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The Asymmetric Effects of Tariffs on Intra-Firm Trade and Offshoring Decisions

Federico J. Díez

Abstract:

This paper studies the effects of tariffs on intra-firm trade. Building on the Antràs and Helpman (2004) North-South theoretical framework, I show that higher Northern tariffs reduce the incentives for outsourcing and offshoring, while higher Southern tariffs have the opposite effects. I also show that increased offshoring and outsourcing imply an increase in the ratio of Northern intra-firm imports to total imports, which is an empirically testable prediction. Using a highly disaggregated dataset of U.S. (the North) imports and relevant tariffs, I find robust evidence to support the model's predictions.

Keywords: intra-firm trade, offshoring, outsourcing tariffs

JEL Classifications: F10, F23, L22, L23

Federico J. Díez is an economist at the Federal Reserve Bank of Boston. His e-mail address is federico.diez@bos.frb.org.

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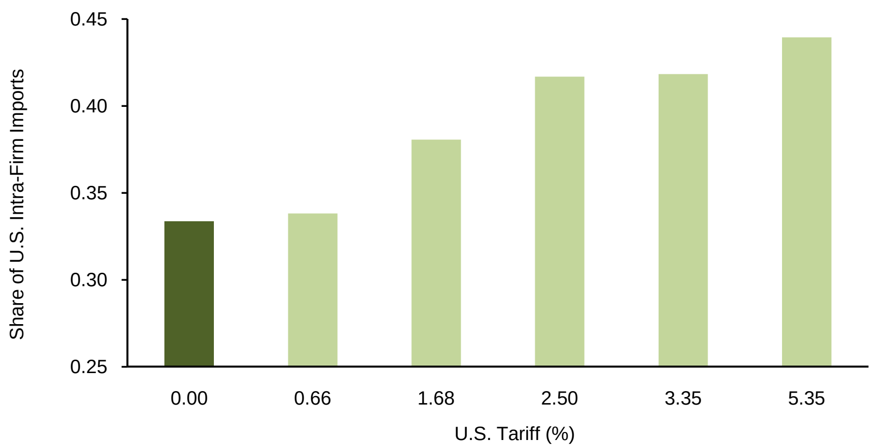
1 Introduction

International trade and foreign direct investment are among the fastest growing economic activities (Helpman, 2006). At the heart of these phenomena is offshoring—the movement of production activities overseas.[1] Offshoring always involves international trade, but these trade flows can take two forms: if an offshoring firm is vertically integrated it engages in intra-firm trade, while if the offshoring firm decides to outsource (to work with an independent supplier) it engages in arm's-length trade. It is very important to have a good understanding of this because almost half of U.S. imports take place within the boundaries of multinational firms. Indeed, during the period from 2000 to 2006, intra-firm imports accounted, on average, for 48.4% of total imports. In this paper, I explore two novel features about U.S. intra-firm imports.

First, U.S intra-firm imports depend positively on U.S. tariffs; that is, U.S. industries with low tariffs show relatively less intra-firm imports than industries with higher tariffs. Figure I provides some graphical evidence for this fact. Industries were clustered in bins according to the tariff values, using U.S. data averaged over the period 2000–2006. As the figure confirms, there is a positive relationship between U.S. tariffs and the share of U.S. intra-firm imports.

Figure I: Share of U.S. Intra-Firm Imports and U.S. Tariffs



Source: Author's calculations.

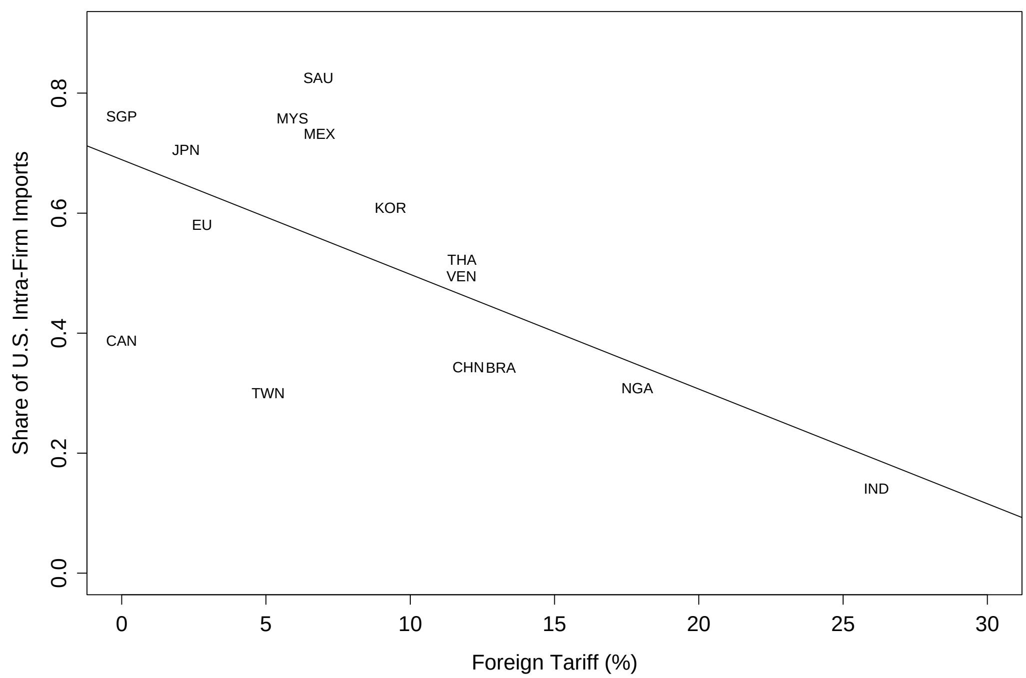
Notes: "Share of U.S. Intra-Firm Imports" is the average ratio of intra-firm imports to total U.S. imports of the respective bin. HS6 industries were assigned to bins according to the U.S. tariff. The dark column contains all industries with a tariff equal to zero (42% of the total). The rest of the sample was divided in quintiles; each light column plots the average share of intra-firm imports for the corresponding quintile. The average tariff value for each quintile is reported at the bottom of the horizontal axis. All data is averaged over the period 2000–2006. See Appendix B for further details.

Second, U.S. intra-firm imports depend negatively on *foreign* tariffs. In other words, U.S.

[1] Feenstra and Hanson (1996) report evidence in favor of increased offshoring for the United States.

imports originating from countries that impose relatively high tariffs include a smaller fraction of intra-firm imports than those coming from countries with lower tariffs. Figure II provides some informal evidence of this fact, using data averaged over 2000–2006. For each of the top-15 U.S. trading partners, I plot the average tariff imposed on U.S. products against the average share of intra-firm imports into the U.S. imports originated from that particular country. The figure shows that there is a clear negative relationship between the tariffs and the share of intra-firm imports.[2]

Figure II: Share of U.S. Intra-Firm Imports and Foreign Tariffs



Source: Author's calculations.

Notes: "Foreign Tariff" is the tariff imposed on U.S. exports by the top 15 countries averaged across industries and over 2000–2006. "Share of U.S. Intra-Firm Imports" is the ratio of intra-firm imports to total U.S. imports for the top 15 countries averaged over 2000-2006. See Appendix B for country codes and further details.

In this paper I develop a theoretical framework to rationalize these facts and I empirically test its implications.[3] In particular, I extend the Antràs and Helpman (2004) North-South model of international trade with incomplete contracts.

Like Antràs and Helpman (2004), in my model the production of a good requires the joint work of two individuals, an entrepreneur and a manager. Entrepreneurs (all located in the North) choose whether to contact an agent in the North or in the South—that is, to produce domestically or to offshore. Regardless of this geographical decision, entrepreneurs also decide

[2]These countries account for 85% of U.S. imports. The negative relationship remains even after removing India (somewhat of an outlier), and Saudi Arabia, Venezuela, and Nigeria (oil-supplying countries).

[3]At this point, one might be concerned about an omitted variable bias driving these facts. As explained below, I tackle these issues in the section on econometric estimation.

if the agent is going to be part of the firm (an employee) or an independent supplier—that is, to vertically integrate or to outsource. For each decision there is a trade-off: (i) the North has lower fixed costs but the South has lower variable costs; (ii) outsourcing requires lower fixed costs than vertical integration but the entrepreneur's *ex-post* share of the surplus is lower. Given the corresponding fixed costs for each organizational form, firms optimally sort based on their own productivity and on the headquarter (HQ) intensity of the industry (meaning, the relative importance of activities like design, research and development, and so on, in the firm's production function). For HQ-intensive industries, the main focus of this paper, four kinds of organizational choices may exist in equilibrium. High-productivity firms offshore production while low-productivity firms assemble domestically—additionally, within each group, low-productivity firms outsource and high-productivity firms integrate.

There are with two major differences between my model and the Antràs and Helpman (2004) framework. First, I explicitly incorporate tariffs into the model. Second, I model offshoring as the foreign sourcing of *assembly services*, whereas in the Antràs and Helpman model offshoring corresponds to the foreign sourcing of inputs.[4] More specifically, I assume that each entrepreneur is in possession of a critical input, such as a blueprint. The entrepreneur then contacts a manager to process the input into a final good. It follows that hiring a Southern manager (i.e., offshoring) implies that the production of final goods will move from North to South.[5] Hence, in contrast to Antràs and Helpman, in my model final goods can be produced in either country.

The following points summarize the main theoretical. A tariff imposed by the North on final goods (i) decreases the market share of offshoring firms, and (ii) decreases the relative market share of outsourcing firms versus vertically integrated firms in *both* countries. Intuitively, the tariff protects firms that assemble in the North and, critically, the tariff's impact is particularly important among firms that are marginally indifferent between vertically integrating in the North and outsourcing in the South. When firms choose the latter option, it is because the variable costs are sufficiently lower in the South to justify the higher fixed costs and lower surplus shares. The tariff, however, increases the variable costs thus causing more firms to lean towards integration in the North. Conversely, a tariff on final goods imposed by the Southern government has the opposite effects: it increases the market shares of offshoring and of outsourcing firms. The Southern tariff works in the opposite direction to the Northern one—it protects those firms assembling in the South, especially those that are marginally indifferent between integrating in the North and outsourcing in the South.

I derive two testable implications from the theory. If offshoring increases (meaning, if there

[4] I use this alternative definition of offshoring for two reasons. First, offshoring the assembly of final goods is less stringent in terms of data requirements when studying the effects of U.S and foreign tariffs. Specifically, it suffices to observe final-good trade flows between countries at the industry-level; in contrast, offshoring of inputs requires matching intermediate goods imports to final goods exports using firm-level data. Second, while offshoring of inputs is a fast-growing phenomenon (see Yeats, 2001), I find that for the United States, offshoring of the assembly of final goods is at least as dynamic an activity.

[5] One can think of this as the overseas assembly activities reported by Swenson (2005) or the export-processing activities in China reported by Feenstra and Hanson (2005).

are more Northern firms producing in the South) Northern imports will increase. Similarly, if there is relatively more vertical integration than outsourcing, the composition of imports will change, with relatively more intra-firm trade and less arm's-length trade. Consequently, the above theoretical predictions can be mapped to empirical predictions about the ratio of intra-firm imports to total imports. In particular, Northern (Southern) tariffs cause the ratio of Northern intra-firm imports to total imports to increase (decrease)—Figure I (Figure II) reflects precisely this idea. Intuitively, Northern (Southern) tariffs decrease (increase) total offshoring but, as explained above, imports due to offshore-vertical-integration decrease (increase) relatively less than imports due to offshore-outsourcing. I test these predictions using highly disaggregated data for the United States (the North) for the period from 2000 to 2006.

The empirical findings provide support for these implications of my theory. In particular, I find that: (i) higher U.S. tariffs increase the ratio of American intra-firm imports to total American imports; and (ii) higher foreign tariffs decrease this ratio. In the relevant subsample of the data, the mean of the ratio is 44% (29% if I include those observations where the ratio is zero). Using this subsample, I find that a 1-percentage point increase in the American tariff is associated with a 1-percentage point increase in the ratio, while a 1-percentage point increase in the foreign tariff implies a 0.3 percentage point decrease in the ratio.

These results hold across several econometric specifications. First, I consider a simple OLS regression of the share of intra-firm imports to total imports on U.S. tariffs, foreign tariffs, and country, industry, and time fixed effects. Next, I show that by relaxing the linearity assumption with quadratic or cubic terms, I obtain similar results. In addition, I show that the results still hold when I control for other variables which the literature has identified as possibly affecting this ratio. These include country-specific variables like capital and human capital abundance, and industry-specific variables like capital- and skill-intensity and transport costs. Moreover, these results are strengthened when I focus the analysis on those industries that are particularly well-suited for overseas assembly: apparel, electronic accessories, electrical machinery, and transport equipment and parts. To address possible complications deriving from the fact that in roughly one-third of the observations, the ratio takes a value of zero, I run two robustness checks: (i) quantile estimation, and (ii) selection correction (parametrically and semi-parametrically). Finally, I indirectly account for the location of component production by exploiting the fact that, in case of offshoring, only the value added abroad is subject to the U.S. tariff. In all of these cases, the data shows strong support for the model's predictions.

The paper is related to a burgeoning empirical literature on the determinants of intra-firm trade. For instance, Antràs (2003) finds that the ratio of intra-firm imports to total imports depends positively on the industry's capital intensity and on the country's capital abundance. Yeaple (2006) finds that capital and R&D intensity as well as productivity dispersion have a positive effect on intra-firm imports. Nunn and Trefler (2007, 2008) confirm the findings of Antràs and of Yeaple, and find evidence that improved contracting may also increase the share of intra-firm imports.[6] Bernard et al. (2008) emphasize the role of the degree of product contractibility.[7]

A handful of recent papers, albeit with setups and goals very different from this paper, also explicitly explore the link between trade liberalization and firms' organizational choices. Ornelas and Turner (2009) develop a model with incomplete contracts in which firms decide to outsource or to insource production, and whether or not to offshore. Their model shows that the welfare effects of tariffs depend on firms' organizational forms, specifically, on the different hold-up problems that arise with each organizational choice. Ornelas and Turner (2008) present a partial equilibrium model where tariffs on inputs aggravate the international hold-up problem. Their model is able to generate non-linear responses of trade flows to lower trade costs, a feature found in the data. Antràs and Staiger (2010) study the Nash equilibrium and internationally efficient trade policy choices of governments in an incomplete-contract environment, in order to understand the implications of offshoring for the design of international trade agreements. Among other differences with my paper, none of these other studies perform an empirical test of the theoretical implications.[8]

The rest of the paper is organized as follows. Section 2 develops the theoretical model. First, I present a slightly modified version of the basic framework of Antràs and Helpman (2004). Next, I introduce tariffs (first Northern, then Southern) into that setting and explore their effects. Section 3 presents my empirical work. First, I describe the testable implications of the theory and the dataset. Second, I present the estimates under several specifications. Finally, Section 4 concludes by outlining how this paper's findings might be further explored.

2 Theory

2.1 Basic Model

In this subsection I review the basic features of the Antràs and Helpman (2004) model to facilitate introducing tariffs in the following subsections. At the same time, I reinterpret the activities of the different agents in such a way that offshoring is now of final goods (and no longer of intermediate inputs). Within this subsection, where the model includes no trade costs, this exercise is just a relabeling of the Antràs and Helpman model. However, with the introduction of tariffs, this modification is shown to have an important effect on the theoretical predictions delivered by the model I propose.

The world is composed of two countries, the North and the South. The world is populated by a unit measure of consumers; a fraction γ of them live in the North while the remaining $(1-\gamma)$ are located in the South.

[6] This last prediction is derived from Antràs and Helpman (2008).

[7] Corcos et al. (2009) and Kohler and Smolka (2009) also look into the determinants of intra-firm trade using data sets of French and Spanish firms, respectively.

[8] Conconi, Legros, and Newman (2009) also study the effects of trade liberalization on organizational choices, although in a setting quite different from the present one.

There are two kinds of goods, homogeneous and differentiated. A homogeneous good, labeled x_0, is used as a numeraire. Additionally, there are J industries producing differentiated goods $x_j(i)$.

Consumers throughout the world share the same Dixit-Stiglitz preferences represented by the utility function

$$U = x_0 + \frac{1}{\mu}\sum_j X_j^{\mu}, \tag{1}$$

where $\mu \in (0,1)$ and $X_j \equiv \left[\int x_j(i)^{\alpha} di\right]^{\frac{1}{\alpha}}$ is the aggregate consumption index for sector j, with $\alpha \in (0,1)$. As usual in the literature, it is assumed $\alpha > \mu$, which implies that the varieties of goods produced within a sector are more substitutable for each other than for x_0 or $x_k(i)$, $k \neq j$. It follows that a differentiated product has inverse demand given by

$$p_j(i) = x_j(i)^{\alpha-1} P_j^{\frac{\alpha-\mu}{1-\mu}}, \tag{2}$$

where $p_j(i)$ is the price of good $x_j(i)$ and $P_j \equiv \left[\int p_j(i)^{\frac{\alpha}{\alpha-1}} di\right]^{\frac{\alpha-1}{\alpha}}$ is the aggregate price index of industry j.

Labor is the only factor of production. To get one unit of x_0, the North requires one unit of labor while the South needs $1/w > 1$ units of labor. It is assumed that the labor supply is sufficiently large in both countries so that, in equilibrium, the homogeneous good is produced at both locations. It follows that the Northern wages will be higher than the Southern ones: $w^N > w^S = w$.

The production of a differentiated good requires the cooperation of two types of agents: an entrepreneur (E) and an assembly manager (A). Entrepreneurs are only located in the North while managers can be found in both countries. Antràs and Helpman (2004) assume that the manager provides an input needed by the entrepreneur, and that the entrepreneur then assembles the input into a final good. Therefore, in their model all final good production takes place in the North. By contrast, I assume that the entrepreneur provides headquarter services $h_j(i)$ (blueprints, or design of the variety i) while the manager supplies assembly services $a_j(i)$. Thus, in my model, final goods assembly can occur either in the North or the South. Both entrepreneur and manager need one unit of labor to get one unit of $h_j(i)$ and $a_j(i)$, respectively.

In order to actually produce $x_j(i)$ an entrepreneur must follow the procedure described below.

First, he pays a fixed entry cost f_E of Northern labor units. Then, he draws a productivity level θ from a known distribution function $G(\theta)$. With this information he decides whether to remain in or to exit the market. If he decides to stay in the market, he will combine the specifically tailored inputs $h_j(i)$ and $a_j(i)$. In particular, the production function will be given by

$$x_j(i) = \theta_i \left(\frac{h_j(i)}{\nu_j}\right)^{\nu_j} \left(\frac{a_j(i)}{1-\nu_j}\right)^{1-\nu_j}, \tag{3}$$

where $\nu_j \in (0,1)$ measures the relative (industry) headquarter (HQ) intensity or, using Helpman (2006) terminology, the contractual input intensity.

Next, the entrepreneur must make two simultaneous decisions: (1) to contact a type A agent in either the North (N) or the South (S); (2) to decide whether to insource (V) or outsource (O) the assembly of the final goods. Both decisions taken together determine each firm's *organizational form.*

There are different fixed costs associated with each organizational form and all are denominated in terms of Northern labor. Thus, $w^N f_k^l$ is the fixed cost associated with a firm that conducts assembly at location $l \in \{N, S\}$ and has ownership structure $k \in \{V, O\}$. Antràs and Helpman (2004) assume that

$$f_V^S > f_O^S > f_V^N > f_O^N. \tag{4}$$

Equation (4) implies that offshoring and vertically integrating production are associated with higher fixed costs than assembling in the North and outsourcing, respectively. In other words, establishing assembly activities abroad generates higher fixed costs than producing domestically. Likewise, the additional managerial activities outweigh any potential economies of scope from integration.

Each entrepreneur E offers a contract in order to attract a manager A. The contract specifies a fee (positive or negative) that must be paid by A—the goal of the fee is to satisfy A's participation constraint at the lowest possible cost. Since there is an infinitely elastic supply of A agents, the manager's profits (net of the participation fee) are equal, in equilibrium, to the outside option.

