Heterogeneous Firms and Trade Liberalization: Theory and Evidence*

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Abstract

We investigate how firms' entry, exit, output and exporting decisions respond to trade liberalization and how the responses differ across sectors. We do this by building a simple multiple sector model featuring comparative advantage and heterogeneous firms, and then perturb it with reduction in trade costs. We then test the hypotheses that arise thereof. The total effect of trade liberalization in a sector can be decomposed into the IRA (intersectoral resource allocation) effect and the within-sector selection effect. The net effect of trade liberalization on the aggregate productivity in a sector changes monotonically with the strength of comparative advantage of the sector. If Home is larger than Foreign, the aggregate productivity in the comparative disadvantage sectors can fall following trade liberalization, as the IRA effect dominates the within-sector selection effect. We call this "reverse-Melitz outcome" as it is opposite to the prediction of the one-sector Melitz model, which emphasizes the within-sector selection effect. We test the hypotheses related to the potential reallocative effects of trade liberalization using firm-level data of Chinese manufacturing industries in the years following China's accession to the WTO. We find empirical support for the existence of an IRA effect that counteracts the within-sector selection effect.

Keywords: inter-industry trade, intra-industry trade, heterogeneous firms, trade liberalization

JEL Classification codes: F12, F14

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1 Introduction

How do firms' entry, exit, output and exporting decisions respond to trade liberalization? Do they respond differently across sectors? How do these responses affect the aggregate variables such as the propensity to export in different sectors and national welfare? We try to answer the above questions by building a model of trade with comparative advantage across sectors and intra-sectoral firm heterogeneity, and test the hypotheses that arise thereof.

There is evidence that different sectors respond differently to trade liberalization. Take the example of changes in Chinese manufacturing sectors in 2001-2006 following the reduction of bilateral trade costs induced by its accession to the WTO in 2001. The left panel of Figure 1 shows that, in the sectors with strong comparative advantage, the fraction of exporting firms increases following trade liberalization, and the effect is statistically significant. Each point represents one 4-digit CIC sector. The right panel, on the other hand, shows that the effect is much weaker in the sectors with the strong comparative disadvantage, and the effect is statistically insignificant. Figure A1 in the appendix shows similar pattern for the share of export revenue in total revenue. How do we explain such pattern?

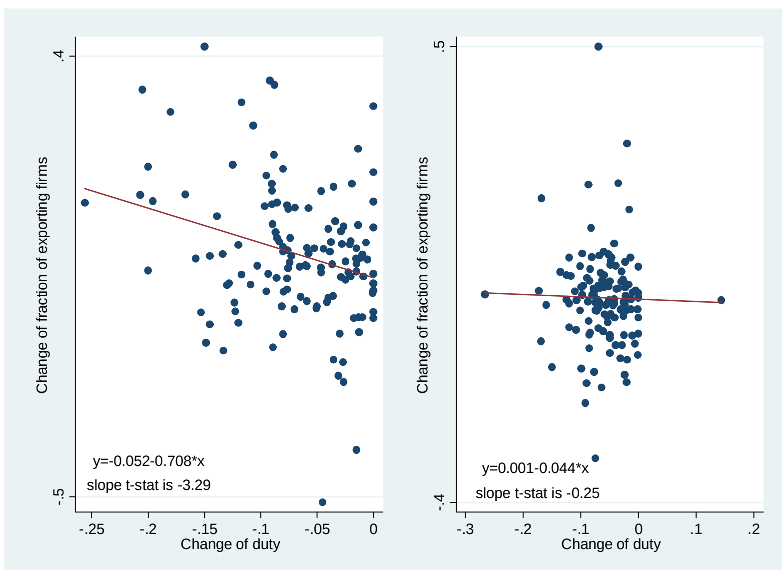

Figure 1: Relation between change in fraction of exporting firms and change of duty

Note: Change of duty is trimmed below 1st percentile and above 99th percentile. The left panel includes firms in sectors in the top 1/3 of the revealed comparative advantage index (i.e. strong comparative advantage); the right panel includes firms in sectors in the bottom 1/3 of the revealed comparative advantage index (strong comparative disadvantage).

To understand how different sectors respond differently to trade liberalization, we incorporate Ricardian comparative advantage into a multi-sector, two-country version of Melitz's (2003) monopolistic competition model with heterogeneous firms. We use the model to explain how comparative advantage and economies of scale interact to sort sectors into ones in which only one of the countries produces (where there is inter-industry trade) and ones in which both countries produce (where there is intra-industry trade). We then analyze the effects of trade liberalization. We decompose the total effect of trade liberalization into those caused by inter-sectoral resource allocation (which we call IRA effect) and by within-sector selection of firms according to productivity (which we call Melitz selection effect).

Melitz's selection effect predicts that trade liberalization tends to increase the productivity cutoff for survival and reduce the exporting productivity cutoff for a sector, and this tends to increase the average productivity of the firms that serve the domestic market, leading to an increase in aggregate productivity in the sector. On the other hand, the IRA effect predicts that trade liberalization leads to resources in the home country being re-allocated away from the differentiated-good sectors in which it has comparative disadvantage to ones in which it has comparative advantage. In the comparative disadvantage sectors, the IRA effect tends to reduce productivity cutoff for survival and increase the productivity cutoff for exporting, leading to a decrease in aggregate productivity in those sectors.

If a country is large, the IRA effect can dominate the Melitz selection effect in the sectors where the country has the strongest comparative disadvantage, leading an outcome that is the reverse of the one-sector Melitz selection effect. We call this "reverse-Melitz outcome". The larger the country, the more likely this can happen. One implication of these reallocative effects is that, following trade liberalization, the fraction of exporters and the share of export revenue in total revenue both increase in the most comparative advantage sectors but decrease in the most comparative disadvantage sectors. We test the hypotheses related to these and other reallocative effects of trade liberalization using Chinese firm-level data for the years after China's accession to WTO in 2001. The results generally support our hypotheses.

The introduction of comparative advantage in a multi-sector Melitz model captures a number of effects that a one-sector Melitz model without comparative advantage cannot, as explained above. Moreover, there is evidence to support the existence of these interesting effects, as revealed by the empirical evidence of this paper.

One could have captured inter-industry trade and intra-industry trade in a unified model without assuming firm heterogeneity.[1] As is found elsewhere in the literature, the aggregate welfare results remain about the same whether or not firm heterogeneity is assumed. However, incorporating firm heterogeneity allows us to analyze firms' entry, exit and exporting decisions in response to trade liberalization and derive hypotheses that can be tested using firm level data. For example, the predictions about the variation in the percentage of exporting firms across sectors cannot be derived from a model with homogeneous firms.

Our paper is not the first one in the literature to introduce multiple sectors as well as asymmetry in country size and technology in the Melitz model. However, we believe we are among the first to use such a model to analyze the interaction between the IRA effect and within-sector selection effect

[1] For example, Helpman and Krugman (1985) integrate the inter-industry trade and intra-industry trade model with homogeneous firms.

following trade liberalization, and then test the model empirically.[2]

The theory part of our paper is inspired by a number of predecessors. All these papers, however, are purely theoretical in nature, whereas ours offer both theory and empirical tests. For example, Okubo (2009) also introduces multiple sectors into the Melitz model, thus making it a hybrid of the multiple-sector Ricardian model and the Melitz model. The bulk of his analysis focuses on the two-sector case, in which he analyzes the general equilibrium effects, allowing for the endogenous determination of the relative wage. But the focus of his paper is quite different from ours. He mainly focuses on changes in population and the effects on the number of varieties. In contrast, we focus on decomposing the total effect of trade liberalization into the IRA effect and Melitz selection effect. Most importantly, we identify the conditions under which there exists a reverse-Melitz outcome from trade liberalization in the comparative disadvantage sectors.

Demidova (2008) extends Melitz's (2003) model to a setting with two countries of the same size but are asymmetric in the distribution of the productivity draws of firms. She assumes that there is only one differentiated-good sector, in which both countries produce and trade with each other in equilibrium. We extend Demidova's basic idea to a continuum of differentiated-good sectors and asymmetric country sizes. In our model, in equilibrium, there are sectors in which only one country produces (with one-way trade) as well as ones in which both countries do (with two-way trade). Like her, we find that the laggard country may lose from falling trade cost. However, we show that this can only happen in the large country.

Bernard, Redding and Schott (2007) incorporate firm heterogeneity into a two-sector, two-country Heckscher-Ohlin model, and analyze how trade leads to the reallocation of resources, both within and across industries. Inter-sectoral resource reallocation changes the ex-ante comparative advantage and provides a new source of welfare gains from trade as well as causes redistribution of income across factors. In their paper, trade raises the productivity cutoff for survival and lowers the exporting productivity cutoff in both industries, with the effect being disproportionately larger in the comparative advantage sectors. Therefore, there is no reverse-Melitz outcome in their paper.[3]

Falvey, Greenaway and Yu (2006) extend a two-country version of Melitz's (2003) model to the case with asymmetry in both country size and technology level in the differentiated-good sector. Based on this setting, Falvey, Greenaway and Yu (2011) further investigate the difference between the short-run (with restricted entry) and long-run (with free entry) while restricting the underlying productivity distribution to be Pareto. In contrast to our model with multiple differentiated-good sectors, theirs has only one differentiated good sector. Moreover, the focus of their paper is quite different from our. We are more interested in the interaction between comparative advantage and Melitz's within-sector selection effect in response to trade liberalization, which they did not analyze.

In the empirical literature, Bombardini, Kurz and Morrow (2012) incorporate Ricardian comparative advantage and Melitz selection effect into a unified model, and use Chilean and Colombian plant-level

[2] One possible exception is Bombardini, Kurz and Morrow (2012), which is discussed below.

[3] Other papers analyzing the effects of trade liberalization based on Melitz-type models include Baldwin and Forslid (2010), which is purely theoretical and does not explicitly model comparative advantage, and Pfluger and Russek (2010).

data to investigate the relationship between firm productivity and exporting behavior. Instead of using the revealed comparative advantage (RCA) measure in our paper, they adopt the peer firm's productivity as the measure of Ricardian comparative advantage. There is also no reverse-Melitz outcome in their paper as they focus on a small open economy.

Alvarez and Lopez (2010) use a fixed effect approach to investigate the effects of trade liberalization on firm number, firm sizes and markups at industry level. In their estimations, both the trade liberalization and comparative advantage are captured by dummy variables. Thus only rough results of the average effects are presented. In contrast, we use detailed information of tariff reduction and revealed comparative advantage of Chinese firms for our investigation, which yields empirical results that can be more readily compared with the theoretical predictions.

The paper is organized as follows. Section 2 presents a two-country model with heterogeneous firms and examines the properties of the global equilibrium. We analyze the pattern of specialization and trade and identify the existence of inter-industry trade as well as intra-industry trade, and we show the impact of opening up to trade on the productivity cutoffs. In section 3, we analyze the effects of trade liberalization, and demonstrate the existence of a reverse-Melitz outcome in the most comparative disadvantage two-way trade sectors when the country is sufficiently large. In section 4, empirical tests of the propositions presented in section 3 are carried out. Section 5 concludes.

2 An Open-economy Model

We consider a global economy with two countries: Home and Foreign. In each country, there is a homogenous-good sector, and a continuum of sectors of differentiated goods. There is only one factor input called labor. The homogeneous good is produced using a constant returns to scale technology, and the sector is under perfect competition. Firms are free to choose the sectors into which they enter. Upon payment of the entry cost f_e, the firm earns the opportunity to make a random draw from a distribution of firm productivity. The labor productivity of a firm in the differentiated-good sector k is the product of two terms: one is a firm-specific, random variable φ_k following a Pareto distribution $P(1,\gamma) = 1 - \left(\frac{1}{\varphi_k}\right)^\gamma$ where $\varphi_k \in [1,\infty]$ and γ $(> \sigma - 1)$ is the shape parameter of the distribution;[4] the other is A_k, which is exogenous and sector-specific. The labor productivity of a firm is thus equal to $A_k\varphi_k$. We attach an asterisk to all the variables pertaining to Foreign. We index sectors such that as the index increases Home's comparative advantage strengthens. In other words, the sector-specific relative productivity $a(k) \equiv a_k \equiv \frac{A_k}{A_k^*}$ increases in $k \in [0,1]$. Therefore, $a'(k) > 0$.

There are L and L^* consumers in Home and Foreign respectively, each supplying one unit of labor. The preferences of a representative consumer in Home is given by a nested Cobb-Douglas function:

$$\ln U = \alpha \ln C_h + \int_0^1 b_k \ln C_k dk \qquad \text{with } \int_0^1 b_k dk = 1 - \alpha$$

$$\text{and } C_k = \left(\int_0^{\theta_k} c_k(j)^\rho dj\right)^{\frac{1}{\rho}} \text{ with } 0 < \rho < 1$$

[4] The assumption $\gamma > \sigma - 1$ ensures that, in equilibrium, the size distribution of firms has a finite mean.

where α denotes the share of expenditure on the homogenous good, b_k is the share of expenditure on differentiated good $k \in [0,1]$; θ_k is the endogenously determined mass of varieties in differentiated-good sector k (which may originate from Home or Foreign) available to consumers in Home; $c_k(j)$ is the consumption of differentiated good j in sector k; C_h is the consumption of homogeneous good. The representative consumer in Foreign has analogous preferences.

On the production side, the labor productivity in the homogeneous good sector are respectively A_h and A_h^* in Home and Foreign. In the rest of the paper, we assume that the homogeneous good sector is sufficiently large so that the homogeneous good is produced in both countries.[5] We also assume that there is no trade cost associated with the homogeneous good. Therefore free trade of homogeneous goods implies that the wage ratio is determined by relative labor productivity in the sector, i.e. $\omega \equiv \frac{w}{w^*} = \frac{A_h}{A_h^*}$, where w^* denotes Foreign's wage. Without loss of generality, we assume that $\frac{A_h}{A_h^*} = 1$ and normalize by setting $w^* = 1$. Therefore, in equilibrium $w = w^* = 1$. The assumptions of a freely traded outside good that is produced by all countries, and Pareto distribution of firm productivity in each differentiated-good sector, greatly simplify the analysis.[6]

The aggregate price index of goods in sector k sold in Home is given by

$$P_k = \left[\int_0^{\theta_k} p_k(j)^{1-\sigma} dj\right]^{\frac{1}{1-\sigma}}, \text{ where } \infty > \sigma = \frac{1}{1-\rho} > 1$$

where $p_k(j)$ denotes the price of variety j in sector k, and σ denotes the elasticity of substitution between varieties. The analogous index for Foreign is P_k^*.

Production labor employed by firm j in sector k is a linear function of output $y_k(j)$:

$$l_k(j) = f + \frac{y_k(j)}{A_k \varphi_k(j)},$$

where f is the fixed cost of production per period.

