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January 2016

The Impact of Demand Shocks on Firms' Offshoring Behaviors: Theory and Evidence

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Abstract

This paper extends the model of Antras et al. (2014) to disentangle the link between demand shocks and firm-level offshoring decisions. The model predicts that a positive demand shock increases the firm-level purchases of imported intermediates in both the extensive and intensive margins. Using a difference-in-difference approach, we examine the response of Chinese exporters to a quota removal on textile and clothing products, which is equivalent to a positive demand shock. The findings indicate that firms import more varieties and higher volumes of intermediates after the quota removal. The results are robust to different regression designs

Keywords: Intermediates Offshoring· Textile and Clothing · Demand Shock · Quota Removal

JEL Classification: F10·F14·L11

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1. Introduction

A key feature of global trade in the new century is the rapid growth of offshoring. Yeats (2001) documents that in 1995 approximately thirty percent of world manufacturing products trade is comprised by intermediate input trade. Ramanarayanan (2006) finds very similar patterns for OECD countries. The benefits of offshoring is to enhance firm-level production efficiency. Bergin et al. (2011), for example, indicates that a considerable number of American manufacturing firms contract to carry out particular stages of productions abroad. This work sharing design decreases production costs. Antras et al. (2014) further document the fact that firms engaging in offshoring are larger and more productive than firms that never import. Therefore, it is of importance to academics and policy makers to analyze firms' offshoring behaviors.

A growing literature investigates the benefits of offshoring and its impact on the labor market (Bergin et al., 2011; Hummels, et al., 2011), how information frictions and trade agreement affect firm-level offshoring behavior (Allen, 2015; Dasgupta et al., 2014; Bernard et al., 2014; Antras and Staiger, 2012), and what intermediates are more likely to be offshored (Furusawa et al., 2015). Little research has been done to assess the link between the shocks to the final product demand and offshoring behavior in intermediates. Demand shocks are often associated with trade liberalization: a reduction in trade costs in final products is often accompanied by an increase in demand for these products. Chinese textile and clothing exporters, for instance, import almost twice as many varieties and 20 percent more volume of intermediates after the Phase IV's quotas removal[1]. The

[1] In 1994, the Agreement on Textile and Clothing (ATC) gradually removed the quota imposed

lack of research investigating the impact of a demand shock to final products on firm-level offshoring behavior leaves the mechanism behind the above mentioned empirical evidence uncovered, and the benefits of trade liberalization underestimated.

This paper theoretically and empirically studies how export firms' offshoring behavior is associated with demand shocks in the final products. We are particularly interested in how a demand shock affects the number of intermediates a firm imports. Bernard et al. (2009) find that the extensive margins of imports accounts for approximately 65 percent of the cross-country variation in U.S. imports. Bergin et al. (2011) document that both the extensive and intensive margins of offshoring affects the volatility of economic activities, such as the fluctuations in employment in Mexico, which is influenced by its offshoring industries. As a result, analyzing firm-level offshoring of the extensive and intensive margin is of economic importance.

This work extends the model of Antras et al. (2014) who build on Eaton and Kortum (2002), to endogenize the firm-level offshoring decision. In this model, all firms produce final goods by assembling a series of intermediates either purchased domestically or offshored from foreign countries. To offshore from foreign countries, firms have to pay a fixed search cost to learn the prices of intermediates in these countries. After searching, each firm offshores the intermediates from the cheapest country they have searched.[2] Differing form Antras et al. (2014), we

on textile and clothing products. The quotas were eliminated over four phases in January 1, 1995, 1998, 2002 and 2005, respectively. The quotas removal in January 1, 2005 is referred to as the Phase IV quotas removal.

[2]For simplicity, I assume that the prices of intermediates in domestic market are observable without searching. This means that firms can always purchase intermediates from domestic market.

allow final products to be exported to foreign countries. As a result, any demand shock in foreign markets will change firm-level offshoring behavior. Intuitively, if the demand faced by a firm increases, this firm would choose to search more countries and offshore, on average, more varieties and a greater volume of intermediates.[3] This is because that searching more countries decreases the unit cost of final products and the benefits of cost reduction is larger after the increase of demand in final products.

We then empirically examine the theoretical predictions using a comprehensive data set witch contains all Chinese firms producing textile and clothing products during 2000-2006. On January 1, 2005 Phase IV of the Agreement on Textile and Clothing (ATC) removed all the remaining quotas on products belonging to textile and clothing categories. This event offers a natural experiment to test firm-level offshoring responses to a demand shock. A rich set of literature has investigated the impact of the quota removal on Chinese textile exporters' performance. Khandelwal et al. (2013) document the rapid export growth of Chinese textile firms to the U.S. after 2005 quota removal. Ahn et al. (2011) further show that the quota removal lead to larger-than-expected gains for Chinese textile exporters. Rotunno et al. (2013) find that while the quota removal on textile products increased Chinese textile exports to US, its exports to Africa dropped significantly. To the best of our knowledge, this is the first paper, which attempts to document the impact of the quota removal on firm-level offshoring behavior.

[3] The increase demand requires a greater volume of intermediate inputs, which increases the firm's incentive to search for lower price of each intermediate. On the one hand, this leads to an increase in the offshoring probability for each intermediate, and more intermediates will be offshored. On the other hand, larger demand and lower intermediate prices drive up the imported volume of intermediates.

We employ a difference-in-difference approach to test the the impact of the quota removal on the firm-level extensive and intensive offshoring margins. Notice that the number of intermediates being offshored is discrete and following Puhani (2012), a nonlinear difference-in-difference estimation has been conducted as a robustness check. Using the firm-level export and import data from textile and clothing industry in China, we find that the firm-level offshoring varieties and volumes of intermediates increase significantly after the quota removal.

This work contributes to the growing literature on the determinants of global production sharing. It disentangles the link between demand shocks in final products and firm-level offshoring behavior. This paper is closely related to Furusawa et al. (2015) who document the determinants of firm-level offshoring decisions, but neglect the influence of foreign demand on firm-level offshoring behavior. This paper finds results similar to Antras and Staiger (2012), who show the impact of trade agreements on the intensive margin of offshoring. Nonetheless, Our model predicts that after accounting for firm search behavior, the impact of trade agreements on on the firm-level intensive margin of offshoring is larger. This is because firm search lowers its own marginal cost, which further increase offshoring volumes. This work is also in line with Bergin et al. (2011) who document that the firm-level offshoring is determined by the relative intermediate production costs in foreign and domestic countries. An exogenous shock to foreign intermediates cost shrinks the domestic firms' offshoring varieties of intermediates. A similar mechanism works in this framework, but in a multi-country setting the relative intermediates cost in foreign and domestic markets is affected by firm-level endogenous searching. Demand shocks change firm-level offshoring behavior through changes in the firm-level search behavior. In contrast to Bernard et al. (2014), who claim that lowering search cost leads to more offshoring and hence an increase in the demand for final products, this paper emphasizes reverse channel; an increase in demand motivates the firm-level extensive and intensive margins for offshoring intermediates.

The rest of the paper proceeds as follows. Section 2 presents the theoretical model. Section 3 introduces the background of the multifiber agreement (MFA) and Chinese textile and clothing exports. Section 4 describes the data. Section 5 discusses the regression design and reports the results. Section 6 concludes.

