorded in any of the available datasets. Nevertheless, the fact that the vast majority of affiliates sell their output to unrelated parties, alleviate part of these concerns. We discuss these issues in more details in a later section.

[3]Notice that the fraction of foreign affiliates that receive or not intermediate inputs from their parents, and sell the vast majority of their output to unrelated parties (in the local market or in a third market), are the observations that lie in this category of horizontal MP with vertical linkages. This observation could be potentially important, because if there is circular intra-firm trade, the parent could provide intermediate inputs to an affiliate that is part of an international production chain, not to satisfy final consumers but to produce intermediate inputs to continue the production process in other countries.

The observed selection to engage in intra-firm trade, the skewness of intra-firm flows towards large corporations and the bias of multinationals sales to local final consumers are robust to the country of destination or the industry of operations.

These findings pose new challenges to existing FDI-intrafirm models. Firstly, existent models take it for granted that all affiliates import from their parents and therefore are silent about the selection and the skewness observed in intra-firm flows. Secondly, if importing from parents is what derives the affiliate's sales to be declining in trade frictions, then FDI-gravity shall be present only for those firms in the upper tail of the firm's size distribution but not for the relatively small size firms.[4,5] Using Orbis dataset, we present evidence showing that the gravity of foreign sales could not solely be explained by intra-firm trade. In fact, we show that even firms that likely do not engage in intra-firm trade exhibit a significant resistance to geographical barriers. This is a finding that contrasts with the predictions of new FDI-intrafrirm models, where the only source of gravity for MP sales is the complementarity between trade and MP imposed by intra-firm flows. It has been well established in the literature that multinational sales, on average, follow the law of gravity that has very well characterized bilateral trade in the geographical space. Alternatively, we divide the sample of firms by its likelihood of engaging in intra-firm transaction. This is, we show that the standard gravity variables (i.e., distance, common border, common language, and regional trade agreements) play a significant role in diminishing the observed foreign affiliates sales, for the lower and the upper tails of the firm's size distribution. As expected, gravity forces diminish the sales of the very large affiliateswhich previews evidence found often involve in intra-firm trade. Surprisingly, the gravity frictions also negatively

[4]Of course, the fact that intra-firm trade is concentrated among the largest multinational corporationsgranularity of intra-firm tradecould be enough to generate FDI-gravity on the entire sample of multinational firms.

[5]The stylized facts about intra-firm trade and the gravity of multinational activity also impose important challenges to the theory of multinational production based on vertical integration. In contrast with horizontal intrafirm-FDI- models, where firms could engage or not in intra-firm flows from parents to affiliates, in models of vertical multinational production, intra-firm transactions are a necessary condition to the existence of foreign affiliates, whose main role is to provide cheaper intermediate inputs to their parents and to other affiliates within the corporation. Therefore, conditional on being a multinational, the vertical integration theory of multinational activity could not rationalize the observed absence of intra-firm flows among firms within a corporation that instead sell the majority of their output to unrelated parties in the host market.

and significantly affect the sales of the relatively small foreign affiliates, which often do not trade with their parents and sell the vast majority of their output to unrelated parties in the host market. This results are very similar when the sample of firms is divided below and above of the fifty percentile of the firm's size distribution and when only the firms below the twenty five percentile to represent small firms while those firms above the seventy five percentile to represent larger affiliates. The results of the impact of gravity on multinational activity are robust to different econometric specifications.

To capture the former stylized fact and to account for the extensive margin of intra-firm trade flows, this paper develops a novel multi-country model of heterogeneous firms, in which parent firms decide whether or not to supply foreign affiliates with intermediate inputsinstead of let them produce those in the host marketand if so, optimally decide the fraction of intermediate inputs that should be imported from the parent company. The proposed theoretical framework matches the distribution of multinational sales as well as the intra-firm trade patterns observed in the data: the less productive firms do not import at all from their parent, whereas the most productive ones engage in intra-firm trade. In the model, the selection is explained by the irreversible investment in which a multinational corporation has to incur in order to establish an adequate platform to carry cross borders transactions within the boundaries of the firm on regular bases. The high cost associated to these important coordination efforts is a fact well explored in the international management literature (Seuring and Goldbach, 2002).

This paper contributes to previous efforts to rationalize intra-firm trade patterns. Irarrazabal et al. (2013) propose a HMY model of horizontal multinational production with intra-firm trade from parents to affiliates. Their model assumes that the final good produced by affiliates is assembled in a Cobb Douglas fashion using local labor and intermediate inputs produced and shipped by the parent. As a consequence, all firms engage in intra-firm trade and the share of imported intermediate inputs from the parent in total cost is the same for all firms regardless of their productivity level. Similarly, Ramondo and Rodriguez-Clare (2013) develop a general equilibrium model of trade and multinational production under perfect competition in which foreign affiliates use an international input bundle in production, where a fraction is obtained in the local market and the rest comes from the parent firm. This paper differs from these approaches in that it endogenizes the existence as well as the degree in which intra-firm trade occurs.

Following Keller and Yeaple (2013), we assume that when a firm produces overseas, either requires to establish communication with the headquarters to receive the instructions to produce the intermediates inputs—direct knowledge transfer or alternatively, the multinational can transfer knowledge across borders by exporting intermediate inputs embodying the technology—indirect knowledge transfer. When the firm produces its intermediate inputs, it faces the costs of transfer knowledge across countries; but if instead, the firm buy the intermediates from its parent, it faces the associated transportation costs. Therefore, under this framework, multinational sales of more knowledge intensive firms will suffer more strongly from gravity, precisely because these companies face relatively high costs of direct knowledge transfer, reducing the elasticity of intra-firm trade to changes in transportation cost. Notice that in Keller and Yeaple (2013) model, although affiliates differ in their share of imported intermediate inputs from the parent, it assumes that all foreign affiliates buy at least some inputs from their headquarters. Nonetheless, in the data, only a small fraction of firms, often relatively large, buy from their parent while a vast majority of them report zero intra-firm flows.[6]

Our paper improves the previous theoretical framework in several dimensions in oder to reproduce several of the recent uncover stylized facts of intra-firm trade. First, knowledge intensity is more heterogeneous across firms within an industry than it is across industries. Based on this fact, we choose to model knowledge intensity as firm-specific rather than sector-specific. A more knowledge-intensive affiliate is so because it requires relatively more

[6]In the appendix of the paper, Keller and Yeaple sketch an extension of the original model in which firms have the option of paying a fixed cost of investing in information and communication technology in order to lower the efficiency cost of knowledge transfers by reducing the efficiency loss of remote production. An implication of this extension is that only the most productive firms produce a larger fraction of their intermediates in the host market, reducing their reliance in imported intermediate inputs, given that, only those affiliates are able to incur in the fixed cost. However, this prediction is contrary to the patterns observed in the data in which only the most productive firms engage in intra firm trade. Instead, our model proposes a very different type of fixed cost that is able to deliver the observed selection. In our model to engage in intra-firm trade, the corporation has to build a complex distribution network that allows frequent trade between related affiliates operating in different countries.

knowledge-intensive intermediate inputs than a less knowledge-intensive firm. Second, the knowledge intensity of production affects not only the composition or degree of in-house production versus imported intermediate inputs, but also the existence of intra-firm trade itself. That is, in the current model some firms could find it optimal not to engage in intra-firm trade because developing a distribution channel entails to incur in a fixed cost.[7] Third, the share of imported intermediate inputs increases with firm's productivity. Fourth, communication costs are higher, the higher the knowledge intensity of the intermediate inputs and the larger the distance between the parent and the affiliate firm.[8]

Notice that in this framework the usage of intermediate inputs has a meaning that differs from most trade models. In Keller and Yeaple (2013) as well as in the model developed in this paper, intermediate inputs are a channel of technology transfer between parent and affiliates to achieve the same productivity level. These intermediate inputs are firm-specific and we assume that they should be produced inside the boundaries of the firm. In this environment, the affiliate faces only two options: either it produces the intermediate inputs by itself, in which case it requires indirect transfer of technology in the form of communication to receive the necessary instruction from its parent firm; or it can import these intermediates from headquarters, saving the communication cost but facing the transportation cost of exporting.[9]

From an empirical perspective, it has been a challenge for the literature of multinational production and intra-firm trade to unveil its determinants. One of the reasons is the limited information in the available datasets in order to distinguish vertical and horizontal FDI. Given that there is no direct measures of the underlying motives of MP, researches have used

[7]It is possible to think that the need of the affiliate of receiving instructions from the parent firm decreases with time, as the affiliate moves along in the learning curve. Nonetheless the multinational firms develop innovation at a high rate and constantly those new techniques will be passed through the affiliates in the form of direct technology transfer.

[8]For example, communications tend to be more cumbersome when firms are located in different time zones, in countries with different languages, among others.

[9]In most models of trade and multinational production, subsidiaries adopt the same technology level as their foreign market by construction; instead in this model, the firm buys or produces intermediate inputs that allow it to reproduce the activity of the parent firm. Some of these models incorporate a measure of productivity losses, to capture difference in productivity between the headquarters and foreign affiliates and they often use "standard" inputs—not firm-specific—which can be outsourced from any market.

intra-firm transactions to obtain some information about the nature of multinational firms. Very often the existence of intra-firm trade has been interpreted as evidence for vertical MP and against horizontal MP.[10] This is because under vertical MP multinational firms decide to produce cheaper intermediate inputs abroad within the boundaries of the firm in order to internalize any product contractibility issue and potential spillovers of proprietary knowledge that could emerge from outsourcing. Under vertical MP, foreign production will always result in intra-firm flows because affiliates are meant to produce firm-specific intermediate inputs, which will be exported to the parent firmor to another affiliatebut not to satisfy the final foreign consumption. In fact, horizontal MP can rationalize intra-firm transactions from the parent to the affiliate when the last one imports knowledge embedded in the form of intermediate inputs. Nonetheless, the workhorse model of horizontal MP will not require intra-firm trade in order to absorb the productivity of the parent, but rather it assumes that the affiliate replicates the same organizational structure of the parent.

Therefore, the magnitude and direction of intra-firm flows could shed light to understand the relative importance of these two alternative theories, given that horizontal MP will be compatible with intra-firm transactions from the parent to the affiliate, while vertical MP will be compatible with transactions in both direction; although more strongly with trade of intermediates from the affiliates to the parent firms or to other affiliates within the corporation.[11] Even though we recognize the richness of intra-firm transactions, which

[10]For instance, Keane and Feinberg (2006) find that the reason of the dramatic growing in intra-firm trade flows among U.S. and Canada over the 1984-1995 period were due to the intensive, rather than the extensive margin. They attribute the low contribution of the extensive margin to the fact that the modest tariff reductions were not sufficient to justify fixed costs of overhauling international supply chains. This is, the extensive margin of intra-firm trade is often associated with the existence of MP. This is a very narrow interpretation given that in fact the majority of foreign affiliates establish operations abroad without establishing any kind of trade with the parent or any other affiliate.

[11]For the U.S. there are two main sources of information. One of them is the U.S. Census Bureau who administrates the information contained in the custom declaration that includes information on ownership ties between the foreign and domestic parties involved in any transactions. The other main source is U.S. Commerce Department's Bureau of Economics Analysis, which conducts extensive surveys to multinational firms that includes questions on the value of specific trade flows between foreign and domestic units of the firm. The Census data is comprehensive in the detail of the traded goods between U.S. parents and affiliates overseas and also between foreign parents and their affiliates operating in the U.S. It allows to identify not only the type of relationship between the parts involved in the international transaction, but also the nationality of the parts. Unfortunately, the Census data does not collect further information of the activity of the foreign

includes sales from affiliates to parents as well as from affiliates to affiliates, the model developed in this paper adopts a horizontal perspective of multinational activity. Intra-firm trade from the parent to their network of foreign affiliates is quantitatively important and it is also consistent with a model of horizontal multinational production and gravity on foreign affiliate sales.[12]

The reminder of the paper is organized as follows. Section 4.2 discusses the main source of data in our analysis and it also describes the main characteristics of multinational sales at the firm level. Section 4.3 presents the three main stylized fact that support our contribution to the literature, both in term of our model and the evidence presented. Section 4.4 lays out the theoretical framework and derives the analytical implications for intra-firm flows and multinational sales. Section 4.5 discuses the parametrization, the functional forms and the estimation strategy of some of the key model's parameters. Section 4.6 presents the general equilibrium and the gravity equation of affiliate sales for firms that do engage in intra-firm trade and those that do not. Section 4.7 concludes. Proofs and detailed derivations can be found in the Appendix.

4.2 Data

In this section, we explain in detail the source and characteristics of the dataset used in the analysis. The primary source of information is Orbis, which gathers firm-level information across a wide range of countries. In particular, it contains relevant information about the ownership structure of the firm, with a detailed list of direct and indirect subsidiaries and stockholders, the company's degree of independence, its ultimate owner and other

part of the transaction, which is relevant to characterize the behavior of multinational corporations. On the other hand, the BEA data offers in-depth information about affiliates operations, including total assets, sales, net income, employment, *R&D*. It also has information about the international transaction between and the affiliate and related and unrelated parties, with the parent company, with the host market, or with third markets. Unfortunately, affiliates do not report the related parties sales to third market disaggregated by countries. For this reason, even when it is possible to track the intra-firm transaction between parents and affiliates, it is not the case for the trade among foreign affiliate that are part of the same company.

[12] Zeile (2003) uses detailed data from the Census Bureau and find U.S. intra-firm exports mainly consist of shipments from U.S. parent companies to their foreign affiliates, and U.S. intra-firm imports mainly consist of shipments from foreign parent groups to U.S. affiliates.

companies in the same family.[13] Orbis does not have information about the transaction between parents and affiliates firms, as the Census Bureau data does, instead it offers more information about the foreign affiliates' operations, including financial statements as well as a comprehensive set of indicators of economic activity.[14]

For the purpose of this analysis we have constructed two samples. The first sample is comprised of U.S. affiliate firms operating outside the United States, but whose ultimate owners—or parents—are located in the United States. The second sample contains information of foreign affiliates firms operating in the U.S., but whose parents are located outside the U.S. Notice that in both samples we only account for those affiliates that have a global ultimate owner (GUO), this is a company who exercises the greater degree of control over the affiliate and that owns at least 50 percent of the shares; thus, a firm is considered foreign owned if it is majorityor wholly owned by a foreign multinational firm.[15] Regarding the sample, it is important to mention that only those firms for which operating revenue is known for at least one of the years in the sample period (2004-2013), are considered in the analysis.

The analysis focuses on manufacturing industries. It covers more than 9 thousand U.S. own affiliates operating in 35 developed countries, and it also covers the foreign own affiliates operating in the U.S. from these 35 countries. Four categories of information are used for each firm: (a) industry information including the 4-digit NACE code of the primary industry in which the establishments operate, (b) location information; (c) non-consolidated

[13] Alfaro and Chen (2012) have assess the extent and coverage of this data set using more aggregated information for alternative sources. Because we concentrate here on affiliates owned by U.S. parent firms, as well as U.S. affiliates owned by foreign parents, we have used the aggregate values in the BEA data to evaluate the accuracy of the information provided by Orbis.

[14] The best characterization of the intra-firm trade can be obtained from the Census Bureau, but it lacks of information about the activity of the affiliates, including the type and destination of its exports, which is contained in the BEA data.

[15] We also consider a company to be an ultimate owner (UO) if it has no identified shareholders or if its shareholder's percentages are not know. It is worthwhile to mention that we consider only Global, rather than Domestic ultimate owners. The Domestic UO is the highest company in the path between a foreign affiliate and its Global UO but that is located in the same country as the affiliate firm. Thus, an affiliate will be considered domestic, rather than foreign, when the GUO and the DUO are both in the same country. The definition of Global Ultimate Owner, with a minimum of fifty percent ownership adopted in this paper, is also the one followed by international agencies and by the U.S. Bureau of Economic Analysis.

financial information including operating revenue, employment, assets, investment, wages, material cost, among others; and (d) degree of ownership and detailed information about the global ultimate owner, including a compressive set of financial information of the parents firms which includes the industry of operation, revenue, employment, assets, research and development expenditures, and number of patents among others.