The subscript "dk" pertains to a domestic firm serving the domestic market in sector k, the subscript "xk" pertains to a domestic firm serving the foreign market in sector k, and the subscript "k" pertains to sector k regardless of who serves the market. Therefore, under monopolistic competition in sector k the profit-maximizing price is given by $p_{dk}(j) = \frac{1}{\rho A_k \varphi_k(j)}$.[7] But Home's exporting firms will set higher prices in Foreign's market due to the existence of an iceberg trade cost, such that τ (> 1) units of goods have to be shipped from the source in order for one unit to arrive at the destination. Therefore, the optimal export price of a Home-produced good sold in Foreign is given by $p_{xk}(j) = \frac{\tau}{\rho A_k \varphi_k(j)}$. Similarly, Foreign's firms' pricing rules are given by $p_{dk}^*(j) = \frac{1}{\rho A_k^* \varphi_k^*(j)}$ and $p_{xk}^*(j) = \frac{\tau}{\rho A_k^* \varphi_k^*(j)}$. Following Melitz (2003), we assume that trade costs are symmetric so that iceberg importing cost of Home is the same

[5] The sufficient condition is $\alpha > \max\left\{\frac{L}{L+L^*}, \frac{L^*}{L+L^*}\right\}$. However, this is just a sufficient, not necessary, condition. In general, we do not need such a strong assumption on α, as each country usually both imports and exports differentiated goods. If trade in differentiated goods is close to balanced, α can be much smaller.

[6] In adopting these assumptions, we follow Chaney (2008), who was probably the first to make these assumptions to simplify the analysis.

[7] Note that we could allow γ and σ to be different across sectors and still obtain all the propositions of this paper, but the derivation would be very tedious and no additional insights are obtained.

as that of Foreign. In addition to the iceberg trade cost, the exporting firm has to bear a fixed cost of exporting, f_x, which is the same for all firms.

2.1 Firm entry and exit

Cost minimization implies that the gross revenue and net profit of firm j in differentiated sector k from domestic sales for Home's firms are, respectively:

$$r_{dk}(j) = b_k L \left[\frac{p_{dk}(j)}{P_k}\right]^{1-\sigma},$$
$$\pi_{dk}(j) = \frac{r_{dk}(j)}{\sigma} - f.$$

The expressions for the corresponding variables for Foreign's firms, $r^*_{dk}(j)$ and $\pi^*_{dk}(j)$, are defined analogously. Following the same logic, the gross exporting revenue and net exporting profit of firm j in sector k for Home's firms are, respectively:

$$r_{xk}(j) = b_k L^* \left[\frac{p_{xk}(j)}{P^*_k}\right]^{1-\sigma},$$
$$\pi_{xk}(j) = \frac{r_{xk}(j)}{\sigma} - f_x.$$

The expressions for the corresponding variables for Foreign's firms, $r^*_{xk}(j)$ and $\pi^*_{xk}(j)$, are defined analogously.

If a firm draws too low a productivity, it would not survive after entry, as its expected economic profit is negative. Likewise, a surviving firm would not export if its productivity is so low that its expected economic profits from exporting is negative. Let $\overline{\varphi}_{dk}$ and $\overline{\varphi}_{xk}$ denote productivity cutoffs in sector k for domestic sales and exporting respectively for Home's firms; $\overline{\varphi}^*_{dk}$ and $\overline{\varphi}^*_{xk}$ denote the corresponding variables for Foreign. Consequently, the mass of exporting firms from Home is equal to:

$$\theta_{xk} = \frac{1 - G(\overline{\varphi}_{xk})}{1 - G(\overline{\varphi}_{dk})}\theta_{dk} = \left(\frac{\overline{\varphi}_{dk}}{\overline{\varphi}_{xk}}\right)^{\gamma} \theta_{dk}$$

where θ_{dk} denotes the mass of operating firms in Home. The corresponding expression relating the variables θ^*_{xk} and θ^*_{dk} for Foreign are defined analogously. Then, in differentiated-good sector k, the mass of varieties available to consumers in Home is equal to

$$\theta_k = \theta_{dk} + \theta^*_{xk}$$

and θ^*_k is defined analogously. The aggregate price indexes are given by:

$$P_k = (\theta_k)^{\frac{1}{1-\sigma}} \, p_{dk}(\widetilde{\varphi}_k), \qquad P^*_k = (\theta^*_k)^{\frac{1}{1-\sigma}} \, p^*_{dk}(\widetilde{\varphi}^*_k) \tag{1}$$

where $\widetilde{\varphi}_k$ and $\widetilde{\varphi}^*_k$ denote the aggregate productivity in differentiated sector k for goods sold in Home and Foreign, respectively. They are given respectively by:

$$(\widetilde{\varphi}_k)^{\sigma-1} = \frac{1}{\theta_k}\left[\theta_{dk}\,(\widetilde{\varphi}_{dk})^{\sigma-1} + \theta^*_{xk}\left(\tau^{-1}\frac{1}{a_k}\widetilde{\varphi}^*_{xk}\right)^{\sigma-1}\right], \tag{2}$$

$$(\widetilde{\varphi}^*_k)^{\sigma-1} = \frac{1}{\theta^*_k}\left[\theta^*_{dk}\,(\widetilde{\varphi}^*_{dk})^{\sigma-1} + \theta_{xk}\left(\tau^{-1}a_k\widetilde{\varphi}_{xk}\right)^{\sigma-1}\right] \tag{3}$$

where $\widetilde{\varphi}_{dk}$ ($\widetilde{\varphi}^*_{dk}$) and $\widetilde{\varphi}_{xk}$ ($\widetilde{\varphi}^*_{xk}$) denote respectively the aggregate productivity level of all of Home's (Foreign's) operating firms and Home's (Foreign's) exporting firms.[8] The relationships between $\widetilde{\varphi}_{dk}$ and $\overline{\varphi}_{dk}$, between $\widetilde{\varphi}^*_{dk}$ and $\overline{\varphi}^*_{dk}$, between $\widetilde{\varphi}_{xk}$ and $\overline{\varphi}_{xk}$, and between $\widetilde{\varphi}^*_{xk}$ and $\overline{\varphi}^*_{xk}$, are given by

$$\widetilde{\varphi}_{sk} = \left(\frac{\gamma}{\gamma-\sigma+1}\right)^{\frac{1}{\sigma-1}} \overline{\varphi}_{sk} \quad \text{and} \quad \widetilde{\varphi}^*_{sk} = \left(\frac{\gamma}{\gamma-\sigma+1}\right)^{\frac{1}{\sigma-1}} \overline{\varphi}^*_{sk} \qquad \text{for } s = x, d. \tag{4}$$

From the above equations, it is obvious that these aggregate productivity measures as well as aggregate price indexes are functions of ($\overline{\varphi}_{dk}$, $\overline{\varphi}^*_{dk}$, $\overline{\varphi}_{xk}$, $\overline{\varphi}^*_{xk}$, θ_{dk}, θ^*_{dk}). As will be shown below, as long as $\frac{f_x}{f}$ is sufficiently large, an entering firm will produce only if it can generate positive expected profit by selling domestically, and export only if it can generate positive expected profit by selling abroad.[9] The zero cutoff profit (ZCP) condition determines that the marginal surviving firm makes zero post-entry expected economic profits. Thus we have the following four ZCP conditions

$$r_{dk}(\overline{\varphi}_{dk}) = b_k L \left(P_k \rho A_k \overline{\varphi}_{dk}\right)^{\sigma-1} = \sigma f \tag{5}$$

$$r^*_{dk}(\overline{\varphi}^*_{dk}) = b_k L^* \left(P^*_k \rho A^*_k \overline{\varphi}^*_{dk}\right)^{\sigma-1} = \sigma f \tag{6}$$

$$r_{xk}(\overline{\varphi}_{xk}) = b_k L^* \left(\frac{P^*_k}{\tau} \rho A_k \overline{\varphi}_{xk}\right)^{\sigma-1} = \sigma f_x \tag{7}$$

$$r^*_{xk}(\overline{\varphi}^*_{xk}) = b_k L \left(\frac{P_k}{\tau} \rho A^*_k \overline{\varphi}^*_{xk}\right)^{\sigma-1} = \sigma f_x \tag{8}$$

Define $\widetilde{\pi}_k$ and $\widetilde{\pi}^*_k$ as the average profit flow of a surviving firm in sector k in Home and Foreign respectively. It can be easily shown that[10]

$$\widetilde{\pi}_k = \pi_{dk}(\widetilde{\varphi}_{dk}) + \left[\frac{1-G(\overline{\varphi}_{xk})}{1-G(\overline{\varphi}_{dk})}\right] \pi_{xk}(\widetilde{\varphi}_{xk}) = \frac{\sigma-1}{\gamma-\sigma+1}\left[f + \left(\frac{\overline{\varphi}_{dk}}{\overline{\varphi}_{xk}}\right)^{\gamma} f_x\right]$$

$$\widetilde{\pi}^*_k = \pi^*_{dk}(\widetilde{\varphi}^*_{dk}) + \left[\frac{1-G(\overline{\varphi}^*_{xk})}{1-G(\overline{\varphi}^*_{dk})}\right] \pi^*_{xk}(\widetilde{\varphi}^*_{xk}) = \frac{\sigma-1}{\gamma-\sigma+1}\left[f + \left(\frac{\overline{\varphi}^*_{dk}}{\overline{\varphi}^*_{xk}}\right)^{\gamma} f_x\right].$$

A firm will enter if her expected post-entry profit is above the cost of entry. The free entry (FE) condition determines that the entry cost is equal to the post-entry expected economic profits. Hence, the FE conditions for Home and Foreign are, respectively

$$f_e = \left[1 - G(\overline{\varphi}_{dk})\right] \widetilde{\pi}_k = \left(\frac{\sigma-1}{\gamma-\sigma+1}\right)\left[f \cdot (\overline{\varphi}_{dk})^{-\gamma} + f_x \cdot (\overline{\varphi}_{xk})^{-\gamma}\right] \tag{9}$$

$$f_e = \left[1 - G(\overline{\varphi}^*_{dk})\right] \widetilde{\pi}^*_k = \left(\frac{\sigma-1}{\gamma-\sigma+1}\right)\left[f \cdot (\overline{\varphi}^*_{dk})^{-\gamma} + f_x \cdot (\overline{\varphi}^*_{xk})^{-\gamma}\right] \tag{10}$$

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[8] The derivation of the above two equations are available from the corresponding author's homepage at http://ihome.ust.hk/~elai/ or upon request.

[9] The condition is $\frac{f_x}{f} > \max\{\frac{L}{L^*}, \frac{L^*}{L}\}$. If this condition is not satisfied, then there exist some sectors in which all firms export (besides serving the domestic market).

[10] $\widetilde{\pi}_{dk} \equiv \pi_{dk}(\widetilde{\varphi}_{dk}) = \frac{r_{dk}(\widetilde{\varphi}_{dk})}{\sigma} - f = \frac{1}{\sigma}\left(\frac{\widetilde{\varphi}_{dk}}{\overline{\varphi}_{dk}}\right)^{\sigma-1} r_{dk}(\overline{\varphi}_{dk}) - f = f\left[\left(\frac{\widetilde{\varphi}_{dk}}{\overline{\varphi}_{dk}}\right)^{\sigma-1} - 1\right] = f \cdot \frac{\sigma-1}{\gamma-\sigma+1}$. The third equality arises from the fact that $\left(\frac{\widetilde{\varphi}_{dk}}{\overline{\varphi}_{dk}}\right)^{\sigma-1} = \frac{r_{dk}(\widetilde{\varphi}_{dk})}{r_{dk}(\overline{\varphi}_{dk})}$. The fourth equality comes from the fact that $\sigma f = r_{dk}(\overline{\varphi}_{dk})$, which is the ZCP condition above. The fifth equality comes from equation (4). Furthermore, $\widetilde{\pi}_{xk} = f_x\left(\frac{\sigma-1}{\gamma-\sigma+1}\right)$ can be derived from similar steps as above by replacing the subscript "d" by "x" and the variable f by f_x. Finally, note that $1 - G(\varphi) = \varphi^{-\gamma}$.

2.2 General equilibrium

Assuming that both countries produce in sector k, given the wage ratio $A_h/A_h^* = 1$, we can solve for $(\overline{\varphi}_{dk}, \overline{\varphi}_{dk}^*, \overline{\varphi}_{xk}, \overline{\varphi}_{xk}^*, \theta_{dk}, \theta_{dk}^*)$ from the four zero cutoff profit conditions and two free entry conditions (5) to (10) since the aggregate prices are functions of these six variables (for details, please refer to Appendix A). The solutions are given below. Define $D_1 \equiv \left(\frac{\sigma-1}{\gamma-\sigma+1}\right)\frac{f}{f_e}$ and $D_2(k) \equiv \left(\frac{\gamma-\sigma+1}{\gamma}\right)\frac{b_k}{\sigma f}$.

$$(\overline{\varphi}_{dk})^{\gamma} = D_1\left[\frac{B-B^{-1}}{B-(a_k)^{\gamma}}\right] \tag{11}$$

$$(\overline{\varphi}_{dk}^*)^{\gamma} = D_1\left[\frac{B-B^{-1}}{B-(a_k)^{-\gamma}}\right] \tag{12}$$

$$\overline{\varphi}_{xk} = \left(\frac{Bf_x}{f}\right)^{\frac{1}{\gamma}}\frac{\overline{\varphi}_{dk}^*}{a_k} \tag{13}$$

$$\overline{\varphi}_{xk}^* = \left(\frac{Bf_x}{f}\right)^{\frac{1}{\gamma}} a_k\overline{\varphi}_{dk} \tag{14}$$

$$\theta_{dk} = D_2(k)\left[\frac{BL - \frac{B-(a_k)^{\gamma}}{B(a_k)^{\gamma}-1}L^*}{B-B^{-1}}\right] \tag{15}$$

$$\theta_{dk}^* = D_2(k)\left[\frac{BL^* - \frac{B(a_k)^{\gamma}-1}{B-(a_k)^{\gamma}}L}{B-B^{-1}}\right] \tag{16}$$

where $B \equiv \tau^{\gamma}\left(\frac{f_x}{f}\right)^{\frac{\gamma}{\sigma-1}-1}$. The variable B can be interpreted as a summary measure of trade barriers; a_k can be interpreted as competitiveness of Home in differentiated goods sector k. Recall that $a_k'(k) > 0$ is assumed.

In a one-sector model, Melitz (2003) imposes the condition $\tau^{\sigma-1}f_x > f$ so as to ensure that some firms produce exclusively for their domestic market in both countries. In this paper, we adopt a more stringent condition, $\frac{f_x}{f} > \max\{\frac{L}{L^*}, \frac{L^*}{L}\}$, so as to ensure that, in each country, some firms sell exclusively to their domestic market in all sectors.[11] This condition implies that $B > 1$.[12]

According to equations (15) and (16) Home's firms will exit sector k when $\theta_{dk} \leq 0$, and Foreign's firms will exit the sector if $\theta_{dk}^* \leq 0$. This implies that $B^{-1}\frac{B-(a_k)^{\gamma}}{B(a_k)^{\gamma}-1} < \frac{L}{L^*} < B\frac{B-(a_k)^{\gamma}}{B(a_k)^{\gamma}-1}$ is needed for both countries to produce positive outputs in sector k, otherwise there will be complete dominance by one country in the sector and one-way trade. Rearranging these inequalities, we can sort the sectors into three types according to Home's strength of comparative advantage. Home will not produce in

[11] The proof is straightforward. From Table 1, we see that $\overline{\varphi}_{dk} < \overline{\varphi}_{xk} \Leftrightarrow \frac{f_x}{f} > \frac{1}{B}\cdot\frac{B(a_k)^{\gamma}-1}{B-(a_k)^{\gamma}}$. Similarly, $\overline{\varphi}_{dk}^* < \overline{\varphi}_{xk}^* \Leftrightarrow \frac{f_x}{f} > \frac{1}{B}\cdot\frac{B-(a_k)^{\gamma}}{B(a_k)^{\gamma}-1}$. Equations (15) and (16) imply that $\frac{1}{B}\cdot\frac{B(a_k)^{\gamma}-1}{B-(a_k)^{\gamma}} \leq \frac{L^*}{L}$ and $\frac{1}{B}\cdot\frac{B-(a_k)^{\gamma}}{B(a_k)^{\gamma}-1} \leq \frac{L}{L^*}$ for $k \in [k_1, k_2]$, where $\theta_{dk} \geq 0$ and $\theta_{dk}^* \geq 0$. Hence $\frac{f_x}{f} > \max\{\frac{L}{L^*}, \frac{L^*}{L}\}$ is a sufficient condition for $\overline{\varphi}_{dk} < \overline{\varphi}_{xk}$ and $\overline{\varphi}_{dk}^* < \overline{\varphi}_{xk}^*$ for all two-way trade sectors.