2. Model

In this section, I extend Antras et al. (2014) model to investigate the impact of demand shocks on extensive and intensive margins of offshoring at firm-level.

2.1. Demand

Suppose there are J countries in the world. The representative consumer's preferences for final goods takes the CES form:

$$U = \left(\int_{\omega \in \Omega_j} q(\omega)^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)}, \tag{1}$$

where Ω_j is the set of all final goods available to consumers in country j, and σ denotes the elasticity of substitution across final products. The preference leads to the following demand for final good ω in country j at period t:

$$q_{jt}(\omega) = A_{jt} p_{jt}(\omega)^{-\sigma}, \tag{2}$$

where $p_{jt}(\omega)$ is the price of final good ω, and A_{jt} is the residual demand of ω in country j at period t. To simplify notation in following sections, we define B_{jt} and

B_t as follows:

$$B_{jt} = \frac{1}{\sigma}\left(\frac{\sigma}{1-\sigma}\right)^{(1-\sigma)} A_{jt}\tau_{ij}^{1-\sigma}. \tag{3}$$

$$B_t = \sum_{j \in J_i^{ex}(\varphi, B_t^w)} B_{jt}, \tag{4}$$

where B_{jt} is the transportation cost adjusted residual demand in country j at period t. Note that B_{jt} is proportional to the residual demand in country j at period t, A_{jt}. $B_t^w = (B_{1t}, B_{2t}, ..., B_{Jt})$, is a vector that contains every country's transportation cost adjusted residual demand in period t, and B_t is the aggregate adjusted residual demand of all countries to which a firm exports.[4] We allow B_t^ω to vary over time, in order to capture exogenous demand shocks. τ_{ij} is the ice-berg transportation cost between country i and j, where $\tau_{ij} = 1$ if $i = j$.[5] $J_i^{ex}(\varphi, B_t^w) \subseteq J$ is the set of countries a firm located in base country i at period t exports to, given its productivity level, φ, and the vector of world adjusted residual demand, B_t^w.

2.2. Supply

In order to produce the final goods, each firm needs to assemble a series of intermediates. Following Antras et al. (2014), intermediates can be offshored and the model's equilibrium will imply the location of the production of different intermediates. Intermediates are assumed to be imperfectly substitutable with each other at a constant elasticity substitution ρ, and distributed continuously over the range [0,1].

[4] Note that the set of countries to which the firm exports depends on B^w, not on B.

[5] In order to stress the impact of demand shocks on firm-level offshoring decisions, we assume the transportation cost is fixed over time so as to isolate other possible mechanism which affect firm-level offshoring behavior.

All intermediates are produced under the constant return to scale technology. Denote $a_j(v)$ the labor requirement associated with the production of intermediate input $v \in [0, 1]$ in country $j \in J$.[6] free-on-board price for intermediate v from country j in period t is given by $a_j(v)\omega_{jt}$, where ω_{jt} is the wage rate in country j at period t. As such, the cost of importing one unit of intermediate v from country j to country i in period t can be written as:

$$c_{ijt}(v) = \tau_{ij} a_j \omega_{jt} \tag{5}$$

The parameter a_j represents country j's efficiency in producing intermediates. For a given wage rate ω_{jt}, a lower labor requirement, lower a_j, implies that country j has greater competitiveness in the production of intermediates. Following Eaton and Kortum (2002), we assume the country specific efficiency a_j follows a Frechet distribution:

$$\Pr(a_j(v) \geq a) = e^{-T_j a^{\theta}}, \text{ with } T_j > 0, \tag{6}$$

where T_j governs the state of the technology in country j. A larger T_j implies a higher country specific efficiency. θ reflects the amount of variation within the distribution where larger θ implies less variability. Two features of equation (6) are worth addressing: first, a country's efficiency in an intermediate is independent of its type; second, a country with a higher T_j will be, on average, more efficient in all intermediates.

With all the above assumptions, the unit assembly cost of final goods for a firm

[6]Similar to the transportation cost, $a_j(v)$ is assumed to be time invariant. This assumption is to exclude the impact of country-level productivity changes on firms' offshoring behavior.

located in country i, with productivity φ in period t is:[7]

$$c_{ft}(\varphi) = \frac{1}{\varphi}\left(\int_0^1 \left(\tau_{ij(v)}(v)a_{j(v)}\omega_{j(v)t}\right)^{1-\rho} dv\right)^{\frac{1}{1-\rho}}, \tag{7}$$

where $j(v)$ denotes the country from which intermediate v is imported. Note that the final goods production cost relies on the firm's productivity, φ. This is to capture the fact that more productive firms can assemble the series of intermediates more efficiently. Different from Antras et al. (2014), we assume the final goods can be sold in both domestic and international markets.

Firms cannot observe a_j for any country, unless it pays a fixed search cost, $f_{ij}^s\omega_{it}$. Denote $J_i^s(\varphi, B_t) \subseteq J$ the set of countries a firm based in i with productivity φ has searched. $J_i^s(\varphi, B_t)$ is called the *searching strategy* of this firm. Different than Antras et al. (2014), the searching strategy not only depends on the firm-level productivity, but also the aggregate residual demand of the countries the firm exports to. The intuition is that as aggregate transportation cost adjusted residual demand, B_t increases so do the benefits of searching for cheaper intermediates.

2.3. Firms' Behavior Conditional on a Sourcing Strategy

Given a searching strategy, a firm based in country i chooses to purchase each required intermediate input from the cheapest country it has searched. The offshoring probability of any intermediate is given by:

$$\chi(\varphi, B_t) = 1 - \frac{T_i\omega_{it}^{-\theta}}{\Theta_i(\varphi, B_t)}, \tag{8}$$

[7] As in Melitz (2003), the firm-level productivity, φ, is fixed after the initial productivity draw. However, the marginal costs may vary over time due to changes in the offshoring behavior.

where

$$\Theta_i(\varphi, B_t) = \sum_{k \in J_i^s(\varphi, B_t)} T_k(\tau_{ik}\omega_{kt})^{-\theta}. \tag{9}$$

Equation (8) and (9) imply that the offshoring probability of any intermediate is increasing in $\Theta_i(\varphi, B_t)$, the *offshoring capability.*

After choosing the cheapest country to import the corresponding intermediates from, the marginal cost of the final goods for the firm with productivity φ is:

$$c_{ft}(\varphi) = \frac{1}{\varphi}(\gamma\Theta_i(\varphi, B_t))^{-1/\theta}, \tag{10}$$

where, $\gamma = \left[\Gamma\left(\frac{\theta+1-\rho}{\theta}\right)\right]^{\theta/(1-\rho)}$. Equation (10) conveys the information that given the firm's searching strategy, more productive firms will have lower marginal costs for assembling final goods. More importantly, a firm which has searched more countries, will have lower marginal costs. The intuition is that, when a firm searches more countries, the expected price for each intermediate falls.