In order to construct a useful sample, the data was subjected to an extensive cleaning up process in which we eliminate firms whose operating revenue is below one million dollar and with less than 15 employees. Furthermore, to alleviate the problem from potential outliers, we eliminate firms below the 0.1th percentile and above the 99.9th percentile in the distribution of sales. The final sample comprises 8,572 foreign affiliates and 2,210 parents, covering 261 manufacturing industries for the period 2004-2013.

4.3 Stylized Facts

In this section we introduce some key regularities about the foreign sales and the location patterns of U.S. multinational firms. First, we show that the knowledge intensity of the U.S. parent firms is very heterogeneous across firms, even within very narrow defined sectors. Second, we show some evidence of the granularity of multinational activity from the parent as well as from the affiliate perspective. Multinationals are a relatively rare type of firms. Despite of the disproportionately contribution of U.S. multinationals to total output and trade, they represent less than 1 percent of all U.S. companies. Moreover, the vast majority of U.S. parents only operate in one foreign market regardless of the manufactured industry; and also for any given market-sector pair the market share of U.S. foreign production is concentrated in a very small set of affiliates. Third, we present some initial empirical evidence that intra-firm trade alone is not enough to reconcile the underlying incentives in *horizontal* FDI models and the observed strong dampening effect of distance on MP. Overall, this section gives the grounds of our motivation and provides support for the building blocks of the model proposed in section 4.

Fact 1: *Research and Development intensity is highly heterogeneous across multinational firms within a narrow defined industry.* The average research intensity varies significantly across parent firms, even in considerable narrow defined industries. Borga and Zeile (2004) find that foreign manufacturing affiliates have a greater propensity to source intermediate goods from their U.S. parents is increasing in their parent R&D and capital intensity. This suggest that the propensity of affiliates to source intermediate inputs from their parents is related to the level of intangible assets embodied in the inputs traded within the firm.

Figure 4.4 shows the density of the parent's share of R&D expenditure for the pool of U.S. parents in the sample regardless of the industry classification. As can be observed the expenditure in research and development is remarkably higher among the most productive U.S. parent firms. In fact, more than eighty percent of the R&D expenditures in a given industry is in hands of few but very large firms. Figure 4.5 shows the density of parent's R&D expenditure share for four selected three-digit level NACE sector classification: (1) manufacturing of parts and accessories for motor vehicles—NACE 293 (top-left panel), (2) manufacture of other special-purpose machinery—NACE 289 (top-right panel), (3) manufacture of basic pharmaceutical products—NACE 211 (bottom-left panel), and (4) manufacture of air and spacecraft and related machinery—NACE 303 (bottom-right panel). The share of R&D is calculated as the fraction of the research and development expenditures of the firm relative to the total R&D expenditures of all U.S. parents firms operating in the same three digit sectoral classification. It is clear, that the concentration of R&D expenditures in few large parents is not being driven by sector- specific characteristics. The results are qualitatively similar even when considering only those the firms belonging to a given sector.

However, only one third of the U.S. ultimate owner with at least one foreign affiliate in the sample (U.S. parent firms) have information about R&D expenditures. In order to address how previous results can be affected for the lack of more complete information on R&D expenditures, Figure 4.6 shows the density of the productivity for two groups of parent firms: those for which Orbis data contains information regarding the expenditures in research and development activities; and those parent firms that contain missing values for the R&D variable. The productivity density is shown for both groups in the same industries used in the analysis above. Firm's productivity is measured by the output per worker of the U.S. parent. Figure 4.6 highlights that those firms for which Orbis does not record information about R&D expenditures are on average less productive than firms for which it does. Therefore, we conclude from this evidence that even when multinationals are responsible for the majority of the private R&D activities, the largest share of the R&D expenditures in any given industry is being mainly carried on by few but very productive U.S. parent firms.

Fact 2: *The distribution of foreign affiliate sales is fat tailed, for each country and sector pair.*

A well documented fact is that firm sales follow a Zipf Law distribution (Gabaix, 2009 and di Giovanni and Levchenko, 2012). In addition, Ramondo et al. (2014) show that intra-firm trade is concentrated among a small number of large affiliates. In particular, firms below the mean of the size distribution do not trade with their parent firms at all. In this section, we show that the distribution of sales of U.S. foreign affiliates—as well as the sales of foreign affiliates in U.S.— is very fat tailed. Not just at overall, within an industry, or within a country; but also for a given country-sector pair.

Figure 4.2 shows the distribution of the market share of each affiliate in each country-sector pair. As can be observe, most of firms represent a very small share in each market, and only a small fraction firms have remarkable large market share. Figure 4.3 evaluates the participation of U.S. parents on foreign markets. Each parent produces on average in two foreign economies, but fifty percent of the parents only produce in one market besides United States. Strikingly, the mean coincide with the number of markets penetrated by a firm in the 75 percentile of the distribution. Ten percent of the parent firms produce in more than four markets and only five percent of all firms set operations in seven or more foreign countries.

Fact 3: *Intra-firm trade alone cannot explain the observed gravity of multinational sales*

Intra-firm trade from the parent to the cross border network of foreign affiliates has been the approach used in the literature to rationalize the gravity of multinational production; meaning that aggregate foreign affiliate sales fall with geographical barriers. Nevertheless, only the most productive foreign affiliates buy intermediate inputs from their parent firms in the U.S.; a fact that is robust across countries and also across industries (Ramondo et al., 2014). From the perspective of the existing models, this implies that only sales of foreign affiliates located at the upper-tail of the size distribution should suffer from gravity. Conversely, in this subsection we present some evidence showing that the gravity of foreign sales could not solely be explained by intra-firm trade. In fact, we show that even firms that likely do not engage in intra-firm trade exhibit a significant resistance to geographical barriers. Because most models of horizontal multinational production that feature intra-firm trade fail to account for the observed selection of intra-firm trade—assuming that all firms will require some fraction of the intermediate inputs from the parents— in section 4.4 we propose a model to account for the intensive and the extensive margin of intra-firm trade.

Ideally, we would like to test the existence of gravity for two groups of firms: those that participate in intra-firm trade transactions and those that do not. Unfortunately, for this paper we do not have access to intra-firm trade data at the firm level.[16] Instead, we proceed to divide the U.S. affiliate firms by their size in two groups for any given host country-sector pair. First, we split the whole sample of firms in two subsamples by the 50th percentile of the affiliates' size distribution. This criteria is based on Ramondo et al. (2014) that found that none of the affiliates below the median import intermediate inputs from their parent firms.[17,18] Second, we divide the sample of firms by those that belong

[16]In oder to overcome this limitation in the near future, we will merge Orbis firm level data with the Census Bureau data, to get a perspective of the transaction between U.S. multinationals and their foreign affiliates as well as of the economic activity of these affiliates overseas.

[17]Our criteria differs from Ramondo et al. (2014) in that they show that their finding is established for the median firm in a given industry and for the median firm in a given region. Instead, we split the sample based on the median firm in each country-sector pair.

[18]As discussed in the introduction of this paper, the fact that firms are not receiving intermediate inputs from the parent firm, does not mean they are not engage in intra-firm trade with other affiliates within the same corporation. Ramondo et al. (2014) find that regardless of its size, the majority of

to the lower-tail (below 25th percentile) and the upper-tail (above 75th percentile) of the firm size distribution, in each country-sector pair. Taking only the extremes of the firm size distribution reduces the likelihood that the so called small firms could engage in intra-firm trade, and increases the likelihood that the very large firms do.

Below we present the results of the gravity equation that comes from different specifications and samples. Table 4.1 presents the results of the regression for the intensive and extensive margin of multinational activity (column 1 and 2) as well as for the extensive margin only (column 3 and 4). It includes all U.S. multinational firms in our sample, and the data has been aggregated up to the country-sector level. As a proxy of geographical barriers we have included the log of physical distance ($ln\,(dist_{i,ua})$), a set of dummy variables indicating whether countries share a common border ($Border_{i,us}$), common language ($Language_{i,us}$), belong to a given regional trade agreement ($RTA_{i,us}$) and whether they had a colony relationship ($Colony_{i,us}$). In column 1 and 3 we also control for some key characteristics of the host country that could determine the scale of foreign operations and so directly affect the volume of local sales as well as the intra-firm trade. These controls include the capital endowment relative to the U.S., a measure of the size of the market (GDP per capita) as well as a proxy of institutional quality measured by the Rule of Law variable from the Worldwide Governance Indicators database of the World Bank. In order to account for other country characteristics that are potential determinants of FDI and that are not included in our regression, such as relative technology differences and skill endowments among others, in column 2 and 3, we include instead country fixed effects to control for any country specific characteristic that could affect the gravity of multinational production. Notice that in both specifications sector fixed effects are included to control for the great observed heterogeneity of MP at the sectoral level that can affect the impact of gravity variables on MP sales as well as on the number of firms that produce overseas.

Consistent with previous studies, both the total affiliates sales and the number of U.S. parents are decreasing with trade barriers, and in particular, they are declining in distance

firms sell their output to unaffiliated parties in the host country, which although indirectly, could partially alleviate concerns about trade among foreign affiliates. Unfortunately, intra-firm imports from other than the U.S. parents is not captured by the available data sources.

from the United Sates in both specifications. Having a common language positively affect both margins as well; nevertheless, it loses statistically significance once we control for country fixed effect. The existence of a trade agreement between the United States and the host economy significantly increases the affiliates' sales but negatively affects the number of firms that engage in foreign production. A potential explanation is that trade agreements increase the sales of the U.S. firms in the foreign market by facilitating intra-firm transactions with the parent firm, but reduce the number of firms that find it profitable to engage in MP given that exporting gets more attractive. Of the hots-country specific variables, the size of the host country market (GDP) and the level of capital were significant and of the expected sign. On the other hand, foreign affiliate sales fall in host country institutional quality.[19]

To further explore whether the negative effect of geographical barriers on MP for the whole sample are not only driven by those firms who engage in intra-firm trade, Table 4.2 and Table 4.3 present the results of gravity on number of firms and MP sales, respectively, but this time dividing the sample on firms below and above the median of the firm size distribution in each country-sector pair. Column 1 and 2 show that, for both groups, the number of firms and the MP sales decrease with distance, showing a negative and statistically significant coefficient for firms below and above the median. Notice that the coefficient of the distance variable in Table 4.3 are very similar when country fixed effects are included. But, in order to evaluate the aggregate effect of the variables associated with gravity, we compute the bilateral MP costs based on the estimated coefficients to evaluate the distribution of MP cost for both groups.[20]. Figure 4.7 shows the density of MP costs for both groups. As can be observed the mean of both groups is similar but the variance of

[19]At a first glance, this seems a very surprisingly result but it is possible that it is driven by the fact that U.S. has less room to exploit its institutional comparative advantage in countries with high law enforcement level. In the light of the theory of the boundaries of the firm, this finding could go with both of the leading theories in this vein: transaction costs theory and property rights theory. According to transaction costs theory, better institutional setting reduces the need for vertical integration-reducing the number of majority own affiliates. Incorporating this finding with the property rights theory is more subtle: if contractibility is a more of issue on the investments carried by the headquarter, then the result is consistent with the property rights theory; as institutions advance, the need to provide more incentives to headquarter declines, leading to less vertical integration.

[20]We calculate the following equation based on the gravity estimated coefficients for each country-

MP cost is considerable higher for smaller firms, showing that some country-sector pairs of this group are strongly affected by MP costs.

Given that we are relying on the size of the firm as a proxy of its participation in intra-firm trade, we reproduce the above exercise but this time we only consider firms under the 25th percentile, which most likely do not to engage in intra-firm trade, as well as firms above the 75th percentile of the distribution, which most likely conduct intra-firm transactions.[21] Table 4.2 reproduces the gravity regression for the group of firms in the tails of the firms size distribution. Consistent with previous results for both groups of firms, foreign sales and number of firms are significantly lower in countries far from the U.S.

So far, the evidence shows that regardless of their size—and therefore on whether or not firms do intra-firm trade—multinational sales are significant affected by gravity forces, either measured by distance only or distance plus other gravity variables. Therefore the collected evidence shows that the data rejects a model in which the only source of MP gravity comes from intra-firm trade. The model presented in the next section attempts to address two important aspects of the data. Fist, the observed selection in intra-firm trade: only very few and large firms conduct intra-firm transaction across border within the firm. Second, it proposes another source of gravity to capture the fact that also multinational firms that do not trade with the affiliates are significantly affected by the gravity forces.

4.4 The Model

Our model is based on Helpman et al. (2004). Firms are heterogeneous in term of their productivities. Goods are horizontally differentiated with each variety produced by a firm that acts as a monopolist. A firm can enter the foreign market via exporting or by opening a foreign affiliate in the destination market (FDI). As is well known, in choosing between either

sector pair:

$$\widehat{\tau}^{mp}_{i,us} = \widehat{\beta}_d \times lndist_{i,us} + \widehat{\beta}_b \times border_{i,us} + \widehat{\beta}_{language} \times lan_{i,us} + \widehat{\beta}_{RTA} \times RTA_{i,us} + \widehat{\beta}_c \times colony_{i,us}$$

[21]The fact that the firm size follows a Zipf law distribution, and also that the distribution of foreign sales is very fat tailed, could induce that some firms above the median are not large enough to trade within the firm.

mode of entry, a firm faces a proximity-concentration trade off: establishing a foreign affiliate is associated with lower variable trade costs but higher fixed cost of conducting multinational production. The model predicts a definitive firms' hierarchy: least productive firms do not produce, low productive firms only sell to the domestic market, medium productive firms export, and most productive firm turn into multinational corporations. Furthermore, as in Irarrazabal et al. (2013) and Keller and Yeaple (2013), we introduce parent-to-affiliate intra-firm trade to generate FDI-gravity akin to the standard trade-gravity.

The model contributes to the literature in many ways. First, in order to be consistent with the stylized facts (i.e., intra-firm trade is concentrated among the very most productive multinational corporations, with the majority of FDI firms report zero intra-firm), we introduce fixed cost of intra-firm trade. Second, in contrast to Irarrazabal et al. (2013), the share of imported intermediate inputs to the total intermediate inputs costs is not constant and varies with firm's size. Unlike Keller and Yeaple (2013) and consistent with the empirical fact that the share of intermediate inputs to total input costs is also increasing with firm size, we tie firm's productivity to firm's knowledge intensity (R&D) to associate intra-firm with firm's size. Finally, we show that FDI-gravity style forces are presented in the model even for the foreign affiliates that do not import from their parents.