In addition, Table 1 shows that $\frac{f_x}{f} > \max\{\frac{L}{L^*}, \frac{L^*}{L}\}$ is also a sufficient condition for $\overline{\varphi}_{dk} < \overline{\varphi}_{xk}$ and $\overline{\varphi}_{dk}^* < \overline{\varphi}_{xk}^*$ (whenever the country produces) for all one-way trade sectors.

[12] As $\tau > 1$, $\frac{f_x}{f} \geq 1$, and $\gamma > \sigma - 1$, it is obvious that $B \equiv \tau^{\gamma}\left(\frac{f_x}{f}\right)^{\frac{\gamma}{\sigma-1}-1} > 1$ under our condition.

sector k *iff* $k \leq k_1$, where k_1 satisfies

$$(a_{k_1})^\gamma = \frac{B\left(\frac{L}{L^*}+1\right)}{B^2\frac{L}{L^*}+1}; \tag{17}$$

and Foreign will not produce in sector k *iff* $k \geq k_2$, where k_2 satisfies[13]

$$(a_{k_2})^\gamma = \frac{B^2\frac{L^*}{L}+1}{B\left(\frac{L^*}{L}+1\right)}. \tag{18}$$

Therefore, the solutions to (11)-(16) are valid if and only if $k \in (k_1, k_2)$. It is clear that $k \in (k_1, k_2)$ implies that $(a_k)^\gamma \in \left(\frac{1}{B}, B\right)$ for any possible GDP ratio L/L^*, which ensures that the productivity cutoffs will never reach the corner for the sectors in which both countries produce.

When $k \notin (k_1, k_2)$, the number of firms in one of the countries solved from the system (11)-(16) is negative. In that case, there is no interior solution to some of the equations in the system. This reflects the fact that no firms from that country enters in sector k, which means that the other country completely dominates that sector. Therefore, a different set of equations need to be solved for this case. Without loss of generality, we consider the **Home-dominated sectors**. As there is no competition from Foreign's firms when Home's firms sell in Foreign, the aggregate price indexes become

$$P_k = (\theta_{dk})^{\frac{1}{1-\sigma}} \frac{1}{\rho A_k \widetilde{\varphi}_{dk}}$$
$$P_k^* = (\theta_{xk})^{\frac{1}{1-\sigma}} \frac{\tau}{\rho A_k \widetilde{\varphi}_{xk}}$$

Accordingly, the two zero cutoff profit conditions for Home (5) and (7) continue to hold.

As the free entry condition (9) for Home's firms continues to hold, solving the diminished system of three equations (5), (7), (9) for three unknowns, we have

$$\theta_{dk} = \frac{b_k L}{\sigma f}\left(\frac{\gamma-\sigma+1}{\gamma}\right) = D_2(k)\, L$$
$$\theta_{xk} = \frac{b_k L^*}{\sigma f_x}\left(\frac{\gamma-\sigma+1}{\gamma}\right) = D_2(k)\, \frac{f}{f_x} L^*$$
$$(\overline{\varphi}_{dk})^\gamma = \frac{L+L^*}{L} D_1.$$

Furthermore, we can easily obtain $(\overline{\varphi}_{xk})^\gamma = \left(\frac{L+L^*}{L^*}\right)\frac{f_x}{f} D_1$ by noting that $\theta_{xk} = \frac{1-G(\overline{\varphi}_{xk})}{1-G(\overline{\varphi}_{dk})}\theta_{dk}$. An analogous set of solutions for the Foreign-dominated sectors can be obtained.[14], [15]

Proposition 1 *In sectors $k \in [k_2, 1]$, where Home has the strongest comparative advantage, only Home produces, and there is one-way trade. An analogous situation applies to Foreign in sectors $k \in [0, k_1]$. In sectors $k \in (k_1, k_2)$, where neither country has strong comparative advantage, both countries produce, and there is two-way trade.*

---

[13] Because $\frac{B^2\frac{L^*}{L}+1}{B\left(\frac{L^*}{L}+1\right)} > \frac{B\left(\frac{L}{L^*}+1\right)}{B^2\frac{L}{L^*}+1}$ holds as long as $B > 1$, we always have $k_1 < k_2$.

[14] They are: $\theta^*_{dk} = \frac{b_k L^*}{\sigma f}\left(\frac{\gamma-\sigma+1}{\gamma}\right) = D_2(k)\, L^*$; $\theta^*_{xk} = \frac{b_k L}{\sigma f_x}\left(\frac{\gamma-\sigma+1}{\gamma}\right) = D_2(k)\, \frac{f}{f_x} L$; and $(\overline{\varphi}^*_{dk})^\gamma = \frac{L+L^*}{L^*} D_1$.

[15] The uniqueness of the above equilibrium is proved in an appendix posted on the corresponding author's homepage at http://ihome.ust.hk/~elai/ or upon request.

We show the three zones of international specialization in Figure 2. The upward sloping curve (including the dotted portions) corresponds to equation (15), while the downward sloping curve (including the dotted portions) corresponds to equation (16). The horizontal portion of θ_{dk} in the diagram corresponds to the equation for θ_{dk} above when Home dominates sector k completely. The horizontal portion of θ^*_{dk} corresponds to the analogous equation for Foreign.

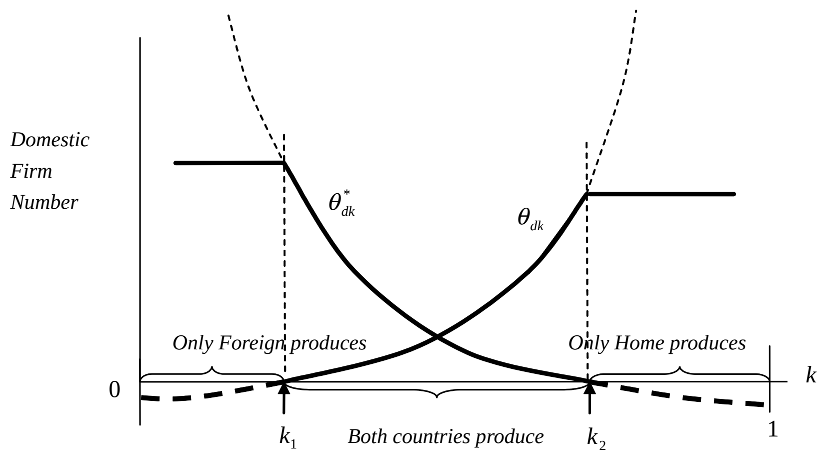


Figure 2. Three Zones of International Specialization (assumption: (i) expenditure shares are equal across sectors, (ii) $L < L^*$).

It is helpful to list the solutions to the relevant variables corresponding to the three types of sectors in Table 1 in the appendix.

Variation of productivity cutoffs across sectors

Recall that if only one country produces, the equilibrium productivity cutoffs for survival are given by $(\overline{\varphi}_{dk})^{\gamma} = \frac{L+L^*}{L} D_1$ if only Home produces, and $(\overline{\varphi}^*_{dk})^{\gamma} = \frac{L+L^*}{L^*} D_1$ if only Foreign produces. If both countries produce, then the equilibrium cutoffs for survival are given by (11) and (12). In that case, the equilibrium cutoff for survival is an increasing function of the sectoral comparative advantage. More precisely, as a_k increases, $\overline{\varphi}_{dk}$ rises but $\overline{\varphi}^*_{dk}$ falls, and, following the free entry conditions (9) and (10), $\overline{\varphi}_{xk}$ falls but $\overline{\varphi}^*_{xk}$ rises. Thus, we have

Proposition 2 *In sectors where both countries produce, for a given country, a sector with stronger comparative advantage has a higher fraction of domestic firms that export and higher fraction of revenue derived from exporting.*

Moreover, $\overline{\varphi}^*_{xk} > \overline{\varphi}_{xk} > \overline{\varphi}_{dk} > \overline{\varphi}^*_{dk}$ iff Home is more competitive in sector k ($a_k > 1$), while $\overline{\varphi}_{xk} > \overline{\varphi}^*_{xk} > \overline{\varphi}^*_{dk} > \overline{\varphi}_{dk}$ iff $a_k < 1$. This result and Proposition 2 are summarized by Figure 3 below.

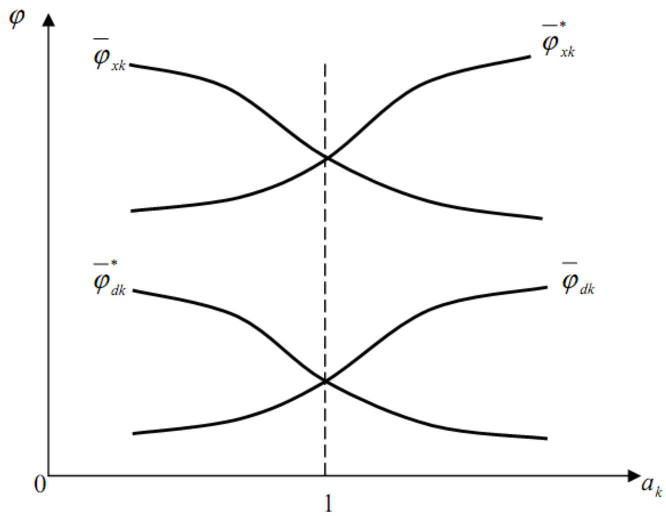


Figure 3. How productivity cutoffs vary across sectors

For shortage of space, we do not present the test of Proposition 2. Instead, we present Figure 4, which shows that the data of Chinese manufacturing sectors support Proposition 2 even when we do not control for other factors.[16]

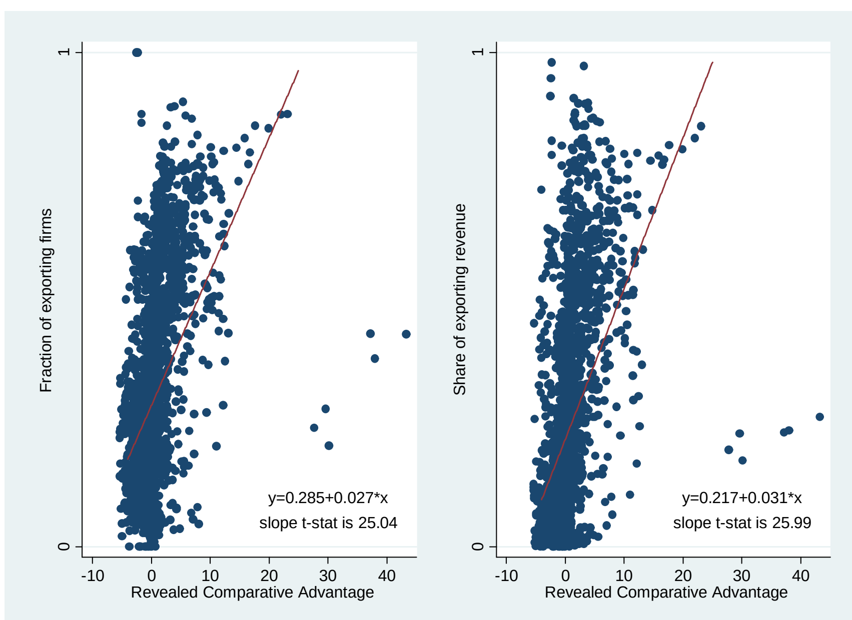


Figure 4. Data supporting Proposition 2

Note: Revealed comparative advantage is trimmed below 1st and above 99th percentiles.

[16] Here, we pool together data of all 4-digit CIC manufacturing sectors in the years 2001-2006.

3 Trade liberalization

In Melitz (2003), both Home and Foreign gain from trade liberalization. Here, we show that trade liberalization has different impacts on different sectors. This is the consequence of its different impacts on the productivity cutoffs for survival and for exporting in different sectors according to their strengths of comparative advantage. This translates into a number of testable hypotheses. Specifically, we derive propositions regarding how the strength of comparative advantage of a sector influences the effects of trade liberalization on firms' probability of exiting, firms' probability of entering exporting, the fraction of exporting firms and revenue share from exporting.

Trade liberalization is interpreted as a reduction of τ or f_x, which lowers $B \equiv \tau^{\gamma}\left(\frac{f_x}{f}\right)^{\frac{\gamma-\sigma+1}{\sigma-1}}$. Without loss of generality, we only focus on the case when $L/L^* \geq 1$. Based on the analysis in the last section, we know that B affects the productivity cutoff for survival, $\overline{\varphi}_{dk}$, and the cutoff for exporting, $\overline{\varphi}_{xk}$, in each country. We calculate

$$\frac{d\left[\ln\left(\overline{\varphi}_{dk}\right)^{\gamma}\right]}{dB} = \frac{1+B^{-2}}{B-B^{-1}} - \frac{1}{B-\left(a_k\right)^{\gamma}}, \tag{19}$$

$$\frac{d\left[\ln\left(\overline{\varphi}^{*}_{dk}\right)^{\gamma}\right]}{dB} = \frac{1+B^{-2}}{B-B^{-1}} - \frac{1}{B-\left(a_k\right)^{-\gamma}}, \tag{20}$$

$$\frac{d\left[\ln\left(\overline{\varphi}_{xk}\right)^{\gamma}\right]}{dB} = \frac{2B}{B^2-1} - \frac{1}{B-\left(a_k\right)^{-\gamma}}$$

$$\frac{d\left[\ln\left(\overline{\varphi}^{*}_{xk}\right)^{\gamma}\right]}{dB} = \frac{2B}{B^2-1} - \frac{1}{B-\left(a_k\right)^{\gamma}}$$

It follows that $\frac{d\overline{\varphi}_{dk}}{dB} > 0$ and $\frac{d\overline{\varphi}_{xk}}{dB} < 0$ iff $(a_k)^{\gamma} < \frac{2B}{1+B^2}$, while $\frac{d\overline{\varphi}^{*}_{dk}}{dB} > 0$ and $\frac{d\overline{\varphi}^{*}_{xk}}{dB} < 0$ iff $(a_k)^{\gamma} > \frac{1+B^2}{2B}$. This in turn implies that trade liberalization affects a number of observable variables, as explained in the following propositions. Their proofs are given in the appendix. In the following propositions, we only consider sectors in which both countries produce (i.e. two-way trade sectors).