Firms in base country i can export to any country j after paying a fixed cost $f_{ij}^{ex}\omega_{it}$. The superscript ex indicates *export*, which is to distinguish from the fixed search cost, $f_{ij}^{s}\omega_{it}$. From the demand function, we can derive the firm-level profits as:

$$\pi_i(\varphi, B_t) = \varphi^{\sigma-1}(\gamma\Theta_i(\varphi, B_t))^{(\sigma-1)/\theta}B_t - \omega_{it}\sum_{j\in J_i^s(\varphi,B_t)} f_{ij}^s - \omega_{it}\sum_{j\in J_i^{ex}(\varphi,B_t^w)} f_{ij}^{ex}. \tag{11}$$

2.4. Firms' Optimization

Each firm needs to make a series of decisions to maximize its per-period profit. The sequence of the game is as follows. Each firm draws a productivity, φ, from a given distribution after paying an entry cost. A demand shock in country j,

ΔB_{jt}, occurs at the beginning of period t, and is observed by all firms. Each firm decides which country it will export to, from which to offshore and set the optimal price in each market. All decisions are made at the beginning of each period. The subsequent sections will show the responses of firm-level offshoring behavior to a demand shock.

2.4.1. Incomplete Information

To guarantee the model is solvable, we assume that this game is a simultaneous game and each firm has incomplete information about the decisions of other firms when it makes its own decisions in each period. In particular, firms with incomplete information at the beginning of period t forecast all state variables, except the demand shock, take the same values as in period $t-1$. For instance, at the beginning of period t, a firm expects the residual demand in country j to be $B_{j,t-1} + \Delta B_{jt}$, where ΔB_{jt} is the observed demand shock in country j at the period t. In another words, a firm with incomplete information does not account for other firms' strategic responses to a demand shock. Instead, it only observe other firms' responses in the subsequent period.[8]

The incomplete information assumption allows to neglect the equilibrium input of demand shocks on local wages. Intuitively, a positive demand shock in country j, ΔB_{jt}, will encourage more domestic firms to start offshoring or search more countries for cheaper intermediates. This change in offshoring behavior reduces firm-level marginal costs and hence changes the labor demand in the home country. If all firms have complete information, they all expect the wage effect

[8]Firm level productivity could be private information. As such, each firm cannot observe other firms' productivity, and may not be able to forecast other firms' responses to a demand shock.

caused by demand shocks. As such, each firm further adjusts its exporting and offshoring strategies. This interdependence between wages and offshoring strategies in the case of complete information makes it difficult to characterize optimal firm behavior.

Note that in equilibrium, the case of incomplete information is equivalent to the case of complete information. The reason is that when no demand shock takes place, the state variables, such as the residual demand, wage, etc, are constant in each country. As a result, $B_{jt} = B_{j,t-1} = B_j$, and $\omega_{jt} = \omega_{j,t-1} = \omega_j$. Therefore, each firm's forecast of the state variables in period t is correct.[9]

2.4.2. Optimal Offshoring Decisions

A firm's optimal offshoring strategy balances the gain from marginal cost reductions against the search costs which arise from searching an additional country. The optimal offshoring strategy depends both on firm-level productivity, φ, and expected aggregate residual demand, EB_t. The two variables determine the firm-level returns from searching one more country. The optimal offshoring strategy at period t maximizes expected profit:

$$max_{I_{ijt}\in\{0,1\}_{j=1}^{J}} E_t\pi_i\left(\varphi, B_t, I_{i1t}..., I_{i2t}\right) = \varphi^{\sigma-1}(\gamma\sum_{j=1}^{J} I_{ijt}T_j(\tau_{ij}\omega_{j,t-1})^{-\theta})^{(\sigma-1)/\theta}EB_t - \omega_{i,t-1}\left[\sum_{j=1}^{J} I_{ijt}f_{ij}^{s} + \sum_{j\in J_i^{ex}(\varphi, EB_t^w)} f_{ij}^{ex}\right], \tag{12}$$

[9]Note that the empirical estimation results still hold even without the incomplete information assumption. The reason is that all firms experience a change in domestic wages. Fortunately, the difference-in-difference approach will control for any change effect.

where, with incomplete information $EB_t = B_{t-1} + \Delta B_t$ and $EB_t^\omega = B_{t-1}^w + \Delta B_t^w$. This implies that when a firm maximizes its profit at the beginning of period t, it is based on the realized world residual demand vector in period t, B_{t-1}^ω and the demand shock, ΔB_t^ω. The economy is assumed to be in an equilibrium before the demand shock, as such, $B_1^\omega = B_2^\omega = ... = B_{t-1}^\omega$. Firm-level optimal strategies are identical from period 1 to period $t-1$.

Similar to the proof in Antras et al. (2014), it can be shown that given the firm-level productivity, φ, the searching strategy under a low expected aggregate adjusted residual demand is a subset of the searching strategy under a high expected aggregate adjusted residual demand. This point is formally presented in the following proposition:

Proposition 1. *Whenever $(\sigma - 1)/\theta > 1$ and the economy is in an equilibrium before period t, which implies $EB_{t-1} = B_{t-1} = ... = B_1$. $J_i^s(\varphi, EB_t) \supseteq J_i^s(\varphi, B_{t-1})$ for $EB_t > B_{t-1}$, where $J_i^s(\varphi, EB_t) = \{j : I_{ijt}(\varphi, EB_t) = 1\}$.*

Proposition 1 implies that if a demand shock at period t increases the expected aggregate demand facing a firm, the set of countries a firm searches will be larger or equal to that at period $t-1$. This is because the benefits from a reduction in marginal costs by searching an additional country is larger after the shock. The proof is in the Appendix. In particular, the export decisions and searching strategies are interdependent. A positive shock to the expected aggregate residual demand, EB_t, increases the firm-level searching strategy, $J_i^s(\varphi, EB_t)$. This increase further lowers firm-level assembly costs. The firm may choose to enter more foreign markets because of its increased competitiveness, which could further increase the aggregate residual demand faced by the firm. The set of countries to which the firm searches for intermediates could increase again. This process lasts until the firm does not export to any new foreign market and no longer searches new countries for intermediates.

Notice that the demand shock is at country level, ΔB_{kt}. It can be proved that the expected aggregate residual demand faced by any firm EB_t is not decreasing in EB_{kt}, for $\forall k$:

$$\frac{\partial EB_t}{\partial EB_{kt}} = \begin{cases} sign(\Delta J^{ex}) \sum_{\Delta J^{ex}} EB_{jt} \text{ if } k \notin J^{ex}(\varphi, B^{\omega}_{t-1}) \\ 1 + sign(\Delta J^{ex}) \sum_{\Delta J^{ex}} EB_{jt} \text{ if } k \in J^{ex}(\varphi, EB^{\omega}_{t-1}) \end{cases} \geq 0, \qquad (13)$$

where $\Delta J^{ex} = J^{ex}(\varphi, EB^{\omega}_t) - J^{ex}(\varphi, B^{\omega}_{t-1})$ is the set of countries to which a firm exports after the positive demand shock, ΔB_{kt}. $EB^{\omega}_t = \{B_{1,t-1}, B_{2,t-1}, ..., B_{k,t-1} + \Delta B_{kt}, ...B_{J,t-1}\}$, is the expected world residual demand at period t and $B^{\omega}_{t-1} = \{B_{1,t-1}, B_{2,t-1}, ..., B_{k,t-1}, ..., B_{J,t-1}\}$ is its counterpart vector before the demand shock. Before the demand shock, the economy was in equilibrium, we have $EB_{jt} = EB_{j,t-1} = B_{j,t-1} = ... = B_{j,1}$. This implies $EB^{\omega}_t = B^{\omega}_{t-1} + \Delta B_{k,t}$. The term $\sum_{\Delta J^{ex}} EB_{jt}$ captures the expected aggregate residual demand change caused by exporting to a larger or smaller number of countries after the demand shock. If the firm exports to more countries, $sign(\Delta J^{ex})$ is positive and otherwise is negative or zero. The proof of inequality (13) is in the Appendix. Intuitively, the country-level demand shock affects the aggregate residual demand, EB_t, faced by a firm in two interdependent channels: on one hand, some of the countries experiencing a demand shock belong to the firm's export set. As such, the country-level demand shock has a positive influence on the expected aggregate residual demand faced by this firm. On the other hand, the firm may choose to export to an additional country, whose residual demand has increased. A firm may chooses to search more countries for cheaper intermediates which enable it to enter a previously nonprofitable market. Either one increases the aggregate residual demand faced by this firm. Therefore, the expected aggregate residual demand, EB_t, faced by a firm is non-decreasing in EB_{kt}, $k \in J$.