4.4.1 Consumer Demand

The world economy consists of N countries (indexed by i, n). Each country is populated by L_n utility-maximizer consumers, with each consumer inelastically supplying one unit of labor (the only factor of production). A representative consumer in country n derives her utility from the consumption of a homogenous good Q_0 and a continuum of differentiated goods that belong to the differentiated sector Q_n. Consumer's preferences between the homogenous good and the differentiated goods sector are represented by the Cobb-Douglas utility function with an income fraction μ spent on the differentiated goods

$$U_n = Q_0^{1-\mu} Q_n^{\mu}, \quad \mu \in (0, 1) \tag{4.1}$$

Preferences over the differentiated goods are CES with elasticity of substitution $\sigma > 1$. The consumption of each variety ω in the set of all available varieties in country n, Ω_n (endogenously determined); $q^d(\omega)$, enters the CES aggregation symmetrically

$$Q_n = \left[\int_{\omega \in \Omega_n} q^d(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}}. \tag{4.2}$$

As is well know, the demand for each variety in country n is given by: $q^d(\omega) = A_n p_n(\omega)^{-\sigma}$. Here, $p_n(\omega)$ denotes the price of variety ω in country n. The index of market size in country n, A_n is exogenous from the point of view of consumers and individual producers.[22]

4.4.2 Production and Market Structure

The market for the homogenous good is perfectly competitive, and the production technology of the homogenous product is linear in labor: w_n units of labor are required to produce one unit of the homogenous good in country n. The homogenous good is freely traded in the world economy. So long as $1 - \mu$, L_n, and the variable trade costs are large enough, the production of the homogenous good Q_0 in country $n \in \{1, 2, \ldots N\}$ is strictly positive. The price of the homogenous good is normalized to one; in effect, the wage in country n is pinned down by the numeraire and is equal to w_n.[23]

Each country n is endowed with exogenously given potential number of firms (producers) J_n. Each firm produces a unique variety using a variety-specific composite intermediate input. Productivity $\varphi \in R_{++}$ is a firm-specific that is drawn from a known cumulative distribution $G(\varphi)$ with probability density distribution $g(\varphi)$. Since φ is firm-specific, and each firm produces a unique variety we index goods with φ instead of ω. A firm with productivity draw φ requires $\frac{1}{\varphi}$ units of the firm-specific composite intermediate input M_φ to produce one unit of variety $\omega(\varphi)$. The composite intermediate input is produced under a CES aggregation of a continuum of intermediate inputs with elasticity of substitution

[22] $A_n \equiv \mu \frac{X_n}{P_n^{1-\sigma}}$. The aggregate price level of the differentiated goods sector in country n is denoted by P_n, and X_n represents the total expenditures in country n.

[23] The incomplete specialization assumption has been used by many researches for tractability and simplification purposes (for example, see Chaney, 2008). Proceeding without the outside sector will not alter the results presented in the paper, however.

$\eta \geq 1$:[24]

$$M_{\varphi} = \left(\int_0^{\infty} \beta(z|\varphi)^{\frac{1}{\eta}} m(z)^{\frac{\eta-1}{\eta}} dz \right)^{\frac{\eta}{\eta-1}}. \tag{4.3}$$

A couple of notes warrant attention here: (i) $m(z)$ is the quantity of an intermediate input of knowledge intensity z, with higher z indicating higher knowledge intensity, (ii) $\beta(z|\varphi)$ is the cost share of intermediate input z to the total cost of intermediate input bundle specific to φ-firm, and $\int_0^{\infty} \beta(z|\varphi)dz = 1$ for any φ, (iii) $\beta(z|\varphi)$ is log-supermodular in z and φ. That is, while all firms employ the same CES aggregation and use the same continuum of intermediate inputs, the share of each intermediate input z to the total cost of intermediate composite is firm specific. To be precise, $\beta(z|\varphi)$ is log-supermodular in z and φ if for $z' > z''$ and $\varphi^1 > \varphi^2$, $\beta(z'|\varphi^1)\beta(z''|\varphi^2) > \beta(z'|\varphi^2)\beta(z''|\varphi^1)$. In words, firm φ^1 is more knowledge-intensive because it requires relatively more knowledge-intensive intermediate inputs relative the low productivity firm φ^2,[25], and (iv) production technology of producing intermediate inputs is common across all firms: one unit of labor is needed to produce one unit of z.

4.4.3 Mode of Entry

A domestic firm gains access to the domestic market in country n after incurring a fixed cost of production f_{nn} units of labor. Country $i \neq n$ exporters to country n are subject to both fixed export cost f_{ni}[26] units of country i labor, and iceberg-type variable trade costs, $\tau_{ni} - 1 > 0$. Country i firms can also serve country n via FDI: pay a fixed cost of FDI, f_{ni}^{fdi} units of country i labor, and start serving n via its affiliates there. In so doing, a firm avoids the transportation costs associated with shipping the final good, but conveys an additional fixed cost of opening an affiliate in country n. Conditional on establishing a foreign affiliate in country n, a parent firm in country i has an option to let its affiliate to produce all

[24]It can be shown that the limit of the CES aggregation as η approaches one is a Cobb-Douglas.

[25]The intermediate composite aggregation and the notion of log-supermodularity were outsourced from Keller and Yeaple (2013). In contrast to Keller and Yeaple (2013), knowledge-intensity is defined on the firm level, not the industry level; a propriety that enables us to generate firm-level prediction regarding intra-firm trade. For a formal treatment of the log-supermodular assumption and its usage in the international trade context, see Costinot (2009).

[26]First subscript refers to the destination market and the second one to the origin country.

intermediate inputs composite M (standard HMY setting), or chooses to ship intermediate inputs to its affiliate (intra-firm trade) where the fraction of inputs offshored and the volume of the intrafirm trade are endogenous. If a parent in country i decides to engage in zero intra-firm trade with its affiliate (i.e., let the affiliate produce all the intermediate inputs and the final good), and since M_φ is firm-specific, the affiliate is not as efficient as its parent; consequently, an affiliate needs $t_{ni}(z) > 1$ units of labor to produce one unit of intermediate input z.[27] In the case of intra-firm trade, a parent firm incurs a fixed cost of initiating an intrafrim trade, f_{ni}^{int} units of country i labor; the shipped intermediate inputs are subject to the standard iceberg-type trade costs τ_{ni}, while the intermediate inputs produced by an affiliate are subject to productivity loss that is intermediate input specific $t_{ni}(z) \geq 1$ (we call it $t(z)$ for notational simplicity).[28]

4.4.3.1 Intra-firm Trade and Knowledge Transfer

The production of intermediate input with knowledge intensity z is firm-knowledge-specific. Moving knowledge over geographic space is costly. Transferring the knowledge required to produce intermediate input z to an affiliate entails, for example, communication cost, mis-implementation and mis-interpretation. Differently put, knowledge is not perfectly codified and therefore any knowledge transfer between a parent and its affiliate is subject to errors. Intuitively, the higher the knowledge intensity of the intermediate input z, the higher are the cost of transferring knowledge from a parent to the affiliate. Knowledge transfer takes two forms (i) *disembodied knowledge transfer*: parent firms directly transfer the necessary knowledge of producing input z to their affiliates who use the transmitted knowledge to produce that particular intermediate input. If this is the case, as mentioned above, the knowledge transfer costs are denoted by $t(z)$. To capture the idea that the cost of moving knowledge over space is increasing with knowledge intensity z, we assume that

[27]A very crucial assumption to our model is that $t_{ni}(\varphi)$ is a function of trade frictions τ_{ni}. Nevertheless, the impact of the distance between the two countries, language, time zone and borders on trade frictions τ_{ni} is stronger in the case of physical shipping compared with its effect on the cost of knowledge transfer. Formally, $0 < \frac{\partial t_{ni}}{\partial \tau} < 1$. We elaborate more in this point and the former one below.

[28]Again, trade costs rise faster with distance and other trade frictions than does $t_{ni}(z)$.

$t(0) = 0$, $\lim_{z\to\infty} t(z) > \tau_{ni}$ and $t'(z) > 0$,[29], and (ii) *embodied knowledge transfer*: simply, a parent produces intermediate input z and ships it to the affiliate in country n.

Finally, the production technology of the final good is invariant to the location of the producer (parent vs affiliate): regardless who produces the final good (parent or affiliate), $\frac{1}{\varphi}$ units of M_φ are needed to produce one unit of the final good. The decisions whether to export, to open an affiliate, and to outsource intermediate inputs production impact the production of final good only through its impact on the production of the composite of intermediate input M_φ.

4.4.4 Partial Equilibrium

First, we characterize the geography of input sourcing. The decision whether to outsource the production of intermediate input z is simply pinned down by comparing the cost of embodied knowledge transfer $w_i\tau_{ni}$ and disembodied knowledge transfer $w_n t(z)$. The cost of obtaining input z of a foreign affiliate is $c(z) = \min\{w_n t(z),\, w_i\tau_{ni}\}$. Given our assumption on the function $t(z)$, there exists an intermediate input with knowledge intensity $\tilde{z}$ such that : for any $z < \tilde{z}$, $t(z) < \varpi\tau_{ni}$, and for $z > \tilde{z}$, $t(z) > \varpi\tau_{ni}$. Then, we define $\tilde{z}(\tau_{ni}\varpi) = t^{-1}(\tau_{ni}, \varpi)$, where $\varpi \equiv \frac{w_i}{w_n}$. Conditional on serving market n by FDI, we characterize the cost of the composite intermediate input to an affiliate with productivity draw φ,[30]

$$C^M_{ni}(\tau_{ni}, \mathcal{I}(\varphi), \varphi, \varpi) =$$

$$\begin{cases} w_n\bar{t} & \text{if} \quad \mathcal{I}(\varphi) = 0, \\ \left(\int_0^{\tilde{z}(\tau_{ni},\varpi)} \beta(z|\varphi)(t(z)w_n)^{1-\eta}dz + (\tau_{ni}w_i)^{1-\eta}\int_{\tilde{z}(\tau_{ni},\varpi)}^{\infty} \beta(z|\varphi)dz\right)^{\frac{1}{1-\eta}} & \text{if} \quad \mathcal{I}(\varphi) = 1. \end{cases}$$

The indicator function $\mathcal{I}(\varphi)$ equals one if an affiliate outsources some of the intermediate inputs from its parent and zero otherwise. As we show below, the indicator function depends

[29] Notice that the cost of knowledge transfer is not firm-specific; however, the aggregate cost of disembodied knowledge transfer for a given fraction of the intermediate inputs varies across firms because of the log-supermodulity assumption.

[30] $\bar{t} \equiv \int_0^\infty \beta(z|\varphi)t(z)^{1-\eta}dz$.

on firm's productivity draw φ. Indeed, $C^M_{ni}(\tau_{ni}, \mathcal{I}(\varphi) = 1, \varphi) < C^M_{ni}(\tau_{ni}, \mathcal{I}(\varphi) = 0, \varphi)$.[31] The elasticity of $C^M_{ni}(\tau_{ni}, \mathcal{I}(\varphi) = 1, \varphi, \varpi)$ with respect to trade costs τ_{ni}, $\varepsilon^{MC}(\tau_{ni}, \varphi, \varpi)$ is given by

$$\varepsilon^{MC}(\tau_{ni}, \varphi, \varpi) = \frac{(w_i\tau_{ni})^{1-\eta}\int_{\tilde{z}(\tau_{ni},\varpi)}^{\infty}\beta(z|\varphi)dz}{\int_0^{\tilde{z}(\tau_{ni},\varpi)}\beta(z|\varphi)(t(z)w_n)^{1-\eta}dz + (\tau_{ni}w_i)^{1-\eta}\int_{\tilde{z}(\tau_{ni},\varpi)}^{\infty}\beta(z|\varphi)dz}. \quad (4.4)$$

In order to show that within all firms that decide to enter country n by establishing a foreign affiliate, only a subset of those firms (the most productive) choose to ship intermediate inputs to its affiliates, we introduce the following lemmas,

Lemma IV.1. *The elasticity of marginal cost of composite intermediate input with respect to trade costs τ_{ni} is increasing in firm's productivity φ. For $\varphi^1 > \varphi^2$, $\varepsilon^{MC}(\tau_{ni}, \varpi, \varphi^1) > \varepsilon^{MC}(\tau_{ni}, \varpi, \varphi^2) > 0$.*

Lemma IV.2. *let $\theta(\tau_{ni}, \varphi, \varpi)$ be the share of imported inputs $M(\tau_{ni}, \varphi, \varpi)$ in total composite intermediate input costs $TC(\tau_{ni}, \varphi, \varpi)$. Then, $\theta(\tau_{ni}, \varphi, \varpi) = \frac{M(\tau_{ni},\varphi,\varpi)}{T(\tau_{ni},\varphi,\varpi)} = \varepsilon^{MC}(\tau_{ni}, \varphi, \varpi)$ is (i) increasing in φ, (ii) the import cost share is declining in trade costs for all firms, and (iii) the rate of decline in the import cost share is slower in the more knowledge intensive firms.*

Despite the fact that all firms choose to import the same range of intermediate inputs (notice that $t(z)$ and τ_{ni} are not firm-specific), the share of the imported intermediate inputs to the total composite intermediate input costs varies across firms in a way consistent with the log-supermodularity assumption. Accordingly, all the variations in the share of the imported intermediate inputs to the total costs are on the intensive margin not the extensive

[31] The results emanates from firm's optimization and the definition of $\tilde{z}(\tau, \varpi)$. In fact, on might even argue that $\bar{t} \leq \left(\int_0^\infty \beta(z|\varphi)(w_n t(z))^{1-\eta}dz\right)^{\frac{1}{1-\eta}}$, since an affiliate that was assigned to produce all the intermediate inputs will be on average more efficient in producing any intermediate input z compared to an affiliate that produces a fraction of the intermediate inputs. This could be as a result of external return to scale or knowledge spillover and learning by doing hypothesis. Regardless, $\bar{t}$ is strictly higher than $C^M_{ni}(\tau, \varphi, \mathcal{I})$. Moreover, an important assumption has to be made here:t $w_n\bar{t} < w_i\tau_{ni}$. Otherwise no firm chooses FDI without intrafirm over exporting.

margin.[32] Lemma IV.1 is of great importance in the current setting: more knowledge intensive firms are more vulnerable to trade costs because they are more dependent on the imported intermediate inputs from their parents (Lemma IV.2). Reframing, the firm-level gains from trade liberalization (savings in marginal cost) are positively related to firm's knowledge intensity, i.e., productivity. The second part of Lemma IV.2 is trivial and intuitive. The third part of the same Lemma spawns from Lemma IV.1.

To sum up, the two lemmas above highlight the role of firm's knowledge intensity (productivity), trade impediments and the interaction between the two in shaping intrafirm trade on the firm level. More knowledge-intensive firms are so because they require more knowledge-intensive intermediate inputs. A more knowledge-intensive affiliate imports higher share of its intermediate inputs from its parent, and consequently an increase in trade costs raises the marginal cost of composite intermediate input of more knowledge-intensive affiliate proportionally more than less knowledge-intensive firms. Changes in trade costs impact firms' decision regarding embodied and disembodied knowledge transfer; yet the degree of substitution between them is significantly less for more knowledge intensive firms. An increase in trade costs, for example, leads to less decrease in the share of imported inputs to aggregate composite intermediate input costs for high knowledge-intensive affiliate since the more knowledge-intensive affiliate's ability to substitute embodied with disembodied knowledge transfer is constrained by the large demand for the highly knowledge-intensive inputs.

Embodied vs Disembodied Knowledge Transfer: Given the isoelastic demand facing each working firm in country n, profits for an affiliate in country n and a parent in country

[32] If we let $t(z)$ be dependent on firm's productivity, both the extensive and the intensive margin of imported inputs will vary across firms. All the results presented in the paper will be reinforced.

i can be written as,[33]

$$\pi_{ni}^{aff} = \varphi^{\sigma-1} B_n C_{ni}^M(\tau_{ni}, \mathcal{I}(\varphi), \varphi, \varpi)^{1-\sigma} - w_i(f_{ni}^{fdi} + \mathcal{I}(\varphi) f_{ni}^{int}), \tag{4.5}$$

An affiliate chooses to outsource intermediate inputs from parent if and only if the increase in its profits due to the decrease in the marginal cost of composite intermediate input is large enough to cover the fixed cost of intrafirm;

$$\varphi^{\sigma-1} B_n \left[\Delta C_{ni}^M(\tau_{ni}, \mathcal{I}(\varphi), \varphi, \varpi)\right] \geq w_i f_{ni}^{int}, \tag{4.6}$$

where $\Delta C_{ni}^M(\tau_{ni}, \mathcal{I}(\varphi), \varphi, \varpi) \equiv C_{ni}^M(\tau_{ni}, \mathcal{I}(\varphi) = 1, \varphi)^{1-\sigma} - C_{ni}^M(\tau_{ni}, \mathcal{I}(\varphi) = 0, \varphi)^{1-\sigma}$ denotes the gains in variable profits as a result of the decline in the marginal cost of composite intermediate input once an affiliate starts intrafirm trade with its parent. In the Appendix, we show that the left hand side of Equation (4.6) is continuos and strictly increasing in φ. As a result, there exists a productivity cutoff φ_{ni}^{int} such that all affiliates with productivity above it choose to import a fraction of its intermediate inputs from their parents, whereas, conditional on FDI, firms with productivity below it do not import from parents.