Proposition 3 *Following trade liberalization, the probability of exit for a firm is higher in a sector with stronger comparative advantage.*

Proposition 4 *Following trade liberalization, the probability of entry into the export market for a previously non-exporting firm is higher in a sector with stronger comparative advantage.*

Proposition 5 *Following trade liberalization, the change in the fraction of firms that export is larger in a sector with stronger comparative advantage.*[17]

[17] This is conditional on $(a_k)^{\gamma} > \frac{1+B^2}{2B}$, i.e. for sectors with sufficiently strong comparative advantage.

Proposition 6 *Following trade liberalization, the change in the revenue share from exporting is larger in a sector with stronger comparative advantage.*

Proposition 7 *Suppose Home is larger than Foreign. Following trade liberalization, $\overline{\varphi}_{dk}$ increases and $\overline{\varphi}_{xk}$ decreases in the sectors in which Home has the strongest comparative advantage (leading to an increase in aggregate productivity in each sector) but $\overline{\varphi}_{dk}$ decreases and $\overline{\varphi}_{xk}$ increases in the sectors in which Home has the strongest comparative disadvantage (leading to a decrease in aggregate productivity in each sector).*

Proposition 8 *Suppose Home is larger than Foreign. Following trade liberalization, the probability of exit, the probability of entry into the export market, the change in the share of exporting firms and the change in the revenue share from exporting are all positive in the sectors in which Home has the strongest comparative advantage. At the same time, these variables are insignificantly different from zero or negative in the sectors in which Home has the strongest comparative disadvantage.*

Proposition 8 can in fact explain the phenomenon depicted in Figures 1 and A1. The the change in the share of exporting firms and the change in the revenue share from exporting both significantly increase with the magnitude of reduction of trade costs in the comparative advantage sectors, but they are not significantly affected by reduction of trade costs in the comparative disadvantage sectors.

Figure 5 summarizes the effects of Proposition 7 graphically. The diagram shows the welfare effects of trade liberalization as explained in Appendix C. The k_1 and k_2 curves show the pattern of international specialization for any given L/L^*. (Recall that $L/L^* \geq 1$ is assumed.) The zone to the left of the k_1 curve corresponds to sectors completely dominated by Foreign. The zone to the right of the k_2 curve corresponds to the sectors completely dominated by Home. The downward sloping k_1 curve indicates that as the relative size of Home becomes larger, it can profitably produce in more sectors. This shows the home market effect as explained by Krugman (1980) — the firms located in the larger country has the advantage of saving the trade costs of serving the larger market, which more than compensates for its cost disadvantage relative to the firms located in the smaller country in the same sector. On the other hand, the downward sloping k_2 curve shows that Foreign, the smaller country, can profitably produce in fewer sectors as the relative size of Home increases.

The figure also shows, for any given value of L/L^*, the signs of the aggregate-productivity effect of trade liberalization on Home and Foreign in different sectors. The upper sign inside a rectangle indicates the sign of the change in Home's aggregate productivity in sector k due to an infinitesimal decrease in τ, and the lower sign indicates the sign of the change in Foreign's aggregate productivity in sector k. For example, for $1 < L/L^* < B^2$ (indicated by the arrow on the vertical axis in Figure 5), when there is an infinitesimal reduction of B (via reduction in τ), Home's aggregate productivity (i) increases in the Foreign-dominated sectors (the zone to the left of the k_1 curve), (ii) decreases in the two-way trade sectors to the right of the k_1 curve but to the left of the vertical line $(a_k)^\gamma = \frac{2B}{1+B^2}$ (this corresponds to the slanted-hatched zone), (iii) increases in the two-way trade sectors to the right of the vertical line $(a_k)^\gamma = \frac{2B}{1+B^2}$ but to the left of the k_2 curve (this corresponds to the vertically-hatched zone), and (iv) does not increase or decrease in the Home-dominated sectors (the zone to the right of the k_2 curve).

Note that Figure 5 indicates that there is a "reverse-Melitz outcome" for Home (the larger country) in the slanted-hatched zone, in the sense that $\overline{\varphi}_{dk}$ decreases and $\overline{\varphi}_{xk}$ increases (so that aggregate productivity falls) in response to trade liberalization. However, there is a Melitz outcome in Home in the vertically-hatched zone, in the sense that $\overline{\varphi}_{dk}$ increases and $\overline{\varphi}_{xk}$ decreases (so that aggregate productivity rises) in response to trade liberalization. These results reflect the algebraic derivation above and in Appendix C. Note that there is no reverse-Melitz outcome for the smaller country following trade liberalization.

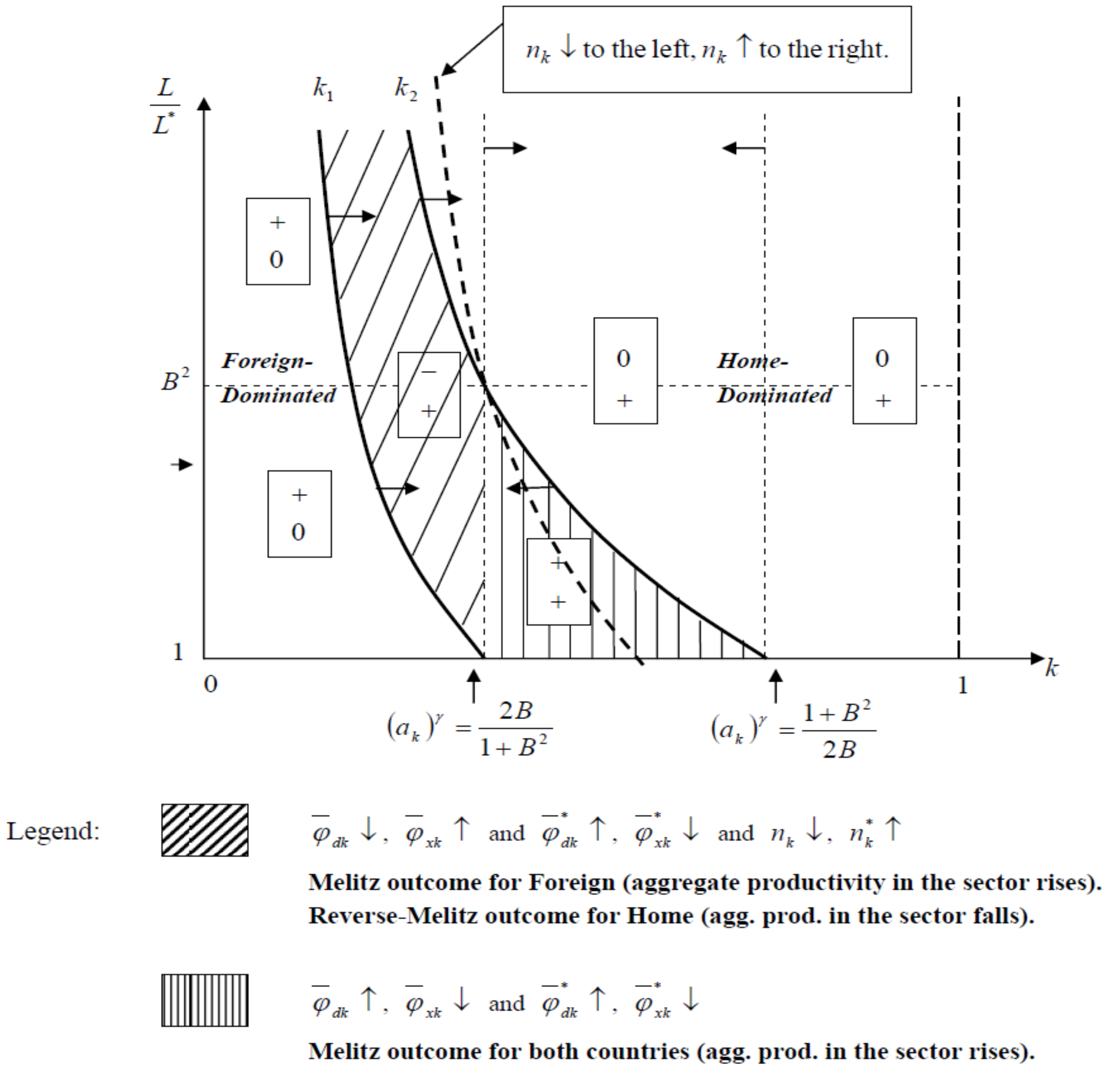


Figure 5. Welfare Effects of Trade Liberalization (infinitesimal reduction of B through a reduction of τ or f_x). In each region, the upper sign inside the rectangle indicates the sectoral aggregate productivity change of Home and the lower sign indicates the aggregate productivity change of Foreign in that sector. The short horizontal arrows indicate the movement of lines as B falls.

As B decreases, the curves for k_1 and k_2, as well as the vertical lines corresponding to $(a_k)^\gamma = \frac{2B}{B^2+1}$ and $(a_k)^\gamma = \frac{B^2+1}{2B}$, will all shift, with the directions of shifts shown by the small horizontal arrows in Figure 5. For any given L/L^*, as τ (and therefore B) decreases from a large number, k_1 increases, k_2 first decreases then increases, the value of k corresponding to $(a_k)^\gamma = \frac{2B}{B^2+1}$ increases while that corresponding to $(a_k)^\gamma = \frac{B^2+1}{2B}$ decreases.[18], [19]

[18]Depending on the range of $[a_0, a_1]$ and the value of L/L^*, it is possible that the k_1 or k_2 curve (or both) may situate outside the range $k \in [0, 1]$ for some or all values of L/L^*. For example, if $a_{k_1} < a_0$ for a given value of L/L^*, then no Foreign-dominated sector exist for that value of L/L^*. This is because as L/L^* gets sufficiently large, the home-market effect in Home gets so strong that Home can compete even in the sector in which it has the weakest comparative advantage, namely sector $k = 0$.

[19]When the two country are of the same size, trade liberalization improves the aggregate productivity in all two-way

The intuition of Proposition 7 deserves more discussion, as it highlights one of the most important results of this paper. If Home is the larger country, the sectors in which reverse Melitz outcome occurs are defined by $\left\{k \mid (a_{k_1})^\gamma < (a_k)^\gamma < (a_{k_2})^\gamma \text{ and } (a_k)^\gamma < \frac{2B}{1+B^2}\right\}$. The first condition indicates that the sector is a two-way trade sector. The second condition indicates that the sector is among those in which the larger country has the weakest comparative advantage. We can explain the existence of the reverse-Melitz outcome by decomposing the total effect of trade liberalization into two effects: the Melitz selection effect and the inter-sectoral resource allocation (IRA) effect. We shall analyze from the perspective of Home and Home's firms.

1. **The inter-sectoral resource allocation (IRA) effect** (leading to $\overline{\varphi}_{dk} \downarrow$ and $\overline{\varphi}_{xk} \uparrow$ in comparative disadvantage sectors, but $\overline{\varphi}_{dk} \uparrow$ and $\overline{\varphi}_{xk} \downarrow$ in comparative advantage sectors)**.** Trade liberalization (a fall in B) leads to resources in Home (as well in Foreign) being re-allocated away from the two-way trade sectors in which it has comparative disadvantage to other two-way trade sectors and the homogeneous good sector. Amongst the two-way trade sectors, the IRA effect tends to reduce the aggregate productivity in the comparative disadvantage sectors and raise the aggregate productivity in other sectors. Define n_k and n_k^* as the mass of entrants in sector k in Home and Foreign respectively.[20] Then $\theta_{dk} = n_k [1 - G(\overline{\varphi}_{dk})]$. Re-allocation of resource (labor) across sectors explains why, in the two-way trade sectors in which Home has comparative disadvantage, the mass of Home's entrants (n_k) decreases, while, in the same sectors, the mass of Foreign's entrants (n_k^*) increases. In Figure 5, we show a dotted downward sloping curve to the left (right) of which n_k decreases (increases) as τ decreases. [21] Let us analyze from the perspective of Home's firms in the comparative disadvantage sectors. As n_k^* increases, Foreign's market becomes more competitive (as there are more firms in Foreign) and so $r_{xk}(\varphi)$ decreases for all φ. **This creates pressure for an increase in** $\overline{\varphi}_{xk}$ (i.e. the Home firms which were marginally profitable in exporting before now become unprofitable in exporting). As n_k decreases, θ_{dk} also decreases. This leads to the expansion of the sizes of the surviving Home firms. Thus, $r_{dk}(\varphi)$ increases for all φ. **This creates pressure for a decrease in** $\overline{\varphi}_{dk}$ as some less productive firms which were expected to be marginally unprofitable before can be expected to be profitable now. In other words, the exporting firms in Home, which are most productive, have to shrink, and so they release resources to the less productive firms. The previously least productive surviving firms in Home would expand, and the marginal firm that were not profitable before now becomes profitable.[22]

2. **The Melitz selection effect** (within-sector resource allocation effect) – leading to $\overline{\varphi}_{dk} \uparrow$ and

trade sectors in both countries.

[20] $n_k = \theta_{dk}(\overline{\varphi}_{dk})^\gamma = D_1 D_2 \left[BL - \frac{B-(a_k)^\gamma}{B(a_k)^\gamma - 1} L^*\right] / [B - (a_k)^\gamma]$; and $n_k^* = \theta_{dk}^*(\overline{\varphi}_{dk}^*)^\gamma = D_1 D_2 \left[BL^* - \frac{B(a_k)^\gamma - 1}{B-(a_k)^\gamma} L\right] / \left[B - (a_k)^{-\gamma}\right]$

[21] Note that if a_k and b_k are both constant for all k, then n_k is the same for all k , even as trade cost decreases. As a_k deviates from being a constant, the IRA effect kicks in. In this case, under trade liberalization, n_k increases (decreases) for the sectors to the left (right) of the dotted curve.

[22] To see the effect more starkly, consider the case when L/L^* is very large. In this case, in the sectors where reverse-Melitz outcome occurs, Home has more firms than Foreign does. The market share of Foreign's firms in these sectors cannot be too high as Foreign's resource (L^*) is too small compared with Home's resource (L). Therefore, a decrease in n_k (as well as θ_{dk}) leads to an increase in the size and revenue of each Home firm that remains. Therefore $r_{dk}(\varphi)$ increases for all φ.

$\overline{\varphi}_{xk} \downarrow$ in all sectors. As B falls, it raises the aggregate productivity of Home in all two-way trade sectors, and leaves the aggregate productivity unchanged in Home-dominated sectors and the homogeneous-good sector. In this analysis, we ignore the IRA effect, i.e. suppose that the masses of entrants n_k and n_k^* were to remain fixed. In other words, the expected toughness of competition for an exporting firm from both countries is unchanged. As a result, the export revenue of a typical exporting firm will increase as trade cost falls. **This creates pressure for both $\overline{\varphi}_{xk}$ and $\overline{\varphi}_{xk}^*$ to decrease.** Meanwhile, this will force the least productive firms in each country to exit (as there are more firms exporting to the domestic market). **This creates pressure for both $\overline{\varphi}_{dk}$ and $\overline{\varphi}_{dk}^*$ to increase.** The decrease in prices of imports and the increase in average productivity of Home's firms raises aggregate productivity of firms serving the sector. This is the Melitz selection effect.