Note that, if a firm does not export to countries experiencing demand shocks neither before nor after the shocks, the firm's exporting and offshoring strategies would be unaffected by the demand shocks. The reason is that these firms, with incomplete information, face the same state variables in period t and $t-1$. As such, these firms' exporting and offshoring strategies would be the same in both periods. This implies that only firms whose export set contains countries experiencing demand shocks will change their offshoring behavior in response to demand shock.[10]

When a firm's searching strategy is non-decreasing in the expected aggregate residual demand of the countries to which it exports, equation (9) implies that the firm's offshoring capability, $\Theta_i(\varphi, EB_t)$, is non-decreasing in EB_t.[11] From equation (8) the offshoring probability of any intermediate input is also non-decreasing in EB_t. This further implies that the firm will import more varieties of intermediates in period t relative to period $t-1$ as long as the demand shock increases the expected aggregate residual demand the firm faces. Formally, we have the following proposition:

[10] The countries experiencing demand shock either belong to these firms' export set as of $t-1$ or are added to the export set at period t.

[11] Equation (9) indicates that the sourcing capability, $\Theta_i(\varphi, EB_t)$, increases in $J_i^s(\varphi, EB_t)$, and $J_i^s(\varphi, EB_t)$ is non-decreasing in EB_t. Therefore, $\Theta_i(\varphi, EB_t)$ is non-decreasing in EB_t.

Proposition 2. *When $(\sigma - 1)/\theta > 1$, the firm-level offshoring probability for any intermediate is increasing in the expected aggregate residual demand, EB_t. As such, a positive demand shock, which influences the expected aggregate residual demand a firm faces, increases the firm-level imported varieties of intermediates.*

Proposition 2 indicates that only firms, whose expected aggregate residual demands are increasing in demand shocks, increase their offshored varieties of intermediates.[12] Instead, the firms, whose expected aggregate residual demands are unaffected by the demand shock, would keep their offshoring strategies.

Since the total cost of intermediates is proportional to total revenue, $C_i^{tot}(\varphi, EB_t) = \frac{\sigma-1}{\sigma} R_i(\varphi, EB_t)$, along with Proposition 1 and 2, the firm-level intensive margin of imports is increasing in the expected aggregate residual demand faced by the firm. Greater expected aggregate residual demand implies higher firm-level revenues and greater offshoring probabilities. Both of them determine the higher-level of import intermediates. As such, demand shocks which increase the expected aggregate residual demand faced by a firm, increases the firm's intensive margin of imports. This point is formally summarized in the following proposition, and the proof is in the Appendix.

Proposition 3. *Whenever $(\sigma-1)/\theta > 1$, the firm-level intensive margin of imports is increasing in the expected aggregate residual demand faced by the firm. As such, a positive demand shock increases the firm-level intensive margin of exports, for those whose expected aggregate residual demands are affected.*

Quota removal could be treated as a positive shock on the residual demand in

[12] Two types of firms are affected by the demand shock: the countries which experience the demand shock must belong to the firms' export set either in period $t - 1$ or period t.

some foreign countries. For exporters, whose expected aggregate residual demand, EB_t, is affected by the demand shock, Proposition 2 and 3 provide two testable predictions that these firms, on average, import more intermediates, in terms of extensive margin (more varieties) and intensive margin (larger volumes).[13] The next section models the connection between the removal of quotas and the expected aggregate demand increase.

2.5. The Impact of Quota Removal on Firms' Behaviors

Under an export quota restriction, the government typically allocates export quotas by auction (Khandelwal et al., 2013). Therefore, each exporter needs to pay a unit license fee for their exports. The export price in market j at period s is given by equation (14)

$$p_{js}(\varphi) = \frac{\sigma}{\sigma - 1}(\tau_{ij}c_{fs}(\varphi) + l_j), \tag{14}$$

where l_j is the unit license fee for firms exporting quota restricted products to country j at period s. $l_j > 0$ for $s = 1, 2, ..., t - 1$ and $l_j = 0$ for $s \geq t$.[14] Let $\widehat{\tau}_{ij} = \tau_{ij} + \frac{l_j}{c_{fs}(\varphi)}$ denote the ice-berg cost for shipping 1 unit of a quota restricted product from country i to country j at period t. We have $\widehat{\tau}_{ij} > \tau_{ij}$ for any product exported under a quota. Using the definition of B_{jt} in equation (3), it is straightforward to show that the removal in period t leads to the following

[13] Proposition 1 is not testable, because the set of countries from which the firm imports is not identical to the set of countries it searches. For instance, suppose a firm originally searches and imports from 3 countries, denoted by {1,2,3}. After the removal of quotas, it searches country 4. The prices of all intermediates are lower in the 4th country, and so the firm imports all intermediates from the 4th country. In this case, after the removal of quotas the set of countries from which it imports is {4}, but the set of countries from which it searches is {1,2,3,4}.

[14] As the economy has been assumed to be in an equilibrium before period t, the unit license fee is assumed to be constant from period 1 to $t - 1$.

inequality:

$$EB_{jt} = \frac{1}{\sigma}\left(\frac{\sigma}{1-\sigma}\right)^{(1-\sigma)} A_j \tau_{ij}^{1-\sigma} > \frac{1}{\sigma}\left(\frac{\sigma}{1-\sigma}\right)^{(1-\sigma)} A_j \widehat{\tau}_{ij}^{1-\sigma} = B_{j,t-1}, \qquad (15)$$

where $B_{j,t-1}$ is the residual demand in country j at period $t-1$. Inequality (15) indicates that a quota removal in country j at period t is equivalent to an increase in the residual demand in country j. This property offers a natural experiment to test Proposition 2 and 3: the quota removal leads firms, which previously exported under quota restriction, to import more intermediates both in terms of varieties and volumes.[15]

The next section introduces the Multifibre Agreement and its later cancellation.

3. Background of MFA and ATC

China's textile and clothing industry accounts for a nonnegligible share of China's overall exports and the world exports of textile and clothing. In 2004, China's textile and clothing exports account for 15% of its total exports and 23% of the world textile and clothing exports.

