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Working Paper No. 05, 2017

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The Impact of Trade with Pure Exporters*

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Abstract

In the present paper we introduce heterogeneity in productivity, entry cost and demand shocks in both domestic and foreign market. Depending on their characteristics firms choose to become pure exporters, ordinary exporters or non-exporters. Pure exporters serve exclusively foreign markets, ordinary exporters both markets and non-exporters exclusively home markets. Pure exporters face lower demand-adjusted foreign entry cost than demand-adjusted domestic entry cost. Pure exporters have lower productivity than ordinary exporters and non-exporters. Therefore depending on the share of pure exporters, the effect of trade on average productivity can be positive or negative. However, the effect of trade on welfare is positive because trade increases the set of available goods. Moreover we explore the effects of trade liberalizations. In particular, a decrease of foreign entry cost across firms pushes some pure exporters and non-exporters out of the market and some ordinary exporters to become pure exporters or non-exporters. Finally, we provide the supportive empirical evidence.

Keywords Pure Exporters · Market Entry Cost · Trade Liberalization · Productivity Premium

JEL-classification F12 · F13 · L1

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*We thank Scott Baier, Jeffrey Bergstrand, Nils Braakmann, Diemo Dietrich, Francis Kiraly, Michael Koch, Gary Lyn, Sara Maioli, Hugh Metcalf, Bin Qiu, Zhihong Yu and other conference participants of GEP, Midwest international trade group, SAET, EEA and DEGIT as well as seminar participants at Newcastle University and Southeast University for helpful comments. This work is supported by the Economic and Social Research Council [ES/J500082/1].

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1 Introduction

In a dominant part of the literature on international trade it is assumed that firms serve the domestic market (non-exporters) or serve both the domestic market and the foreign market (ordinary exporters). However in many countries a large share of firms serve exclusively the foreign market (pure exporters). Naturally firm characteristics that make firms choose to be pure exporters are different from the characteristics that make firms choose to be ordinary exporters. Therefore, studies on the impact of trade that are ignoring the presence of pure exporters ignore a large part of trade. In the present paper we provide a general model of pure exporters, ordinary exporters and non-exporters and study the impact of trade in the presence of pure exporters. The results suggest that depending on the share of pure exporters the average productivity of exporters can be lower or higher than the average productivity of non-exporters. The presence of pure exporters makes the impact of trade on average productivity arbitrary. However trade increases welfare because trade increases the set of available varieties.

We consider a general equilibrium model with a continuum of heterogeneous firms in the spirit of Melitz (2003). Firms face idiosyncratic shocks with respect to productivity, entry cost for domestic as well as foreign market and demand in domestic as well as foreign market as in Eaton et al. (2011). Based on their shocks firms choose to be pure exporters, ordinary exporters, non-exporters or non-active. Hardly surprising we find that: a pure exporter faces lower demand-adjusted foreign entry cost than demand-adjusted domestic entry cost; and, its productivity allows it to earn profit in the foreign market, but not in the domestic market. It is the reverse for non-exporters. A ordinary exporter earns profit in both domestic and foreign market given its productivity and a non-active firm cannot make profit in any market. In our model, the joint distribution of productivity, entry cost for domestic and foreign market as well as demand in domestic and foreign market endogenously determines the distribution of firms.

Lower demand-adjusted foreign entry cost than demand-adjusted domestic entry cost has at least two possible sources: relatively low foreign entry cost or relatively high foreign demand. For China, provinces (and in some cases even cities) compete with other provinces and build barriers to trade to protect their own firms (Young, 2000). Therefore the domestic market is quite segmented. As a consequence Chinese firms can face relatively high domestic entry cost. Moreover firms participating in the global production fragmentation can face relatively low foreign entry costs because of their experiences or networks with foreign firms. Relatively high demand in foreign markets can happen when they locate in a small or developing country. Note that a firm with relatively high foreign demand may have lower demand-adjusted foreign entry cost than demand-adjusted domestic entry cost, even its foreign entry cost is higher than domestic entry cost.

In our model, pure exporters, ordinary exporters and non-exporters coexist. The distribution of productivity, entry cost and demand endogenously determines the share of pure exporters. In Theorem 2 we show that the average productivity of exporters can be lower than the average productivity of non-exporters. The reason is that the productivity of pure exporters is lower than productivity of non-exporters and ordinary exporters. Therefore the productivity difference between exporters and non-exporters or productivity premium is negatively related to the share of pure exporters. So if the share of pure exporters is large, then the premium will be negative. The result is surprisingly different from empirical as well as theoretical studies that neglect pure exporters. We provide supportive evidence to these results in the empirical section.

Exploring the impact of trade on equilibrium we next study a move from autarky to trade. Trade on the one hand forces firms with low productivity and high demand-adjusted foreign entry cost out of the market; and, on the other hand induces firms with even lower productivity but low demand-adjusted foreign entry cost to enter the market as pure exporters. Therefore if trade results in a large share of pure exporters, then the move from autarky to trade can lower average productivity as we show in Theorem 3. The results indicate that studying the impact of trade without considerations of pure exporters can be misleading.

We study the effects of trade liberalizations interpreted as changes of the conditional distribution of foreign entry cost and variable export cost. A decrease in foreign entry costs raises the minimum productivity needed to serve both domestic and foreign market. Therefore among firms with any given combination of demand-adjusted domestic and foreign entry costs, the least productive firms (pure exporters or non-exporters) are forced out of the market and the least productive ordinary exporters become pure exporters or non-exporters as described in Theorem 5. A decrease in variable export costs raises the minimum productivity needed to serve the domestic market and decreases the minimum productivity needed to serve the foreign market. Hence some non-exporters are forced out of the market and some non-active firms and ordinary exporters become pure exporters as described in Theorem 6. The effects of trade liberalization are channelled through labor markets, where competition for labor becomes more intensive resulting in higher real wage.

In empirical section, we provide the supportive evidence of the model. As in Defever and Riaño (2012), we define pure exporters as the exporters that sell at least 90% of their gross sales in foreign markets. Firstly we observe the pervasive existence of pure exporters across countries. In China, 11% of all firms and 40% of all exporters are pure exporters. According to the World Bank enterprise surveys in 135 countries, pure exporters account at least 7% of all firms in more than 25% of the countries, and account at least 19% (10%) of all exporters in more than 50% (75%) of the countries. In the model, the share of pure exporters depends on the distribution of firm characteristics. Therefore different distributions of firms across countries generate different shares of pure exporters. Secondly we document the non-trivial roles of pure exporters in economies. In China, pure exporters export 53% of total exports. Moreover, the average exports of pure exporters are 1.65 times of the average exports of ordinary exporters. Pure exporters account for 22% of gross sales, 33% of total employment, 14% of fixed asset and 15% of total asset of all exporters.

Thirdly we estimate the total factor productivity of Chinese firms and show that pure exporters have lower productivity than non-exporters and ordinary exporters have higher productivity than non-exporters. Controlling for firm size, the productivity of pure exporters is 1.7% lower than the productivity of non-exporters and the productivity of ordinary exporters is 1.2% higher than the productivity of non-exporters. The pattern is robust to variations in the definition of pure exporters (export at least 95%, 99% and 100% of gross sales) and in the estimation of productivity (revenue and value-added function estimated with the Olley and Pakes (1996) approach as well as value-added function estimated with Levinsohn and Petrin (2003) approach). Moreover, the pattern holds in most of the sectors. The empirically observed pattern is consistent with our model: productivity of pure exporters can be lower than productivity of non-exporters.

Fourthly we find that the productivity premium of exporters can be negative and is negatively related to the share of pure exporters as predicted by our model. In particular, the productivity premium is negative in 16 sectors out of 27 sectors and is statistically significant in 11 sectors. The simple average across these 11 sectors shows that exporters have 2% lower productivity than non-exporters. Furthermore, our estimations suggest that as the share of pure exporters is increased by 1%, the premium decreases by 0.083%. Our results also suggest if the share of pure exporters is larger than 14.5%, then the productivity premium of exporters will be negative. The results are very robust for alternative definitions of pure exporters and alternative productivity estimations.

Obviously pure exporters and processing firms are related. Processing firms simply produce final products or intermediaries for foreign firms. However, pure exporters are not necessarily processing firms and processing firms are not necessarily pure exporters. In Defever and Riaño (2012) it is found that 51.6% of processing firms are pure exporters and 37.0% of pure exporters are processing firms. In our model all firms transform inputs to outputs, so there is no role for processing firms. However, the model can potentially explain why processing firms become pure exporters because the logic behind the choice to become processing firms should be the same as the logic leading firms to become pure exporters, namely profit maximization. Since firms directly sell their production to other multinational firms that may allocate the sales across the world, they face low demand-adjusted foreign entry cost, i.e., low foreign entry cost or high foreign demand.

Lu (2010), Defever and Riaño (2012) and Lu et al. (2014) provide different theoretical explanations for the existence of Chinese pure exporters. In Lu (2010) pure exporters exist in sectors that have comparative advantage, i.e. where the locally abundant factor is intensively used. In these sectors, prices are higher in the foreign market than in the domestic market because the relative price of the locally abundant factor is higher in the foreign market. Hence competition in the foreign market is less intensive. As a result, less productive firms solely serve the foreign market and become pure exporters. However, we have documented empirically that pure exporters exist in all sectors in China. In Defever and Riaño (2012), most of the Chinese pure exporters are located in the special economic zones and are entitled to a preferential tax scheme. Therefore in their model, pure exporters sacrifice the domestic market in return for the tax advantage. However, a large share of pure exporters exist in a wide range of countries. Our model is not relying on the tax scheme, and thus can be applied to other countries. Lu et al. (2014) explain pure exporters as the exporters with large foreign demand corresponding to large foreign demand shock in our model.

There is a rich literature on productivity of exporters and non-exporters showing that exporters are more productive than non-exporters (e.g. Bernard and Jensen, 1999; Bernard et al., 2003; De Loecker, 2007; Lileeva and Trefler, 2010; and Bustos, 2011). However, using Chinese firm-level data, Lu (2010) finds that productivity of exporters (value-added per worker) is lower than productivity of non-exporters while Ma et al. (2014) find the same pattern in terms of capital labor ratio. Estimating total factor productivity, Defever and Riaño (2012) and Lu et al. (2014) find the productivity of pure exporters is higher than non-exporters while Dai et al. (2016) find the productivity of processing exporters (which highly overlap with pure exporters) is lower than productivity of non-exporters. These findings are compatible with our analysis suggesting that the average productivity of exporters compared with the average productivity of non-exporters depends on the share of pure exporters, and the average productivity of pure exporters compared with the average productivity of non-exporters depends on the entry costs and demand shocks of the markets.

A large and established literature has documented that trade forces the least productive firms to exit markets leading to increased overall productivity (e.g. Pavcnik, 2002; Melitz, 2003; Trefler, 2004; Bernard et al., 2011; Melitz and Ottaviano, 2008; Mayer et al., 2014). The finding is compatible with our model provided the distribution of firm characteristics results in a small share of pure exporters. The paper also contributes to the literature on firm heterogeneity beyond productivity, e.g. entry costs (Jørgensen and Schröder, 2008; Das et al., 2007; Arkolakis, 2010; Krautheim, 2012; Kasahara and Lapham, 2013). Eaton et al. (2011) also introduces heterogeneity in entry costs aand demand shocks, but they focus on the pattern of firm entry and sales across foreign markets. We focus on the choice of which markets to serve and study the impact of trade on average productivity and firm exit and entry in the presence of pure exporters.

The rest of this paper is organized as follows. Section 2 is the set up of the model. In section 3 we describe the equilibrium. In section 4 we explore the effects of trade liberalization. Section 5 is the supportive evidence of our model. Section 6 is the conclusion.

2 Set Up

We consider an economy with two identical countries. Labor is the only input factor of firms and fixed in both countries. Consumers and firms face domestic and foreign market. Firms pay entry cost whereby they learn their characteristics. Based on these characteristics they choose to serve the domestic market, foreign market or both markets. Firms have to pay entry cost to enter domestic or foreign market. There are demand shocks in both markets. At every date a share of the firms die but the same amount of new firms successfully enter. There is a dynamic process of firm entry and exit to keep the distribution of firms stationary. Therefore profit is zero in the equilibrium.

2.1 Commodities

There are labor and a continuum of goods. Let Ω be the set of goods with $\omega \in \Omega$. The price of labor (wage) is normalized to one.

2.2 Consumers

There is a continuum of identical consumers with mass one in both countries. Every consumer has one unit of labor, that is supplied inelastically, and a CES utility function:

$$U((q(\omega))_{\omega\in\Omega}) \;=\; \left(\int_{\omega\in\Omega} [A(\omega)q(\omega)\,]^{\rho}\,\mathrm{d}\omega\right)^{\frac{1}{\rho}}$$

with $0<\rho<1$. For every good ω all consumers in a country have the same demand shock $A(\omega)$, but consumers in different countries can have different demand shocks. In addition, consumers have shares in firms. However, since there is free entry, average profit of firms is zero so ownership of firms can be disregarded. The problem of a consumer is to maximize utility subject to the budget constraint.

Let $\sigma = 1/(1-\rho)$ so $\sigma > 1$ because $0<\rho<1$. The price index P and the quantity index Q are defined as follows:

$$P \;=\; \left(\int_{\omega\in\Omega} [\frac{p(\omega)}{A(\omega)}\,]^{1-\sigma}\mathrm{d}\omega\right)^{\frac{1}{1-\sigma}} \text{ and } Q \;=\; \left(\int_{\omega\in\Omega} [A(\omega)q(\omega)\,]^{\rho}\,\mathrm{d}\omega\right)^{\frac{1}{\rho}}.$$

The solution to the consumer problem derives the aggregate demand $q(\omega)_{\omega\in\Omega}$:

$$q(\omega) \;= A(\omega)^{\sigma-1}\,Q\left(\frac{p(\omega)}{P}\right)^{-\sigma}. \tag{1}$$

Let $r(\omega) = p(\omega)q(\omega)$ for all ω and $R = PQ = \int_{\omega\in\Omega} r(\omega)\,\mathrm{d}\omega$.

2.3 Firms

Firm ω uses labor to produce good ω. Firms face identical entry cost $F_e > 0$. If a firm enters, then its cost parameters and demand shocks are revealed. The cost parameters and demand shocks are $(\varphi, F_d, F_x, A_d, A_x)$ where: φ is the productivity; F_d the domestic entry cost; F_x the foreign entry cost; A_d demand shock in the domestic market; and A_x demand shock in the foreign market. Therefore a firm is characterized by its productivity, market entry costs and demand shocks $(\varphi, F_d, F_x, A_d, A_x)$. We assume that the parameters are drawn from a common probability distribution with density $\xi : \mathbb{R}^5_+ \to \mathbb{R}_{++}$ and cumulative distribution $\Xi : \mathbb{R}^5_+ \to [0,1]$.

There is a continuum of active firms. Let Ω be the set of active firms with $\omega \in \Omega$.

Production

Every firm has probability $\delta > 0$ of dying at every date. Let $f_d = \delta F_d$ and $f_x = \delta F_x$ be the amortized per date market entry costs. In the sequel we use amortized per date market entry costs and calculate profit per date rather than market entry costs and expected lifetime profit. Clearly the density $\lambda : \mathbb{R}^5_+ \to \mathbb{R}_{++}$ on productivity, amortized entry costs and demand shocks is defined by $\lambda(\varphi, f_d, f_x, A_d, A_x) = \xi(\varphi, f_d/\delta, f_x/\delta, A_d, A_x)$ with cumulative distribution $\Lambda(\varphi, f_d, f_x, A_d, A_x) = \Xi(\varphi, f_d/\delta, f_x/\delta, A_d, A_x)$.