Proposition IV.1. *There exists a productivity cutoff φ_{ni}^{int} such that*

$$\mathcal{I}(\varphi) = \begin{cases} 1 & \text{if} \quad \varphi \geq \varphi_{ni}^{int} \\ 0 & \text{otherwise} \end{cases}$$

That is, only the most productive foreign affiliates in country n engage in intrafirm trade with their parents (import intermediate inputs from their parents).

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[33] $B_n \equiv \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} A_n$. Notice that the marginal cost of producing the final good is given by $\frac{C_{ni}^M(\varphi,.)}{\varphi}$, which we require to be strictly decreasing in φ. This can be done by imposing a specific functional form on $C_{ni}^M(\varphi)$ such that the marginal cost of the final good is decreasing in φ or, equivalently, we assume that firm's draw φ is transformed to actual firm's productivity via a strictly increasing function $f(\varphi)$ such that the marginal cost of the final good is decreasing in φ.

The productivity cutoff φ_{ni}^{int} is simply pinned down from equation (4.6):

$$(\varphi_{ni}^{int})^{\sigma-1} B_n \left[\Delta C_{ni}^{M}(\tau_{ni}, \mathcal{I}(\varphi), \varphi_{ni}^{int}, \varpi)\right] = w_i f_{ni}^{int}. \tag{4.7}$$

The FDI cutoff $\varphi_{ni}^{fdi} < \varphi_{ni}^{int}$ is found by the usual way: equating export profits $\pi_{ni}(\varphi)$ with FDI profits without intrafirm π_{ni}^{fdi}

$$(\varphi_{ni}^{fdi})^{\sigma-1} B_n \left[C_{ni}^{M}(\tau_{ni}, \mathcal{I}(\varphi) = 0, \varphi_{ni}^{fdi}, \varpi)^{1-\sigma} - (w_i \tau_{ni})^{1-\sigma}\right] = w_i (f_{ni}^{fdi} - f_{ni}). \tag{4.8}$$

Exporting cutoff to country n is given by;,

$$\varphi_{ni}^{\sigma-1} B_n (w_i \tau_{ni})^{1-\sigma} - w_i f_{ni} = 0 \tag{4.9}$$

To complete the characterization of varieties produced and consumed in country n, the zero profit cutoff (ZPC) is as usual,

$$\varphi_{nn}^{\sigma-1} B_n w_n^{1-\sigma} - w_n f_{nn} = 0 \tag{4.10}$$

Parameter Restrictions and Firms Hierarchy: Consistent with the literature we impose the following restrictions on the model's parameters to sustain firms' hierarchy in the HMY.

- Exporters are more productive than nonexporters: $\varphi_{ii} < \varphi_{ni}$; if, under symmetric countries, $f_{ni} > \tau_{in}^{1-\sigma} f_{ii}$.
- Exporters are less productive than multinational firms: $\varphi_{ni} < \varphi_{ni}^{fdi}$; if $f_{ni}^{fdi} > (\tau_{ni}\varpi)^{\sigma-1}\bar{t}^{1-\sigma} f_{ni}$, and $\bar{t} < \varpi\tau_{ni}$.
- Multinational firms with nonzero intrafirm are more productive than multinational with zero intarfirm: $\varphi_{ni}^{int} > \varphi_{ni}^{fdi}$; if $f_{ni}^{int} > 0$.[34]

The geography of foreign affiliate sales: A country i foreign affiliate sales in country

[34]In fact, f_{ni}^{int} has to be greater than $f_{ni}^{fdi} - f_{ni}$.

n, $r_{ni}^{aff}(\varphi)$ are given by

$$r_{ni}^{aff}(\varphi) = \sigma\varphi^{\sigma-1}B_n\left[C_{ni}^M(\tau_{ni}, \mathcal{I}(\varphi), \varphi, \varpi)\right]^{1-\sigma} \tag{4.11}$$

Proposition IV.2. ***(Gravity)****: Country i foreign affiliate sales (conditional on opening an affiliate) in country n,* $r_{ni}^{aff}(\varphi)$ *are decreasing in trade costs* τ_{ni}*. Let* $\varepsilon_{ni}^r(\varphi, \tau_{ni}) < 0$ *be the elasticity of affiliate sales with respect to trade costs, then the absolute value of* $\varepsilon_{ni}^r(\varphi, \tau_{ni})$ *is increasing in* φ*. In words, the sales of more knowledge intensive firms (affiliates) are more sensitive to trade costs. That is,* ***FDI-Gravity*** *is more pronounce for more knowledge intensive parents-affiliates.*

4.5 Parameterization, Functional Forms and Estimation

First, we provide functional forms of the log-supermodular function $\beta(z|\varphi)$, the cost of disembodied knowledge transfer, and the distribution of productivity draw. Before proceeding further, we set $\eta = 1$, and therefore M_φ is a Cobb-Douglas composite intermediate input: $M_\varphi = \mathcal{C}.exp\left\{\int_0^\infty \beta(z|\varphi)\ln m(z)dz\right\}$.[35] The correspondent cost function of the intermediate input composite: $C = exp\left\{\int_0^\infty \beta(z|\varphi)\ln w_z dz\right\}$. In our context, assuming $w_i = 1$ for $i \in \{1, 2, \ldots, N\}$, domestic producers composite intermediate input cost is given by $C_{nn}^M = 1$, while

$$C_{ni}^M(\tau_{ni}, \varphi, \mathcal{I}) = \begin{cases} \bar{t} & \text{if} \quad \mathcal{I} = 0, \\ \exp\left\{\int_0^{\tilde{z}} \beta(z|\varphi)\ln t(z)dz + \int_{\tilde{z}}^\infty \beta(z|\varphi)\ln \tau_{ni}dz\right\} & \text{if} \quad \mathcal{I} = 1 \end{cases}$$

Following Keller and Yeaple (2013), we set the knowledge transfer function $t(z) = \exp\{z\}$. Let $\phi(\varphi)$ denote φ-firm's knowledge intensity where $\phi(\varphi)$ is weakly increasing in φ. In order to simplify the analysis, we assume that $\phi(\varphi)$ takes two values low and high: $\phi(\varphi) \in \{\phi^l, \phi^h\}$.

[35] $\mathcal{C} \equiv \int_0^\infty \beta(z|\varphi)\ln \beta(z|\varphi)dz$ is constant.

We adopted a very simple reduced form to connect the well documented relationship between firm's size (productivity) and knowledge intensity; specifically, for any $\varphi(\phi) > \varphi_{ni}^{int}$, $\phi = \phi^h$ and $\phi = \phi^l$ otherwise. This greatly simplifies the analysis without altering our results regarding the correlation between intrafirm trade and firm's knowledge-intensity. We still able to use this simple functional form to compare intrafirm trade across firms with different knowledge intensity. Accordingly, we change the notation slightly: we use $\beta(z|\phi)$ instead of $\beta(z|\varphi)$. The cost share function $\beta(z|\phi)$ is log-supermodular in z and ϕ; therefore, we let $\beta(z|\phi)$ be an exponential with parameter $\frac{1}{\phi}$.[36]

We additionally assume that the costs of disembodied technology transfer also vary with destination-original pair characteristics. Broadly, the factors that are widely used in estimating trade costs between countries are also expected to affect the costs of disembodied technology transfer but with less order of magnitude: $t_{ni}(z) = g_{ni}t(z)$. Hence, $\bar{t}_{ni} = g_{ni}\exp\left\{\int_0^\infty \beta(z|\phi)\ln t(z)dz\right\}$.[37] To operationalize the model we let $g_{ni} = \tau_{ni}^{\alpha}$, where $\alpha \in (0,1)$. With the functional forms at hand, the marginal cost of obtaining the composite intermediate input for an affiliate with knowledge intensity $\phi \in \{\phi^l, \phi^h\}$ is

$$C_{ni}^{M}(\tau_{ni}, \mathcal{I}, \phi) = \begin{cases} \bar{t} = \tau_{ni}^{\alpha}\exp\{\phi\} & \text{if} \quad \mathcal{I} = 0, \\ \exp\left\{\phi\left(1 - \tau_{ni}^{\frac{\alpha-1}{\phi}}\right) + \alpha\ln\tau_{ni}\right\} & \text{if} \quad \mathcal{I} = 1 \end{cases} \tag{4.12}$$

Providing that $\tau_{ni} > g_{ni}\exp\{\phi^l\}$.[38]

4.5.1 Foreign affiliate's sales: firm-level gravity

Foreign affiliate's sales are given by equation (4.11). Given the functional forms provided in this section, we have:

$$r_{ni}^{fdi} = \sigma\varphi^{\sigma-1}B_n\left(\tau_{ni}^{\alpha}exp(\phi)\right)^{1-\sigma}, \tag{4.13}$$

[36] $\beta(z|\phi) = \frac{1}{\phi}\exp\left\{\frac{-z}{\phi}\right\}$. It is straightforward to check that $\log\beta(z|\phi)$ is supermodular and $\int_0^\infty \beta(z|\phi)dz = 1$.

[37] $1 < g_{ni} < \tau_{ni}$. Akin to τ_{ni}, g_{ni} denotes the costs of disembodied knowledge transfer as a function of distance, common border and language, the time zone of n, i, colonial origins,...

[38] This assumption is needed in order for the FDI cutoff to be well defined. ϕ^l is very small such that $\exp(\phi^l) \approx 1$.

and

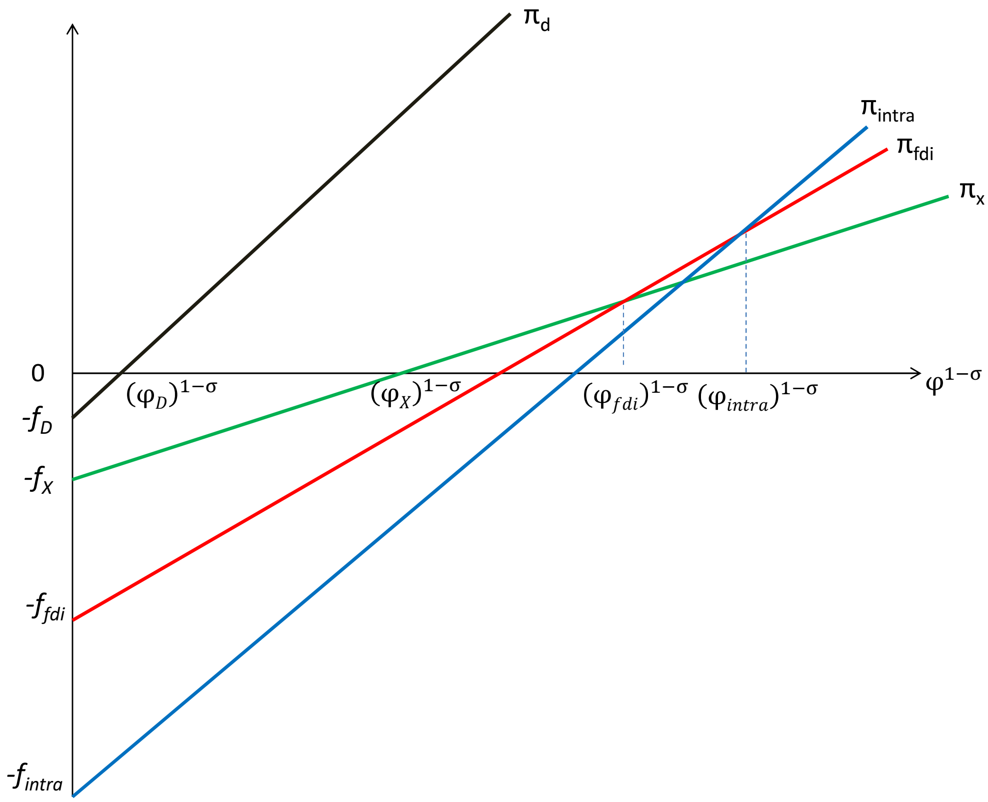
$$r_{ni}^{int} = \sigma\varphi^{\sigma-1}B_n\left(exp\left\{\phi(1-\tau_{ni}^{\frac{\alpha-1}{\phi}})+\alpha\ln\tau_{ni}\right\}\right)^{1-\sigma}. \tag{4.14}$$

Accordingly, the elasticity of foreign affiliate's sales with respect to trade costs is given by;

$$\varepsilon_{ni}^{r}(\phi,\tau_{ni},\mathcal{I}) = \begin{cases}(1-\sigma)\alpha < 0, & \text{if} \quad \mathcal{I}=0,\\ (1-\sigma)\left((1-\alpha)\tau_{ni}^{\frac{\alpha-1}{\phi}}+\alpha\right) < 0, & \text{if} \quad \mathcal{I}=1\end{cases} \tag{4.15}$$

It is straightforward to verify that the sales of affiliates who import from their parents respond relatively more than the sales of affiliates who do do important from parents. Furthermore, for affiliates who import from their parents, their sales are more responsive to change in trade costs the higher the knowledge intensity: $\frac{\partial\varepsilon_{ni}^{r}(\phi,\tau_{ni})}{\partial\phi} < 0$.

Figure 4.1: Profit from domestic sales, exports, FDI and intra-firm trade



Notes: This figure shows the different productivity cutoff for different firms, where $(\varphi_D)^{1-\sigma}$ represents the cutoff for domestic producers, $(\varphi_X)^{1-\sigma}$ represents the cutoff for exporters, $(\varphi_{fdi})^{1-\sigma}$ represents the cutoff for firms engaging in multinational production, and $(\varphi_{intra})^{1-\sigma}$ represents the cutoff for foreign affiliates that also engage in intra-firm trade

4.6 General Equilibrium

Using the functional forms in the previous section, here we solve the economy general equilibrium aggregate variables. Consistent with the literature, we assume that firm's productivity is distributed Pareto with shape parameter κ,[39]

$$G(\varphi) = 1 - \varphi^{-\kappa}, \quad \text{for} \quad \varphi > 1, \quad \text{and} \quad \kappa > \sigma - 1.$$

The relevant cutoffs for country-pair (n, i) are given as follows[40]

$$\begin{aligned}
\text{Zero profit cutoff ZPC} : \varphi_{nn}^{\sigma-1} &= \frac{f_{nn}}{B_n} \\
\text{Export cuttoff} : \varphi_{ni}^{\sigma-1} &= \frac{f_{ni}}{B_n}\tau_{ni}^{\sigma-1} \\
\text{FDI cutoff} : (\varphi_{ni}^{fdi})^{\sigma-1} &= \frac{f_{ni}^{fdi} - f_{ni}}{B_n C_{1ni}} \\
\text{Intrafirm cutoff} : (\varphi_{ni}^{int})^{\sigma-1} &= \frac{f_{ni}^{int}}{B_n C_{2ni}}
\end{aligned}$$

As we show in Figure 4.1, the logic of the standard HMY model is strongly presented in our framework. At the heart of it is the proximity-concentration trade-off (in figure proximity is represented by the slope of each profit's line, while concentration is represented by y-axis intersection). However, in HMY model, the line representing the profits for affiliates who import π_{int} does not exist, and the line denoted by π_{fdi} is parallel to the domestic profits line. In a model with FDI and Intra-firm Irarrazabal et al. (2013), the line representing the profits for affiliates who do not import from parents π_{fdi} is missing since by default all

[39]The assumption that $\kappa > \sigma - 1$ ensures the the distribution of firm's size has a finite mean. In general, $G(\varphi) = 1 - \left(\frac{\varphi_{min}}{\varphi}\right)^{\kappa}$, and $\kappa > 2$. We work with $\varphi_{min} = 1$. In this section we assume that all firms in a given sector share the same knowledge-intensity given by the mean of knowledge-intensity of all firms operating in that particular sector. Our main goal in this sectionderiving sectoral aggregate affiliates' sales (sectoral aggregate gravity) is preserved under this simplification. In this vein, our model becomes very similar to Keller and Yeaple (2013) with an exception of affiliates' endogenous selection into importers and non-importers from their parents.

