Assortative Matching of Exporters and Importers

Yoichi Sugita — SSE
Kensuke Teshima — ITAM
Enrique Seira — ITAM

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Abstract: This paper examines what determines matching of exporters and importers by investigating how matching changes in a large trade liberalization episode. In Mexican textile/apparel exports to the US, both exporters and importers concentrate more than 80% of product-level trade with the single largest partners (the main partners). To understand how firms choose the main partners and change them in response to liberalization, our model introduces one-to-one matching of exporters and importers based on the complementarity/substitutability of firm capability (productivity/quality) within matches in an otherwise standard heterogeneous firm trade model. Our data shows increases in Chinese exporters to the US at the end of the Multi-Fiber Arrangement in 2005 caused Mexican exporters to downgrade and US importers to upgrade their main partners. Our model shows this pattern is consistent with complementary-driven positive assortative matching, but not with capability-independent random matching or substitutability-driven negative assortative matching. The presence of complementarity we find suggests trade liberalization improves matching of firms in supply chains as a part of within industry reallocation that improves the aggregate industrial performance.

Keywords: Firm heterogeneity, assortative matching, two-sided heterogeneity, trade liberalization

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Author: Yoichi Sugita, Stockholm School of Economics, Department of Economics, Box 6501, 11383 Stockholm, Sweden (E-mail: yoichi.sugita@gmail.com Tel: +46-8-7369254, Fax: +46-8-313207).

Author: Kensuke Teshima, Centro de Investigación Económica, Instituto Tecnológico Autónomo de México Av. Santa Teresa # 930, México, D. F. 10700 (E-mail: kensuke.teshima@itam.mx)

Author: Enrique Seira, Centro de Investigación Económica, Instituto Tecnológico Autónomo de México Av. Santa Teresa # 930, México, D. F. 10700 (E-mail: enrique.seira@itam.mx)

1 Introduction

The last decade has witnessed a rise in research in heterogeneous firms and trade. A robust finding that firms with relatively high productivity/quality (capability) participate in exporting and/or importing within industries (e.g. Bernard and Jensen, 1995, 1999) has developed new theories emphasizing within industry reallocation by trade (Melitz, 2003; Bernard, Eaton, Jensen, and Kortum, 2003): trade improves aggregate industrial performance by shifting production factors to more capable firms within industries as empirical studies observe (e.g. Pavcnik, 2002). This new reallocation mechanism has been applied for various issues and centered in the trade research of the last decade.[1]

In contrast to the level of our knowledge about which firms participate in trade, we know little about which exporters trade with which importers, i.e. matching of exporters and importers. Do exporters and importers match based systematically on any firm characteristics? Do trade liberalization change matching of exporters and importers in any systematic way? This paper is one of the first attempts to answer these questions empirically.

Workhorse trade models consider types of international trade where considering matching of exporters and importers is not important. Perfectly competitive models such as the Ricardian and Heckscher-Ohlin models do not predict any systematic matching pattern because in equilibrium exporters and importers are indifferent on whom they trade with.[2] The love of variety model also abstracts away from matching, predicting that all exporters trade with all importers.

Data suggests understanding matching is important at least for some industries. In our customs transaction data set of Mexican textile/apparel exports to the US, we are able to observe the identities of exporters and importers at transaction level. Table 1 presents a striking fact on matching: a one-to-one matching model is a good approximation for markets of HS 6 digit textile/apparel products. Each column in Table 1 reports the volume share of a type of trade in the total export volume for Mexico's Textile/Apparel (HS50-63) exports to the US. The "One to One" column reports the share of trade in which both the exporter and the importer are the only partners of each other in a given product-year combination. Trade between one-to-one relationship accounts for around 28% of textile/apparel trade. Furthermore, even firms trading with multiple partners conduct most of their product-level trade with

[1]See survey papers e.g. Bernard, Jensen, Redding, and Schott (2007; 2012) and Redding (2011) for more papers in the literature.

[2]Because of this prediction, perfectly competitive models are sometimes called "anonymous market" models.

a single partner. For each product-year combination, we identify the "main partner" of each firm, with whom the firm makes the largest trade volume. The "Main to Main" column reports the share of trade in which the exporter is the main partner of the importer and at the same time the importer is the main partner of the exporter. The column shows that trade within one-to-one matches of the main partners accounts for 80% of textile/apparel trade volume.[3] This huge share of trade between the main partners suggests that understanding matching of the main partners is important for better understanding of international trade.

Year	One to One	Main to Main	Main2 to Main2
2004	0.32	0.77	0.92
2005	0.29	0.79	0.92
2006	0.25	0.80	0.94
2007	0.28	0.81	0.93
2008	0.26	0.78	0.94

Note: Each column reports the volume share of a type of transactions in the total export volume for Mexico's Textile/Apparel (HS50-63) exports to the US. In a "One to One" transaction, the exporter and the importer trade in the product only with each other; in a "Main to Main" transaction, the exporter and the importer trade in the product by the largest volume with each other; In a "Main2 to Main2" transaction, the exporter and the importer trade in the product by the largest or the second largest volumes with each other. Data cover transaction from June to December for 2004 and from January to December for other years. See section 4 for the data source.

Table 1: Shares of trade volume with the Main Partners in Mexico's Textile/Apparel exports to the US

Motivated by Table 1, we analyze the determinants of matching of the main partners in Mexico's Textile/Apparel exports to the US in light of a one-to-one matching model of exporters and importers. Our base model is Sugita (2013) who developed a Becker (1973) type positive assortative matching model of quality-differentiated exporters and importers and integrated it to a standard Melitz type model. To guide our empirical exercise, we extend the Sugita (2013) model to allow for more general sorting patterns and consider the heterogeneity in firm's "capability" nesting two types of firm heterogeneity considered in productivity (e.g. Melitz, 2003) and in quality (e.g. Baldwin and Harrigan, 2010; Johnson, 2012). Suppliers (exporters) and final producers (importers) are both heterogeneous

[3] We identify the second main partner for each firm with whom the firm makes the second largest trade volume for a given product-year combination. The "Main2 to Main2" column in Table 2 reports the share of trade in which the exporter is the main partner or the second main partner of the importer and the importer is the main partner or the second main partner of the exporter.

in capability and match in one-to-one to form global supply chains under perfect information. As well known from classic matching models (e.g. Becker, 1973), the interaction of capabilities within matches determines the sign of sorting in matching. If capabilities are complement, a positive assortative matching (PAM) holds that firms match with those with similar capabilities. If capabilities are substitute, a negative assortative matching (NAM) holds that firms with high capability match with those with low capability. If capabilities are independent, matching patterns are not determined and firms match randomly.

The model demonstrates the importance of identifying the sorting in matching of exporters and importers in two respects. First, if matching is systematically determined by complementarity or substitutability of firms, trade liberalization may improve matching of firms in global supply chains as a part of within industry reallocation that improves the aggregate industrial performance as Antras, Garicano, and Rossi-Hansberg (2006) and Sugita (2013) demonstrated in their models exhibiting PAM. Second, the sign of sorting and the existence of importer heterogeneity may affect the measurement of firm's performance in empirical research. Our model is suitable for analyzing this question since the model nests standard models of heterogeneous exporters with no importer heterogeneity as a special case. We consider a conventional measure of productivity, revenue productivity, as an example. We found that the existence of importer heterogeneity affects revenue productivity of exporters and that the direction of the effect is the opposite between the case of PAM and the case of NAM.

Finally, we empirically identify the sign of sorting exploiting a large scale and arguably exogenous trade liberalization episode, the end of the Multi-Fiber Arrangement (MFA) in 2005. Before 2005 Mexican exporters had already acquired free access to the US market through the North American Free Trade Agreement and enjoyed the advantage over exporters from other countries that faced severe quota restrictions to the US market. In 2005 when the US removed quota restrictions, there was a surge in imports in the US apparel/textile market mostly due to the new entry of Chinese exporters (Brambilla, Khandelwal, and Schott, 2010; Khandelwal, Schott, and Wei, 2013). As a result of this, Mexican exporters faced an increase in competition with Chinese exporters in the US market. If the matching of Mexican exporters and US importers were positive assortative due to the complementarity of capabilities, after the end of the MFA we should observe the following change. Some US importers terminate trade with Mexican exporters to import form Chinese exporters.Mexican exporters are forced to switch to US importers with lower capability than their previous partners. This means that US importers who continue to imports from Mexico now can trade with Mexican exporters with higher capability than their previous partners. Using firm's trade volume in 2004 as a proxy for firm's capability, we create a ranking of Mexican exporters and a ranking of US importers and investigate the difference in the rank of the main partner in 2004 and the rank of the main partner in 2007 for Mexican exporters and US importers. We found a strong support for the above prediction of complementary driven positive assortative matching. Namely, Mexican exporters downgraded US importers and US importers upgraded Mexican importers more often in industries liberalized in 2005 than in industries already liberalized before 2005. Furthermore, we found no other systematic pattern of partner changes, which rejects capability-independent random matching and substitutability-driven negative assortative matching. We present a number of additional analysis to support the robustness of our basic findings and to reject possible alternative explanations for our empirical results.

Our finding provides the first evidence from transaction-level trade data for complementarity-driven assortative matching emphasized by Antras et al. (2006) and Sugita (2013). The systematic change in matching we find also suggests that trade liberalization improves matching of firms in global supply chains as a part of within industry reallocation that improves the aggregate industrial performance.

Related Literature

Our paper is related to the growing literature on importer-exporter matched transaction data. As pioneering studies on the static characteristics of matching of exporters and importers, Blum, Claro, and Horstmann (2011, 2012) and Eaton, Eslava, Jinkins, Krizan, and Tybout (2012) studied trade between two countries, Chile-Colombia trade, Argentina-Chile trade, and Colombia-US trade, respectively. Bernard, Moxnes, and Ulltveit-Moe (2013) and Carballo, Ottaviano, and Volpe Martincus (2013) studied exports from one country to multiple destinations in Norwegian customs data and in the customs data of Costa Rica, Ecuador, and Uruguay, respectively. These studies typically decompose firm's exports into extensive margins and intensive margins, extending the method of Eaton, Kortum and Kramartz (2010), to include the number of buyers as another extensive margin and investigate how the difference in the number of buyers explains the difference in export volumes across exporters.

Our focus is different from these studies in several points. First, while these studies define a match of an exporter and an importer at destination-year level, we define a match more narrowly at product-destination-year level. Second, motivated by Table 1, our main interest is in the determinant of matching between the main partners, which was not studied in the above mentioned papers. Third, while these studies analyze matching at one point of time, our main focus is on the response of matching to a specific type of shock.

Those transaction data sets that these studies and our study used do not contain financial information of exporters and importers for the estimation of capability. Our contribution is to develop a methodology for identifying the sign of sorting in matching without estimating capability.

Regarding dynamic characteristics of matching, Machiavello (2010) and Eaton et al. (2012) are pioneering studies on how new exporters acquire or change buyers in Chilean exports of wine to the UK and in Colombian exports to the US. While these two studies consider steady state dynamics, we focus on how matching responds to a specific shock to a market.

Our theoretical part rests on positive assortative matching models of exporters and importers developed by Antras, Garicano, and Rossi-Hansberg (2006) and Sugita (2013).[4] Antras et al. (2006) and Sugita (2013) differ in the source of the heterogeneity of firms. In Antras et al. (2006), firms are heterogeneous in the skills of workers and technology is identical; in Sugita (2013), firms are heterogeneous in technology but workers are homogeneous.[5] Our finding supports for complementary-driven positive assortative matching in Antras et al. (2006) and Sugita (2013) though we need to work further to distinguish the two models. Our theoretical contribution is to extend Sugita (2013) in two points. First, the model introduce firm heterogeneity in capability, which nests firm heterogeneity in productivity and quality. Second, the model allows for more general interactions of capabilities within matches, which can predict negative assortative matching and random matching, to derive predictions that can be used for identifying the sign of sorting from data.

[4]The trade literature has also developed other matching models. The early models analyze *random* matching of *symmetric and horizontally* differentiated exporters and importers (Casella and Rauch, 2001; Rauch and Casella, 2003; Rauch and Trindade, 2003; Grossman and Helpman, 2005).

[5]The difference between Sugita (2013) and Antras et al. (2006) is reminiscent of the difference between Melitz (2003) and Yeaple (2005).

2 Theoretical Framework

2.1 A Matching Model of Global Supply Chains

We consider a partial equilibrium model of global supply chains producing differentiated goods. Our model is a partial equilibrium version of Sugita (2010; 2013), but consider three countries and more general sorting patterns.[6] The production involves three countries, Mexico, China, and the US. There are two types of firms, final producers and intermediate goods suppliers (suppliers). Suppliers in Mexico and in China export intermediate goods to the US. Final producers in the US import intermediate goods, produce differentiated final goods, and sell them in the US market. At this moment, no trade barrier is imposed on exports from Mexico or China.

The representative consumer in the US maximizes the following utility function:

$$U = \frac{\delta}{\rho}\ln\left[\int_{\omega\in\Omega}\theta(\omega)^{\alpha}q(\omega)^{\rho}d\omega\right] + q_0 \text{ s.t. } \int_{\omega\in\Omega}p(\omega)q(\omega)d\omega + q_0 = I.$$

where Ω is a set of available differentiated final goods, ω is a variety of differentiated final goods, $p(\omega)$ is a price of ω, $q(\omega)$ is consumption of ω, q_0 is consumption of a numeraire good, and I is an exogenously given income. Parameter δ captures industry-wide demand shocks. Parameter $\theta(\omega)$ is "capability" of the producer of ω and $\alpha \geq 0$ determines the interpretation of capability as we will discuss below. Consumer's demand for a variety with price p and capability θ is derived as

$$q(p,\theta) = \frac{\delta\theta^{a\sigma}p^{-\sigma}}{P^{1-\sigma}}, \tag{1}$$

where $\sigma \equiv 1/(1-\rho) > 1$ is the elasticity of substitution and $P \equiv \left[\int_{\omega\in\Omega}p(\omega)^{1-\sigma}\theta(\omega)^{\alpha\sigma}d\omega\right]^{1/(1-\sigma)}$ is a price index.