Contracts are incomplete: E and A cannot sign *ex-ante* any enforceable contract specifying $h(i)$ and $a(i)$, but rather they bargain over the relationship's *ex-post* surplus. Bargaining is Nash-type and the entrepreneur's bargaining weight is equal to $\beta \in (0,1)$ of the resulting revenue. The revenue of firm i is given by $R_j(i) = p_j(i)\, x_j(i)$ or[9]

$$R_j(i) = P_j^{\frac{\alpha-\mu}{1-\mu}} \theta^\alpha \left(\frac{h_i}{\nu_j}\right)^{\nu_j \alpha} \left(\frac{a_i}{1-\nu_j}\right)^{\alpha(1-\nu_j)}. \tag{5}$$

One must consider each agents' outside options in order to determine the bargaining outcome. Each manager has an outside option of zero because his work $a(i)$ is specially customized for manufacturing the product $x(i)$. Likewise, entrepreneurs have an outside option of zero if the organizational form chosen is one that uses outsourcing. In contrast, under vertical integration, each E has property rights over the work of the managers. Thus, the entrepreneur can fire the manager and seize the production. However, without A's cooperation, E will only

[9] It is assumed that trade occurs costlessly.

get a fraction $\delta^l \in (0,1)$ of the output—thus, his outside option is $\left(\delta^l\right)^\alpha R(i)$.[10] It follows that the *ex-post* bargaining shares will be the following:

$$\beta_V^N = (\delta^N)^\alpha + \beta\left[1-(\delta^N)^\alpha\right] \geq \beta_V^S = (\delta^S)^\alpha + \beta\left[1-(\delta^S)^\alpha\right] > \beta_O^N = \beta_O^S = \beta. \tag{6}$$

For any given organizational form (l,k), the entrepreneur chooses $h(i)$ to maximize $\beta_k^l R(i) - w^N h(i)$ while the manager chooses $a(i)$ to maximize $\left(1-\beta_k^l\right) R(i) - w^l a(i)$. Solving these two problems, one finds the operating profits of a firm whose manager is at location l and has ownership structure k,[11]

$$\pi_k^l(\theta, P, \nu) = \Psi_k^l(P)^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}}\theta^{\frac{\alpha}{1-\alpha}} - f_k^l w^N, \tag{7}$$

where

$$\Psi_k^l(\nu) = \frac{1-\alpha\left[\beta_k^l\nu + (1-\beta_k^l(1-\nu)\right]}{\left[\frac{1}{\alpha}\left(\frac{w^N}{\beta_k^l}\right)^\nu\left(\frac{w^l}{1-\beta_k^l}\right)^{1-\nu}\right]^{\frac{\alpha}{1-\alpha}}}. \tag{8}$$

Each entrepreneur's problem is to choose the optimal organizational form. Analogously, the problem is to select one of the four triplets $\left(\beta_k^l, w^l, f_k^l\right)$ for $l \in \{N,S\}$ and $k \in \{V,O\}$. It is clear from equation (7) that profits are decreasing in both w^l and f_k^l. However, it is unclear how profits depend on β. As explained by Antràs and Helpman (2004), there is a $\beta^*(\nu) \in [0,1]$ that is the optimal surplus share that an entrepreneur would chose (*ceteris paribus*) if there were a continuum of possible organizational forms. This optimal share $\beta^*(\nu)$ is increasing in ν, reflecting the fact that *ex-ante* efficiency requires that a larger share of the revenue must be given to the party undertaking the relatively more important activity. However, since each entrepreneur chooses from among only four values of β, he will pick the pair $\{l,k\}$ that is closest to the ideal β^*. Given $\beta^*(0) = 0$ and $\beta^*(1) = 1$ we have that

$$\begin{array}{lll} \text{Low } \nu \text{ (close to 0):} & \beta^*(\nu) < \beta_O^N = \beta_O^S = \beta < \beta_V^S \leq \beta_V^N & \Rightarrow \quad \frac{\partial}{\partial\beta}\pi(\cdot) < 0, \\ \text{High } \nu \text{ (close to 1):} & \beta^*(\nu) > \beta_V^N \geq \beta_V^S > \beta_O^N = \beta_O^S = \beta & \Rightarrow \quad \frac{\partial}{\partial\beta}\pi(\cdot) > 0. \end{array}$$

In this paper, I am interested in those sectors with relatively high HQ intensity. Thus, I make the following assumption.

Assumption 1. *Throughout the paper I assume that ν is high, so profits depend positively on E's bargaining share: $\frac{\partial}{\partial\beta}\pi(\cdot) > 0$.*[12]

[10] Additionally, Antràs and Helpman assume $\delta^N \geq \delta^S$, reflecting that the lack of agreement is more costly to the entrepreneur when the manager is located in the South.

[11] Hereafter, I drop the j subscripts.

[12] In the case where ν is "low," outsourcing always dominates vertical integration—the only types of firms that may exist in equilibrium are (N,O) and (S,O). Hence, the ratio of intra-firm imports to total imports, the object I study on the empirical section, will always be zero. This means that, according to the theory for the low-ν case, *any* regressor, including tariffs, that attempts to explain the share of intra-firm imports should be insignificant. Nunn and Trefler (2008b), focusing on the effects of productivity dispersion on the share of intra-firm trade, find supportive evidence of this broader prediction: while for high-ν industries they obtain significant estimates, for low-ν industries their estimates are not statistically significant.

This means that in a relatively HQ-intensive sector (with high ν), if there were no other cost/benefit differences among the four organizational forms, the entrepreneur would choose to integrate production in the North. However, since there actually are other differences in costs and benefits among the different forms, the optimal choice of $\{l, k\}$ will depend on the firm specific productivity parameter θ.[13]

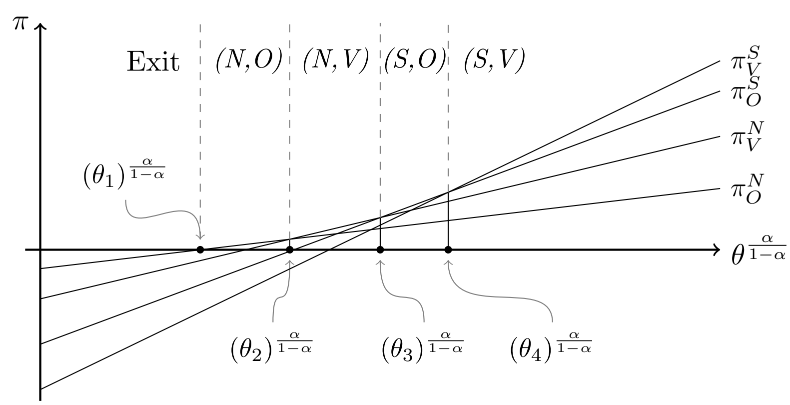
Equilibrium. Antràs and Helpman (2004) show that all four possible organizational forms may occur in equilibrium. The analysis follows from the alternative profits given by equation (7). First, note that profits are linear in $\theta^{\frac{\alpha}{1-\alpha}}$, with the slope equal to $\Psi_k^l P^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}}$. Next, note that π_O^l is flatter than π_V^l for both N and S. In contrast, it is unclear whether π_V^N is steeper or flatter that π_O^S. The reason for this ambiguity is two-fold. On the one hand, (N, V) gives the entrepreneur a larger surplus share, which makes π_V^N steeper. On the other hand, Southern wages are lower, making π_O^S steeper. To avoid this ambiguity, it is assumed that the wage differential is large relative to the difference between β and β_V^N. Specifically,

$$\left(\frac{w^N}{w}\right)^{1-\nu} > \phi(\beta_V^N, \nu)/\phi(\beta, \nu) \tag{9}$$

where $\phi(\gamma, \nu) \equiv \{1 - \alpha[\gamma\nu + (1-\gamma)(1-\nu)]\}^{(1-\alpha)/\alpha}\gamma^{\nu}(1-\gamma)^{1-\nu}$. When this condition is satisfied, the following ordering holds:

$$\Psi_V^S(\nu) > \Psi_O^S(\nu) > \Psi_V^N(\nu) > \Psi_O^N(\nu). \tag{10}$$

Figure III: Profit lines from Equation (7)



Using this fact (see Table I and Figure III) it follows that the least productive firms—those

[13] A free-entry condition, equating the expected profits of a potential entrant to the fixed entry cost, closes the model. Specifically,

$$\int_{\theta_1(P)}^{\infty} \pi(\theta, P, \nu) dG(\theta) = w^N f_E.$$

From this expression one can solve for P, and the other variables.

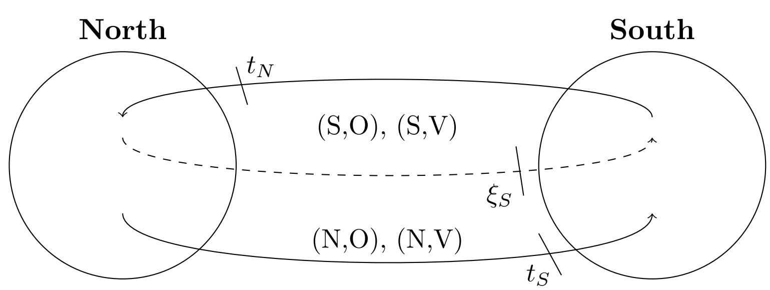
with productivities below θ_1—will immediately exit the market. Of the remaining firms, the more (less) productive ones assemble their inputs in the South (North). Within each of these two groups, those with higher θ integrate, while the others outsource.[14,15]

Table I: Organizational Form by Productivity

$\theta_i \in$	Firm-type
$(0, \theta_1)$	*Exit*
(θ_1, θ_2)	(N, O)
(θ_2, θ_3)	(N, V)
(θ_3, θ_4)	(S, O)
(θ_4, ∞)	(S, V)

Intuitively, firms with low productivity will have low levels of production and will try to reduce their fixed costs by conducting their assembly in the North. In contrast, high productivity firms will have high levels of output (and so low average fixed costs) and will therefore be more concerned in reducing their variable costs. Thus, they will conduct their assembly in the low-wage South.[16]

Figure IV: Trade Flows



Consequently, the least productive firms (those not offshoring) export differentiated final goods from the North to the South. In contrast, the more productive ones (those offshoring)

[14] It is easy to check that any of the three types $\{(N, O), (N, V), (S, O)\}$ may not exist in equilibrium. In contrast, as long as there is no upper bound in the support of $G(\theta)$, there will always be firms choosing (S, V). Moreover, if in any equilibrium there is more than one type, firms are going to sort in the way described above.

[15] To guarantee that all four types will exist in equilibrium one needs $\theta_1 < \theta_2 < \theta_3 < \theta_4$. This requires $\frac{f_O^N}{\Psi_O^N} < \frac{f_O^N - f_V^N}{\Psi_O^N - \Psi_V^N} < \frac{f_V^N - f_O^S}{\Psi_V^N - \Psi_O^S} < \frac{f_O^S - f_V^S}{\Psi_O^S - \Psi_V^S}$.

[16] In equilibrium, all firms engage in international trade, a feature already found in Antràs and Helpman (2004). This is somewhat counterfactual, especially in the case of the least productive firms (see Bernard et al., 2007). The model delivers this prediction because there are no fixed export costs: when a firm chooses to produce, it faces two demands (Northern and Southern) but the fixed cost needs to be incurred only once. The inclusion of a fixed export cost would greatly affect the model's tractability. Moreover, within the "new" trade literature, some papers model features like "only some firms are exporters" while others model the internalization decision. To the best of my knowledge, there is no paper dealing with both, although this is clearly an important direction for future research.

export differentiated final goods from the South to the North and blueprints (or, more generally, inputs) from the North to the South. Figure IV represents these international trade flows, with the solid lines representing final goods and the dashed line representing the flows in inputs (the homogeneous good, not in the figure, will keep trade balanced). Additionally, one can see that different tariffs will affect the firms in any given industry in an asymmetric fashion. If the Northern government decides to impose a tariff t_N on the imports of differentiated goods it will (directly) affect only the offshoring firms, (S,V) and (S,O). Similarly, if the Southern government imposes a tariff t_S on their imports of differentiated goods, the (N,V) and (N,O) firms will be the ones directly affected. In the following two sections I study precisely the effects of these policies.[17,18]

2.2 Northern Tariffs

Suppose the Northern government imposes a tariff t_N ($\tau_N \equiv 1+t_N$) on the imports of differentiated goods assembled in the South. For simplicity, assume that the Southern government follows a free trade policy: $t_S = 0$.[19]

The tariff creates a *wedge* between both markets. Consequently, Northern and Southern aggregate prices (P_N and P_S, respectively) will differ.

As shown in the Appendix, the profit functions of those firms producing in the North will be the following:

$$\begin{aligned}\pi_k^N(i) &= \left((1-\gamma)\,P_S^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}} + \gamma P_N^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}}\right)\Psi_k^l \theta_i^{\frac{\alpha}{1-\alpha}} - f_k^N w^N \qquad (11)\\ &= \mathcal{A}\Psi_k^l \theta_i^{\frac{\alpha}{1-\alpha}} - f_k^N w^N,\end{aligned}$$

where $\mathcal{A} \equiv \left((1-\gamma)\,P_S^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}} + \gamma P_N^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}}\right)$ and $k \in \{O,V\}$.

Likewise, offshoring firms will have the following profit functions:

$$\begin{aligned}\pi_k^S(i) &= \left((1-\gamma)\,P_S^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}} + \gamma P_N^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}}\tau_N^{\frac{1}{\alpha-1}}\right)\Psi_k^l \theta_i^{\frac{\alpha}{1-\alpha}} - f_k^S w^N \qquad (12)\\ &= \mathcal{B}\Psi_k^l \theta_i^{\frac{\alpha}{1-\alpha}} - f_k^S w^N,\end{aligned}$$

[17] If h referred to intermediate goods (and not just blueprints), these could be subject to tariffs like ξ_S in Figure IV (whose theoretical effects of ξ_S would be analogous to those of t_N). Additionally, if a final good produced in the South contains Northern inputs, it could be that only a fraction of its value would be subject to t_N. Given my dataset, I am not able to perform the ideal experiment: to attribute intermediate goods to a particular final good. Thus, my empirical work cannot handle the effects of Southern tariffs on inputs. However, in Section 3.4.3, I am able to (indirectly) take into account the second fact just mentioned.

[18] Although transport costs would have a similar effect to tariffs, I focus on tariffs because they are naturally asymmetric across counties, while this might not be the case for transport costs. Nonetheless, I do take transport costs into account in my empirical work. Additionally, Baier and Bergstrand (2001) find evidence for OECD countries that the impact of tariff decreases on the growth of trade has been three times the impact of lower transport costs.

[19] All the results still hold if both tariffs are positive, although the algebra becomes more complicated.

where $\mathcal{B} \equiv \left((1-\gamma) P_S^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}} + \gamma P_N^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}} \tau_N^{\frac{1}{\alpha-1}} \right)$ and $k \in \{O, V\}$.

From the above equations it is clear that profits are still linear in $\theta^{\frac{\alpha}{1-\alpha}}$. Firms performing assembly in the North will have profit functions with slope equal to $\mathcal{A}\Psi_k^N$, while offshoring firms will have profit functions with slope $\mathcal{B}\Psi_k^S$. Comparing $\mathcal{A}$ and $\mathcal{B}$, it is clear that the tariff will affect the slope of the profit lines of offshoring firms relative to non-offshoring firms. Indeed, while profits of all firms will depend positively on both aggregate prices, those firms performing assembly in the South will get only a fraction $\tau_N^{\frac{1}{\alpha-1}} < 1$ of the profits that are attributable to Northern sales. In other words, while non-offshoring firms will receive the full price paid by Northern consumers, offshoring firms will keep only a fraction: the price net of the tariff t_N.

From these four profit functions, I obtain four expressions for the cutoffs as functions of the tariff and both aggregate prices:[20]

$$\begin{aligned} \pi_O^N = 0 \ &\Rightarrow \theta_1(P_N, P_S, \tau_N) = \left[\frac{w^N f_O^N}{\Psi_O^N} \frac{1}{\mathcal{A}} \right]^{(1-\alpha)/\alpha} \\ \pi_O^N = \pi_V^N &\Rightarrow \theta_2(P_N, P_S, \tau_N) = \left[\frac{w^N (f_O^N - f_V^N)}{(\Psi_O^N - \Psi_V^N)} \frac{1}{\mathcal{A}} \right]^{(1-\alpha)/\alpha} \\ \pi_O^S = \pi_V^N &\Rightarrow \theta_3(P_N, P_S, \tau_N) = \left[\frac{w^N (f_V^N - f_O^S)}{(\Psi_V^N \mathcal{A} - \Psi_O^S \mathcal{B})} \right]^{(1-\alpha)/\alpha} \\ \pi_O^S = \pi_V^S &\Rightarrow \theta_4(P_N, P_S, \tau_N) = \left[\frac{w^N (f_O^S - f_V^S)}{(\Psi_O^S - \Psi_V^S)} \frac{1}{\mathcal{B}} \right]^{(1-\alpha)/\alpha} . \end{aligned} \tag{13}$$

Additionally, both aggregate prices P_N and P_S are related. Specifically, as I show in the Appendix, these can be expressed in the following way:

$$P_S^{\frac{\alpha}{\alpha-1}} = P_N^{\frac{\alpha}{\alpha-1}} + \left(1 - \tau_N^{\frac{\alpha}{\alpha-1}}\right) \left(\rho_O^S \left[V(\theta_4) - V(\theta_3) \right] + \rho_V^S \left[V(\infty) - V(\theta_4) \right] \right), \tag{14}$$

where $\rho_k^l = \left[\alpha \left(\frac{\beta_k^l}{w^N} \right)^{\nu} \left(\frac{1-\beta_k^l}{w^l} \right)^{1-\nu} \right]^{\frac{\alpha}{1-\alpha}}$ and $V(\theta) \equiv \int_0^\theta \theta'^{\frac{\alpha}{1-\alpha}} g(\theta') d\theta'$.

From equation (14) it is clear that when $\tau_N = 1$ (free trade) the two aggregate prices are equal. However, in the presence of a Northern tariff, these indices will differ because offshoring firms (those with productivities above θ_3) will face a tariff when selling in the Northern market: Southern prices will be lower than Northern prices. The second term of equation (14) captures this idea.

Finally, a free entry condition, stating that expected profits must be equal to the fixed

[20] To guarantee, at least initially, that all four types of firms exist in equilibrium, one needs

$$0 < \theta_1 < \theta_2 < \theta_3 < \theta_4.$$

This equilibrium requires the following conditions: $\frac{f_O^N}{\Psi_O^N \mathcal{A}} < \frac{f_O^N - f_V^N}{(\Psi_O^N - \Psi_V^N)\mathcal{A}} < \frac{f_V^N - f_O^S}{\Psi_V^N \mathcal{A} - \Psi_O^S \mathcal{B}} < \frac{f_O^S - f_V^S}{(\Psi_O^S - \Psi_V^S)\mathcal{B}}$.

entry cost, closes the model. It may be written as

$$w^N f_E = \int_{\theta_1}^{\theta_2} \pi_O^N g(\theta)\, d\theta + \int_{\theta_2}^{\theta_3} \pi_V^N g(\theta)\, d\theta + \int_{\theta_3}^{\theta_4} \pi_O^S g(\theta)\, d\theta + \int_{\theta_4}^{\infty} \pi_V^S g(\theta)\, d\theta. \tag{15}$$

2.2.1 Effects on Cutoffs

From the above discussion, it is apparent that I have a system of six equations (13-15) and six unknowns: θ_1, θ_2, θ_3, θ_4, P_N, and P_S. My interest is in how the tariff t_N affects the firms' decisions; that is, what is the effect of t_N on the productivity cutoffs?

Small Tariffs. For simplicity, I will first focus the analysis locally around free trade, that is, when the original trade policy is $t_N = 0$. In my dataset, the relevant variation seems to be centered around free trade. Indeed, in the subset used for my estimations, the Northern tariff has a median of 0 and a mean of 0.8%; likewise, the Southern tariff has a median of 0 and a mean of 5.5%. Hence, the theoretical analysis around free trade seems especially relevant given these features of my dataset. Nevertheless, I extend the analysis to consider the large-tariff case below.

Replacing the expressions for profits, cutoffs, and prices in the free entry condition (15), I can evaluate the effects of t_N. I summarize these effects in the following proposition.

Proposition 1. *In the benchmark case, for any differentiable distribution function $G(\cdot)$, if the Northern government previously maintained a free trade policy ($t_N = 0$) and then imposes a small tariff $t_N > 0$ on the Northern imports of Southern differentiated goods, it will have the following effects:*

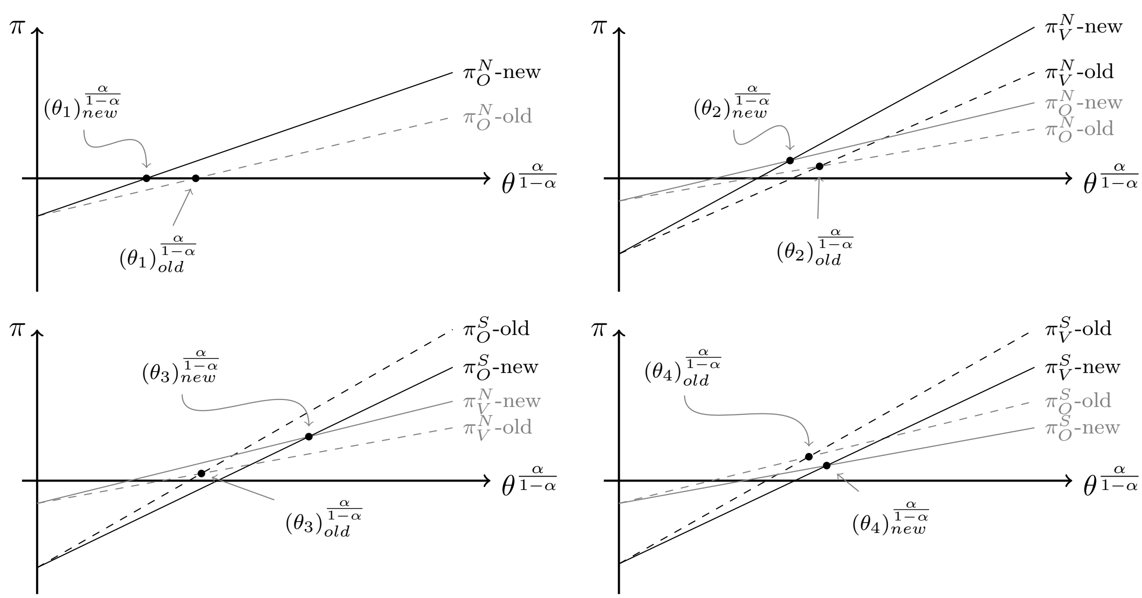
1. *Cutoffs θ_1 and θ_2 will decrease.*
2. *Cutoffs θ_3 and θ_4 will increase.*
3. *The Northern aggregate price P_N will increase.*

Proof. See Appendix. ■

Intuitively, this policy *protects* the firms producing domestically in the North. Thus, there is a decrease in the minimum productivity required to be either a (N, O) or (N, V) firm. At the same, the tariff *hurts* offshoring firms by restricting their access to the Northern market. Consequently, the least productive firms within (S, O) and (S, V) will have to reorganize as (N, V) or (S, O) firms. Finally, as expected, the tariff also increases the aggregate prices payed by consumers in the North.

Figure V presents a graphical representation of Proposition 1. The tariff t_N protects those firms producing in the North, making their profit lines steeper and, therefore, reducing the cutoffs θ_1 and θ_2. In contrast, the tariff t_N restricts the access of offshoring firms to the Northern market, reducing the slope of their profit functions, thus increasing the cutoffs θ_3 and θ_4.

Figure V: Effects of t_N



Large Tariffs. Higher values of the tariff t_N would reinforce this process: further increases of t_N will cause offshoring firms' profits to decrease and non-offshoring firms' profits to increase. Hence, the productivity cutoffs will react to the tariff t_N in the same way as in the locally-around-free-trade case.