[40]$C_{1ni} \equiv \tau_{ni}^{\alpha(1-\sigma)}\exp\{\phi(1-\sigma)\} - \tau_{ni}^{1-\sigma} > 0$.
$C_{2ni} \equiv \exp\{\phi(1 - \tau_{ni}^{\frac{\alpha-1}{\phi}}) + \alpha\ln\tau_{ni}\}^{1-\sigma} - \tau_{ni}^{\alpha(1-\sigma)}\exp\{\phi(1-\sigma)\} > 0$.

affiliates import from parents.

Aggregate price index: The aggregate price index in country n is given by;

$$P_n^{1-\sigma} = J_n \int_{\varphi_{nn}}^{\infty} p_{nn}(\varphi)^{1-\sigma} dG(\varphi) + \sum_{i \neq n}^{N} J_i \int_{\varphi_{ni}}^{\infty} p_{ni}(\varphi)^{1-\sigma} dG(\varphi), \tag{4.16}$$

$$p_{ni}(\varphi) = \begin{cases} \frac{\sigma}{\sigma-1} \frac{\tau_{ni}}{\varphi} & \text{if} \quad \varphi_{ni} < \varphi < \varphi_{ni}^{fdi} \\ \frac{\sigma}{\sigma-1} \frac{\tau_{ni}^{\alpha} exp(\phi)}{\varphi} & \text{if} \quad \varphi_{ni}^{fdi} < \varphi < \varphi_{ni}^{int} \\ \frac{\sigma}{\sigma-1} \frac{exp(\phi(1-\tau_{ni}^{\frac{\alpha-1}{\phi}}) + \alpha \ln \tau_{ni})}{\varphi} & \text{if} \quad \varphi_{ni}^{int} < \varphi \end{cases}$$

Evaluating the integration and using the Pareto distribution assumption,[41]

$$P_n^{-\kappa} = \frac{\kappa}{\kappa - (\sigma - 1)} \left(\frac{\sigma}{\sigma - 1} \right)^{-\kappa} \left(\frac{\mu X_n}{\sigma} \right)^{\frac{\kappa - (\sigma - 1)}{\sigma - 1}} \Xi_n \tag{4.17}$$

Indeed, X_n is an endogenous variable. Since the mass of firms is exogenously given, the aggregate profits of country n firms, including affiliates' profits, are strictly positive. Accordingly, total income/expenditure in country n is the sum of labor income and aggregate profits of all country n firms: $X_n = w_n L_n + \Pi_n$. As in Chaney (2008), we assume that each consumer in country n holds w_n shares in a completely diversified mutual global fund with s dividends per share in terms of the numeriare. Additionally, as in Eaton and Kortum (2002) and Chaney (2008), J_i is proportional to the size of labor force in country n; $J_n = w_n L_n$. Therefore, $X_n = w_n L_n (1 + s)$, and $J_n = \frac{X_n}{1+s}$. In the Appendix, we show that s is a function of the model's exogenous parameters: $s = \frac{\sigma - 1}{\sigma(\kappa - 1) + 1}$.

The aggregate equilibrium price level in country n is the solution of Equation (4.17) in terms of the model's exogenous parameters. Once P_n obtained, we can retrieve all the relevant cutoffs, trade flows, foreign affiliates' sales, and economic welfare.

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[41] $\Xi_n \equiv \sum_{i=1}^{N} J_i \left(\tau_{ni}^{-\kappa} f_{ni}^{\frac{\sigma-1-\kappa}{\sigma-1}} + \mathcal{I}_{i \neq n} \left\{ (f_{ni}^{fdi} - f_{ni})^{\frac{\sigma-1-\kappa}{\sigma-1}} C_{1ni}^{\frac{\kappa}{\sigma-1}} + (f_{ni}^{int})^{\frac{\sigma-1-\kappa}{\sigma-1}} C_{2ni}^{\frac{\kappa}{\sigma-1}} \right\} \right)$. The indicator function $\mathcal{I}_{i \neq n} = 1$ if $i \neq n$ and zero otherwise.

4.6.1 Aggregate Sales: Gravity Equations

The model delivers three gravity equations: (i) Aggregate export sales from country i to country n: X_{ni}, (ii) Country i foreign affiliates' sales in country n, with no intrafirm between parents and affiliates; X_{ni}^{fdi}, and (iii) Country i foreign affiliates' sales in country n, for affiliates that import from parents; X_{ni}^{int}.[42]

$$X_{ni} = \frac{\mu X_n X_i \tau_{ni}^{-\kappa}\,\delta_{ni}}{\Xi_n} \tag{4.18}$$

$$X_{ni}^{fdi} = \frac{\mu X_n X_i \left\{\tau_{ni}^{\alpha} exp(\phi)\right\}^{-\kappa}\lambda_{ni}}{\Xi_n} \tag{4.19}$$

$$X_{ni}^{int} = \frac{\mu X_n X_i exp\left\{\phi\left(1-\tau_{ni}^{\frac{\alpha-1}{\phi}}\right)+\alpha(\ln\tau_{ni})\right\}^{-\kappa}\vartheta_{ni}}{\Xi_n} \tag{4.20}$$

Ξ_n is a reminiscent of the multilateral resistance term in Eaton and Kortum (2002). It is a measure of country n attractiveness (remoteness) taking into account all trading countries. The bilateral terms δ_{ni}, λ_{ni}, and ϑ_{ni} depend only on country i and country n parameters.[43] Relative to the standard gravity equation (e.g., Melitz-Chaney style model with no FDI), the impact of variable trade costs on country i exporters to country n is more involved. Without FDI sales, country i aggregate exports to country n can be decomposed into the intensive and the extensive margins, with the average exporter's sales being invariant to variable trade costs and the mass of exporting firms negatively associated with trade costs. In the presence of FDI sales, variable trade costs impact both the mass of exporters and the average export sales per firm. In Chaney (2008), for instance, δ_{ni} is a function of fixed costs of export f_{ni}, and does not depend on τ_{ni}. Here, λ_{ni} is a function of τ_{ni}, and therefore the

[42] With a slight abuse of notation, we redefine $\Xi_n \equiv \sum_{i=1}^{N} L_i(1+s)\left(\tau_{ni}^{-\kappa} f_{ni}^{\frac{\sigma-1-\kappa}{\sigma-1}} + \mathcal{I}_{i\neq n}\left\{(f_{ni}^{fdi}-f_{ni})^{\frac{\sigma-1-\kappa}{\sigma-1}} C_{1ni}^{\frac{\kappa}{\sigma-1}} + (f_{ni}^{int})^{\frac{\sigma-1-\kappa}{\sigma-1}} C_{2ni}^{\frac{\kappa}{\sigma-1}}\right\}\right)$.

[43] $\delta_{ni} \equiv f_{ni}^{\frac{\sigma-1-\kappa}{\sigma-1}} - \left[\frac{f_{ni}^{fdi}-f_{ni}}{\tau_{ni}^{(1-\sigma)(\alpha-1)} exp(\phi(1-\sigma))-1}\right]^{\frac{\sigma-1-\kappa}{\sigma-1}}$, $\lambda_{ni} \equiv \left[\frac{f_{ni}^{fdi}-f_{ni}}{1-\tau_{ni}^{(1-\sigma)(1-\alpha)} exp(\phi(\sigma-1))}\right]^{\frac{\sigma-1-\kappa}{\sigma-1}} - \left[\frac{f_{ni}^{int}}{(\tau_{ni}^{\alpha} exp(\phi))^{\sigma-1} C_{2ni}}\right]^{\frac{\sigma-1-\kappa}{\sigma-1}}$, and $\vartheta_{ni} \equiv \left[\frac{f_{ni}^{int}}{\left(\exp((\phi(1-\tau_{ni}^{\frac{\alpha-1}{\phi}})+\alpha\ln\tau_{ni})\right)^{\sigma-1} C_{2ni}}\right]^{\frac{\sigma-1-\kappa}{\sigma-1}}$. Our assumptions about firms hierarchy and the necessary parameter restrictions to maintain it are sufficient for both δ_{ni} and ϑ_{ni} to be positive. On the other hand λ_{ni} is positive if $f_{ni}^{int} > (f_{ni}^{fdi} - f_{ni})\frac{C_{2ni}}{C_{1ni}}$.

response of X_{ni} to changes in τ_{ni} depends on changes in δ_{ni} and $\tau_{ni}^{-\kappa}$. Formally, let $\xi_{X,\tau}$ be the elasticity of aggregate exports sales between countries i and n with respect to variable trade costs τ_{ni}, and $\xi_{\delta,\tau}$ is the elasticity of δ with respect to τ, then[44]

$$\xi_{X,\tau} = -\kappa - |\xi_{\delta,\tau}| < 0, \tag{4.21}$$

Likewise, the elasticity of of aggregate foreign affiliate sales for affiliates that do not import from their parents with respect to variable trade costs, and the elasticity of aggregate foreign affiliates' sales for affiliates the import from their parents are, respectively, given by[45]

$$\xi_{X^{fdi},\tau} = -\alpha\kappa + \xi_{\lambda,\tau} < 0 \tag{4.22}$$

$$\xi_{X^{int},\tau} = -\left[\tau_{ni}^{\frac{\alpha-1}{\phi}}(1-\alpha) + \alpha\right]\kappa + \xi_{\vartheta,\tau} < 0 \tag{4.23}$$

Aggregate affiliates' sales (for importer affiliates) decrease as trade costs increase. It is straightforward to show this since the second term of Equation (4.23) is negative for any $\alpha \in (0,1)$. The finding that foreign affiliates' sales are negatively correlated with trade costs for the affiliates who import from their parents is not surprising and consistent with the models that introduce intrafirm trade between affiliates and parents Irarrazabal et al. (2013) and Keller and Yeaple (2013). We are mainly interested in the gravity equation for affiliates who report zero intrafirm with their parents. The intrafirm trade mechanism that puts gravity forces in play is ceased in the case of small affiliates who never import from parents. Nonetheless, as we show in equation (4.22), the sales of non-importer affiliates are still suffering from gravity forces (see the Appendix for formal derivations and the conditions for DI gravity to hold). In our context, affiliates need the knowledge-specific to produce the final good, which it can obtain through importing intermediate inputs from parents-embodying knowledge- or through direct knowledge transfer, which is not observed in the

[44] $\xi_{\delta,\tau} = -\frac{\kappa-(\sigma-1)}{\sigma-1}\left[\frac{f_{ni}^{fdi}-f_{ni}}{\tau^{\sigma-1}C_{1ni}}\right]^{\frac{\sigma-1-\kappa}{\sigma-1}-1}\left[\frac{(1-\sigma)(\alpha-1)\tau^{(1-\sigma)(\alpha-1)-1}exp(\phi(1-\sigma)}{(\tau^{\sigma-1}C_{1ni})^2}\right]\frac{\tau}{\delta} < 0.$

[45] $\xi_{\vartheta,\tau} = (\kappa-(\sigma-1))\left[\tau^{\alpha(1-\sigma)}\frac{exp(\phi(1-\sigma))}{C_{2ni}}\left((\alpha-1)\tau^{\frac{\alpha-1}{\phi}}\right)\right] < 0$. Deriving the sign of $\xi_{\lambda,\tau}$ involves a tremendous algebra and is not trivial. In general, $\xi_{\lambda,\tau}$ is negative if α and f_{ni}^{int} are large enough (see the Appendix for details). Nonetheless, $\xi_{X^{fdi},\tau}$ is negative as long as α is not very close to zero.

data. Since trade frictions impact the cost of knowledge transfer, affiliates' marginal cost and sales are negatively affected by the distance from headquarter and other common trade frictions.

In order to comment on the role of intensive and extensive margins in the gravity equations above, in a line with Chaney (2008), we formally introduce the impact of changing variable trade costs on the intensive margin (sales of existing firms) and the extensive margin (sales of new entrants). By differentiating the expression for aggregate exports from country i to country n $X_{ni} = J_i \int_{\varphi_{ni}}^{\varphi_{ni}^{fdi}} r_{ni}(\varphi) dG(\varphi)$, the following expression for the elasticity of X_{ni} with respect to τ_{ni} is obtained,[46]

$$\xi_{X,\tau} = \overbrace{(1-\sigma)}^{\text{Intensive margin}} + \overbrace{\frac{\kappa-(\sigma-1)}{\varphi_{ni}^{\sigma-1-\kappa} - (\varphi_{ni}^{fdi})^{\sigma-1-\kappa}} \Big[\xi_{\varphi^{fdi},\tau} (\varphi_{ni}^{fdi})^{\sigma-1-\kappa} - \varphi_{ni}^{\sigma-1-\kappa}\Big]}^{\text{Extensive margin}}, \qquad (4.24)$$

where, $\xi_{\varphi^{fdi},\tau}$ denotes the elasticity of FDI cutoff with respect to variable trade costs. If $\xi_{\varphi^{fdi},\tau}$ is negative then both the sales of existing exporters and the sales of new exporters decrease with trade costs. By contrast, if α is large enough, $\xi_{\varphi^{fdi},\tau}$ is positive; yet it is still small enough such that the extensive margin continues to be negative. In fact, $\xi_{\varphi^{fdi},\tau} < 1$ for any value of $\alpha \in (0,1)$.[47] Consistent with our finding that the number of foreign affiliates in the lower tail of firm's size distribution decreases as the distance from headquarter increases, we proceed with positive elasticity of FDI cutoff with respect to trade costs, $0 < \xi_{\varphi^{fdi},\tau} < 1$ (i,e., α is large enough). Interestingly, even if the FDI cutoff is increasing in τ, as in HMY, the ratio of the number of multinational firms to the number of exporters increases as trade costs increase. Clearly, if FDI cutoff is ∞, the model collapses to Chaney's model and $\xi_{X,\tau} = -\kappa$.

The same analysis for the aggregate sales of affiliates who do not import from parents,

[46] We use Leibniz integral rule to differentiate the aggregate exports expression.

[47] Specifically, $\xi_{\varphi^{fdi},\tau} = \frac{\alpha exp(\phi(1-\sigma)) - \tau_{ni}^{(1-\sigma)(1-\alpha)}}{exp(\phi(1-\sigma)) - \tau_{ni}^{(1-\sigma)(1-\alpha)}} < 1$.

X_{ni}^{fdi} is executed,

$$\xi_{X^{fdi},\tau} = \overbrace{\alpha(1-\sigma)}^{\text{Intensive margin}} + \overbrace{\frac{\kappa-(\sigma-1)}{(\varphi_{ni}^{fdi})^{\sigma-1-\kappa}-(\varphi_{ni}^{int})^{\sigma-1-\kappa}}\left[\xi_{\varphi^{int},\tau}(\varphi_{ni}^{int})^{\sigma-1-\kappa}-\xi_{\varphi^{fdi},\tau}(\varphi_{ni}^{fdi})^{\sigma-1-\kappa}\right]}^{\text{Extensive margin}} \tag{4.25}$$

The elasticity of intra-firm cutoff with respect to variable trade costs is denoted by $\xi_{\varphi^{int},\tau}$.[48] In the Appendix we show that if the fixed cost of intrafirm trade is sufficiently hight, the impact of trade costs on the extensive margin is negative as well.[49]

The impact of variable trade costs on the intensive and the extensive margins for affiliates who import from their parents is as follows

$$\xi_{X^{int},\tau} = \overbrace{(1-\sigma)\left[(1-\alpha)\tau_{ni}^{\frac{\alpha-1}{\phi}}+\alpha\right]}^{\text{Intensive margin}} - \overbrace{(\kappa-(\sigma-1))\xi_{\varphi^{int},\tau}}^{\text{Extensive margin}}. \tag{4.26}$$

Both sales per existing affiliates and the sales of new importer affiliates decline as trade costs increase. An intriguing result here is that although the impact of trade costs on the intensive margin unambiguously larger for importer-affiliates than non-importer affiliates, the relative impact on the extensive margin for non-importer affiliates relative to importer affiliates is ambiguous: the sales of new entrants/existing non-importer affiliates might decline more than its counterpart for importer-affiliates as trade costs increase. In effect, the overall impact of trade costs on the aggregate sales of non-importer affiliates might even be stronger than its impact on the overall sales of importer affiliates because of the extensive margin responses to increasing trade costs. In other word, gravity forces could be stronger for affiliates who do not report intrafirm relative to affiliates who import from parents.