3. **If the IRA effect counteracts and dominates the Melitz selection effect, we will have a reverse-Melitz outcome.** In the sectors to the left of the dotted curve in Figure 5, the IRA effect counteracts the Melitz selection effect. This is because the Melitz selection effect leads trade liberalization to increase Home firms' advantage in selling to Foreign, whereas the IRA effect leads trade liberalization to reduce Home firms' advantage in selling to Foreign (as n_k decreases and n_k^* increases). If the IRA effect dominates, we will have a reverse-Melitz outcome. This will be the case in the two-way trade sectors where Home has the strongest comparative disadvantage. For Foreign, the IRA effect is always positive and so it reinforces the Melitz selection effect. Therefore, there cannot be reverse-Melitz outcome for the small country.[23]

4 Empirical Tests

4.1 Tests of Propositions 3 and 4

To examine the potential reallocative effects of trade liberalization, we estimate the impact on plant survival and the entry into the exporting market using logistic regressions. Based on our model, we know that the probability of exit for all firms and probability of entry into the exporting market for previously non-exporting firms between year t and year $t+1$ are given by:

$$\Pr\left(\text{Exit}_{f,t+1} = 1\right) = \Phi\left(\beta_1 \Delta\text{duty}_{i,t} + \beta_2 \Delta\text{duty}_{i,t} \times \text{RCA}_{i,t} + \beta_3 \text{RCA}_{i,t} + \gamma \text{X}_{f,t} + \delta_s + \delta_t\right)$$
$$\Pr\left(\text{Export}_{f,t+1} = 1\right) = \Phi\left(\beta_1 \Delta\text{duty}_{i,t} + \beta_2 \Delta\text{duty}_{i,t} \times \text{RCA}_{i,t} + \beta_3 \text{RCA}_{i,t} + \gamma \text{X}_{f,t} + \delta_s + \delta_t\right)$$

where $\Delta\text{duty}_{i,t}$ is the annual average change in CIC 4-digit industry tariff between year t and year $t+1$; $\text{RCA}_{i,t}$ is the revealed comparative advantage of CIC 4-digit industry i at year t; $\Delta\text{duty}_{i,t} \times \text{RCA}_{i,t}$ is an interactive term between the tariff change and the revealed comparative advantage; $\text{X}_{f,t}$ is a vector of firm characteristics including firm productivity, labor employment, capital-labor ratio and the wage per worker, δ_s is a set of CIC 2-digit industry dummies and δ_t is a set of time dummies.[24]

[23] If Home's relative size is sufficiently large, and the Foreign-dominated sector is sufficiently small, then the welfare of Home's workers can even fall following trade liberalization.

[24] Our results are robust to using $\Delta\text{duty}_{i,t-1}$ and $\Delta\text{duty}_{i,t-1} \times \text{RCA}_{i,t}$ instead of $\Delta\text{duty}_{i,t}$ and $\Delta\text{duty}_{i,t} \times \text{RCA}_{i,t}$. These results are available upon request.

We test the potential reallocative effects of trade liberalization using firm-level data conducted by the National Bureau of Statistics of China (NBSC), trade flows data from CEPII and tariff data from the World Trade Organization (WTO) from the years 2001 to 2006. The firm-level production data from NBSC are from the annual surveys of Chinese manufacturing firms. The database covers all state-owned enterprises (SOEs), and non-state-owned enterprises with annual sales of at least 5 million RMB (Chinese currency).[25] This database has been widely used by previous studies of Chinese economy (e.g., Cai and Liu (2009); Feenstra, Li and Yu (2014); Brandt, Biesebroeck and Zhang (2012); among others) as it contains detailed firm-level information of manufacturing enterprises in China, such as ownership structure, employment, capital stock, gross output, value added, complete information on the three major accounting statements (i.e., balance sheets, profit & loss accounts, and cash flow statements). Of all the information in the NBSC Database, we are mostly interested in the variables related to measures of the dependent variables which we are interested in (the probability of exit, the probability of entry into the foreign market, the fraction of exporting firms and the exporting revenue share) and firm characteristics. As there are some reporting errors in the NBSC Database, to clean this database, we follow Cai and Liu (2009), Fan, Li and Yeaple (2014) and the Generally Accepted Accounting Principles to discard observations for which one of the following criteria is violated: (i) the total assets must be higher than the liquid assets; (ii) the total assets must be larger than the total fixed assets; (iii) the total assets must be larger than the net value of the fixed assets; (iv) a firm's identification number cannot be missing and must be unique; and (v) the established time must be valid.

To control for firm productivity, we use the augmented Olley-Pakes method (Olley and Pakes, 1996) to estimate firm's productivity (TFP).[26] The augmentation takes into account a number of additional firm level decisions. As in Amiti and Konings (2007), we include an export dummy (equal to one for exporters and zero otherwise) and a WTO dummy (i.e., one for a year in or after 2002 and zero otherwise) in the Olley-Pakes estimation.[27] We use value-added to measure production output, and deflate firms' inputs (e.g., capital) and value added using the input price deflators and output price deflators from Brandt, Biesebroeck and Zhang (2012).[28] Then we construct the real investment variable by adopting the perpetual inventory method to investigate the law of motion for real capital and real investment. To measure the depreciation rate, we use each firm's real depreciation rate provided by the NBSC firm-level database.

China acceded to the WTO in December 2001. Since then there was a series of tariff reductions for a number of years. The average tariff rate at the six-digit HS6 level fell from 15.9% in 2001 to 9.8% in 2006, as shown in Figure A2. We should therefore expect there to be a reallocation across industries

[25] It equals US$640,000 approximately, according to the official end-of-period exchange rate in 2006, reported by the central bank of China.

[26] Our results are robust to different approaches in estimating TFP, including the OLS method, the Levinsohn-Petrin method (Levinsohn and Petrin, 2003), and the Ackerberg-Caves-Frazer augmented O-P and L-P methods (Ackerberg, Caves and Frazer, 2006), and value added per worker. These results are available upon request.

[27] We do not add any import dummy since the NBSC firm-level database does not have a firm's import-decision information.

[28] The output deflators are constructed using "reference price"information from China's Statistical Yearbooks, and the input deflators are constructed based on output deflators and China's national input-output table (2002). The data can be accessed via http://www.econ.kuleuven.be/public/N07057/CHINA/appendix/.

after China's accession to WTO. The first important variable we need to proxy for is the change in trade cost of a sector since year 2001.[29],[30] Here, we construct the industry tariff rate through aggregating tariffs to the 4-digit CIC level.[31] The second important variable we need to proxy for is the comparative advantage of a sector. The Balassa (1965) index provides a measure of the "revealed" comparative advantage of a sector in a country. Since then, the Balassa index has undergone several modifications. In what follow, we shall explain the different measures of revealed comparative advantage developed after Balassa. The Balassa (1965) index in industry i is expressed as:

$$\text{RCA}_1 = \frac{X_{i,c}}{X_c} / \frac{X_{i,w}}{X_w}$$

where $X_{i,c}$ and $X_{i,w}$ represent respectively the exports from China and that from the rest of world in the industry i; X_c and X_w represent respectively the exports from China and that from the rest of world in all industries. The index RCA_1 is the ratio of China's exports in industry i relative to its total exports, to the corresponding measure for the rest of world. Therefore, a higher RCA_1 means stronger revealed comparative advantage. However, the Balassa index is criticized for omitting imports in its analysis. To address this issue, we use a second index, which is expressed as:

$$\text{RCA}_2 = \frac{X_{i,c}}{X_c} / \frac{X_{i,w}}{X_w} - \frac{M_{i,c}}{M_c} / \frac{M_{i,w}}{M_w}$$

where $M_{i,c}$ and $M_{i,w}$ represent respectively the imports by China and the rest of world in the industry i; M_c and M_w represent respectively the imports by China and the rest of world in all industries. The construction of this index requires the data of exports and imports of China and those of the rest of world. We shall use this index as our main index. Another index of RCA, which is based on China's exports and imports, is expressed as:

$$\text{RCA}_3 = \frac{X_{ic} - M_{i,c}}{X_{ic} + M_{i,c}}$$

[29] By and large trade costs consist of transportation costs, tariff barriers and non-tariff barriers. We believe transportation costs should not have changed much during the short period from 2001 to 2006. While tariffs can be measured, non-tariff barriers cannot be easily measured. Nonetheless, according to the protocol of China's accession to the WTO in 2001, China was to reduce both tariffs and non-tariff barriers in tandem. Therefore, we assume that each annual percentage reduction in tariffs during the period 2001 to 2006 roughly represent the annual percentage reduction in the combination of tariffs and non-tariff barriers. Moreover, we also observe that not only did China's yearly sectoral export value and sectoral import value both increase dramatically during this period, but the two quantities are strongly correlated with each other statistically. Therefore, we infer that each annual reduction in import barriers was roughly matched by a similar percentage reduction in the export barriers.

[30] It should be noted that the tariff rates for different sectors are different, which is not consistent with the assumption of our model. Fortunately, it turns out that the theoretical predictions of the model will not be qualitatively affected by the heterogeneity of trade costs across sectors.

[31] The NBSC provide a concordance table between the 6-digit HS code and the 4-digit Chinese industry code. Source of this table can be found at: http://www.5000.gov.cn/release/FrontManage/next_page.aspx?currentPosition=2&cateid=2. In addition, we also use the concordance given by Upward, Wang and Zheng (2013) for robustness check. The results are qualitatively the same. The corresponding concordance table can be found at http://zhengwang.weebly.com/research.html. The results are available upon request.

Moreover, there was a major reclassification in the international HS 6-digit codes in 2002. Hence we construct a mapping of the 6-digit HS coding system from the pre-2002 to the post-2002 periods. With these matchings in place, we connect this 6-digit HS code with the standardized 4-digit CIC code for each year.

Another two indexes of RCA, which are based on China's exports and imports, are:

$$\text{RCA}_4 = \frac{X_{i,c}}{X_c} / \frac{M_{i,c}}{M_c}$$
$$\text{RCA}_5 = \ln\left(\frac{X_{i,c}}{X_c} / \frac{M_{i,c}}{M_c}\right) * 100$$

Considering that China is relatively abundant in labor, it should have a comparative advantage in the labor-intensive sectors. Hence, we also use the labor-capital ratio in a sector as an index for the revealed comparative advantage of that sector. Table 2 shows the correlation coefficient among the above five RCA indexes and the labor-capital ratio (based on 4-digit CIC sectors). The mean, median, minimum and maximum of these indexes are reported Table 7 in the appendix.

Table 2: The correlation coefficient among measures of CA

	RCA_1	RCA_2	RCA_3	RCA_4	RCA_5	log(L/K)
RCA_1	1.000					
RCA_2	0.925	1.000				
RCA_3	0.470	0.648	1.000			
RCA_4	0.115	0.123	0.105	1.000		
RCA_5	0.584	0.735	0.941	0.238	1.000	
log(L/K)	0.419	0.426	0.379	0.029	0.422	1.000

Note that all the results in this section are robust to using the rank of the RCA instead of the value of the RCA as the right hand side variable.

Tables 3A and 3B report the regression results regarding the probability of exit and on the probability of entering the exporting market, respectively.[32] According to our theory, the probability of exit and the probability of entering the exporting market for previously non-exporting firms should be higher in sectors with stronger comparative advantage following trade liberalization. As predicted, the coefficients of the interactive term "tariff change x RCA" in columns 1 to 5 in both Tables 3A and 3B are significantly negative. The coefficients of the interactive term in column 6 is not significant. This may be because labor-capital ratio cannot totally capture revealed comparative advantage. Besides, Tables 3A and 3B show that the variables of interest increase with a firm's productivity, employment, capital-labor ratio, and wage per worker. All in all, the results in Tables 3A and 3B offer support for Propositions 3 and 4.

[32] To judge whether or not the firms in two consecutive years are same firm, we first link the firms by firm ID. Then, we use additional information to link them. We create new codes that use various combinations of firm name (in Chinese), name of legal person representative (in Chinese), geographic code, phone number.

Table 3A: Probability of exit

Regressor	Logit	Logit	Logit	Logit	Logit	Logit
	(1)	(2)	(3)	(4)	(5)	(6)
Proxy for RCA	RCA_1	RCA_2	RCA_3	RCA_4	RCA_5	log(L/K)
Δduty	-1.371***	-1.557***	-1.551***	-1.535***	-1.757***	-2.950**
	(0.164)	(0.158)	(0.160)	(0.158)	(0.165)	(1.265)
Δduty×RCA	**-0.277*****	**-0.317*****	**-1.417*****	**-0.006****	**-0.004*****	**-0.322**
	(0.074)	(0.063)	(0.231)	(0.003)	(0.001)	(0.270)
RCA	-0.006***	-0.005***	-0.016**	-0.000**	-0.000***	-0.066***
	(0.001)	(0.001)	(0.007)	(0.000)	(0.000)	(0.007)
TFP	-0.209***	-0.209***	-0.209***	-0.209***	-0.210***	-0.211***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
log(Empl)	-0.292***	-0.292***	-0.292***	-0.293***	-0.292***	-0.292***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
log(K/L)	-0.082***	-0.082***	-0.081***	-0.081***	-0.082***	-0.085***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
log(Wage)	-0.217***	-0.217***	-0.217***	-0.217***	-0.217***	-0.217***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	838,339	838,339	838,339	838,339	838,339	838,339
Log likelihood	-420,345	-420,340	-420,338	-420,353	-420,342	-420,312

Note: ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level.

Table 3B: Probability of entry into the exporting market

Regressor	Logit (1)	Logit (2)	Logit (3)	Logit (4)	Logit (5)	Logit (6)
Proxy for RCA	RCA_1	RCA_2	RCA_3	RCA_4	RCA_5	log(L/K)
Δduty	3.722***	2.513***	2.975***	3.455***	2.123***	-2.196
	(0.450)	(0.408)	(0.441)	(0.424)	(0.436)	(2.834)
Δduty×RCA	**-1.330***	**-0.897***	**-3.074***	**-0.033***	**-0.014***	**0.004**
	(0.142)	(0.118)	(0.563)	(0.007)	(0.002)	(0.616)
RCA	0.025***	0.025***	0.306***	-0.000***	0.001***	0.517***
	(0.002)	(0.002)	(0.016)	(0.000)	(0.000)	(0.017)
TFP	0.077***	0.077***	0.079***	0.075***	0.081***	0.089***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
log(Empl)	0.345***	0.345***	0.347***	0.346***	0.347***	0.352***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
log(K/L)	0.048***	0.049***	0.052***	0.044***	0.055***	0.075***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
log(Wage)	0.359***	0.359***	0.360***	0.353***	0.362***	0.362***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	587,799	587,799	587,799	587,799	587,799	587,799
Log Likelihood	-108,063	-108,087	-107,983	-108,234	-107,836	-107,759

Note: ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level.

In Tables 3A and 3B, all results are based on one-year difference, i.e. the change is between t and $t+1$. In Table 3C, posted in the online appendix, we report the impacts on the variables of interest based on two-year difference; three-year difference; four-year difference and five-year difference. There, we only report the results based on the index RCA_2. For other indexes, the results are qualitatively the same. As shown, the coefficients of the interaction of tariff reduction and RCA except column 8 are statistically significant and negative. This further supports our Propositions 3 and 4.