Proposition 2. *In the benchmark case, for any differentiable distribution function $G(\cdot)$, an increase of the tariff t_N imposed on the Northern imports of Southern differentiated goods will have the following effects:*

1. *Cutoffs θ_1 and θ_2 will decrease.*

2. *Cutoffs θ_3 and θ_4 will increase.*

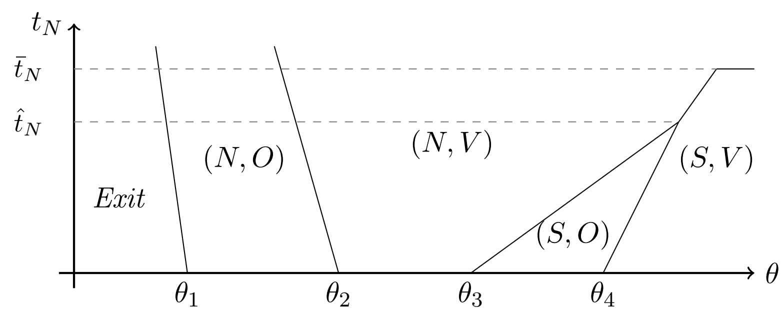
Proof. See Appendix. ■

Recall that the benchmark-case equilibrium with four different kinds of firms requires $0 < \theta_1 < \theta_2 < \theta_3 < \theta_4$. It is straightforward to check that $0 < \theta_1 < \theta_2$ for any (finite) value of t_N. Thus, there will always be firms choosing to organize as (N, O) and (N, V).

However, provided that the number of consumers in the North, γ, is large relative to the wage differential, there will be a prohibitive tariff level, $\bar{t}_N$, such that no firm will offshore whenever $t_N \geq \bar{t}_N$. Intuitively, if the tariff is very large and there are "enough" consumers in the North, no firm will find it profitable to exploit the wage differential by offshoring because of the "lost" sales in the Northern market. Graphically, this means that the profit function π_V^N

is now steeper than π_V^S: hence, (N, V) is always preferred to (S, V).[21] Moreover, this implies that π_V^N is also steeper than π_V^S. Since π_V^S is steeper than π_O^S, there will also exist a tariff level $\hat{t}_N < \bar{t}_N$ such that for all tariffs $t_N > \hat{t}_N$, (N, V) is always preferred to (S, O).[22]

Figure VI: Cutoffs as a function of t_N



To sum up, the magnitude of the tariff t_N will determine the outcome of the industry equilibrium as shown in Figure VI.[23] Indeed, high values of t_N will allow for only two kinds of firms, (N, O) and (N, V). Thus, if the Northern tariff is sufficiently high, there will be no offshoring and, hence, no Northern imports of differentiated goods. As t_N starts decreasing, however, the most productive firms will find offshoring profitable and some (S, V) firms will appear: for this relatively high range of t_N, Northern imports of differentiated goods will appear, and these will only involve intra-firm transactions. Finally, for even lower values of t_N, as more firms decide to offshore assembly, an increasing fraction of these will organize as (S, O), resulting in the benchmark case equilibrium. Here, the share of Northern imports of differentiated goods that is intra-firm will be strictly less than one.

2.2.2 Effects on Market Shares

If I specify a particular distribution function for the productivities of the firms, then I am able to measure tariff's effects on each organizational form's market share.

Following the literature (see Antràs and Helpman 2004; Helpman, Melitz, and Yeaple

[21] Formally, this requires $\frac{\Psi_V^N}{\Psi_V^S} > \frac{\mathcal{B}}{\mathcal{A}}$. The left-hand side (LHS) of the inequality is fixed while its right-hand side (RHS) is decreasing in t_N – in the appendix I show that $\frac{d\mathcal{A}}{dt_N} > 0$ and $\frac{d\mathcal{B}}{dt_N} < 0$. Thus, if the LHS of the inequality, which depends on w^S/w^N, is sufficiently high, there is a tariff level beyond which the inequality always holds.

[22] For tariffs $t_N \in (\hat{t}_N, \bar{t}_N)$, high-productivity firms will organize as (S, V) and less productive firms will organize as either (N, O) or (N, V). Whenever this is the case, there will be a new cutoff θ_3' originating from the intersection of π_V^N and π_V^S.:

$$\theta_3' = \left[\frac{w^N(f_V^N - f_V^S)}{(\mathcal{A}\Psi_V^N - \mathcal{B}\Psi_V^S)}\right]^{(1-\alpha)/\alpha}.$$

From the previous analysis, this new cutoff θ_3' will increase with t_N.

[23] In general, the movements of the cutoffs with respect to t_N will not be linear.

2004), suppose that θ is Pareto distributed:

$$G(\theta) = 1 - \left(\frac{b}{\theta}\right)^z,$$

where z is the shape parameter of the function and assumed to be large enough so that the variance is finite. Then, the distribution of firm sales is also Pareto, with shape parameter $z - \frac{\alpha}{1-\alpha}$.

Define σ_k^l as the market share of firms that produce at location l and have ownership structure k. Making use of the expressions for the cutoffs, one can compute these shares as follows:

$$\begin{aligned}
\sigma_O^N &= \left[V(\theta_2) - V(\theta_1)\right]\mathcal{A}\rho_O^N(v)/R(v) \\
\sigma_V^N &= \left[V(\theta_3) - V(\theta_2)\right]\mathcal{A}\rho_V^N(v)/R(v) \\
\sigma_O^S &= \left[V(\theta_4) - V(\theta_3)\right]\mathcal{B}\rho_O^S(v)/R(v) \\
\sigma_V^S &= \left[V(\infty) - V(\theta_4)\right]\mathcal{B}\rho_V^S(v)/R(v),
\end{aligned}$$

where ρ_k^l, $V(\theta)$, $\mathcal{A}$ and $\mathcal{B}$ are defined as before, and

$$\begin{aligned}
R(\nu) = &\left[V\left(\theta_O^N\right) - V(\underline{\theta})\right]\mathcal{A}\rho_O^N(v) + \left[V\left(\theta_V^N\right) - V\left(\theta_O^N\right)\right]\mathcal{A}\rho_V^N(v) \\
&+ \left[V\left(\theta_O^S\right) - V\left(\theta_V^N\right)\right]\mathcal{B}\rho_O^S(v) + \left[V(\infty) - V\left(\theta_O^S\right)\right]\mathcal{B}\rho_V^S(v).
\end{aligned}$$

Proposition 3. *In the benchmark case, if $G(\cdot)$ is Pareto, the imposition of a tariff t_N on Northern imports of differentiated goods causes $\frac{\sigma_O^S}{\sigma_V^S}$, $\frac{\sigma_V^S}{\sigma_O^N}$, and $\frac{\sigma_O^N}{\sigma_V^N}$ to decrease. Hence,*

1. *total offshoring $\left(\sigma_O^S + \sigma_V^S\right)$ decreases,*

2. *outsourcing decreases relative to integration in both countries.*

Moreover, an increase in t_N decreases the sales of firms organizing as (S,O) and (S,V) (especially in Northern markets). Hence, it also decreases total imports.

Proof. See Appendix. ■

As expected, the tariff t_N decreases the market shares of offshoring firms. The effect of the tariff is particularly important for firms with mid-range productivities (firms with productivities close to θ_3). These are the firms that are on the margin between (N,V) and (S,O). They weigh higher bargaining shares, higher variable costs, and lower fixed costs in the North against lower shares, lower variables costs, and higher fixed costs in the South. A Northern tariff, from the firm's point of view, is equivalent to an increase in Southern variable costs and makes (N,V) relatively more attractive than (S,O). Thus, while overall offshoring decreases, the decrease is especially significant among firms organized as (S,O); likewise, although overall domestic assembly increases, the increase of firms organized as (N,V) is relatively greater.

With a tariff t_N, Northern imports decrease because of the lower sales of offshoring firms. However, this effect is relatively stronger in the case of outsourcing firms (see the second point of Proposition 3). Therefore, arm's-length imports decrease relatively more than intra-firm imports. I summarize this in the following corollary.

Corollary. *The ratio of Northern intra-firm imports to total imports increases with the Northern tariff.*

This positive relationship between the tariff and the ratio of intra-firm imports to total imports is the first prediction I test in the empirical section.

2.3 Southern Tariffs

In this subsection I assume that the North follows a free trade policy ($t_N = 0$), while the South imposes a tariff t_S ($\tau_S \equiv 1 + t_S$) on their imports of Northern differentiated goods. The analysis is analogous to the previous case.

The profit functions of those firms producing in the North will now be:

$$\begin{aligned} \pi_k^N(i) &= \left((1-\gamma) P_S^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}} \tau_S^{\frac{1}{\alpha-1}} + \gamma P_N^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}}\right) \Psi_k^S \theta_i^{\frac{\alpha}{1-\alpha}} - f_k^N w^N \\ &= \mathcal{C} \Psi_k^S \theta_i^{\frac{\alpha}{1-\alpha}} - f_k^N w^N, \end{aligned} \tag{16}$$

where $\mathcal{C} \equiv \left((1-\gamma) P_S^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}} \tau_S^{\frac{1}{\alpha-1}} + \gamma P_N^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}}\right)$ and $k \in \{O, V\}$.

Likewise,the new profit functions of offshoring firms will be:

$$\begin{aligned} \pi_k^S(i) &= \left((1-\gamma) P_S^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}} + \gamma P_N^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}}\right) \Psi_k^S \theta_i^{\frac{\alpha}{1-\alpha}} - f_k^S w^N \\ &= \mathcal{A} \Psi_k^S \theta_i^{\frac{\alpha}{1-\alpha}} - f_k^S w^N, \end{aligned} \tag{17}$$

where $\mathcal{A}$ is defined as before and $k \in \{O, V\}$.

From these profit functions, I obtain the new expressions for the cutoffs:[24]

$$\begin{aligned} \pi_O^N = 0 \ &\Rightarrow \theta_1(P_N, P_S, \tau_S) = \left[\frac{w^N f_O^N}{\Psi_O^N} \frac{1}{\mathcal{C}}\right]^{(1-\alpha)/\alpha} \\ \pi_O^N = \pi_V^N \ &\Rightarrow \theta_2(P_N, P_S, \tau_S) = \left[\frac{w^N (f_O^N - f_V^N)}{(\Psi_O^N - \Psi_V^N)} \frac{1}{\mathcal{C}}\right]^{(1-\alpha)/\alpha} \\ \pi_O^S = \pi_V^N \ &\Rightarrow \theta_3(P_N, P_S, \tau_S) = \left[\frac{w^N (f_V^N - f_O^S)}{(\Psi_V^N \mathcal{C} - \Psi_O^S \mathcal{A})}\right]^{(1-\alpha)/\alpha} \\ \pi_O^S = \pi_V^S \ &\Rightarrow \theta_4(P_N, P_S, \tau_S) = \left[\frac{w^N (f_O^S - f_V^S)}{(\Psi_O^S - \Psi_V^S)} \frac{1}{\mathcal{A}}\right]^{(1-\alpha)/\alpha}. \end{aligned} \tag{18}$$

[24] Once again, to guarantee that all four types of firms exist in equilibrium one needs $0 < \theta_1 < \theta_2 < \theta_3 < \theta_4$. This requires the following conditions: $\frac{f_O^N}{\Psi_O^N \mathcal{C}} < \frac{f_O^N - f_V^N}{(\Psi_O^N - \Psi_V^N)\mathcal{C}} < \frac{f_V^N - f_O^S}{\Psi_V^N \mathcal{C} - \Psi_O^S \mathcal{A}} < \frac{f_O^S - f_V^S}{(\Psi_O^S - \Psi_V^S)\mathcal{A}}$.

Aggregate prices are related by an expression analogous to (14) (see the Appendix for the details):

$$P_N^{\frac{\alpha}{\alpha-1}} = P_S^{\frac{\alpha}{\alpha-1}} + \left(1 - \tau_S^{\frac{\alpha}{\alpha-1}}\right) \left[\rho_O^N \left[V(\theta_2) - V(\theta_1)\right] + \rho_V^N \left[V(\theta_3) - V(\theta_2)\right]\right], \tag{19}$$

where ρ_k^l and $V(\cdot)$ are defined as before.

Absent the tariff, aggregate prices are equal. However, the second term of equation (19) shows that whenever $t_S > 0$ these aggregate prices will be different because the tariff only affects those firms producing in the North (those with productivities in the range $[\theta_1, \theta_3]$). In particular, Southern prices will be higher than Northern prices. Along the same lines, from the definition of $\mathcal{C}$, firms assembling in the North will get only a fraction $\tau_S^{\frac{1}{\alpha-1}} < 1$ of the profits that are attributable to Southern sales.

2.3.1 Effects on Cutoffs

Small Tariffs. Proceeding as in the previous subsection, I use the free entry condition in equation (15) along with equations (16-19) to evaluate how the imposition of the tariff t_S affects the cutoffs.[25]

I summarize these results in the following proposition (see the Appendix for the details).

Proposition 4. *In the benchmark case, for any differentiable distribution function $G(\cdot)$, if the Southern government previously maintained a free trade policy ($t_S = 0$), and then imposes a small tariff $t_S > 0$ on the Southern imports of Northern differentiated goods, it will have the following effects:*

1. *Cutoffs θ_1 and θ_2 will increase.*
2. *Cutoffs θ_3 and θ_4 will decrease.*
3. *The Southern aggregate price P_S will increase.*

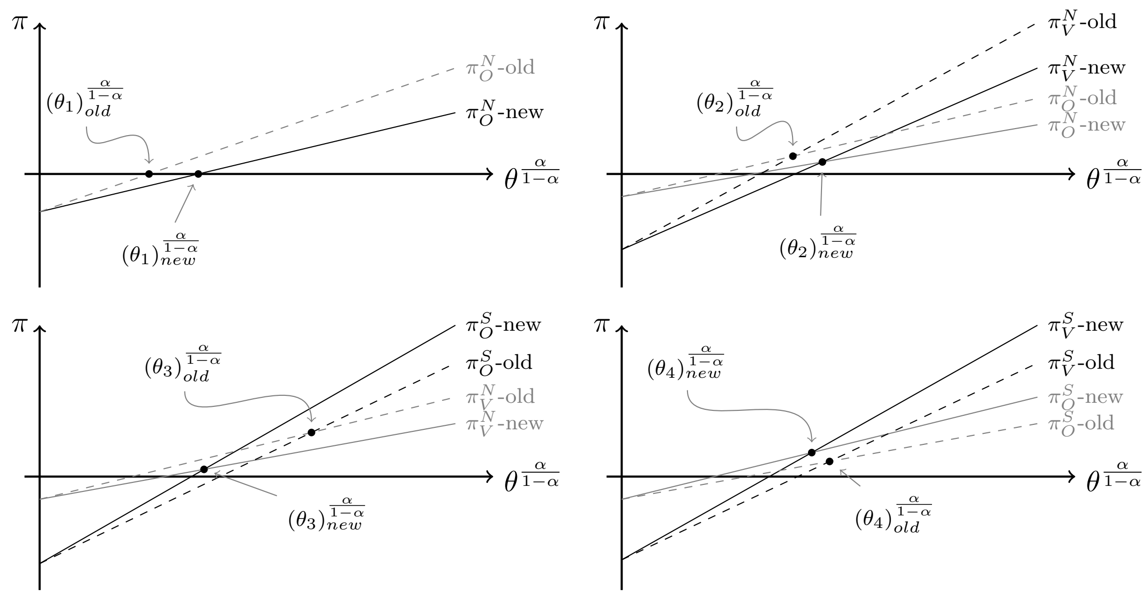
Proof. See Appendix. ■

The tariff t_S, in contrast to t_N, *hurts* the firms producing in the North and *protects* those engaging in offshoring. Thus, after t_S is imposed, profits of (N, O) and (N, V) firms decrease so that a higher productivity level is required for assembly in the North to be profitable. In contrast, the tariff increases the profits of offshoring firms (through the higher aggregate prices P_S) so a lower productivity level is needed to organize as an (S, O) or (S, V) firm.

Graphically, as seen in Figure VII, the tariff t_S reduces the slope of the profit lines of those firms producing in the North (increasing θ_1 and θ_2). Thus, some firms with productivity close to the original value of θ_1 will exit the market, while others that were (N, V) will reorganize as (N, O). Conversely, the tariff makes offshoring profit lines steeper (reducing θ_3 and θ_4).

[25] Once more, I focus the analysis locally around free trade.

Figure VII: Effects of t_S.



Therefore, firms near the old value of θ_3 will reorganize as (S, O), while those close to the original θ_4 will switch to (S, V).

Large Tariffs. High values of the tariff t_S have analogous effects to those described for t_N. Recall that the benchmark case, where there are four types of firms in equilibrium, will hold as long as the tariff is moderate.

Proposition 5. *In the benchmark case, for any differentiable distribution function $G(\cdot)$, an increase of the tariff t_S imposed on the Southern imports of Northern differentiated goods will have the following effects:*

1. *Cutoffs θ_1 and θ_2 will increase.*

2. *Cutoffs θ_3 and θ_4 will decrease.*

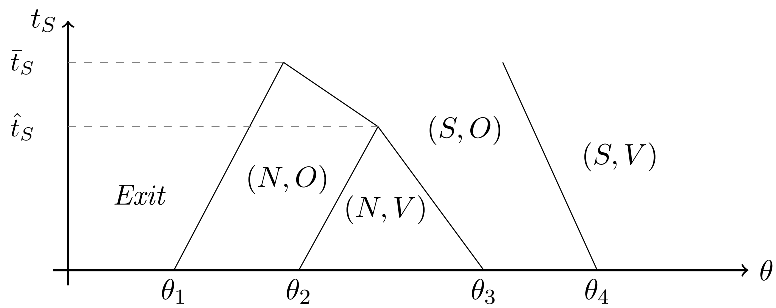
Proof. See Appendix. ■

The benchmark case requires $0 < \theta_1 < \theta_2 < \theta_3 < \theta_4$. However, as t_S increases this ordering may not be satisfied since θ_1 and θ_2 will increase while θ_3 and θ_4 will decrease.[26] Thus, there may exist a value $\hat{t}_S$ such that $\theta_3 < \theta_2$ for all $t_S \geq \hat{t}_S$ – in which case no firm will organize as (N, V). Moreover, there may also exist some other value $\bar{t}_S > \hat{t}_S$ such that $\theta_3 < \theta_1$: if $t_S \geq \bar{t}_S$ then no firm will organize as (N, O) either.[27]

[26] Graphically, with t_S the profit lines π_O^N and π_V^N become flatter while π_O^S and π_V^S become steeper.

[27] Formally, $\theta_2 < \theta_3 \Leftrightarrow \frac{f_V^N - f_O^N}{f_O^S - f_V^S} < \frac{(\Psi_V^N - \Psi_O^N)\mathcal{C}}{\Psi_O^S \mathcal{A} - \Psi_V^N \mathcal{C}}$ and $\theta_1 < \theta_3 \Leftrightarrow \frac{f_O^N}{f_O^S - f_V^N} < \frac{\Psi_O^N \mathcal{C}}{\Psi_O^S \mathcal{A} - \Psi_V^N \mathcal{C}}$. Since $\frac{d\mathcal{A}}{dt_S} > 0$ and $\frac{d\mathcal{C}}{dt_S} < 0$ (see Appendix), as t_S increases it gets harder for both conditions to be satisfied.

Figure VIII: Cutoffs as a function of t_S



In summary, the magnitude of the tariff t_S will determine the outcome of the industry equilibrium as shown in the example of Figure VIII.[28] High values of t_S will allow only two kinds of firms, (S,O) and (S,V), and no Northern production of differentiated goods. As t_S starts decreasing some (N,O) firms will appear. Finally, for even lower values of t_S, some firms will organize as (N,V), resulting in the benchmark case with four different kinds of firms in equilibrium.

2.3.2 Effects on Market Shares

Assuming again a Pareto distribution for the productivities, one can compute the market shares of each type of organizational form:

$$\begin{aligned}
\sigma_O^N &= \left[V(\theta_2) - V(\theta_1)\right] \mathcal{C} \rho_O^N(v) / R(v) \\
\sigma_V^N &= \left[V(\theta_3) - V(\theta_2)\right] \mathcal{C} \rho_V^N(v) / R(v) \\
\sigma_O^S &= \left[V(\theta_4) - V(\theta_3)\right] \mathcal{A} \rho_O^S(v) / R(v) \\
\sigma_V^S &= \left[V(\infty) - V(\theta_4)\right] \mathcal{A} \rho_V^S(v) / R(v),
\end{aligned}$$

where $V(\cdot)$, ρ_k^l, $\mathcal{A}$ and $\mathcal{C}$ are defined as before and

$$\begin{aligned}
R(\nu) = &\left[V\left(\theta_O^N\right) - V(\underline{\theta})\right] \mathcal{C} \rho_O^N(v) + \left[V\left(\theta_V^N\right) - V\left(\theta_O^N\right)\right] \mathcal{C} \rho_V^N(v) \\
&+ \left[V\left(\theta_O^S\right) - V\left(\theta_V^N\right)\right] \mathcal{A} \rho_O^S(v) + \left[V(\infty) - V\left(\theta_O^S\right)\right] \mathcal{A} \rho_V^S(v).
\end{aligned}$$

Proposition 6. *In the benchmark case, if $G(\cdot)$ is Pareto, the imposition of a tariff t_S on Southern imports of differentiated goods causes $\frac{\sigma_O^S}{\sigma_V^S}$, $\frac{\sigma_V^S}{\sigma_O^N}$, and $\frac{\sigma_O^N}{\sigma_V^N}$ to increase. Hence,*

1. *total offshoring $\left(\sigma_O^S + \sigma_V^S\right)$ increases,*
2. *outsourcing increases relative to integration in both countries.*

Moreover, an increase in t_S increases the sales from firms organized as (S,O) and (S,V) (especially in Northern markets). Hence, it increases total imports.

[28] The movements of the cutoffs with respect to t_S in general will not be linear.