[48] $\xi_{\varphi^{int},\tau} = \frac{1}{1-\sigma}\frac{\partial \ln C_{2ni}}{\partial \ln \tau} > 0$.

[49] In fact, we also show the conditions under which FDI gravity equation holds even with positive extensive margin. In general this will be the case for a wide range of parameter values.

4.7 Conclusion

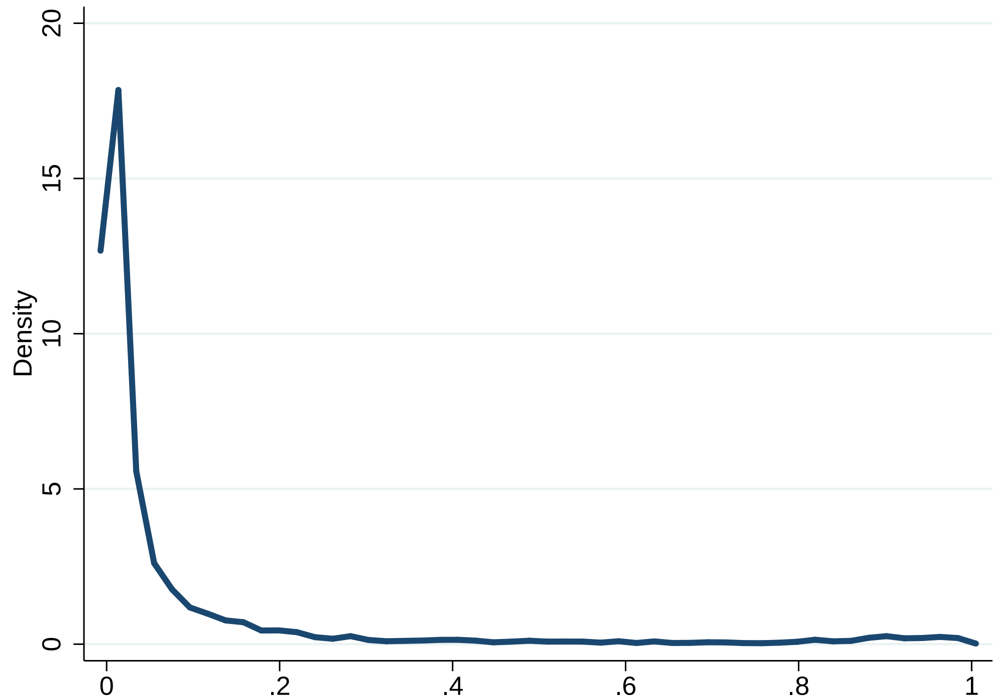
This paper starts by documenting an empirical regularity that cannot be fully taken into account by existing theoretical frameworks: foreign affiliates' sales are decreasing in trade costs even for those affiliates who do not engage in intra-firm transactions. In order to close this gap, we propose a new theoretical framework to rationalize this finding together with another stylize fact: the majority of firms do not engage in intra-firm transactions and even among those that do, intra-firm trade is highly concentrated in a small set of large multinational firms. Internalizing these regularities into an unified model improves our understanding of the nature and structure of multinational firms and the complex network connections between parents and affiliates. In addition, it provides a guide to further develop a quantitative framework that allows us to measure the welfare gains associated to reduction in trade barriers in a granular economy, where not only exports and multinational activity are subject to selection and are concentrated in a few big firms, but also the intra-firm transaction across borders.

This paper is part of a larger research agenda which attempts to quantify the potentially large gains from trade as well as the gains from multinational production that take place in an economy where trade liberalization will not only impact physical trade but also transfer of knowledge across countries. This could affect the employment in the host and the home country, and consequently could have sizable implications in the skilled composition of workers in both economies. Moreover, the interaction between trade costs and knowledge transfer across firms might be an useful tool to advance the theory of the boundaries of multinational firms.

Finally, relying on the quantitative extension of the presented theoretical framework, we will proceed to evaluate the impact of idiosyncratic firms' shocks on aggregate outcomes, in an economy in which production and trade—both arm's length and intra-firm—are concentrated among a small number of large multinational corporations. In particular, compared with a counterfactual scenario in which producing overseas is prohibitively costly for all firms, the observed aggregated volatility is expected to be significantly lower. This can be explained by the fact that in granular economies a large fraction of the small set of firms that dominate the market are indeed foreign affiliate firms rather than solely local exporters. The empirical analysis will use firm-level data to track the transactions of U.S. parents with their foreign multinationals and to explore the heterogeneity of intra-firm trade in the upper tail of the distribution and the persistence of gravity along firms of all sizes.

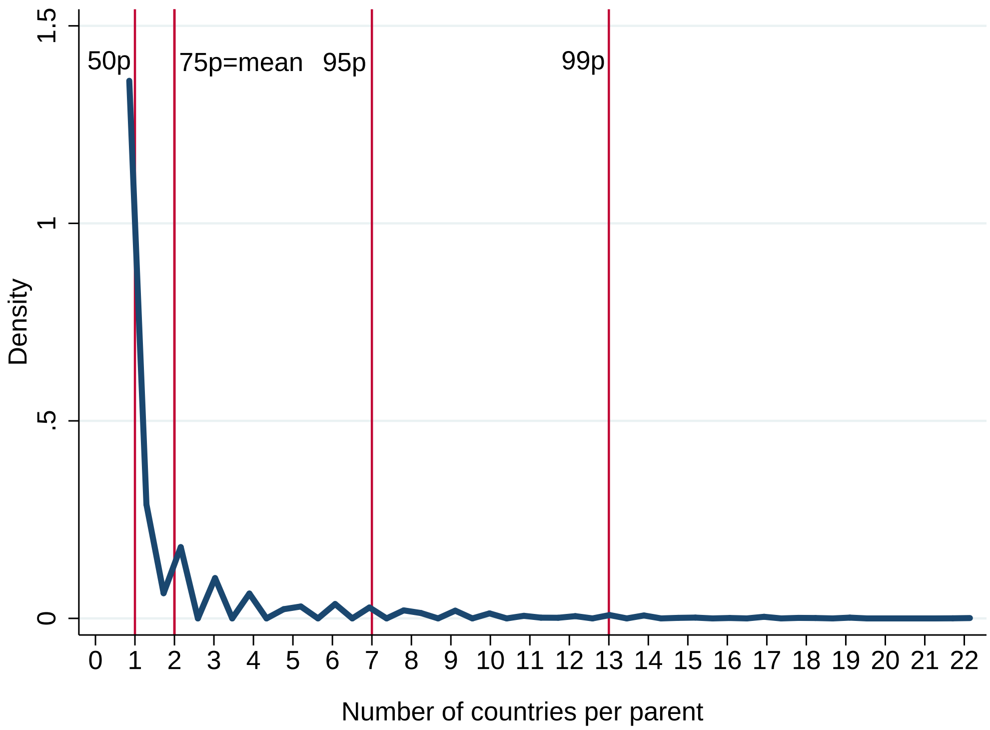
Tables and Figures

Figure 4.2: Density of U.S Foreign Affiliate Sales



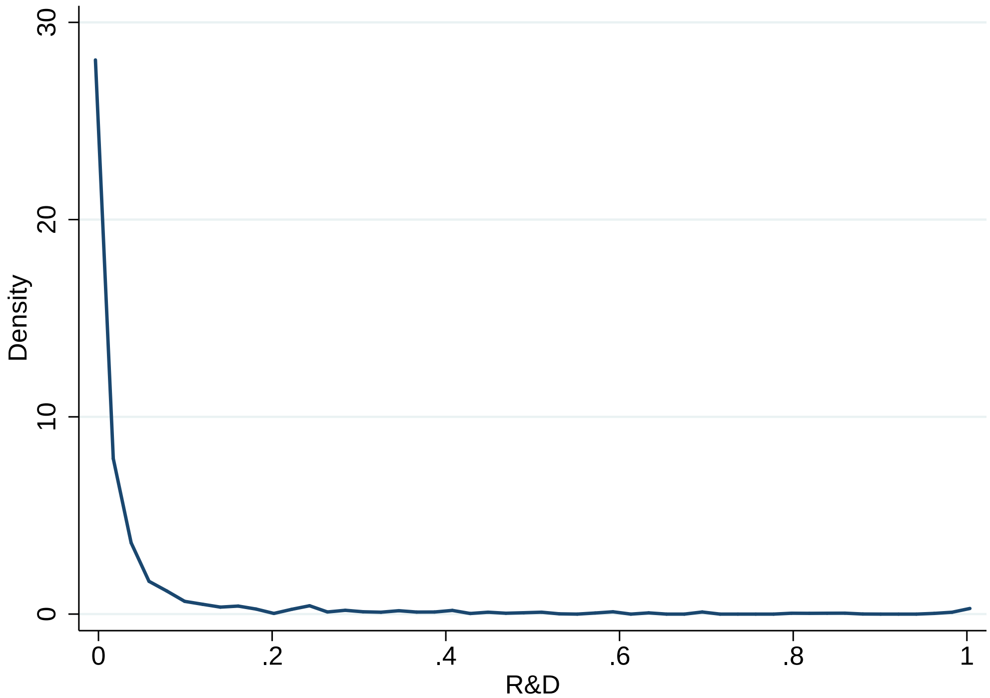
This figure represents the density of U.S Foreign Affiliate Sales as a fraction of parent's sales. As can be observe the distribution of foreign affiliate sales is dominated by small affiliates, with the presence of only few but large affiliates firms that account for the majority of the U.S. multinational production.

Figure 4.3: Market Penetration



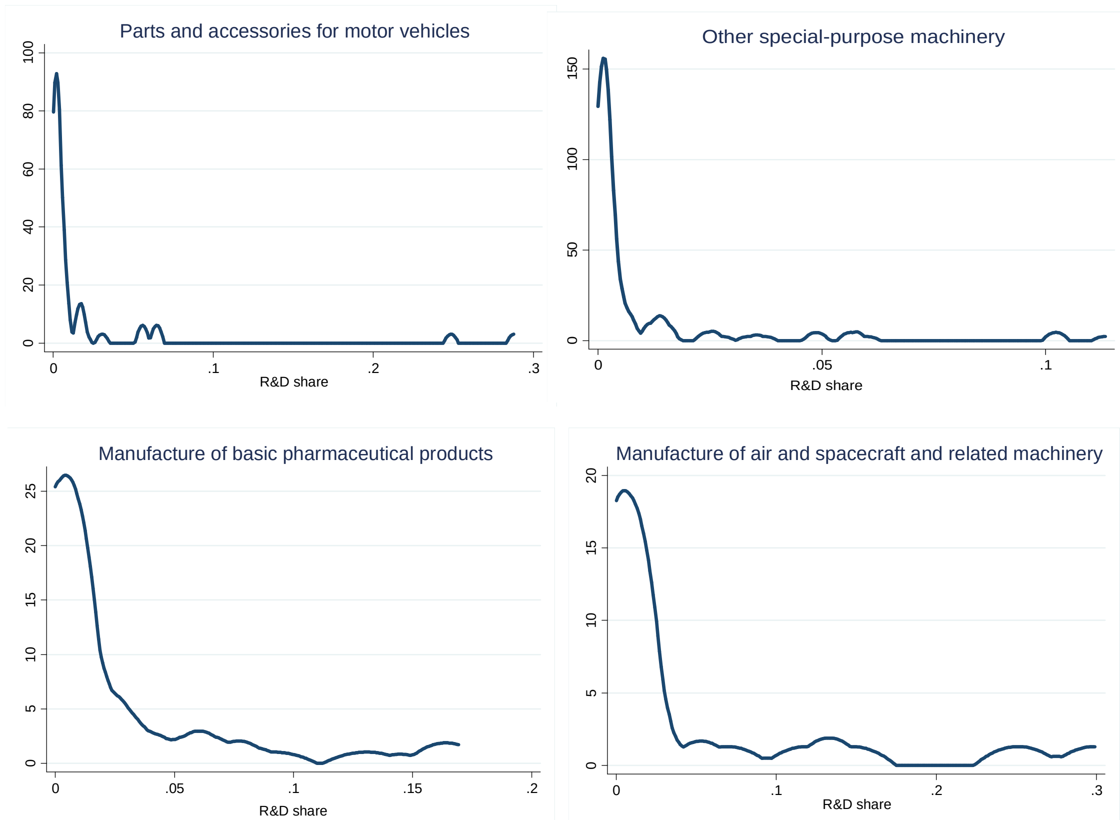
This figure represents the density of the number of markets in which U.S. parent firms produce. The vertical lines represent the cutoff the the 50, 75, 95 and 99 percentile, respectively. Half of the firms only have operations in only two or one foreign country. Only few parents engage in multinational activity in more than seven foreign markets.

Figure 4.4: Research and Development Share



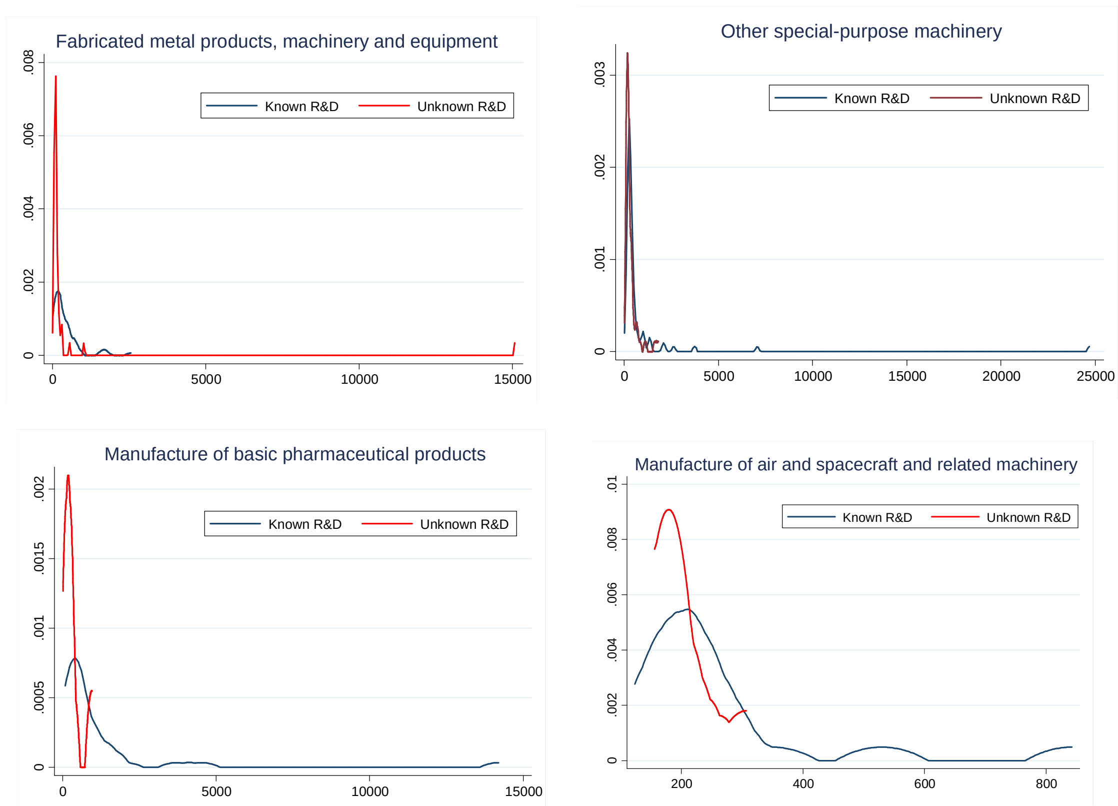
This figure shows the density of the parent's R&D expenditure share in each of the 104 manufactured sectors of the NACE classification at three digit level of disaggregation. The share of R&D is calculated as the fraction of the total Research and Development expenditure of the firm relative to the total R&D expenditure of all U.S parents firms operating the the same NACE3 sectoral classification. The density is showed for the pool of firms-sectors in the sample

Figure 4.5: Density of Firms' R&D shares for selected industries



This figure shows the density of the parent's share of R&D expenditure share for four selected three-digit level of NACE sector classification: 1) manufacturing of parts and accessories for motor vehicles—NACE 293 (top-left panel); 2) manufacture of other special-purpose machinery—NACE 289 (top-right panel); 3) manufacture of basic pharmaceutical products—NACE 211 (bottom-left panel), and 4) manufacture of air and spacecraft and related machinery—NACE 303 (bottom-right panel). The share of R&D is calculated as the fraction of the total Research and Development expenditure of the firm relative to the total R&D expenditure of all U.S parents firms operating the the same 3 digit sectoral classification.