In order to supply $q > 0$ units of good ω to the domestic market the firm uses $f_d + q/\varphi$ units of labor. There is a variable export cost $\tau \geq 1$, so in order to supply $q > 0$ units of the good to the export market the firm uses $f_x + q\tau/\varphi$ units of labor.

There is monopolistic competition in both countries. Therefore for given price and quantity indices, every firm faces the demand function described in (1). A firm supplying the domestic market maximizes its profit on that market:

$$\max_p \; pA_d^{\sigma-1} Q \left(\frac{p}{P}\right)^{-\sigma} - \frac{1}{\varphi} A_d^{\sigma-1} Q \left(\frac{p}{P}\right)^{-\sigma}$$

The solution is $p_d(\varphi) = 1/(\rho\varphi)$, the total revenue is $r_d(P, \varphi, A_d) = R(PA_d\rho\varphi)^{\sigma-1}$ and the profit is $\pi_d(P, \varphi, f_d, A_d) = r_d(P, \varphi, A_d)/\sigma - f_d$. A firm supplying the foreign market maximizes its profit on that market:

$$\max_p \; pA_x^{\sigma-1} Q \left(\frac{p}{P}\right)^{-\sigma} - \frac{\tau}{\varphi} A_x^{\sigma-1} Q \left(\frac{p}{P}\right)^{-\sigma}$$

The solution is $p_x(\varphi) = \tau/(\rho\varphi)$, the total revenue is $r_x(P, \varphi, A_x) = R(PA_x\rho\varphi/\tau)^{\sigma-1}$ and the profit is $\pi_x(P, \varphi, f_x, A_x) = r_x(P, \varphi, A_x)/\sigma - f_x$.

Behavior

Firms can be: non-active firms; non-exporters; ordinary exporters; or, pure exporters. For every combination of market entry cost and demand shock (f_i, A_i), there is a pair of cut-off productivities $\varphi_i^*(P, f_i, A_i)$ with $i \in \{d, x\}$ such that a firm is active in market i if and only if $\varphi \geq \varphi_i^*(P, f_i, A_i)$. The cut-off productivities are determined by $\pi_i(P, \varphi_i^*, f_i, A_i) = 0$. Therefore for $\Theta = (\sigma/R)^{1/(\sigma-1)}/\rho$ the cut-off productivities are:

$$\begin{cases} \varphi_d^*(P, f_d, A_d) &= \dfrac{\Theta}{P} \dfrac{f_d^{1/(\sigma-1)}}{A_d} \\ \varphi_x^*(P, f_x, A_x) &= \dfrac{\tau\Theta}{P} \dfrac{f_x^{1/(\sigma-1)}}{A_x}. \end{cases} \tag{2}$$

Hence the behavior of a firm $(\varphi, f_d, f_x, A_d, A_x)$ can be characterized as follows:

Non-active firm: A firm is non-active provided

$$\varphi < \varphi_d^*(P, f_d, A_d) \text{ and } \varphi < \varphi_x^*(P, f_x, A_x).$$

Non-exporter: A firm is a non-exporter provided

$$\varphi_d^*(P, f_d, A_d) < \varphi < \varphi_x^*(P, f_x, A_x).$$

Ordinary exporter: A firm is an ordinary exporter provided

$$\varphi > \varphi_d^*(P, f_d, A_d) \text{ and } \varphi > \varphi_x^*(P, f_x, A_x).$$

Pure exporter: A firm is a pure exporter provided

$$\varphi_x^*(P, f_x, A_x) < \varphi < \varphi_d^*(P, f_d, A_d).$$

Equation (2) shows that cut-off productivities are linear in demand-adjusted market entry costs $z_i = f_i^{1/(\sigma-1)}/A_i$ with $i \in \{d, x\}$. For a pure exporter, $\varphi_x^*(P, f_x, A_x) < \varphi_d^*(P, f_d, A_d)$ means $\tau z_x < z_d$. Therefore a pure exporters faces lower demand-adjusted foreign entry cost than demand-adjusted domestic entry cost. Lower demand-adjusted foreign entry cost than demand-adjusted domestic entry cost has at least two possible sources: relatively low foreign entry cost $f_x < f_d$ or relatively high demand in foreign markets $A_x > A_d$. Take China as en example, provinces (and in some cases even cities) compete with other provinces and build barriers to trade to protect their firms (Young, 2000). Therefore the domestic market is quite segmented. As a consequence Chinese firms can face relatively high domestic entry cost. Moreover firms participating in the global production fragmentation can face relatively low foreign entry costs because of their experiences or the networks with foreign firms. Relatively high demand in foreign markets can happen when they locate in a small or developing country. If a firm has relatively higher foreign demand than domestic demand, it may have lower demand-adjusted foreign entry cost than demand-adjusted domestic entry cost even the foreign entry cost is higher than domestic entry cost. For a pure exporter, its productivity allows it to earn profit in the foreign market, but not in the domestic market. It is the reverse for non-exporters. A ordinary exporter earns profit in both domestic and foreign market given its productivity and a non-active firm cannot make profit in any market. Figure 1 illustrates the different kinds of behavior in the demand-adjusted market entry costs and productivity space. There are two hyperplanes of cut-off productivities defined by $\varphi = \varphi_d^*(P, f_d, A_d)$ and $\varphi = \varphi_x^*(P, f_x, A_x)$ as in equation (2). The two planes divide the space into four parts: non-exporters (NE), ordinary exporters (OE), pure exporters (PE) and non-active firms (N).

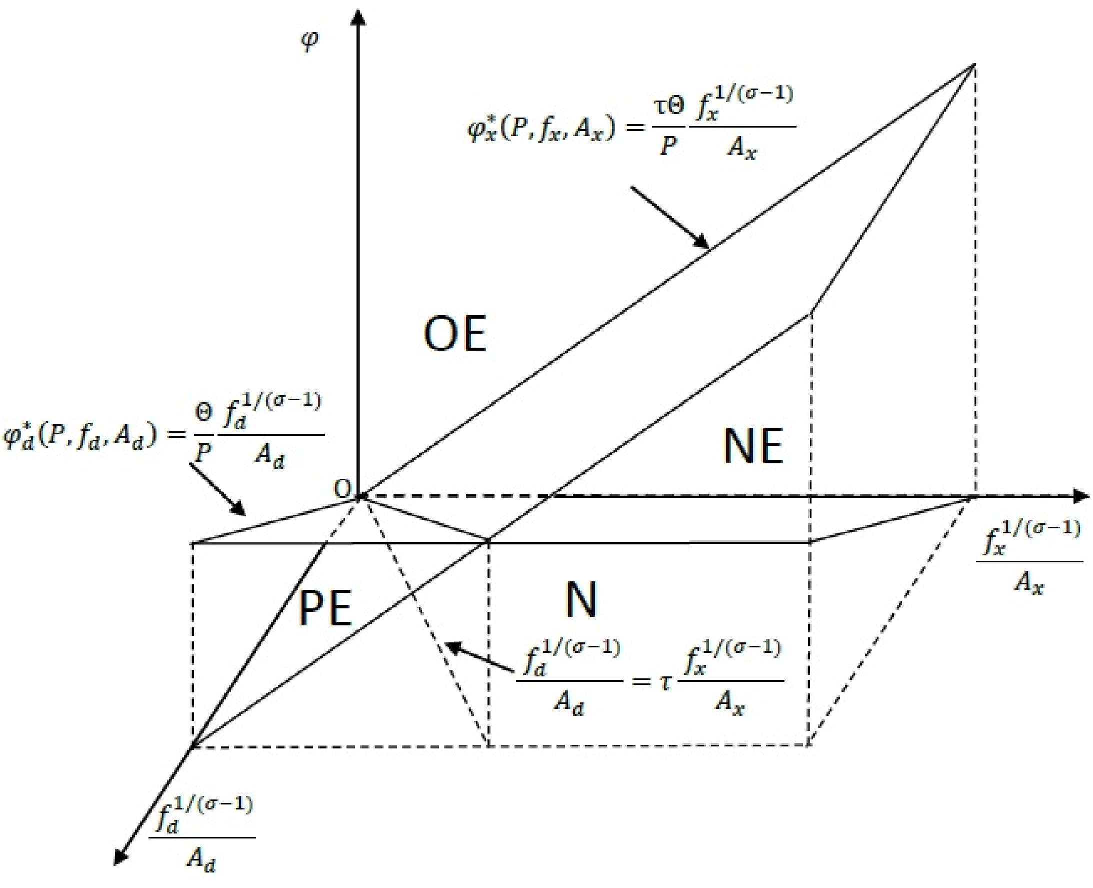


Figure 1: Firm behavior based on market entry costs and demand shocks

Behavior is illustrated in Figure 2 for given demand-adjusted market entry costs: in Figure 2.a for given demand-adjusted domestic entry cost; and in Figure 2.b for given demand-adjusted foreign entry cost. For given demand-adjusted domestic entry cost, pure exporters are characterized by low productivity and low demand-adjusted foreign entry cost. Indeed pure exporters have lower productivity than non-exporters. For given demand-adjusted foreign entry cost, pure exporters are characterized by higher productivity and demand-adjusted domestic entry cost than non-exporters. This suggests that pure exporters are different from ordinary exporters in terms of productivity.

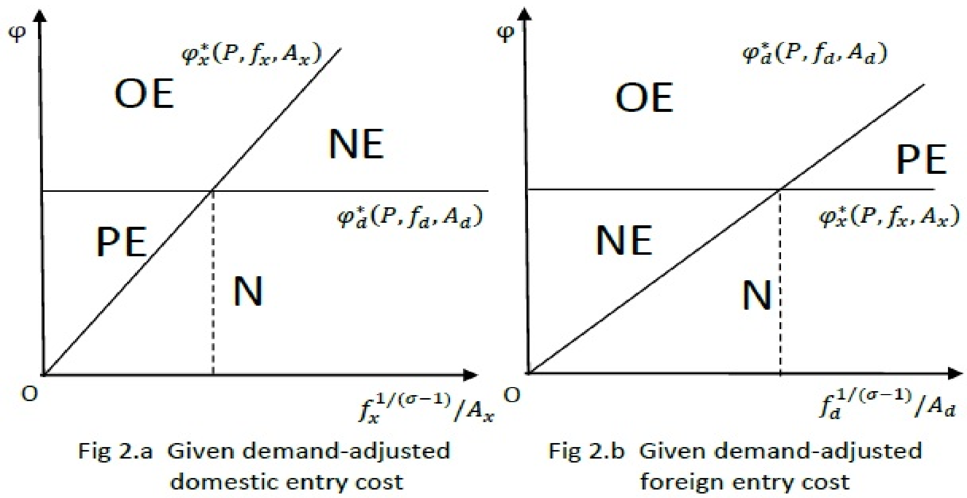


Figure 2: Firm behavior for given demand-adjusted market entry cost

Firm Entry and Exit

At every date a fraction δ of firms die, making the expected profit of entry positive. New firms enter until the last entrant earns zero profit. Since there is an unlimited amount of potential entrants, the dead firms are replaced by new firms. Therefore entry and exit do not affect the distribution of firms.

2.4 Stationary Equilibrium

We consider a stationary equilibrium where all aggregate variables are constant over time. In equilibrium consumers maximize their utilities, firms maximize their profits and markets clear. Since there is free entry, the expected lifetime profit of firms is equal to the entry cost. Let Π be the expected profit per date, then the *zero profit condition* is:

$$\frac{\Pi}{\delta} = F_e. \tag{3}$$

3 Equilibrium

There is a unique equilibrium in which all aggregate variables are constant over time.

Theorem 1 *There is a unique equilibrium.*

Proof: Let $\eta = (f_d, f_x, A_d, A_x)$ to ease notation. For price index P and parameters (φ, η) let $\pi(P, \varphi, \eta)$ be the profit per date. Then the expected profit per date is:

$$\Pi(P) \;=\; \int_{\varphi,\eta} \pi(P, \varphi, \eta)\,\lambda(\varphi, \eta)\,\mathrm{d}(\varphi, \eta) \;=\; \int_{\eta} \pi(P\,|\,\eta)\,\lambda(\eta)\,\mathrm{d}\eta \tag{4}$$

where $\lambda(\eta) = \int_{\varphi} \lambda(\varphi, \eta)\,\mathrm{d}\varphi$ is the marginal density of η and $\pi(P\,|\,\eta) = \int_{\varphi} \pi(P, \varphi, \eta)\,\lambda(\varphi\,|\,\eta)\,\mathrm{d}\varphi$ is expected profit conditional on η. $\lambda(\varphi\,|\,\eta) = \lambda(\varphi, \eta)/\lambda(\eta)$ is the distribution of productivity conditional on η. The profit $\pi(P, \varphi, \eta)$ consists of profit from the domestic market $\pi_d(P, \varphi, f_d, A_d)$ and profit from the foreign market $\pi_x(P, \varphi, f_x, A_x)$:

$$\pi(P\,|\,\eta) \;=\; \int_{\varphi_d^*(P, f_d, A_d)}^{\infty} \pi_d(P, \varphi, f_d, A_d)\,\lambda(\varphi\,|\,\eta)\,\mathrm{d}\varphi + \int_{\varphi_x^*(P, f_x, A_x)}^{\infty} \pi_x(P, \varphi, f_x, A_x)\,\lambda(\varphi\,|\,\eta)\,\mathrm{d}\varphi \tag{5}$$

Therefore for $\Phi : \mathbb{R}_+ \to \mathbb{R}_+$ and $k : \mathbb{R}_+ \to \mathbb{R}_+$ defined by

$$\Phi(x) = \left(\frac{1}{1 - \Lambda(x\,|\,\eta)} \int_x^{\infty} \varphi^{\sigma-1} \lambda(\varphi\,|\,\eta)\,\mathrm{d}\varphi \right)^{\frac{1}{\sigma-1}} \tag{6}$$

$$k(x) = (1 - \Lambda(x\,|\,\eta)) \left(\left(\frac{\Phi(x)}{x} \right)^{\sigma-1} - 1 \right) \tag{7}$$

where $\Lambda(x\,|\,\eta)$ is conditional cumulative distribution, the expected profit conditional on η is

$$\pi(P\,|\,\eta) = f_d k(\varphi_d^*(P, f_d, A_d)) + f_x k(\varphi_x^*(P, f_x, A_x)) \tag{8}$$

Then we prove that $\Pi(P)$ is an increasing function of P. From equation (6) and (7), $k'(x) = (1-\sigma) \int_x^{\infty} \varphi^{\sigma-1} \lambda(\varphi\,|\,\eta)\,\mathrm{d}\varphi / x^{\sigma} < 0$. According to Equation (2), the derivatives of the cut-off productivities with respect to P are negative, i.e. $\partial \varphi_d^*(P, f_d, A_d)/\partial P < 0$ and $\partial \varphi_x^*(P, f_x, A_x)/\partial P < 0$. Hence $\pi'(P\,|\,\eta) > 0$ so $\Pi'(P) > 0$. Moreover $\lim_{P\to 0} \Pi(P) = 0$ and $\lim_{P\to\infty} \Pi(P) = \infty$. Thus there is a unique P such that Equation (3) is satisfied. □

Corollary 1 *In equilibrium non-exporters, pure exporters and ordinary exporters co-exist.*

Given the distribution $\lambda(\varphi, \eta)$ where $\eta = (f_d, f_x, A_d, A_x)$, the firms which can afford both demand-adjusted domestic and foreign entry costs will become ordinary exporters. The firms that can only cover demand-adjusted domestic entry cost will become non-exporters, while those that are only able to cover demand-adjusted foreign entry cost will be pure exporters. Pure exporters present due to either relatively lower foreign entry cost than domestic entry cost and (or) higher foreign demand than domestic demand. Figure 1 has illustrated all the combinations of parameters for different firm behavior.