Proof. See Appendix. ■

By protecting the Southern market, this policy encourages entrepreneurs to offshore (to look for Southern managers). Thus, not surprisingly, the imposition of the tariff t_S increases the market shares of offshoring firms. Again, the effect is particularly important among firms with mid-range productivities. With the tariff, these firms organize as (S, O) rather than as (N, V), and therefore increasing outsourcing relative to vertical integration.

With a higher tariff t_S, Northern imports increase because of the higher sales of the offshoring firms. However, this effect is relatively stronger for outsourcing firms (see the second point of Proposition 6). Therefore, arm's-length imports increase relatively more than intra-firm imports. I summarize this in the following corollary.

Corollary. *The ratio of Northern intra-firm imports to total imports decreases with the Southern tariff.*

The negative relation between Southern tariffs and the ratio of Northern intra-firm imports to total imports is the second prediction that I test in the following section.

3 Empirical Evidence

3.1 Testable Implications

In this section I test the main theoretical predictions from the previous section. From the Corollaries to Propositions 3 and 6, for any sector j, I expect Northern imports to behave in the following way:

$$\tilde{m} \equiv \frac{M_V}{M_V + M_O} = f(\underbrace{t^N}_{(+)}, \underbrace{t^S}_{(-)}) \tag{20}$$

where $\tilde{m}$ is the ratio of intra-firm imports to total imports in sector j, M_V are the imports due to the activity of firms that vertically integrate in the South, and M_O are the imports from firms that outsource in the South. From the theoretical discussion in the previous section, the ratio $\tilde{m}$ depends positively on Northern tariffs and negatively on Southern tariffs.

Therefore, for any particular industry, I can study how the ratio of intra-firm imports to total imports is affected by U.S. and foreign tariffs. Specifically, I will want to test whether for any final good industry with relatively *high headquarters intensity*:[29]

- Higher U.S. tariffs increase the ratio of intra-firm imports to total imports.
- Higher foreign tariffs decrease the ratio of intra-firm imports to total imports.

Next, I describe the dataset with which I will test the predictions embodied by equation (20).

[29] Recall from Assumption 1 that I focus on sectors with high HQ-intensity.

3.2 Data

3.2.1 Sources

The trade data is from the Foreign Trade Division of the U.S. Census Bureau.[30] Importers must declare whether or not the transaction is with a related party, a requirement which makes it possible to distinguish between intra-firm (related party) and arm's-length (non-related party) imports. The data are at the 6-digit level of the Harmonized System (HS) for the years 2000 through 2006.[31] The database includes imports from a group of selected countries—Canada, Mexico, China, Malaysia, Ireland, and Brazil—that are the top-six U.S. suppliers, conditional on at least two-thirds of the intra-firm imports involving a U.S. parent firm.[32] This criterion stems from the theory: I want to analyze the behavior of offshoring firms based in the United States.

Tariff data comes from the United Nation's TRAINS database. For each HS6 industry, for the period 2000–2006, I observe the tariffs "effectively applied" by the United States on American imports and by the foreign countries on their imports from the United States The "effectively applied tariff" is defined as the minimum of the most-favored nation (MFN) tariff and a preferential tariff, if the latter exists.

Finally, to measure headquarter's intensity I use the NBER productivity database put together by Bartelsman, Becker, and Gray (see Bartelsman and Gray, 1996). For each U.S. 4-digit SIC industry, the database contains information on total employment (l), non-production workers (s), and capital (k) for 1996. With this data I construct skill- (s/l) and capital-intensity (k/l) measures. I use the former as the default measure of HQ intensity since it is closer to the theoretical concept; nonetheless, I use the latter measure to check its robustness.

3.2.2 Description

Table II presents some information on intra-firm imports for 2006. Overall, American imports were \$1.8 trillion, of which \$863 billion (47%) were imported from a related party. Taken together, the countries in the sample account for (roughly) 48% of total imports and 45% of intra-firm imports.

The last column of Table II presents my variable of interest: the ratio of intra-firm imports to total imports, hereafter labeled as m. The ratio shows huge variation across countries—it ranges from 24% for China up to 89% for Ireland. Note that there is no clear factor (meaning, income or geography) determining this behavior. The two lowest ratios are from relatively poor countries (China and Brazil) but, at the same time, there are two other relatively poor

[30] I am grateful to Andy Bernard for pointing out the existence of this database to me.

[31] The data is highly disaggregated: it involves roughly 5,000 industries. This allows me to exclude those sectors that are clearly input producers (recall from the theory that the Northern country only imports final goods from the South). To do this, I exclude from the sample any HS6 sector whose definition contains the word "part" or "component." This data is available from Peter Schott's webpage and was used in Schott (2004). In the appendix I present some results for the predictions on intermediate inputs found in Díez (2006).

[32] The breakdown of related-party imports into an American or foreign parent firm is from Zeile (2003).

countries (Mexico and Malaysia) with ratios above Canada. Likewise, Canada and Mexico, neighboring countries to the United States, have relatively high ratios, while distant countries as Ireland and Malaysia have even higher values.[33]

Table II: U.S. Total and Intra-Firm Imports in 2006

Country	Intra-Firm Imports		Total Imports		Related /
	Value	Share	Value	Share	Total
Brazil	8.3	1%	26.2	1%	32%
Canada	139.5	16%	303.0	16%	46%
China	70.7	8%	287.1	16%	25%
Ireland	25.8	3%	28.9	2%	89%
Malaysia	26.3	3%	36.4	2%	72%
Mexico	114.5	13%	197.1	11%	58%
Sample	385.2	45%	878.7	48%	44%
World	862.7	100%	1,845.1	100%	47%

Note: Import values are expressed in billions of U.S. dollars.

The theoretical ratio $\tilde{m}$ and the observed ratio m are not perfectly mapped. Theoretically, the object of interest is the composition of imports due to offshoring American firms. However, the data also includes those imports due to the activities of foreign firms. For example, related party imports from China include the imports due to American firms offshoring and integrating production in China along with those imports due to the exports from Chinese firms to their subsidiaries in the United States. Hence, the observed M_{rel} related-party imports also are only a proxy for the theoretical M_V imports: $M_{rel} \geq M_V$. Likewise, the observed M_{non} non-related imports are just a proxy for the theoretical M_O imports: $M_{non} \geq M_O$.[34] More specifically, I only observe the left-hand side of the following two expressions:

$$\begin{aligned} M_{non} &= M_{non}^{US} + M_{non}^{F} \\ M_{rel} &= M_{rel}^{US} + M_{rel}^{F}, \end{aligned}$$

where M_k^{US} are those imports whose origin involves the offshoring decision of an American firm and M_k^F are those imports that do not include American offshoring, for $k \in \{non, rel\}$. Thus, the observed M_{non}^{US} corresponds to the theoretical M_O, while the observed M_{rel}^{US} corresponds to the theoretical M_V.

[33] Developed countries usually have medium-to-high ratios whereas developing countries show great variation. For example, among the tiniest exporters to the United States, on the one hand, all imports from Burma and East Timor are intra-firm; and on the other hand, almost all imports from Eritrea or Sudan are arm's-length imports. The website of the Foreign Trade Division of the U.S. Census, provides data by country and 6-digit NAICS industries.

[34] By selecting the countries I was able to (partially at least) take care of this in regards of intra-firm imports. For the countries in the sample, in the case of intra-firm imports, at least 66% of them involve an U.S. parent firm. Unfortunately, there is no way of doing something similar with the arm's-length imports.

It is possible to show that the observed ratio m and the theoretical ratio $\tilde{m}$ are equivalent when, for any industry and country, the following relation holds:

$$\frac{M_{rel}^{US}}{M_{non}^{US}} = \frac{M_{rel}^{F}}{M_{non}^{F}}. \tag{21}$$

Going back to the example of U.S. imports from China, I need to assume that when one considers the American imports from China, the ratio of related to non-related party imports is the same, whether the imports involve American or Chinese firms.[35]

Tables III and IV summarize the basic statistics of the ratio m and the tariffs by-country and by-industry, respectively.[36] There are several features to point out.

First, there are many observations where the ratio m takes a value of zero (see the fifth column on either table). Overall, 35% of the observations have $m = 0$. This holds across countries (varying from 24% of the observations for Canada to 45% for Brazil) and across industries (from 28% for HS8 to 51% for HS5). Consequently, the mean and the median are always substantially different. This is one of the reasons why I check the robustness of the conditional mean estimates (OLS) with quantile regressions.

Second, U.S. tariffs are on average lower than foreign tariffs. In fact, there are many observations where the U.S. tariffs are zero. This is true both, by-country and by-industry, where the median is usually zero. Overall, the mean of the American tariffs is 1.5% but the median is zero.

Third, the tariffs imposed by the *foreign* countries show greater variation across countries and across industries. Indeed, while Canada and Mexico usually impose zero tariffs on the United States, the rest of the countries usually impose much higher tariff values, especially China and Brazil. Likewise, across industries one observes sectors such as HS1 where the median is zero and others like HS6 where the median is 10%. Overall, these tariffs have a mean of 7.2% and a median of 2.9%.

Consequently, as will become clear in the following subsections, the inclusion of those observations with $m = 0$ will be relevant. And, at the same time, the lack of variation in the tariffs will make it hard to obtain significant estimates, especially in the case of American tariffs.[37]

[35]If the difference between the theoretical ratio $\tilde{m}$ and the observed ratio m is on average zero and is uncorrelated with the regressors, then the estimates will be unbiased. Additionally, all empirical papers based on the Antràs and Helpman (2004) framework face the same issue, so they implicitly make the same assumption.

[36]The 6-digit industries are aggregated up to the 1-digit HS. See the Appendix for a description of them.

[37]My original idea was to use primarily time-series variation to identify the effects. However, given the little variation of the tariff data, I rely mostly on the cross-sectional variation. Even if this were not so, the limited time range of my data would also be a restriction to time-series identification. Indeed, with data from 2000 through 2006, I would not be able to properly take into account the dynamic responses of firms to anticipated or unanticipated tariff changes. See Freund and McLaren (1999) for evidence of anticipatory sunk investments made to prepare for accession to a trading block.

Table III: Statistics by Country

Country	Obs.	$m(\%)$			$t^{US}(\%)$			$t^{F}(\%)$		
		mean	median	$m=0$	mean	median	sd	mean	median	sd
Brazil	10,217	0.28	0.01	0.45	1.8	0.0	6.4	14.8	15.5	5.3
Canada	21,935	0.24	0.08	0.24	0.0	0.0	0.2	0.0	0.0	0.0
China	15,074	0.11	0.01	0.38	3.7	2.9	4.3	12.1	10.0	8.0
Ireland	6,973	0.32	0.03	0.47	4.0	2.7	11.7	4.3	3.2	4.5
Malaysia	4,273	0.24	0.00	0.50	2.8	1.7	3.8	10.2	5.0	11.2
Mexico	17,050	0.38	0.19	0.30	0.2	0.0	2.8	8.0	0.0	11.0

Table IV: Statistics by Industry

HS	Obs.	$m(\%)$			$t^{US}(\%)$			$t^{F}(\%)$		
		mean	median	$m=0$	mean	median	sd	mean	median	sd
Pooled	75,522	0.26	0.05	0.35	1.5	0.0	5.2	7.2	2.9	9.1
0	1,480	0.13	0.00	0.48	1.1	0.0	3.4	6.7	0.0	13.0
1	1,926	0.20	0.01	0.46	1.3	0.0	2.8	7.3	0.0	11.8
2	8,416	0.25	0.02	0.44	1.6	0.0	12.4	4.9	2.0	7.7
3	8,899	0.33	0.14	0.29	1.3	0.0	2.2	7.0	5.0	8.0
4	6,388	0.20	0.03	0.35	0.8	0.0	2.3	7.4	3.0	8.7
5	8,065	0.15	0.00	0.51	3.4	0.0	5.1	7.9	5.0	8.9
6	7,172	0.17	0.02	0.32	3.9	0.0	5.8	11.0	10.0	11.4
7	10,493	0.26	0.06	0.31	1.0	0.0	2.2	6.7	3.0	8.1
8	17,557	0.33	0.14	0.28	0.7	0.0	1.7	6.7	1.8	8.6
9	5,126	0.29	0.09	0.29	0.9	0.0	1.9	7.4	2.0	9.2

3.3 Baseline Results

3.3.1 Simple Estimation

The theoretical predictions refer to industries with relatively high HQ intensity. The ratio of skilled workers measures how important are the the *white-collar* activities relative to the *blue-collar* activities in a given industry. Although I acknowledge this measure is not perfect, I use it as my default measure of HQ intensity.[38] Additionally, the theory does not pin down what level should be considered high. Consequently, I use the median as the default but I also check using the 25^{th} and 75^{th} percentiles as alternative cutoff values.

At the same time, from the theory we know that in sectors with high HQ intensity there should not be any observations with $m = 0$, while in sectors with low HQ intensity all observations should have $m = 0$. This provides me with a second criterion of what is a HQ-intensive sector. However, given that the observed m includes not only the imports due to offshoring U.S. firms but also the "ordinary" imports (exports of foreign firms to the United States) this

[38] Nunn and Trefler (2008a) also use this same ratio as one of their measures of HQ intensity. In a different context, this measure has also been used by Domowitz, Hubbard, and Petersen (1988).

criterion is not entirely satisfactory either.

Therefore, I have two possible ways of identifying an industry as a HQ-intensive sector. Since neither criterion is completely accurate, in this subsection I will take a relatively conservative approach and keep in the sample only those that satisfy both criteria.[39]

Definition 1. *An industry i has high HQ intensity if:*

1. *the ratio of skilled workers is above the sample median,*
   and,
2. *the observed $m_i > 0$.*

The basic estimation equation is the following:

$$m_{ict} = \beta_0 + \beta_1 \cdot t_{ict}^{US} + \beta_2 \cdot t_{ict}^{F} + \beta_3 \cdot X_{ict} + \varepsilon_{ict} \tag{22}$$

where for industry i, country c and year t, m_{ict} is the ratio of intra-firm imports to total imports, t_{ict}^{US} is the tariff applied by the United States on foreign country c, t_{ict}^{F} is the tariff applied by the foreign country on the United States, and X_{ict} is a group of controls. From the theory, I expect to find β_1 to be positive and β_2 to be negative.

Table V presents the results for different specifications. All results on the table are OLS estimates, and the standard errors are heteroskedasticity-robust. The different columns vary through alternative choices of fixed effect controls as well as the inclusion (or not) of Chinese observations. There are several things to point out.[40,41]

First and foremost, the results show strong support for the theory: the estimated β_1's are positive and significant and likewise the estimated β_2's are negative and significant. Just as the theory predicted, tariffs affect the imports of all offshoring firms but their effect is especially important among those firms that are outsourcing. Therefore, higher U.S. tariffs *hurt* all imports but especially non-related party imports. Thus, U.S. tariffs have a positive effect on the ratio of intra-firm imports to total imports. Conversely, foreign tariffs have a negative effect on the ratio.

Second, the estimates of β_1 are quite sensitive to including Chinese observations: their omission greatly increases the estimated values as well as their level of statistical significance. In contrast, the estimates for β_2 do not seem to be affected by the inclusion or omission of Chinese observations. Thus, with the full sample (including China), the absolute value of the estimates of β_1 and β_2 are similar. But when I omit these observations the magnitude of β_1 is greater than β_2, suggesting that the effect on m of changes in American tariffs is greater than the effect of changes in foreign tariffs.

[39] "Conservative" in the sense that it is *hard* to remain in the sample. Hence, I am quite confident that those industries that satisfy this criteria are indeed HQ-intensive sectors. I relax this definition in the next subsection.

[40] The software used for all the empirical work was R, version 2.6.0.

[41] The sensitivity to Chinese observations is not entirely surprising given China's particular regulations towards foreign investment (see OECD, 2006).

Table V: OLS Simple Regression

	Linear		Quadratic	
	-1-	-2-	-3-	-4-
t^{US}	0.002*	0.013***	0.005*	0.022***
	(0.001)	(0.002)	(0.003)	(0.004)
t^{F}	-0.004***	-0.004***	-0.004***	-0.004***
	(0.000)	(0.001)	(0.001)	(0.001)
Obs.	24,323	19,726	24,323	19,726
China	Yes	No	Yes	No

Notes: "***", "**" and "*" refers to statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors are heteroskedasticity-robust. All regressions include year and country fixed effects. The estimates for the quadratic model are the marginal effects $\partial m/\partial t^{US}$ and $\partial m/\partial t^{F}$.

Finally, in the last two columns, I relax the linearity assumption, and present the estimates for the case of a quadratic model. Specifically, I estimate the following equation:

$$m_{ict} = \beta_0 + \beta_1 \cdot t^{US}_{ict} + \beta_2 \cdot (t^{US}_{ict})^2 + \beta_3 \cdot t^{F}_{ict} + \beta_8 \cdot (t^{F}_{ict})^2 + \beta_5 \cdot t^{US}_{ict} \cdot t^{F}_{ict} + \beta_6 \cdot X_{ct} + \epsilon_{ict}. \quad (23)$$

The reported estimates are the marginal effects and the standard errors were obtained computing the conditional variance. Both estimates and standard errors are evaluated at the sample mean of the covariates. The estimates look very similar to those of the linear model, although I should also point out that there is an big increase in the magnitude of β_1.[42]

Overall, these results are supportive of the theory. Higher U.S. tariffs are associated with higher intra-firm import shares and higher foreign tariffs are associated to lower intra-firm import shares.

3.3.2 Estimation with industry- and country-controls

The literature has identified some other factors that might affect the behavior of the intra-firm import ratio m. Therefore, in this subsection I add to the basic equation (22) industry and country controls that have been highlighted by Antràs (2003), Yeaple (2006), Bernard, Jensen, Redding, and Schott (2008) and Nunn and Trefler (2008a).

Thus, the new estimation equation is the following:

$$m_{ict} = \beta_0 + \beta_1 \cdot t^{US}_{ict} + \beta_2 \cdot t^{F}_{ict} + \beta_3 \left(\frac{k}{l}\right)_i + \beta_4 \left(\frac{s}{l}\right)_i + \beta_5 \cdot freight_i + \beta_6 \left(\frac{K}{L}\right)_c + \beta_7 \left(\frac{H}{L}\right)_c + \beta_8 X_t + \varepsilon_{ict}, \quad (24)$$

where $\left(\frac{k}{l}\right)_i$ is industry i's log of capital intensity, $\left(\frac{s}{l}\right)_i$ is industry i's skill intensity, $freight_i$

[42] I also tried other alternatives to the linear specification such as a cubic model. The results were very similar to those reported on Table V.

is industry i's transport cost, $\left(\frac{K}{L}\right)_c$ is country c's log of capital abundance, $\left(\frac{H}{L}\right)_c$ is country c's log of human capital abundance and X_t is a year fixed effect. Again, I expect to find $\beta_1 > 0$ and $\beta_2 < 0$.[43]

Table VI: OLS Regressions with Country and Industry Controls

	Without $m = 0$		With $m = 0$	
	-1-	-2-	-3-	-4-
t^{US}	0.013***	0.029***	0.003	0.013***
	(0.004)	(0.005)	(0.003)	(0.003)
t^F	-0.003***	-0.004***	-0.002***	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
Obs.	24,263	19,678	37,100	29,478
China	Yes	No	Yes	No

Notes: "***", "**" and "*" refers to statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors clustered by (4-digit SIC Industry, Country) pairs.

The first two columns of Table VI present the results using Definition 1.[44,45] Note that the estimates have the right sign and are statistically significant. Hence, once I take into account most of the factors previously identified by the literature, the tariffs continue affecting the ratio of intra-firm imports as predicted by the theory. Moreover, the estimates are similar to those found in the previous subsection, without the inclusion the country- and industry-controls. Thus, taking the first column as the baseline results, I find that a 1-percentage point increase in the U.S. tariff is associated with a 1.3-percentage point increase in the ratio m, while a 1-percentage point increase in the foreign tariff implies a 0.3-percentage point decrease in the ratio. In the last two columns of Table VI I relax the second criterion of Definition 1: I estimate equation (24) including those observations with $m = 0$. Note that when I include these observations, the magnitude of the estimates is reduced and the estimate for the U.S. tariff loses significance. Finally, Chinese observations still affect the magnitude and significance of the U.S. tariffs estimate.

[43] Data for the country variables is from Hall and Jones (1999). The data for the freight costs is from Bernard, Jensen, and Schott (2006). Some of these papers also mention productivity dispersion as an important factor affecting m – unfortunately, I could not gain access to such data.

[44] Since the controls vary at the 4-digit SIC level or at the country level, and not at the HS6 level like the trade and tariff data, I report standard errors clustered by (4-digit SIC Industry, Country) pairs. See Nunn and Trefler (2008a) for a similar treatment of the standard errors.

[45] The estimates for the country- and industry-controls (not reported here) have the expected signs and most times are statistically significant.

3.3.3 Industries of Particular Relevance

There are certain industries that are particularly well-suited for the offshoring of some their production stages. These industries are apparel, electronic accessories, electrical machinery and transport equipment and parts. Bergin, Feenstra, and Hanson (2009) report that over 70% of the maquiladora sector in Mexico is concentrated in these four industries. As they note, these industries tend to have production stages that are physically separable, allowing multinational firms to locate assembly activities in foreign countries.

Therefore, in this subsection I focus the analysis on these four industries and compare how the previous results are modified. Specifically, I re-estimate equation (24) but using only the data for the industries mentioned above.[46] Table VII presents the results.

Table VII: OLS Regressions with Controls for Selected Industries

	Without $m = 0$		With $m = 0$	
	-1-	-2-	-3-	-4-
t^{US}	0.020***	0.040***	0.008*	0.019***
	(0.006)	(0.011)	(0.005)	(0.006)
t^{F}	-0.005***	-0.005***	-0.003***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Obs.	9,180	7,453	13,081	10,597
China	Yes	No	Yes	No

Notes: "***", "**" and "*" refers to statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors clustered by (4-digit SIC Industry, Country) pairs.