4.2 Tests of Propositions 5 and 6

In this subsection, we will test these two propositions according to the following two equations:

$$\Delta\frac{\theta_{x,i}}{\theta_{d,i}} = \beta_1\Delta\text{duty}_{i,t} + \beta_2\Delta\text{duty}_{i,t}\times\text{RCA}_{i,t} + \beta_3\text{RCA}_{i,t} + \gamma\text{X}_{i,t} + \delta_s + \delta_t + \varepsilon_{it}$$
$$\Delta\frac{V_{x,i}}{V_i} = \beta_1\Delta\text{duty}_{i,t} + \beta_2\Delta\text{duty}_{i,t}\times\text{RCA}_{i,t} + \beta_3\text{RCA}_{i,t} + \gamma\text{X}_{i,t} + \delta_s + \delta_t + \varepsilon_{it}$$

where $\theta_{x,i}$ and $\theta_{d,i}$ denote respectively the exporting firm mass and total producing firm mass in industry i; $V_{x,i}$ and V_i respectively represent the exporting revenue and the total revenue in industry i; $\text{X}_{i,t}$ is a vector of industry characteristics including the firm-revenue-weighted average TFP, labor employment, capital-labor ratio and the wage per worker in industry i; δ_s is a set of CIC 2-digit industry dummies and δ_t is a set of the time dummies.

In a similar format as in Tables 3A and 3B, Tables 4A and 4B report the regression results regarding the change in the fraction of exporting firms and the change in the share of exporting revenue in total revenue, respectively. The theory predicts that these variables are larger in the sectors with stronger comparative advantage. As predicted, the coefficients of the interactive term "tariff change x RCA" are negative in all six columns in both tables. They are statistically significant except for columns 4.[33],[34],[35]

Table 4A: Change in fraction of exporting firms

Regressor	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)
Proxy for RCA	RCA_1	RCA_2	RCA_3	RCA_4	RCA_5	log(L/K)
Δduty	-0.052	-0.134*	-0.125*	-0.115	-0.172**	-0.898**
	(0.079)	(0.076)	(0.076)	(0.076)	(0.077)	(0.428)
Δduty×RCA	**-0.091***	**-0.094***	**-0.222**	**-0.002**	**-0.001***	**-0.168***
	(0.030)	(0.023)	(0.090)	(0.001)	(0.000)	(0.091)
RCA	-0.001*	-0.001	0.003	-0.000	0.000	-0.004
	(0.001)	(0.001)	(0.003)	(0.000)	(0.000)	(0.004)
TFP	0.003	0.003	0.003	0.004	0.003	0.004
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
log(Empl)	-0.004***	-0.004***	-0.004***	-0.004***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
log(K/L)	0.001	0.002	0.004	0.002	0.005	
	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)	
log(Wage)	0.004	0.004	0.004	0.004	0.004	0.004
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,005	2,005	2,005	2,005	2,005	2,005
R-squared	0.068	0.071	0.068	0.065	0.071	0.065

Note: ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level.

[33] That is, except for RCA_4. In fact, even the coefficient of RCA_4 would be significantly negative if we use the rank of the sectors for the regressions instead.

[34] In column 6, we use log(L/K) to proxy for revealed comparative advantage. Therefore, we do not add log(K/L) in this regression in both tables.

[35] Based on our theory, we know that the effect of trade liberalization on the fraction of exporting firms is not clear in the sectors with strong comparative disadvantage, i.e., $a_k^\gamma \leq \frac{2B}{1+B^2}$. In these sectors with $a_k^\gamma \leq \frac{2B}{1+B^2}$, fraction of exporting firms would decrease instead of increase. To be strictly consistent with our theory, we also test our Proposition 5 only for sectors with its revealed comparative advantage's rank no less than 25% and 50% percentile respectively as well as only for sectors where the fraction of exporting firms increases. The results continue to hold.

Table 4B: Change in share of exporting revenue in total revenue

Regressor	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)
Proxy for RCA	RCA_1	RCA_2	RCA_3	RCA_4	RCA_5	log(L/K)
Δduty	0.058	-0.042	-0.033	-0.022	-0.106	-1.187**
	(0.093)	(0.088)	(0.088)	(0.089)	(0.090)	(0.501)
Δduty$\times$RCA	**-0.117*** **	**-0.119*** **	**-0.353*** **	**-0.002**	**-0.001*** **	**-0.251** **
	(0.035)	(0.027)	(0.105)	(0.001)	(0.000)	(0.107)
RCA	-0.000	0.001	0.003	-0.000	0.000	-0.013***
	(0.001)	(0.001)	(0.004)	(0.000)	(0.000)	(0.004)
TFP	-0.005	-0.006	-0.005	-0.004	-0.005	-0.004
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
log(Empl)	-0.004***	-0.005***	-0.005***	-0.004***	-0.005***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
log(K/L)	0.013***	0.015***	0.014***	0.011***	0.014***	
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	
log(Wage)	0.010	0.011	0.011	0.011	0.011	0.011
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,005	2,005	2,005	2,005	2,005	2,005
R-squared	0.052	0.059	0.054	0.047	0.058	0.048

Note: ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level.

In Tables 4A and 4B, all results are based on one-year difference. In Table 4C, posted in the online appendix, we report the impacts on the variables of interest based on two-year differences; three-year differences; four-year differences and five-year differences. There, we again only report the results based on the index RCA_2. For other indexes, the results are similar. We can see that the coefficients of the interaction of tariff reduction and RCA in all columns are by and large statistically significant and negative. This further supports our Propositions 5 and 6.

4.3 Tests of Proposition 8

Can we find empirical evidence to support the propositions that the two-way trade sectors with the strongest comparative disadvantage exhibit reverse-Melitz outcome and those with the strongest comparative advantage exhibit Melitz outcome? Proposition 8 requires that Home be sufficiently larger than Foreign. China, being a country with a huge supply of labor that participated in global trade, is the best candidate for testing these hypotheses. We test the implications of Proposition 8 using the following equations:

$$\Pr\left(\text{Exit}_{f,t+1}=1\right)=\Phi\left(\beta_1\Delta\text{duty}_{i,t}\times\text{index}_1+\beta_2\Delta\text{duty}_{i,t}\times\text{Index}_2+\text{RCA}_{i,t}\times\text{Index}_3+\gamma\text{X}_{f,t}+\delta_t\right)$$

$$\Pr\left(\text{Export}_{f,t+1}=1\right)=\Phi\left(\beta_1\Delta\text{duty}_{i,t}\times\text{index}_1+\beta_2\Delta\text{duty}_{i,t}\times\text{Index}_2+\text{RCA}_{i,t}\times\text{Index}_3+\gamma\text{X}_{f,t}+\delta_t\right)$$

$$\Delta\frac{\theta_{x,i}}{\theta_{d,i}}=\beta_1\Delta\text{duty}_{i,t}\times\text{index}_1+\beta_2\Delta\text{duty}_{i,t}\times\text{Index}_2+\text{RCA}_{i,t}\times\text{Index}_3+\gamma\text{X}_{i,t}+\delta_t+\varepsilon_{it}$$

$$\Delta\frac{V_{x,i}}{V_i}=\beta_1\Delta\text{duty}_{i,t}\times\text{index}_1+\beta_2\Delta\text{duty}_{i,t}\times\text{Index}_2+\text{RCA}_{i,t}\times\text{Index}_3+\gamma\text{X}_{i,t}+\delta_t+\varepsilon_{it}$$

where index_1 denotes the dummy variable which is equal to one if the sector's rank is below bottom 1/3 according to the RCA index; index_2 between bottom 1/3 and top 1/3; index_3 above top 1/3. Therefore, index_1 being equal to one indicates that the sectors have strong comparative disadvantage; while index_3 being equal to one indicates that the sectors have strong comparative advantage. Here, we use RCA_2 to proxy for revealed comparative advantage. The results are qualitatively the same when other indexes are used. The rank based on different RCA indexes are highly correlated, as shown in Table 5:

Table 5: The Spearman's rank correlation among different RCA

	RCA_1	RCA_2	RCA_3	RCA_4	RCA_5	log(L/K)
RCA_1	1.000					
RCA_2	0.777	1.000				
RCA_3	0.800	0.939	1.000			
RCA_4	0.800	0.939	1.000	1.000		
RCA_5	0.800	0.939	1.000	1.000	1.000	
log(L/K)	0.485	0.416	0.395	0.395	0.395	1.000

Tables 6A and 6B report the results of the tests. In both tables, columns 1 and 5 correspond to the sectors with rank below bottom 1/3; columns 2 and 6 correspond to the sectors with rank between 1/3 and 2/3; columns 3 and 7 correspond to the sectors with rank above 2/3.[36] In columns 4 and 8 of both tables, we use the whole sample and include the interaction of tariff change and three dummy variables of the sector's rank according to RCA. The classical Melitz outcome is statistically significant in almost all relevant regressions in Tables 6A and 6B as demonstrated by the negative and significant coefficients for $\Delta duty$ in the first row of column 3 and 7 as well as those for $\Delta duty \times index_3$ in Columns 4 and 8 of both tables.

The reverse-Melitz outcome is not as statistically significant but there is still clear evidence of the differential impacts of trade liberalization in different sectors based on their strengths of CA (comparative advantage). In the first row of Table 6A, for the probability of exit as well as probability of entry into exporting market, the coefficient of $\Delta duty$ changes from positive (sometimes insignificant) for sectors with weak CA to negative for sectors with strong CA (always significant). In columns 4 and 8, the coefficient of $\Delta duty \times index_i$ changes from positive (sometimes insignificant) to negative (always significant) as i increases from 1 to 3.

[36] We used other percentiles to divide the sectors into groups of different strengths of CA, and the results turned out to be qualitatively the same.

In the first row of columns 1-3 and 5-7 as well as rows 7&9 of columns 4 and 8 of Table 6B, we can see that the effects of trade liberalization on the change in share of exporting revenue and change in share of exporting firms are insignificant for sectors with weak CA, consistent with the theory's prediction of the existence of an IRA effect that counteracts the Melitz selection effect. In the sectors with strong CA, the effects are always negative and significant, consistent with the theory.

Table 6A

	Probability of exit				Probability of entry into the exporting market			
Regressor	Logit	Logit	Logit	Logit	Logit	Logit	Logit	Logit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Strength of CA	Weak	Medium	Strong		Weak	Medium	Strong	
Δduty	**1.725*****	**-0.711*****	**-4.029*****		**0.743**	**0.398**	**-2.407*****	
	(0.402)	(0.172)	(0.375)		(0.824)	(0.461)	(0.743)	
RCA	-0.023***	0.073***	0.000	-0.002*	-0.046***	-0.126***	0.037***	0.039***
	(0.004)	(0.017)	(0.001)	(0.001)	(0.010)	(0.044)	(0.002)	(0.002)
TFP	-0.182***	-0.181***	-0.158***	-0.173***	0.107***	0.170***	0.057***	0.105***
	(0.005)	(0.004)	(0.004)	(0.002)	(0.011)	(0.011)	(0.009)	(0.006)
log(Empl)	-0.278***	-0.279***	-0.305***	-0.288***	0.382***	0.273***	0.318***	0.332***
	(0.005)	(0.004)	(0.004)	(0.003)	(0.010)	(0.010)	(0.009)	(0.006)
log(K/L)	-0.068***	-0.097***	-0.070***	-0.078***	0.127***	0.070***	-0.119***	-0.007
	(0.004)	(0.004)	(0.003)	(0.002)	(0.010)	(0.009)	(0.007)	(0.005)
log(Wage)	-0.235***	-0.230***	-0.224***	-0.230***	0.460***	0.355***	0.393***	0.411***
	(0.009)	(0.007)	(0.007)	(0.004)	(0.020)	(0.019)	(0.015)	(0.010)
Δduty$\times$index$_1$				**0.918*****				**1.092**
				(0.325)				(0.675)
Δduty$\times$index$_2$				**-0.741*****				**1.843*****
				(0.157)				(0.454)
Δduty$\times$index$_3$				**-2.820*****				**-4.222*****
				(0.316)				(0.631)
Yr fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	221,608	282,408	334,323	838,339	171,571	230,974	185,254	587,799
Log likelihood	-110,777	-142,935	-168,165	-422,184	-28,626	-33,347	-47,246	-109,735

Note 1: ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level.

Note 2: In the Columns 4 and 8, we also control index$_1$, index$_2$ and index$_3$. In order to save space, we don't report them.

Table 6B

	Change in fraction of exporting firms				Change in share of exporting revenue			
Regressor	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Strength of CA	Weak	Medium	Strong		Weak	Medium	Strong	
Δduty	**-0.007**	**-0.130**	**-0.356****		**0.084**	**-0.061**	**-0.376***	
	(0.162)	(0.083)	(0.165)		(0.170)	(0.099)	(0.209)	
RCA	0.002	-0.005	-0.001	-0.000	0.004**	-0.002	0.000	0.001
	(0.001)	(0.008)	(0.001)	(0.000)	(0.002)	(0.009)	(0.001)	(0.001)
TFP	0.002	-0.003	0.000	-0.000	-0.001	-0.001	-0.001	0.000
	(0.003)	(0.002)	(0.003)	(0.001)	(0.003)	(0.003)	(0.004)	(0.002)
log(Empl)	-0.006***	-0.003*	-0.002	-0.003***	-0.003	-0.005***	-0.004*	-0.004***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)
log(K/L)	0.002	-0.010**	-0.002	-0.002	0.008*	-0.011*	0.006	0.003
	(0.004)	(0.005)	(0.005)	(0.003)	(0.004)	(0.006)	(0.006)	(0.003)
log(Wage)	-0.002	0.015**	0.025**	0.012**	-0.000	0.024***	0.039***	0.019***
	(0.009)	(0.007)	(0.010)	(0.005)	(0.010)	(0.008)	(0.012)	(0.006)
Δduty$\times$index$_1$				**-0.077**				**0.130**
				(0.085)				(0.094)
Δduty$\times$index$_2$				**-0.084**				**-0.113**
				(0.117)				(0.126)
Δduty$\times$index$_3$				**-0.466*****				**-0.480*****
				(0.130)				(0.153)
Yr fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	669	667	669	2,005	669	667	669	2,005
R-squared	0.026	0.064	0.137	0.057	0.028	0.048	0.082	0.037

Note 1: ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level.

Note 2: In the Columns 4 and 8, we also control for index$_1$, index$_2$ and index$_3$. In order to save space, we don't report them.

There can be a few reasons why the reverse-Melitz outcome is not as significant as our theory predicts. First, perhaps China is still not large enough compared with the rest of the world, at least for some sectors. Second, it is possible that trade barriers (including artificial and real ones) were still too high so that the set of sectors with reverse-Melitz outcome is too small to be empirically detectable. Third, there may be some other factors that affect firm behavior, such as policy changes other than WTO-mandated ones, or changes in the magnitude of rural-urban migration, that we have not accounted for.

5 Conclusion

In this paper, we investigate how firms' entry, exit, output and exporting decisions respond to trade liberalization and how the responses differ across sectors. We do this by building a simple multiple sector model featuring comparative advantage and heterogeneous firms, and then perturb it with reduction in trade costs. We then test the hypotheses that arise thereof. The total effect of trade liberalization in a sector can be decomposed into the IRA (intersectoral resource allocation) effect and the within-sector selection effect. The total effect of trade liberalization in a sector changes monotonically with the strength of comparative advantage of the sector. If Home is larger than Foreign, the total aggregate-productivity effect in a comparative disadvantage sector can be negative, as the IRA effect dominates the within-sector selection effect. We call this "reverse-Melitz outcome" as it is opposite to the prediction of the one-sector Melitz model, which emphasizes the within-sector selection effect. We test the hypotheses related to these reallocative effects of trade liberalization using firm-level data of Chinese manufacturing industries in the years following China's accession to the WTO. We find empirical support for the existence of an IRA effect that counteracts the within-sector selection effect.