Firms are heterogeneous in their own capability. Capability expresses either productivity or quality, depending on other parameters in the model.[7] Let x and y be the capability of suppliers and final producers, respectively. There are mass M_M of suppliers in Mexico, M_C of suppliers in China and

[6] Sugita (2013) integrates a positive assortative matching model of quality-differentiated final producers and suppliers with Melitz (2003) type of heterogeneous firms with endogenous entry and a Ricardian comparative advantage model of global supply chains. Our model is more similar to Sugita (2013)'s old version, Sugita (2010). The main difference between Sugita (2010) and Sugita (2013) is that the former uses a CES utility function and the latter uses a quadratic utility function.

[7] The heterogeneous firm trade literature has considered two types of firm heterogeneity, productivity and quality. We borrow the term "capability" from Sutton (2007).

M_U of final producers in the US. For simplicity, a Chinese supplier is a perfect substitute for a Mexican supplier with the same capability. The capability of Mexican suppliers and that of Chinese suppliers also follow an identical distribution and the c.d.f. is given by $F(x)$. The c.d.f. for the capability of the US final producers is given by $G(y)$.

Final goods are produced in team. A final producer and a supplier form a team to produce one variety of final goods. Once teams are formed, suppliers tailor intermediate goods for a particular variety of final goods; therefore, firms transact intermediate goods only within their team. Each firm joins only one team.

We introduce the capability of a team θ and assume $\theta(x, y)$ is an increasing function of capabilities of team members, $\theta_1 \equiv \partial\theta(x, y)/\partial x \geq 0$ and $\theta_2 \equiv \partial\theta(x, y)/\partial y \geq 0$. The cross partial derivative $\theta_{12} \equiv \partial^2\theta(x, y)/\partial x\partial y$ expresses the complementarity or substitutability of capabilities within teams. Throughout the paper, we focus on the following three cases that generate sharp predictions on matching patterns: (1) Case-C (Complement) $\theta_{12} > 0$ (θ is strict supermodular) for all x and y; (2) Case-I (Independent) $\theta_{12} = 0$ (θ is additive separable) for all x and y; (3) Case-S (Substitute) $\theta_{12} < 0$ (θ is strict submodular) for all x and y. Both Case-C and Case-S (and the intermediate Case-I) are theoretically plausible (e.g. Grossman and Maggi, 2000). An example for Case-C is the complementarity of quality of tasks in a production process (Kremer, 1993; Kugler and Verhoogen, 2012; Sugita, 2013). For instance, a high quality car part is more useful when it is combined with other high quality car parts. An example for Case-S is technological spillovers through learning and teaching. Gains from learning from high capable partners might be greater for low capable firms.

Production technology is of Leontief type. When a team produces q units of final goods, the supplier in the team produces q units of intermediate goods with costs $c_x\theta^\beta q + f_x$; then, using them, the final producer assemble final goods with costs $c_y\theta^\beta q + f_y$. The total costs for team with capabilty θ producing q units of final goods are

$$c(\theta, q) = c\theta^\beta q + f, \tag{2}$$

where $c \equiv c_x + c_y$ and $f \equiv f_x + f_y$. The marginal cost of each firm is assumed to depend on team's capability. This assumption is mainly for simplicity, but it also aims to express externality within teams that makes marginal costs to depend on partner's capability as well as its own.[8]

Team capability θ can be interpreted as either productivity or quality, depending on parameters α and β. When $\alpha = 0$ and $\beta < 0$, team's marginal cost in (2) is decreasing in θ; each teams face a symmetric demand function (1). In this case capability θ can be interpreted as productivity and teams are heterogeneous in productivity as firms in Melitz (2003). When $\alpha > 0$ and $\beta > 0$, the demand for a final good variety (1) increases in θ; at the same time team's marginal costs in (2) also increase in θ. In this case capability θ can be interpreted as quality as in Baldwin and Harrigan (2011) and Johnson (2012).

The model has two stages. In Stage 1, final producers and suppliers form teams under perfect information. After teams are formed, in Stage 2, teams compete in the US final good market in a monopolistically competitive fashion.

Stage 2 We obtain an equilibrium by backward induction. Team's optimal price is $p(\theta) = c\theta^{\beta}/\rho$. Hence, team's revenue $R(\theta)$, total costs $C(\theta)$, and joint profits $\Pi(\theta)$ are

$$R(\theta) = \sigma A\theta^{\gamma},\ C(\theta) = (\sigma - 1)\,A\theta^{\gamma} + f,\ \text{and}\ \Pi(\theta) = A\theta^{\gamma} - f,$$

where $A \equiv \frac{\delta}{\sigma}\left(\frac{\rho P}{c}\right)^{\sigma-1}$. Parameter $\gamma \equiv \beta + (\alpha - \beta)\sigma$ summarizes how capability affects demand and costs. When $\gamma = 1$, the sign of the cross derivative of joint profits $\partial^2\Pi/\partial x\partial y$ is equal to the sign of θ_{12}. We assume $\gamma = 1$ in the following to simplify expositions.[9]

Stage 1 Firms choose their partners, taking A as given. Since no resale of intermediate goods is possible, each supplier charges a non-linear price (payment per match) instead of a conventional linear price (payment per good). The payment between a final producer and a supplier is endogenously determined so as to make matching stable. Profit schedules, $\pi_x(x)$ and $\pi_y(y)$, and matching functions,

[8] One example for this is that producing high quality final goods need extra costs of quality control at each production stage because even one defective component can destroy the whole product (Kremer, 1993). Another example is productivity spillovers through teaching and learning within a team.

[9] The cross derivative of joint profits becomes

$$\Pi_{xy} \equiv \frac{\partial^2\Pi(\theta(x,y))}{\partial x\partial y} = \gamma A\theta^{\gamma-1}\left[\theta_{12} + (\gamma - 1)\frac{\theta_2}{\theta}\right].$$

Therefore, the sign of Π_{xy} is equal to the sign of θ_{12} if $\gamma = 1$. If $\gamma > 1$, there is a possibility that $\Pi_{xy} > 0$ and $\theta_{12} \le 0$ hold; if $\gamma < 1$, there is a possibility that $\Pi_{xy} < 0$ and $\theta_{12} \ge 0$.

$m_x(x)$ and $m_y(y)$, characterize equilibrium matching. A supplier with capability x matches with a final producer with capability $m_x(x)$ and receives the residual profit $\pi_x(x)$ after paying profits $\pi_y(m_x(x))$ for the partner. A function $m_y(y)$ is the inverse function of $m_x(x)$ such that $m_x(m_y(y)) = y$. We focus on stable matching that satisfies two conditions: (i) (*individual rationality*) all firms earn non-negative profit, $\pi_x(x) \geq 0$ and $\pi_y(y) \geq 0$ for all x and y; (ii) (*pair-wise stability*) each firm is the optimal partner for the other team member:

$$\begin{aligned}\pi_x(x) &= A\theta(x, m_x(x)) - \pi_y(m_x(x)) - f = \max_y A\theta(x,y) - \pi_y(y) - f \\ \pi_y(y) &= A\theta(m_y(y), y) - \pi_x(m_y(y)) - f = \max_x A\theta(x,y) - \pi_x(x) - f.\end{aligned} \tag{3}$$

The first order conditions for the maximization in (3) are

$$A\theta_2(x, m_y(x)) = \pi_y'(m_y(x)) \text{ and } A\theta_1(m_y(y), y) = \pi_x'(m_y(y)).$$

Using $m_x(x) = y$ and $m_y(y) = x$, the above first order conditions become:

$$\pi_x'(x) = A\theta_1(x, m_x(x)) > 0 \text{ and } \pi_y'(y) = A\theta_2(m_y(y), y) > 0 \tag{4}$$

and prove that profit schedules are increasing in capability. Because of fixed costs, final goods with the lowest capability θ_L are not sold on the market. There are capability cutoffs x_L and y_L such that only final producers with $x \geq x_L$ and suppliers with $y \geq y_L$ participate in the matching market, i.e. in international trade. These cutoffs satisfy

$$\pi_x(x_L) = \pi_y(y_L) = 0 \text{ and } (M_M + M_C)[1 - F(x_L)] = M_U[1 - G(y_L)]. \tag{5}$$

The second condition in (5) expresses the mass of suppliers in the matching market is equal to that of final producers.

Integrating the first order conditions (4) with initial conditions (5), we obtain profit schedules as

$$\pi_x(x) = A\int_{x_L}^{x} \theta_1(t, m_x(t))dt \text{ and } \pi_y(y) = A\int_{y_L}^{y} \theta_2(m_y(t), t)dt.$$

The export volume $X(x)$ and the total costs $c_x(x)$ of a supplier depend on its capability as well as that of the partner:

$$X(x) = C_x(x) + \pi_x(x) \text{ and } C_x(x) = \frac{c_x}{c} (\sigma - 1) A\theta(x, m_x(x)) + f_x. \tag{6}$$

It is known that the sign of the cross derivative of team's joint payoff, which corresponds to the sign of θ_{12}, determines the sign of sorting in stable matching in a frictionless one-to-one matching model (e.g. Becker, 1973). In Case-C, we have positive assortative matching (PAM) ($m'_x(x) > 0$): high quality firms match high quality firms while low quality firms match low quality firms. In Case-S, we have negative assortative matching (NAM) ($m'_x(x) < 0$): high quality firms match low quality firms. In Case-I, we cannot determine a matching pattern ($m_x(x)$ cannot be defined as a function) since each firm is indifferent about partner's capability. Therefore, we assume matching is random in Case-I. A formal proof for these results is given in Appendix.

In Case-C, matching functions $m_x(x)$ satisfies the following "matching market clearing" condition.

$$\text{(Case-C)} \ (M_M + M_C) [1 - F(x)] = M_U [1 - G(m_x(x))] \text{ for all } x \geq x_L, \tag{7}$$

The left hand side of (7) is the mass of suppliers that have higher capability than x and the right hand side is the mass of final producers who match with them. Figure 1 describes the matching market clearing condition (7). Each rectangle describes the capability distribution in each sector. The width of the left rectangle is equal to the mass of Mexican and Chinese suppliers and the width of the right rectangle is equal to the mass of US final producers. The left vertical axis expresses the value of $F(x)$ and the right vertical axis does the value of $G(y)$. The left gray area is equal to the mass of suppliers with higher capability than x and the right gray area is the mass of final producers with higher capability them $m_x(x)$. The matching market clearing condition (7) requires the two areas to have the same size.

In Case-S, matching function $m_x(x)$ satisfies the following "matching market clearing" condition.

$$\text{(Case-S)} \ (M_M + M_C) [1 - F(x)] = M_U [G(m_x(x)) - G(y_L)] \text{ for all } x \geq x_L. \tag{8}$$

The left hand side of (7) is the mass of suppliers that have higher capability than x and the right hand

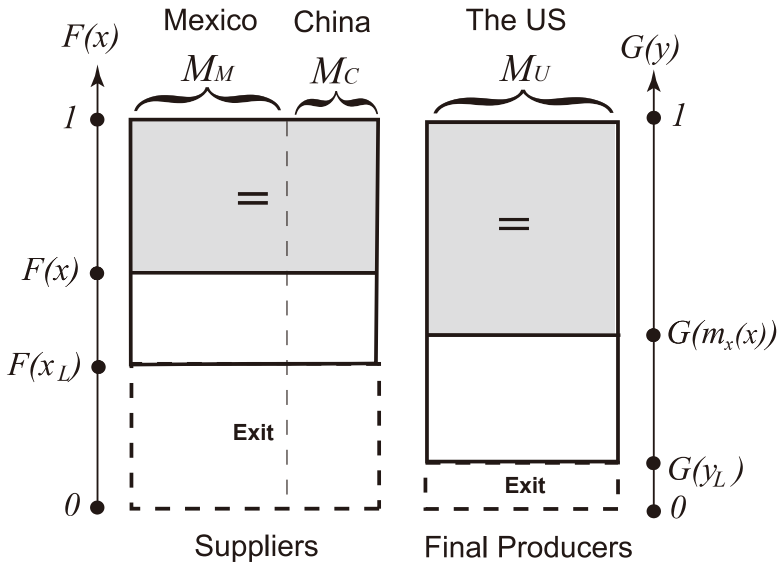

Figure 1: Case-C: Positive Assortative Matching (PAM)

side is the mass of final producers who match with them. Figure 2 describes the matching market clearing condition (8). The left rectangle for suppliers is described in the same way as in Figure 1. The right rectangle describes the rectangle for US final producers in Figure 1 turned upside down. Therefore, a lower position in the rectangle expresses a high capability. The right gray area is equal to the mass of US final producers whose capability is between $m_x(x)$ and x_L. The matching market clearing condition (7) requires the two gray areas to have the same size.

The existence of systematic matching in Case-C and Case-S implies a channel of within industry reallocation by trade liberalization. In Case-C and Case-S, equilibrium matching depends on the distributions of final producers and suppliers. When countries differ in the distribution of final producers and suppliers, which is possibly due to comparative advantage as in Sugita (2003), trade liberalization changes the distribution of firms in the matching market and firms change their matching. We will analyze the response of matching to trade liberalization in Section 2.3.

