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

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Abstract:

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

Keywords: intra-firm trade, offshoring, outsourcing, tariffs

JEL Classifications: F10, F23, L22, L23

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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 2009, intra-firm imports accounted, on average, for 47.1 percent 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 1 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 2000–2009. As the figure confirms, there is a positive relationship between U.S. tariffs and the share of U.S. intra-firm imports.

Second, U.S. intra-firm imports depend negatively on *foreign* tariffs. In other words, U.S. 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 2 provides some informal evidence of this fact, using data averaged over 2000–2009. U.S. trading partners were sorted into quintiles according to the average tariff imposed on U.S. products. The figure shows that there is a clear negative relationship between foreign tariffs and the share of U.S. intra-firm imports.

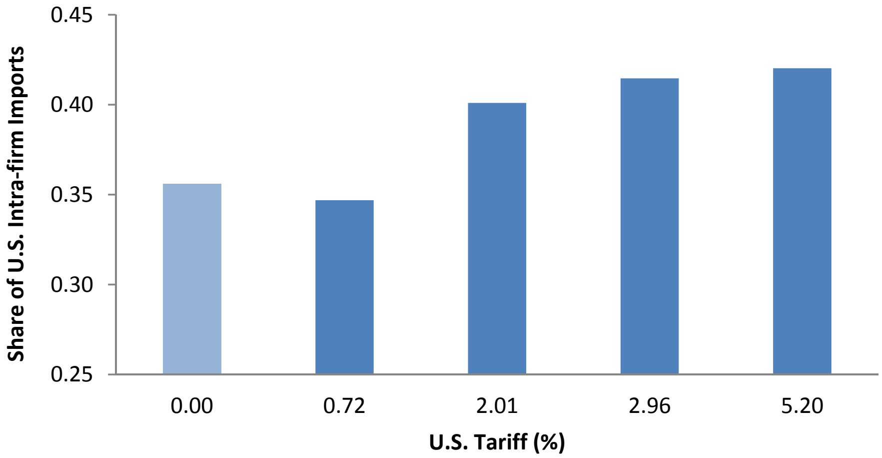
In this paper I develop a theoretical framework to rationalize these facts and I empirically test its implications.[2] In particular, I extend the Antràs and Helpman (2004) North-South model of international trade with incomplete contracts.

As in Antràs and Helpman (2004), 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 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

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

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

Figure 1: Share of U.S. Intra-Firm Imports and U.S. Tariffs



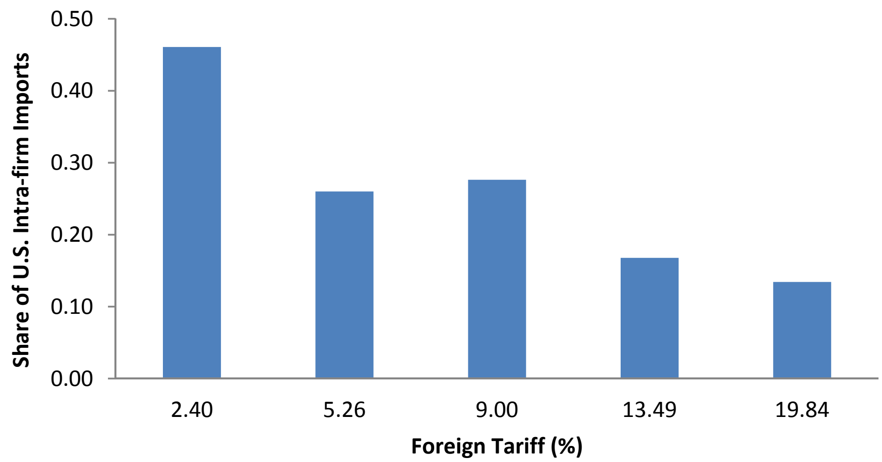
Source: Author's calculations.
Notes: "Share of U.S. Intra-Firm Imports" is the average ratio of intra-firm imports to total U.S. imports of the respective bin. HS6 industries were assigned to bins according to the U.S. tariff. The light column contains all industries with a tariff equal to zero. The rest of the sample was divided in quartiles; each column plots the average share of intra-firm imports for the corresponding bin. The average tariff value for each quartile is reported at the bottom of the horizontal axis. All data are averaged over the period 2000–2009.

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.[3] More specifically, I assume that each entrepreneur possesses a critical input, such as a blueprint. The entrepreneur then

[3]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.

Figure 2: 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 each trading partner country, averaged across industries. Countries were sorted into quintiles according to their tariff value. The average (across countries) tariff value for each quintile is reported at the bottom of the horizontal axis. "Share of U.S. Intra-Firm Imports" is the ratio of intra-firm imports to total U.S. imports from each of these countries. Each column plots the average share of intra-firm imports for the corresponding bin. All data are averaged over the period 2000–2009.

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.[4] 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 findings. 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—thereby 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

[4]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).

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 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; there will be 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 1 (Figure 2) precisely reflects 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) during the 2000–2009 period.

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 30 percent. Using this subsample, I find that a 1-percentage point increase in the American tariff is associated with a 0.25 percentage point increase in the ratio, while a 1-percentage point increase in the foreign tariff implies a 0.12 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 obtain identification by specifying alternative choices of 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 countries where, consistent with the theory, intra-firm imports involve mostly American firms. 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). In both cases, the data show strong support for the model's predictions. Finally, consistent with the theory, I also find that these tariff effects are particularly important among industries with high HQ intensity.

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 (2008, 2012) confirm the findings of Antràs and of Yeaple, and find evidence that improved contracting may also increase the share of intra-firm imports (this last prediction is derived from Antràs and Helpman, 2008). Bernard et al. (2008) emphasize the role of the degree of product contractibility.[5]

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 (2012) develop a model with incomplete contracts in which firms decide whether 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 nonlinear responses of trade flows to lower trade costs, a feature found in the data. Antràs and Staiger (2012) 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. A key difference with my paper (among others), is that none of these other studies perform an empirical test of the theoretical implications.