Our analysis may be helpful to policy-makers in predicting the firm-level changes in different sectors in response to trade liberalization policy or other exogenous changes in trade costs. This can help them formulate plans in anticipation of such changes.

Appendixes

A Different responses from different sectors

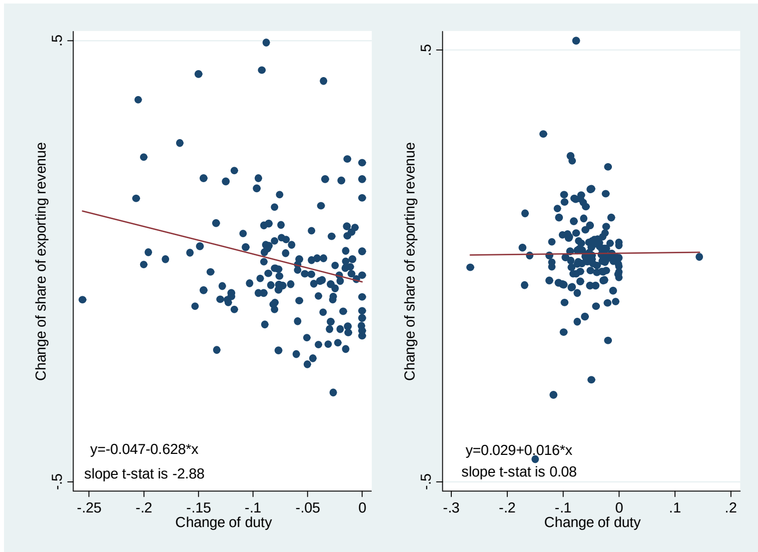


Figure A1: Relation between change in share of exporting revenue and change of duty

Note: Change of duty is trimmed below 1st percentile and above 99th percentile. The left panel includes firms in sectors in the top 1/3 measure of revealed comparative advantage (i.e. strong comparative advantage); the right panel includes firms in sectors in the bottom 1/3 measure of revealed comparative advantage (i.e. strong comparative disadvantage).

B Solving for the System

In this appendix, we will show how to solve the model for the sectors where both countries produce. In other words, we solve for ($\overline{\varphi}_{dk}$, $\overline{\varphi}^*_{dk}$, $\overline{\varphi}_{xk}$, $\overline{\varphi}^*_{xk}$, θ_{dk}, θ^*_{dk}) from the system constituted of the four zero cutoff profit conditions and two free entry conditions. Combining the two zero cutoff conditions for firms serving the Home market, (5) and (8), we have

$$\frac{\overline{\varphi}^*_{xk}}{\overline{\varphi}_{dk}} = a_k \left(\frac{Bf_x}{f}\right)^{\frac{1}{\gamma}} \tag{21}$$

Similarly, combining those for firms serving Foreign's market, (6) and (7), we can get

$$\frac{\overline{\varphi}_{xk}}{\overline{\varphi}^*_{dk}} = \frac{1}{a_k} \left(\frac{Bf_x}{f}\right)^{\frac{1}{\gamma}} \tag{22}$$

Equations (21), (22), and the FE conditions (9), and (10) now form a system of four equations and four unknowns, $\overline{\varphi}_{dk}$,$\overline{\varphi}_{xk}$,$\overline{\varphi}^*_{dk}$ and $\overline{\varphi}^*_{xk}$. Solving, we obtain (11), (12), (13) and (14).

Then recall that the aggregate price indexes are given by $P_k = \theta_k^{\frac{1}{1-\sigma}} p_{dk}(\widetilde{\varphi}_k)$ and $P_k^* = (\theta_k^*)^{\frac{1}{1-\sigma}} p_{dk}^*(\widetilde{\varphi}_k^*)$. Substituting these price indexes into Zero Cutoff Conditions (5) and (6), and with the help of equation (2) and (3), we have

$$\sigma f = \frac{b_k L}{\theta_k}\left(\frac{\overline{\varphi}_{dk}}{\widetilde{\varphi}_k}\right)^{\sigma-1} = \left(\frac{\gamma-\sigma+1}{\gamma}\right)\cdot\frac{b_k L}{\theta_{dk}+\theta_{xk}^*\frac{f_x}{f}} \tag{23}$$

$$\sigma f = \frac{b_k L^*}{\theta_k^*}\left(\frac{\overline{\varphi}_{dk}^*}{\widetilde{\varphi}_k^*}\right)^{\sigma-1} = \left(\frac{\gamma-\sigma+1}{\gamma}\right)\cdot\frac{b_k L^*}{\theta_{dk}^*+\theta_{xk}\frac{f_x}{f}} \tag{24}$$

From the equilibrium productivity cutoffs (11) and (12) in both countries, we get

$$\left(\frac{\overline{\varphi}_{dk}}{\overline{\varphi}_{dk}^*}\right)^{\gamma} = \frac{B-(a_k)^{-\gamma}}{B-(a_k)^{\gamma}} \tag{25}$$

Therefore, the number of exporting firms in Home and Foreign are respectively:

$$\theta_{xk} = \left(\frac{\overline{\varphi}_{dk}}{\overline{\varphi}_{xk}}\right)^{\gamma}\theta_{dk} = \left(a_k\frac{\overline{\varphi}_{dk}}{\overline{\varphi}_{dk}^*}\right)^{\gamma}\left(\frac{f}{Bf_x}\right)\theta_{dk} \tag{26}$$

$$\theta_{xk}^* = \left(\frac{\overline{\varphi}_{dk}^*}{\overline{\varphi}_{xk}^*}\right)^{\gamma}\theta_{dk}^* = \left(\frac{\overline{\varphi}_{dk}^*}{a_k\cdot\overline{\varphi}_{dk}}\right)^{\gamma}\left(\frac{f}{Bf_x}\right)\theta_{dk}^* \tag{27}$$

Equations (23), (24), (25), (26), (27) then imply (15) and (16).

θ_{xk} and θ_{xk}^* can be obtained by substituting (25), (15), (16) into (26) and (27) respectively. Table 1 below summarizes the equilibrium variables of the system.

Sector type	Foreign-dominated	Two-way trade	Home-dominated
	$k < k_1$	$k_1 < k < k_2$	$k > k_2$
$(\overline{\varphi}_{dk})^{\gamma}$	$\varnothing$	$D_1 \frac{B-B^{-1}}{B-(a_k)^{\gamma}}$	$D_1 \frac{L+L^*}{L}$
$(\overline{\varphi}_{xk})^{\gamma}$	$\varnothing$	$D_1 \frac{B-B^{-1}}{B-(a_k)^{-\gamma}} \left(\frac{1}{a_k}\right)^{\gamma} \left(\frac{Bf_x}{f}\right)$	$D_1 \frac{f_x}{f} \left(\frac{L+L^*}{L^*}\right)$
$(\overline{\varphi}^*_{dk})^{\gamma}$	$D_1 \frac{L+L^*}{L^*}$	$D_1 \frac{B-B^{-1}}{B-(a_k)^{-\gamma}}$	$\varnothing$
$(\overline{\varphi}^*_{xk})^{\gamma}$	$D_1 \frac{f_x}{f} \frac{L+L^*}{L}$	$D_1 \frac{B-B^{-1}}{B-(a_k)^{\gamma}} (a_k)^{\gamma} \left(\frac{Bf_x}{f}\right)$	$\varnothing$
θ_{dk}	0	$D_2(k) \frac{BL - \frac{B-(a_k)^{\gamma}}{B(a_k)^{\gamma}-1} L^*}{B-B^{-1}}$	$D_2(k)\, L$
θ_{xk}	0	$\left(\frac{\overline{\varphi}_{dk}}{\overline{\varphi}_{xk}}\right)^{\gamma} \theta_{dk}$	$D_2(k) \frac{f}{f_x} L^*$
θ^*_{dk}	$D_2(k)\, L^*$	$D_2(k) \frac{BL^* - \frac{B(a_k)^{\gamma}-1}{B-(a_k)^{\gamma}} L}{B-B^{-1}}$	0
θ^*_{xk}	$D_2(k) \frac{f}{f_x} L$	$\left(\frac{\overline{\varphi}^*_{dk}}{\overline{\varphi}^*_{xk}}\right)^{\gamma} \theta^*_{dk}$	0
P_k	$[D_2(k)\, L]^{\frac{1}{1-\sigma}} a_k B^{\frac{1}{\gamma}} \left(\frac{L}{L+L^*}\right)^{\frac{1}{\gamma}} \frac{1}{\rho A_k \widetilde{\varphi}_{ck}}$	$[D_2(k)\, L]^{\frac{1}{1-\sigma}} \frac{1}{\rho A_k \widetilde{\varphi}_{dk}}$	$[D_2(k)\, L]^{\frac{1}{1-\sigma}} \frac{1}{\rho A_k \widetilde{\varphi}_{dk}}$
P^*_k	$[D_2(k)\, L^*]^{\frac{1}{1-\sigma}} \frac{1}{\rho A^*_k \widetilde{\varphi}^*_{dk}}$	$[D_2(k)\, L^*]^{\frac{1}{1-\sigma}} \frac{1}{\rho A^*_k \widetilde{\varphi}^*_{dk}}$	$\frac{[D_2(k)L^*]^{\frac{1}{1-\sigma}}}{\rho A^*_k \widetilde{\varphi}_{ck}} \frac{B^{\frac{1}{\gamma}}}{a_k} \left(\frac{L^*}{L+L^*}\right)^{\frac{1}{\gamma}}$

Table 1: Solution of the System

$$D_1 = \left(\frac{\sigma-1}{\gamma-\sigma+1}\right)\frac{f}{f_e}\ ;\quad D_2(k) = \left(\frac{\gamma-\sigma+1}{\gamma}\right)\frac{b_k}{\sigma f}\ ;\quad (a_{k_1})^{\gamma} = \frac{B\left(\frac{L}{L^*}+1\right)}{B^2\frac{L}{L^*}+1};\quad (a_{k_2})^{\gamma} = \frac{B^2\frac{L^*}{L}+1}{B\left(\frac{L^*}{L}+1\right)}$$

$$\widetilde{\varphi}_{ck} = \left[\frac{b_k}{\sigma f D_2(k)}\right]^{\frac{1}{\sigma-1}} D_1^{\frac{-1}{\gamma}}$$

C Welfare Impact of Trade Liberalization

In this appendix, we will prove how the real wage in terms of the aggregate good of sector k (thereafter called real wage in terms of good k) changes after trade liberalization in three cases. The changes will be equivalent to changes in aggregate productivity in sector k because of constant markup. Without loss of generality, we assume that $L > L^*$.

1. Foreign-dominated sectors: $k \in (0, k_1)$. The real wage in terms of good k in this zone in Home and Foreign are, respectively:

$$\frac{1}{P_k} = (\theta^*_{xk})^{\frac{1}{\sigma-1}} \rho A^*_k \widetilde{\varphi}^*_{xk} \frac{1}{\tau} = \rho A^*_k B^{-\frac{1}{\gamma}} \left(\frac{L+L^*}{L} D_1\right)^{\frac{1}{\gamma}} \left(\frac{\gamma}{\gamma-\sigma+1} D_2(k)\, L\right)^{\frac{1}{\sigma-1}}$$

$$\frac{1}{P^*_k} = (\theta^*_{dk})^{\frac{1}{\sigma-1}} \rho A^*_k \widetilde{\varphi}^*_{dk} = \rho A^*_k \left(\frac{L+L^*}{L^*} D_1\right)^{\frac{1}{\gamma}} \left(\frac{\gamma}{\gamma-\sigma+1} D_2(k)\, L^*\right)^{\frac{1}{\sigma-1}}$$

Since trade liberalization will increase $\frac{1}{P_k}$ as B falls, the real wage in terms of good k in Home will be improved. However, the real wage in Foreign, $\frac{1}{P^*_k}$, is not related to the trade barriers. That's, trade liberalization does not affect the real wage in Foreign.

2. Both countries produce: $k \in (k_1, k_2)$. The real wage in Home and Foreign in terms of good k are equal to:

$$\frac{1}{P_k} = (\theta_{ck})^{\frac{1}{\sigma-1}} \rho A_k \widetilde{\varphi}_{dk} = \rho A_k \left(D_1 \frac{B - B^{-1}}{B - (a_k)^{\gamma}} \right)^{\frac{1}{\gamma}} \left(\frac{\gamma}{\gamma - \sigma + 1} D_2(k) L \right)^{\frac{1}{\sigma-1}}$$
$$\frac{1}{P_k^*} = (\theta_{ck}^*)^{\frac{1}{\sigma-1}} \rho A_k^* \widetilde{\varphi}_{dk}^* = \rho A_k^* \left(D_1 \frac{B - B^{-1}}{B - (a_k)^{-\gamma}} \right)^{\frac{1}{\gamma}} \left(\frac{\gamma}{\gamma - \sigma + 1} D_2(k) L^* \right)^{\frac{1}{\sigma-1}}$$

This zone is divided into two cases:

(a) Scenario A: $(a_k)^{\gamma} < \frac{2B}{1+B^2}$.

Note that $\frac{B-B^{-1}}{B-(a_k)^{\gamma}}$ decreases but $\frac{B-B^{-1}}{B-(a_k)^{-\gamma}}$ increases as trade barrier B falls, as $(a_k)^{\gamma} < \frac{2B}{1+B^2}$. Therefore, the real wage in terms of good k in Home will decline, but the real wage in Foreign rises. This is the case with reverse-Melitz outcome in Home.

(b) Scenario B: $(a_k)^{\gamma} \in \left(\frac{2B}{1+B^2}, \frac{1+B^2}{2B} \right)$.

Since both $\frac{B-B^{-1}}{B-(a_k)^{\gamma}}$ and $\frac{B-B^{-1}}{B-(a_k)^{-\gamma}}$ increase as trade barrier B falls when $(a_k)^{\gamma} \in \left(\frac{2B}{1+B^2}, \frac{1+B^2}{2B} \right)$, the real wages in terms of good k in both countries increase in this zone.

3. Home-dominated sectors: $k \in (k_2, 1)$. Real wages in terms of good k are given by

$$\frac{1}{P_k} = (\theta_{dk})^{\frac{1}{\sigma-1}} \rho A_k \widetilde{\varphi}_{dk} = \rho A_k \left(\frac{L + L^*}{L} D_1 \right)^{\frac{1}{\gamma}} \left(\frac{\gamma}{\gamma - \sigma + 1} D_2(k) L \right)^{\frac{1}{\sigma-1}}$$
$$\frac{1}{P_k^*} = (\theta_{xk})^{\frac{1}{\sigma-1}} \rho A_k \widetilde{\varphi}_{xk} \frac{1}{\tau} = \rho A_k B^{-\frac{1}{\gamma}} \left(\frac{L + L^*}{L^*} D_1 \right)^{\frac{1}{\gamma}} \left(\frac{\gamma}{\gamma - \sigma + 1} D_2(k) L^* \right)^{\frac{1}{\sigma-1}}$$

It is clear that real wage in terms of good k in Home is unchanged but that in Foreign increases as B falls.