2.2 Revenue Productivity and Assortative Matching

One of the important differences between workhorse trade models and our matching model is the divisibility of transaction. On the one hand, workhorse models consider markets where transaction is infinitely divisible and an arbitrage is possible for each unit of good. Sellers are forced to set a

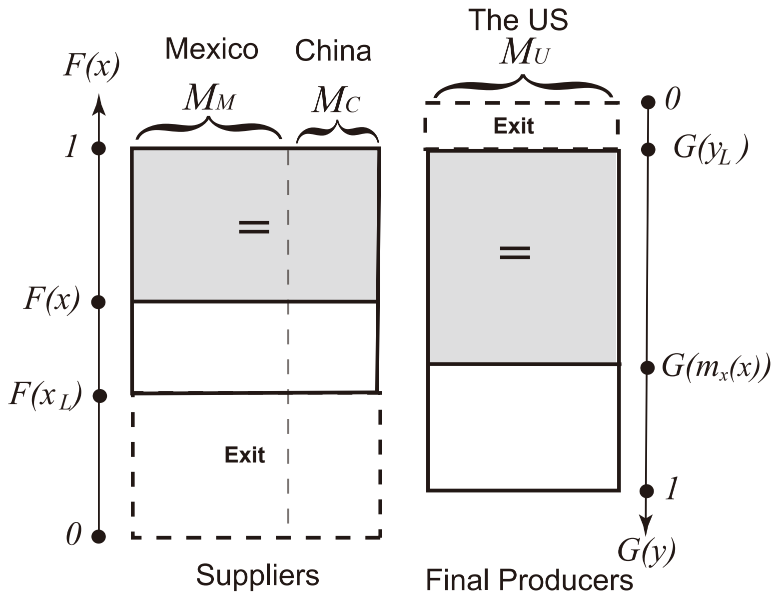

Figure 2: Case-S: Negative Assortative Matching (NAM)

linear price (price per unit of good) that is common for all consumers. Because sellers are indifferent across buyers, by which markets are sometime called "anonymous", no systematic matching of buyers and sellers arises. On the other hand, our matching model considers markets where transaction is indivisible and arbitrage for each unit of good is not possible. Systematic matching of buyers and sellers may arise to reflect the complementarity or substitutability of capabilities of buyers and sellers.

Empirical research have developed several empirical measures of firm's performance under the assumption of anonymous markets. How do those measures work in a matching market we are considering? To fully answer this question is clearly beyond the scope of this paper. As one example, this section chooses one measure, productivity, and analyzes how the sign of sorting (the sign of θ_{12}) and the coexistence of heterogeneity of importers affect the measurement of productivity of exporters.

We consider "revenue productivity" (or revenue-based total factor productivity), which is estimated as the residual of a regression of a firm's revenue, instead of physical outputs, on inputs.[10] Revenue productivity is one of the most widely estimated measures because it is usually difficult for researchers to obtain information on output prices of each firm. We assume labor is the only production factor for simplicity. Then, revenue productivity is obtained as real value-added per worker $V(x) = \frac{X(x)/\tilde{P}}{C_x(x)/w}$,

[10] See Foster, Haltiwanger, and Syversson (2008) for the differences between revenue productivity and ideal physical productivity.

where w is (exogenously given) wage and $\tilde{P}$ is a price deflator. From $X(x) = C_x(x) + \pi_x(x)$, revenue productivity is written as an increasing function of profits per costs:

$$V(x) = \frac{w}{\widetilde{P}}\left[1 + \frac{\pi_x(x)}{C_x(x)}\right] \text{ and } \frac{\pi_x(x)}{C_x(x)} = \frac{\int_{x_L}^{x} \theta_1(t, m_x(t))dt}{\frac{c_x}{c}(\sigma - 1)\,\theta(x, m_x(x)) + \frac{f_x}{f}\theta_L}. \tag{9}$$

Our model deviates from standard models of heterogeneous exporters in three points: (1) one-to-one matching; (2) heterogeneous importers; (3) interactions of capabilities within matches (θ_{12}). We first eliminate the second and the third factors by considering a special case of Case-I, $\theta_2 = 0$, where there is no essential heterogeneity among final producers. We call this case Case-N (No importer heterogeneity). In Case-N, all importer receive zero profits and exporter's profits become $\pi_x(x) = A\theta(x) - f_x$. Then, profits per costs $\pi_x(x)/C_x(x)$ and revenue productivity $V(x)$ behave in the same way as in standard models of heterogeneous exporters with constant markups and fixed costs such as Melitz (2003) and Baldwin and Harrigan (2008). Second, we introduce importer heterogeneity $\theta_2 > 0$ in Case-I with $\theta_{12} = 0$. Revenue productivity turns to behave very differently. The denominator of $\pi_x(x)/C_x(x)$ in (9) increases in $m_x(x)$ but the numerator does not depend on it. Therefore, $V(x)$ decreases in partner's capability $m_x(x)$. Since matching is random in Case-I, revenue productivity $V(x)$ is a decreasing function of a random variable of the capability y of partner importers.

Proposition 1. *In Case-I ($\theta_{12} = 0$) with importer heterogeneity ($\theta_2 > 0$), revenue productivity $V(x)$ of exporters is a decreasing function of a random variable of the capability y of partner importers.*

Proposition 1 implies that in Case-I, revenue productivity is a noisy measure of true capability x even in an environment with no fundamental uncertainty. This would impose a challenge on the inference of the distribution of true capability x from observed revenue productivity because $V(x)$ includes partner capability $m_x(x)$ in a non linear way and the distribution of capability y is typically unobservable. The gap between the distributions of $V(x)$ and true x would become large when the capability of final producers is important (θ_2 is large) and when the dispersion of y is large.

Finally, we compare revenue productivity $V(x)$ of Case-C and Case-S with that in Case-N. We consider three models, model-i ($i = N, C, S$).

Definition 1. Model-i ($i = N, C, S$) is defined as follows. (1) Each model-i has a θ function of Case-i and an identical set of parameters (except θ^i) and identical distributions of capabilities x and

y; (2) θ^i function and matching function $m_x^i(x)$ of model i satisfy that $\theta^N(x, y) = \theta^C(x, m_x^C(x)) = \theta^S(x, m_x^S(x))$ for all $x \geq x_L$.

It is straightforward to show that each model generates an identical cutoff x_L and an identical distribution of employment $C_x(x)$ for active Mexican suppliers. In sum, we compare revenue productivity under three θ functions that generate identical employment. Using these models, we obtain the following Proposition 2.

Proposition 2. *Revenue productivity in model-i (i=N, C, S), $V^i(x)$, satisfy that $V^S(x_L) = V^N(x_L) = V^C(x_L)$ and that $V^S(x) > V^N(x) > V^C(x)$ for all $x > x_L$.*

Proof. The values of $d\theta^i(x)/dx = \theta_1^i(x, m_x^i(x)) + \theta_2^i(x, m_x^i(x))m_x^i(x)$ are identical across the three models. Since $\theta_2^C(x, m_x^C(x))m_x^C(x) > 0$, $\theta_2^N(x, m_x^N(x)) = 0$, and $\theta_2(x, m_x^S(x))m_x^S(x) < 0$, we obtain $\theta_1^S(x, m_x^S(x)) > \theta_1^N(x, m_x^N(x)) > \theta_1^C(x, m_x^C(x))$ for all $x \geq x_L$. Since $C_x(x)$ is identical across the three models and $\pi_x(x_L) = 0$, we obtain the proposition. □

The intuition for Proposition 2 is simple. Revenue productivity is increasing in profits per costs. On one hand, exporter's costs are increasing in the sales of final goods and depend on the team capability (θ), which includes partner's as well as its own capability. On the other hand, exporter's profits depends on its contribution within team (θ_1). In Case-S, a high capable supplier matches a low capable final producer, while in Case-C, a high capable supplier matches a high capable supplier. When producing the same level of team capability, high capable suppliers in Case-S should make greater contributions within teams and therefore receive greater profits than those in Case-C.

Proposition 2 implies that the existence of importer heterogeneity affects revenue productivity and the direction of the effect depends on the sign of sorting. With complementarity, the importer heterogeneity tends to reduce revenue productivity, while with substitutability, the importer heterogeneity tends to increase revenue productivity. This may have a potential implication for studies of productivity involving multiple industries. If industries have different signs of sorting and different degrees of importer heterogeneity, one should be careful when comparing revenue productivity across industries.

2.3 Identifying the Sign of Sorting

How can we identify the sign of sorting (the sign of θ_{12}) from typical trade data? One strategy may be to estimate capabilities x and y for each firm and then to look at their correlation across matches. However, this strategy faces two difficulties. First, it is difficult to assemble a data set linking financial variables of both exporters and importers to customs transaction data. Second, even with such data, the methodology of estimating capabilities in a matching market is not well established. Conventional measures of capability developed for a market with infinitely divisible transaction may not work in a matching market with indivisible transaction.[11]

We develop an alternative strategy to identify the sign of sorting that uses only customs transaction data documenting the identities (names or id numbers) of exporters and importers, product categories, and trade volume. Similar data have recently become available for several countries. The key idea is that the way firms change their partners in response to a shock to a matching market could differ across models-i depending on the sign of sorting. Although there will be multiple shocks creating such changes, we consider a particular shock, an exogenous increase in the mass of Chinese suppliers in the US market.

2.3.1 Comparative Statics: an Increase in the mass of Chinese Suppliers

Suppose that the mass of Chinese suppliers increases ($dM_C > 0$). We call this shock "liberalization" because we will analyze an event of liberalization later that induced a surge in Chinese suppliers in the US market. For simplicity, we assume positive but negligible switching costs so that a firm changes its partner only if it strictly prefers the new match to the current match.

We consider how Mexican suppliers and US importers change their partners. Particularly, we focus on Mexican suppliers that export to the US both before and after liberalization and US final producers that import from Mexico both before and after liberalization. We call them "continuing Mexican

[11] For example, think about using firm's employment as a proxy for firm's capability and looking at a correlation of employment of exporters and importers across matches. One might want to interpret their positive correlation as evidence for complementarity-driven PAM and their negative correlation as evidence for substitutability-driven NAM. This strategy might appear reasonable since using employment as a proxy for capability has appeared in previous studies assuming a model with infinitely divisible transaction. However, looking at employment correlations of exporters and importers is not informative at all about the sign of sorting in the current matching model. All Case-i ($i = I, N, S, C,$) including even Case-S of NAM predict positive correlations simply because importer's employment is increasing in the amount of imported intermediate goods, which is again increasing in exporter's employment.

exporters” and “continuing US importers”, respectively.

In Case-I including Case-N, firms are indifferent about partner’s capability. Therefore, the change in matching is minimized. Therefore, continuing Mexican exporters and continuing US importers do not change their partners

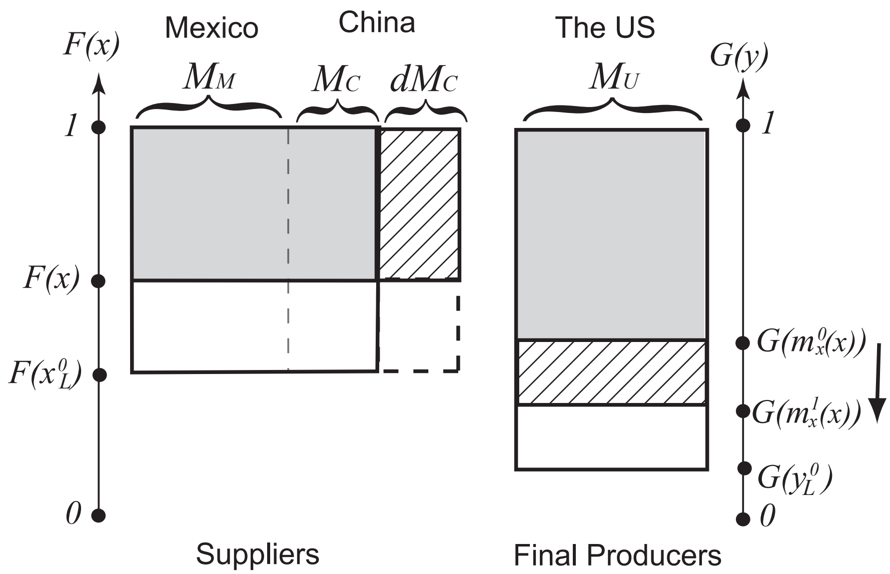

Figure 3: Case-C: the Response of Matching to an Entry of Chinese Exporters ($dM_C > 0$)

In Case-C, matching function $m_x(x)$ systematically changes to satisfy the matching market clearing condition (7). Figure 3 describes how Mexican exporters with capability x changes the capability of their partners from $m_x^0(x)$ to $m_x^1(x)$. After liberalization, the mass of suppliers with higher capability than x increases by $dM_C[1 - F(x)]$, which is expressed as the left striped area. The mass of US final producers with higher quality than $m_x(x)$ should increase by the size of the right striped area, the size of which is equal to the size of the left striped area. Therefore, continuing Mexican exporters downgrade partner’s capability. This means that continuing US importers upgrade partner’s capability.