Comparing Tables VI and VII, it is clear that the data strongly support the theoretical predictions. Looking at these four industries, those that best *match* the idea of offshoring as foreign assembly, the results improve even further with respect to the previous section: the estimates increase both in magnitude and in statistical significance.

3.4 Alternative Specifications

In this subsection I explore alternatives to the baseline case. The main interest is on the sensitivity of the estimates to the inclusion or exclusion of those observations with $m = 0$. I analyze this sensitivity in two different ways. First, I present some quantile-regression estimations. Second, I address the possible selection problem of the ratio m parametrically and semi-parametrically.[47,48] Finally, in the last specification I address the issue of where the

[46] In particular, I use the data of HS sections 11, 16, 17, and 18.

[47] Given the large number of zeros (and to a much smaller degree, of ones), I also tried a Tobit estimation, taking 0 and 1 as censoring points. The results were almost exactly like the OLS estimates presented above.

[48] I also performed a difference-in-differences estimation. I took industries with no tariff changes as the control group and I had different treatment groups for those industries where the U.S. (foreign) tariff increased (decreased). The point estimates had the right sign although they were not statistically significant.

inputs are produced in an indirect way.

3.4.1 Quantile Estimation

In this subsection I depart from the linear regression model and estimate quantile regressions instead. I am interested in learning how the tariffs affect the ratio m at different parts of m's distribution. This seems particularly relevant in my case: recall that roughly one-third of the observations have $m = 0$—thus, I believe it is really important to extend the knowledge of m's response beyond the conditional mean implied by OLS regressions (Koenker and Hallock, 2001).

The new estimating equation, analogous to equation (24), is the following:

$$Q(m_{ict}|Z_{ict}) = \lambda_0 + \lambda_1 \cdot t_{ict}^{US} + \lambda_2 \cdot t_{ict}^{F} + \lambda_3 \left(\frac{k}{l}\right)_i + \lambda_4 \left(\frac{s}{l}\right)_i + \lambda_5 \cdot freight_i + \lambda_6 \left(\frac{K}{L}\right)_c + \lambda_7 \left(\frac{H}{L}\right)_c, \quad (25)$$

where $Q(m_{ict}|Z_{ict})$ is the conditional quantile function and I condition on the variables $Z_{ict} = \{t_{ict}^{US}, t_{ict}^{F}, \left(\frac{k}{l}\right)_i, \left(\frac{s}{l}\right)_i, freight_i, \left(\frac{K}{L}\right)_c, \left(\frac{H}{L}\right)_c\}$.

Table VIII shows the results of estimating equation (25) for four different quantiles of m. The algorithm used for fitting is the variant of the Barrodale and Roberts simplex algorithm described in Koenker and D'Orey (1987). Standard errors were computed through a bootstrap procedure, resampling over (SIC 4-digit Industry, country) pairs, with 500 replications. From the theory, I expect to find $\lambda_1 > 0$ and $\lambda_2 < 0$.[49]

Table VIII: Quantile Regressions with Country and Industry Controls

	Quantile:			
	$Q = 0.5$	$Q = 0.7$	$Q = 0.8$	$Q = 0.9$
t^{US}	-0.0005	0.0035	0.0080*	0.0101***
	(0.0015)	(0.0045)	(0.0047)	(0.0030)
t^{F}	-0.0005	-0.0017*	-0.0020**	-0.0010**
	(0.0004)	(0.0009)	(0.0008)	(0.0005)

Notes: "***", "**" and "*" refers to statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors obtained through bootstrap. The total number of observations was 37,100.

As can be seen from Table VIII, high-quantile estimates work better than low-quantile estimates—something expected given the mixed distribution of the observed variable m, where $m = 0$ for one-third of the observations. The estimates for λ_2 are always negative and almost always significant. In the case of λ_1, the estimate in the median regression is not significant

[49] Estimation was done using the package "quantreg" for R. The idea for the block bootstrap procedure is to take into account that the observations are not *iid* (i.e., clustering of standard errors).

and, in fact, has the opposite sign. However, for the upper quantiles, the estimated λ_1 becomes positive and significant.[50]

Overall, these results suggest that the theory finds support in the data even when looking at functionals of m's distribution. However, the median regression also indicates that the large amount of observations with $m = 0$ play a significant role.

3.4.2 Selection Model

In this subsection I address the selection problem that is likely to exist with the ratio m: intra-firm trade can only be observed if firms have established affiliates in the foreign country. I correct for selection in two ways, parametrically and semi-parametrically.

First, I estimate a two-step Heckman model. An appropriate instrument should be correlated with the fixed cost of establishing a plant in a foreign country but uncorrelated with the variable cost of sourcing from that facility. Following Bernard, Jensen, Redding, and Schott (2008), I proxy the fixed costs of a facility in country c with (i) the number of airline departures from country c in 1998, and (ii) the average cost of a three-minute phone call from country c to the United States in 1998.[51]

In the first stage of the estimation, the selection equation consists of a probit regression, in which the dependent variable is a dummy variable that equals one if there is intra-firm trade and zero otherwise. The regressors used on the selection equation are those of equations (24) and (25), with the addition of the two instruments mentioned on the previous paragraph. In the estimation's second stage, I use the inverse Mills ratio from the probit estimation and the variables from equation (24) to calculate the outcome equation.[52]

The first column of Table IX shows the results of the Heckman estimation. As expected, the probability of positive intra-firm trade is positively related to the number of airline departures and negatively related to phone call fares. Moreover, the second-stage estimates for both tariffs strongly support my theoretical predictions: higher American tariffs increase the ratio of intra-firm imports to total imports, and higher foreign tariffs decrease this ratio. In fact, the tariff estimates are similar to the baseline OLS estimates. Notice that the coefficient of the inverse Mills ratio is not significant, suggesting that there is no selection.

Next, I follow a semi-parametric approach to correct for selection. I still estimate the first-stage probit, but I relax the normality assumption and use a control function method instead. Specifically, in the second stage I replace the inverse Mills ratio by a polynomial (cubic) approximation, using the probabilities estimated in the first stage—see Heckman and

[50] Given the large number of observations with $m = 0$, I do not report estimates for lower quantiles because there would be no variation in m.

[51] I also tried alternative instruments like the number of days needed to start up a new business, the cost of setting up a new business, the rate of the population with HIV, and the number of phone land lines per 100 people. The results were qualitatively identical to those I present here. The data source for all these variables is the World Banks's World Development Indicators.

[52] The estimation was done using the package "sampleSelection" for R. Standard errors were computed through a bootstrap procedure, resampling over (SIC 4-digit Industry, country) pairs, with 500 replications.

Table IX: Selection Corrections

First stage:		
Departing flights	0.0380**	
	(0.0172)	
Phone fares	-0.3118***	
	(0.0479)	
Second stage:		
	Heckit	Control Function
t^{US}	0.0117***	0.0064**
	(0.0043)	(0.0026)
t^F	-0.0024***	-0.0017***
	(0.0006)	(0.0005)
IMR	0.0548	
	(0.1508)	
p		-26.98***
		(7.70)
p^2		47.46***
		(12.83)
p^3		-26.98***
		(7.09)

Notes: "***", "**" and "*" refers to statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors obtained through bootstrap with clustering. The total number of observations was 37,100. IMR stands for Inverse Mills ratio.

Robb (1985) and Heckman and Navarro-Lozano (2004) for specifics on this procedure.

The second column of Table IX presents the results. The estimates for both tariffs still have the expected sign and are statistically significant, although their magnitude is smaller than before. Additionally, the estimates of the probability coefficients (p, p^2, and p^3) are statistically significant, so it is not possible to reject the null hypothesis about the existence of selection of unobservables.

3.4.3 (Indirectly) Accounting for Inputs

As previously mentioned, given the available data I am unable to carry out the ideal experiment—to track down the parts that are assembled into a final good. This may raise some concerns when mapping from the theoretical predictions to the data. Specifically, one concern might be what would happen if the theoretical h, flowing from North to South, referred not only to headquarter services but also to inputs; that is, if the multinational firm sends to its offshore affiliate not just blueprints (or other headquarter services) but also something tangible as intermediate goods, potentially subject to tariffs. In this subsection I account for these inputs in an indirect way and find that the baseline results remain mostly unaffected.[53]

Suppose that the production of a good needs parts and assembly (abstracting from HQ activities for the moment). Assembly is the last production stage, after which the final good is shipped to the United States. As for parts, if they are produced in United States, then by U.S. trade rules firms only pay duties on the value added abroad (the assembly services) when items are shipped back into the United States. But if the (U.S.) multinational firm chooses to produce the parts abroad, it will pay duties on the entire value of the good upon entry into the United States. Thus, the decision to produce parts at home or abroad will depend on the labor intensity needed to produce the good in question and where the assembly is located. If the assembly takes place far away from the United States, say in China, then it might be optimal for the U.S. firm to produce parts near China. Or if the industry is labor intensive it might be reasonable to have parts produced in a low-wage country. This implies that the share of the value added of a good that is produced abroad will depend on the labor intensity of the good and the location of the final assembly. Since the share of value added abroad determines the fraction of the value of the good that is exposed to U.S. tariffs, I now have two additional regressors: tariffs interacted with transport costs to the country doing the assembly and tariffs interacted with labor intensity.

Therefore, I estimate the following equation:[54,55]

$$\begin{aligned} m_{ict} \;=\;& \beta_0 + \beta_1 \cdot t^{US}_{ict} + \beta_2 \cdot t^{F}_{ict} + \beta_3 \cdot t^{US}_{ict} \cdot \left(\frac{k}{l}\right)_i + \beta_4 \cdot t^{US}_{ict} \cdot transp_{ict} + \beta_5 \left(\frac{k}{l}\right)_i \\ & + \beta_6 \left(\frac{s}{l}\right)_i + \beta_7 \cdot transp_{ict} + \beta_8 \left(\frac{K}{L}\right)_c + \beta_9 \left(\frac{H}{L}\right)_c + \beta_{10} X_t + \varepsilon_{ict}. \end{aligned} \tag{26}$$

Table X presents the results obtained. As in previous sections, I present the results including and excluding those observations where $m = 0$ and/or Chinese observations. The upper part of the table contains the results for all industries, while the bottom part repeats the estimation but only for the "particularly relevant" industries mentioned in Section 3.3.3. Once again, the results are strongly supportive of the theory. The marginal effect of the U.S. tariff on the share of intra-firm imports is positive across all specifications and almost always statistically significant. Likewise, the foreign tariff always has a statistically significant negative impact over the ratio m. Moreover, these effects are strengthened when I focus only those industries that are particularly well suited for overseas assembly.[56]

[53] I am very grateful to Gordon Hanson who suggested this particular analysis.

[54] This regression requires a new measure of transport cost that varies also by country. I generated the variable *trasnp* as the ratio of Import Charges (inclusive of freight and insurance) to Customs Value (of those imports), for each HS industry, country and year. These data are available at Feenstra's webpage: http://cid.econ.ucdavis.edu. This method implicitly assumes symmetry in transport costs: shipping a good from country x to country y is as costly as shipping it from y to x.

[55] Admittedly, one drawback of this estimation is that I assume that the capital-labor intensity is the same for the final and the intermediate good – it seems reasonable to think this is not usually the case. However, I make this assumption due to the data limitation already mentioned.

[56] Table X reports the marginal effect of t^{US} on m. The (unreported) estimates for β_1, β_3 and β_4 are usually not statistically different from zero.

Table X: Model with Interactions

	Without $m = 0$		With $m = 0$	
	-1-	-2-	-3-	-4-
Full sample				
$\partial m/\partial t^{US}$	0.0125***	0.0297***	0.0027	0.0131***
	(0.0042)	(0.0050)	(0.0029)	(0.0033)
t^F	-0.0031***	-0.0039***	-0.0017***	-0.0023***
	(0.0007)	(0.0006)	(0.0006)	(0.0006)
Obs.	24,247	19,665	37,047	29,441
Subsample				
$\partial m/\partial t^{US}$	0.0232***	0.0426***	0.0092*	0.0199***
	(0.0066)	(0.0103)	(0.0051)	(0.0062)
t^F	-0.0047***	-0.0051***	-0.0029**	-0.0030**
	(0.0012)	(0.0014)	(0.0011)	(0.0013)
Obs.	9,180	7,453	13,081	10,597

Notes: '***', '**' and '*' refers to statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors clustered by (4-digit SIC Industry, Country) pairs. Columns -1- & -3- include Chinese observations while columns -2- & -4- exclude them. Sub-sample comprises HS sections 11, 16, 17, and 18. All regressions include year fixed effects.

4 Concluding Remarks

This paper aims to explain the effects of tariffs on the optimal organizational form chosen by firms. In particular, I attempt to develop a theoretical framework capable of matching some stylized facts such as increasing offshoring and outsourcing as well as a general trend towards trade liberalization.

I show that a increase in the tariff t_N imposed by the Northern government decreases the market shares of firms that choose to offshore their production as well as the shares of those that choose to outsource. In contrast, an increase in the tariff t_S imposed by the Southern government has the opposite effects.

Additionally, I find that U.S. data strongly supports my theoretical predictions. Under different specifications I find evidence in favor of the following two facts: (i) higher U.S. tariffs increase the ratio of U.S. intra-firm imports to total imports, and (ii) higher foreign tariffs decrease the ratio.

There are several directions in which these findings may be extended. First, in light of these findings and those of Ornelas and Turner (2009), it would be very interesting to study the welfare effects of tariffs. Indeed, on the one hand, I find that tariffs not only affect offshoring but also the firm's insourcing/outsourcing decision. On the other hand, Ornelas and Turner find that the welfare effects of tariffs depend on whether trade is intra-firm or arm's-length.

Thus, these combined results imply that the design of trade policies needs to take into account the firm-level effects of tariffs, particularly the effects on the firm's internalization decisions. Proceeding along these lines, one could characterize governments' optimal tariff policies and explore the role (if any) for trade agreements. Second, I believe that a better understanding of the different kinds of offshoring is needed. Although this paper focuses on the offshoring of final goods, efforts must be made to incorporate the offshoring of inputs.[57] Third, it would also be very interesting to develop a (tractable) theoretical framework to deal with the outsourcing decision when only some firms are exporters, thereby matching a stylized fact found in the data. Finally, the theory has another testable implication to extend the empirical analysis. Indeed, while negotiated trade liberalization in the GATT/WTO has been conducted mainly by "Northern" countries, it now seems that in the future "Southern" countries will play a bigger role in these negotiations. Thus, if in the near future, both Northern and Southern tariffs decrease, then, according to the theory, the share of intra-firm imports, m, should remain fairly constant (after controlling for market sizes). Alternatively, if just Southern tariffs decrease, then m should increase. This also seems an interesting prediction for future study.

[57]See the Appendix for a brief analysis of input offshoring.

Appendix

A Theoretical Derivations

A.1 General Considerations

A.1.1 Consumers' problem

Preferences are given by

$$U = x_0 + \frac{1}{\mu}\sum_j X_j^{\mu},$$

where $X_j = \left(\int x_j(i)^{\alpha}\, di\right)^{1/\alpha}$ is the aggregate consumption index of industry j, $\alpha > \mu$ and $\alpha, \mu \in (0,1)$.

The Marshallian (individual) demands for the differentiated good $x_j(i)$ is given by

$$\begin{aligned} x(i) &= p(i)^{\frac{1}{\alpha-1}}\, P^{\frac{\mu-\alpha}{(\alpha-1)(1-\mu)}} \\ &\Leftrightarrow \\ p(i) &= x(i)^{\alpha-1}\, P^{\frac{\alpha-\mu}{1-\mu}}. \end{aligned} \tag{A-1}$$

Alternatively, if there is a tariff τ on imported differentiated goods, the demand will be given by

$$\begin{aligned} x(i) &= (\tau p(i))^{\frac{1}{\alpha-1}}\, (P)^{\frac{\mu-\alpha}{(\alpha-1)(1-\mu)}} \\ &\Leftrightarrow \\ p(i) &= x(i)^{\alpha-1}\, P^{\frac{\alpha-\mu}{1-\mu}}\tau^{-1}. \end{aligned} \tag{A-2}$$

A.1.2 Firms' problem

Firms producing in North

Sales in each market. In the presence of a Southern tariff τ_S, firms will face two different demands and therefore will have to make two decisions—the quantities to offer in the North and in the South. This decision is expressed as

$$p_N(i) = \gamma^{1-\alpha} x_N(i)^{\alpha-1}\, P_N^{\frac{\alpha-\mu}{1-\mu}}; \qquad p_S(i) = (1-\gamma)^{1-\alpha}\, x_S(i)^{\alpha-1}\, P_S^{\frac{\alpha-\mu}{1-\mu}}\tau_S^{-1},$$

where $x_N(i) + x_S(i) = x(i)$. Assuming that there are γ consumers in the North and $(1-\gamma)$ consumers in the South, the revenue of a firm will be given by

$$R = \gamma^{1-\alpha} P_N^{\frac{\alpha-\mu}{1-\mu}} x_N(i)^{\alpha} + (1-\gamma)^{1-\alpha}\, P_S^{\frac{\alpha-\mu}{1-\mu}} \tau_S^{-1} x_S(i)^{\alpha}.$$

In order to decide how to split a given production level $x(i)$ between the Northern and Southern markets the firm will solve

$$\max \gamma^{1-\alpha} P_N^{\frac{\alpha-\mu}{1-\mu}} x_N(i)^{\alpha} + (1-\gamma)^{1-\alpha}\, P_S^{\frac{\alpha-\mu}{1-\mu}} \tau_S^{-1} (x(i) - x_N(i))^{\alpha}.$$

The resulting optimal quantities are:[58]

$$x_N(i) = \frac{\gamma P_N^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}}}{(1-\gamma) P_S^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}} \tau_S^{\frac{1}{\alpha-1}} + \gamma P_N^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}}} x(i) \tag{A-3}$$

$$x_S(i) = \frac{(1-\gamma) P_S^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}} \tau_S^{\frac{1}{\alpha-1}}}{(1-\gamma) P_S^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}} \tau_S^{\frac{1}{\alpha-1}} + \gamma P_N^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}}} x(i). \tag{A-4}$$

Output and revenue. Next, I plug in these quantities into the revenue function. After some algebra, the resulting revenue function is:

$$R = \mathcal{C} x^{\alpha}$$

where $\mathcal{C}$ is defined as in the main text.

The production of $x(i) = \theta_i \left(\frac{h}{\nu}\right)^{\nu} \left(\frac{m}{1-\nu}\right)^{1-\nu}$ requires cooperation between an entrepreneur and a manager. Since contracts are incomplete they will choose h and m non-cooperatively—each one will get a fraction (β_k^l or $\left(1-\beta_k^l\right)$) of the ex-post surplus.

The entrepreneur chooses h, taking m as given, in order to maximize:

$$\max_h \beta R - w^N h$$

$$\max_h \beta_k^l \mathcal{C} \left(\theta \left(\frac{h}{\nu}\right)^{\nu} \left(\frac{m}{1-\nu}\right)^{1-\nu}\right)^{\alpha} - w^N h.$$

In the same way, the manager chooses m, taking h as given:

$$\max_m \left(1-\beta_k^l\right) R - w^l m$$

$$\max_m \left(1-\beta_k^l\right) \mathcal{C} \left(\theta \left(\frac{h}{\nu}\right)^{\nu} \left(\frac{m}{1-\nu}\right)^{1-\nu}\right)^{\alpha} - w^l m.$$

Thus, for a given R, the optimal decisions for the entrepreneur and the manager are the following:

$$h^* = \frac{\beta \alpha \nu R}{w^N} \tag{A-5}$$

$$m^* = \frac{(1-\beta)\alpha(1-\nu) R}{w^l}.$$

Replacing h^* and m^* in the expression for R, I get the final expression for the revenue collected by the firm:

$$R = \mathcal{C} \theta^{\frac{\alpha}{1-\alpha}} \left[\alpha \left(\frac{\beta}{w^N}\right)^{\nu} \left(\frac{(1-\beta)}{w^l}\right)^{1-\nu}\right]^{\frac{\alpha}{1-\alpha}}. \tag{A-6}$$

Combining this last expression with $R = \mathcal{A} x^{\alpha}$ I can solve for $x(i)$:

$$x(i) = \mathcal{C} \theta^{\frac{1}{1-\alpha}} \left[\alpha \left(\frac{\beta}{w^N}\right)^{\nu} \left(\frac{(1-\beta)}{w^l}\right)^{1-\nu}\right]^{\frac{1}{1-\alpha}}. \tag{A-7}$$

Profits. From the revenue expression, I can compute the profits earned by a firm:[59]

[58] Given these quantities, note that although I allow firms to price discriminate, they choose to set the same "factory gate" prices for both markets.

[59] As explained in the paper, under the current contract structure, the manager will have zero profits and hence the entrepreneur's profits will be equal to the firm's profits.

$$\pi_k^l = R - f_k^l w^N - w^N h^* - w^l m^*$$

Finally, I plug in the expressions for R, h^*, and m^* to get:

$$\pi_k^l = \mathcal{C}\Psi_k^l \theta^{\frac{\alpha}{1-\alpha}} - f_k^l w^N \tag{A-8}$$

where Ψ_k^l is defined as in the main text.