Figure 4.6: Density of Fimrs' Producivity by R&D group



This figure shows the density of the productivity for two groups of parent firms: those for which Orbis data contains information regarding the expenditure in research and development activities (Known R&D); and those parent firms that contain missing values for R&D (Unknown R&D). The productivity density is show for both groups in four selected industries at three-digit level of NACE sector classification: 1) manufacturing of parts and accessories for motor vehicles—NACE 293 (top-left panel); 2) manufacture of other special-purpose machinery—NACE 289 (top-right panel); 3) manufacture of basic pharmaceutical products—NACE 211 (bottom-left panel), and 4) manufacture of air and spacecraft and related machinery—NACE 303 (bottom-right panel). Firms productivity is measured by the output per worker of the U.S parent. Only one third of the U.S parent firms (that at least have one affiliate overseas) show positive values of R&D expenditures.

Table 4.1: Gravity Equation of MP (country-sector level)

Dep. Variable	MP sales		N. of firms	
	(1)	(2)	(3)	(4)
ln *Dist*	–0.6999***	–0.7044***	–0.5525***	–0.0893**
	(0.2165)	(0.1190)	(0.0687)	(0.0427)
Border	–2.8115***	–0.6675	–0.0831	1.7173***
	(0.6920)	(0.6752)	(0.2231)	(0.2990)
Language	0.3939*	1.0690	0.3643**	0.3681
	(0.2069)	(0.9952)	(0.0711)	(0.3664)
Colony	–0.0449	1.1371***	0.5632**	1.9199***
	(0.1822)	(0.3812)	(0.0648)	(0.1366)
RTA	1.5951***	1.5730**	–0.1314	–0.3411*
	(0.3972)	(0.7277)	(0.1237)	(0.1896)
Capital (relative US)	2.1510***		2.1014***	
	(0.6134)		(0.2844)	
ln *GDPperc*	0.5664*		0.7646***	
	(0.3928)		(0.1184)	
Rule of Law	–0.0198**		–0.0196**	
	(0.0094)		(0.0028)	
Country FE	No	Yes	No	Yes
Sector FE	Yes	Yes	Yes	Yes
N.Observations	1111	1111	1194	1194

Notes: Dependent variables: foreign affiliates sales relative to parent's sales operating in each host country-sector pair in column (1) and (2); Number of US parents with at least one affiliates in each host country-sector pair in column (3) and (4). The regressors include the natural log of the distance between U.S and the host market (ln *Dist*); a dummy for the participation of the host market in a regional trade agreement (*RTA*), a dummy of common border (*border*), common language (*language*) and whether or not the host market and U.S. had a colonial relationship (*colony*). Other controls includes the level of capital endowment (*Capital*), the natural log of GDP per capita and a measure of the institutional quality of the host country (*Rule of Law*). Robust standard errors reported in parentheses. Significance is denoted: * $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$.

Table 4.2: Gravity Equation of MP (country-sector level)

Dep. Variable	Number of firms			
	(<50p)	(>50p)	(<50p)	(>50p)
ln *Dist*	–0.3536***	–0.5443***	–0.4954***	–0.4774***
	(0.0573)	(0.0819)	(0.0743)	(0.0672)
Border	n/a	n/a	–0.3300	-0.1060
			(0.2440)	(0.2142)
Language	0.1747	0.7719***	0.2371***	0.3315***
	(0.1282)	(0.1938)	(0.0790)	(0.0738)
Colony	1.3362***	0.7263**	0.4838***	0.3913***
	(0.1330)	(0.2360)	(0.0651)	(0.0608)
RTA	0.5152***	–0.2478	0.0628	–0.1443
	(0.1543)	(0.2291)	(0.1388)	(0.1243)
Capital (relative US)			1.8563***	1.6531***
			(0.2701)	(0.2720)
ln *GDPperc*			0.5076***	0.4968***
			(0.1232)	(0.1153)
Rule of Law			–0.0129***	–0.0136***
			(0.0031)	(0.0029)
Country FE	Yes	Yes	No	No
Sector FE	Yes	Yes	Yes	Yes
N.Observations	938	942	938	942

Notes: Dependent variables: Number of US parents with at least one affiliates in each host country-sector pair. The regressors include the natural log of the distance between U.S and the host market (ln *Dist*); a dummy for the participation of the host market in a regional trade agreement (*RTA*), a dummy of common border (*border*), common language (*language*) and whether or not the host market and U.S. had a colonial relationship (*colony*). Other controls includes the level of capital endowment (*Capital*), the natural log of GDP per capita and a measure of the institutional quality of the host country (*Rule of Law*). Robust standard errors reported in parentheses. Significance is denoted: * $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$. n/a mean not available, because a variable is collinear with country fixed effects

Table 4.3: Gravity Equation of MP (country-sector level)

Dep. Variable	MP Sales			
	(<50p)	(>50p)	(<50p)	(>50p)
ln *Dist*	–0.8568***	–0.8399***	–0.2594	–0.4007*
	(0.1601)	(0.1235)	(0.0687)	(0.2660)
Border	–0.9984**	–0.3156	–1.4844	–2.3741***
	(0.4678)	(0.7528)	(0.2231)	(0.8410)
Language	1.6716	1.1554	0.3216**	0.3004
	(1.4587)	(0.9505)	(0.0711)	(0.2294)
Colony	0.3474	1.2135**	0.5915**	–0.0531
	(1.3918)	(0.4905)	(0.0648)	(0.1904)
RTA	0.8893	1.5286**	–0.7275	1.7651*
	(1.3877)	(0.6900)	(0.1237)	(0.1896)
Capital (relative US)			1.4399***	1.8031***
			(0.2844)	(0.6635)
ln *GDPperc*			0.7646***	0.9009**
			(0.1184)	(0.4539)
Rule of Law			–0.0196**	-0.0197*
			(0.0028)	(0.0102)
Country FE	Yes	Yes	No	No
Sector FE	Yes	Yes	Yes	Yes
N.Observations	875	904	875	904

Notes: Dependent variables: foreign affiliates sales relative to parent's sales operating in each host country-sector pair. The regressors include the natural log of the distance between U.S and the host market (ln *Dist*); a dummy for the participation of the host market in a regional trade agreement (*RTA*), a dummy of common border (*border*), common language (*language*) and whether or not the host market and U.S. had a colonial relationship (*colony*). Other controls includes the level of capital endowment (*Capital*), the natural log of GDP per capita and a measure of the institutional quality of the host country (*Rule of Law*). Robust standard errors reported in parentheses. Significance is denoted: * $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$.

Table 4.4: Gravity Equation of MP (country-sector level)

Dep. Variable	Number of firms			
	(<25p)	(>75p)	(<25p)	(>75p)
ln *Dist*	–0.2780***	–0.4082***	–0.3604***	–0.2499***
	(0.0289)	(0.0479)	(0.0674)	(0.0600)
Border	n/a	n/a	–0.1449	0.1369
			(0.2123)	(0.1782)
Language	0.0830	0.3979***	0.2649***	0.3179***
	(0.2251)	(0.0976)	(0.0732)	(0.0662)
Colony	0.2217	0.4821***	0.3449***	0.2496***
	(0.2114)	(0.1272)	(0.0616)	(0.0534)
RTA	0.3339***	–0.4197***	–0.0920	–0.1666*
	(0.1089)	(0.1226)	(0.1129)	(0.1011)
Capital (relative US)			1.3084***	1.2075***
			(0.2844)	(0.2343)
ln *GDPperc*			0.3277***	0.2043**
			(0.1117)	(0.0926)
Rule of Law			–0.0080**	-0.0061***
			(0.0029)	(0.0023)
Country FE	No	Yes	No	Yes
Sector FE	Yes	Yes	Yes	Yes
N.Observations	762	780	762	780

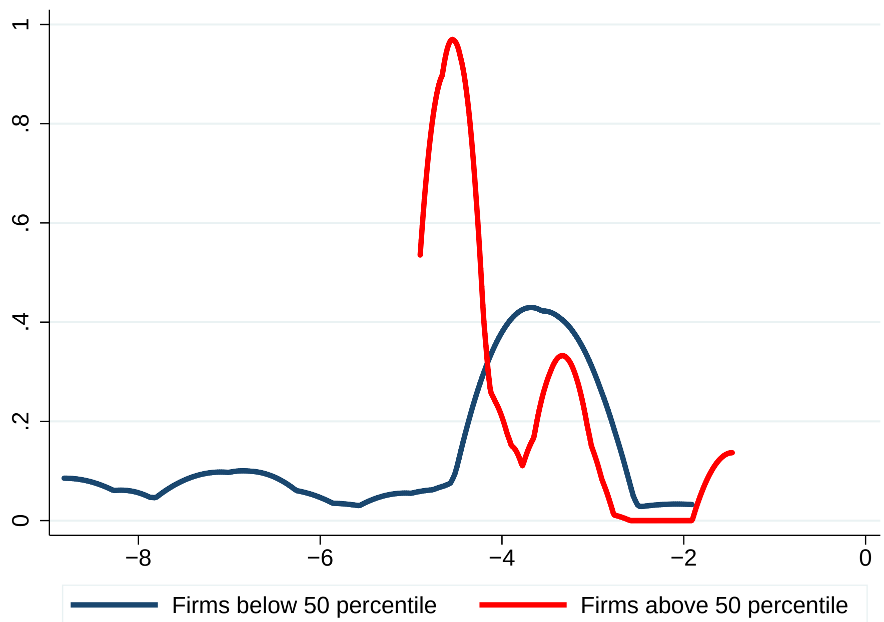
Notes: Dependent variables: Number of US parents with at least one affiliates in each host country-sector pair. The regressors include the natural log of the distance between U.S and the host market (ln *Dist*); a dummy for the participation of the host market in a regional trade agreement (*RTA*), a dummy of common border (*border*), common language (*language*) and whether or not the host market and U.S. had a colonial relationship (*colony*). Other controls includes the level of capital endowment (*Capital*), the natural log of GDP per capita and a measure of the institutional quality of the host country (*Rule of Law*). Robust standard errors reported in parentheses. Significance is denoted: * $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$. n/a mean not available, because a variable is collinear with country fixed effects

Table 4.5: Gravity Equation of MP (country-sector level)

Dep. Variable	MP Sales			
	(<25p)	(>75p)	(<25p)	(>75p)
ln *Dist*	–1.0994***	–0.7857***	–0.6170*	–0.8584***
	(0.1897)	(0.1464)	(0.3553)	(0.2971)
Border	–5.0072**	–0.2373	–1.8248	–3.4116***
	(0.2.1279)	(0.7628)	(1.2137)	(0.9378)
Language	3.8818*	1.7033	0.5525**	0.6566**
	(1.1.7287)	(1.1007)	(0.2874)	(0.2631)
Colony	2.1475	1.8609	–1.0250***	–0.0164
	(1.7119)	(1.2184)	(0.2286)	(0.2220)
RTA	2.1991	2.1108**	0.3802	1.8904***
	(1.6473)	(0.9123)	(0.6421)	(0.4956)
Capital (relative US)			1.0083***	2.5191***
			(0.9921)	(0.7881)
ln *GDPperc*			–0.4518	1.1348**
			(0.5731)	(0.5132)
Rule of Law			0.0083**	–0.0318***
			(0.0146)	(0.0114)
Country FE	No	Yes	No	No
Sector FE	Yes	Yes	Yes	Yes
N.Observations	703	753	703	753

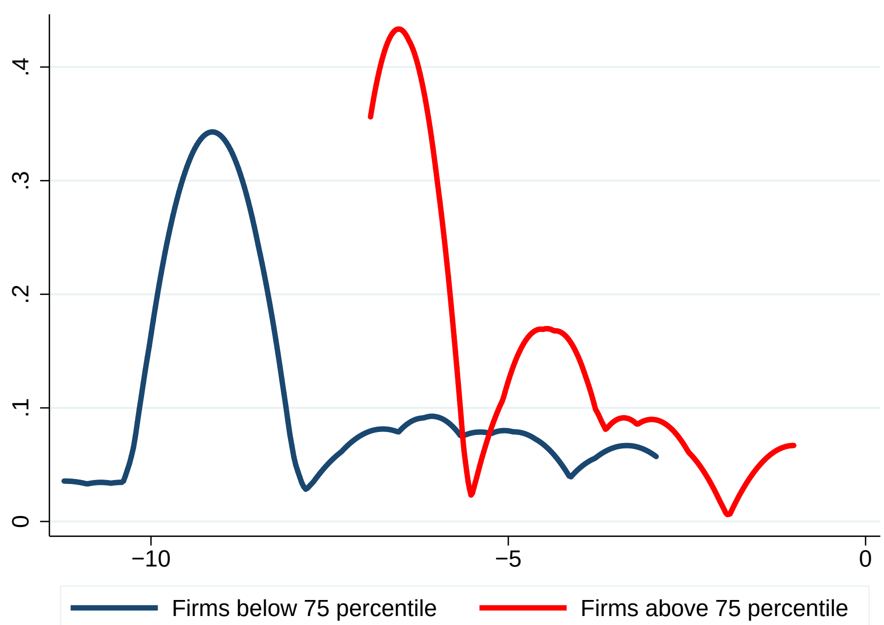
Notes: Dependent variables: foreign affiliates sales relative to parent's sales operating in each host country-sector pair. The regressors include the natural log of the distance between U.S and the host market (ln *Dist*); a dummy for the participation of the host market in a regional trade agreement (*RTA*), a dummy of common border (*border*), common language (*language*) and whether or not the host market and U.S. had a colonial relationship (*colony*). Other controls includes the level of capital endowment (*Capital*), the natural log of GDP per capita and a measure of the institutional quality of the host country (*Rule of Law*). Robust standard errors reported in parentheses. Significance is denoted: * $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$..