In Case-S, the change in matching is more complex since the matching market clearing condition includes the cutoff of final producers y_L. The change of y_L is in general ambiguous, depending on whether the least capable final producers improve team capability more than other final producers. Figure 4 describes how exporters with capability x change their partners from $m_x^0(x)$ to $m_x^1(x)$ when y_L is fixed at the pre-liberalization level y_L^0. The figure looks similar to Figure 3 of the case of NAM. As the entry of Chinese exporters increased the mass of suppliers with higher capability than x by the size

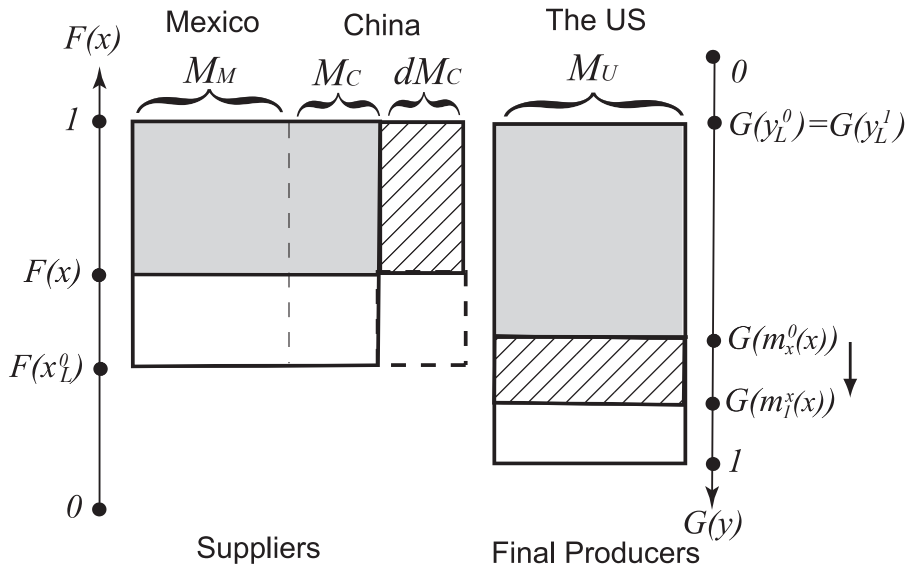

Figure 4: Case-S ($dy_L = 0$): the Response of Matching to an Entry of Chinese Exporters ($dM_C > 0$)

of the striped area, the mass of final producers with capability between y_L and $m_x(x)$ have to increase by the same size of the right striped area. Notice that in contrast to Figure 3, the vertical axis for $G(y)$ in Figure 4 is turned upside down. Therefore, continuing Mexican exporters upgrade partner's capability. This also means that continuing US importers upgrade partner's capability. When y_L increases in Case-S, the change in matching follows the same pattern. The increase in y_L is described as a downward move in y_L in Figure 4. Therefore, $m_x(x)$ moves down further than in the case of no change in y_L. This means that both continuing Mexican exporters and continuing US importers upgrade partner's capability.

When y_L decreases in Case-S, the direction in the change in matching is not uniform. There are two changes in the matching market: (1) new Chinese exporters enter; (2) the lowest capable final producers enter after liberalization. We have already seen the case without the latter effect in Figure 4. The increase in Chinese exporters lead both continuing US and Mexican firms upgrade their partners if there is no entry of final producers. Suppose the lowest capable final producers enter without new entry in Chinese exporters. The right dotted area in Figure 5 expresses the entry of final producers. Exporters with capability x change their partners capability upward in the figure, which means they downgrade the capability of partners. This also means that US final producers downgrade partner's capability. In sum, the entry of Chinese exporters tends to upgrade partner capability and the entry of low capable final producers tends to downgrade partner capability for both continuing

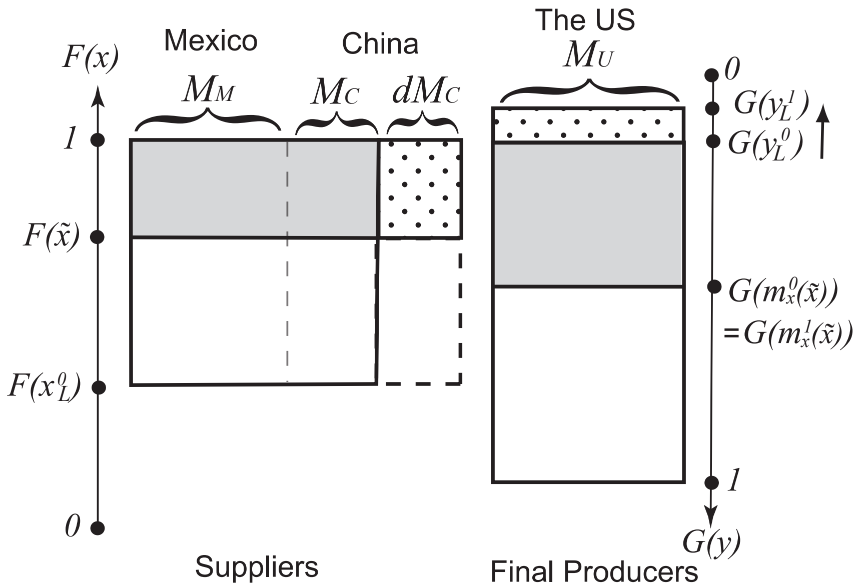

Figure 5: Case-S ($dy_L < 0$): the Response of Matching to an Entry of Chinese Exporters ($dM_C > 0$)

Mexican exporters and continuing US importers. The net effect depends on the level of x. Figure 5 draws exporters with threshold capability $\tilde{x}$ who do not change partner capability because these two forces exactly offset each other. Since the mass of new Chinese exporters with higher quality than x decreases in x, for exporters with $x > \tilde{x}$, the effect of the entry of final producers dominates; while for exporters with $x < \tilde{x}$, the effect of the entry of new Chinese exporters dominates. Therefore, we can classify matches of Mexican exporters and US importers before liberalization into two groups: Group A of matches where Mexican exporters have higher capabilities than $\tilde{x}$ and Group B of matches where Mexican exporters have lower capabilities than $\tilde{x}$. Then, continuing Mexican exporters and continuing US importers in Group A both downgrade partner's capability, while those in Group B upgrade partner's capability.

Table 2 summarizes how continuing Mexican exporters and continuing US importers change partner's capability after liberalization. As Table 2 shows, the direction of the changes in partner capability vary across Cases. Therefore, the observation of the change in partner's capability in response to an increase in Chinese exporters identifies the sign of sorting.

Table 2: The response of matching to an increase in Chinese exporters ($dM_C > 0$)

<table>
<tr><th>Cases</th><th>Sign of sorting</th><th></th><th></th><th>Mexican exporter's partner capability</th><th>US importer's partner capability</th></tr>
<tr><td>Case-C</td><td>Complement ($\theta_{12} > 0$)</td><td></td><td></td><td>Down</td><td>Up</td></tr>
<tr><td>Case-I</td><td>Independent ($\theta_{12} = 0$)</td><td></td><td></td><td>No Change</td><td>No Change</td></tr>
<tr><td rowspan="3">Case-S</td><td rowspan="3">Substitute ($\theta_{12} < 0$)</td><td>$dy_L > 0$</td><td></td><td>Up</td><td>Up</td></tr>
<tr><td rowspan="2">$dy_L < 0$</td><td>Group A</td><td>Down</td><td>Down</td></tr>
<tr><td>Group B</td><td>Up</td><td>Up</td></tr>
</table>

Note: The table summarizes how the capability of partner changes for Mexican exporters who exports both before and after liberalization and US importers who import from Mexico both before and after liberalization. Group A is a group of matches before liberalization where the Mexican suppliers have higher capability than a threshold $\tilde{x}$ while Group B is a group of matches before liberalization where the Mexican suppliers have lower capability than $\tilde{x}$.

2.3.2 Ranking based Trade Volume

Table 2 shows that partner's capability changes in different directions across Cases with different signs of sorting. Since capabilities are not observable in our data set, we are not able to directly test predictions in Table 2. Instead we use firm's trade volume before liberalization as a proxy for capability in the following two steps. First, we create a ranking of Mexican exporters and a ranking of US importers based on their trade volume before liberalization. We call firm's rank based on these rankings the firm's trade-based rank. Second, we examine how continuing exporters and continuing US importers change the trade-based rank of their partners after liberalization in each Case-i ($i = C, I, S$).

In Case-I, continuing Mexican exporters and continuing US importers do not change their partners. Therefore, we should not observe any change in the trade-based rank of their partners, even when we use any other proxy for capability.

In Case-C, trade volume of exporters $X(x)$ and that of importers $X(m_y(y))$ are increasing functions of x and y, respectively. Therefore, the trade based rank of exporters coincides with the rank of capability of the exporters and the trade based rank of importers coincides with the rank of capability of the importers. Therefore, we expect that Mexican suppliers downgrade and US final producers upgrade the trade-based rank of their partners after liberalization.

In Case-S, the relationship between trade volume and capability is complex. The negative assortative matching $m'_y(y) < 0$ implies that the sign of $dX(x)/dx$ is the opposite of the sign of $dX(m_y(y))/dy$ locally at $(x, y) = (m_y(y), y)$. Therefore, $X(x)$ need not be a monotonic function. We consider three possible cases: (i) $X(x)$ is non-monotonic in x; (ii) $X(x)$ is monotonically decreasing in x; (iii) $X(x)$ is monotonically increasing in x. First, when $X(x)$ is non-monotonic in x, $X(m_y(y))$ is also non-monotonic in y. In this case, the change in capability of partners in Table 2 does not correspond to the change in the trade-based rank of partners. Therefore, we should observe both upgrading and downgrading of the trade-based rank of partners for both continuing Mexican exporters and continuing US importers. Second, when $X(x)$ is monotonically decreasing in x, $X(m_y(y))$ is monotonically decreasing in y. We should observe: (1) if $dy_L \geq 0$, continuing Mexican exporters upgrade and continuing US importers downgrade the trade-based rank of partners, respectively; (2) if $dy_L < 0$, we should observe both upgrading and downgrading of trade based partner ranks both for continuing Mexican exporters and for continuing US importers.

The final case for Case-S is when $X(x)$ is monotonically increasing in x and $X(m_y(y))$ is monotonically decreasing. We reject this case because the model predicts the following unrealistic pattern on the selection of importers when they face the change in industrial demand, i.e. the change in δ.

Lemma 1. *Suppose $X(x)$ is monotonically increasing in x in Case-S. A negative shock to the demand for final goods induces the largest importers to exit.*

The reason for Lemma 1 is simple. As in normal cases, a negative demand shock increases y_L ($\delta \downarrow \Rightarrow y_L \uparrow$) and forces final producer with the lowest capability to exit. If $X(x)$ is increasing in x, import volume $X(m_y(y))$ is decreasing in y. Therefore, final producers who exit due to the negative demand shock are the largest importers in the industry. It is well established that the probability of firm's exit is negatively related to firm size and that facing import competition, smaller firms are more likely to exit. Lemma 1 contradicts with these established facts on the selection of firms; therefore, we reject the case that $X(x)$ is monotonically increasing in x. Therefore, for Case-S, we expect two possibilities: (i) both upgrading and downgrading of the trade-based rank of partners are observed for both continuing Mexican exporters and US importers; (ii) continuing Mexican exporters upgrade and continuing US importers downgrade the trade based rank of their main partners.

Table 3 summarizes expected changes of partner's ranks when ranking is based on trade volume before liberalization. If we do not observe any change, that would support for Case I; if we observe partner downgrading by continuing Mexican suppliers and partner upgrading by continuing US importers, that would support for Case-C; if we observe both upgrading and downgrading for both continuing Mexican exporters and continuing US importers that would support for Case-S; if we observe partner upgrading by continuing Mexican suppliers and partner downgrading by continuing US importers, that would also support for Case-S.

Table 3: Expected changes of partner's ranks when ranking is measured by trade volume

Cases	Sign of θ_{12}		Mexican exporter's partner rank	US importer's partner partner rank
Case-C	Complement ($\theta_{12} > 0$)		Down	Up
Case-I	Independent ($\theta_{12} = 0$)		No Change	No Change
Case-S	Substitute ($\theta_{12} < 0$)	Case i	Both Up and Down	Both Up and Down
		Case ii	Up	Down

3 The End of the MFA in 2005

As Table 3 summarizes, an exogenous increase in third country exporters at various capability level ($dM_C > 0$) can identify the sign of sorting between exporters and importers. This section explains that the end of the Multi-Fiber Arrangement (MFA) in 2005 brought this type of shock to Mexican exports of some textile/apparel goods to the US. Specifically, we will exploit three natures of this event. First, in the US market, the increase in imports from China after the end of the MFA dominated imports from other countries. Second, the exports by new entrants rather than incumbents accounted for the increase in Chinese exports after 2005. These new entrants have various levels of capability and some of them are more productive than incumbents assigned quota licenses before 2005. Third, Mexican exports to the US significantly dropped among products China faced binding quota in 2004. These features of the end of the MFA are known from previous studies, so we briefly summarize them here.

The Surge in Chinese Exports to the US The MFA and its successor, the Agreement on Textile and Clothing, are agreements on quota restriction on textile/apparel imports among the GATT/WTO member countries. At the GATT Uruguay round, the US (and other member countries) promised to abolish their quota in four steps: quotas that are equivalent with 16, 17, 18, and 49% of imports in 1990 were removed on January 1, 1995, 1998, 2002, and 2005, respectively.

The quota removal of 2005 triggered a surge in imports to the US, mostly from China. Brambilla, Khandelwal, and Schott (2009) estimated that in 2005, US imports from China disproportionally increased by 271%, while imports from almost all other countries decreased. Seeing a huge import growth, the US and China had agreed to impose new quota until 2008, but imports from China never went back to the pre-2005 level. The new quota system covered fewer product categories than the old system (Dayaranta-Banda and Whalley, 2007) and the level of quota is substantially greater than the MFA level (see Table 2 in Brambilla et al., 2009).

Exports by New and More Productive Entrants Khandelwal, Schott, and Wei (2013) investigated Chinese customs transaction data and decomposed the increase in Chinese exports after the quota removal into intensive and extensive margins. The authors found that the increase in Chinese exports of quota constrained products were mostly driven by the entry of Chinese firms who did not export the product before 2005. Furthermore, while incumbent exporters include a number of state owned firms, these new exporters include more private and foreign firms, which are more productive than state owned firms. Indeed, the distribution of unit prices of new entrants has a lower mean and a greater support than that of unit prices of incumbent exporters. These findings suggest that the removal of import quota induced new entrants at various levels of capability, which corresponds $dM_C > 0$ in the previous section.[12]

Mexican Exports and Competition from China Mexico had already had tariff-and-quota free access to the US market through the North American free trade agreement before 2005.[13] At the end of MFA, Mexico had lost its advantage to third country exporters and faced an increase in competition with Chinese exporters in the US market. Figure 6 is based on the data on Mexican product-level ex-

[12] These findings contradicts with the predictions of models of optimal quota allocations. If quota licenses are efficiently allocated to the most capable firms, then the removal of quota mainly increases exports by incumbents and the new exporters are the least capable firms. See Khandelwal, Schott, and Wei (2013) for a formal demonstration of this claim. Seeing the opposite patten in data, Khandelwal, Schott, and Wei (2013) therefore concluded the allocation of quota licenses were far different from the optimal allocation and produced additional inefficiency.