Clearly all endogenous variables, including the share of non-exporters, ordinary exporters and pure exporters are determined in equilibrium (See Appendix 1 for full details). The profit earned by incumbents is equal to the entry cost of the entrants, therefore the total revenue is equal to the total labor $R = L$. The total revenue is fixed as the total labor.

Figure 1 shows that some pure exporters have lower productivity than non-exporters. Whether the average productivity of exporters is higher or lower than the average productivity of non-exporters depends on the share of pure exporters, which is further determined by the distribution of firms. In Theorem 2 we show by use of an example that the average productivity of exporters can be lower than the average productivity of non-exporters.

Theorem 2 *Average productivity of exporters, consisting of ordinary exporters and pure exporters, can be lower than average productivity of non-exporters.*

Proof: To quantitatively see that the average productivity of exporters can be lower than non-exporters, we simplify the calculation by using a specific form of the distribution as an example. Assume a distribution $\lambda(\varphi,\eta)$ such that 1) marginal density distribution of productivity φ is $g(\varphi)$, 2) demand-adjusted foreign entry cost z_x is under distribution $\gamma(z_x)$ and 3) demand-adjusted domestic entry cost z_d is under distribution $\psi(z_d)$.

As widely used, productivity distribution is Pareto distribution on $(\underline{\varphi},\infty)$, with density distribution $g(\varphi) = \theta\underline{\varphi}^{\theta}\varphi^{-\theta-1}$ and cumulative distribution $G(\varphi)$, where $\underline{\varphi}$ is assumed very small and $\theta > 1$. We also assume that distribution $\gamma(z_x) = \beta {Z_x}^{\beta} z_x^{-\beta-1}$ with support on (Z_x,∞) and $\psi(z_d) = \beta {Z_d}^{\alpha} z_d^{-\alpha-1}$ with support on (Z_d,∞), $\beta > 1$ and $\alpha > 1$. Assume $\tau Z_x < Z_d$. These distributions tend to give a high share of pure exporters, thereby more likely giving lower average productivity of exporters than non-exporters. Then in the equilibrium, average productivity of exporters and non-exporters are (see appendix 2 for proof):

$$\Psi_e = \frac{\theta}{\theta-1}\frac{\theta+\beta}{\theta+\beta-1}\frac{\Theta}{P}\tau Z_x$$

$$\Psi_{ne} = \frac{\theta+\beta}{\theta+\beta-1}\frac{\theta+\beta+\alpha}{\theta+\beta+\alpha-1}\cdot\frac{\Theta}{P}Z_d$$

Therefore, the ratio between average productivity of exporters and non-exporters is:

$$\frac{\Psi_e}{\Psi_{ne}} = \frac{\theta}{\theta-1}\cdot\frac{\theta+\beta+\alpha-1}{\theta+\beta+\alpha}\cdot\frac{\tau Z_x}{Z_d}.$$

The ratio is an increasing function with $\tau Z_x/Z_d$. And we can see:

$$\frac{\Psi_e}{\Psi_{ne}} < 1 \text{ provided } \frac{\tau Z_x}{Z_d} < \frac{1+(\beta+\alpha)/\theta}{1+(\beta+\alpha)/(\theta-1)} < 1.$$

The share of pure exporters is a decreasing function of the ratio Z_x/Z_d. The reason is that the lower Z_x/Z_d is, the more are firms with relative lower demand-adjusted foreign entry cost than demand-adjusted domestic entry cost. Therefore there are distributions such that average productivity of exporters is lower than average productivity of non-exporters. □

Theorem 2 is surprisingly different from studies that neglect pure exporters. The productivity difference between exporters and non-exporters, i.e. productivity premium, is negatively related to the share of pure exporters. The larger the share of pure exporters, the lower the productivity premium. If the share of pure exporters is sufficiently large, then the premium will be negative. We provide supportive evidence to these results in the empirical section.

4 Trade Liberalization

4.1 From Autarky to Trade

In autarky, all firms are non-exporters by definition, therefore foreign entry cost and foreign demand shock play no role on firms' profit and cut-off productivity. In order to do comparative study between autarky and trade, we firstly prove a unique equilibrium in autarky and lower price index with trade than in autarky. To see that, the average profit of firms conditional on η in autarky is determined as:

$$\pi(P_a\,|\,\eta) = \int_{\varphi_d^*(P_a,f_d,A_d)}^{\infty} \pi_d(P_a,\varphi,f_d,A_d)\,\lambda(\varphi\,|\,\eta)\,\mathrm{d}\varphi = f_d k(\varphi_d^*(P_a,f_d,A_d))$$

where P_a is the price level in autarky. The expected profit in autarky $\Pi(P_a)$ is :

$$\Pi(P_a) = \int_{\eta} f_d k(\varphi_d^*(P_a,f_d,A_d))\,\lambda(\eta)\mathrm{d}\eta \tag{9}$$

Since $k'(\cdot) < 0$ and $\varphi_d^*(P_a,f_d,A_d)$ is monotonically decreasing with P_a, $\Pi(P_a)$ is an increasing function. $\lim_{P_a\to 0}\Pi(P_a) = 0$ and $\lim_{P_a\to\infty}\Pi(P_a) = \infty$. Therefore according to equilibrium equation (3), there is a unique price level P_a.

The expected profit in autarky $\Pi(P_a)$ in equation (9) is less than the expected profit with trade $\Pi(P)$ determined by equations (4) and (5). Since $\Pi(\cdot)$ is a monotonically increasing function, we have $P < P_a$.

Because $P < P_a$, the cut-off productivity for the domestic market in equation (2) become higher with trade than in autarky. Therefore the plane $\varphi_d^*(P_a, f_d, A_d)$ is underneath the plane $\varphi_d^*(P, f_d, A_d)$ as shown in Figure 3. From Figure 3, we see trade not only forces the low productive firms with relatively high demand-adjusted foreign entry cost ($\tau z_x > z_d$) out of the market, as shown in O space, but also induces the less productive firms with relatively low demand-adjusted foreign entry cost ($\tau z_x < z_d$) into the market as pure exporters, shown as in PE space. The effect of trade on average productivity can be positive or negative. In particular, if the share of pure exporters is large, the effect can be negative.

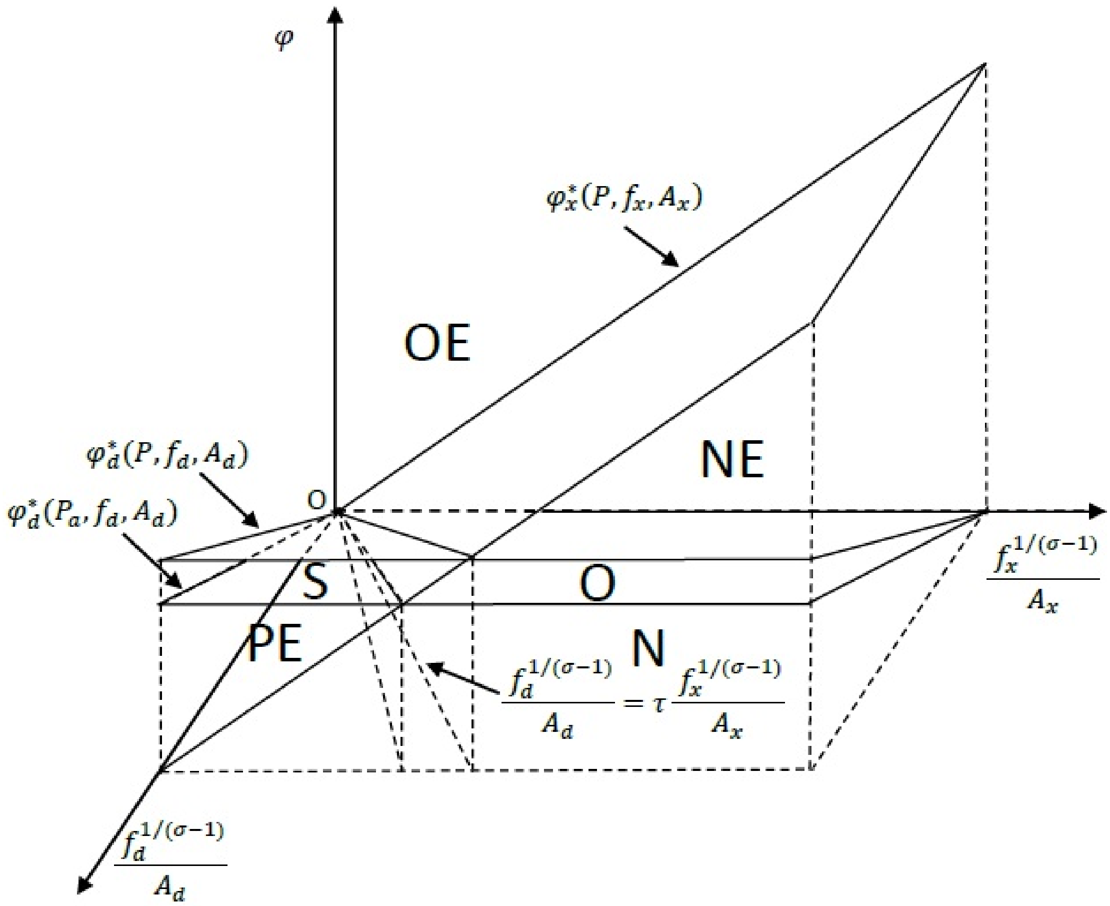


Figure 3: Firm behavior from autarky to trade

Theorem 3 *Moving from autarky to trade can lower average productivity.*

Proof: Using the same distributions of productivity and demand-adjusted market entry costs as in the proof in Theorem 2, the average productivities in autarky and trade are (see appendix 3 for proof):

$$\Psi_a = \frac{\theta}{\theta-1} \cdot \frac{\theta+\alpha}{\theta+\alpha-1} \cdot \frac{\Theta}{P_a} \cdot Z_d$$

$$\Psi = \frac{\theta}{\theta-1} \cdot \frac{\theta+\beta}{\theta+\beta-1} \cdot \frac{\frac{\alpha(\theta-1)}{\theta+\beta+\alpha-1} Z_d (\frac{\tau Z_x}{Z_d})^{\theta+\beta} + \beta \tau Z_x}{\frac{\alpha\theta}{\theta+\beta+\alpha} (\frac{\tau Z_x}{Z_d})^{\theta+\beta} + \beta} \cdot \frac{\Theta}{P}$$

Therefore the ratio between overall productivity after trade and autarky is:

$$\frac{\Psi}{\Psi_a} = \frac{\theta+\beta}{\theta+\beta-1} \frac{\theta+\alpha-1}{\theta+\alpha} \frac{\frac{\alpha(\theta-1)}{\theta+\beta+\alpha-1} (\frac{\tau Z_x}{Z_d})^{\theta+\beta} + \beta (\frac{\tau Z_x}{Z_d})}{\frac{\alpha\theta}{\theta+\beta+\alpha} (\frac{\tau Z_x}{Z_d})^{\theta+\beta} + \beta} \cdot \frac{P_a}{P}$$

It is straightforward that

$$\lim_{\tau Z_x / Z_d \to 0} \frac{\Psi}{\Psi_a} = 0$$

As $\tau Z_x / Z_d$ becomes lower, the share of pure exporters becomes higher, leading to lower overall productivity with trade than in autarky. Because P_a/P is larger than 1, average productivity after trade can easily be higher than in autarky as the share of pure exporters decreases. □

With trade the competition for labor is more intensive than in autarky. Therefore the real wage is higher with trade than in autarky. As shown in Figure 3, medium productive firms can afford the new wage and will serve the domestic market solely (NE). High productive firms will serve both markets (OE). Low productive firms cannot afford demand-adjusted domestic entry cost because of the high wage. Hence part of them are pushed out of the market (O), while rest of them are pushed to become pure-exporters because of low demand-adjusted foreign entry cost (S). Furthermore, some non-active firms with low demand-adjusted foreign entry cost are induced into the market as pure-exporters (PE). The effect of moving from autarky to trade on productivity is ambiguous. The outcome depends on distribution $\lambda(\varphi, \eta)$, which determines the portfolio of firms that are pushed out of and induced into the market. Theorem 3 is a surprise indicating that the impact of trade without considerations of pure exporters can be misleading.

Theorem 4 *Moving from autarky to trade increases welfare.*

Proof: Welfare, equal to utility, is defined as:

$$W = \frac{R}{PL} = \frac{1}{P}$$

Welfare in autarky W_a and with trade W are:

$$W_a = \frac{1}{P_a} \text{ and } W = \frac{1}{P} \tag{10}$$

From the inequality $P < P_a$, it follows that $W_a < W$. $\square$

The effect of trade on the average productivity can be positive or negative, but the welfare gains from trade is positive. This indicates that the dominant source of trade gains here is the access to more varieties.

4.2 A Decrease in Foreign Entry Cost

Trade liberalization in form of lower foreign entry cost can be interpreted as a change of the conditional distribution of foreign entry cost. An example is the enlargement of EU in 2004 that standardized the regulatory environment for a lot of European firms leading to lower foreign entry cost. Figure 4.a illustrates a possible decrease in foreign entry cost.

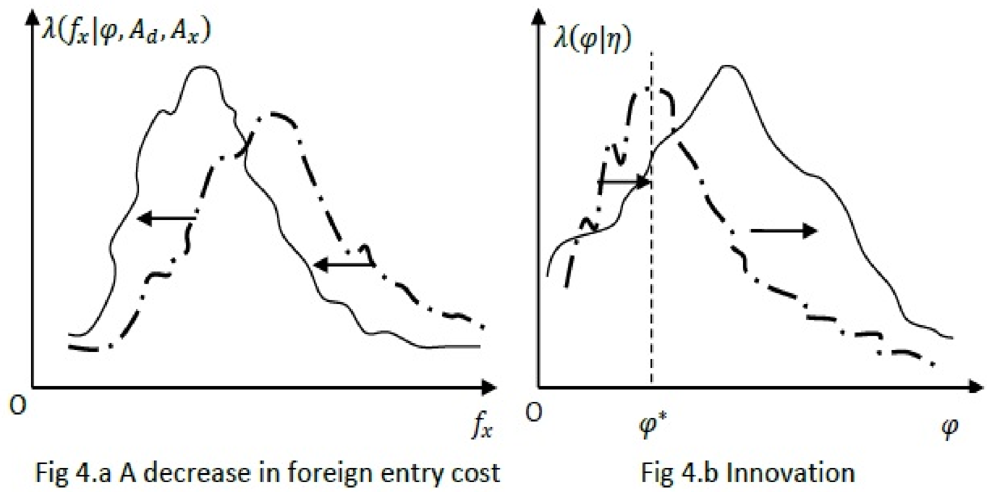


Figure 4: Shift of distributions

In order to analyse the effects of a decrease in foreign entry cost, we assume that for two distributions of characteristics, the conditional distributions of foreign entry cost f_x on (φ, A_d, A_x) can be ranked by first-order stochastic dominance:

Lower Foreign Entry Cost (LFEC): *For two distributions of characteristics* λ *and* λ'*,* λ *has lower foreign entry cost than* λ' *provided* $\Lambda(f_x \,|\, \varphi, A_d, A_x) \geq \Lambda'(f_x \,|\, \varphi, A_d, A_x)$ *for all* (φ, η).

With LFEC, the effects of a decrease in foreign entry cost are summarized as in following theorem.