The Multifibre Agreement (MFA) had been used to restrain the import of textiles, especially from developing countries. It was initially used by the United States to limit textile imports from Japan in 1955. A consequence of the MFA is that the textile and clothing products were held out of the multinational trade negotiation. In 1994, the Uruguay Round of trade negotiations included the Agreement on Textile and Clothing (ATC), which was to end the MFA and

[15]Strictly speaking, the impact of a quota removal on residual demand varies across firms. This is because firms with different productivities, φ, will have different unit costs $c_f(\varphi)$. As a result, $\widehat{\tau}_{ij}$ reduces more for firms with high productivities after the quota removal.

gradually remove the quota imposed on textile and clothing products. The quotas were eliminated over four phases by integrating textile and clothing products into GATT/WTO rules. The U.S., E.U., and Canada were required to remove textile and clothing quotas on January 1, 1995, 1998, 2002 and 2005, respectively. In the first three phases the the countries have to integrate products representing 16, 17, and 18 percent of their 1990 import volumes, and in Phase IV this figure increased to 49 percent. A considerable share of quotas removed in Phase IV were binding.[16] In particular, about 65 percent quotas are binding in the U.S., E.U. and Canada. The detailed quota binding rates in each region are reported in Table 1.

[Table 1 is to be here]

Table 1 shows that about 1,500 types of textile and clothing products exported to the U.S., E.U., or Canada were under quota restrictions, and more than 900 quotas were binding in 2004.

Removing the binding quotas lead to a surge of textile and clothing exports. China, for instance, saw its textile and clothing exports to the U.S. almost double after the Phase IV quota removal, while the exports to the rest of the world increased by less than 3%. More details are reported in Table 2.

[Table 2 is to be here]

The distinct growth patterns between the rest of the world and the regions removing quotas indicate the significant role quotas played in restricting firm exports. Under a quota restriction, firms have to pay a unit license fee for their

[16] Following Evans and Harrigan (2005); Brambilla et al. (2009), if a quota's fill rate exceeds 90%, the quota is treated as binding.

exports (e.g. Demidova et al., 2011). This license fee increases each firm's export price and, as such, its demand in the foreign market shrinks. The removal of quotas reduces the license fee to zero and hence, all other things equal, increases the foreign demand for each firm. As such, the Phase IV quota removal offers an ideal setting to analyze Chinese export firms' offshoring response to a demand shock.

4. Data

The empirical exercises require data from two sources. One is the Chinese Custom data collected by the Chinese Custom Trade Statistics (CCTS), which report the firm-level exports and imports at HS8 disaggregated level. In addition, this dataset reports the firm-product specific export destinations. The other data source is MFA/ATC quotas, which provides the product-level quota information in the U.S., E.U. and Canada.[17]

The first step is to clean the CCTS data by deleting all firms which never exported textile or clothing products in 2004 and 2005. Second, we carefully match the two pieces of data using the HS code provided in both of them. The matched sample offers the following information: 1. the number of each firm's imported intermediates; 2. the firm-level import values; 3. countries to which each firm's products are exported; 4. the country-product specific quota status;[18] 5. the number of products each firm exports. The matched sample exhibits a clear increase pattern in the number of imported intermediates for firms exporting textile and clothing to the U.S., E.U., or Canada. Detailed results are reported in

[17] The data have been sorted by Peter Schott, and is downloadable at his homepage: *http://faculty.som.yale.edu/peterschott/sub_international.htm*

[18] The information reflects whether exported product is subject to a quota in a given country, and what the quota fill rate is.

Table 3.

[Table 3 is to be here]

Part A and Part B of Table 3 report the average number of imported varieties and the total value of imported intermediates for firms exporting to different destinations, respectively. Column 1 of Part A reports the average number of varieties imported intermediates by firms exporting to the rest of the world (ROW) other than U.S., E.U., and Canada. Columns 2-4 of Part A show the figures for firms exporting to the U.S., E.U., or Canada, respectively, while columns 5-8 show the same information for firms engaged ordinary trade.[19] The results indicate that among firms engaged in ordinary trade, the number of imported varieties more than doubled between 2004 to 2005 on average. Part B suggests a similar pattern for average firm-level import values between 2004 and 2005, except for firms exporting to ROW in the full sample. Whereas, it is unclear whether the increase trend is caused by Phase IV's quota removal or simply represents a time trend.

Making use of the quota information, I can classify firms into treatment and control groups based on the quota status of their exports. According to the model, the treated group contains firms whose expected residual demands are affected by the quota removal, while all other firms belong to the control group. In 2004, there are 12,137 firms that export textile and clothing products, of which 3,843 firms export under binding quotas. The classification rules are discussed in detail in the next section. By comparing the offshoring responses across treatment and

[19] A firm is treated as an exporter to a destination if the firm exports at least one product to this destination. Therefore, if a firm exports to the U.S., E.U. and Canada, this firm will be used repeatedly in Table 3.

control groups, we can identify the impact of the quota removal on firms' offshoring behavior.

5. Estimation and Results

In this section, we use a difference-in-different strategy to analyze how firm offshoring behavior changes after the quota removal on textile and clothing on January of 2005. The identification relies on the comparison between firms in the affected product category (the treatment group) and those in the unaffected product category (the control group). Firms are classified into treatment and control groups in several ways.

In the baseline regression, firms which never export quota restricted products belong to the control group, while all other firms make up the treatment group.[20] There are several issues that are worth addressing here. First, consider a product that is subject to a quota restriction only in the U.S., but a firm which exports this product to a country without any quota restrictions (South Africa, for instance). In the baseline regression, this firm is considered to be treated. One reason for this is that Chinese textile and clothing exporters often use third countries as quota-hopping export platforms (Rotunno et al., 2013). Therefore, a quota removal in the U.S. might still have an impact on the firm's expected aggregate residual demand. This sensitivity of our results to our classification of firms will be evaluated in our robustness checks.

Second, it could be the case that some firms export quota restricted products in 2004, but stopping export these products in 2005. In this case, these firms

[20]The full sample contains firms exporting textile or clothing products at least in one year.

experience a negative demand shock. It seems problematic to treat these firms as treated. To address this concern, we calculate the share of firms dropping quota restricted products in a treated group and find that they represent less than 4% of all firms. Dropping these firms and re-estimating the baseline model, we find very similar results.

The baseline regression is as follows:

$$y_{it} = \beta_1 Treatment_i + \beta_2 Post_t + \beta_3 Treatment_i \times Post_t + \beta_4 x_{it} + \epsilon_{it}, \qquad (16)$$

where y_{it} represents the firm-level outcome variables including the number and total values of imported intermediates for firm i in year t. $Treatment_i$ is a dummy variable which takes value 1 if firm i belongs to the treatment group, 0 otherwise. $Post_t$ is the time dummy variable taking the value 1 after year 2004, 0 otherwise. x_{it} are control variables, including the number of products each firm exports, ownership fixed effect and product fixed effects[21]. The reason we include the number of products a firm export in the regression is to control for the impact of the number of final products on firm-level offshoring behavior. For instance, firms producing more final products usually require more varieties of intermediates.

Note that one of the dependent variables, the number of varieties of imported intermediates, is discrete. This count data feature suggests that a Poisson

[21] The product fixed effect are to control for the influence of firm-level exports on firm-level offshoring behavior. The product fixed effect is aggregated at HS2 level as a number of firms export multiple products.

regression to evaluate the treatment effect:

$$
\begin{aligned}
& f(y|z) = \Phi(\beta z), \qquad (17)\\
& \Phi(\beta z) = exp\left[-exp(\beta z)\right]\left[exp(\beta z)\right]^{y}/y!,\\
& \quad \beta z = \beta_1 Treatment_i + \beta_2 Post_t + \beta_3 Treatment_i \times Post_t + \beta_4 x_{it} + \epsilon_{it}.
\end{aligned}
$$

We make use of regression (17) to evaluate the treatment effect as a robustness check of the baseline model. Puhani (2012) points out that the nonlinear treatment effect is different from a linear treatment effect. In particular, in the nonlinear case, the treatment effect is not the cross difference, but the difference between two cross differences. Mathmatically, the treatment effect is:

$$
treatment = \Phi(\beta_1 + \beta_2 + \beta_3 + \beta_4 x_{it}) - \Phi(\beta_1 + \beta_2 + \beta_4 x_{it}). \qquad (18)
$$

Equation (18) implies that although the treatment effect is not identical across individuals, a positive β_3 still indicates a positive treatment effect. The results from the baseline regression for the extensive and intensive margin of offshoring are reported in Table 4 and Table 5.