[13] In NAFTA, the US market was liberalized to Mexican exports in 1994, 1999, and 2003.

ports to the US for textile and apparel industries (Chapters 50 to 63 of the Harmonized System Codes) from 2000 to 2010. The upper dashed line in Figure 6 represents the sum of the export value of all the products on which the US had imposed binding quotas against China until the end of 2004, while the lower solid line represents that of the products with non-binding quotas. The vertical line in year 2005 represents the year in which the MFA expired, implying that any of the products that were included in the MFA had no longer quotas. The figure shows that the two series had moved in parallel before the expiration of the MFA, while the total value of the exports of the products with the US binding quotas against China exhibits a much larger decline after the expiration, suggesting that the surge of Chinese exports to the U.S. due to the end of MFA had a substantial impact on the competition that Mexican exporters face in the U.S. market and on the availability of foreign sellers for the U.S. importers.

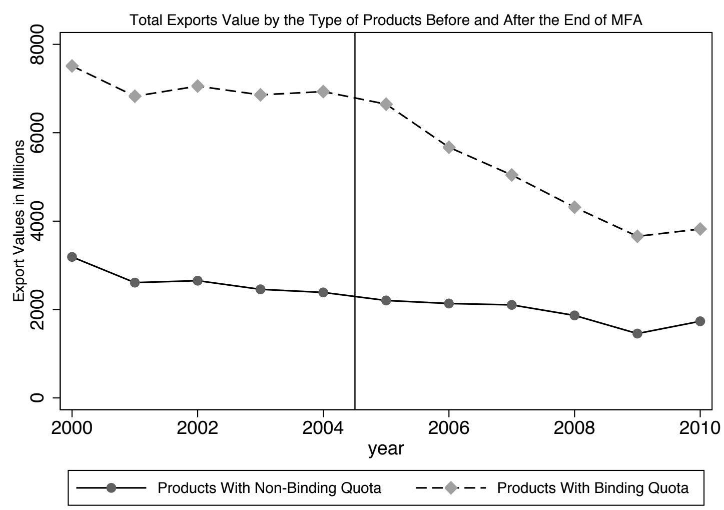

Figure 6: Impacts of the end of MFA on Mexican textile/apparel exports to the US
Note: Export values in millions in the vertical axis are export values from Mexico to the US from product-level trade data for textile and apparel industries (Chapters 50 to 63 of the Harmonized System Codes) from 2000 to 2010. The upper dashed line in the Figure represents the sum of the export value of all the products on which which US had imposed binding quotas against China until the end of 2004, while the lower solid line represents that of the products with non-binding quotas.

4 Data and Specification

4.1 Data Construction

Customs transaction data Our primary data set is the Mexican customs transaction data set for Mexican textile/apparel exports to the US. The data set is created from the administrative records on every transaction crossing the Mexican border from June 2004 to December 2011. The Mexican customs agency requires both individuals and firms who ship goods across the border to submit a customs form (pedimento aduanal in Spanish) that must be prepared by an authorized agent. The form contains information on: (1) the total value of shipment (in US dollars); (2) the 8 digit HS product code (we use from HS50 to HS63); (3) the quantity; (4) the name, the address and the tax identification number of the exporter; (5) the name, the address and the tax identification number (employment identification number, EIN) of the importer, and other information. Information on the importer is not complete for some transactions, which we will explain below.

Assign firm IDs We assigned identification numbers for both Mexican exporters and US importers (exporter-ID and importer-ID) throughout the data set. It is straightforward to assign exporter-ids for Mexican exporters since the Mexican tax number uniquely identifies each Mexican firm. However, there exists a challenge for assigning importer-ids for US firms. It is known that one US firm often has multiple names, addresses, and EINs. This happens because a firm sometimes uses multiple names or changes names, owns multiple plants, and changes tax numbers. Therefore, simply matching firms by one of three linking variables (names, addresses and EINs) would wrongly assign more than one id for one US buyer and would result in overestimating the number of US buyers for each Mexican exporter.

We used a series of methods developed in the record linkage research for data cleaning to assign importer-ID.[14] First, since the focus of our study is firm-to-firm matching, we dropped transactions for which exporters were individuals and courier companies (e.g. FedEx, UPS, etc.). Second, a company name often included generic words that did not help identify a particular company such as legal terms (e.g. "Co.") and words commonly appearing in the industry (e.g. "apparel"). We removed these

[14] An excellent textbook for record linkage is Herzog, Scheuren, and Winkler (2007). A webpage of "Virtual RDC@Cornell" (http://www2.vrdc.cornell.edu/news/) at Cornell University is also a great source of information on data cleaning. We particularly benefit from lecture slides on "Record Linkage" by John Abowd and Lars Vilhuber. We plan to prepare a long Appendix on data cleaning in the next version of this paper.

words from company names. Third, we standardized addresses by a software, ZP4, which received a CASS certification of address cleaning by the United States Postal Services. Fourth, we prepared lists of fictitious names, previous names and name abbreviations, a list of addresses of company branches, and a list of EINs from data on company information, Orbis made by Bureau van Dijk, which covered 20 millions company branches, subsidiaries, and headquarters in the US. We used Orbis information for manufacturing firms and intermediary firms (wholesales and retails) due to the capacity of our workstation. For each HS 2 digit industry, we matched names within customs data and names between customs data and name lists from Orbis mentioned above; we did similar matches for address and EIN. When matching them, we used fuzzy matching techniques allowing small typographical errors.[15] Fifth, using matched relations and a software of the network theory, we created clusters of information (names, addresses, EINs) in which one cluster identifies one firm. We identified a cluster basically under a rule that each entry in a cluster fuzzy matches with some other entries in the cluster through two of three linking variables (names, addresses, EINs). Finally, we assigned importer-ids for clusters.

Dropping missing information From the above processes, the data set includes information on exporter ids, importer ids, value of shipment, product code, and transaction date. We then aggregated value of shipment for a given combination of exporter, importer, HS 6 digit product, and year.[16] Information on importers was not complete for some transactions. Mexican customs do not mandate the custom agents to report information of US importers for processing re-exports called Maquiladora (now called IMMEX since 2007) exports which are exports by the outsourcing contracts between Mexican firms and the foreign (in most cases US) firms. The exemption of the information is because Maquiladora/IMMEX exporters register the information of buyers in advance.

The Mexican customs transaction data set covers only information from June to December for 2004. To make the information of other years comparable to that of 2004, we dropped observations from January to May for other years, too. We remark that the "Main to Main" shares in Table 1 changed very little (a 1 percentage point change only for 2007) from the drop of January-May observations.

[15]We used Jaro-Winkler metric in the Record Linkage package of R and other methods, which will be explained in the next version.

[16]We decided to aggregate the data from the Mexican 8-digit to 6-digit because the Mexican 6-digit code is same as the HS code while it is difficult to construct a concordance between the Mexican 8-digit and the U.S. 10-digit, at which the MFA quotas are defined. We performed all the analysis in the paper using data at the 8-digit aggregation and confirmed that the results are qualitatively the same and quantitatively similar.

Therefore, we believe this drop of observations caused little selection problems.

For each exporter-product (HS6)-year combination, we dropped entries for which we could not identify importers for more than 20 percent of export values. Though we dropped around 30-40 percent of exporters and around 60-70 percent of export values, we think sample selection problems are likely to be small. Non-Maquiladora trade and Maquiladora trade show very similar patterns on firm's average number of partners and Main-to-Main trade shares (as in Table 1). Further notes of the data construction and the section issue will be available in the next version of this paper. We dropped the products for which there was only one exporter or one importer in 2004, as such markets that do not have multiple firms on both sides are out of the focus of our analysis.[17]

Ranking The next step is to create rankings of exporters and importers based on their trade volume. In the model, all matches are one-to-one, but in data, exporters and importers may have multiple partners. We created rankings of firms by trade volume with their main partners in 2004. Let x_{empt} be exports of product p from exporter e to importer m in year t, $M_{pt}(e)$ be the set of importers with which exporter e trade p in year t and $E_{pt}(m)$ be the set of exporters with which importer m trade p in year t. Exporter e's export to the main partner was obtained as $EX_{ept} = \max_{m \in M_{pt}(e)} x_{empt}$ and importer m's import from the main partner was obtained as $IM_{mpt} = \max_{e \in E_{pt}(m)} x_{empt}$. Finally, we created the trade-based ranking of exporters by EX_{ep2004} and the trade-based ranking of importers by IM_{mp2004}.[18]

Partner Downgrading and Upgrading We constructed dummy variables $Downgrading_i$ and $Upgrading_i$ that indicate downgrading and upgrading of the trade-based rank of the main partner for each firm i, respectively. We constructed $Downgrading_i$ and $Upgrading_i$ for each Mexican exporter i as follows. First, we identified the main partner in 2004 and the main partner in 2007 for the exporter. Using the trade-based ranking of US importers, we defined $Downgrading_i = 1$ if the rank of firm i's main

[17] We performed all the analysis in the paper without dropping such products and confirmed that the results are the same.

[18] We prefer to use trade volume with the main partners as our measure of $X(x)$ and $X(m^y(y))$ rather than firm's total trade volume. For instance, an alternative measure for ranking importers would be the total imports for importers, $\sum_{e \in E_{pt}(m)} x_{empt}$. However, this measure may not capture the ranking of profit opportunities for an exporter. An importer may make large imports by buying small amounts from each of many partners, but a typical exporter might see trading with this importer less profitable than trading with another importer who makes smaller total imports but imports greater amounts from each of few partners. In the robustness check session, we show that our main empirical results are robust to the use of an alternative ranking measure based on the total firm-product trade volume.

partner in 2007 was strictly lower than the rank of firm i's partner in 2004 and $Downgrading_i = 0$ otherwise. Similarly we defined $Upgrading_i = 1$ if the rank of firm i's main partner in 2007 was strictly lower than the rank of firm i's partner in 2004 and $Upgrading_i = 0$ otherwise. Notice that for $Downgrading_i$ and $Upgrading_i$ to be defined, two conditions must hold. First, the Mexican exporter i exported the product both in 2004 and 2007. Second, the main partner of the exporter in 2007 imported the product from some Mexican exporter in 2004. We constructed $Downgrading_i$ and $Upgrading_i$ for an US importer in a similar manner.

MFA Quota We constructed measures on which products Chinese exporters faced binding quota constraints in 2004, following Brambilla et al. (2009) and Khandelwal et al. (2013). Brambilla et al. (2009) constructed an indicator on binding quota for Chinese exports for each HS 10 digit category for the US.[19] Since the HS 8 digit categories of Mexican exports are comparable to the HS 10 digit categories of US import only up to the first 6 digits, we aggregated these indicators up to HS 6 digit. Let x^m_{g2004} be US imports of product g from Mexico in 2004. Let j be a HS 6 digit product and $G(j)$ be the set of US HS 10 digit products in category j.Then, we constructed a dummy variable indicating whether Chinese exports of HS 6 digit product j to the US faced binding quotas in 2004 as:

$$Binding_j = I\left\{\frac{\sum_{g\in G(j)} x^m_{g2004} I\{g \in \text{binding quota in 2004}\}}{\sum_{g\in G(j)} x^m_{g2004}} \geq 0.5\right\}, \tag{10}$$

where the indicator function $I\{X\} = 1$ if X is true and $I\{X\} = 0$ otherwise. We chose the cutoff value as 0.5 but the choice of this value is not likely to affect the results since most of values inside the indicator function are close to either one or zero.

[19] A quota is binding if the fill rate, realized imports value over the quota value, is bigger than 0.8. Our results are robust to the choice of other cutoffs.

4.2 Specification

4.2.1 Mexican exporter's change of US partners

We estimate the following pair of regressions for Mexican exporters:

$$\begin{aligned} Downgrading_{igs}^{Mex} &= \beta_1 Binding_{gs} + \lambda_s + u_{igs}^{m} \\ Upgrading_{igs}^{Mex} &= \beta_2 Binding_{gs} + \lambda_s + \varepsilon_{igs}^{m} \end{aligned} \quad (11)$$

where i, g and s index firm, product at the HS 6-digit level and sector (HS 2 digit chapters), respectively. $Downgrading_{igs}^{Mex}$ and $Upgrading_{igs}^{Mex}$ are dummy variables indicating whether Mexican exporters downgrade and upgrade the trade-based rank of their main US partner between 2004 and 2007, respectively. $Binding_{gs}$ is a dummy variable (10) indicating whether Chinese exports of product g to the US had faced a binding quota in 2004. λ_s is a chapter fixed effect. u_{igs}^{m} and ε_{ijs}^{m} are error terms. The construction of variables was discussed in the last section.

The coefficients of interest in (11) are β_1 and β_2. These coefficients are identified by the comparison of the treatment group and the control group. The treatment is the removal of binding quotas on Chinese exports to the US. The coefficients β_1 and β_2 estimate the impact of removing binding quotas for Chinese exporters to the US on the probability that Mexican exporters downgrade or upgrade US partners, respectively. We include the chapter fixed effects to control for the unobservable and observable shocks at the broad sector level.

A crucial assumption for our analysis is that the treatment and control groups would have behaved similarly in the absence of the treatment (the end of the MFA). As this assumption is not directly testable, a typical check that researchers do is to examine whether the treatment and control groups had had a similar trend prior to the treatment. We cannot do this check at the firm level because our data do not contain information before June 2004. Instead, Figure 6 draws the trajectories of product-level exports for firms in the treatment group (products with binding quota) and firms in the control group (products with non-binding quota). The figure shows no differential trend in exports of the two groups several years before the end of the MFA (the treatment).