Firms producing in South

Offshoring firms producing in the South only have to pay the tariff τ_N for their exports to the Northern market. They face the following two demands:

$$p_S(i) = \gamma^{1-\alpha} x_S(i)^{\alpha-1} P_S^{\frac{\alpha-\mu}{1-\mu}}$$
$$p_N(i) = (1-\gamma)^{1-\alpha} x_N(i)^{\alpha-1} P_N^{\frac{\alpha-\mu}{1-\mu}} \tau_N^{-1}.$$

Therefore, their revenue is

$$R = \gamma^{1-\alpha} P_N^{\frac{\alpha-\mu}{1-\mu}} \tau_N^{-1} x_N(i)^\alpha + (1-\gamma)^{1-\alpha} P_S^{\frac{\alpha-\mu}{1-\mu}} x_S(i)^\alpha.$$

Proceeding in an analogous way as before, given a total production level $x(i)$, the optimal quantities sold in each market are the following:

$$x_N(i) = \frac{\gamma P_N^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}} \tau_N^{\frac{1}{\alpha-1}}}{(1-\gamma) P_S^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}} + \gamma P_N^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}} \tau_N^{\frac{1}{\alpha-1}}} x(i) \tag{A-9}$$

$$x_S(i) = \frac{(1-\gamma) P_S^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}}}{(1-\gamma) P_S^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}} + \gamma P_N^{\frac{\alpha-\mu}{(1-\mu)(1-\alpha)}} \tau_N^{\frac{1}{\alpha-1}}} x(i). \tag{A-10}$$

Finally, after replacing these quantities and solving the game between the entrepreneur and the manager, the resulting expressions for output, revenue and profit functions are the following:

$$x(i) = \mathcal{B}\theta_i^{\frac{1}{1-\alpha}} \left[\alpha \left(\frac{\beta}{w^N}\right)^\nu \left(\frac{(1-\beta)}{w^l}\right)^{1-\nu}\right]^{\frac{1}{1-\alpha}} \tag{A-11}$$

$$R(i) = \mathcal{B}\theta_i^{\frac{\alpha}{1-\alpha}} \left[\alpha \left(\frac{\beta}{w^N}\right)^\nu \left(\frac{(1-\beta)}{w^l}\right)^{1-\nu}\right]^{\frac{1}{1-\alpha}} \tag{A-12}$$

$$\pi_k^l(i) = \mathcal{B}\Psi_k^l \theta_i^{\frac{\alpha}{1-\alpha}} - f_k^l w^N. \tag{A-13}$$

where $\mathcal{B}$ is defined as in the main text.

A.1.3 Are $\mathbf{P_N}$ and $\mathbf{P_S}$ related?

So far I have found expressions for the total quantity $x(i)$, the quantities sold in each market, ($x_N(i)$ and $x_S(i)$), the choices of the entrepreneur (h) and the manager (m), the revenue R and the profits π_k^l earned by a firm. All of them are functions of the aggregate prices in the North P_N and in the South P_S and of the tariffs τ_N and τ_S. In this section, I show that the two aggregate prices are related.

Let $p_N^1(i)$ and $p_S^1(i)$ be the demands faced by non-offshoring firms in Northern and Southern markets, respectively. As shown in the paper, the productivity range of these firms is $(\theta_1, \theta_{3...})$. Likewise, let $p_N^2(i)$ and $p_S^2(i)$ be the demands faced by offshoring firms in Northern and Southern markets, respectively. These firms have productivities in (θ_3, ∞).

The aggregate prices are defined in the following way:

$$P_S = \left(\int p_S(i)^{\frac{\alpha}{\alpha-1}} di \right)^{\frac{\alpha-1}{\alpha}}$$
$$= \left(\int_{\theta_1}^{\theta_3} \left(\tau_S \cdot p_S^1(\theta) \right)^{\frac{\alpha}{\alpha-1}} g(\theta)d\theta + \int_{\theta_3}^{\infty} p_S^2(\theta)^{\frac{\alpha}{\alpha-1}} g(\theta)d\theta \right)^{\frac{\alpha-1}{\alpha}}.$$

$$P_N = \left(\int p_N(i)^{\frac{\alpha}{\alpha-1}} di \right)^{\frac{\alpha-1}{\alpha}}$$
$$= \left(\int_{\theta_1}^{\theta_3} p_N^1(\theta)^{\frac{\alpha}{\alpha-1}} g(\theta)d\theta + \int_{\theta_3}^{\infty} \left(\tau_N \cdot p_N^2(\theta) \right)^{\frac{\alpha}{\alpha-1}} g(\theta)d\theta \right)^{\frac{\alpha-1}{\alpha}}.$$

Then, replacing the demands for their optimal values:

$$P_S^{\frac{\alpha}{\alpha-1}} = \tau_S^{\frac{\alpha}{\alpha-1}} \rho_O^N \left[V(\theta_2) - V(\theta_1) \right] + \tau_S^{\frac{\alpha}{\alpha-1}} \rho_V^N \left[V(\theta_3) - V(\theta_2) \right] + \rho_O^S \left[V(\theta_4) - V(\theta_3) \right] + \rho_V^S \left[V(\infty) - V(\theta_4) \right] \tag{A-14}$$

$$P_N^{\frac{\alpha}{\alpha-1}} = \rho_O^N \left[V(\theta_2) - V(\theta_1) \right] + \rho_V^N \left[V(\theta_3) - V(\theta_2) \right] + \tau_N^{\frac{\alpha}{\alpha-1}} \rho_O^S \left[V(\theta_4) - V(\theta_3) \right] + \tau_N^{\frac{\alpha}{\alpha-1}} \rho_V^S \left[V(\infty) - V(\theta_4) \right]. \tag{A-15}$$

where ρ_k^l and $V(\theta)$ are defined as in the main text.

From equations (A-14) and (A-15) it is clear that the two aggregate prices are related. If there were no tariffs, they would be equal. In contrast, if there are tariffs, they will differ.

Suppose $\tau_S = 1$, then

$$P_S^{\frac{\alpha}{\alpha-1}} = P_N^{\frac{\alpha}{\alpha-1}} + \left(1 - \tau_N^{\frac{\alpha}{\alpha-1}} \right) \left[\rho_O^S \left[V(\theta_4) - V(\theta_3) \right] + \rho_V^S \left[V(\infty) - V(\theta_4) \right] \right].$$

Similarly, if $\tau_N = 1$, then

$$P_N^{\frac{\alpha}{\alpha-1}} = P_S^{\frac{\alpha}{\alpha-1}} + \left(1 - \tau_S^{\frac{\alpha}{\alpha-1}} \right) \left[\rho_O^N \left[V(\theta_2) - V(\theta_1) \right] + \rho_V^N \left[V(\theta_3) - V(\theta_2) \right] \right].$$

A.2 Proofs of Subsection 2.2 (Northern Tariffs)

From the main text, I have six equations (four cutoff definitions, the free entry condition and the expression relating the aggregate prices) and six equations (the four cutoffs $\{\theta_1, \ldots, \theta_4\}$, and the two aggregate prices P_N and P_S).

Differentiating the free entry condition with respect to P_N and τ_N, I can obtain $\frac{dP_N}{d\tau_N}$ in the following way:

$$\frac{dP_N}{d\tau_N} = -\frac{\frac{\partial RHS}{\partial \tau_N}}{\frac{\partial RHS}{\partial P_N}}. \tag{A-16}$$

Thus,

$$\frac{\partial RHS}{\partial \tau_N} = \frac{\partial \mathcal{A}}{\partial \tau_N}\left(\Psi_O^N\left[V(\theta_2)-V(\theta_1)\right]+\Psi_V^N\left[V(\theta_3)-V(\theta_2)\right]\right) + \frac{\partial \mathcal{B}}{\partial \tau_N}\left(\Psi_O^S\left[V(\theta_4)-V(\theta_3)\right]+\Psi_V^S\left[V(\infty)-V(\theta_4)\right]\right). \tag{A-17}$$

$$\frac{\partial RHS}{\partial P_N} = \frac{\partial \mathcal{A}}{\partial P_N}\left(\Psi_O^N\left[V(\theta_2)-V(\theta_1)\right]+\Psi_V^N\left[V(\theta_3)-V(\theta_2)\right]\right) + \frac{\partial \mathcal{B}}{\partial P_N}\left(\Psi_O^S\left[V(\theta_4)-V(\theta_3)\right]+\Psi_V^S\left[V(\infty)-V(\theta_4)\right]\right). \tag{A-18}$$

Let $\mathcal{I} \equiv \frac{\alpha-\mu}{(1-\mu)(1-\alpha)} > 0$. Also, recall from the main text that I evaluate the results around free trade (meaning at $\tau_N = 1$), then we get

$$\left.\frac{\partial \mathcal{A}}{\partial P_N}\right|_{\tau_N=1} = \mathcal{I}\left[(1-\gamma)P_S^{\mathcal{I}-1}+\gamma P_N^{\mathcal{I}-1}\right] > 0,$$
$$\left.\frac{\partial \mathcal{B}}{\partial P_N}\right|_{\tau_N=1} = \mathcal{I}\left[(1-\gamma)P_S^{\mathcal{I}-1}+\gamma P_N^{\mathcal{I}-1}\right] > 0,$$
$$\left.\frac{\partial \mathcal{A}}{\partial \tau_N}\right|_{\tau_N=1} = -\mathcal{I}(1-\gamma)P_S^{\mathcal{I}-1}P_N^{\frac{1}{1-\alpha}}\left[\rho_O^S\left[V(\theta_4)-V(\theta_3)\right]+\rho_V^S\left[V(\infty)-V(\theta_4)\right]\right] < 0,$$
$$\left.\frac{\partial \mathcal{B}}{\partial \tau_N}\right|_{\tau_N=1} = -\mathcal{I}(1-\gamma)P_S^{\mathcal{I}-1}P_N^{\frac{1}{1-\alpha}}\left[\rho_O^S\left[V(\theta_4)-V(\theta_3)\right]+\rho_V^S\left[V(\infty)-V(\theta_4)\right]\right] - \gamma P_N^{\mathcal{I}}\frac{1}{1-\alpha} < 0.$$

After I plug these partial derivativies in (A-17) and (A-18), I am able to find the exact expression for (A-16).

$$\frac{dP_N}{d\tau_N} = \frac{(1-\gamma)P_S^{\mathcal{I}-1}P_N^{\frac{1}{1-\alpha}}\left[\rho_O^S[V(\theta_4)-V(\theta_3)]+\rho_V^S[V(\infty)-V(\theta_4)]\right]}{(1-\gamma)P_S^{\mathcal{I}-1}+\gamma P_N^{\mathcal{I}-1}} + \frac{\gamma P_N^{\mathcal{I}}\frac{1}{1-\alpha}\left\{\Psi_O^S[V(\theta_4)-V(\theta_3)]+\Psi_V^S[V(\infty)-V(\theta_4)]\right\}}{\mathcal{I}\left[(1-\gamma)P_S^{\mathcal{I}-1}+\gamma P_N^{\mathcal{I}-1}\right]\left\{\Psi_O^N[V(\theta_2)-V(\theta_1)]+\Psi_V^N[V(\theta_3)-V(\theta_2)]+\Psi_O^S[V(\theta_4)-V(\theta_3)]+\Psi_V^S[V(\infty)-V(\theta_4)]\right\}}.$$

Therefore,

$$\left.\frac{dP_N}{d\tau_N}\right|_{\tau_N=1} > 0. \tag{A-19}$$

Knowing $\frac{dP_N}{d\tau_N}$, I can find $\frac{dP_S}{d\tau_N}$

$$\left.\frac{dP_S}{d\tau_N}\right|_{\tau_N=1} = \frac{\partial P_S}{\partial P_N}\frac{dP_N}{d\tau_N} + \frac{\partial P_S}{\partial \tau_N}d\tau_N$$
$$= \frac{dP_N}{d\tau_N} - P_N^{\frac{1}{1-\alpha}}\left[\rho_O^S\left[V(\theta_4)-V(\theta_3)\right]+\rho_V^S\left[V(\infty)-V(\theta_4)\right]\right].$$

Given the changes in the aggregate prices, the slopes of the profit lines will change in the following way:

$$\frac{d\mathcal{A}}{d\tau_N} = \mathcal{I}\left[(1-\gamma)P_s^{\mathcal{I}-1}\frac{dP_S}{d\tau_N} + \gamma P_N^{\mathcal{I}-1}\frac{dP_N}{d\tau_N}\right]$$
$$\frac{d\mathcal{A}}{d\tau_N} = \frac{\gamma P_N^{\mathcal{I}}\frac{1}{1-\alpha}\left\{\Psi_O^S[V(\theta_4)-V(\theta_3)]+\Psi_V^S[V(\infty)-V(\theta_4)]\right\}}{\Psi_O^N[V(\theta_2)-V(\theta_1)]+\Psi_V^N[V(\theta_3)-V(\theta_2)]+\Psi_O^S[V(\theta_4)-V(\theta_3)]+\Psi_V^S[V(\infty)-V(\theta_4)]} > 0.$$

$$\frac{d\mathcal{B}}{d\tau_N} = \mathcal{I}\left[(1-\gamma)P_s^{\mathcal{I}-1}\frac{dP_S}{d\tau_N} + \gamma\tau^{\frac{1}{\alpha-1}}P_N^{\mathcal{I}-1}\frac{dP_N}{d\tau_N}\right] - \frac{1}{1-\alpha}\tau_N^{\frac{1}{\alpha-1}-1}\gamma P_N^{\mathcal{I}}$$
$$\frac{d\mathcal{B}}{d\tau_N} = \frac{1}{1-\alpha}\gamma P_N^{\mathcal{I}}\left[\frac{\left\{\Psi_O^S[V(\theta_4)-V(\theta_3)]+\Psi_V^S[V(\infty)-V(\theta_4)]\right\}}{\Psi_O^N[V(\theta_2)-V(\theta_1)]+\Psi_V^N[V(\theta_3)-V(\theta_2)]+\Psi_O^S[V(\theta_4)-V(\theta_3)]+\Psi_V^S[V(\infty)-V(\theta_4)]} - 1\right] < 0.$$

A.2.1 Effects on Cutoffs

Given that $\frac{d\mathcal{A}}{d\tau_N} > 0$ and $\frac{d\mathcal{B}}{d\tau_N} < 0$, it is straightforward to check that

$$\left.\frac{d\theta_1}{d\tau_N}\right|_{\tau_N=1} = \left[\frac{w^N f_O^N}{\Psi_O^N}\frac{1}{\mathcal{A}}\right]^{\frac{1-\alpha}{\alpha}-1} \frac{w^N f_O^N}{\Psi_O^N}\frac{-1}{\mathcal{A}^2}\frac{d\mathcal{A}}{d\tau_N} < 0.$$

$$\left.\frac{d\theta_2}{d\tau_N}\right|_{\tau_N=1} = \left[\frac{w^N (f_V^N - f_O^N)}{(\Psi_V^N - \Psi_O^N)}\frac{1}{\mathcal{A}}\right]^{\frac{1-\alpha}{\alpha}-1} \frac{w^N (f_V^N - f_O^N)}{(\Psi_V^N - \Psi_O^N)}\frac{-1}{\mathcal{A}^2}\frac{d\mathcal{A}}{d\tau_N} < 0.$$

$$\left.\frac{d\theta_3}{d\tau_N}\right|_{\tau_N=1} = \left[\frac{w^N (f_O^S - f_V^N)}{(\Psi_O^S\mathcal{B} - \Psi_V^N\mathcal{A})}\right]^{\frac{1-\alpha}{\alpha}-1} \frac{-w^N (f_O^S - f_V^N)}{(\Psi_O^S\mathcal{B} - \Psi_V^N\mathcal{A})^2}\left(\Psi_O^S\frac{d\mathcal{B}}{d\tau_N} - \Psi_V^N\frac{d\mathcal{A}}{d\tau_N}\right) > 0.$$

$$\left.\frac{d\theta_4}{d\tau_N}\right|_{\tau_N=1} = \left[\frac{w^N (f_V^S - f_O^S)}{(\Psi_V^S - \Psi_O^S)}\frac{1}{\mathcal{B}}\right]^{\frac{1-\alpha}{\alpha}-1} \frac{w^N (f_V^S - f_O^S)}{(\Psi_V^S - \Psi_O^S)}\frac{-1}{\mathcal{B}^2}\frac{d\mathcal{B}}{d\tau_N} > 0.$$

A.2.2 Effects on Market Shares

First, I study how $\frac{\sigma_O^S}{\sigma_V^S}$, $\frac{\sigma_V^S}{\sigma_O^N}$ and $\frac{\sigma_O^N}{\sigma_V^N}$ are affected by the tariffs.

- $\frac{\sigma_O^S}{\sigma_V^S} = \frac{[V(\theta_4) - V(\theta_3)]\rho_O^S}{[V(\infty) - V(\theta_4)]\rho_V^S}$

$$\frac{\sigma_O^S}{\sigma_V^S} = \frac{\rho_O^S}{\rho_V^S}\left(\left[\frac{f_V^S - f_O^S}{\Psi_V^S - \Psi_O^S}\frac{\Psi_O^S - \Psi_V^N\frac{\mathcal{A}}{\mathcal{B}}}{f_O^S - f_V^N}\right]^{\frac{1-\alpha}{\alpha}z-1} - 1\right)$$

Given that $\frac{d\mathcal{A}}{d\tau_N} > 0$, $\frac{d\mathcal{B}}{d\tau_N} < 0$ and $z > \frac{\alpha}{1-\alpha}$ it follows that $\left.\frac{d\left(\frac{\sigma_O^S}{\sigma_V^S}\right)}{d\tau_N}\right|_{\tau_N=1} < 0.$

- $\frac{\sigma_V^S}{\sigma_O^N} = \frac{[V(\infty) - V(\theta_4)]\mathcal{B}\rho_V^S}{[V(\theta_2) - V(\theta_1)]\mathcal{A}\rho_O^N}$

$$\frac{\sigma_V^S}{\sigma_O^N} = \frac{\rho_V^S}{\rho_O^N}\frac{\left(\frac{\mathcal{B}}{\mathcal{A}}\right)^{\frac{1-\alpha}{\alpha}z}\left[\frac{f_V^S - f_O^S}{\Psi_V^S - \Psi_O^S}\right]^{1-\frac{1-\alpha}{\alpha}z}}{\left[\frac{f_O^N}{\Psi_O^N}\right]^{1-\frac{1-\alpha}{\alpha}z} - \left[\frac{f_V^N - f_O^N}{\Psi_V^N - \Psi_O^N}\right]^{1-\frac{1-\alpha}{\alpha}z}}$$

Given that $\frac{d\mathcal{A}}{d\tau_N} > 0$, $\frac{d\mathcal{B}}{d\tau_N} < 0$ it follows that $\left.\frac{d\left(\frac{\sigma_V^S}{\sigma_O^N}\right)}{d\tau_N}\right|_{\tau_N=1} < 0.$

- $\frac{\sigma_O^N}{\sigma_V^N} = \frac{[V(\theta_2) - V(\theta_1)]\rho_O^N}{[V(\theta_3) - V(\theta_2)]\rho_V^N}$

$$= \frac{\rho_O^N}{\rho_V^N}\frac{\left[\frac{f_O^N}{\Psi_O^N}\right]^{1-\frac{1-\alpha}{\alpha}z} - \left[\frac{f_V^N - f_O^N}{\Psi_V^N - \Psi_O^N}\right]^{1-\frac{1-\alpha}{\alpha}z}}{\left[\frac{f_V^N - f_O^N}{\Psi_V^N - \Psi_O^N}\right]^{1-\frac{1-\alpha}{\alpha}z} - \left[\frac{f_O^S - f_V^N}{\Psi_O^S\frac{\mathcal{B}}{\mathcal{A}} - \Psi_V^N}\right]^{1-\frac{1-\alpha}{\alpha}z}}$$

Given that $\frac{d\mathcal{A}}{d\tau_N} > 0$, $\frac{d\mathcal{B}}{d\tau_N} < 0$ and $1 < \frac{1-\alpha}{\alpha}z$ it follows that $\left.\frac{d\left(\frac{\sigma_O^N}{\sigma_V^N}\right)}{d\tau_N}\right|_{\tau_N=1} < 0.$

Next, I am interested on the effects of tariffs on the sales of offshoring firms.

$$sales_O^S = \mathcal{B}\rho_O^S\left[V(\theta_4) - V(\theta_3)\right]$$
$$= \mathcal{B}^{\frac{1-\alpha}{\alpha}z}\rho_O^S b^{z-\frac{\alpha}{1-\alpha}}\left[\left[\frac{w^N(f_O^S - f_V^N)}{(\Psi_O^S - \Psi_V^N\frac{\mathcal{A}}{\mathcal{B}})}\right]^{1-\frac{1-\alpha}{\alpha}z} - \left[\frac{w^N(f_V^S - f_O^S)}{(\Psi_V^S - \Psi_O^S)}\right]^{1-\frac{1-\alpha}{\alpha}z}\right]$$

$\frac{dsales_O^S}{d\tau_N} < 0$. (given that $1 - \frac{1-\alpha}{\alpha}z < 0$).

$sales_V^S = \mathcal{B}\rho_V^S \left[V(\infty) - V(\theta_4)\right]$
$\frac{dsales_V^S}{d\tau_N} < 0.$

Finally, I check how sales of offshoring firms are split between both markets:
$\frac{revenue^N}{revenue^S} = \frac{\gamma^{1-\alpha}\tau_N^{-1}x_N^\alpha}{(1-\gamma)^{1-\alpha}x_S^\alpha} = \frac{\gamma\tau_N^{\frac{1}{\alpha-1}}}{(1-\gamma)}$
$\frac{d\left(R^N/R^S\right)}{d\tau_N} < 0.$

Therefore:

1. The imposition of t^N decreases $\frac{\sigma_O^S}{\sigma_V^S}$, $\frac{\sigma_V^S}{\sigma_O^N}$, and $\frac{\sigma_O^N}{\sigma_V^N}$.
2. The imposition of t^N, decreases the sales of both (S, O) and (S, V) (especially in Northern markets). Hence, it also decreases total imports.