[Table 4 is to be here]

[Table 5 is to be here]

Table 4 reports the treatment effects of the quota removal on the extensive margin of offshoring, which are estimated using OLS and Poisson regressions, respectively. Columns 1-2 in Table 4 report the treatment effect results by dividing all textile products exporters into treatment and control groups. In contrast, columns 3-4 report the treatment effect results by restricting the sample to firms engaged in ordinary trade. The results indicate a positive impact of the quota removal on offshoring decisions. Specifically, the treatment group imports, on average, $0.7-0.9$ more varieties of intermediates than the control group, after the quota removal. At the the same time, Table 5 reports the treatment effects of the quota removal on the intensive offshoring margin. Similar to Table 4, column 1 shows the treatment effect for all firms, and column 2 reports the results by restricting the sample to ordinary trade exporters. The results indicate that for the quota removal increases the value of imported intermediates by $13-20$ percent.

In January 2005, the U.S., E.U., and Canada were the only regions removing quotas on textile and clothing products from developing countries. This implies that the quota removal mainly influences firms which export textile products to the set of countries lifting the quota restrictions. For example, shipments of "men's or boy's jackets" (HS 610339) were subjected to an import quota in the U.S., E.U., and Canada in 2004 but not in the other countries. In this case, the impact of quota removal on firm-level offshoring behavior is much more limited among firms exporting to countries other than the U.S., E.U., and Canada.

It is also possible that a firm exports textile products to regions with quota restrictions, but the fill rate, which is defined as the percentage a quota that is used, does not bind. For instance, China's exports of "Multiple or Cabled Yarn" (HS 550912) to the U.S. is exported under an unbinding quota.[22] In this case, classifying firms which export products subject to an unbinding quota into the treatment group may be inappropriate.

[22]Following the definition of Khandelwal et al. (2013), if the quota fill rate is less than 90%, the quota is treated as not binding

To check if the classification of firms into treatment and control groups in the baseline regression biases the evaluation of the treatment effect, we redefine firms as belonging to the treatment group if 1. firms export to the U.S., E.U., or Canada; 2. at least one of the products they export is subject to a binding quota. All other firms belong to the control group.

Using the newly defined treatment and control groups we re-estimate equation (16) and (17), respectively. The results are reported in Table 6 and Table 7:

[Table 6 is to be here]

[Table 7 is to be here]

The results in Table 6 indicate that the quota removal had a positive impact on the number of offshored varieties regardless of our estimation methodology. For firms engaged in ordinary trade, the quota removal increases, on average, the number of imported intermediates by 0.5 units. For the full sample the effect is even stronger; we find that the quota removal increases the average number of imported intermediates by more than 2 units. This might suggests that firms engaged in processing trade respond more to the quota removal than firms engaged in ordinary trade. At the same time, the results in Table 7 show that the quota removal tends to increase the values of offshored intermediates by 19 and 27 percent for the full sample and firms engaged in ordinary trade, respectively.

Another concern is that multi-product firms often introduce new products or drop old products. The products-switching within multi-product firms may have a significant impact on the firm-level offshoring behavior. For instance, a firm which begins offshoring more varieties of intermediates might also be introducing products. Thus may confuse product-switching with the removal of quotas. In contrast, some multi-product firms might export only a small share of its products to quota restricted regions. As a result, the impact of the quota removal on these multi-product firms may be relatively small. For the above reason, classifying these multi-product firms as treated firms may be controversial. To exclude the impact of within-firm product and destination churning on their offshoring behaviors, we restrict attention to firms whose main product accounts for at least 50% of their total export revenue. These firms are treated as single product firms (e.g. Hu et al., 2015) and it is straightforward to track their export decisions over time. These 'single product' firms are classified into treatment and control groups based on the destination that their main product is exported to and the quota fill rate as in the second specification. The results are reported in Table 8 and Table 9:

[Table 8 is to be here]

[Table 9 is to be here]

All results in Table 8 and Table 9 exhibit a very similar pattern to those in Table 6 and Table 7. Relative to the control group, the firms in the treatment group tend to import more intermediates, both on the extensive and intensive margins, after the quota removal.

6. Conclusions

This paper presents a model that disentangles the link between a demand shock in final product market and the firm-level offshoring behavior. The model predicts that higher final product demand causes firms to search more countries for cheaper intermediates. This is because the higher demand increases firm profitability, which in turn covers higher fixed search costs. After firms search more source countries, more varieties and higher volumes of intermediates will be offshored instead of being purchased from the domestic market.

Using the textile and clothing export and import data from China, we find that the removal of quotas on textile and clothing products increases the number of varieties and volume of intermediates offshored. This implies that a positive demand shock on final products enhances exporters' participation in offshoring. The empirical results are robust to different regression designs.

Documented by a number of research papers, the global work sharing is an effective way to enhance firm-level production efficiency. One implication of this paper is that increased final product demand encourages global offshoring, and improves firm-level production efficiency. Neglecting this effect suggests the benefits of trade liberalization may be underaluated.

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Appendix (Tables)

Table 1: Quota Fill Rate

	All Three Regions	U.S.	E.U.	cCAN
Number of Quotas	1,415	467	507	441
Number of Binding Quotas	917	426	287	204
Fill Rate	64.81%	91.22%	56.61%	46.26%

Notes: A quota is defined as a binding quota when its fill rate exceeds 90%. The products are disaggregated at HS8 digit level

Table 2: The Export Values and Growth Rate

Year	ROW	U.S.	E.U.	CAN
2004	589	70	76	10.7
2005	605	139	140	17.5
Growth Rate	2.83%	97.91%	72.83%	63.55%

Notes: Table 2 reports the export revenue growth of textiles and clothing to the U.S., E.U., Canada, and rest of the world, respectively. Revenues are measured in 10 million US dollars.

Table 3: The Average Number of Imported Intermediates

A: Average Imported Varieties								
	Full Sample				Ordinary Trade			
Year	ROW	U.S.	E.U.	CAN	ROW	U.S.	E.U.	CAN
	1	2	3	4	5	6	7	8
2004	1.90	2.81	2.51	2.31	2.47	1.86	2.07	1.38
2005	2.59	3.10	2.74	3.50	2.59	4.67	4.33	7.05
B: Average Imported Values								
Year	ROW	U.S.	E.U.	CAN	ROW	U.S.	E.U.	CAN
	1	2	3	4	5	6	7	8
2004	1.47	1.29	1.38	1.68	1.05	0.92	0.91	0.92
2005	1.49	1.32	1.45	1.60	1.10	0.97	1.04	0.97

Notes: Table 3 reports the average number of imported varieties and the total value of importing intermediates for firms exporting to the U.S., E.U., CA, and the rest of the world. The varieties of intermediates are defined at HS6 disaggregate level, and the value are measured in 10 thousand of USD.