Positive values of β_1 and β_2 mean that Mexican exporters downgrade or upgrade more frequently in industries (products) that faced an increase in competition with Chinese exporters than in other industries. Table 4 summarizes expected combinations of β_1 and β_2 for each sign of sorting in matching: (1) $\beta_1 > 0$ and $\beta_2 = 0$ for complementarity-driven positive assortative matching (Case-C); (2) $\beta_1 = 0$ and $\beta_2 = 0$ for capability-independent random matching (Case-I); (3)$\beta_1 > 0$ and $\beta_2 > 0$ for substitutability-driven negative assortative matching (Case-S); (4) $\beta_1 = 0$ and $\beta_2 > 0$ for substitutability-driven negative assortative matching (Case-S).

4.2.2 US importer's change of Mexican partners

We also estimate similar regressions to (11) for US importers:

$$\begin{aligned} Downgrading^{US}_{igs} &= \beta_3 Binding_{gs} + \lambda_s + \varepsilon^u_{igs} \\ Upgrading^{US}_{igs} &= \beta_4 Binding_{gs} + \lambda_s + \varepsilon^u_{igs}. \end{aligned} \tag{12}$$

$Downgrading^{US}_{igs}$ and $Upgrading^{US}_{igs}$ are dummy variables indicating whether US importers downgrade and upgrade the trade-based rank of their main Mexican partner between 2004 and 2007, respectively. u^u_{igs} and ε^u_{ijs} are error terms.

The coefficients of interest in (12) are β_3 and β_4. Positive values of β_3 and β_4 mean that US importers downgrade or upgrade more frequently in industries (products) that faced an increase in competition with Chinese exporters than in other industries. Table 4 summarizes expected combinations of β_3 and β_4 for each sign of sorting in matching: (1) $\beta_3 = 0$ and $\beta_4 > 0$ for complementarity-driven positive assortative matching (Case-C); (2) $\beta_3 = 0$ and $\beta_4 = 0$ for capability-independent random matching (Case-I); (3)$\beta_3 > 0$ and $\beta_4 > 0$ for substitutability-driven negative assortative matching (Case-S); (4)$\beta_3 > 0$ and $\beta_4 = 0$ for substitutability-driven negative assortative matching (Case-S).

Table 4: Model's Predictions on the Coefficients in the Main Regressions

Cases	Sign of θ_X		Predictions β_1	β_2	β_3	β_4
Case-C	Complement ($\theta_{12} > 0$)		+	0	0	+
Case-I	Independent ($\theta_{12} = 0$)		0	0	0	0
Case-S	Substitute ($\theta_{12} < 0$)	Case i	+	+	+	+
		Case ii	0	+	+	0

5 Results

5.1 Main Results

5.1.1 Changes in the Main Partners

This section reports the results of the regressions. Table 5 reports the estimation of β_1 and β_2 in (11) for the partner changes by Mexican exporters during 2004-07. Column (1) shows that the coefficient β_1 on the Binding measure is 0.127 and statistically significant at the 1% significance level in the linear probability regression controlling for chapter effects. This means that Mexican exporters downgrade the main partners by almost 13 percentage points more frequently in industries (products) that faced an increase in competition with Chinese exporters than in other industries within HS 2 digit chapters. Column (2) shows that the results do not change when we use probit regressions instead of linear probability regressions. Columns (3) and (4) show that the coefficients β_2 on the Binding measure are very close to zero and statistically insignificant both in the linear regression and in the probit regression.

Table 6 reports the estimation of β_3 and β_4 in (12) for the partner changes by US importers. Columns (1) and (2) show that the coefficients β_3 on the Binding measure are very close to zero and statistically insignificant both in the linear probability regression and in the probit regression. Column (3) shows that the coefficient β_4 on the Binding measure is 0.052 and statistically significant at the 5% significance level in the linear probability regression controlling for chapter effects. This means that US importers upgrade the main partners by 5.2 percentage points more frequently in industries (products) that faced an increase in competition with Chinese exporters than in other industries within HS 2 digit chapters. Column (4) shows that the results do not change when we use probit regressions instead of linear probability regressions.

The positive estimate of β_4 implies that US importers improve their matching from liberalization of imports from China even when they may not directly use products made in China. The mechanism of this improvement is same as the "matching spillover effect" in Sugita (2013) who showed liberalization of trade in intermediate goods allows final producers to improve matching with domestic suppliers in a two country model. The US's liberalization of intermediate goods to non-Mexican imports benefit even US firms importing from Mexico.[20]

[20]This finding is consistent with Amiti and Konings (2007) who found liberalization of tariffs on intermediate goods improve the productivity of even firms not using imported intermediate goods for Indonesian firms. These findings are

Furthermore, the positive β_4 reveals a previously unknown aspect of trade diversion induced by the NAFTA. Trade diversion has been usually documented in terms of prices of traded goods: when a country maintains tariffs or quotas on imports from non-partner countries, preferential trade agreements can force importers to buy more expensive products from partners countries. The positive β_4 shows that trade diversion can arise in a form of "mismatch" of importers and exporters. With restrictive import quota on textile/apparel products, the NAFTA forced the US firms to match with less capable partners in Mexico.

The systematic partner changes we find reveal the mechanism of matching between Mexican suppliers and US final producers. An increase in the entry of Chinese exporters forces Mexican exporters to switch their main partners to those with lower capability and allows US firms to switch their main partners to those with high capability. We did not find any evidence that Mexican exporters upgrade the main partners or US importers downgrade the main partners in response to the same shock. The positive significant estimates of β_1 and β_4 and the negligible insignificant estimates of β_2 and β_3 are the prediction of complementarity-driven positive assortative matching in Table 4. Furthermore, they are not consistent with the predictions of capability-independent random matching or substitutability-driven negative assortative matching.

5.1.2 Gradual Adjustment

The adjustment in matching from an old equilibrium to a new equilibrium is likely to be dynamic and gradual. In this section, we report the estimates for different ending periods to show that the adjustment of the partner upgrading and downgrading happens gradually as well as that our qualitative conclusion is robust to the choice of the final period.

Table 7 presents the results of the effect of the end of the MFA on downgrading of US partners for Mexican exporters for the period 2004-2006 in Column (1), 2004-2007, which were already reported, in Column (2), and 2004-2008 in Column (3). Column (1) shows that the coefficient is still positive 0.056 but statistically significant only at the 10% significance level in the linear probability regression.

surprising in views of standard models of heterogeneous importers where only firms that use imported intermediate goods can benefit from liberalization of intermediate goods (Kasahara and Lapham, 2013; Halpern, Koren, and Szeidl, 2011). As a theoretical explanation for the Amiti-Konings finding, Sugita (2013) demonstrated that final producers improve matching with domestic intermediate goods suppliers in face to liberalization of intermediate goods in a positive assortative matching model.

Column (2) shows that the effect becomes bigger in 2007 than in 2006, suggesting that the changes of partners take place gradually. Column (3) shows that the coefficient is similarly between the case of using 2008 as the final period and that of 2007. Column (4), (5) and (6) show that the results are similar when we use probit regressions instead of linear probability regressions.

Table 8 present the corresponding results for US importers. Column (1) shows that the coefficient on the Binding measure is 0.036 and statistically significant at the 5% significance level in the linear probability regression for the case of 2006 as the final period. This coefficient now increases for the case of 2007, which is shown in Column (2). Column (3) shows that the coefficient is further a little bigger for the case of using 2008 as the final period than that of 2007. Column (4), (5) and (6) show that the results do not change when we use probit regressions instead of linear probability regressions. The results are again consistent with the gradual adjustment.

5.2 Robustness Checks

5.2.1 Joint Analysis of Upgrading and Downgrading

So far we have analyzed downgrading and upgrading separately, one at a time. In the earlier analysis we have put together upgrading and staying in the same category as opposed to downgrading when we analyze downgrading, and downgrading and staying in the same category as opposed to upgrading when we analyze upgrading. We run ordered probit regressions, in which we use the dependent variable indicating downgrading if the value is -1, staying if the value is zero and upgrading if the value is 1, to take into account the fact that these two categories are different. Table 9 shows the results. The coefficients in these regressions do not have quantitative information themselves, and their signs do not contain even qualitative information on the probability of staying but do convey qualitative information on the relative probability of downgrading and upgrading. The results that the coefficient from Mexican exporters regression is positive and significant while that from the US importer regression is negative and significant suggest that Mexican exporters of the affected products are more likely to downgrade rather than upgrade their US buyers than those of the non-affected products and that US importers of the affected products are more likely to upgrade rather than downgrade their Mexican sellers than those of the non-affected products.

5.2.2 Alternative Ranking Measure

We have used the ranking of exporters and importers based on trade volume with their main partners in 2004. Although this is in line with our theoretical framework as we discuss in footnote 18, we check the robustness of our results to alternation of the ranking measure. We recreate the ranking based on the total product-level trade volume (aggregating over partners) and analyze whether the results are robust to different ways of ranking firms. Table 10 shows the results for Mexican exporters for the period 2004-2007, while Table 11 shows the results for US importers. Both tables show evidence of partner downgrading of Mexican exporters and partner upgrading of US importers. Thus, our main results are robust to the choice of the ranking measures.

5.2.3 Differential Background Trends

If industries with binding MFA quotas and other industries had differential background time trends in the change in the main partners even in absence of the MFA, our findings on the difference in the changes in the main partners might arise from such differential background trends instead of the causal effect of the MFA quota removal. We have already shown in Figure 1 that the aggregate export volumes exhibit similar trends before 2004. In this section, we show another set of results to rule out this possibility.

We conduct our analysis for different time periods to check the existence of differential background trends. We choose the three periods (1) 2007-2011 (2) 2008-2011, and (3) 2009-2011. For each period, we redefine downgrading/upgrading dummies using the ranking based on the new respective initial year. Then, we run regressions of these new downgrading/upgrading dummies on the binding dummy and chapter fixed effects. If any difference in intrinsic time trends other than the MFA quota removal were driving our result, we should find positive significant estimates for β_1 and β_4. On the other hand, if our main regressions capture the causal effect of the MFA removal and if the adjustment of matching to a new equilibrium is mostly completed by 2007, we should not observe any positive significant estimates for β_1 and β_4.

We find very small and insignificant estimates for β_1 and β_4 for 2007-2011 and 2009-2011. Table 12 shows estimates of β_1 for Mexican exporters and Table 13 shows estimates of β_4 for US importers. All estimates of both β_1 and β_4 are statistically insignificant and very close to zero for 2007-2011

(Columns (1) and (4) in each table) and for 2007-2011 (Columns (3) and (6)). For the period 2008-2011, both β_1 and β_4 have somewhat greater point estimates than other periods, though they are still much smaller than estimates from our main regressions for 2004-2007, and β_4 becomes statistically significant. One possible reason for the big difference between 2008-2011 and other two periods is the effects of the Great Trade Collapse. As exports from other countries, the Mexican exports declined by a huge amount in the second half of 2008 and this might introduce a noise in the initial ranking measure. Overall, we do not find evidence that our results are driven by potential differential trends between the products with the binding quotas and other products.

5.2.4 Product and Firm Characteristics

We also add some product and firm characteristics to our main regressions to check whether possible correlations of these characteristics with the binding dummy may be driving our main results. Table 14 shows the results for partner downgrading of Mexican exporters. Column (1) reproduces our baseline estimate in Table 5 for reference. Columns (2) and (3) check whether our results are driven by Maquiladora trade (processing trade) by adding the ratio of Maquiladora trade (processing trade) in the firm's trade in the product with the main partner in 2004. Column (3) also adds its interaction term with the binding dummy. The results from both columns show that the binding dummy remains statistically significant and similar in magnitude. Furthermore, the interaction term suggests the end of the MFA has no differential impact on Maquiladora trade and non-Maquiladora trade. These results confirm that our main results are not driven by exporters or importers specializing on the processing trade. Columns (4) shows the results controlling for total firm-product level exports in 2004. Columns (5) shows the results controlling for product characteristics such as whether products are for men, women or not specific to gender and whether products are made of cotton, wool or man-made (chemical) textile.[21] Column (6) shows the results controlling for the dummies for Mexican states of exporters, which will control any difference in location-specific trends in partner downgrading and upgrading.[22]Columns (4)-(6) show that the binding dummy remains statistically significant and similar in magnitude, suggesting that our main results are not driven by possible correlations of firm and product characteristics

[21]These product characteristics dummies are essentially for apparel products. Since HS 2 categories for textile products are defined on differences in materials, HS 2 digit chapter fixed effects absorb these product characteristics dummies.

[22]For example, exporters in the northern border states may change their partners more often than exporters in other states because they produce different types of products or because they are more linked to US firms.

with the MFA quota removal. Table 15 shows the results for partner upgrading of US importers for the same set of analysis and shows that the results are qualitatively similar to the results for Mexican exporters.[23]

5.3 Alternative Explanations

The results from our regression analysis are consistent with complementarity driven assortative matching. This section discusses alternative explanations for some of the results and provide additional evidence to reject them.

5.3.1 Heterogeneity in Growth Rates and Survival Rates

Our partner downgrading/upgrading regressions can be performed only for exporters and importers that survive until the final period of the analysis. There would be a bias if the survival/exit is correlated both with the liberalization and with our outcome variables. As standard heterogeneous firms trade models predict, an increase in competition of Chinese exporters is likely to force small Mexican exporters with low capability to exit from exporting. Furthermore, it may be true that conditional on survival, low capable small Mexican exporters upgrade their partners more often than high capable large Mexican exporters, independently of the end of the MFA. An example is a model where firms repeat random matching in every period and the time-series change in matching exhibits mean reversion. In this case, the exit of low capable Mexican exporters mechanically in liberalized industries may create a positive correlation between the binding measures and the downgrading by Mexican exporters in our regression. If this happens, it is a mechanical result of survival bias and cannot be interpreted as support for the complementarity driven assortative matching.

This repeated random matching model cannot predict the zero estimate of β_2 in Tables 5. If this hypothesis is true, Mexican exporters upgrade more frequently in non-liberalized industries where more low capable Mexican exporters survive than in liberalized industries and we should observe a negative and significant estimate of β_2. Therefore, we reject this hypothesis.