Theorem 5 *Suppose λ has lower lower foreign entry cost than λ'. Then a change from λ' to λ forces some pure exporters and non-exporters out of the market and induces some ordinary exporters to become pure exporters or non-exporters.*

Proof: Instead of cut-off productivities $\varphi_i^*(P,f_i,A_i)$, $\pi_i(P,\varphi,f_i,A_i)=0$ can alternatively determine cut-off market entry costs $f_i^*(P,\varphi,A_i)$, $i\in\{d,x\}$. In particular, $f_d^*(P,\varphi,A_d)=(PA_d\varphi/\Theta)^{\sigma-1}$ and $f_x^*(P,\varphi,A_x)=(PA_x\varphi/(\Theta\tau))^{\sigma-1}$. Then the firms with market entry cost lower than the cut-off will serve that market. The profit in the domestic and foreign market are $\pi_d(P,\varphi,f_d,A_d)=f_d^*(P,\varphi,A_d)-f_d$ and $\pi_x(P,\varphi,f_x,A_x)=f_x^*(P,\varphi,A_x)-f_x$ respectively.

Let $\lambda(\varphi,A_d,A_x)=\int_{f_d,f_x}\lambda(\varphi,\eta)\mathrm{d}(f_d,f_x)$ be the marginal distribution and $\pi(P\,|\,\varphi,A_d,A_x)$ conditional profit on (φ,A_d,A_x), then the expected profit determined as in equation (4) can be expressed alternatively as

$$\Pi(P)=\int_{\varphi,A_d,A_x}\pi(P\,|\,\varphi,A_d,A_x)\lambda(\varphi,A_d,A_x)\,\mathrm{d}(\varphi,A_d,A_x)$$

Let $\lambda(f_d\,|\,\varphi,A_d,A_x)=\int_{f_x}\lambda(\varphi,\eta)\mathrm{d}f_x/\lambda(\varphi,A_d,A_x)$ be the conditional distribution of domestic entry cost on (φ,A_d,A_x) and $\lambda(f_x\,|\,\varphi,A_d,A_x)=\int_{f_d}\lambda(\varphi,\eta)\mathrm{d}f_d/\lambda(\varphi,A_d,A_x)$ conditional distribution of foreign entry cost.

$$\begin{aligned}\pi(P\,|\,\varphi,A_d,A_x) &= \int_0^{f_d^*(P,\varphi,A_d)}(f_d^*(P,\varphi,A_d)-f_d)\lambda(f_d\,|\,\varphi,A_d,A_x)\mathrm{d}f_d\\ &\quad+\int_0^{f_x^*(P,\varphi,A_x)}(f_x^*(P,\varphi,A_x)-f_x)\lambda(f_x\,|\,\varphi,A_d,A_x)\mathrm{d}f_x\end{aligned}$$

Here a decrease in foreign entry cost will shift conditional distribution $\lambda(f_x\,|\,\varphi,A_d,A_x)$ while leaving $\lambda(f_d\,|\,\varphi,A_d,A_x)$ and $\lambda(\varphi,A_d,A_x)$ unchanged. With property LFEC, the decrease of foreign entry cost will increase the conditional profit $\pi(P\,|\,\varphi,A_d,A_x)$ (See Appendix 4). As a result, $\Pi(P)$ is higher. We have shown that $\Pi(P)$ is an monotonically increasing function. Therefore price level P is decreased, leading to higher cut-off productivity for both domestic and foreign market. As shown in Figure 5, among firms for any given combination of demand-adjusted domestic and foreign entry cost, the least productive firms (pure exporters or non-exporters) are pushed out of the market, while the least productive ordinary exporters become pure exporters or non-exporters. □

A decrease in foreign entry cost across firms raises average profit and intensifies the competition for labor. Hence real wage is increased. As a result, some low productive non-exporters and pure exporters are pushed out of the market and some ordinary exporters are pushed out of the non-profitable market. After a decrease in foreign entry cost, average productivity is increased as some low productive firms are pushed out of the market. Meanwhile, according to equation (10), welfare is improved because price level P is decreased.

We also find that innovation in form of higher productivity across firms has the same effects as a decrease of foreign entry cost in Theorem 5 (See appendix 5). Innovation can be interpreted as a change of the conditional distribution of productivity. An example is the digitalization starting in the 1980s. Figure 4.b illustrates a possible increase in productivity. Innovation will increase the average productivity of incumbents and increase the average profit, thereby intensifying the competition for labor. Real wage is increased as well. Therefore the effects are the same with a decrease in foreign entry cost.

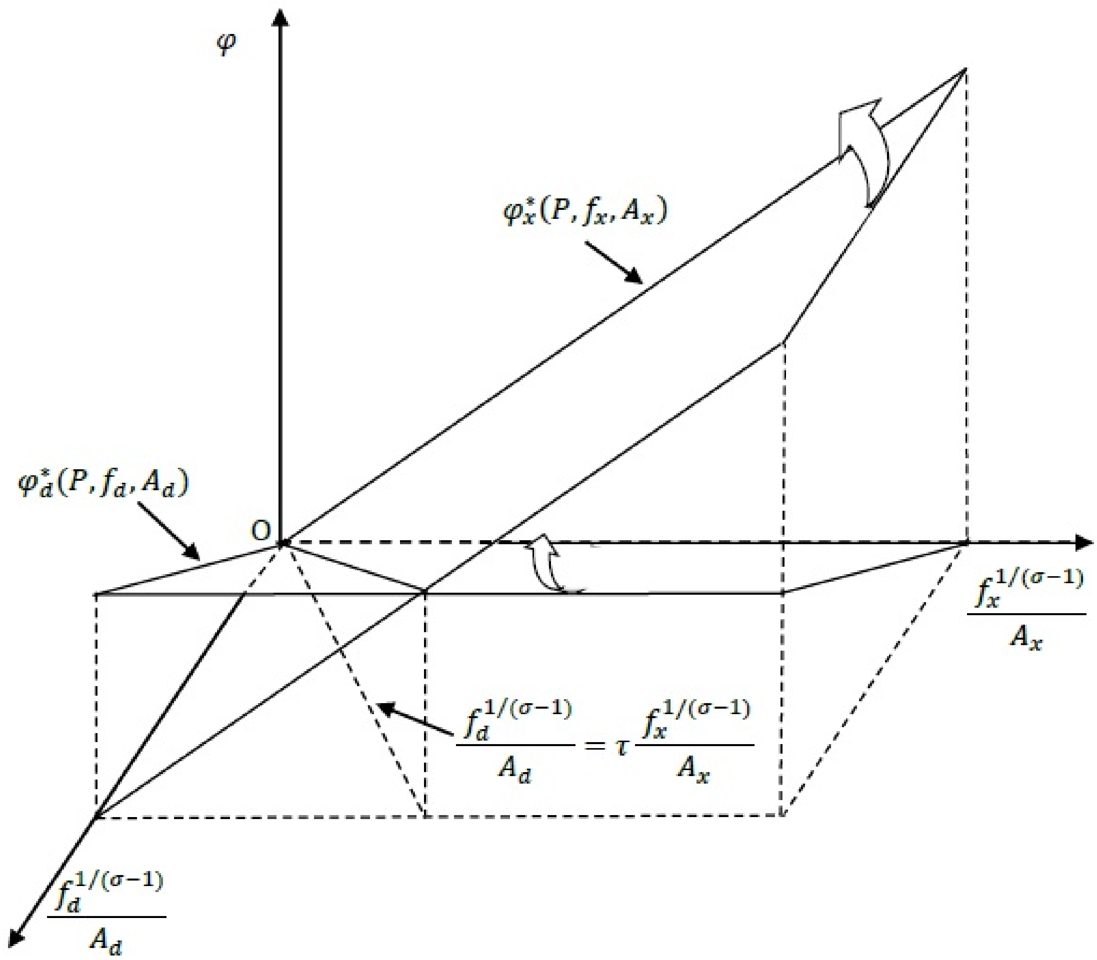


Figure 5: A decrease in foreign entry cost

4.3 A Decrease in Variable Export Cost

In this part, we study the effects of a decrease in variable export cost. The effects are summarized in the following theorem.

Theorem 6 *A decrease in the variable export cost forces some non-exporters out of the market or to become ordinary exporters and induces some non-active firms and ordinary exporters to become pure exporters.*

Proof: As variable export cost τ is decreased, the profit from the foreign market $\pi_x(P, \varphi, f_x, A_x)$ is increased. Therefore conditional profit $\pi(P \mid \eta)$ in equation (5) is increased. It is followed that $\Pi(P)$ is increased. We have shown that $\Pi(P)$ is an monotonically increasing function. Hence price index is decreased. This raises cut-off productivity in the domestic market to pushes some non-exporters out of the market and some ordinary exporters to become pure exporters.

To see the effect of τ on cut-off productivity of the foreign market, we assume $r = P/\tau$, equation (2) becomes $\varphi_d^*(P, f_d, A_d) = \varphi_d^*(r, f_d, A_d) = \Theta/(r\tau) \cdot f_d^{1/(\sigma-1)}/A_d$ and $\varphi_x^*(P, f_x, A_x) = \varphi_x^*(r, f_x, A_x) = \Theta/r \cdot f_x^{1/(\sigma-1)}/A_x$. Equilibrium determination (3) can be written as $\Pi(r, \tau) = F_e\delta$. Hence we have $\mathrm{d}r/\mathrm{d}\tau = -(\partial\Pi(r,\tau)/\partial\tau)/(\partial\Pi(r,\tau)/\partial r)$.

Equation (8) becomes a function of r, $\pi(P \mid \eta) = \pi(r, \tau \mid \eta)$. Therefore, we have

$$
\begin{aligned}
\frac{\partial \pi(r,\tau \mid \eta)}{\partial \tau} &= f_d k'(\cdot) \frac{\partial \varphi_d^*(r, f_d, A_d)}{\partial \tau} > 0 \\
\frac{\partial \pi(r,\tau \mid \eta)}{\partial r} &= f_d k'(\cdot) \frac{\partial \varphi_d^*(r, f_d, A_d)}{\partial r} + f_x k'(\cdot) \frac{\partial \varphi_x^*(r, f_x, A_x)}{\partial r} > 0
\end{aligned}
$$

Hence $\partial\Pi(r,\tau)/\partial\tau > 0$ and $\partial\Pi(r,\tau)/\partial r > 0$. We have $\mathrm{d}r/\mathrm{d}\tau < 0$. Therefore, the cut-off productivity of the foreign market is decreased by a decrease in variable export cost, pushing some non-active firms to be pure exporters and some non-exporters to be ordinary exporters. □

A decrease in variable export cost will make firms that serve the foreign market get more profit, thereby increasing the demand for labor. The real wage will be higher. As shown in Figure 6, the plane of cut-off productivity for the domestic market is shifted up. Therefore, some low productive non-exporters are pushed out of the market and become non-active. Low productive ordinary exporters with relative low demand-adjusted foreign entry cost become pure exporters. However, even though the real wage is higher, the exporters still benefit from a lower variable export cost. The plane of cut-off productivity to export becomes lower to induce more firms to export. In particular, the low productive firms with relative low demand-adjusted foreign entry cost, which are otherwise non-active, will become pure exporters.

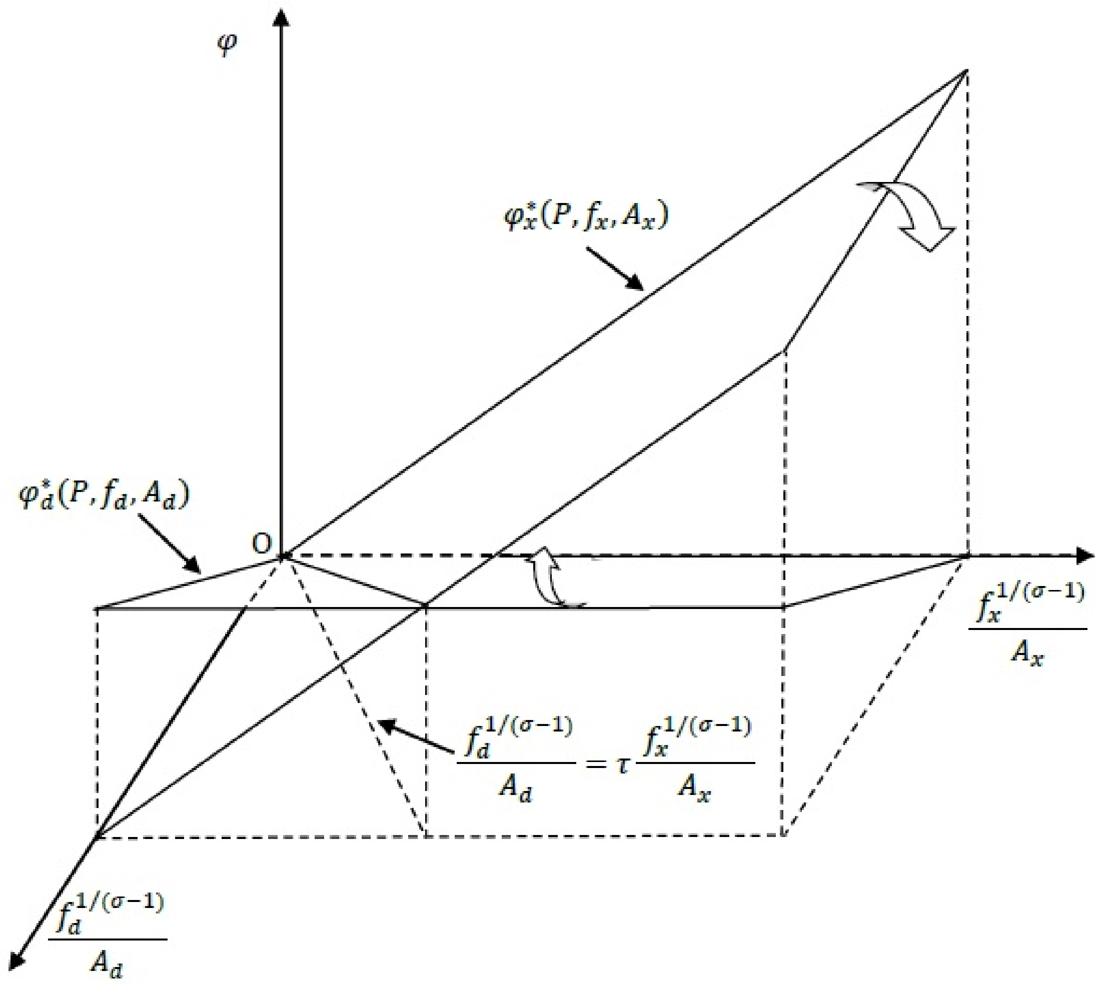


Figure 6: A decrease in variable export cost

5 Empirical Evidence

In this section, we provide the supportive evidence of our model. We firstly present the observation of pervasive existence of pure exporters across countries. Secondly, we document the non-trivial roles of pure exporters in economies. Thirdly, we estimate the total factor productivity of Chinese firms and show that pure exporters have lower productivity than non-exporters and ordinary exporters have higher productivity than non-exporters. Finally, we show that the productivity premium of exporters, i.e. productivity difference between exporters and non-exporters, can be negative and is negatively related to the share of pure exporters as predicted by our model.

5.1 Pervasive Existence

Pure exporters account for a large share of firms in a large number of countries. As in Defever and Riaño (2012), pure exporters are defined as exporters that sell more than 90% of their gross sales in foreign markets. We use the World Bank enterprise surveys in 135 countries to calculate the share of pure exporters in all firms and the share of pure exporters in all exporters. The results are shown in Figure 7. Pure exporters account for at least 7% of all firms in more than 25% of the countries. Moreover, pure exporters account for at least 19% of all exporters in more than 50% of the countries, and account for at least 10% of all exporters in more than 75% of the countries.