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

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

There are two kinds of goods, homogeneous and differentiated. A homogeneous good,

[5]See Antràs and Yeaple (2013) for an exhaustive review of the literature on multinationals and the structure of international trade.

labeled x_0, is used as a numeraire. Additionally, there are J industries producing differentiated goods $x_j\left(i\right)$.

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

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

where $p_j\left(i\right)$ is the price of good $x_j\left(i\right)$ and $P_j \equiv \left[\int p_j\left(i\right)^{\frac{\alpha}{\alpha-1}} di\right]^{\frac{\alpha-1}{\alpha}}$ 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 $h_j\left(i\right)$ (blueprints, or design of the variety i) while the manager supplies assembly services $a_j\left(i\right)$. Thus, 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 $h_j\left(i\right)$ and $a_j\left(i\right)$, respectively.

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

First, he pays a fixed entry cost f_E of Northern labor units. Then, the entrepreneur draws a productivity level θ from a known distribution function $G\left(\theta\right)$. 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 $h_j\left(i\right)$ and $a_j\left(i\right)$. 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 the terminology in Helpman (2006), 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 $k \in \{V, O\}$. Following Antràs and Helpman (2004), assume that

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

Expression (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 purpose 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 power is equal to $\beta \in (0,1)$ of the resulting revenue. Dropping the j subscripts, the revenue of firm i is given by $R(i) = p(i)\, x(i)$ or

$$R(i) = P^{\frac{\alpha-\mu}{1-\mu}} \theta_i^{\alpha} \left(\frac{h_i}{\nu} \right)^{\nu\alpha} \left(\frac{a_i}{1-\nu} \right)^{\alpha(1-\nu)}. \tag{5}$$

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 manager's work. Thus, the entrepreneur can fire the manager and seize the production. However, without A's cooperation, E will only get a fraction $\delta^l \in (0,1)$ of the output, with $\delta^N \geq \delta^S$ reflecting that the lack of agreement is costlier to the entrepreneur when the manager is located in the South. Thus, E's outside option is $\left(\delta^l\right)^\alpha R(i)$. 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,

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

where $\omega \equiv \frac{\alpha-\mu}{(1-\mu)(1-\alpha)} > 0$ and

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

The 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: $\frac{\partial}{\partial\beta}\pi(\cdot) > 0$.*[6]

[6] In the case where ν is low, outsourcing always dominates vertical integration—the only types of firms

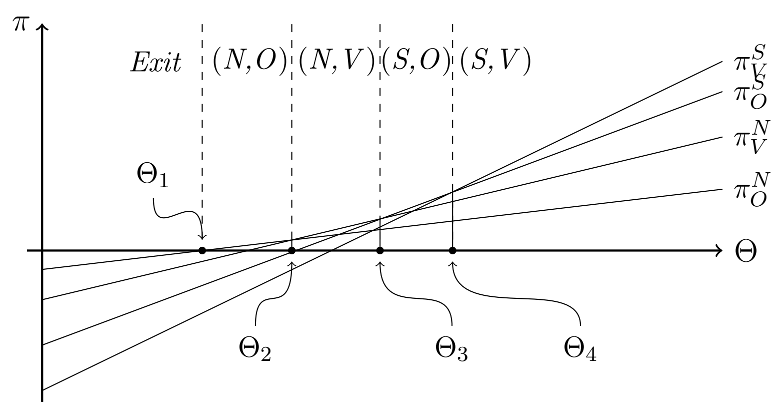
Finally, a free-entry condition, equating the expected profits of a potential entrant to the fixed entry cost, closes the model. Specifically,

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

Equilibrium. All four possible organizational forms may occur in equilibrium (henceforth, I call this the benchmark case). The analysis follows from the alternative profits given by equation (7). First, note that profits are linear in $\Theta \equiv \theta^{\frac{\alpha}{1-\alpha}}$, with the slope equal to $\Psi_k^l P^\omega$. 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 than π_O^S. 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.[7] When this is satisfied, the following ordering holds:

$$\Psi_V^S > \Psi_O^S > \Psi_V^N > \Psi_O^N. \tag{9}$$

Figure 3: Profit Lines [Equation (7)]



Using this fact (see Figure 3) it follows that the least productive firms—those 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

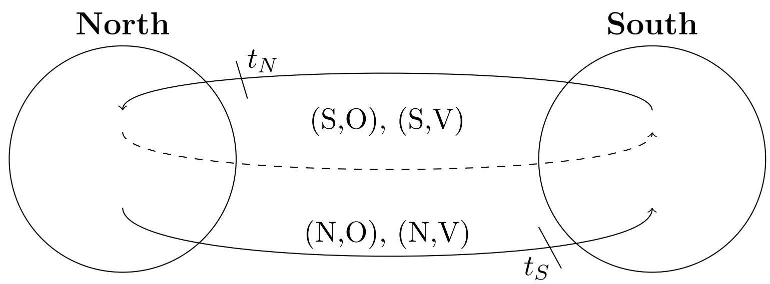
that may exist in equilibrium are (N, O) and (S, O). Hence, the ratio of intra-firm imports to total imports, the object I study on the empirical section, will always be zero. This means that, for the low-ν case, *any* regressor that attempts to explain the share of intra-firm imports should be insignificant. Nunn and Trefler (2012), focusing on the effects of productivity dispersion on the share of intra-firm trade, find some evidence supporting this broader prediction.

[7]Specifically, $\left(\frac{w^N}{w}\right)^{1-\nu} > \phi(\beta_V^N)/\phi(\beta)$, with $\phi \equiv \{1 - \alpha[\gamma\nu + (1-\gamma)(1-\nu)]\}^{(1-\alpha)/\alpha} \gamma^\nu (1-\gamma)^{1-\nu}$.

groups, those with higher θ integrate, while the others outsource.[8]

Intuitively, firms with low productivity will have low production levels 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.