[23]In Tables 14 and 15, we report the results from the linear probability regressions, but the conclusion from the probit regressions is the same.

5.3.2 Asymmetric Substitution of Final Goods

Following standard heterogeneous firm trade models, we have assumed all final goods have symmetric elasticities of substitution. However, US final producers making large import volume and those making small import volume may produce very different final goods even within one HS 6 digit (or even 8 digit) product category.[24] One HS 6 digit (or 8 digit) product may have two segments as in the Holmes and Stevens (2014) model. The large US importers may produce low-value-added "standardized" products for large chain stores, while the small US importers may produce high-value-added "custom" products for small-scale retail shops. Chinese exporters that entered after the end of the MFA may produce only "standardized" products.

The heterogeneous impact of the MFA quota removal across multiple segments within one product category does not invalidate our identification strategy if the following two conditions are met. First, each Mexican firm and US firm specialize in one segment. Second, each Mexican firm and US firm continue their specialization after the end of MFA. Under these conditions, if Mexican exporters and US importers positive-assortatively match based on complementarity, it still holds that Mexican exporters downgrade and US importers upgrade their main partners in the "standardized" segment, while firms do not change partners in the "custom" segment. Even when each product category includes both the two segments, our identification strategy shown in Table 4 is valid. On the other hand, the existence of multiple segments might help to explain why not all firms change their partners even in liberalized industries.

The existence of multiple segments can impose a problem to our identification strategy if firms switch their segments after the shock. Mexican exporters who initially produced "standardized" products may switch to "custom" products to escape competition from China. This change may be observed as Mexican exporters' downgrading and US importers' upgrading in our regressions, if firms with smaller trade volumes are more likely to be in the "custom" product segment.

We perform three additional exercises to explore the validity of this hypothesis. We assume that US importers who make small imports before the shock are likely to produce "custom" products and US importers who make large imports before the shock are likely to produce "standardized" products.

[24]We obtained the main results when we run the same main regressions at Mexican HS 8 digit level with the same binding measure, which is defined at HS 6 digit level since the product categories of the US and Mexico are comparable only up to 6 digit.

We also assume US importers do not switch their segments, following Holmes and Stevens (2014). We test the following three predictions. First, in response to the end of the MFA, small "custom" US importers grow more rapidly than large "standardized" US importers, as small "custom" US importers become more attractive to Mexican exporters and match better Mexican exporters. Second, in response to the end of the MFA, small "custom" US importers upgrade the main partners more frequently than large "standardized" US importers. Finally, the downgrading of Mexican exporters in response to the end of the MFA is concentrated in those with high pre-shock ranks who initially trade with large "standardized" US importers before the shock.

In all of the three exercises, we find no evidence supporting the hypothesis that Mexican exporters' switching across segments are driving our results. Table 16 shows the results of the three exercises. Column (1) reports the first exercise, regression of import growth of US importers at the firm-product level from 2004 to 2007 on the binding dummy, the firm's initial rank (mvrank2004), the interaction of the two together with HS 2 digit chapter fixed effects. The positive coefficient of initial rank (mvrank 2004) suggests that small "custom" US importers grow relative to large "standardized" US importers. However, the sign of the coefficient of the interaction of the binding dummy with the initial rank is opposite to what the hypothesis predicts. The growth of small "custom" US importers relative to large "standardized" US importers is smaller in liberalized industries than in non-liberalized industries. Columns (2) and (3) report the second exercise, regressions of the dummy of US importer's upgrading, which is used for our main analysis, on the binding dummy, firm's initial rank (mvrank2004), the interaction of the two together with HS 2 digit chapter fixed effects. Column (2) reports estimates from linear probability estimation and Column (3) from probit estimation. Again, the sign of the coefficient of the interaction of the binding dummy with the initial rank is opposite to what the hypothesis predicts. The coefficients of the firm's initial rank suggests that small "custom" US importers upgrade the main partners more frequently than large "standardized" US importers in non-liberalized industries. However, this difference between small "custom" US importers and large "standardized" US importers do not exist in industries actually liberalized by the end of the MFA. Columns (4) and (5) report the third exercise regressions of the dummy of Mexican exporter's downgrading, which is used for our main analysis, on the binding dummy, firm's initial rank (mvrank2004), the interaction of the two together with HS 2 digit chapter fixed effects. The very small and insignificant coefficients of the interaction term again are inconsistent with the segment-switching hypothesis. The coefficients suggest that the downgrading of the main partners happen in the entire range of Mexican exporters' initial ranking and not concentrated among those who had high trade volume with the main partners. Overall, we do not find evidence consistent with the segment-switching hypothesis, thus we conclude that this alternative hypothesis cannot explain our main results.

6 Conclusion

This paper has examined the determinants of exporters-importers matches using customs transaction data from Mexican textile/apparel exports to the US. We found evidence of one-to-one positive assortative matching driven by complementarity of productivity/quality within matches. First, both exporters and importers concentrate more than 80% of product-level trade volume on transaction with a single partner firm. Second, increases in Chinese exporters to the US market due to the end of the Multi-Fiber Arrangement caused Mexican exporters to downgrade but allowed US importer to upgrade the trade-based rank of their main partners.

Our finding suggests trade liberalization improves matching of firms in global supply chains as a part of within industry reallocation that improves the aggregate industrial productivity. Quantification of this new gains using more detail data on exporters and importers is left for future research.

References

[1] Amiti, Mary, and Jozef Konings. 2007. "Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia." *American Economic Review*, 97(5): 1611–38.

[2] Antràs, Pol, Luis Garicano, and Esteban Rossi-Hansberg. 2006. "Offshoring in a Knowledge Economy." *Quarterly Journal of Economics*, 121(1): 31–77.

[3] Baldwin, Richard, and James Harrigan. 2011. "Zeros, Quality and Space: Trade Theory and Trade Evidence." *American Economic Journal: Microeconomics,* 3(May): 1–3.

[4] Becker, Gary S. 1973. "A Theory of Marriage: Part I." *Journal of Political Economy*, 81(4): 813–46.

[5] Bernard, Andrew B., and J. Bradford Jensen. 1995. "Exporters, Jobs, and Wages in U.S. Manufacturing: 1976-1987." *Brookings Papers on Economic Activity. Microeconomics,*1995: 67-119

[6] Bernard, Andrew B., and J. Bradford Jensen. 1999. "Exceptional Exporter Performance: Cause, Effect, or Both?" *Journal of International Economics*, 47(1): 1–25.

[7] Bernard, Andrew B., J. Bradford Jensen, Stephen J. Redding, and Peter K. Schott. 2007. "Firms in International Trade." *Journal of Economic Perspectives*, 21(3): 105–30.

[8] Bernard, Andrew B., J. Bradford Jensen, Stephen J. Redding, and Peter K. Schott. 2012. "The Empirics of Firm Heterogeneity and International Trade," *Annual Review of Economics,* 4, 283-313

[9] Bernard, Andrew B., Andreas Moxnes, and Karen Helene Ulltveit-Moe. 2013. "Two-Sided Heterogeneity and Trade." CEPR Discussion Paper 9681.

[10] Blum, Bernardo S., Sebastian Claro, and Ignatius Horstmann. 2010. "Facts and Figures on Intermediated Trade." *American Economic Review Paper and Proceedings*, 100(2): 419-23.

[11] Blum, Bernardo S., Sebastian Claro, and Ignatius Horstmann. 2011. "Intermediation and the Nature of Trade Costs: Theory and Evidence." http://www.rotman.utoronto.ca/bblum/personal/front.htm.

[12] Brambilla, Irene, Amit K. Khandelwal, and Peter K. Schott. 2010. "China's Experience under the Multi-fiber Arrangement (MFA) and the Agreement on Textiles and Clothing (ATC)." Robert C. Feenstra and Shang-Jin Wei ed., *China's Growing Role in World Trade.* University of Chicago Press: 345-387.

[13] Carballo, Jerónimo, Gianmarco Ottaviano, Christian Volpe Martincus. 2013. "The Buyer Margins of Firms' Exports." CEPR Discussion Paper 9584.

[14] Casella, Alessandra, and James E. Rauch. 2002 "Anonymous market and group ties in international trade." *Journal of International Economics,* 58(1): 19-47.

[15] Dayarantna-Banda, OG and John Whalley. 2007. "After the MFA, the CCAs (China Containment Agreements)." CIGI working paper No. 24.

[16] Drozd, Lukasz A., and Jaromir B. Nosal. 2012. "Understanding international prices: Customers as capital." *American Economic Review,* 102(1): 364-395.

[17] Eaton, Jonathan, Marcela Eslava, David Jinkins, C. J. Krizan, and James Tybout. 2012 "A Search and Learning Model of Export Dynamics." mimeo.

[18] Eaton, Jonathan, Samuel Kortum, and Francis Kramarz. 2011. "An Anatomy of International Trade: Evidence from French Firms." *Econometrica*, 79(5): 1453-1498.

[19] Foster, Lucia, John Haltiwanger, and Chad Syverson. 2008. "Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability?" *American Economic Review,* 98(1): 394–425.

[20] Grossman, Gene M., and Elhanan Helpman. 2005. "Outsourcing in a Global Economy." *Review of Economic Studies*, 72(1): 135-59.

[21] Halpern, László, Miklós Koren, and Adam Szeidl. 2011. "Imported Inputs and Productivity." http://miklos.koren.hu/view/list/.

[22] Herzog, Thomas N., Fritz J. Scheuren, and William E. Winkler. *Data quality and record linkage techniques*. Springer, 2007.

[23] Holmes, Thomas J. and John Stevens. 2014. "An Alternative Theory of the Plant Size Distribution, with Geography and Intra- and International Trade." forthcoming in *Journal of Political Economy*.

[24] Johnson, Robert C. 2012. "Trade and Prices with Heterogeneous Firms." *Journal of International Economic*s, 86 (1): 43-56.

[25] Khandelwal, Amit K., Peter K. Schott, and Shang-Jin Wei. 2013. "Trade Liberalization and Embedded Institutional Reform: Evidence from Chinese Exporters." *American Economic Review*, 103(6): 2169-95

[26] Kasahara, Hiroyuki, and Beverly Lapham. 2013. "Productivity and the Decision to Import and Export: Theory and Evidence." *Journal of International Economic*s, 89(2): 297-316.

[27] Kremer, Michael. 1993. "The O-Ring Theory of Economic Development." *Quarterly Journal of Economics*, 108(3): 551–75.

[28] Kugler, Maurice, and Eric Verhoogen. 2012. "Prices, Plant Size, and Product Quality." *Review of Economic Studies*, 79(1): 307-339

[29] Macchiavello, Rocco. 2010. "Development Uncorked: Reputation Acquisition in the New Market for Chilean Wines in the UK." http://www2.warwick.ac.uk/fac/soc/economics/staff/academic/macchiavello/

[30] Melitz, Marc J. 2003. "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity." *Econometrica*, 71(6): 1695–725.

[31] Pavcnik, Nina. 2002. "Trade Liberalization, Exit, and Productivity Improvements: Evidence from Chilean Plants." *Review of Economic Studies*, 69(1): 245-76.

[32] Rauch, James E., and Alessandra Casella. 2003. "Overcoming Informational Barriers to International Resource Allocation: Prices and Ties." *Economic Journal*, 113(484): 21-42.

[33] Rauch, James E., and Vitor Trindade. 2003. "Information, International Substitutability, and Globalization." *American Economic Review*, 93(3): 775-91.

[34] Redding, Stephen J. 2011. "Theories of Hetrogeneous Firms and Trade," *Annual Review of Economics,* 3, 77-105.

[35] Roth, Alvin E., and Marilda A. Oliveira Sotomayor. 1990. *Two-sided Matching: A Study in Game-theoretic Modeling and Analysis,* Cambridge University Press, Cambridge.

[36] Sattinger, Michael. 1979. "Differential Rents and the Distribution of Earnings." *Oxford Economic Papers*, 31(1): 60–71.

[37] Sugita, Yoichi. 2010. "Matching, Quality, and Comparative Advantage: A Unified Theory of Heterogeneous Firm Trade." mimeo.

[38] Sugita, Yoichi. 2013. "A Matching Theory of Global Supply Chains with Two-Sided Firm Heterogeneity." mimeo. https://sites.google.com/site/yoichisugita/index

[39] Sutton, John. 2007. "Quality, Trade and the Moving Window: The Globalisation Process." *Economic Journal*, 117(524): F469-F498.

[40] Yeaple, Stephen Ross. 2005. "A simple model of firm heterogeneity, international trade, and wages." *Journal of International Economics*, 65(1): 1-20.