Table 4: The Impact of Quota Removal on Firms' Extensive Importing Margin

	Full Sample		Ordinary Trade	
	1	2	3	4
	OLS	Poisson	OLS	Poisson
Treatment	0.7221*	0.0363***	0.9682**	0.0476***
	(*0.4416*)	(*0.0058*)	(*0.4641*)	(*0.0072*)
# of Product	0.2208***	0.0005***	0.1422***	0.0010***
	(*0.0030*)	(*0.0001*)	(*0.0041*)	(*0.0001*)
Ownership FE	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes
R-square	0.22	0.32	0.15	0.30
Obs	90,330	90,330	76,231	76,231

Notes: Table 4 presents the treatment effect of the quota removal on the numbers of imported varieties at the firm-level. The treatment group contains firms exporting textile products which were subject to quota restrictions before 2005. Standard errors are in parenthesis. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 5: The Impact of Quota Removal on Firms' Intensive Importing Margin

	Full Sample	Ordinary Trade
	1	2
Treatment	0.1313**	0.2024***
	(*0.0529*)	(*0.0679*)
# of Product	0.0025***	0.0096***
	(*0.0003*)	(*0.0004*)
Ownership FE	Yes	Yes
Product FE	Yes	Yes
R-square	0.08	0.08
Obs	66,927	34,710

Notes: Table 5 presents the treatment effect of the quota removal on firm-level total import volume. The treatment group contains firms exporting textile products to the U.S., Canada, or EU with a quota fill rate above 90%. Standard errors are in parenthesis. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 6: The Impact of the Quota Removal on Firm-level Extensive Import Decisions (Fill Rate)

	Full Sample		Ordinary Trade	
	1	2	3	4
	OLS	Poisson	OLS	Poisson
Treatment	2.0686***	0.0809***	0.5466**	0.0224***
	(*0.3300*)	(*0.0052*)	(*0.2757*)	(*0.0057*)
# of Product	1.2050***	0.0173***	0.6909***	0.0074***
	(*0.0163*)	(*0.0000*)	(*0.0163*)	(*0.0000*)
Ownership FE	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes
R-square	0.24	0.23	0.12	0.23
Obs	66,927	66,927	34,710	34,710

Notes: Table 6 presents the treatment effect of the quota removal on the firm-level imported varieties of intermediates at firm-level. The treatment group contains firms exporting textile products to the U.S., Canada, or EU with a quota fill rate above 90%. Standard errors are in parenthesis. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 7: The Impact of the Quota Removal on Firm-level Intensive Import Margin (Fill Rate)

	Full Sample	Ordinary Trade
	1	2
Treatment	0.1922***	0.2677***
	(*0.0607*)	(*0.0760*)
# of Product	0.0054***	0.0346***
	(*0.0005*)	(*0.0025*)
Ownership FE	Yes	Yes
Product FE	Yes	Yes
R-square	0.09	0.11
Obs	66,927	34,710

Notes: Table 7 presents the treatment effect of quota removal on firm-level total import volume. The treatment group contains firms exporting textile products to the U.S., Canada, or EU with a quota fill rate above 90%. Standard errors are in parenthesis. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 8: The Impact of the Quota Removal on Firm-level Extensive Import Margins (Single Product Firms)

	Full Sample		Ordinary Trade	
	1	2	3	4
	OLS	Poisson	OLS	Poisson
Treatment	2.0110***	0.0972***	0.6922**	0.0502***
	(0.3759)	*(0.0078)*	*(0.3232)*	*(0.0105)*
# of Product	1.6954***	0.0487***	1.0319***	0.0545***
	(0.0209)	*(0.0001)*	*(0.0226)*	*(0.0001)*
Ownership FE	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes
R-square	0.27	0.31	0.14	0.32
Obs	56,056	56,056	27,651	27,651

Notes: Table 6 presents the treatment effect of the quota removal on the number of imported varieties at the firm-level. The treatment group contains firms exporting textile products to the U.S., Canada, or EU with a quota fill rate above 90%. All firms are single product firms. Standard errors are in parenthesis. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 9: The Impact of the Quota Removal on Firm-level Intensive Import Margins (Single Product Firms)

	Full Sample	Ordinary Trade
	1	2
Treatment	0.2822***	0.2477***
	(0.0779)	*(0.0957)*
# of Product	0.0398***	0.0603***
	(0.0021)	*(0.0038)*
Ownership FE	Yes	Yes
Product FE	Yes	Yes
R-square	0.10	0.12
Obs	66,927	34,710

Notes: Table 9 presents the treatment effect of the quota removal on firm-level total imported volumes. The treatment group contains firms exporting textile products to the U.S., Canada, or EU with a quota fill rate above 90%. Standard errors are in parenthesis. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

Appendix (Proofs)

Proof of Proposition 1

Proof. Similar to Antras et al. (2014), when $(\sigma - 1)/\theta > 1$, the profit function in (12) exhibits increasing differences in (I_{ijt}, I_{ikt}) for $j, k \in \{1, ...J\}$ with $j \neq k$. Furthermore, it also features increasing difference in (I_{ijt}, EB_t) for $j \in J$. Making using of Topkis's monotonicity theorem, I can then conclude that for any demand shock such that $EB_t > B_{t-1}$, there must be $(I_{i1t}(\varphi, EB_t), I_{i2t}(\varphi, EB_t)..., I_{iJt}(\varphi, EB_t)) \geq (I_{i1}(\varphi, B_{t-1}), I_{i2t}(\varphi, B_{t-1})..., I_{iJt}(\varphi, B_{t-1}))$. Therefore, this inequality rules out a situation in which $I_{ijt}(\varphi, EB_t) = 0$ but $I_{i1t}(\varphi, B_{t-1}) = 1$, and as a result the conclusion $J_i(\varphi, EB_t) \supseteq J_i(\varphi, B_{t-1})$ for $EB_t > B_{t-1}$ holds. □

Proof of Intensive Margin of Imports

Proof. The total cost of intermediates is proportional to operating revenue, that is:

$$\begin{aligned} C_i^{tot}(\varphi, EB_t) &= \frac{\sigma - 1}{\sigma} R_i(\varphi, EB_t) \\ &= \frac{\sigma - 1}{\sigma} \varphi^{\sigma-1} (\gamma \Theta_i(\varphi, EB_t))^{(\sigma-1)/\theta} EB_t. \end{aligned} \tag{A1}$$

where $R_i(\varphi, EB_t)$ and $C_i^{tot}(\varphi, EB_t)$ are the total revenue and costs of a firm with productivity φ based in country i, respectively. From Proposition 1, for any demand shock in period t such that $EB_t > B_{t-1}$, it follows that $J_i(\varphi, EB_t) \supseteq J_i(\varphi, B_{t-1})$. This inequality further implies that the offshoring capability is increasing in the demand shock, which in turn increases the expected aggregate residual demand, EB_t:

$$\Theta_i(\varphi, EB_t) > \Theta_i(\varphi, B_{t-1}). \tag{A2}$$

Inequality (A1) and (A2) imply that positive correlation between expected aggregate residual demand (or demand shocks) and the total cost of intermediates:

$$C_i^{tot}(\varphi, EB_t) > C_i^{tot}(\varphi, B_{t-1}). \tag{A3}$$

Recall that Proposition 2 implies that the offshoring probability of each intermediate, $\chi(\varphi, EB_t)$, is non-decreasing in the expected aggregate residual demand, EB_t, or $\chi(\varphi, EB_t) > \chi(\varphi, B_{t-1})$. Along with inequality (A3), the costs of importing are increasing in the residual demand:

$$C_i^{im}(\varphi, EB_t) = C_i^{tot}(\varphi, EB_t)\chi(\varphi, EB_t) > C_i^{tot}(\varphi, B_{t-1})\chi(\varphi, B_{t-1}) = C_i^{im}(\varphi, B_{t-1}). \tag{A4}$$