Figure 4: 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) export differentiated final goods from the South to the North and blueprints (or, more generally, inputs) from the North to the South. Figure 4 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.[9]

[8] It is easy to check that $\{(N, O), (N, V), (S, O)\}$ 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). To guarantee that all four types will exist in equilibrium one needs $\theta_1 < \theta_2 < \theta_3 < \theta_4$. This, in turn, requires $\frac{f_O^N}{\Psi_O^N} < \frac{f_O^N - f_V^N}{\Psi_O^N - \Psi_V^N} < \frac{f_V^N - f_O^S}{\Psi_V^N - \Psi_O^S} < \frac{f_O^S - f_V^S}{\Psi_O^S - \Psi_V^S}$.

[9] Although transport costs would have a similar effect to tariffs, I focus on tariffs because these 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.

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

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

$$\begin{aligned} \pi_k^N(i) &= \left(\left(1-\gamma\right) P_S^{\omega} + \gamma P_N^{\omega}\right) \Psi_k^N \Theta_i - f_k^N w^N \\ &= \mathcal{A}\Psi_k^N \Theta_i - f_k^N w^N, \end{aligned} \tag{10}$$

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

Likewise, offshoring firms will have the following profit functions:

$$\begin{aligned} \pi_k^S(i) &= \left(\left(1-\gamma\right) P_S^{\omega} + \gamma P_N^{\omega} \tau_N^{\frac{1}{\alpha-1}}\right) \Psi_k^S \Theta_i - f_k^S w^N \\ &= \mathcal{B}\Psi_k^S \Theta_i - f_k^S w^N, \end{aligned} \tag{11}$$

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

From the above equations it is clear that profits are still linear in Θ. Firms performing assembly in the North will have profit functions with a 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 nonoffshoring firms.

Effects on Cutoffs. The next proposition describes the effects that tariff t_N has on the profit functions and on the different productivity cutoffs.[11]

Proposition 1. *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. ■

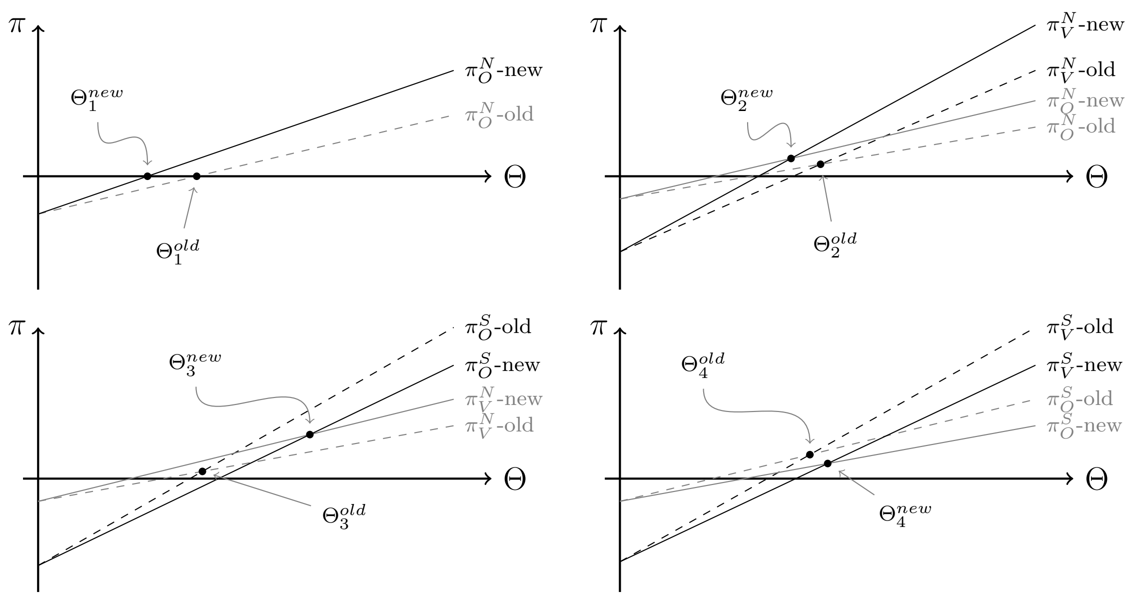
Intuitively, this policy *protects* the firms producing domestically in the North. Thus, there is a decrease in the minimum productivity required to be either a (N, O) or (N, V) firm. At

[10] For simplicity, I assume that the Southern government follows a free trade policy: $t_S = 0$. All the results still hold if both tariffs are positive, although the algebra becomes more complicated.

[11] To guarantee 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: $\frac{f_O^N}{\Psi_O^N \mathcal{A}} < \frac{f_O^N - f_V^N}{(\Psi_O^N - \Psi_V^N)\mathcal{A}} < \frac{f_V^N - f_O^S}{\Psi_V^N \mathcal{A} - \Psi_O^S \mathcal{B}} < \frac{f_O^S - f_V^S}{(\Psi_O^S - \Psi_V^S)\mathcal{B}}$.

the same time, the tariff *hurts* offshoring firms by restricting their access to the Northern market, reducing the slope of their profit functions, thus increasing the productivity cutoffs θ_3 and θ_4. Figure 5 presents a graphical representation of Proposition 1.

Figure 5: Effects of t_N



Effects on Market Shares. Following the literature, suppose that θ is Pareto distributed:

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

where z is the function's shape parameter and is 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 $\rho_k^l = \left[\alpha \left(\frac{\beta_k^l}{w^N}\right)^{\nu} \left(\frac{1-\beta_k^l}{w^l}\right)^{1-\nu}\right]^{\frac{\alpha}{1-\alpha}}$, $V(\theta) \equiv \int_0^{\theta} \theta'^{\frac{\alpha}{1-\alpha}} g(\theta') d\theta'$, and

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

Proposition 2. *In the benchmark case, if $G(\cdot)$ is Pareto, an increase of 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 2). Therefore, arm's-length imports decrease relatively more than intra-firm imports. I summarize this result in the following corollary.