In our model pure exporters co-exist with ordinary exporters and non-exporters. Moreover, the share of pure exporters depends on the distribution of firms. Therefore different distributions of firms across countries generate different shares of pure exporters.

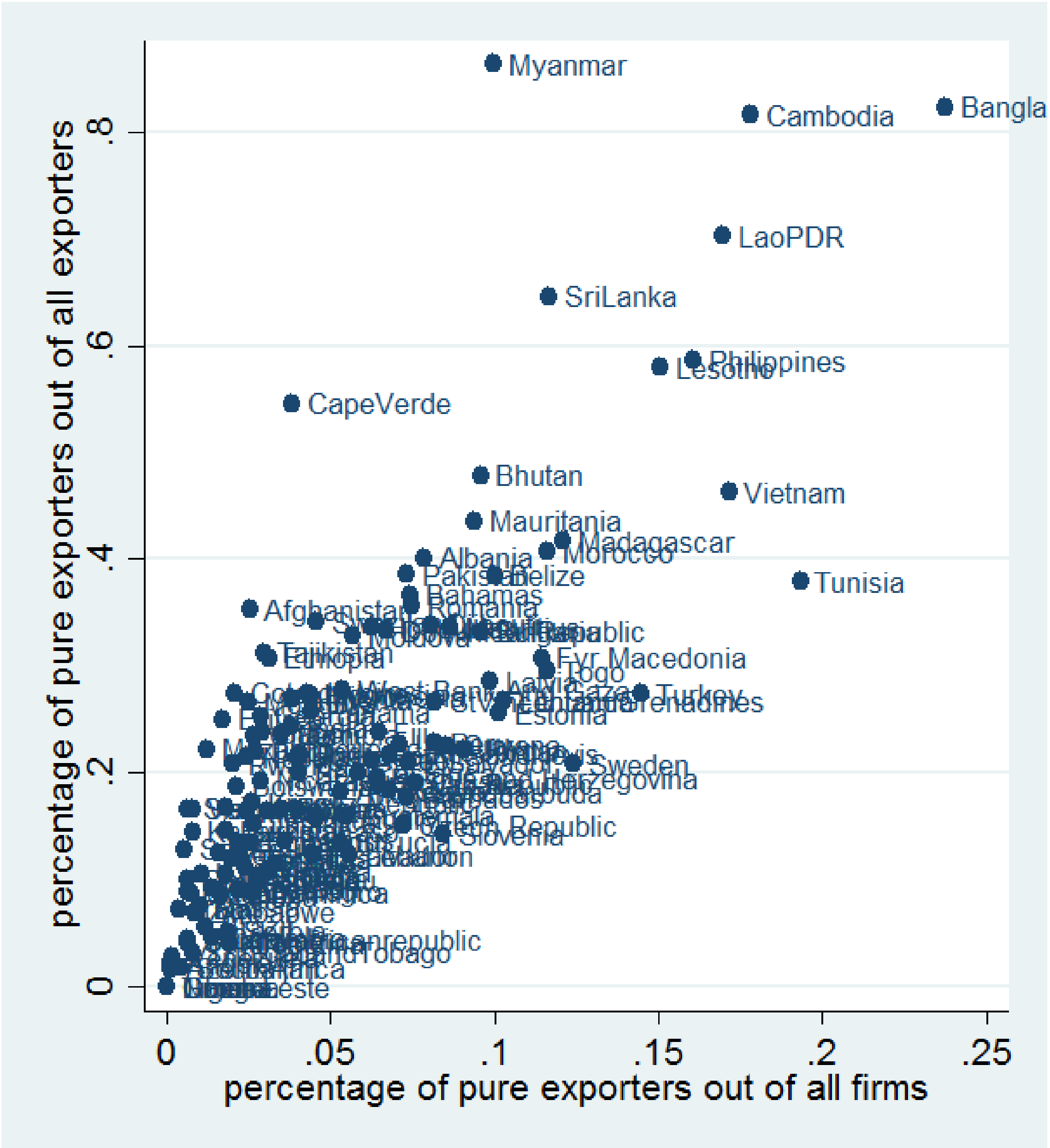
5.2 Non-trivial Roles

We use data on Chinese annual survey of manufacturing firms to calculate the share of total exports, gross sales, employment and asset for pure exporters. The Chinese annual survey of manufacturing firms is collected by the National Bureau of Statistics of China. The survey covers all state-owned firms and firms of other ownership with sales above RMB 5 million (above-scale firms) (Previous studies exploiting this database include Yu (2015) and Manova and Yu (2016).). The survey records firm production data, including employment, total wage, capital, intermediate input, sales, export and etc. The survey also records financial variables of firms, e.g. asset, debt and cash flow. Moreover, the survey reports the information about firm location, ownership and the sector that the firm operates within as well.

The descriptive statistics of pure exporters are shown in Table 1. Pure exporters account for a large share of total exports, and a non-trivial share of gross sales, employment and asset. In China, 11% of all firms and 40% of exporters are pure exporters. Pure exporters export 53% of total exports. Moreover, the average exports of pure exporters are 1.65 times of the average exports of ordinary exporters. Pure exporters account for 22% of gross sales, 33% of total employment, 14% of fixed asset and 15% of total asset of all exporters.

5.3 Productivity Performance

In our model, we allow the productivity of pure exporters to be lower than non-exporters (see Figure 2.a). To verify this point, we estimate the total factor productivity of Chinese firms and find that pure exporters have lower productivity than non-exporters and ordinary exporters have higher than non-exporters.



Note: The data is from World Bank Enterprise Surveys, which offers an expansive array of economic data on 130,000 firms in 135 countries. More than 90% of the countries are developing countries. As in Defever and Riaño (2012), pure exporters are defined as exporters that export more than 90% of their gross sales. The figure shows that a large share of pure exporters exist in a wide range of countries. In particular, pure exporters account at least 7% of all firms in more than 25% of the countries, and account at least 19% (10%) of all exporters in more than 50% (75%) of the countries.

Figure 7: Percentage of pure exporters across countries

To estimate the productivity of firms, we assume the production function as:

$$\ln Y_{it}^{j} = \kappa_0^j + \kappa_1^j \ln L_{it}^j + \kappa_2^j \ln K_{it}^j + \kappa_3^j \ln M_{it}^j + \ln \varphi_{it}^j$$

Table 1: Descriptive statistics of pure exporters

Variable	Share/ratio	2002	2003	2005	2006	2007	Average
Number	Share in all firms	0.11	0.12	0.12	0.11	0.10	0.11
	Share in all exporters	0.40	0.42	0.40	0.39	0.41	0.40
Exports	Share in all firms	0.51	0.54	0.53	0.53	0.52	0.53
	Ratio to ordinary exporters	1.61	1.61	1.69	1.74	1.58	1.65
Gross sales	Share in all firms	0.11	0.12	0.13	0.13	0.12	0.12
	Share in all exporters	0.20	0.22	0.23	0.23	0.23	0.22
	Ratio to ordinary exporters	0.39	0.39	0.44	0.47	0.44	0.43
Employment	Share in all firms	0.13	0.16	0.18	0.18	0.18	0.17
	Share in all exporters	0.28	0.32	0.35	0.35	0.35	0.33
	Ratio to ordinary exporters	0.60	0.66	0.82	0.84	0.79	0.74
Fixed asset	Share in all firms	0.06	0.07	0.09	0.08	0.09	0.08
	Share in all exporters	0.12	0.13	0.15	0.15	0.16	0.14
	Ratio to ordinary exporters	0.20	0.20	0.28	0.27	0.27	0.24
Total asset	Share in all firms	0.07	0.08	0.09	0.09	0.09	0.08
	Share in all exporters	0.13	0.14	0.16	0.16	0.16	0.15
	Ratio to ordinary exporters	0.22	0.22	0.29	0.30	0.28	0.26

Notes: Source from China Industrial Firm-level database which covers manufacturing firms with sales more than 5 million RMB and accounts for more than 90% of Chinese industrial output. Ratio is calculated as the average value of a variable of all pure exporters divided by the average value of the variable of all ordinary exporters. We do not include data of year 2004 as some data is missing in our database.

where $\ln Y_{it}^{j}$, $\ln L_{it}^{j}$, $\ln K_{it}^{j}$, $\ln M_{it}^{j}$ and $\ln \varphi_{it}^{j}$ are the logarithms of output, labor, capital, material and total factor productivity of firm i in industry j at year t. To estimate the equation, we adopt the Olley and Pakes (1996) approach using investment to control the unobservable productivity. Following previous studies, such as Amiti and Konings (2007) and Yu (2015), the investment function is revised by adding a dummy for exporter. As the robustness checks, we also add dummies of pure exporters and state-owned firms to the investment function. We also estimate the value-added function with Olley and Pakes (1996) approach and Levinsohn and Petrin (2003) approach to calculate the productivity for the robustness checks. We use industry-wide price index as in Brandt et al. (2012) to deflate the output, capital, investment and material for all the regressions. The details of estimation methods are described in the appendix 6.

After estimating the productivity, we use the following equation to test productivity performance of pure exporters compared with ordinary exporters and non-exporters:

$$\ln \varphi_{it}^{j} = \alpha + \alpha_1 PE_{it}^{j} + \alpha_2 OE_{it}^{j} + \alpha_3 Size_{it}^{j} + \varsigma_j + \varsigma_t + \varepsilon_{it}^{j} \tag{11}$$

where PE_{it}^{j} and OE_{it}^{j} are dummies. PE_{it}^{j} takes value of one if the firm is a pure exporter while OE_{it}^{j} takes the value of one if the firm is an ordinary exporter. ς_j and ς_t are industry and year fixed effects. As shown in Bernard and Jensen (1999) and Bernard et al. (2012), the correlation between firm size and exporting partially accounts for the differences between exporters and non-exporters. Therefore, we add firm size $Size_{it}^{j}$ measured by logarithm of labor into the regression.

The results with the productivity estimated from revenue function with Olley and Pakes (1996) approach are shown in Table 2. Column (1) uses the sample of ordinary exporters and non-exporters while column (2) uses the sample of pure exporters and non-exporters. We see that the productivity of ordinary exporters is higher than productivity of non-exporters and the productivity of pure exporters is lower than the productivity of non-exporters. Columns (3)-(6) use the whole sample to estimate equation (11). As shown in column (4) without controlling for firm size, the productivity of pure exporters is 2.2% lower than non-exporters and the productivity of ordinary exporters is 0.7% higher than non-exporters. After controlling for firm size in column (6), the productivity of pure exporters is 1.7% lower than non-exporters and the productivity of ordinary exporters is 1.2% higher than non-exporters.

Table 2: Productivity performance of pure exporters

	(1)	(2)	(3)	(4)	(5)	(6)
	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$
OE	0.014		0.039	0.007	0.046	0.012
	(0.001)***		(0.001)***	(0.001)***	(0.001)***	(0.001)***
PE		-0.018	0.069	-0.022	0.075	-0.017
		(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***
Size	-0.009	-0.009			-0.009	-0.007
	(0.0003)***	(0.0004)***			(0.0004)***	(0.0003)***
Time	YES	YES	NO	YES	NO	YES
Industry	YES	YES	NO	YES	NO	YES
# obs.	970,457	909,058	1,096,423	1,096,423	1,096,423	1,096,423

PE and OE are dummy variables which take the value of one if the firm is a pure exporter and ordinary exporter respectively. Pure exporters are defined as exporters that sell more than 90% of their gross sales in foreign markets. Standard errors are stated in parentheses below point estimates. ***, ** and * mean 1%, 5% and 10% significance levels respectively.

We report the robustness checks for alternative definitions of pure exporters in Table 3. Pure exporters are defined as exporters that export more than 95% of gross sales in columns (1) and (2), as exporters that export more than 99% of gross sales in columns (3) and (4) and exporters that export 100% of gross sales in columns (5) and (6). The results are very consistent with the main results in Table 2. When controlling for firm size, the productivity of pure exporters is 1.6-1.7% lower than non-exporters and the productivity of ordinary exporters is 0.7-1.0% higher than non-exporters.

Table 3: Robustness checks for alternative definitions of pure exporters

	95% of gross sales		99% of gross sales		100% of gross sales	
	(1)	(2)	(3)	(4)	(5)	(6)
	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$
OE	0.005	0.010	0.003	0.008	0.002	0.007
	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***
PE	-0.021	-0.017	-0.021	-0.016	-0.021	-0.017
	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***
Size		-0.007		-0.007		-0.007
		(0.0003)***		(0.0003)***		(0.0003)***
Time	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES
# obs.	1,096,423	1,096,423	1,096,423	1,096,423	1,096,423	1,096,423

PE and OE are dummy variables which take the value of one if the firm is a pure exporter and ordinary exporter respectively. Pure exporters are defined as exporters that export more than 95% of gross sales in columns (1) and (2), as exporters that export more than 99% of gross sales in columns (3) and (4) and exporters that export 100% of gross sales in columns (5) and (6). Standard errors are stated in parentheses below point estimates. ***, ** and * mean 1%, 5% and 10% significance levels respectively.

We also report the robustness checks for alternative productivity estimations in Table 4. In column (1) and (2) we use the productivity estimated from revenue function with Olley and Pakes (1996) approach, in which more controls, i.e. dummies of exporters, pure exporters and state-owned firms, are added in the investment function. The results are very consistent with the main results shown in Table 2. In column (3), (4), (5) and (6), we use productivity estimated from value-added function with Olley and Pakes (1996) approach. More specifically, in (3) and (4), dummy of exporter is added into investment function while in in (5) and (6) more controls are added. When controlling for firm size, the productivity of pure exporters is 9.8-14.7% lower than non-exporters while the productivity of ordinary exporters is 13.2-17.9% higher than non-exporters. In column (7) and (8), we are using the productivity estimated from value-added function with Levinsohn and Petrin (2003) approach. The results are very consistent that, the productivity of pure exporters (ordinary exporters) is 11.9% lower (16.7% higher) than non-exporters. With estimations of value-added function, the productivity performance of pure exporters compared with ordinary exporters and non-exporters are consistent with estimations of revenue function. The productivity difference with estimations of value-added function is even larger than the estimations of revenue function.