Table 5: The Impact of the end of the MFA on Mexican Exporter's Partner Changes during 2004-07

	$Downgrading^{Mex}$ (β_1)		$Upgrading^{Mex}$(β_2)	
	Linear Prob.	Probit	Linear Prob.	Probit
	(1)	(2)	(3)	(4)
Binding	0.127***	0.150***	-0.003	-0.003
	(0.035)	(0.044)	(0.020)	(0.019)
Chapter Effects	Yes	Yes	Yes	Yes
Obs.	601	601	601	522

Note: The dependent variables are a dummy variable on whether Mexican exporters downgraded the main US partners between 2004-07 (columns 1 and 2) and a dummy variable on whether Mexican exporters upgraded the main US partners between 2004-07 (columns 3 and 4). The columns report coefficients from firm-product level regressions of the dependent variables on a product-level dummy on whether the US imposed binding quotas (Binding), together with chapter (HS 2 digit product) fixed effects. The probit results report the marginal effects. Standard errors are clustered at the 6-digit product level and shown in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 6: The Impact of the end of the MFA on US Importer's Partner Changes during 2004-07

	$Downgrading^{US}$ (β_3)		$Upgrading^{US}$(β_4)	
	Linear Prob.	Probit	Linear Prob.	Probit
	(1)	(2)	(3)	(4)
Binding	-0.017	-0.017	0.052**	0.052***
	(0.027)	(0.024)	(0.021)	(0.020)
Chapter Effects	Yes	Yes	Yes	Yes
Obs.	718	707	718	707

Note: The dependent variables are a dummy variable on whether US importers downgraded the main Mexican partners between 2004-07(columns 1 and 2) and a dummy variable on whether US importers upgraded the main Mexican partners between 2004-07 (columns 3 and 4). The columns report coefficients from firm-product level regressions of the dependent variables on a product-level dummy on whether the US imposed binding quotas (Binding) together with chapter (HS 2 digit product) fixed effects. The probit results report the marginal effects. Standard errors are clustered at the 6-digit product level and shown in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 7: The Impact of the End of the MFA on Downgrading of US Partners for Mexican Exporter: Different Periods

	$Downgrading^{Mex}$ (β_1)					
	Linear Prob.			Probit		
	2004-06	2004-07	2004-08	2004-06	2004-07	2004-08
	(1)	(2)	(3)	(4)	(5)	(6)
Binding	0.056*	0.127***	0.121***	0.061*	0.150***	0.172***
	(0.031)	(0.035)	(0.032)	(0.032)	(0.044)	(0.051)
Chapter Effects	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	767	601	442	767	601	426

Note: The dependent variables are dummy variables indicating whether Mexican exporters downgrade the main US partners during different time periods, 2004-06, 2004-07, and 2004-08. The table reports coefficients from firm-product level regressions of the dependent variables on a dummy on whether the US imposed binding quotas on imports from China in 2004 (Binding) together with chapter (HS 2 digit product) fixed effects. The probit results report the marginal effects. Standard errors are clustered at the 6-digit product level and shown in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 8: The Impact of the End of the MFA on Upgrading of Mexican Partners for US Exporter: Different Periods

	$Upgrading^{US}(\beta_4)$					
	Linear Prob.			Probit		
	2004-06	2004-07	2004-08	2004-06	2004-07	2004-08
	(1)	(2)	(3)	(4)	(5)	(6)
Binding	0.036**	0.052**	0.066**	0.039***	0.052***	0.082***
	(0.015)	(0.021)	(0.027)	(0.015)	(0.020)	(0.028)
Chapter Effects	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	964	718	515	875	707	425

Note: The dependent variables are dummy variables indicating whether US importers upgrade the main Mexican partners during different time periods, 2004-06, 2004-07, and 2004-08. The table reports coefficients from firm-product level regressions of the dependent variables on a dummy on whether the US imposed binding quotas on imports from China in 2004 (Binding) together with chapter (HS 2 digit product) fixed effects. The probit results report the marginal effects. Standard errors are clustered at the 6-digit product level and shown in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 9: The Impact of the End of the MFA on Up/downgrading of Mexican Partners for US Importer and US Partners for Mexican Exporters from 2004 to 2007

	Mexican Exporter	US Importer
	Ordered Probit	Ordered Probit
	(1)	(2)
Binding	-0.478***	0.320**
	(0.159)	(0.143)
Chapter Effects	Yes	Yes
Obs.	601	718

Note: The table reports coefficients on the binding dummy from firm-product level ordered probit regressions of the downgrading/upgrading indicator (1=upgrading, 0=stay, -1=downgrading) on the dummy variable indicating whether USA had imposed binding quota on the product and either product category fixed effects or chapter fixed effects. The probit results report the coefficients. Standard errors are clustered at the 6-digit product level and shown in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 10: The Impact of the end of the MFA on Downgrading or Upgrading of US Partners for Mexican Exporters from 2004 to 2007: Total Trade Volume Based Ranking

	$Downgrading^{Mex}$ (β_1)		$Upgrading^{Mex}$(β_2)	
	Linear	Probit	Linear	Probit
	(1)	(2)	(3)	(4)
Binding	0.123***	0.144***	0.001	0.001
	(0.035)	(0.043)	(0.019)	(0.019)
Hs2-level Effects	Yes	Yes	Yes	Yes
Obs.	601	601	601	522

Note: The dependent variables are a dummy variable on whether Mexican exporters downgraded the main US partners between 2004-07 (columns 1 and 2) and a dummy variable on whether Mexican exporters upgraded the main US partners between 2004-07 (columns 3 and 4). The columns report coefficients from firm-product level regressions of the dependent variables on a product-level dummy on whether the US imposed binding quotas (Binding), together with chapter (HS 2 digit product) fixed effects. . The difference from Table 5 is that we now define downgrading and upgrading using the rank based on firm-product total trade volumes. Standard errors are clustered at the 6-digit product level and shown in parentheses. The probit results report the marginal effects. Standard errors are clustered at the 6-digit product level and shown in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 11: The Impact of the end of the MFA on Downgrading or Upgrading of Mexican Partners for US Importers from 2004 to 2007: Total Trade Volume Based Ranking

	$Downgrading^{US}$ (β_3)		$Upgrading^{US}$(β_4)	
	Linear	Probit	Linear	Probit
	(1)	(2)	(1)	(2)
Binding	-0.017	-0.014	0.052**	0.054***
	(0.027)	(0.023)	(0.021)	(0.021)
Hs2-level Effects	Yes	Yes	Yes	Yes
Obs.	718	707	718	707

Note: The dependent variables are a dummy variable on whether Mexican exporters downgraded the main US partners between 2004-07 (columns 1 and 2) and a dummy variable on whether Mexican exporters upgraded the main US partners between 2004-07 (columns 3 and 4). The columns report coefficients from firm-product level regressions of the dependent variables on a product-level dummy on whether the US imposed binding quotas (Binding), together with chapter (HS 2 digit product) fixed effects. The probit results report the marginal effects. The difference from Table 6 is that we now define downgrading and upgrading using the rank based on firm-product total trade volumes. Standard errors are clustered at the 6-digit product level and shown in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 12: The Impact of the End of the MFA on Downgrading of US Partners for Mexican Exporters: Placebo Check

	$Downgrading^{Mex}$					
	Linear Prob.			Probit		
	2007-11	2008-11	2009-11	2007-11	2008-11	2009-11
	(1)	(2)	(3)	(4)	(5)	(6)
Binding	-0.008	0.047	0.005	-0.006	0.043	0.008
	(0.036)	(0.031)	(0.020)	(0.031)	(0.029)	(0.020)
HS2-level effects	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	393	499	655	393	483	621

Note: The dependent variables are dummy variables indicating whether US importers upgrade the main Mexican partners during different time periods, 2007-11, 2008-11, and 2009-11. The table reports coefficients from firm-product level regressions of the dependent variables on a dummy on whether the US imposed binding quotas on imports from China in 2004 (Binding) together with chapter (HS 2 digit product) fixed effects. The probit results report the marginal effects. Standard errors are clustered at the 6-digit product level and shown in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 13: The Impact of the End of the MFA on Upgrading of Mexican Partners for US Importers: Placebo Check

	$Upgrading^{US}$					
	Linear Prob.			Probit		
	2007-11	2008-11	2009-11	2007-11	2008-11	2009-11
	(1)	(2)	(3)	(4)	(5)	(6)
Binding	-0.001	0.027**	-0.000	-0.000	0.038***	0.001
	(0.018)	(0.011)	(0.006)	(0.023)	(0.013)	(0.007)
HS2-level effects	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	449	575	747	350	462	688

Note: The dependent variables are dummy variables indicating whether US importers upgrade the main Mexican partners during different time periods, 2007-11, 2008-11, and 2009-11. The table reports coefficients from firm-product level regressions of the dependent variables on a dummy on whether the US imposed binding quotas on imports from China in 2004 (Binding) together with chapter (HS 2 digit product) fixed effects. The probit results report the marginal effects. Standard errors are clustered at the 6-digit product level and shown in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 14: The Impact of the End of the MFA on Downgrading of US Partners for Mexican Exporters from 2004 to 2007

	$Downgrading^{Mex}$					
	Linear Prob.					
	(1)	(2)	(3)	(4)	(5)	(6)
Binding	0.127**	0.127***	0.103**	0.123***	0.130***	0.117***
	(0.044)	(0.035)	(0.042)	(0.038)	(0.037)	(0.035)
Maquila Ratio		-0.025	-0.058*			
		(0.024)	(0.031)			
Maquila Ratio*Binding			0.062			
			(0.049)			
Initial Value				0.002		
				(0.007)		
Men					0.090*	
					(0.049)	
Women					0.041	
					(0.037)	
Cotton					-0.042	
					(0.039)	
Wool					-0.010	
					(0.051)	
Man-made					-0.079**	
					(0.039)	
HS2-level effects	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects	No	No	No	No	No	Yes
Obs.	601	601	601	601	601	588

Note: The dependent variables are dummy variables indicating whether US importers upgrade the main Mexican partners during 2004-07. The table reports coefficients from firm-product level regressions of the dependent variables on a dummy on whether the US imposed binding quotas on imports from China in 2004 (Binding) together with chapter (HS 2 digit product) fixed effects and control variables. The probit results report the marginal effects. Standard errors are clustered at the 6-digit product level and shown in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 15: The Impact of the End of the MFA on Upgrading of Mexican Partners for US Importers from 2004 to 2007

	$Upgrading^{US}$					
	Linear					
	(1)	(2)	(3)	(4)	(5)	(6)
Binding	0.052***	0.053**	0.074**	0.049**	0.042*	0.048**
	(0.020)	(0.022)	(0.029)	(0.022)	(0.024)	(0.022)
Maquila Ratio		-0.015	0.015			
		(0.017)	(0.019)			
Binding*Maquila Ratio			-0.053			
			(0.032)			
Initial Value				0.002		
				(0.004)		
Men					0.005	
					(0.022)	
Women					-0.040**	
					(0.018)	
Cotton					0.020	
					(0.020)	
Wool					-0.045**	
					0.020	
Man-made					0.014	
					(0.019)	
HS2-level effects	Yes	Yes	Yes	Yes	Yes	Yes
State Fixed Effects	No	No	No	No	No	Yes
Obs.	707	718	718	718	718	707

Note: The dependent variables are dummy variables indicating whether US importers upgrade the main Mexican partners between 2004 and 2007, and 2004-08. The table reports coefficients from firm-product level regressions of the dependent variables on a dummy on whether the US imposed binding quotas on imports from China in 2004 (Binding) together with chapter (HS 2 digit product) fixed effects and other control variables. The probit results report the marginal effects. Standard errors are clustered at the 6-digit product level and shown in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.

Table 16: Segment-Switching Hypothesis

	DLog Imports	US Importer		Mexican Exporter	
	(1)	(2)	(3)	(4)	(5)
	Linear	Linear	Probit	Linear	Probit
Binding	-0.061	0.62***	0.056***	0.132***	0.156***
	(0.292)	(0.024)	(0.021)	(0.038)	(0.046)
mvrank2004	0.022***	0.002***	0.001***	-0.001*	-0.001
	(0.006)	(0.001)	(0.000)	(0.001)	(0.001)
rank binding	-0.016**	-0.002*	-0.001*	0.000	-0.001
	(0.008)	(0.001)	(0.000)	(0.001)	(0.001)
Hs2-level Effects	Yes	Yes	Yes	Yes	Yes
R-Squared	0.018	0.060		0.034	
Obs.	966	601	601	718	707

Note: In the first column, the dependent variable is the log difference of imports at the importer product level. In the second and third columns, the dependent variable is a dummy variables indicating whether US importers upgrade the main Mexican partners. .In the fourth and fifth columns, the dependent variable is a dummy variables indicating whether Mexican exporters downgrade the main US partners. The table reports coefficients from firm-product level regressions of the dependent variables on a dummy on whether the US imposed binding quotas on imports from China in 2004 (Binding), the initial rank, and interaction between both of them together with chapter (HS 2 digit product) fixed effects. The probit results report the marginal effects. Standard errors are clustered at the 6-digit product level and shown in parentheses. Significance: * 10 percent, ** 5 percent, *** 1 percent.

Appendix

A.1 The Sign of Sorting

Consider two teams in a stable matching. Firms in team 1 have task quality (x, y) and firms in team 2 have (x', y'). Let $\Pi(x, y)$ be the joint profit for the team with a supplier of capability x and a final producer of capability y. We first prove two claims.

Claim 1. The following inequality holds in a stable matching:

$$\Pi(x,y) + \Pi(x',y') \geq \Pi(x',y) + \Pi(x,y') \tag{A.1}$$

Proof. From the maximization of suppliers, the following inequalities must hold

$$\begin{aligned} \pi^x(x) &= \Pi(x,y) - \pi^y(y) \geq \Pi(x,y') - \pi^y(y') \\ \pi^x(x') &= \Pi(x',y') - \pi^y(y') \geq \Pi(x',y) - \pi^y(y). \end{aligned}$$

Adding up the above two equations leads to (A.1). □

Notice that

$$\int_y^{y'} \int_x^{x'} \frac{\partial^2 \Pi(\tilde{x},\tilde{y})}{\partial \tilde{x} \partial \tilde{y}} d\tilde{x} d\tilde{y} = \Pi(x,y) + \Pi(x',y') - \Pi(x',y) - \Pi(x,y'). \tag{A.2}$$

The right hand side of (A.2) is always non-negative from (A.1).

In Case-C, $\partial^2 \Pi(x,y)/\partial x \partial y = \theta_{xy} > 0$. Therefore, if $x' > x$, then $y' \geq y$ must hold to make the right hand side of (A.2) to be non-negative. This is positive assortative matching (PAM).

In Case-S, $\partial^2 \Pi(x,y)/\partial x \partial y = \theta_{xy} < 0$. Therefore, if $x' > x$, then $y' \leq y$ must hold to make the right hand side of (A.2) to be non-negative. This is negative assortative matching (PAM).

In Case-I, $\partial^2 \Pi(x,y)/\partial x \partial y = \theta_{xy} = 0$. In this case, the right hand side of (A.2) is zero. The inequality of (A.1) holds with equality, which implies firms are indifferent among all possible matches. Therefore, the matching pattern is not determined.