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

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

$$\begin{aligned} \pi_k^N(i) &= \left((1-\gamma) P_S^\omega \tau_S^{\frac{1}{\alpha-1}} + \gamma P_N^\omega \right) \Psi_k^N \Theta_i - f_k^N w^N \\ &= \mathcal{C} \Psi_k^N \Theta_i - f_k^N w^N, \end{aligned} \tag{12}$$

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

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

$$\begin{aligned} \pi_k^S(i) &= \left((1-\gamma) P_S^\omega + \gamma P_N^\omega \right) \Psi_k^S \Theta_i - f_k^S w^N \\ &= \mathcal{A} \Psi_k^S \Theta_i - f_k^S w^N, \end{aligned} \tag{13}$$

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

Effects on Cutoffs. The next proposition describes the effects that tariff t_S has on the profit functions and on the different productivity cutoffs.[12]

Proposition 3. *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.*

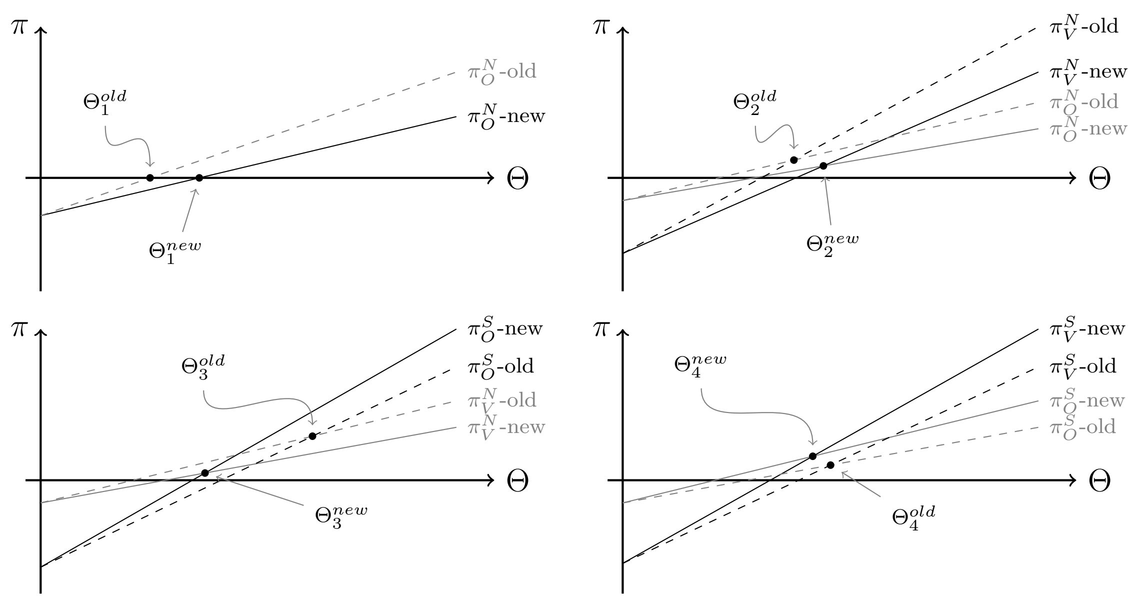
Proof. See Appendix. ■

The tariff t_S, in contrast to t_N, *hurts* the firms producing in the North and *protects* those engaging in offshoring. Thus, the 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 so a lower productivity level is needed to organize as an (S, O) or (S, V) firm. Figure 6 provides a graphical representation of Proposition 3.

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

[12] 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: $\frac{f_O^N}{\Psi_O^N \mathcal{C}} < \frac{f_O^N - f_V^N}{(\Psi_O^N - \Psi_V^N)\mathcal{C}} < \frac{f_V^N - f_O^S}{\Psi_V^N \mathcal{C} - \Psi_O^S \mathcal{A}} < \frac{f_O^S - f_V^S}{(\Psi_O^S - \Psi_V^S)\mathcal{A}}$.

Figure 6: Effects of t_S



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

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

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

Proposition 4. *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.

Proof. See Appendix. ■

By protecting the Southern market, this policy encourages entrepreneurs to offshore (to look for Southern managers). Thus, not surprisingly, 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 outsourcing increases 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 4). Therefore, arm's-length imports increase relatively more than intra-firm imports. I summarize this result in the following corollary.

Corollary 2. *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 theoretical section. From Corollaries 1 and 2, for any sector j, I expect Northern imports to behave in the following way:

$$\tilde{m} \equiv \frac{M_V}{M_V + M_O} = f(\underbrace{t^N}_{(+)}, \underbrace{t^S}_{(-)}), \tag{14}$$

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 want to test whether for any final good industry with relatively *high headquarters intensity*:

- 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 test the predictions embodied by equation (14).

3.2 Data

3.2.1 Sources

The trade data are from the Foreign Trade Division of the U.S. Census Bureau. Importers must declare if 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), by country of origin, for the years 2000 through 2009.[13]

The tariff data come from the United Nation's TRAINS database. For each HS6 industry, over the 2000–2009 period, 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 HQ 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), nonproduction workers (s), and capital (k) for 1996. With these 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 1 presents basic information on U.S. imports during the 2000s. From the table, one can observe that total imports accounted for between \$1.2 and \$2 trillion, whereas related-party imports ranged from \$527 to \$975 billion. Interestingly, as shown in the last column, the share of related-party imports varied within a narrow range of 46.5 to 47.8 percent of total imports.

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

[13] The data are highly disaggregated, as it tracks 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." These data are available from Peter Schott's webpage and was used in Schott (2004). Alternatively, one could use the United Nation's Broad Economic Categories.