To investigate the productivity performance of pure exporters by sectors, we estimate the equation (11) for every sector. As shown in Figure 8, the results are very consistent between

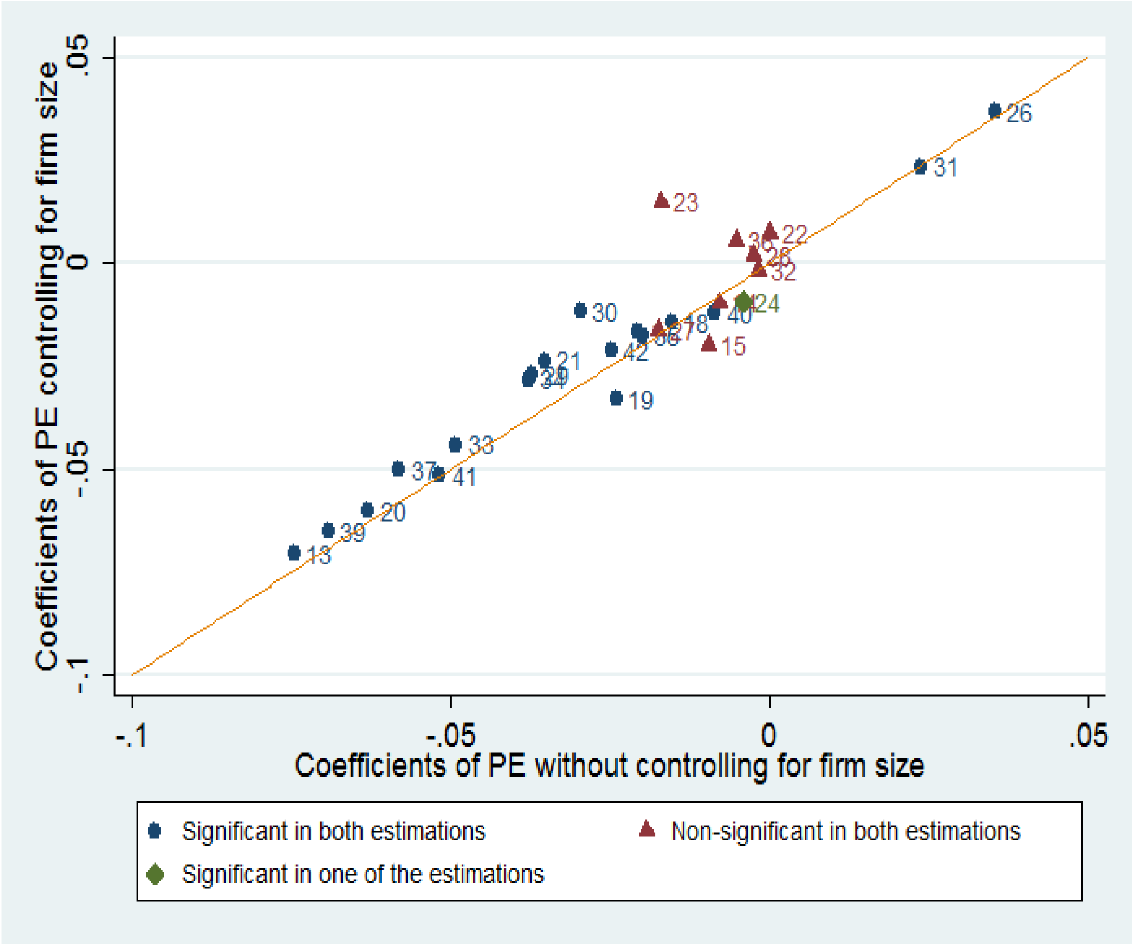
Table 4: Robustness checks for alternative productivity estimations

	OP_revenue_2		OP_valueadded_1		OP_valueadded_2		LP_valueadded	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$
OE	0.038	0.022	0.186	0.132	0.335	0.179	0.522	0.167
	(0.001)***	(0.001)***	(0.003)***	(0.003)***	(0.003)***	(0.003)***	(0.003)***	(0.003)***
PE	-0.008	-0.021	-0.051	-0.098	-0.012	-0.147	0.188	-0.119
	(0.001)***	(0.001)***	(0.003)***	(0.003)***	(0.003)***	(0.003)***	(0.004)***	(0.003)***
Size		0.021		0.076		0.218		0.496
		(0.0003)***		(0.001)***		(0.001)***		(0.001)***
Time	YES	YES	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES	YES	YES
# obs.	1,088,485	1,088,485	1,052,000	1,052,000	1,048,985	1,048,985	1,052,824	1,052,824

PE and OE are dummy variables which take the value of one if the firm is a pure exporter and ordinary exporter respectively. Pure exporters are defined as exporters that export more than 90% of their gross sales. OP_revenue_2 means estimation of revenue function with Olley and Pakes (1996) approach, in which more controls, i.e. dummies of exporters, pure exporters and state-owned firms, are added in the investment function. OP_valueadded_1 means estimation of value-added function with Olley and Pakes (1996) approach in which dummy of exporter is added in the investment function. OP_valueadded_2 means estimation of value-added function with Olley and Pakes (1996) approach in which more controls are added in the investment function. LP_valueadded means the estimation of value-added function with Levinsohn and Petrin (2003) approach. Standard errors are stated in parentheses below point estimates. ***, ** and * mean 1%, 5% and 10% significance levels respectively.

estimations controlling for firm size and estimations without controlling for firm size. The coefficients lie generally in the 45 degree line. In particular, out of 27 sectors, pure exporters have lower productivity than non-exporters in 21 (24) sectors with the estimations controlling (without controlling) for firm size. The robustness checks with alternative productivity estimations are reported in Figure 9. With the productivity estimated from revenue function with Olley and Pakes (1996) approach in which more controls are added in the investment function, the productivity of pure exporters is lower than non-exporters in 22 sectors when controlling for firm size. With the productivity estimated from value-added function with Olley and Pakes (1996) approach, the productivity of pure exporters is lower than non-exporters in 20 sectors and 23 sectors respectively. With the productivity estimated from value-added function with Levinsohn and Petrin (2003), the productivity of pure exporters is lower than non-exporters in 23 sectors.

We have shown that in general pure exporters have lower productivity than non-exporters and ordinary exporters have higher productivity than non-exporters. This pattern holds with variations for alternative definitions of pure exporters and alternative productivity estimations. Though the pattern does not hold in all sectors, it holds in most of the sectors. Our model is consistent with this pattern. In our model, the productivity of pure exporters can be lower or higher than productivity of non-exporters.



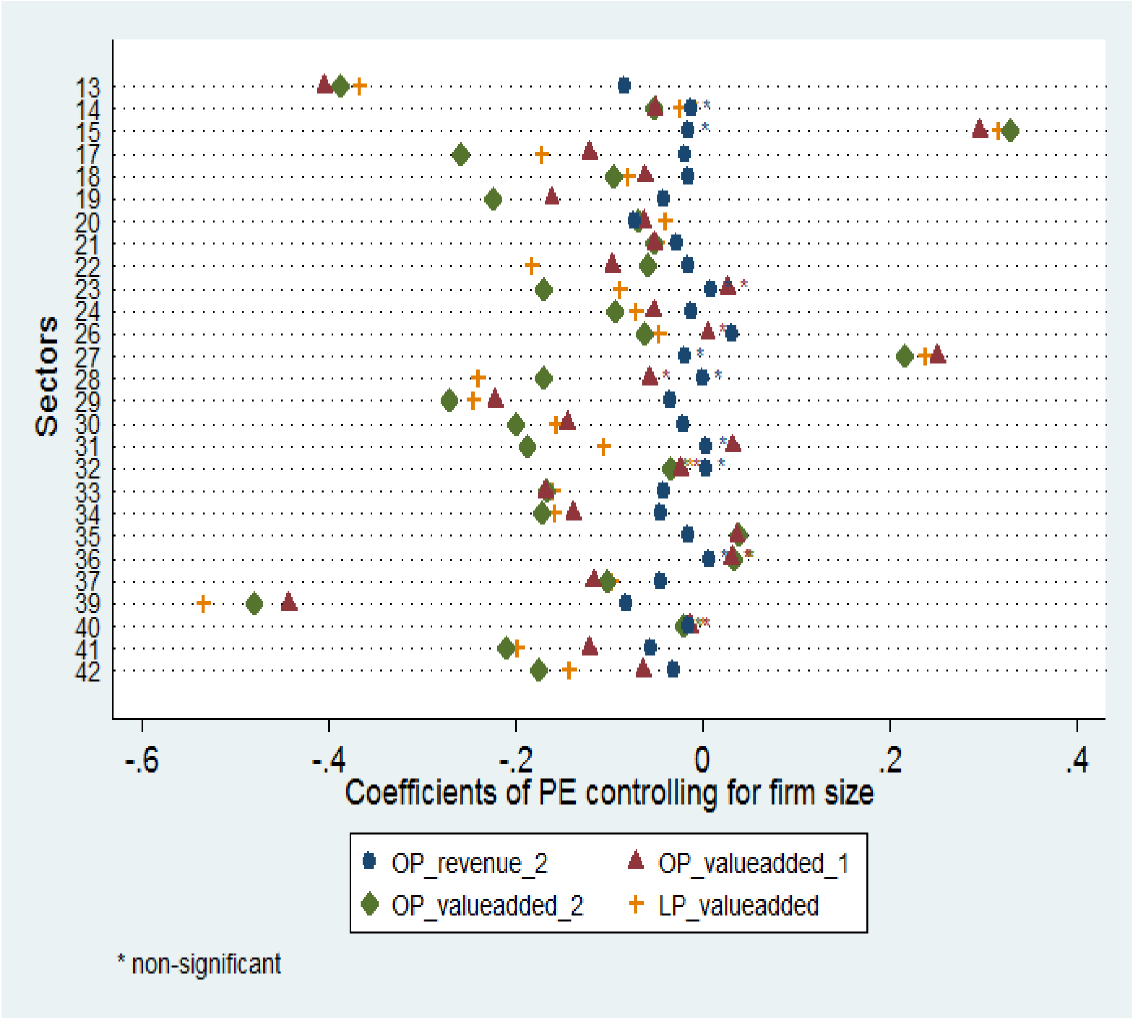
Note: As in Yu (2015), the Chinese sectors are classified as: processing of foods (13), manufacture of foods (14), beverages (15), textiles (17), apparel (18), leather (19), timber (20), furniture (21), paper (22), printing (23), articles for cultures and sports (24), raw chemicals (26), medicines (27), chemical fibres (28), rubber (29), plastics (30), non-metallic minerals (31), smelting of ferrous metals (32), smelting of non-ferrous metals (33), metal (34), general machinery (35), special machinery (36), transport equipment (37), electrical machinery (39), communication equipment (40), measuring instruments (41) and manufacture of artwork (42).

Figure 8: Productivity performance of pure exporters across sectors

5.4 Productivity Premium of Exporters

In Theorem 2, our model predicts that the average productivity of exporters can be lower than the average productivity of non-exporters, i.e. the productivity premium of exporters can be negative. Moreover, our model suggests whether and to what extent the average productivity of exporters is lower than the average productivity of non-exporters depend on the share of pure exporters. In this section, we provide the evidence that productivity premium of exporters can be negative and productivity premium of exporters is lower in the sector with larger share of pure exporters.

To study if there is negative productivity premium of exporters, we estimate the follow-



Note: OP_revenue_2 means estimation of revenue function with Olley and Pakes (1996) approach, in which more controls, i.e. dummies of exporters, pure exporters and state-owned firms, are added in the investment function. OP_valueadded_1 means estimation of value-added function with Olley and Pakes (1996) approach in which dummy of exporter is added in the investment function. OP_valueadded_2 means estimation of value-added function with Olley and Pakes (1996) approach in which more controls are added in the investment function. LP_valueadded means the estimation of value-added function with Levinsohn and Petrin (2003) approach.

Figure 9: Robustness on the productivity performance of pure exporters across sectors

ing equation for every sector:

$$\ln \varphi_{it} = \alpha + \alpha_1 EX_{it} + \alpha_2 Size_{it} + \varsigma_t + \varepsilon_{it}$$

where EX_{it} is the dummy variable that takes value of one if the firm i at year t is an exporter. The results are shown in Table 5. The results with time fixed effects and without controlling for firm size suggest that 18 out of 27 sectors have negative productivity premium of exporters. The negative premium is statistically significant in 15 sectors. Controlling for the firm size, negative productivity premium exists in 16 sectors and is statistically significant in 11 sectors. As a comparison, positive productivity premium is significant in 9 sectors. The simple average of coefficients across the 11 sectors with significantly negative productivity premium is -0.02, indicating that exporters have 2% lower productivity than non-exporters in average. The results with alternative productivity estimations are very consistent. In particular, for the four alternative productivity estimations, in average 10 sectors have negative productivity premium of exporters (refer to Figure 11 for details).

We have shown that productivity premium of exporters is significantly negative in almost half of the sectors. To investigate whether the premium is negatively related to the share of pure exporters, we firstly plot the coefficients of the exporter dummy EX_{it} in last column of Table 5 and the shares of pure exporters of corresponding sectors. As shown in Figure 10, the productivity premium of exporters is smaller in the sector with larger share of pure exporters in all firms. The productivity premium of exporters tends to be negative given a large share of pure exporters. This pattern holds if we use the share of pure exporters in all exporters. It suggests that the productivity premium of exporters is negatively related to share of pure exporters. The robustness checks with alternative productivity estimations are reported in Figure 11. For all alternative productivity estimations, the premium is smaller when the share of pure exporters is larger and the premium tends to be negative when the share is large.

Furthermore, we estimate the following equation to test the negative relationship between productivity premium of exporters and share of pure exporters:

$$\ln \varphi_{it}^{j} = \alpha + \alpha_1 EX_{it}^{j} + \alpha_2 EX_{it}^{j} \times share_{jt} + \alpha_3 share_{jt} + \alpha_4 Size_{it}^{j} + \varsigma_j + \varsigma_t + \varepsilon_{it}^{j}$$

where $share_{jt}$ is the share of pure exporters in all firms of sector j at year t. The coefficient α_2 of the interaction term $EX_{it}^{j} \times share_{jt}$ measures the relationship between productivity premium of exporters and share of pure exporters. If it is negative, it means that in the sector with larger share of pure exporters, the productivity premium of exporters is lower. We also use the share of pure exporters in all exporters to check the robustness.

The results are shown in Table 6. As shown in column (1), in general the productivity of exporters is slightly higher than non-exporters. From column (2) to column (6), the coefficients of interaction term are all significantly negative, which means that the productivity premium of exporters is negatively related to the share of pure exporters. As shown in column (6), if there are no pure exporters, the productivity of exporters is 1.2% higher than non-exporters. However, when the share of pure exporters in all firms is increased by 1%, the premium is decreased by 0.083%. This suggests that if the share of pure exporters in all firms is larger than 14.5%, the productivity premium of exporters will be negative. As shown in column (7) and (8), the results are very consistent when we use the share of

Table 5: Productivity premium of exporters across sectors

	EX		EX		EX	
Sector	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
13	-0.019	(0.004)***	-0.023	(0.004)***	-0.018	(0.004)***
14	0.011	(0.005)**	0.011	(0.005)**	0.006	(0.005)
15	0.040	(0.009)***	0.042	(0.009)***	0.046	(0.009)***
17	-0.021	(0.002)***	-0.013	(0.002)***	-0.007	(0.002)***
18	-0.025	(0.003)***	-0.010	(0.002)***	-0.009	(0.003)***
19	-0.018	(0.003)***	-0.010	(0.003)***	-0.018	(0.003)***
20	-0.063	(0.006)***	-0.042	(0.005)***	-0.038	(0.005)***
21	-0.016	(0.006)**	-0.028	(0.005)***	-0.018	(0.006)***
22	0.024	(0.005)***	0.020	(0.005)***	0.029	(0.005)***
23	-0.001	(0.008)	-0.029	(0.007)***	-0.004	(0.007)
24	-0.017	(0.005)***	-0.002	(0.004)	-0.007	(0.005)
25	0.053	(0.017)***	0.038	(0.016)**	0.049	(0.017)***
26	0.036	(0.003)***	0.040	(0.003)***	0.042	(0.003)***
27	0.045	(0.007)***	0.048	(0.007)***	0.043	(0.007)***
28	-0.005	(0.008)	0.000	(0.008)	0.015	(0.008)*
29	-0.022	(0.007)***	-0.022	(0.006)***	-0.011	(0.007)
30	-0.025	(0.003)***	-0.018	(0.003)***	-0.002	(0.003)
31	0.052	(0.003)***	0.042	(0.003)***	0.041	(0.003)***
32	0.017	(0.006)***	0.019	(0.006)***	0.024	(0.007)***
33	0.004	(0.006)	-0.012	(0.006)**	0.003	(0.006)
34	-0.027	(0.003)***	-0.024	(0.003)***	-0.015	(0.003)***
35	-0.009	(0.003)***	-0.003	(0.003)	0.000	(0.003)
36	0.012	(0.004)***	0.004	(0.004)	0.017	(0.004)***
37	-0.030	(0.004)***	-0.033	(0.004)***	-0.019	(0.004)***
39	-0.040	(0.003)***	-0.040	(0.003)***	-0.036	(0.003)***
40	0.057	(0.004)***	-0.001	(0.004)	-0.004	(0.004)
41	-0.055	(0.007)***	-0.028	(0.007)***	-0.028	(0.007)***
42	-0.022	(0.004)***	-0.022	(0.004)***	-0.019	(0.004)***
Time	NO		YES		YES	
Firm size	NO		NO		YES	

Columns Coef. are the coefficients of dummy variable *EX* which take the value of one if the firm is an exporter. Standard errors are stated in columns Std. Err.. ***, ** and * mean 1%, 5% and 10% significance levels respectively.

pure exporters in all exporters. The result in column (8) suggests that, if the share of pure exporters in all exporters is larger than 38.75%, the productivity premium will be negative.