D Proofs of propositions

Proof of Proposition 3:

After trade liberalization, firms with productivity in the interval $\left[\overline{\varphi}_{dk,t}, \overline{\varphi}_{dk,t+1}\right]$ will exit the market between year t and year $t+1$. The probability of exit for a firm that exists at t in sector k and exits at $t+1$ is given by

$$\Pr(Exit) = \frac{\left(\overline{\varphi}_{dk,t}\right)^{-\gamma} - \left(\overline{\varphi}_{dk,t+1}\right)^{-\gamma}}{\left(\overline{\varphi}_{dk,t}\right)^{-\gamma}} = -\frac{d\left(\overline{\varphi}_{dk}\right)^{-\gamma}}{\left(\overline{\varphi}_{dk}\right)^{-\gamma}} = -d\left[\ln\left(\overline{\varphi}_{dk}\right)^{-\gamma}\right].$$

Hence, the effect of trade liberalization on the probability of the firm exiting is equal to $-\frac{d\left[\ln(\overline{\varphi}_{dk})^{-\gamma}\right]}{dB} = \frac{1+B^{-2}}{B-B^{-1}} - \frac{1}{B-(a_k)^{\gamma}}$, which decreases with a_k. Since $dB < 0$ as trade liberalizes, $\Pr(Exit)$ will be higher for firms in a sector with stronger comparative advantage. As a result, we have Proposition 3.

We use the logit model to test this proposition. We set a dummy variable to be equal to one if the firm exits the market between year t and year $t+1$ and zero otherwise, and use it as the dependent variable in the regression. Note that $d\overline{\varphi}_{dk} > 0$ (i.e. $\overline{\varphi}_{dk,t} < \overline{\varphi}_{dk,t+1}$) is required for there to be some firms exiting after trade liberalization. This is consistent with the way we construct the dummy variable.

Proof of Proposition 4:

Similarly, after trade liberalization, firms with productivity in the interval $\left[\overline{\varphi}_{xk,t+1}, \overline{\varphi}_{xk,t}\right]$ will enter the export market between year t and year $t+1$. The probability of entry into the export market at $t+1$ for a firm in sector k that does not export at t is given by

$$\Pr(\text{Export entry}) = \frac{\left(\overline{\varphi}_{xk,t+1}\right)^{-\gamma} - \left(\overline{\varphi}_{xk,t}\right)^{-\gamma}}{\left(\overline{\varphi}_{dk,t}\right)^{-\gamma} - \left(\overline{\varphi}_{xk,t}\right)^{-\gamma}} = \frac{\left(\overline{\varphi}_{xk,t}\right)^{-\gamma}}{\left(\overline{\varphi}_{dk,t}\right)^{-\gamma} - \left(\overline{\varphi}_{xk,t}\right)^{-\gamma}} d\left[\ln\left(\overline{\varphi}_{xk}\right)^{-\gamma}\right].$$

Hence, the effect of trade liberalization on the probability of a firm entering the export market is equal to $\frac{\left(\overline{\varphi}_{xk,t}\right)^{-\gamma}}{\left(\overline{\varphi}_{dk,t}\right)^{-\gamma} - \left(\overline{\varphi}_{xk,t}\right)^{-\gamma}} \frac{d\left[\ln\left(\overline{\varphi}_{xk}\right)^{-\gamma}\right]}{dB} = \frac{1}{\frac{f_x}{f}\left[\frac{B-(a_k)^{\gamma}}{(a_k)^{\gamma}-B^{-1}}\right]-1}\left(\frac{1}{B-(a_k)^{-\gamma}} - \frac{2B}{B^2-1}\right)$. Note that $d\overline{\varphi}_{xk} < 0$ is required for there to be new firms entering the export market after trade liberalization. In this case, the last expression will be negative and decreases with a_k (as its magnitude increases with a_k). As $dB < 0$, Pr(Export entry) will be higher for the firms in a sector with stronger comparative advantage. As a result, we have Proposition 4.

Again, we use the logit model to test this proposition. We set a dummy variable to be equal to one if the firm becomes exporter from year t to year $t+1$ and zero otherwise, and use it as the dependent variable in the regression.

Proof of Proposition 5:

After each firm has made its own decision about whether to exit or export following trade liberalization, the fraction of firms in sector k that export is given by $\frac{\theta_{xk}}{\theta_{dk}} = \left(\frac{\overline{\varphi}_{dk}}{\overline{\varphi}_{xk}}\right)^{\gamma} = \frac{f}{f_x}\left[\frac{(a_k)^{\gamma}-B^{-1}}{B-(a_k)^{\gamma}}\right]$. The effect of trade liberalization on this fraction is given by

$$\frac{d\left(\frac{\overline{\varphi}_{dk}}{\overline{\varphi}_{xk}}\right)^{\gamma}}{dB} = \frac{f}{f_x}\left[\frac{2B^{-1} - \left(1+B^{-2}\right)(a_k)^{\gamma}}{\left(B-(a_k)^{\gamma}\right)^2}\right] \tag{28}$$

which is negative and decreases with a_k if $(a_k)^{\gamma} > \frac{2B}{1+B^2}$. Thus we have Proposition 5.

Proof of Proposition 6:

The share of export revenue in total revenue is given by $\frac{f_x \cdot \theta_{xk}}{f \cdot \theta_{dk} + f_x \cdot \theta_{xk}} = \frac{\left(\overline{\varphi}_{xk}\right)^{-\gamma}}{\left(\overline{\varphi}_{dk}\right)^{-\gamma} f/f_x + \left(\overline{\varphi}_{xk}\right)^{-\gamma}} = \frac{(a_k)^{\gamma}-B^{-1}}{B-B^{-1}}$. The effect of trade liberalization on this share is given by

$$\frac{d\left[\frac{(a_k)^{\gamma}-B^{-1}}{B-B^{-1}}\right]}{dB} = \frac{2B^{-1} - \left(1+B^{-2}\right)(a_k)^{\gamma}}{\left(B-B^{-1}\right)^2} \tag{29}$$

which clearly decreases with a_k. Thus we have Proposition 6.

Proof of Proposition 7:

From equation (19) we can show that $\overline{\varphi}_{dk}$ increases with B (and $\overline{\varphi}_{xk}$ decreases with B according to (9)) if and only if $(a_k)^\gamma < \frac{2B}{1+B^2}$. Recall that $(a_{k_1})^\gamma = \frac{B\left(\frac{L}{L^*}+1\right)}{B^2\frac{L}{L^*}+1}$ and $(a_{k_2})^\gamma = \frac{B^2\frac{L^*}{L}+1}{B\left(\frac{L^*}{L}+1\right)}$, and compare them with the above thresholds. We can see that, starting from $L = L^*$, as L/L^* increases above one, k_1 and k_2 decrease, as shown in Figure 5. Thus, there exist some two-way trade sectors $k \in \left[k_1, \frac{2B}{1+B^2}\right]$, in which $\overline{\varphi}_{dk}$ increases with B and $\overline{\varphi}_{xk}$ decreases with B.

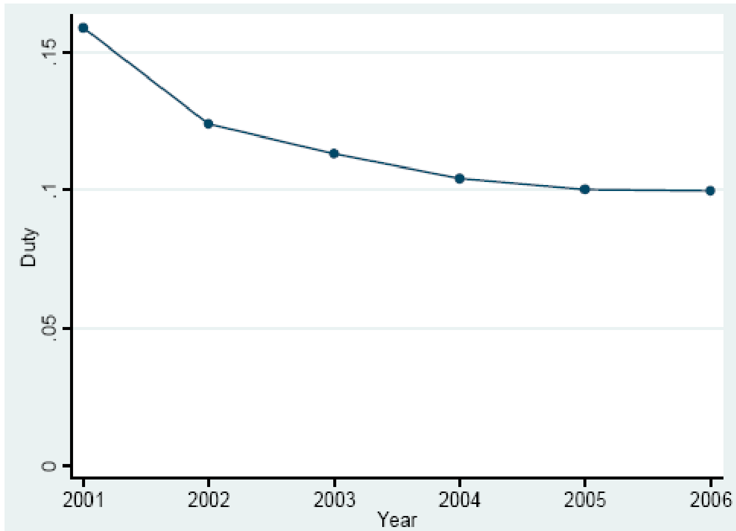
Proof of Proposition 8:

From the proof of proposition 3, we have $\frac{d\Pr(Exit)}{dB} = -\frac{d\left[\ln(\overline{\varphi}_{dk})^{-\gamma}\right]}{dB} = \frac{1+B^{-2}}{B-B^{-1}} - \frac{1}{B-(a_k)^\gamma}$, which is negative iff $(a_k)^\gamma > \frac{2B}{1+B^2}$. From the proof of proposition 4, we have $\frac{d\Pr(\text{Export entry})}{dB} = \frac{\left(\overline{\varphi}_{xk,t}\right)^{-\gamma}}{\left(\overline{\varphi}_{dk,t}\right)^{-\gamma}-\left(\overline{\varphi}_{xk,t}\right)^{-\gamma}} \frac{d\left[\ln(\overline{\varphi}_{xk})^{-\gamma}\right]}{dB} = \frac{1}{\frac{f_x}{f}\left[\frac{B-(a_k)^\gamma}{(a_k)^\gamma-B^{-1}}\right]-1} \left(\frac{1}{B-(a_k)^{-\gamma}} - \frac{2B}{B^2-1}\right)$, which is negative iff $(a_k)^\gamma > \frac{2B}{1+B^2}$. From the proof of proposition 5, we have the change of the share of exporting firms following trade liberalization $\frac{d\left(\frac{\theta_{xk}}{\theta_{dk}}\right)}{dB} = \frac{f}{f_x}\left[\frac{2B^{-1}-\left(1+B^{-2}\right)(a_k)^\gamma}{\left(B-(a_k)^\gamma\right)^2}\right]$, which is negative iff $(a_k)^\gamma > \frac{2B}{1+B^2}$. From the proof of proposition 6, we have the change of the share of export revenue in total revenue following trade liberalization equals to $\frac{d\left[\frac{(a_k)^\gamma-B^{-1}}{B-B^{-1}}\right]}{dB} = \frac{2B^{-1}-\left(1+B^{-2}\right)(a_k)^\gamma}{\left(B-B^{-1}\right)^2}$, which is negative iff $(a_k)^\gamma > \frac{2B}{1+B^2}$.

Consequently, in the sectors with the strongest comparative advantage i.e., $(a_k)^\gamma > \frac{2B}{1+B^2}$, the probability of exit, the probability of entry into the export market, the change in the share of exporting firms and the change in revenue share from exporting are all positive following trade liberalization; in the sectors with the strongest comparative disadvantage, where $(a_k)^\gamma < \frac{2B}{1+B^2}$, the probability of exit, the probability of entry into the export market are zero, while the change in share of exporting firms and the change in revenue share from exporting are negative following trade liberalization.

E The average tariff from year 2001 to year 2006

Figure A2: The average tariff from year 2001 to year 2006



F The summary statistics of RCA measures

Table 7: The summary statistics of RCA measures

	No. of Obs.	Mean	Median	Min	Max
RCA_1	2406	1.612	0.619	0.002	43.65
RCA_2	2406	0.564	0.021	-13.10	43.30
RCA_3	2406	0.266	0.413	-0.988	1.000
RCA_4	2406	15.60	1.051	0.003	6302
RCA_5	2406	19.30	4.996	-595.4	874.9
log(L/K)	2406	-4.245	-4.206	-6.718	-2.437

G Online appendix

Table 3C

	Probability of exit				Probability of entry into the exporting market			
Regressor	Logit	Logit	Logit	Logit	Logit	Logit	Logit	Logit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Yr-difference	2-yr	3-yr	4-yr	5-yr	2-yr	3-yr	4-yr	5-yr
Δduty	-1.435***	-1.407***	-1.462***	-1.479***	2.388***	1.830***	0.855**	1.229**
	(0.142)	(0.147)	(0.161)	(0.183)	(0.397)	(0.389)	(0.410)	(0.485)
Δduty×RCA	**-0.456***	**-0.530***	**-0.296***	**-0.306***	**-0.562***	**-0.284**	**-0.445**	**-0.193**
	(0.057)	(0.059)	(0.068)	(0.081)	(0.127)	(0.140)	(0.173)	(0.209)
RCA	-0.006***	-0.007***	-0.004***	-0.003	0.020***	0.016***	0.009**	0.012**
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	(0.005)
TFP	-0.178***	-0.157***	-0.161***	-0.174***	0.129***	0.160***	0.178***	0.211***
	(0.003)	(0.003)	(0.004)	(0.006)	(0.007)	(0.008)	(0.011)	(0.015)
log(Empl)	-0.289***	-0.274***	-0.269***	-0.269***	0.358***	0.369***	0.353***	0.374***
	(0.003)	(0.003)	(0.004)	(0.005)	(0.006)	(0.007)	(0.009)	(0.013)
log(K/L)	-0.095***	-0.089***	-0.083***	-0.080***	0.094***	0.127***	0.129***	0.130***
	(0.002)	(0.003)	(0.003)	(0.005)	(0.005)	(0.007)	(0.008)	(0.012)
log(Wage)	-0.322***	-0.391***	-0.452***	-0.460***	0.368***	0.419***	0.426***	0.476***
	(0.004)	(0.005)	(0.006)	(0.009)	(0.011)	(0.013)	(0.016)	(0.023)
Yr fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ind fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	641,952	429,403	271,671	131,389	452,435	303,978	193,359	94,245
Log Likelihood	-394,556	-281,935	-178,604	-85,435	-91,565	-64,582	-40,142	-19,030

Note: ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level. RCA = RCA_2

Table 4C

	Change in fraction of exporting firms				Change in share of exporting revenue			
Regressor	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Yr-difference	2-yr	3-yr	4-yr	5-yr	2-yr	3-yr	4-yr	5-yr
Δduty	-0.204**	-0.366***	-0.431***	-0.431**	-0.057	-0.096	-0.096	-0.116
	(0.101)	(0.121)	(0.144)	(0.168)	(0.111)	(0.136)	(0.159)	(0.188)
Δduty×RCA	**-0.165*****	**-0.255*****	**-0.244*****	**-0.218*****	**-0.240*****	**-0.328*****	**-0.274*****	**-0.247*****
	(0.032)	(0.039)	(0.048)	(0.058)	(0.035)	(0.044)	(0.053)	(0.065)
RCA	-0.001	-0.003***	-0.004***	-0.006***	0.001	0.001	-0.000	-0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
TFP	0.001	0.009	0.006	-0.003	-0.006	0.004	0.000	-0.006
	(0.005)	(0.007)	(0.009)	(0.014)	(0.006)	(0.008)	(0.010)	(0.016)
log(Empl)	-0.008***	-0.012***	-0.013***	-0.013***	-0.010***	-0.014***	-0.016***	-0.019***
	(0.002)	(0.002)	(0.003)	(0.004)	(0.002)	(0.002)	(0.003)	(0.005)
log(K/L)	0.004	0.004	0.003	0.000	0.031***	0.040***	0.041***	0.045***
	(0.005)	(0.007)	(0.010)	(0.015)	(0.006)	(0.008)	(0.011)	(0.016)
log(Wage)	0.013	0.006	0.006	0.024	0.006	0.008	0.010	0.032
	(0.009)	(0.012)	(0.016)	(0.022)	(0.010)	(0.014)	(0.018)	(0.025)
Yr fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ind fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,604	1,203	802	401	1,604	1,203	802	401
R-squared	0.110	0.151	0.161	0.196	0.133	0.182	0.210	0.246

Note: ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level. RCA = RCA_2

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