Table 1: U.S. Total and Intra-Firm Imports, 2000–2009

Year	Total Imports ($ Bn)	Related Party Imports ($ Bn)	Share (%)
2000	1,205	563	46.7
2001	1,133	527	46.5
2002	1,155	549	47.6
2003	1,250	594	47.5
2004	1,460	698	47.8
2005	1,662	776	46.7
2006	1,845	863	46.8
2007	1,943	920	47.4
2008	2,090	975	46.6
2009	1,549	740	47.8

a proxy for the theoretical M_V imports: $M_{rel} \geq M_V$. Likewise, the observed M_{non} nonrelated imports are just a proxy for the theoretical M_O imports: $M_{non} \geq M_O$.

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.

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:

$$\frac{M_{rel}^{US}}{M_{non}^{US}} = \frac{M_{rel}^{F}}{M_{non}^{F}}. \tag{15}$$

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 nonrelated party imports is the same, whether the imports involve American or Chinese firms.[14] In subsection 3.3.3, I try to account for this potential drawback by controlling the group of countries in the sample.

[14]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 these studies implicitly make the same assumption.

Table 2 presents some basic statistics for the main variables from the dataset used for estimation. There are several features worth pointing out. First, the ratio m of intra-firm imports has a mean of 30 percent but a median of 6.9 percent—the reason for this big difference is that $m = 0$ accounts for almost 37 percent of the observations. Second, U.S. tariffs are on average lower than foreign tariffs. In fact, the mean of U.S. tariffs is 1.64 percent while the median is zero. Third, the tariffs imposed by the *foreign* countries show greater variation than the U.S. tariffs.

Table 2: U.S. Total and Intra-Firm Imports, 2000–2009

	Obs.	Mean	Std. Dev.	Median
m	314,478	30.24	37.52	6.90
τ^{US}	314,478	1.64	2.55	0.00
τ^{F}	314,478	4.85	6.65	2.70

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. While I acknowledge this measure is not perfect, I use it as my default measure of HQ intensity.[15] Additionally, the theory does not pin down what level should be considered high. Consequently, I use the median as the default, but I also look into the full sample in the last section.

The basic estimation equation as follows:

$$m_{ict} = \beta_0 + \beta_1 \cdot t^{US}_{ict} + \beta_2 \cdot t^{F}_{ict} + \beta_3 \cdot X_{ict} + \varepsilon_{ict}, \tag{16}$$

where for industry i, country c and year t, m_{ict} is the ratio of intra-firm imports to total imports, t^{US}_{ict} is the tariff applied by the United States on foreign country c, t^{F}_{ict} 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.[16]

[15] 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 et al. (1988).

[16] When regressing imports on U.S. tariffs one might worry about potential endogeneity issues. However, one should not be concerned in the present setting. Note that the dependent variable is not total imports but rather the *composition* of imports, and that the tariff due is the same regardless of a good being imported as an intra-firm transaction or at arm's-length. Additionally, U.S. tariffs do not seem to be determined by

Table 3 presents the results for different specifications. All the results reported in the table are OLS estimates, and the standard errors are heteroskedasticity-robust.[17]

Table 3: Baseline Regressions

	-1-	-2-	-3-	-4-	-5-	-6-
t^{US}	0.304***	0.251***	0.381***	0.959***	0.548***	0.671***
	(0.076)	(0.043)	(0.046)	(0.050)	(0.101)	(0.117)
t^{F}	–0.049**	–0.124***	–0.260***	–0.550***	–0.070**	–0.063
	(0.024)	(0.023)	(0.023)	(0.011)	(0.035)	(0.046)
FE	c, y, hs2	c-y-hs2	c-y	y-hs6	c, y, hs2	c, y, hs2
R^2	0.142	0.244	0.101	0.150	0.129	0.129
Obs.	314,478	314,478	314,478	314,478	314,478	314,478

Notes: "***", "**" and "*" refer to statistical significance at the 1, 5 and 10 percent levels, respectively. Robust standard errors are reported in parentheses. Standard errors in columns 1, 5 and 6 are clustered by (HS4, country) pairs. c, y, hs2, and hs6 stand for country, year, 2-digit HS industry, and 6-digit HS industry, respectively.

Column 1 presents the estimated coefficients using country, year, and 2-digit industry (HS2) fixed effects. The empirical results are supportive of the theoretical predictions, as higher U.S. (foreign) tariffs are associated with higher (lower) values of the ratio of intra-firm imports m.

In the next columns I adjust the fixed effects to examine the sensitivity of these findings. Thus, in column 2, the fixed effect is (jointly) country-year-HS2, so the identification comes from the variation across 6-digit industries within a (country-year-HS2) triplet. Similarly, in column 3, I adjust the fixed effect to be country-year, exploiting the variation across 6-digit industries for a given country-year pair. In column 4, the fixed effect is, instead, year-HS6, using the variation across countries to obtain identification. In all these cases, the results are consistent with the theory.

Finally, in the last two columns, I relax the linearity assumption, and present the estimates for quadratic and cubic models, using the same fixed effects as in column 1. 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 quite similar to those of the linear model, although there is a decrease in the magnitude and significance of β_2.

industry or country characteristics affecting the ratio m. Indeed, the correlation between U.S. tariffs the industry- and country-level control variables is quite small—less than 0.13—and the estimates on tariffs do not change significantly with the inclusion of these controls.

[17]The results are essentially unchanged if I drop 2009, the year of the Great Trade Collapse.

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 with 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 (16) industry and country controls that have been highlighted by Antràs (2003), Yeaple (2006), Bernard et al. (2010), and Nunn and Trefler (2008a).

Thus, the new estimation equation is the following:

$$m_{ict} = \beta_0 + \beta_1 \cdot t_{ict}^{US} + \beta_2 \cdot t_{ict}^{F} + \beta_3 \left(\frac{k}{l}\right)_i + \beta_4 \left(\frac{s}{l}\right)_i + \beta_5 \cdot freight_{ict} + \beta_6 \left(\frac{K}{L}\right)_c + \beta_7 \left(\frac{H}{L}\right)_c + \beta_8 X_t + \varepsilon_{ict}, \tag{17}$$

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, $freight_{ict}$ is industry i-country c's transport cost in year t, $\left(\frac{K}{L}\right)_c$ 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 $\beta_2 < 0$.[18]

The results are presented in Table 4. In the first column, I include both country and industry controls and use year fixed effects. Column 2 includes industry controls only and adjusts the fixed effect to be country-year pair. Conversely, column 3 only includes country controls and HS6-year fixed effects. Note that in all cases the estimates have the expected 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 of the same order of magnitude as those found in the previous subsection.