Inequality (A4) implies that the imported value of intermediates is increasing in the demand shock, which affects the expected residual demand a firm faces. □

Proof of Inequality (13)

Proof. There are two situations when a demand shock takes place in country k at period t: country k dose not belong to a firm's export set at period $t-1$, $k \notin J^{ex}(\varphi, B^{\omega}_{t-1})$ or country k belongs to a firm's export set at period $t-1$, $k \in J^{ex}(\varphi, B^{\omega}_{t-1})$.

Case 1: When country k does not belong to a firm's export set in period $t-1$

$$\frac{\partial EB_t}{\partial EB_{kt}} = sign(\Delta J^{ex}(\varphi, B^{\omega})) \sum_{\Delta J^{ex}(\varphi, B^{\omega})} EB_{jt}, \tag{A5}$$

$$\Delta J^{ex}(\varphi, B^{\omega}) = J^{ex}(\varphi, EB_t^{\omega}) - J^{ex}(\varphi, B_{t-1}^{\omega}). \tag{A6}$$

where $EB_t^{\omega} = \{B_{1,t-1}, B_{2,t-1}, ..., B_{k,t-1} + \Delta B_{kt}, ...B_{J,t-1}\}$ is the expected world residual demand vector in period t, and $B_{t-1}^{\omega} = \{B_{1,t-1}, B_{2,t-1}, ..., B_{k,t-1}, ...B_{J,t-1}\}$ is the counterpart before the demand shock. Note that the economy is in an equilibrium before the demand shock, as such, the residual demand in each country is constant before period t. The expected residual demand in each country equals to its realization. I claim that if $\Delta B_{kt} > 0$, equation (*A6*) must be positive. Suppose the opposite is true, $\Delta B_{kt} > 0$, but $J^{ex}(\varphi, EB_t^{\omega}) - J^{ex}(\varphi, B_{t-1}^{\omega}) < 0$. From Proposition 1, we must have

$$J_i^s(\varphi, EB_t) \subseteq J_i^s(\varphi, B_{t-1}), \tag{A7}$$

where EB_t and B_{t-1} are the expected aggregate residual demand faced by a firm in period t and $t-1$, respectively. Condition (A7) says that when the demand shock is in the country not belonging to the firm's export set, and this shock causes this firm to export to fewer countries, $EB_t < B_{t-1}$. Condition (A7) further implies that the offshoring capability

$$\Theta(\varphi, EB_t) < \Theta(\varphi, B_{t-1}).$$

This indicates that if a positive demand shock in country k at period t shrinks a firm's export set, it also reduces this firm's offshoring capability. All of the above discussion shows that when the firm faces a world residual demand vector EB_t^ω, it maximizes its profit by exporting to fewer countries and searching fewer countries than it did when facing the world residual demand vector B_{t-1}^ω. This is a contradiction because this firm could search and export to the same set of countries after the demand shock, which will result in firm the same expected profit as that before the demand shock. The profit associated with the original search and export strategies must be higher than the current profit, otherwise, this firm does not maximize its profit when facing the aggregate residual demand before the demand shock, B_{t-1}.

Therefore, if country k does not belong to a firm's export set, after a positive demand shock, this firm must keep its original export set of countries or export to more countries. This implies $\frac{\partial EB_t}{\partial EB_{kt}} \geq 0$.

Case 2: country k belongs to a firm's export set.

$$\frac{\partial EB_t}{\partial EB_{kt}} = 1 + sign(\Delta J^{ex}(\varphi, B^\omega)) \sum_{\Delta J^{ex}(\varphi, B^\omega)} EB_{jt}. \tag{A8}$$

If $sign(\Delta J^{ex}(\varphi, B^\omega)) \sum_{\Delta J^{ex}(\varphi, B^\omega)} EB_{jt} < -1$, which implies $\frac{\partial EB_t}{\partial EB_{kt}} < 0$, following the same logic as in case 1, we can show the contradiction. It is straight forward to show $sign(\Delta J^{ex}(\varphi, B^\omega)) > 0$. Since $\frac{\partial EB_t}{\partial B_{kt}} > 0$, from Proposition 1 $J_i^s(\varphi, EB_t) \supseteq J_i^s(\varphi, B_{t-1})$. This further implies $\Theta(\varphi, EB_t) \geq \Theta(\varphi, B_{t-1})$. After the demand shock, the firm increases its search set, and hence reduces its marginal assembly costs. If a country belongs to this firm's export set before the shock, it must belong to the set after the shock. This is because, the profit from exporting to any country belonging to the original export set increases after the cost reduction. Furthermore, with reduced marginal costs, this firm could penetrate other countries which do not belong to its export set before the demand shock. Therefore, $sign(\Delta J^{ex}(\varphi, B^{\omega})) > 0$.

In sum, a firm's export set and search set are both non-decreasing for a positive demand shock in any country.

Proof for Inequality (15)

Proof. The unit export costs for a firm exporting from base country i to country j in period s, under the unit license fee is:

$$c_{fs}^{quota}(\varphi) = \tau_{ij} c_{fs}(\varphi) + l_j. \tag{A9}$$

where $c_{fs}^{quota}(\varphi)$ is the unit assembly cost under the quota restriction. $l_j > 0$ if country j is subject to an import quota and $s < t$, while $l_j = 0$ if $t \geq s$ or country j does not impose as import quota. The unit export cost under the unit license fee becomes:

$$p_{js}(\varphi) = \frac{\sigma}{\sigma - 1}(\tau_{ij} c_{fs}(\varphi) + l_j). \tag{A10}$$

Equation (A10) implies that the unit license fee accounts for a larger cost share for firms with higher productivity. This further means that a quota removal would have a larger impact on more productive firms' price, quantity, and profit. Let $\widehat{\tau}_{ij} = \tau_{ij} + \frac{l_j}{c_{fs}(\varphi)}$, the profit in market j in period s without considering any fixed cost is:

$$\pi_{js} = \frac{1}{\sigma}\left(\frac{\sigma}{1-\sigma}\right)^{1-\sigma} A_j \widehat{\tau}_{ij}^{1-\sigma} c_{fs}(\varphi)^{1-\sigma}. \tag{A11}$$

Similar to equation (3), we can show inequality (15) as follows:

$$B_{j,t-1} = \frac{1}{\sigma}\left(\frac{\sigma}{1-\sigma}\right)^{(1-\sigma)} A_j \widehat{\tau}_{ij}^{1-\sigma} < \frac{1}{\sigma}\left(\frac{\sigma}{1-\sigma}\right)^{(1-\sigma)} A_j \tau_{ij}^{1-\sigma} = EB_{jt}. \quad \text{(A12)}$$

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