A.2.3 Proof of Proposition 2

Recall that the cutoffs are defined in the following way:

$$\begin{aligned}
\theta_1 &= \left[\frac{w^N f_O^N}{\Psi_O^N}\frac{1}{\mathcal{A}}\right]^{\frac{1-\alpha}{\alpha}} \\
\theta_2 &= \left[\frac{w^N (f_V^N - f_O^N)}{(\Psi_V^N - \Psi_O^N)}\frac{1}{\mathcal{A}}\right]^{\frac{1-\alpha}{\alpha}} \\
\theta_3 &= \left[\frac{w^N\left(f_O^S - f_V^N\right)}{\left(\Psi_O^S\mathcal{B} - \Psi_V^N\mathcal{A}\right)}\right]^{\frac{1-\alpha}{\alpha}} \\
\theta_4 &= \left[\frac{w^N (f_V^S - f_O^S)}{(\Psi_V^S - \Psi_O^S)}\frac{1}{\mathcal{B}}\right]^{\frac{1-\alpha}{\alpha}},
\end{aligned} \tag{A-20}$$

where $\mathcal{A}$ determines the slope of the profit functions of non-offshoring firms,

$$\mathcal{A} \equiv (1-\gamma) P_S^{\mathcal{I}} + \gamma P_N^{\mathcal{I}} \tag{A-21}$$

and $\mathcal{B}$ determines the slope of offshoring firms' profit functions:

$$\mathcal{B} \equiv (1-\gamma) P_S^{\mathcal{I}} + \gamma P_N^{\mathcal{I}}\tau_N^{\frac{1}{\alpha-1}}, \tag{A-22}$$

with $\mathcal{I} \equiv \frac{\alpha-\mu}{(1-\mu)(1-\alpha)} > 0$ and $\frac{1}{\alpha-1} < 0$.

Proposition 2. *In the benchmark case, for any differentiable distribution function $G(\cdot)$, a tariff τ_N imposed on the Northern imports of differentiated goods will have the following effects:*

1. *Cutoffs θ_1 and θ_2 will decrease: $\frac{d\theta_1}{d\tau_N} < 0$, $\frac{d\theta_2}{d\tau_N} < 0$,*
2. *Cutoffs θ_3 and θ_4 will increase: $\frac{d\theta_3}{d\tau_N} > 0$, $\frac{d\theta_4}{d\tau_N} > 0$.*

Proof. The result follows from simple differentiation of (A-20), given that $\frac{d\mathcal{A}}{d\tau_N} > 0$ and $\frac{d\mathcal{B}}{d\tau_N} < 0$ by Lemma A.4 (see below). ■

Thus, I now need to show that $\frac{d\mathcal{A}}{d\tau_N} > 0$ and $\frac{d\mathcal{B}}{d\tau_N} < 0$. I prove it using the free entry condition and some intermediate results that I describe next.

Recall the free entry condition:

$$\int_{\theta_1}^{\theta_2} \pi_O^N g(\theta)d\theta + \int_{\theta_2}^{\theta_3} \pi_V^N g(\theta)d\theta + \int_{\theta_3}^{\theta_4} \pi_O^S g(\theta)d\theta + \int_{\theta_4}^{\infty} \pi_V^S g(\theta)d\theta = w^N f_E. \tag{A-23}$$

Making use of the free entry condition I rule out that $\mathcal{A}$ and $\mathcal{B}$ (slopes of the profit functions) move in the same direction. Intuitively, the free entry condition states that the area below the four profit functions must integrate to $w^N f_E$. Since $w^N f_E$ is fixed, it follows that if some lines become steeper, others must become flatter to compensate. I summarize this in the following Lemma.

Lemma A.1. *If an increase of τ_N causes $\mathcal{A}$ to increase ($\frac{d\mathcal{A}}{d\tau_N} > 0$), then $\mathcal{B}$ will decrease ($\frac{d\mathcal{B}}{d\tau_N} < 0$). Conversely, if τ_N causes $\mathcal{A}$ to decrease ($\frac{d\mathcal{A}}{d\tau_N} < 0$), then $\mathcal{B}$ will increase ($\frac{d\mathcal{B}}{d\tau_N} > 0$).*

Proof. First, re-write the free entry condition:

$$\begin{aligned} w^N f_E \quad = \quad & \int_{\theta_1}^{\theta_2} \left(\mathcal{A}\Psi_O^N \theta^{\frac{\alpha}{1-\alpha}} - w^N f_O^N\right) dG(\theta) + \int_{\theta_2}^{\theta_3} \left(\mathcal{A}\Psi_V^N \theta^{\frac{\alpha}{1-\alpha}} - w^N f_V^N\right) dG(\theta) \\ & + \int_{\theta_3}^{\theta_4} \left(\mathcal{B}\Psi_O^S \theta^{\frac{\alpha}{1-\alpha}} - w^N f_O^S\right) dG(\theta) + \int_{\theta_4}^{\infty} \left(\mathcal{B}\Psi_V^S \theta^{\frac{\alpha}{1-\alpha}} - w^N f_V^S\right) dG(\theta). \end{aligned}$$

Next, totally differentiate with respect to τ_N:

$$0 = \frac{d\mathcal{A}}{d\tau_N}\left(\Psi_O^N\left[V(\theta_2) - V(\theta_1)\right] + \Psi_V^N\left[V(\theta_3) - V(\theta_2)\right]\right) + \frac{d\mathcal{B}}{d\tau_N}\left(\Psi_O^S\left[V(\theta_4) - V(\theta_3)\right] + \Psi_V^S\left[V(\infty) - V(\theta_4)\right]\right),$$

where, by the Envelope Theorem, the derivatives with respect to the cutoffs cancel each other out. Since both terms in brackets are positive, it follows that $sign\left(\frac{d\mathcal{A}}{d\tau_N}\right) = -sign\left(\frac{d\mathcal{B}}{d\tau_N}\right)$. ■

Lemma A.2. *Suppose that τ_N causes P_N to increase ($\frac{dP_N}{d\tau_N} > 0$). Then, $\mathcal{A}$ must also increase ($\frac{d\mathcal{A}}{d\tau_N} > 0$).*

Proof. Given the assumption of $\frac{dP_N}{d\tau_N} > 0$, if P_S increases ($\frac{dP_S}{d\tau_N} > 0$), $\mathcal{A}$ will increase by definition. Instead, suppose that they both decrease: $\frac{dP_S}{d\tau_N} < 0$ and $\frac{d\mathcal{A}}{d\tau_N} < 0$. Then, $\mathcal{B}$ must also decrease since:

$$\frac{d\mathcal{B}}{d\tau_N} = \underbrace{\frac{d\mathcal{A}}{d\tau_N}}_{<0} + \gamma\mathcal{I}P_N^{\mathcal{I}-1}\underbrace{\frac{dP_N}{d\tau_N}}_{>0}\underbrace{\left(\tau_N^{\frac{1}{\alpha-1}} - 1\right)}_{<0} + \gamma P_N^{\mathcal{I}}\underbrace{\left(\frac{1}{\alpha-1}\right)}_{<0}\tau_N^{\frac{1}{\alpha-1}} < 0.$$

But, by Lemma A.1 it is not possible for both $\mathcal{A}$ and $\mathcal{B}$ to decrease. ■

Lemma A.3. *It is not possible for these four conditions to hold at the same time: (i) $\frac{dP_S}{d\tau_N} > 0$, (ii) $\frac{dP_N}{d\tau_N} < 0$, (iii) $\frac{d\mathcal{A}}{d\tau_N} < 0$, and (iv) $\frac{d\mathcal{B}}{d\tau_N} > 0$.*

Proof. First, note that if this is the case, then $\frac{d\theta_3}{d\tau_N} < 0$ and $\frac{d\theta_4}{d\tau_N} < 0$. Next, recall how the aggregate prices are related:

$$P_S^{\frac{\alpha}{\alpha-1}} = P_N^{\frac{\alpha}{\alpha-1}} + \left(1 - \tau_N^{\frac{\alpha}{\alpha-1}}\right) \left\{\rho_O^S \left[V(\theta_4) - V(\theta_3)\right] + \rho_V^S \left[V(\infty) - V(\theta_4)\right]\right\}$$
$$\Rightarrow$$
$$P_S^{\frac{\alpha}{\alpha-1}} - P_N^{\frac{\alpha}{\alpha-1}} = \left(1 - \tau_N^{\frac{\alpha}{\alpha-1}}\right) \left\{\rho_O^S \left[V(\theta_4) - V(\theta_3)\right] + \rho_V^S \left[V(\infty) - V(\theta_4)\right]\right\}.$$

Finally, I differentiate the last expression:

$$\underbrace{\frac{\alpha}{\alpha-1}}_{<0} P_S^{\frac{\alpha}{\alpha-1}-1} \underbrace{\frac{dP_S}{d\tau_N}}_{>0} - \underbrace{\frac{\alpha}{\alpha-1}}_{<0} P_N^{\frac{\alpha}{\alpha-1}-1} \underbrace{\frac{dP_N}{d\tau_N}}_{<0} = -\underbrace{\frac{\alpha}{\alpha-1}}_{>0} \tau_N^{\frac{\alpha}{\alpha-1}-1} \{\cdot\} + \underbrace{\left(1 - \tau_N^{\frac{\alpha}{\alpha-1}}\right)}_{>0} \underbrace{\left\{-\rho_O^S \frac{dV(\theta_3)}{d\tau_N} - \left(\rho_V^S - \rho_O^S\right) \frac{dV(\theta_4)}{d\tau_N}\right\}}_{>0}$$

where $sign\left(\frac{d\theta}{d\tau_N}\right) = sign\left(\frac{dV(\theta)}{d\tau_N}\right) = sign\left(\theta^{\frac{\alpha}{1-\alpha}} g(\theta) \frac{d\theta}{d\tau_N}\right)$. Since the LHS is negative and the RHS is positive, there is a contradiction: so I can rule out this case. ■

Corollary A.1. *If* $\frac{dP_S}{d\tau_N} > 0$ *and* $\frac{dP_N}{d\tau_N} < 0$*, then* $\frac{d\mathcal{A}}{d\tau_N} > 0$*, and* $\frac{d\mathcal{B}}{d\tau_N} < 0$.

Proof. If $\frac{dP_S}{d\tau_N} > 0$ and $\frac{dP_N}{d\tau_N} < 0$ then, by the free entry condition, either (i) $\frac{d\mathcal{A}}{d\tau_N} > 0$ and $\frac{d\mathcal{B}}{d\tau_N} < 0$, or (ii) $\frac{d\mathcal{A}}{d\tau_N} < 0$ and $\frac{d\mathcal{B}}{d\tau_N} > 0$. However, case (ii) is not possible by Lemma A.3. ■

Lemma A.4. *If* τ_N *increases, then* A *will increase and* $\mathcal{B}$ *will decrease:* $\frac{d\mathcal{A}}{d\tau_N} > 0$ *and* $\frac{d\mathcal{B}}{d\tau_N} < 0$.

Proof. There are four possible ways in which the aggregate prices may change in response to τ_N:

1. $P_S \uparrow$, $P_N \uparrow \Rightarrow \mathcal{A} \uparrow$ (by definition of $\mathcal{A}$)$\Rightarrow \mathcal{B} \downarrow$ (by Lemma A.1).
2. $P_S \downarrow$, $P_N \uparrow \Rightarrow \mathcal{A} \uparrow$ (by Lemma A.2)$\Rightarrow \mathcal{B} \downarrow$ (by Lemma A.1).
3. $P_S \downarrow$, $P_N \downarrow \Rightarrow \mathcal{A} \downarrow$, $\mathcal{B} \downarrow$ (Impossible by Lemma A.1).
4. $P_S \uparrow$, $P_N \downarrow \Rightarrow \mathcal{A} \uparrow$, $\mathcal{B} \downarrow$ (by Lemma A.1 and Corollary A.1).

■

A.3 Proofs of Subsection 2.3 (Southern Tariffs)

The derivations are completely analogous to those above. Thus, differentiating the free entry condition with respect to P_S and τ_S allows me to obtain:

$$\frac{dP_S}{d\tau_S} = -\frac{\frac{\partial RHS}{\partial \tau_S}}{\frac{\partial RHS}{\partial P_S}}, \tag{A-24}$$

$$\begin{aligned} \frac{\partial RHS}{\partial \tau_S} &= \frac{\partial \mathcal{C}}{\partial \tau_S} \left(\Psi_O^N \left[V(\theta_2) - V(\theta_1)\right] + \Psi_V^N \left[V(\theta_3) - V(\theta_2)\right]\right) \\ &+ \frac{\partial \mathcal{A}}{\partial \tau_S} \left(\Psi_O^S \left[V(\theta_4) - V(\theta_3)\right] + \Psi_V^S \left[V(\infty) - V(\theta_4)\right]\right), \end{aligned} \tag{A-25}$$

$$\frac{\partial RHS}{\partial P_S} = \frac{\partial \mathcal{C}}{\partial P_S}\left(\Psi_O^N\left[V(\theta_2)-V(\theta_1)\right]+\Psi_V^N\left[V(\theta_3)-V(\theta_2)\right]\right) + \frac{\partial \mathcal{A}}{\partial P_S}\left(\Psi_O^S\left[V(\theta_4)-V(\theta_3)\right]+\Psi_V^S\left[V(\infty)-V(\theta_4)\right]\right). \tag{A-26}$$

Once again, recall from the main text that I evaluate the results around free trade (i.e., at $\tau_S = 1$), then:

$$\left.\frac{\partial \mathcal{A}}{\partial P_S}\right|_{\tau_S=1} = \mathcal{I}\left[(1-\gamma)P_S^{\mathcal{I}-1}+\gamma P_N^{\mathcal{I}-1}\right] > 0,$$
$$\left.\frac{\partial \mathcal{C}}{\partial P_S}\right|_{\tau_S=1} = \mathcal{I}\left[(1-\gamma)P_S^{\mathcal{I}-1}+\gamma P_N^{\mathcal{I}-1}\right] > 0,$$
$$\left.\frac{\partial \mathcal{A}}{\partial \tau_S}\right|_{\tau_S=1} = -\mathcal{I}\gamma P_N^{\mathcal{I}-1}P_S^{\frac{-1}{\alpha-1}}\left[\rho_O^N\left[V\left(\theta_2\right)-V\left(\theta_1\right)\right]+\rho_V^N\left[V\left(\theta_3\right)-V\left(\theta_2\right)\right]\right] < 0,$$
$$\left.\frac{\partial \mathcal{C}}{\partial \tau_S}\right|_{\tau_S=1} = (1-\gamma)P_S^{\mathcal{I}}\frac{1}{\alpha-1} - \mathcal{I}\gamma P_N^{\mathcal{I}-1}P_S^{\frac{-1}{\alpha-1}}\left[\rho_O^N\left[V\left(\theta_2\right)-V\left(\theta_1\right)\right]+\rho_V^N\left[V\left(\theta_3\right)-V\left(\theta_2\right)\right]\right] < 0.$$

After I plug these partial derivativies in (A-25) and (A-26), I am able to find the exact expression for (A-24):

$$\left.\frac{dP_S}{d\tau_S}\right|_{\tau_S=1} = \frac{\gamma P_N^{\mathcal{I}-1}\left(P_S^{\frac{-1}{\alpha-1}}\left[\rho_O^N[V(\theta_2)-V(\theta_1)]+\rho_V^N[V(\theta_3)-V(\theta_2)]\right]\right)}{(1-\gamma)P_S^{\mathcal{I}-1}+\gamma P_N^{\mathcal{I}-1}} + \frac{(1-\gamma)P_S^{\mathcal{I}}\frac{1}{1-\alpha}\left\{\Psi_O^N[V(\theta_2)-V(\theta_1)]+\Psi_V^N[V(\theta_3)-V(\theta_2)]\right\}}{\mathcal{I}\left[(1-\gamma)P_S^{\mathcal{I}-1}+\gamma P_N^{\mathcal{I}-1}\right]\left\{\Psi_O^N[V(\theta_2)-V(\theta_1)]+\Psi_V^N[V(\theta_3)-V(\theta_2)]+\Psi_O^S[V(\theta_4)-V(\theta_3)]+\Psi_V^S[V(\infty)-V(\theta_4)]\right\}} > 0.$$

Therefore,

$$\left.\frac{dP_S}{d\tau_S}\right|_{\tau_S=1} > 0. \tag{A-27}$$

Knowing $\frac{dP_S}{d\tau_S}$, I can find $\frac{dP_N}{d\tau_S}$

$$\left.\frac{dP_N}{d\tau_S}\right|_{\tau_S=1} = \frac{\partial P_N}{\partial P_S}\frac{dP_S}{d\tau_S} + \frac{\partial P_N}{\partial \tau_S}d\tau_S$$
$$= \frac{dP_S}{d\tau_S} - P_S^{\frac{1}{1-\alpha}}\left[\rho_O^N\left[V\left(\theta_2\right)-V\left(\theta_1\right)\right]+\rho_V^N\left[V\left(\theta_3\right)-V\left(\theta_2\right)\right]\right].$$

Given the changes in the aggregate prices, the slopes of the profit lines will change in the following way:

$$\frac{d\mathcal{A}}{d\tau_S} = \mathcal{I}\left[\left(1-\gamma\right)P_s^{\mathcal{I}-1}\frac{dP_S}{d\tau_N} + \gamma P_N^{\mathcal{I}-1}\frac{dP_N}{d\tau_N}\right]$$
$$\frac{d\mathcal{A}}{d\tau_S} = \frac{(1-\gamma)P_S^{\mathcal{I}}\frac{1}{1-\alpha}\left\{\Psi_O^N[V(\theta_2)-V(\theta_1)]+\Psi_V^N[V(\theta_3)-V(\theta_2)]\right\}}{\Psi_O^N[V(\theta_2)-V(\theta_1)]+\Psi_V^N[V(\theta_3)-V(\theta_2)]+\Psi_O^S[V(\theta_4)-V(\theta_3)]+\Psi_V^S[V(\infty)-V(\theta_4)]} > 0.$$

$$\frac{d\mathcal{C}}{d\tau_S} = \mathcal{I}\left[\left(1-\gamma\right)P_s^{\mathcal{I}-1}\frac{dP_S}{d\tau_N} + \gamma P_N^{\mathcal{I}-1}\frac{dP_N}{d\tau_N}\right] - \frac{1}{1-\alpha}\tau_S^{\frac{1}{\alpha-1}-1}\left(1-\gamma\right)P_S^{\mathcal{I}}$$
$$= \frac{1}{1-\alpha}\left(1-\gamma\right)P_S^{\mathcal{I}}\left(\frac{\Psi_O^N[V(\theta_2)-V(\theta_1)]+\Psi_V^N[V(\theta_3)-V(\theta_2)]}{\Psi_O^N[V(\theta_2)-V(\theta_1)]+\Psi_V^N[V(\theta_3)-V(\theta_2)]+\Psi_O^S[V(\theta_4)-V(\theta_3)]+\Psi_V^S[V(\infty)-V(\theta_4)]} - 1\right) < 0.$$

A.3.1 Effects on Cutoffs

Given that $\frac{d\mathcal{A}}{d\tau_S} > 0$ and $\frac{d\mathcal{C}}{d\tau_S} < 0$, it is straightforward to check that

$$\left.\frac{d\theta_1}{d\tau_S}\right|_{\tau_S=1} = \left[\frac{w^N f_O^N}{\Psi_O^N}\frac{1}{\mathcal{C}}\right]^{\frac{1-\alpha}{\alpha}-1} \frac{w^N f_O^N}{\Psi_O^N}\frac{-1}{\mathcal{C}^2}\frac{d\mathcal{C}}{d\tau_S} > 0.$$

$$\left.\frac{d\theta_2}{d\tau_S}\right|_{\tau_S=1} = \left[\frac{w^N (f_V^N - f_O^N)}{(\Psi_V^N - \Psi_O^N)}\frac{1}{\mathcal{C}}\right]^{\frac{1-\alpha}{\alpha}-1} \frac{w^N (f_V^N - f_O^N)}{(\Psi_V^N - \Psi_O^N)}\frac{-1}{\mathcal{C}^2}\frac{d\mathcal{C}}{d\tau_S} > 0.$$

$$\left.\frac{d\theta_3}{d\tau_S}\right|_{\tau_S=1} = \left[\frac{w^N (f_O^S - f_V^N)}{(\Psi_O^S\mathcal{A} - \Psi_V^N\mathcal{C})}\right]^{\frac{1-\alpha}{\alpha}-1} \frac{-w^N (f_O^S - f_V^N)}{(\Psi_O^S\mathcal{A} - \Psi_V^N\mathcal{C})^2}\left(\Psi_O^S\frac{d\mathcal{A}}{d\tau_N} - \Psi_V^N\frac{d\mathcal{C}}{d\tau_N}\right) < 0.$$

$$\left.\frac{d\theta_4}{d\tau_S}\right|_{\tau_S=1} = \left[\frac{w^N (f_V^S - f_O^S)}{(\Psi_V^S - \Psi_O^S)}\frac{1}{\mathcal{A}}\right]^{\frac{1-\alpha}{\alpha}-1} \frac{w^N (f_V^S - f_O^S)}{(\Psi_V^S - \Psi_O^S)}\frac{-1}{\mathcal{A}^2}\frac{d\mathcal{A}}{d\tau_N} < 0.$$

A.3.2 Effects on Market Shares

First, I want to study how $\frac{\sigma_O^S}{\sigma_V^S}$, $\frac{\sigma_V^S}{\sigma_O^N}$ and $\frac{\sigma_O^N}{\sigma_V^N}$ are affected by the tariffs.