3.3.3 Controlling for U.S. Parents

The theory assumes that all firms are based in North, which translates to the data as being based on the United States. Of course, in reality this is not the case. However, my data do not allow me to separate imports based on the nationality of firms. As a way to control for this, I follow Nunn and Trefler (2012) that, using data from the Orbis database, rank countries according to the share of parent-subsidiary pairs involving U.S. parents.

Nunn and Trefler (2012) find that for most countries, the vast majority of paired relations involve a U.S. parent. Still, for a small group of countries, mostly developed, this pattern does

[18]Data for the country variables is from Hall and Jones (1999). The freight costs are estimated as the ratio of CIF to FOB imports.

Table 4: OLS Regressions with Country and Industry Controls

	-1-	-2-	-3-
t^{US}	0.501***	0.366***	0.374***
	(0.074)	(0.044)	(0.048)
t^F	–0.127***	–0.130***	–0.014
	(0.027)	(0.025)	(0.013)
$freight$	–0.371***	–0.311***	–0.310***
	(0.015)	(0.011)	(0.010)
$\frac{s}{l}$	12.812***	10.470***	-
	(2.170)	(1.170)	-
$\frac{k}{l}$	4.555***	3.782***	-
	(0.252)	0.244	-
$\frac{K}{L}$	7.049***	-	7.439***
	(0.279)	-	(0.101)
$\frac{H}{L}$	–6.823***	-	–6.094***
	(1.309)	-	(0.443)
FE	y	c-y	y-hs6
R^2	0.055	0.114	0.180
Obs.	300,176	313,373	300,176

Notes: "***", "**" and "*" refer to statistical significance at the 1, 5 and 10 percent levels, respectively. Robust standard errors are reported in parentheses. Standard errors in column 1 are clustered by (HS4, country) pairs. c, y, and hs6 stand for country, year, and 6-digit HS industry, respectively.

not hold. Thus, it is possible to keep in the sample only those countries for which, consistent with the theory, related-party imports are more likely to be from a foreign affiliate of a U.S. parent.

Table 5 re-estimates part of Table 3 by limiting the sample to those countries for which intra-firm imports involve a U.S. parent in at least 50 percent of the cases (left panel) or at least 60 percent of the cases (right panel).[19] For all specifications, the estimates have the expected signs and are strongly significant. Thus, regardless of the fixed effect (and the variation exploited for identification) and the restrictions imposed on the group of countries, the data support the theory's predictions.

[19]In the first case, the countries dropped are: Iceland, Italy, Finland, Liechtenstein, and Switzerland. For the second case, Sweden, Taiwan, Belgium, Bermuda, Norway, Denmark, Korea, Japan, Spain, and Israel are also dropped.

Table 5: Controlling for U.S. Parents

	U.S. Parent > 50%			U.S. Parent > 66%		
	-1-	-2-	-3-	-4-	-5-	-6-
t^{US}	0.256***	0.210***	0.956***	0.216**	0.130**	0.862***
	(0.079)	(0.046)	(0.051)	(0.093)	(0.052)	(0.055)
t^F	–0.048**	–0.121***	–0.545***	–0.039	–0.099***	–0.454***
	(0.024)	(0.023)	(0.011)	(0.025)	(0.024)	(0.011)
FE	c, y, hs2	c-y-hs2	y-hs6	c, y, hs2	c-y-hs2	y-hs6
R^2	0.132	0.245	0.152	0.122	0.247	0.170
Obs.	293,870	293,870	293,870	224,176	224,176	224,176

Notes: "***", "**", and "*" refer to statistical significance at the 1, 5 and 10 percent levels, respectively. Robust standard errors are reported in parentheses. Columns 1 and 4 have standard errors clustered by (HS4, country) pairs. c, y, hs2, and hs6 stand for country, year, 2-digit HS industry, and 6-digit HS industry, respectively.

3.4 Robustness

3.4.1 Quantile Estimation

In this subsection I depart from the linear regression model and instead estimate quantile regressions. I am interested in learning how the tariffs affect the ratio m at different parts of m's distribution. This seems particularly relevant for the case I am examining: 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 (17), is the following:

$$Q(m_{ict}|Z_{ict}) = \lambda_0 + \lambda_1 \cdot t^{US}_{ict} + \lambda_2 \cdot t^F_{ict} + \lambda_3 \left(\frac{k}{l}\right)_i + \lambda_4 \left(\frac{s}{l}\right)_i + \lambda_5 \cdot freight_{ict} + \lambda_6 \left(\frac{K}{L}\right)_c + \lambda_7 \left(\frac{H}{L}\right)_c, \quad (18)$$

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

Table 6 shows the results of estimating equation (18) for six different quantiles of m. Standard errors were computed through a bootstrap procedure, resampling over (HS4 Industry, country) pairs, with 500 replications. From the theory, I expect to find $\lambda_1 > 0$ and $\lambda_2 < 0$.[20]

As can be seen from Table 6, the estimates for λ_1 and λ_2 have the expected signs and are always statistically significant.[21] Overall, these results suggest that the theory finds support

[20]The idea for the block bootstrap procedure is to take into account that the observations are not *iid* (i.e., clustering of standard errors).