The robustness checks on productivity premium for alternative definitions of pure exporters are reported in Table 7. The results are quantitatively robust. The robustness checks for alternative productivity estimations are reported in Table 8. All the results show that the larger the share of pure exporters is, the lower is the productivity premium of exporters.

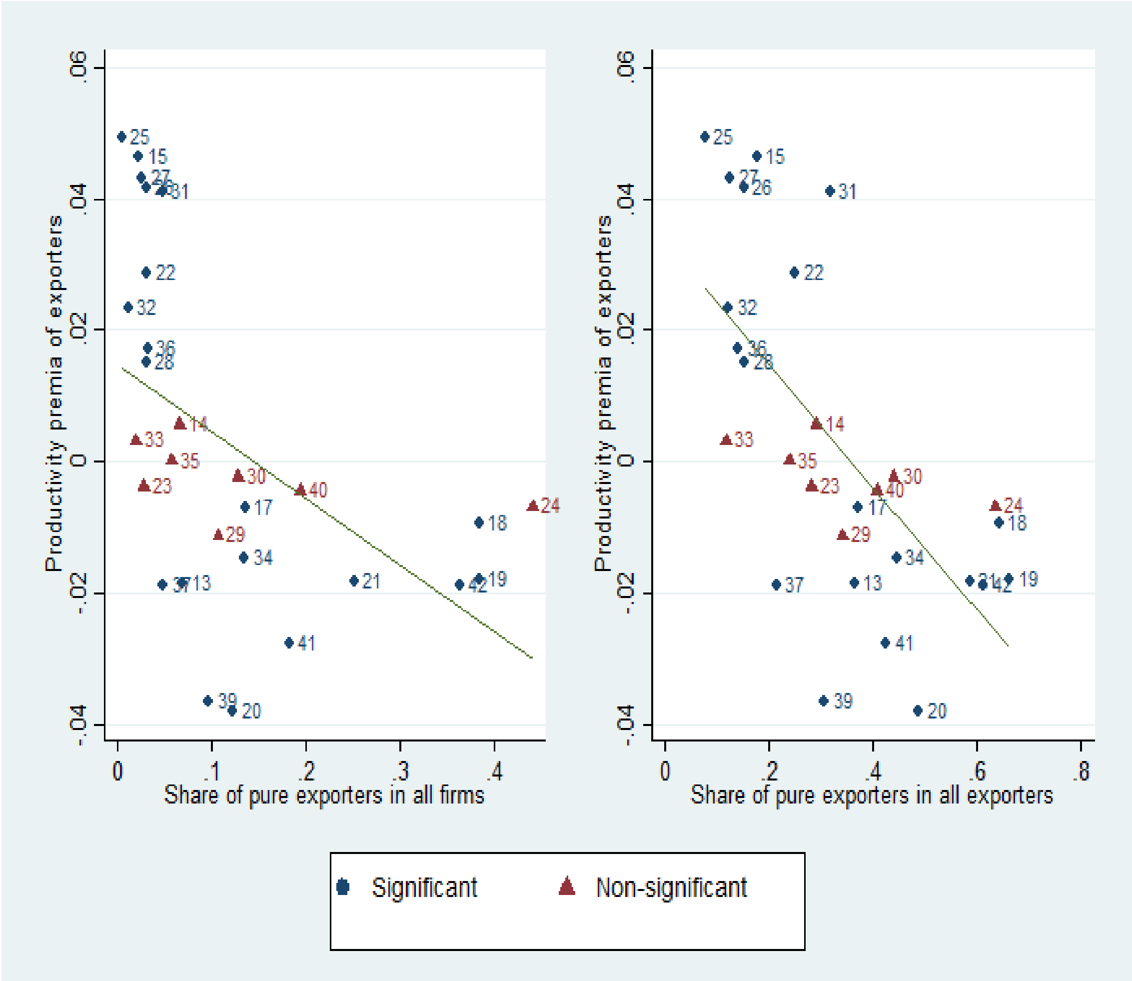


Figure 10: Productivity premium of exporters and the share of pure exporters

Across the estimations, the productivity premium of exporters will be negative if the share of pure exporters in all firms is larger than 19.14-20.80% or if the share of pure exporters in all exporters is larger than 43.96-45.39%.

6 Conclusion

In the present paper we have studied what pushes firms to become pure exporters, ordinary exporters and non-exporters. We have also investigated the impacts of trade on average productivity and welfare (Theorems 3 and 4) and how trade liberalization pushes firms to change the markets they serve (Theorems 5 and 6) in the presence of pure exporters. Two important findings were that the average productivity of exporters consisting of pure exporters and ordinary exporters can be lower than productivity of non-exporters (Theorem 2) depending on the share of pure exporters and that moving from autarky to trade can lower

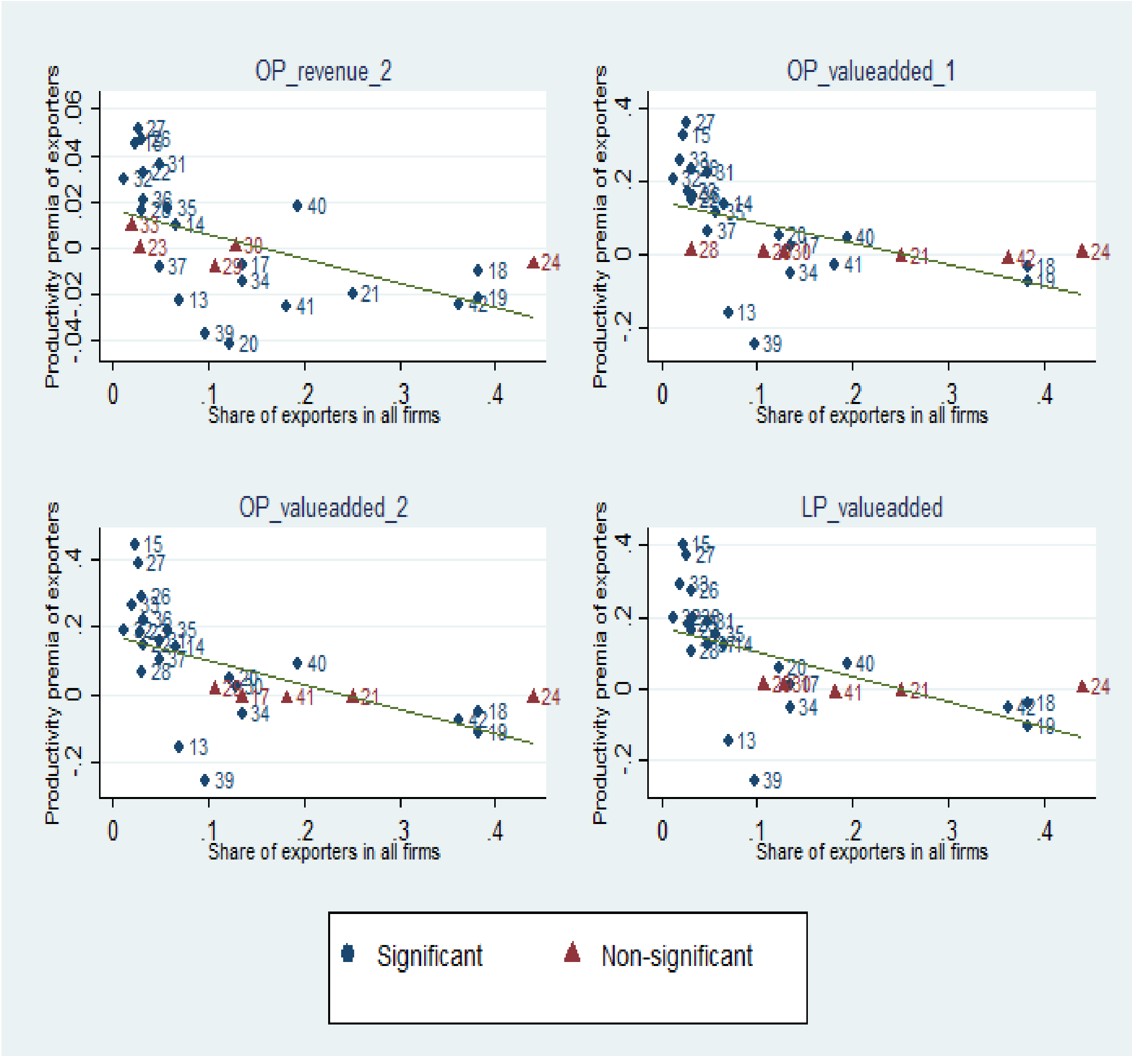


Figure 11: Robustness checks on the productivity premium of exporters

average productivity (Theorem 3). Despite the ambiguous effect of moving from autarky to trade on productivity, such a move leads to higher welfare because the variety of goods goes up (Theorem 4).

We provide the supportive evidence of our model. Firstly, we present the pervasive existence and non-trivial roles of pure exporters. Then, we estimate the total factor productivity of Chinese firms and show that pure exporters have lower productivity than non-exporters and ordinary exporters have higher productivity than non-exporters. Finally, we show that the productivity premium of exporters, i.e. productivity difference between exporters and non-exporters, is negative in almost half of the sectors and is negatively related to the share of pure exporters.

In the paper there are no processing firms producing inputs or goods for other firms and there is monopolistic competition between firms. In order to enrich our understanding of

Table 6: Results on the productivity premium of exporters and the share of pure exporters

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$
EX	0.001	0.045	0.041	0.008	0.007	0.012	0.026	0.031
	(0.001)*	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.002)***	(0.002)***
EX × share		-0.342	-0.304	-0.103	-0.082	-0.083		
		(0.007)***	(0.007)***	(0.007)***	(0.006)***	(0.006)***		
Share		0.856	0.857	-0.045	0.440	0.441		
		(0.005)***	(0.005)***	(0.018)**	(0.019)***	(0.019)***		
EX × share_2							-0.078	-0.080
							(0.005)***	(0.005)***
Share_2							-0.459	-0.463
							(0.013)***	(0.013)***
Firm size	-0.007					-0.007		-0.007
	(0.0003)***					(0.0003)***		(0.0003)***
Time	YES	NO	YES	NO	YES	YES	YES	YES
Industry	YES	NO	NO	YES	YES	YES	YES	YES
# obs.	1,096,423	1,096,423	1,096,423	1,096,423	1,096,423	1,096,423	1,096,423	1,096,423

Share is the share of pure exporters in all firms while *share_2* is the share of pure exporters in all exporters. Standard errors are stated in parentheses below point estimates. ***, ** and * mean 1%, 5% and 10% significance levels respectively.

pure exporters or exporters with high export intensity, it would be interesting to allow firms to become processing plants for other firms, thereby lowering their market entry cost in possibly more competitive markets.

Table 7: Robustness checks on productivity premium for alternative definitions of pure exporters

	95% of gross sales		99% of gross sales		100% of gross sales	
	(1)	(2)	(3)	(4)	(5)	(6)
	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$
EX	0.011	0.028	0.010	0.025	0.010	0.023
	(0.001)***	(0.002)***	(0.001)***	(0.002)***	(0.001)***	(0.002)***
EX × share	-0.083		-0.089		-0.092	
	(0.007)***		(0.008)***		(0.008)***	
Share	0.353		0.287		0.207	
	(0.0120)***		(0.023)***		(0.024)***	
EX × share_2		-0.080		-0.084		-0.087
		(0.005)***		(0.005)***		(0.006)***
Share_2		-0.562		-0.592		-0.615
		(0.014)***		(0.014)***		(0.015)***
Firm size	-0.007	-0.007	-0.007	-0.007	-0.007	-0.007
	(0.0003)***	(0.0003)***	(0.0003)***	(0.0003)***	(0.0003)***	(0.0003)***
Time	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES
# obs.	1,096,423	1,096,423	1,096,423	1,096,423	1,096,423	1,096,423

Share is the share of pure exporters in all firms while *share_2* is the share of pure exporters in exporters. Pure exporters are defined as exporters that export more than 95% of gross sales in columns (1) and (2), as exporters that export more than 99% of gross sales in columns (3) and (4) and exporters that export 100% of gross sales in columns (5) and (6). Standard errors are stated in parentheses below point estimates. ***, ** and * mean 1%, 5% and 10% significance levels respectively.

Table 8: Robustness checks on productivity premium for alternative productivity estimations

	OP_revenue_2		OP_valueadded_1		OP_valueadded_2		LP_valueadded	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$	$\ln \varphi_{it}^{j}$
EX	0.018	0.040	0.141	0.270	0.167	0.336	0.167	0.325
	(0.001)***	(0.002)***	(0.004)***	(0.006)***	(0.004)***	(0.006)***	(0.004)***	(0.006)***
EX $\times$ share	-0.094		-0.716		-0.821		-0.803	
	(0.006)***		(0.019)***		(0.020)***		(0.019)***	
Share	0.479		1.622		1.638		1.655	
	(0.019)***		(0.057)***		(0.058)***		(0.057)***	
EX $\times$ share_2		-0.091		-0.605		-0.751		-0.716
		(0.005)***		(0.014)***		(0.015)***		(0.014)***
Share_2		-0.436		-0.700		-0.672		-0.711
		(0.013)***		(0.040)***		(0.041)***		(0.041)***
Firm size	0.021	0.021	0.077	0.077	0.220	0.219	0.498	0.497
	(0.0003)***	(0.0003)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***
Time	YES	YES	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES	YES	YES
# obs.	1,088,485	1,088,485	1,052,000	1,052,000	1,048,985	1,048,985	1,052,824	1,052,824

Share is the share of pure exporters in all firms while *share_2* is the share of pure exporters in exporters. OP_revenue_2 means estimation of revenue function with Olley and Pakes (1996) approach, in which more controls, i.e. dummies of exporters, pure exporters and state-owned firms, are added in the investment function. OP_valueadded_1 means estimation of value-added function with Olley and Pakes (1996) approach in which dummy of exporter is added in the investment function. OP_valueadded_2 means estimation of value-added function with Olley and Pakes (1996) approach in which more controls are added in the investment function. LP_valueadded means the estimation of value-added function with Levinsohn and Petrin (2003) approach. Standard errors are stated in parentheses below point estimates. ***, ** and * mean 1%, 5% and 10% significance levels respectively.

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Appendix

Appendix 1: All variables in the equilibrium

Let Υ be the probability of an entrant becoming active, then

$$\Upsilon = \int_{\eta} \int_{\varphi^*(\eta)} \lambda(\varphi, \eta) \, \mathrm{d}(\varphi, \eta)$$

where $\varphi^*(\eta) = \min\{ \varphi_d^*(P, f_d, A_d), \varphi_x^*(P, f_x, A_x) \}$. For (f_i, A_i), $z_i = f_i^{1/(\sigma-1)}/A_i$. It follows from equation (2) that $\varphi^*(\eta) = \varphi_d^*(P, f_d, A_d)$ if $z_d < \tau z_x$ and $\varphi^*(\eta) = \varphi_x^*(P, f_x, A_x)$ if $z_d > \tau z_x$.