- $\frac{\sigma_O^S}{\sigma_V^S} = \frac{[V(\theta_4)-V(\theta_3)]\rho_O^S}{[V(\infty)-V(\theta_4)]\rho_V^S}$

$$\frac{\sigma_O^S}{\sigma_V^S} = \frac{\rho_O^S}{\rho_V^S}\left[\left[\frac{\frac{f_O^S - f_V^N}{\Psi_O^S - \Psi_V^N\frac{\mathcal{C}}{\mathcal{A}}}}{\frac{f_V^S - f_O^S}{\Psi_V^S - \Psi_O^S}}\right]^{1-\frac{1-\alpha}{\alpha}z} - 1\right].$$

Given that $\frac{d\mathcal{A}}{d\tau_S} > 0$, $\frac{d\mathcal{C}}{d\tau_S} < 0$ and $1 < \frac{z(1-\alpha)}{\alpha}$ it follows that $\left.\frac{d\left(\frac{\sigma_O^S}{\sigma_V^S}\right)}{d\tau_S}\right|_{\tau_S=1} > 0.$

- $\frac{\sigma_V^S}{\sigma_O^N} = \frac{[V(\infty)-V(\theta_4)]\mathcal{A}\rho_V^S}{[V(\theta_2)-V(\theta_1)]\mathcal{C}\rho_O^N}$

$$\frac{\sigma_V^S}{\sigma_O^N} = \frac{\mathcal{A}^{\frac{1-\alpha}{\alpha}z}\rho_V^S}{\mathcal{C}^{\frac{1-\alpha}{\alpha}z}\rho_O^N}\frac{\left[\frac{f_V^S - f_O^S}{\Psi_V^S - \Psi_O^S}\right]^{1-\frac{1-\alpha}{\alpha}z}}{\left[\frac{f_O^N}{\Psi_O^N}\right]^{1-\frac{1-\alpha}{\alpha}z} - \left[\frac{f_V^N - f_O^N}{\Psi_V^N - \Psi_O^N}\right]^{1-\frac{1-\alpha}{\alpha}z}}$$

Given that $\frac{d\mathcal{A}}{d\tau_S} > 0$, $\frac{d\mathcal{C}}{d\tau_S} < 0$ and $0 < \frac{z(1-\alpha)}{\alpha}$ it follows that $\left.\frac{d\left(\frac{\sigma_V^S}{\sigma_O^N}\right)}{d\tau_S}\right|_{\tau_S=1} > 0.$

- $\frac{\sigma_O^N}{\sigma_V^N} = \frac{[V(\theta_2)-V(\theta_1)]\rho_O^N}{[V(\theta 3)-V(\theta_2)]\rho_V^N}$

$$\frac{\sigma_O^N}{\sigma_V^N} = \frac{\rho_O^N}{\rho_V^N}\frac{\left[\frac{f_O^N}{\Psi_O^N}\right]^{1-\frac{1-\alpha}{\alpha}z} - \left[\frac{f_V^N - f_O^N}{\Psi_V^N - \Psi_O^N}\right]^{1-\frac{1-\alpha}{\alpha}z}}{\left[\frac{f_V^N - f_O^N}{(\Psi_V^N - \Psi_O^N)}\right]^{1-\frac{1-\alpha}{\alpha}z} - \left[\frac{f_O^S - f_V^N}{\Psi_O^S\frac{\mathcal{A}}{\mathcal{C}} - \Psi_V^N}\right]^{1-\frac{1-\alpha}{\alpha}z}}$$

Given that $\frac{d\mathcal{A}}{d\tau_S} > 0$, $\frac{d\mathcal{C}}{d\tau_S} < 0$ and $1 < \frac{z(1-\alpha)}{\alpha}$ it follows that $\left.\frac{d\left(\frac{\sigma_O^N}{\sigma_V^N}\right)}{d\tau_S}\right|_{\tau_S=1} > 0.$

Next, I am interested on the effects of tariffs on the sales of offshoring firms.

$$sales_O^S = \mathcal{A}\rho_O^S\left[V(\theta_4) - V(\theta_3)\right]$$
$$= \mathcal{A}^{\frac{1-\alpha}{\alpha}z}\rho_O^S b^{z-\frac{\alpha}{1-\alpha}}\left[\left[\frac{w^N(f_O^S - f_V^N)}{(\Psi_O^S - \Psi_V^N\frac{\mathcal{C}}{\mathcal{A}})}\right]^{1-\frac{1-\alpha}{\alpha}z} - \left[\frac{w^N(f_V^S - f_O^S)}{(\Psi_V^S - \Psi_O^S)}\right]^{1-\frac{1-\alpha}{\alpha}z}\right]$$

$\frac{dsales_O^S}{d\tau_S} > 0$. (given that $1 - \frac{1-\alpha}{\alpha}z < 0$).

$sales_V^S = \mathcal{A}\rho_V^S \left[V(\infty) - V(\theta_4)\right]$
$= \mathcal{A}^{\frac{1-\alpha}{\alpha}z}\rho_V^S b^{z-\frac{\alpha}{1-\alpha}} \left[\frac{w^N(f_V^S - f_O^S)}{(\Psi_V^S - \Psi_O^S)}\right]^{1-\frac{1-\alpha}{\alpha}z}$
$\frac{dsales_V^S}{d\tau_S} > 0.$

Finally, I check how sales of offshoring firms are splitted between both markets:
$\frac{revenue^N}{revenue^S} = \frac{\gamma^{1-\alpha}x_N^\alpha}{(1-\gamma)^{1-\alpha}\tau_S^{-1}x_S^\alpha} = \frac{\gamma}{(1-\gamma)\tau_S^{\frac{1}{\alpha-1}}}$
$\frac{d\left(R^N/R^S\right)}{d\tau_S} > 0.$

Therefore:

1. The imposition of t^S increases $\frac{\sigma_O^S}{\sigma_V^S}$, $\frac{\sigma_V^S}{\sigma_O^N}$, and $\frac{\sigma_O^N}{\sigma_V^N}$.
2. The imposition of t^S, increases the sales of both (S,O) and (S,V) (especially in Northern markets). Hence, it also increases total imports.

A.3.3 Proof of Proposition 5

Recall that the cutoffs are defined in the following way:

$$\theta_1 = \left[\frac{w^N f_O^N}{\Psi_O^N}\frac{1}{\mathcal{C}}\right]^{\frac{1-\alpha}{\alpha}} \tag{A-28}$$
$$\theta_2 = \left[\frac{w^N(f_V^N - f_O^N)}{(\Psi_V^N - \Psi_O^N)}\frac{1}{\mathcal{C}}\right]^{\frac{1-\alpha}{\alpha}}$$
$$\theta_3 = \left[\frac{w^N\left(f_O^S - f_V^N\right)}{\left(\Psi_O^S\mathcal{A} - \Psi_V^N\mathcal{C}\right)}\right]^{\frac{1-\alpha}{\alpha}}$$
$$\theta_4 = \left[\frac{w^N(f_V^S - f_O^S)}{(\Psi_V^S - \Psi_O^S)}\frac{1}{\mathcal{A}}\right]^{\frac{1-\alpha}{\alpha}}$$

where $\mathcal{A}$ determines the slope of the profit functions of offshoring firms:

$$\mathcal{A} \equiv (1-\gamma)P_S^{\mathcal{I}} + \gamma P_N^{\mathcal{I}} \tag{A-29}$$

and $\mathcal{C}$ determines the slope of non-offshoring firms' profit functions:

$$\mathcal{C} \equiv (1-\gamma)P_S^{\mathcal{I}}\tau_S^{\frac{1}{\alpha-1}} + \gamma P_N^{\mathcal{I}} \tag{A-30}$$

with $\mathcal{I} \equiv \frac{\alpha-\mu}{(1-\mu)(1-\alpha)} > 0$ and $\frac{1}{\alpha-1} < 0$.

Proposition 5. *In the benchmark case, for any differentiable distribution function $G(\cdot)$, a tariff τ_S imposed on the Southern imports of differentiated goods will have the following effects:*

1. *Cutoffs θ_1 and θ_2 will increase:* $\frac{d\theta_1}{d\tau_S} > 0$, $\frac{d\theta_2}{d\tau_S} > 0$,
2. *Cutoffs θ_3 and θ_4 will decrease:* $\frac{d\theta_3}{d\tau_S} < 0$, $\frac{d\theta_4}{d\tau_S} < 0$.

Proof. The result follows from simple differentiation of (A-28), given that $\frac{d\mathcal{A}}{d\tau_S} > 0$ and $\frac{d\mathcal{C}}{d\tau_S} < 0$ by Lemma A.8 (see below). ■

Lemma A.5. *If an increase of τ_S causes $\mathcal{A}$ to increase ($\frac{d\mathcal{A}}{d\tau_S} > 0$), then $\mathcal{C}$ will decrease ($\frac{d\mathcal{C}}{d\tau_S} < 0$). Conversely, if τ_S causes $\mathcal{A}$ to decrease ($\frac{d\mathcal{A}}{d\tau_S} < 0$), then $\mathcal{C}$ will increase ($\frac{d\mathcal{C}}{d\tau_S} > 0$).*

Proof. First, re-write the free entry condition:

$$\begin{aligned} w^N f_E &= \int_{\theta_1}^{\theta_2} \left(\mathcal{C}\Psi_O^N \theta^{\frac{\alpha}{1-\alpha}} - w^N f_O^N\right) dG(\theta) + \int_{\theta_2}^{\theta_3} \left(\mathcal{C}\Psi_V^N \theta^{\frac{\alpha}{1-\alpha}} - w^N f_V^N\right) dG(\theta) \\ &+ \int_{\theta_3}^{\theta_4} \left(\mathcal{A}\Psi_O^S \theta^{\frac{\alpha}{1-\alpha}} - w^N f_O^S\right) dG(\theta) + \int_{\theta_4}^{\infty} \left(\mathcal{A}\Psi_V^S \theta^{\frac{\alpha}{1-\alpha}} - w^N f_V^S\right) dG(\theta). \end{aligned}$$

Next, totally differentiate with respect to τ_S:

$$0 = \frac{d\mathcal{C}}{d\tau_S}\left(\Psi_O^N [V(\theta_2) - V(\theta_1)] + \Psi_V^N [V(\theta_3) - V(\theta_2)]\right) + \frac{d\mathcal{A}}{d\tau_S}\left(\Psi_O^S [V(\theta_4) - V(\theta_3)] + \Psi_V^S [V(\infty) - V(\theta_4)]\right),$$

where, by the Envelope Theorem, the derivatives with respect to the cutoffs cancel each other out. Since both terms in brackets are positive, it follows that $sign\left(\frac{d\mathcal{A}}{d\tau_S}\right) = -sign\left(\frac{d\mathcal{C}}{d\tau_S}\right)$. ■

Lemma A.6. *Suppose that τ_S causes P_S to increase ($\frac{dP_S}{d\tau_S} > 0$). Then, $\mathcal{A}$ must also increase ($\frac{d\mathcal{A}}{d\tau_S} > 0$).*

Proof. Given the assumption of $\frac{dP_S}{d\tau_S} > 0$, if P_N increases ($\frac{dP_N}{d\tau_S} > 0$), $\mathcal{A}$ will increase by definition. Instead, suppose that they both decrease: $\frac{dP_N}{d\tau_S} < 0$ and $\frac{d\mathcal{A}}{d\tau_S} < 0$. Then, $\mathcal{C}$ must also decrease since:

$$\frac{d\mathcal{C}}{d\tau_S} = \underbrace{\frac{d\mathcal{A}}{d\tau_S}}_{<0} + (1-\gamma)\mathcal{I}P_S^{\mathcal{I}-1}\underbrace{\frac{dP_S}{d\tau_S}}_{>0}\underbrace{\left(\tau_S^{\frac{1}{\alpha-1}} - 1\right)}_{<0} + (1-\gamma)P_S^{\mathcal{I}}\underbrace{\left(\frac{1}{\alpha-1}\right)}_{<0}\tau_S^{\frac{1}{\alpha-1}} < 0.$$

But, by Lemma A.5 it is not possible for both $\mathcal{A}$ and $\mathcal{C}$ to decrease. ■

Lemma A.7. *It is not possible for these four conditions to hold at the same time: (i) $\frac{dP_N}{d\tau_S} > 0$, (ii) $\frac{dP_S}{d\tau_S} < 0$, (iii) $\frac{d\mathcal{A}}{d\tau_S} < 0$, and (iv) $\frac{d\mathcal{C}}{d\tau_S} > 0$.*

Proof. First, note that if this is the case, then $\frac{d\theta_1}{d\tau_S} < 0$, and $\frac{d\theta_2}{d\tau_S} < 0$ and $\frac{d\theta_3}{d\tau_S} > 0$. Next, recall how the aggregate prices are related:

$$\begin{aligned} P_N^{\frac{\alpha}{\alpha-1}} &= P_S^{\frac{\alpha}{\alpha-1}} + \left(1 - \tau_S^{\frac{\alpha}{\alpha-1}}\right)\left\{\rho_O^N [V(\theta_2) - V(\theta_1)] + \rho_V^N [V(\theta_3) - V(\theta_2)]\right\} \\ &\Rightarrow \\ P_N^{\frac{\alpha}{\alpha-1}} - P_S^{\frac{\alpha}{\alpha-1}} &= \left(1 - \tau_S^{\frac{\alpha}{\alpha-1}}\right)\left\{\rho_O^N [V(\theta_2) - V(\theta_1)] + \rho_V^N [V(\theta_3) - V(\theta_2)]\right\}. \end{aligned}$$

Finally, I differentiate the last expression:

$$\underbrace{\frac{\alpha}{\alpha-1}}_{<0} P_N^{\frac{1}{\alpha-1}}\underbrace{\frac{dP_N}{d\tau_S}}_{>0} - \underbrace{\frac{\alpha}{\alpha-1}}_{<0} P_S^{\frac{1}{\alpha-1}}\underbrace{\frac{dP_S}{d\tau_S}}_{<0} = \underbrace{\frac{-\alpha}{\alpha-1}}_{>0}\tau_S^{\frac{1}{\alpha-1}}\{\cdot\} + \underbrace{\left(1 - \tau_S^{\frac{\alpha}{\alpha-1}}\right)}_{>0}\underbrace{\left\{\rho_V^N \frac{dV(\theta_3)}{d\tau_S} - \rho_O^N \frac{dV(\theta_1)}{d\tau_S} - \left(\rho_V^N - \rho_O^N\right)\frac{dV(\theta_2)}{d\tau_S}\right\}}_{>0}$$

where $sign\left(\frac{d\theta}{d\tau_S}\right) = sign\left(\frac{dV(\theta)}{d\tau_S}\right) = sign\left(\theta^{\frac{\alpha}{1-\alpha}} g(\theta)\frac{d\theta}{d\tau_S}\right)$. Since the LHS is negative and the RHS is positive, there is a contradiction, so I can rule out this case. ■

Corollary A.2. *If $\frac{dP_N}{d\tau_S} > 0$ and $\frac{dP_S}{d\tau_S} < 0$, then $\frac{d\mathcal{A}}{d\tau_S} > 0$, and $\frac{d\mathcal{C}}{d\tau_S} < 0$.*

Proof. If $\frac{dP_N}{d\tau_S} > 0$ and $\frac{dP_S}{d\tau_S} < 0$ then, by the free entry condition, either (i) $\frac{d\mathcal{A}}{d\tau_S} > 0$ and $\frac{d\mathcal{C}}{d\tau_S} < 0$, or (ii) $\frac{d\mathcal{A}}{d\tau_S} < 0$ and $\frac{d\mathcal{C}}{d\tau_S} > 0$. However, case (ii) is not possible by Lemma A.7. ■

Lemma A.8. *If τ_S increases, then $\mathcal{A}$ will increase and $\mathcal{C}$ will decrease: $\frac{d\mathcal{A}}{d\tau_S} > 0$ and $\frac{d\mathcal{C}}{d\tau_S} < 0$.*

Proof. There are four possible ways in which the aggregate prices may change in response to τ_S:

1. $P_S \uparrow$, $P_N \uparrow \Rightarrow \mathcal{A} \uparrow$ (by definition of $\mathcal{A}$)$\Rightarrow \mathcal{C} \downarrow$ (by Lemma A.5).
2. $P_S \uparrow$, $P_N \downarrow \Rightarrow \mathcal{A} \uparrow$ (by Lemma A.6)$\Rightarrow \mathcal{C} \downarrow$ (by Lemma A.5).
3. $P_S \downarrow$, $P_N \downarrow \Rightarrow \mathcal{A} \downarrow$, $\mathcal{C} \downarrow$ (Impossible by Lemma A.5).
4. $P_S \downarrow$, $P_N \uparrow \Rightarrow \mathcal{A} \uparrow$, $\mathcal{C} \downarrow$ (by Lemma A.5 and Corollary A.2).

■

B Data Description for Figures I and II

Figures I and II are constructed using tariff data from TRAINS and import data from the U.S. Census, averaged over the period 2000–2006. For the first figure, I use the imports into the United States from the rest of the world by HS6 industries and the corresponding U.S. tariffs. The first bin (those industries with a tariff of zero) contains 861 observations; the remaining bins contain 241 observations. For the second figure, I use the overall imports into the United States from each of the top-15 U.S. suppliers (that is, the countries ranked by total U.S. imports), along with the corresponding tariff. Table XI lists the countries (and its codes) used in Figure II. Following the criteria of the main text, the figures exclude the industries below the median skill intensity and the intermediate good industries—footnote 31 explains how these industries were identified.

Table XI: Country Codes

Rank	Code	Country
1	EU	European Union
2	CAN	Canada
3	CHN	China
4	MEX	Mexico
5	JPN	Japan
6	KOR	South Korea
7	TWN	Taiwan
8	MYS	Malaysia
9	SAU	Saudi Arabia
10	BRA	Brazil
11	VEN	Venezuela
12	THA	Thailand
13	SGP	Singapore
14	NGA	Nigeria
15	IND	India

C Simple OLS Estimates by Industry and Country

In this appendix I present the estimates of equation (22) for each 1-digit HS aggregate industry (pooling over countries) and for each country in our sample (pooling over industries).[60] There are several features to point out. First, overall the estimates have the right sign, although they are not always significant. Industries 8 and 9, which are mostly industrial differentiated goods, have significant estimates. Third, as highlighted on the main text, Chinese observations seem to behave against the theoretical predictions. Fourth, to handle the lack of significance, I ran a weaker test with the null hypothesis: "the estimate of β_1 (β_2) has the right sign." The results are shown on the columns labeled $\beta_1 \geq 0$ and $\beta_2 \leq 0$. As can be seen on the tables, in almost all cases, I cannot the reject the null hypothesis.

[60] In the case of Canada, there is very little tariff variation, and therefore Canada is dropped out when performing the by-country estimations.

Table XII: Baseline Results by Industry

HS	Obs.	β_1	$\beta_1 \geq 0$	β_2	$\beta_2 \leq 0$
Pool	19,726	0.013***	Y	-0.0039***	Y
		(0.002)		(0.001)	
0	190	0.0184**	Y	-0.0031*	Y
		(0.01)		(0.002)	
1	625	0.0613**	Y	-0.0027***	Y
		(0.026)		(0.001)	
2	3,296	0.0359***	Y	-0.0025***	Y
		(0.006)		(0.001)	
3	4,240	0.0148***	Y	-0.0047***	Y
		(0.004)		(0.001)	
4	975	-0.0081	N*	-0.0024	Y
		(0.005)		(0.002)	
5	103	0.074***	Y	-0.0012	Y
		(0.02)		(0.009)	
6	453	0.0101	Y	-0.0030	Y
		(0.020)		(0.003)	
7	1,438	-0.0049	Y	-0.0028	Y
		(0.013)		(0.002)	
8	6,091	0.0126***	Y	-0.0017*	Y
		(0.004)		(0.001)	
9	2,315	0.0327***	Y	-0.0067***	Y
		(0.008)		(0.001)	

Notes: "***", "**" and "*" refers to statistical significance at the 1%, 5% and 10% levels, respectively. Country and year fixed effects included. Chinese observations were excluded.

Table XIII: Baseline Results by Country

Country	Obs.	β_1		β_2	
		Estimate	≥ 0	Estimate	≤ 0
Brazil	2,825	0.0119***	Y	-0.0068***	Y
		(0.005)		(0.001)	
China	4,597	-0.0081***	N***	-0.003***	Y
		(0.001)		(0.001)	
Ireland	2,098	0.005	Y	0.0157***	N***
		(0.004)		(0.004)	
Malaysia	1,177	0.0002	Y	-0.0099***	Y
		(0.005)		(0.001)	
Mexico	5,444	0.0151***	Y	-0.0019***	Y
		(0.003)		(0.001)	

Notes: "***", "**" and "*" refers to statistical significance at the 1%, 5% and 10% levels, respectively. Regressions include year fixed effects.

D Offshoring of Intermediate Inputs

In Díez (2006) I studied the effects of tariffs on the ratio of intra-firm to total imports when trade flows occur just like in Antràs and Helpman (2004). In that setting, all final goods a produced in the Northern country and when a firm offshores is to obtain an intermediate good overseas.[61]

One of the theoretical predictions from Díez (2006) is that, in the case of intermediate goods, the ratio of intra-firm imports to total imports m_{ict} depends positively on American tariffs.

Accordingly, I ran the following regression for those industries whose definition contains the word "component" or "part:"

$$m_{ict} = \alpha_0 + \alpha_1 \cdot t_{ict}^{US} + \alpha_3 \left(\frac{k}{l}\right)_i + \alpha_4 \left(\frac{s}{l}\right)_i + \alpha_5 \cdot freight_i + \alpha_6 \left(\frac{K}{L}\right)_c + \alpha_7 \left(\frac{H}{L}\right)_c + X_t + \varepsilon_{ict}. \quad \text{(D-31)}$$

I expect to find $\alpha_1 > 0$.[62]

Table XIV shows that this theoretical result finds very weak support on the data. Indeed, the only case when the estimate has the right sign and is statistically significant is when Chinese and $m_i = 0$ observations are dropped.

Table XIV: OLS Regressions

	-1-	-2-	-3-	-4-
α_1	-0.007	-0.001	0.004	0.0226*
	(0.005)	(0.009)	(0.006)	(0.012)
Obs.	5,510	4,531	4,251	3,407
$m_i = 0$	Yes	Yes	No	No
China	Yes	No	Yes	No

Notes: "***", "**" and "*" refers to statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors clustered by (4-digit SIC industry, Country) pairs.

To sum up, the data does not seem to support the theoretical predictions regarding the effects of tariffs on the ratio of intra-firm imports to total imports when offshoring is defined as procuring intermediate inputs overseas. Of course, for reasons discussed in the Introduction (the need to observe firm-level data and to match input imports to final-good exports) the results of this appendix are not conclusive. Further and deeper research on this phenomena is needed but this exploration goes beyond the scope of the present paper.

[61] Since all final goods are produced in North, a Southern tariff on final goods will have no effect the ratio of intra-firm imports because it will affect all types of firms in exactly the same way.

[62] In this setting, the Southern countries does not import any intermediate goods. Therefore, the estimating equation does not include t_{ict}^F as a covariate.

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