[21]Given the large number of observations with $m = 0$, I do not report estimates for lower quantiles because

Table 6: Quantile Regressions

	$Q = 0.5$	$Q = 0.6$	$Q = 0.65$	$Q = 0.7$	$Q = 0.75$	$Q = 0.8$
t^{US}	0.682***	1.127***	1.144***	1.032***	0.718***	0.263*
	(0.114)	(0.160)	(0.166)	(0.162)	(0.163)	(0.143)
t^{F}	–0.025*	–0.062**	–0.105***	–0.153***	–0.250***	–0.411***
	(0.013)	(0.031)	(0.036)	(0.049)	(0.055)	(0.063)

Notes: "***", "**" and "*" refer to statistical significance at the 1, 5 and 10 percent levels, respectively. Standard errors are obtained through bootstrap. The total number of observations is 300,176.

in the data even when looking at different functionals of m's distribution.

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 et al. (2010), 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.[22]

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 is zero otherwise. The regressors used on the selection equation are those of equations (17) and (18), 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 (17) to calculate the outcome equation.[23]

The first column of table 7 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

there would be no variation in m.

[22]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.

[23]Standard errors were computed through a bootstrap procedure, resampling over (HS4, country) pairs, with 500 replications.

Table 7: Selection Corrections

	Heckit	Control Function
First stage:		
Air transport	0.9694***	
	(0.0266)	
Start business	–0.0009***	
	(0.0003)	
Second stage:		
t^{US}	0.749***	0.425***
	(0.117)	(0.079)
t^{F}	–0.269***	–0.131***
	(0.051)	(0.031)
IMR	42.254***	
	(2.10)	
p		–354.58***
		(20.07)
p^2		679.14***
		(38.20)
p^3		–396.09***
		(23.89)

Notes: "***", "**" and "*" refer to statistical significance at the 1, 5 and 10 percent levels, respectively. Standard errors are obtained through bootstrap with clustering. The total number of observation is 281,756. IMR stands for Inverse Mills Ratio.

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 significant, suggesting that the null hypothesis of selection cannot be rejected.

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

The second column of Table 7 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 Full Sample Estimation

The empirical analysis so far has focused on sectors with HQ intensity, presenting evidence that suggests that tariffs affect these sectors in a manner consistent with the theory. The reason for this focus comes from Antràs and Helpman (2004), as their framework predicts that variables such as productivity dispersion (or tariffs) should affect the ratio of intra-firm imports for sectors with high HQ intensity but should have no effect on the ratio in the case of sectors with low HQ intensity. As already mentioned, the empirical work presented so far uses only data for industries with a ratio of skilled workers above the median. In this subsection, however, I use the entire dataset to test whether there is indeed a differential effect of tariffs depending on a sector's level of skill intensity.

The empirical strategy follows Nunn and Trefler (2008b, 2012). I classify industries into quintiles according to their level of HQ (skill) intensity. Thus, let $q = 1, ..., 5$ index the quintiles, with $q = 1$ indexing the lowest intensity quintile. Also, define five indicator functions, $I^{sl}_{i,q}$, that take a value of one if industry i is in quintile q and is zero otherwise. I then run the following regression:

$$m_{ict} = \sum_{q=1}^{5} \beta_q^{US} \left(t_{ict}^{US} \cdot I_{i,q}^{sl} \right) + \sum_{q=1}^{5} \beta_q^{F} \left(t_{ict}^{F} \cdot I_{i,q}^{sl} \right) + \sum_{q=1}^{5} \beta_q I_{i,q}^{sl} + \beta_t + \beta_c + \beta_{HS2} + \varepsilon_{ict}, \qquad (19)$$

Based on the theoretical predictions, I expect to find that β_q^{US} and β_q^{F} are estimated to be positive and negative, respectively, for high q and zero for low q. Additionally, I let the data determine what exactly low and high q mean. The results are presented in table 8:

The results presented in Table 8 are consistent with the theory. That is, we observe a significant increase in the estimates after the first quintile. In the case of the U.S. tariff, the coefficient for the first quintile is estimated to be negative and significant while all the coefficients on all other quintiles are estimated to be positive and significant. Similarly, for the foreign tariff, the coefficient for the first quintile is statistically not different from zero while all the other estimates are negative and statistically different from zero (in fact, F-tests cannot reject the null that these other estimates are equal to each other). In line with Nunn and Trefler (2008b), these results offer strong evidence in favor of the theory.

Table 8: Full Sample Estimations

Tariff interacted with:	t^{US}	t^{F}
I_1^{sl}	–0.156***	–0.043
	(0.049)	(0.029)
I_2^{sl}	0.157**	–0.066**
	(0.065)	(0.028)
I_3^{sl}	0.186**	–0.091***
	(0.076)	(0.025)
I_4^{sl}	0.382***	–0.053*
	(0.090)	(0.030)
I_5^{sl}	0.982***	–0.115***
	(0.141)	(0.040)

Notes: "***", "**" and "*" refer to statistical significance at the 1, 5 and 10 percent levels, respectively. Standard errors are clustered by (4-digit HS industry, country) pairs. The regression includes country, year, and HS2 industry fixed effects. The R^2 is 0.139. The total number of observations is 574,203.

4 Concluding Remarks

This paper aims to explain the effects that tariffs have on the optimal organizational form chosen by firms. In particular, I develop a theoretical framework capable of matching some stylized facts such as increased offshoring and outsourcing within 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 the U.S. data strongly support 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 (2012), 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, 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 interesting prediction is also a topic for future study.