Figure 4.7: Distribution of Estimated MP Cost



Notes: This figures shows the combined effect of gravity variables on MP sales for firms below and above the median in each country-sector pair. For each country sector-pair and firm group in the sample we compute the following equation:
$\widehat{\tau}^{mp}_{i,us} = \widehat{\beta}_d \times lndist_{i,us} + \widehat{\beta}_b \times border_{i,us} + \widehat{\beta}_{language} \times lan_{i,us} + \widehat{\beta}_{RTA} \times RTA_{i,us} + \widehat{\beta}_c \times colony_{i,us}$

Figure 4.8: Distribution of Estimated MP Cost



Notes: This figures shows the combined effect of gravity variables on MP sales for firms below the 25th percentile and those firms above the 75th percentile in each country-sector pair. For each country sector-pair and firm group in the sample we compute the following equation:
$\widehat{\tau}^{mp}_{i,us} = \widehat{\beta}_d \times lndist_{i,us} + \widehat{\beta}_b \times border_{i,us} + \widehat{\beta}_{language} \times lan_{i,us} + \widehat{\beta}_{RTA} \times RTA_{i,us} + \widehat{\beta}_c \times colony_{i,us}$

4.8 Appendix A: Proofs

Lemma IV.1: *The elasticity of marginal cost of composite intermediate input with respect to trade costs* τ_{ni} *is increasing in firm's productivity* φ. *For* $\varphi^1 > \varphi^2$, $\varepsilon^{MC}(\tau_{ni}, \varpi, \varphi^1) > \varepsilon^{MC}(\tau_{ni}, \varpi, \varphi^2) > 0$.

Proof. The proof is based on Keller and Yeaple (2013). By contradiction method, assume that $\varepsilon^{MC}(\tau_{ni}, \varpi, \varphi^1) < \varepsilon^{MC}(\tau_{ni}, \varpi, \varphi^2)$. Then,

$$\int_{\tilde{z}}^{\infty} \beta(z|\varphi^1)dz \int_0^{\tilde{z}} \beta(z|\varphi^2)t(z)^{1-\eta}dz < \int_{\tilde{z}}^{\infty} \beta(z|\varphi^2)dz \int_0^{\tilde{z}} \beta(z|\varphi^1)t(z)^{1-\eta}dz. \tag{4.27}$$

Without loss of generality we set $\varpi = 1$. By definition, if $\beta(z|\varphi)$ is log-supermodular in z and α, then for $z' > z''$,

$$\beta(z'|\varphi^1)\beta(z''|\varphi^2)t(z)^{1-\eta} > \beta(z'|\varphi^2)\beta(z''|\varphi^1)t(z)^{1-\eta}. \tag{4.28}$$

Integrate with respect to z'' over $[0, z')$ and with respect to z' over $[z', \infty)$, and replace z' with $\tilde{z}$ we get

$$\int_{\tilde{z}}^{\infty} \beta(z|\varphi^1)dz \int_0^{\tilde{z}} \beta(z|\varphi^2)t(z)^{1-\eta}dz > \int_{\tilde{z}}^{\infty} \beta(z|\varphi^2)dx \int_0^{\tilde{z}} \beta(z|\varphi^1)t(z)^{1-\eta}dz \tag{4.29}$$

Contradiction □

Lemma IV.2: *let* $\theta(\tau_{ni}, \varphi, \varpi)$ *be the share of imported inputs* $M(\tau_{ni}, \varphi, \varpi)$ *in total composite intermediate input costs* $TC(\tau_{ni}, \varphi, \varpi)$. *Then,* $\theta(\tau_{ni}, \varphi, \varpi) = \frac{M(\tau_{ni},\varphi,\varpi)}{T(\tau_{ni},\varphi,\varpi)} = \varepsilon^{MC}(\tau_{ni}, \varphi, \varpi)$ *is i) increasing in* φ, *ii) the import cost share is declining in trade costs for all firms, and iii) the rate of decline in the import cost share is slower in the more knowledge intensive firms.*

Proof. Part i) follows immediately Lemma IV.1. For part two, the elasticity of $\theta(\tau_{ni}, \varphi)$

with respect to τ_{ni} is given by (w.l.o. $\partial t(z)/\partial\tau = 1$)

$$\xi_{\theta,\tau} = -(\eta-1)(1-\theta(\tau,\varphi)) - \frac{\partial\tilde{z}(\tau)}{\partial\tau}\frac{\beta(z|\varphi)\tau}{\int_{\tilde{z}(\tau)}^{\infty} b(z|\varphi)dz} < 0. \tag{4.30}$$

The third part is implied by the monotone likelihood ratio property: $\frac{\beta(z|\varphi^i)}{\int_{\tilde{z}}^{\infty}\beta(z|\varphi^1)dx} < \frac{\beta(z|\varphi^2)}{\int_{\tilde{z}}^{\infty}\beta(z|\varphi^2)dz}$, and $\theta(\tau,\varphi^1) > \theta(\tau,\varphi^2)$ □

Proposition IV.1: *There exists a productivity cutoff* φ_{ni}^{int} *such that*

$$\mathcal{I}(\varphi) = \begin{cases} 1 & \textit{if} \quad \varphi \geq \varphi_{ni}^{int} \\ 0 & \textit{otherwise} \end{cases}$$

That is, only the most productive foreign affiliates in country n engage in intrafirm trade with their parents (import intermediate inputs form their parents).

Proof. An affiliate chooses to import from its parent if,

$$\varphi^{\sigma-1}B_n\left[\Delta C_{ni}^M(\tau_{ni},\mathcal{I}(\varphi),\varphi,\varpi)\right] \geq w_i f_{ni}^{int}, \tag{4.31}$$

The first term in the left hand side of the equation above $\varphi^{\sigma-1}$ is increasing in φ. The second term $\Delta C_{ni}^M(\tau_{ni},\mathcal{I}(\varphi),\varphi,\varpi) \equiv C_{ni}^M(\tau_{ni},\mathcal{I}(\varphi)=1,\varphi)^{1-\sigma} - C_{ni}^M(\tau_{ni},\mathcal{I}(\varphi)=0,\varphi)^{1-\sigma}$ is also increasing in φ. Notice that $C(\mathcal{I}=0,\varphi^1) > C(\mathcal{I}=0,\varphi^2)$,[50] whereas $C(\tau=1,\mathcal{I}=1,\varphi^1) = C(\tau=1,\mathcal{I}=1,\varphi^2)$. By Lemma IV.1, $\varepsilon^{MC}(.,\varphi^1) > \varepsilon^{MC}(.,\varphi^2)$, then moving from no intra-firm trade to importing any fraction of intermediate inputs from parents yields larger saving in the cost of producing the intermediate composite input for the higher knowledge-intensive firm (more productive). □

Proposition IV.2: *Country i foreign affiliate sales (conditional on opening an affiliate) in country n,* $r_{ni}^{aff}(\varphi)$ *are decreasing in trade costs* τ_{ni}. *Let* $\varepsilon_{ni}^r(\varphi,\tau_{ni}) < 0$ *be the elasticity of*

[50] Notice that $C(\mathcal{I}=0,\varphi) = \bar{t} = \int_0^{\infty}\beta(z|\varphi)t(z)^{1-\eta}dz$, which is indeed increasing in φ under the assumptions about $\beta(z|\varphi)$ and $t(z)$.

affiliate sales with respect to trade costs, then the absolute value of $\varepsilon^r_{ni}(\varphi, \tau_{ni})$ *is increasing in* φ*. In words, the sales of more knowledge intensive firms (affiliates) are more sensitive to trade costs. That is,* ***FDI-Gravity*** *is more pronounce for more knowledge intensive parents-affiliates.*

Proof. Notice that

$$\varepsilon^r_{ni}(\varphi, \tau_{ni}, \mathcal{I}) = (1-\sigma)\varepsilon^{MC}_{ni}(\varphi, \tau_{ni}, \mathcal{I}) \tag{4.32}$$

The proof then follows immediately from the properties of $\varepsilon^{MC}_{ni}(\varphi, \tau_{ni}, \mathcal{I})$. Moreover, when $\mathcal{I} = 0$, as explained in the text $\bar{t}$ is increasing with τ_{ni}. Thus the proof is complete. □

4.9 Appendix B: Detail Derivations

Dividends per share s: In the text we claim that $s = \frac{\sigma-1}{\sigma(\kappa-1)+1}$. Let Π_n be the aggregate profits of all firms in country n, including foreign affiliates profits,

$$\Pi_n = \sum_{i=1}^{N} J_n \left\{ \int_{\varphi_{in}}^{\varphi^{fdi}_{in}} \pi_{in}(\varphi) dG(\varphi) + \int_{\varphi^{fdi}_{in}}^{\varphi^{int}_{in}} \pi^{fdi}_{in}(\varphi) dG(\varphi) + \int_{\varphi^{int}_{in}}^{\infty} \pi^{int}_{in}(\varphi) dG(\varphi) \right\}, \tag{4.33}$$

and $\varphi^{fdi}_{nn} = \varphi^{int}_{nn} = \infty$. The domestic/export profits, non-importer foreign affiliates profits and importer affiliates profits are denoted by $\pi_{in}(\varphi), \pi^{fdi}_{in}(\varphi)$, and $\pi^{int}_{in}(\varphi)$, respectively. Using the functional forms of the profits, the Pareto distribution, the cutoffs' equations and integrating, we get

$$\Pi_n = \frac{\sigma-1}{\sigma\kappa} \sum_{i=1}^{N} R_{in} + R^{fdi}_{in} + R^{int}_{in} \tag{4.34}$$

R_{in}, R^{fdi}_{in} and R^{int}_{in} denote the values of the aggregate sales of exporting to country i, the aggregate foreign affiliates sales-who do not import-, and the importer aggregate affiliate sales, respectively. Indeed, $R^{fdi}_{nn} = R^{int}_{nn} = 0$. Let Π denote the world aggregate profits:

$\Pi = \sum_{n \in N} \Pi_n$, then

$$\Pi = \frac{\sigma - 1}{\sigma\kappa} \sum_{n \in N} \sum_{i \in N} R_{in} + R_{in}^{fdi} + R_{in}^{int} \tag{4.35}$$
$$= \frac{\sigma - 1}{\sigma\kappa} Y \tag{4.36}$$

Here, Y is the world total sales/expenditures. World's total profits Π is also given by the dividends per share times the total number of shares. Thus, $\Pi = \sum_{n \in N} sL_n = \frac{\sigma-1}{\sigma\kappa} Y = \frac{\sigma-1}{\sigma\kappa} \sum_{n \in N} L_n(1+s)$, where the last equality follows from balanced trade and the fact that $X_n = L_n + \Pi_n = L_n + sL_n$. Then,

$$s = \frac{\Pi}{\sum_{n \in N} L_n} = \frac{\sigma - 1}{\sigma\kappa}(1+s)$$
$$\rightarrow s = \frac{\sigma - 1}{\sigma(\kappa - 1) + 1}$$

Derivation of Gravity Equations

Aggregate exports from country i to country n is given by[51]

$$X_{ni} = J_i \int_{\varphi_{ni}}^{\varphi_{ni}^{fdi}} \sigma \varphi^{\sigma-1} \left(\mu X_n / P_n^{1-\sigma}\right) \tau_{ni}^{1-\sigma} dG(\varphi) \tag{4.37}$$

Evaluating the integration, using the formula for the aggregate price level, and substituting out the cutoffs and $J_i = X_i/(1+s)$, we obtain the gravity equation derived in the text. Similarly, non-importer affiliates' aggregate sales and importer affiliates' aggregate sales can by expressed by

$$X_{ni}^{fdi} = J_i \int_{\varphi_{ni}^{fdi}}^{\varphi_{ni}^{int}} \sigma \varphi^{\sigma-1} \left(X_n / P_n^{1-\sigma}\right) \left[\tau_{ni}^{\alpha} exp(\phi)\right]^{1-\sigma} dG(\varphi) \tag{4.38}$$

$$X_{ni}^{int} = J_i \int_{\varphi_{ni}^{int}}^{\infty} \sigma \varphi^{\sigma-1} \left(X_n / P_n^{1-\sigma}\right) \left(exp(\phi(1 - \tau_{ni}^{\frac{\alpha-1}{\phi}}) + \alpha \ln)\right)^{1-\sigma} dG(\varphi) \tag{4.39}$$

[51] Notice that we do not include the intrafirm export in the total exports. It is easy to show that total intrafirm exports is constant share of the importer total affiliates sales.

Using the same steps as before, we get the gravity equations for non-importer affiliates' sales and importer affiliates' sales.

FDI- Gravity: Affiliates who do not import from parents:

In the text we claimed that the sales of non-importer decrease in trade frictions; equation (4.22). In order to prove this formally we use our analysis of the intensive/extensive margin. Remember that we can disentangle the impact of trade costs on affiliates' sales into the intensive and the extensive margins;

$$\xi_{X^{fdi},\tau} = \overbrace{\alpha(1-\sigma)}^{\text{Intensive margin}} + \overbrace{\frac{\kappa-(\sigma-1)}{(\varphi_{ni}^{fdi})^{\sigma-1-\kappa}-(\varphi_{ni}^{int})^{\sigma-1-\kappa}}\left[\xi_{\varphi^{int},\tau}(\varphi_{ni}^{int})^{\sigma-1-\kappa}-\xi_{\varphi^{fdi},\tau}(\varphi_{ni}^{fdi})^{\sigma-1-\kappa}\right]}^{\text{Extensive margin}} \tag{4.40}$$

The extensive margin is negative if and only if, $\xi_{\varphi^{fdi},\tau}(\varphi^{fdi})^{\sigma-1-\kappa} > \xi_{\varphi^{int},\tau}(\varphi^{int})^{\sigma-1-\kappa}$. This will be the case if, $\frac{\alpha C^M(.,\mathcal{I}=0)^{1-\sigma}-\tau^{1-\sigma}}{\varepsilon^{MC}C^M(.,\mathcal{I}=1)^{1-\sigma}-\alpha C^M(.,\mathcal{I}=0)^{1-\sigma}} > \left(\frac{f_{ni}^{fdi}-f_{ni}}{f_{ni}^{int}}\right)^{(1-\sigma)(\sigma-1-\kappa)}\left(\frac{C_{2ni}}{C_{1ni}}\right)^{(1-\sigma)(\sigma-1-\kappa)}$. For FDI cutoff be well defined, we require $f_{ni}^{int} > (f_{ni}^{fdi}-f_{ni})\frac{C_{2ni}}{C_{1ni}}$. If f_{ni}^{int} is way larger than the last term then the last term of the previous inequality becomes very small and approaches zero as $f_{ni}^{int} \to \infty$. Therefore, there exists $f_{ni}^{int} < \infty$ such that the extensive margin is negative. If this condition does not hold, all what we need to have FDI-gravity is $-\frac{\xi_{\varphi^{int},\tau}(\varphi_{ni}^{int})^{\sigma-1-\kappa}-\xi_{\varphi^{fdi},\tau}(\varphi_{ni}^{fdi})^{\sigma-1-\kappa}}{\varphi_{ni}^{fdi})^{\sigma-1-\kappa}-(\varphi_{ni}^{int})^{\sigma-1-\kappa}} < \frac{\alpha(\sigma-1)}{\kappa-(\sigma-1)}$, which is easily satisfied for reasonable parameter values. If either of these two conditions is satisfied, FDI sales must be negatively correlated with trade frictions.

Derivation of the marginal cost of intermediate input composite: equation (4.12)

$$C_{ni}^M(\tau,\phi,\mathcal{I}) = \begin{cases} \tau^{\alpha}\exp\left\{\int_0^{\infty}\frac{1}{\phi}exp(-z/\phi)zdz\right\} & \text{if} \quad \mathcal{I}=0 \\ \exp\left\{\int_0^{\tilde{z}}\frac{1}{\phi}exp(-z/\phi)(\alpha\ln\tau+z)dz+\ln\tau\int_{\tilde{z}}^{\infty}\frac{1}{\phi}exp(-z/\phi)dz\right\} & \text{if} \quad \mathcal{I}=1 \end{cases} \tag{4.41}$$

Integrating by parts and substituting out $\tilde{z}=(1-\alpha)\ln\tau_{ni}$, the required results are obtained.

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