Appendix

A Theoretical Derivations

From the theory section, under the presence of Northern tariffs, the cutoffs are defined in the following way:

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

where $\mathcal{A}$ determines the slope of the profit functions of nonoffshoring firms,

$$\mathcal{A} \equiv (1-\gamma)\, P_S^{\omega} + \gamma P_N^{\omega} \tag{A-2}$$

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

$$\mathcal{B} \equiv (1-\gamma)\, P_S^{\omega} + \gamma P_N^{\omega} \tau_N^{\frac{1}{\alpha-1}}, \tag{A-3}$$

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

In order to prove Propositions 1 and 2 I 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:

$$\int_{\theta_1}^{\theta_2} \pi_O^N g(\theta)d\theta + \int_{\theta_2}^{\theta_3} \pi_V^N g(\theta)d\theta + \int_{\theta_3}^{\theta_4} \pi_O^S g(\theta)d\theta + \int_{\theta_4}^{\infty} \pi_V^S g(\theta)d\theta = w^N f_E. \tag{A-4}$$

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:

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

Next, totally differentiate this condition 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:

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

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 $\frac{d\theta_1}{d\tau_N} > 0$, $\frac{d\theta_2}{d\tau_N} > 0$, $\frac{d\theta_3}{d\tau_N} < 0$ and $\frac{d\theta_4}{d\tau_N} < 0$. Next, the aggregate prices are defined as $P_N = \left(\int M p_N(\theta)^{\frac{\alpha}{\alpha-1}} dG(\theta)\right)^{\frac{\alpha-1}{\alpha}}$ and $P_S = \left(\int M p_S(\theta)^{\frac{\alpha}{\alpha-1}} dG(\theta)\right)^{\frac{\alpha-1}{\alpha}}$, where M is the mass of firms (in this model all firms operate in both countries so the mass is the same). Plugging in the demands for their optimal values we can write the relative prices $\mathcal{P}$ as:

$$\left(\frac{P_N}{P_S}\right)^{\frac{\alpha}{\alpha-1}} = \frac{\rho_1(V_2 - V_1) + \rho_2(V_3 - V_2) + \rho_3(V_4 - V_3)\tau_N^{\alpha/\alpha-1} + \rho_4(V_\infty - V_4)\tau_N^{\alpha/\alpha-1}}{\rho_1(V_2 - V_1) + \rho_2(V_3 - V_2) + \rho_3(V_4 - V_3) + \rho_4(V_\infty - V_4)} \tag{A-5}$$

where V_i is shorthand for $V(\theta_i)$, $i = \{1, 2, 3, 4\}$ and $\rho_1 = \rho_O^N < \rho_2 = \rho_V^N < \rho_3 = \rho_O^S < \rho_4 = \rho_V^S$ are constants defined in the main text. Finally, I differentiate both sides of the last expression:

$$\frac{dLHS(\mathcal{P})}{d\tau_N} = \underbrace{\frac{\alpha}{\alpha-1}}_{<0}\underbrace{\left(\frac{P_N}{P_S}\right)^{\frac{\alpha}{\alpha-1}-1}}_{>0}\underbrace{\left(\frac{\frac{dP_N}{d\tau_N}P_S - \frac{dP_S}{d\tau_N}P_N}{P_S^2}\right)}_{<0} > 0.$$

$$
\begin{aligned}
\frac{dRHS(\mathcal{P})}{d\tau_N} &= \frac{dV_1}{d\tau_N}\rho_1(1-T)\left[\rho_3(V_3-V_4)+\rho_4(V_4-V_\infty)\right]+\frac{dV_2}{d\tau_N}(\rho_2-\rho_1)(1-T)\\
&\quad \left[\rho_3(V_3-V_4)+\rho_4(V_4-V_\infty)\right]+\frac{\alpha}{1-\alpha}T^{-1}\left[\rho_3(V_3-V_4)+\rho_4(V_4-V_\infty)\right]\\
&\quad +\frac{dV_3}{d\tau_N}(T-1)\left[\rho_3\rho_1(V_1-V_2)+\rho_3\rho_2(V_2-V_4)+\rho_2\rho_4(V_\infty-V_4)\right]\\
&\quad +\frac{dV_4}{d\tau_N}(T-1)(\rho_4-\rho_3)\left[\rho_1(V_1-V_2)+\rho_2(V_2-V_3)\right]\\
&< 0.
\end{aligned}
$$

where $T \equiv \tau_N^{\alpha/\alpha-1}$ and $sign\left(\frac{d\theta}{d\tau_N}\right) = sign\left(\frac{dV(\theta)}{d\tau_N}\right) = sign\left(\theta^{\frac{\alpha}{1-\alpha}}g(\theta)\frac{d\theta}{d\tau_N}\right)$. Since the LHS is positive and the RHS is negative, there is a contradiction and 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).

■

With these results I can now prove the propositions presented in the main text.[24]

Proposition 1. *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 differentiation of (A-1), given that $\frac{d\mathcal{A}}{d\tau_N}>0$ and $\frac{d\mathcal{B}}{d\tau_N}<0$ by Lemma A.4. ■

Proposition 2. *In the benchmark case, if $G(\cdot)$ is Pareto, an increase of 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,*

[24]Given the symmetric structure of the model, the proofs of Propositions 3 and 4 are completely analogous to those of Propositions 1 and 2 (just showing $\frac{d\mathcal{A}}{d\tau_S}>0$ and $\frac{d\mathcal{C}}{d\tau_S}<0$). Therefore, they are omitted in the interest of brevity—of course, they are available upon request.

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. First, I show 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.

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

  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 $\frac{d\left(\frac{\sigma_O^S}{\sigma_V^S}\right)}{d\tau_N} < 0$.

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

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

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

  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 $\frac{d\left(\frac{\sigma_O^N}{\sigma_V^N}\right)}{d\tau_N} < 0$.

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

$sales_O^S = \mathcal{B}\rho_O^S\left[V\left(\theta_4\right) - V\left(\theta_3\right)\right]$
$= \mathcal{B}^{\frac{1-\alpha}{\alpha}z}\rho_O^S b^{z-\frac{\alpha}{1-\alpha}}\left[\left[\frac{w^N(f_O^S - f_V^N)}{(\Psi_O^S - \Psi_V^N\frac{\mathcal{A}}{\mathcal{B}})}\right]^{1-\frac{1-\alpha}{\alpha}z} - \left[\frac{w^N(f_V^S - f_O^S)}{(\Psi_V^S - \Psi_O^S)}\right]^{1-\frac{1-\alpha}{\alpha}z}\right]$
Given that $1 - \frac{1-\alpha}{\alpha}z < 0$ it follows that $\frac{dsales_O^S}{d\tau_N} < 0$.

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

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, 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. ■

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