Let Π_p be the average profit earned by incumbents. In equilibrium we use Π to denote the expected profit per date, so Π should be equal to the profit earned conditional on successful entry, i.e. $\Pi = \Upsilon \Pi_p$.

Let M_e denote the amount of entrants and M the amount of incumbents. Since successful entrants will replace the dead firms, we have $M\delta = M_e \Upsilon$. Labor L is used for production by incumbents L_p and investment by entrants L_e. The labor for entrants is $L_e = M_e F_e$. With equation (3), we have

$$L_e = M_e F_e = \frac{\delta M}{\Upsilon} \frac{\Pi}{\delta} = M \frac{\Pi}{\Upsilon} = M \Pi_p$$

$M\Pi_p$ is the total profit eared by all incumbents, therefore we have $R = L_p + M\Pi_p = L_p + L_e = L$. Total revenue is fixed as the total labor. Let $\bar{r}$ and $\bar{f}$ be the average revenue and fixed cost of incumbents respectively. Then $\Pi_p = \bar{r}/\sigma - \bar{f}$. It follows that $\bar{r} = \sigma(\Pi_p + \bar{f}) = \sigma(\delta F_e/\Upsilon + \bar{f})$. With Υ, we can also denote the distribution of incumbents as $\lambda(\varphi, \eta)/\Upsilon$. $\bar{f}$ is the average market entry cost of incumbents,

$$\bar{f} = \int_{\eta} \int_{\varphi_d^*(P, f_d, A_d)} f_d \frac{\lambda(\varphi, \eta)}{\Upsilon} \mathrm{d}(\varphi, \eta) + \int_{\eta} \int_{\varphi_x^*(P, f_x, A_x)} f_x \frac{\lambda(\varphi, \eta)}{\Upsilon} \mathrm{d}(\varphi, \eta)$$

In equilibrium, we have found the price index and cut-off productivities. So Υ and $\bar{f}$ are known. Then the amount of incumbents M can be determined by:

$$M = \frac{R}{\bar{r}} = \frac{L}{\sigma(\delta F_e/\Upsilon + \bar{f})}$$

Appendix 1.1 contains an alternative route to above equation using labor market.

Let the S_d denote the area $\{\eta \,|\, z_d < \tau z_x\}$ and S_x the area $\{\eta \,|\, z_d > \tau z_x\}$. Non-exporters are located in the S_d area and the amount is determined by:

$$M_{ne} = M \int_{S_d} \int_{\varphi_d^*(P,f_d,A_d)}^{\varphi_x^*(P,f_x,A_x)} \frac{\lambda(\varphi,\eta)}{\Upsilon} \, \mathrm{d}(\varphi,\eta)$$

Pure exporters are located in S_x area and amount of pure exporters is determined by:

$$M_{pe} = M \int_{S_x} \int_{\varphi_x^*(P,f_x,A_x)}^{\varphi_d^*(P,f_d,A_d)} \frac{\lambda(\varphi,\eta)}{\Upsilon} \, \mathrm{d}(\varphi,\eta)$$

Then the share of pure exporters is determined as M_{pe}/M.

Appendix 1.1: An alternative way to find number of incumbents M

For a firm $(\varphi, f_d, f_x, A_d, A_x)$, let q be the output in the domestic market, labor used to serve the domestic market is $f_d + q/\varphi = f_d + \rho p(\varphi) q = f_d + \sigma\rho(\pi_d(P,\varphi,f_d,A_d) + f_d) = (\sigma - 1)\pi_d(P,\varphi,f_d,A_d) + \sigma f_d$. By analogy, the labor used to export is $(\sigma-1)\pi_x(P,\varphi,f_x,A_x) + \sigma f_x$.

With Υ, the distribution of incumbents is $\lambda(\varphi,\eta)/\Upsilon$. Then the total labor for incumbents L_p is

$$\begin{aligned} L_p &= M \int_\eta \int_{\varphi_d^*(P,f_d,A_d)}^{\infty} ((\sigma-1)\pi_d(P,\varphi,f_d,A_d) + \sigma f_d) \, \frac{\lambda(\varphi,\eta)}{\Upsilon} \mathrm{d}(\varphi,\eta) \\ &\quad + M \int_\eta \int_{\varphi_x^*(P,f_x,A_x)}^{\infty} ((\sigma-1)\pi_x(P,\varphi,f_x,A_x) + \sigma f_x) \, \frac{\lambda(\varphi,\eta)}{\Upsilon} \mathrm{d}(\varphi,\eta) \end{aligned}$$

Combine with equation (4) and (5), we get

$$L_p = \frac{M}{\Upsilon} \cdot \left((\sigma-1)\Pi + \sigma \, \Upsilon \bar{f} \right)$$

where $\bar{f}$ has been shown in Appendix 1. The labor for entrants L_e is:

$$Le = M_e \cdot F_e = \frac{\delta M}{\Upsilon} \cdot \frac{\Pi}{\delta} = \frac{M\Pi}{\Upsilon}$$

Then total labor L is:

$$L = L_p + L_e = \frac{M}{\Upsilon} \cdot \left(\sigma\Pi + \sigma \, \Upsilon \bar{f} \right)$$

With equation (3), we have the number of incumbents:

$$M = \frac{R}{\bar{r}} = \frac{L}{\sigma(\delta F_e/\Upsilon + \bar{f})}$$

This equation has been shown in Appendix 1.

Appendix 2: Average productivity of exporters and non-exporters

Let $\varphi_d^*(z_d) = \varphi_d^*(P, f_d, A_d)$ and $\varphi_x^*(z_x) = \varphi_x^*(P, f_x, A_x)$ denote the cut-off productivities. Let $\varphi^*(z_d, z_x) = \min\{\varphi_d^*(z_d), \varphi_x^*(z_x)\}$. Then the probability of an entrant becoming active Υ is determined as:

$$\Upsilon = \int_{z_d, z_x} \int_{\varphi^*(z_d, z_x)} g(\varphi)\gamma(z_x)\psi(z_d)\,\mathrm{d}(\varphi, z_d, z_x)$$

According to equation (2), $\varphi^*(z_d, z_x) = \varphi_d^*(z_d)$ if $z_d < \tau z_x$ and $\varphi^*(z_x, z_d) = \varphi_x^*(z_x)$ if $z_d > \tau z_x$. The distribution of incumbents is then $g(\varphi)\gamma(z_x)\psi(z_d)/\Upsilon$.

Therefore the average productivity of exporters can be denoted as:

$$\begin{aligned}
\Psi_e &= \frac{\displaystyle\int_{z_d, z_x} \int_{\varphi_x^*(z_x)}^{\infty} \varphi \frac{g(\varphi)\gamma(z_x)\psi(z_d)}{\Upsilon} M\,\mathrm{d}(\varphi, z_d, z_x)}{\displaystyle\int_{z_d, z_x} \int_{\varphi_x^*(z_x)}^{\infty} \frac{g(\varphi)\gamma(z_x)\psi(z_d)}{\Upsilon} M\,\mathrm{d}(\varphi, z_d, z_x)} \\
&= \frac{\displaystyle\int_{z_d} \int_{z_x} \int_{\varphi_x^*(z_x)}^{\infty} \varphi g(\varphi)\gamma(z_x)\psi(z_d)\,\mathrm{d}\varphi \mathrm{d}z_x \mathrm{d}z_d}{\displaystyle\int_{z_d} \int_{z_x} (1 - G(\varphi_x^*(z_x)))\gamma(z_x)\psi(z_d)\,\mathrm{d}z_x \mathrm{d}z_d}
\end{aligned}$$

In equilibrium, P is determined. Together with equation (2), we can get:

$$\begin{aligned}
\Psi_e &= \frac{\theta}{\theta - 1} \cdot \frac{\displaystyle\int_{z_x} \varphi_x^*(z_x)^{1-\theta} \gamma(z_x)\,\mathrm{d}z_x}{\displaystyle\int_{z_x} \varphi_x^*(z_x)^{-\theta} \gamma(z_x)\,\mathrm{d}z_x} \\
&= \frac{\theta}{\theta - 1} \cdot \frac{\theta + \beta}{\theta + \beta - 1} \cdot \frac{\Theta}{P} \cdot \tau Z_x
\end{aligned}$$

Let S_d denote the area $\{(z_d, z_x) \mid z_d < \tau z_x\}$ and S_x the area $\{(z_d, z_x) \mid z_d > \tau z_x\}$. Average productivity of non-exporters is :

$$\begin{aligned}
\Psi_{ne} &= \frac{\displaystyle\int_{S_d} \int_{\varphi_d^*(z_d)}^{\varphi_x^*(z_x)} \varphi \frac{g(\varphi)\gamma(z_x)\psi(z_d)}{\Upsilon} M\,\mathrm{d}(\varphi, z_d, z_x)}{\displaystyle\int_{S_d} \int_{\varphi_d^*(z_d)}^{\varphi_x^*(z_x)} \frac{g(\varphi)\gamma(z_x)\psi(z_d)}{\Upsilon} M\,\mathrm{d}(\varphi, z_d, z_x)} \\
&= \frac{\displaystyle\int_{z_d} \int_{z_d/\tau}^{\infty} \int_{\varphi_d^*(z_d)}^{\varphi_x^*(z_x)} \varphi g(\varphi)\gamma(z_x)\psi(z_d)\,\mathrm{d}\varphi \mathrm{d}z_x \mathrm{d}z_d}{\displaystyle\int_{z_d} \int_{z_d/\tau}^{\infty} (G(\varphi_x^*(z_x)) - G(\varphi_d^*(z_d)))\gamma(z_x)\psi(z_d)\,\mathrm{d}z_x \mathrm{d}z_d}
\end{aligned}$$

In equilibrium, P is determined. Together with equation (2), we can get:

$$\begin{aligned}\Psi_{ne} &= \frac{\theta}{\theta-1}\cdot\frac{\int_{z_d}\int_{z_d/\tau}^{\infty}({\varphi_d^*(z_d)}^{1-\theta}-{\varphi_x^*(z_x)}^{1-\theta})\gamma(z_x)\psi(z_d)\,\mathrm{d}z_x\mathrm{d}z_d}{\int_{z_d}\int_{z_d/\tau}^{\infty}(\varphi_d^{*-\theta}-\varphi_x^{*-\theta})\gamma(z_x)\psi(z_d)\,\mathrm{d}z_x\mathrm{d}z_d}\\ &= \frac{\theta+\beta}{\theta+\beta-1}\frac{\theta+\beta+\alpha}{\theta+\beta+\alpha-1}\cdot\frac{\Theta}{P}\cdot Z_d\end{aligned}$$

Appendix 3: Average productivity in autarky and with trade

In autarky, the probability of an entrant becoming active Υ_a is determined as:

$$\Upsilon_a=\int_{z_d}\int_{\varphi_d^*(z_d)} g(\varphi)\psi(z_d)\,\mathrm{d}(\varphi,z_d)$$

The average productivity in autarky is:

$$\begin{aligned}\Psi_a &= \frac{\int_{z_d}\int_{\varphi_d^*(z_d)}^{\infty}\varphi\frac{g(\varphi)\psi(z_d)}{\Upsilon_a}M\,\mathrm{d}(\varphi,z_d)}{M}\\ &= \frac{\int_{z_d}\int_{\varphi_d^*(z_d)}^{\infty}\varphi g(\varphi)\psi(z_d)\,\mathrm{d}\varphi\mathrm{d}z_d}{\int_{z_d}(1-G(\varphi_d^*(z_d)))\psi(z_d)\,\mathrm{d}z_d}\\ &= \frac{\theta}{\theta-1}\cdot\frac{\theta+\alpha}{\theta+\alpha-1}\cdot\frac{\Theta}{P_a}\cdot Z_d\end{aligned}$$

With trade the average productivity after trade can be expressed as:

$$\begin{aligned}\Psi &= \frac{\int_{z_x,z_d}\int_{\varphi^*(z_d,z_x)}^{\infty}\varphi\frac{g(\varphi)\gamma(z_x)\psi(z_d)}{\Upsilon}M\,\mathrm{d}(\varphi,z_d,z_x)}{M}\\ &= \frac{\int_{S_d}\int_{\varphi_d^*(z_d)}^{\infty}\varphi g(\varphi)\gamma(z_x)\psi(z_d)\,\mathrm{d}\varphi\mathrm{d}z_x\mathrm{d}z_d+\int_{S_x}\int_{\varphi_x^*(z_x)}^{\infty}\varphi g(\varphi)\gamma(z_x)\psi(z_d)\,\mathrm{d}\varphi\mathrm{d}z_x\mathrm{d}z_d}{\int_{S_d}(1-G(\varphi_d^*(z_d)))\gamma(z_x)\psi(z_d)\,\mathrm{d}\varphi\mathrm{d}z_x\mathrm{d}z_d+\int_{S_x}(1-G(\varphi_x^*(z_x)))\gamma(z_x)\psi(z_d)\,\mathrm{d}\varphi\mathrm{d}z_x\mathrm{d}z_d}\\ &= \frac{\theta}{\theta-1}\cdot\frac{\int_{Z_d}^{\infty}\int_{z_d/\tau}^{\infty}{\varphi_d^*(z_d)}^{1-\theta}\gamma(z_x)\psi(z_d)\,\mathrm{d}z_x\mathrm{d}z_d+\int_{Z_d}^{\infty}\int_{Z_x}^{z_d/\tau}{\varphi_x^*(z_x)}^{1-\theta}\gamma(z_x)\psi(z_d)\,\mathrm{d}z_x\mathrm{d}z_d}{\int_{Z_d}^{\infty}\int_{z_d/\tau}^{\infty}{\varphi_d^*(z_d)}^{-\theta}\gamma(z_x)\psi(z_d)\,\mathrm{d}\varphi\mathrm{d}z_x\mathrm{d}z_d+\int_{Z_d}^{\infty}\int_{Z_x}^{z_d/\tau}{\varphi_x^*(z_x)}^{-\theta}\gamma(z_x)\psi(z_d)\,\mathrm{d}\varphi\mathrm{d}z_x\mathrm{d}z_d}\\ &= \frac{\theta}{\theta-1}\cdot\frac{\theta+\beta}{\theta+\beta-1}\cdot\frac{\frac{\alpha(\theta-1)}{\theta+\beta+\alpha-1}Z_d(\frac{\tau Z_x}{Z_d})^{\theta+\beta}+\beta\tau Z_x}{\frac{\alpha\theta}{\theta+\beta+\alpha}(\frac{\tau Z_x}{Z_d})^{\theta+\beta}+\beta}\cdot\frac{\Theta}{P}\end{aligned}$$

Appendix 4: A decrease in foreign entry cost

$\lambda'(f_x \mid \varphi, A_d, A_x)$ is the conditional distribution of foreign entry cost, and $\lambda(f_x \mid \varphi, A_d, A_x)$ is the conditional distribution with a decrease of foreign entry cost. $\Lambda'(f_x \mid \varphi, A_d, A_x)$ and $\Lambda(f_x \mid \varphi, A_d, A_x)$ are the corresponding cumulative distributions. The change of conditional profit $\Delta\pi(P \mid \varphi, A_d, A_x)$ is then:

$$\begin{aligned}
\Delta\pi(P \mid \varphi, A_d, A_x) &= \int_0^{f_x^*(P,\varphi,A_x)} (f_x^*(P,\varphi,A_x) - f_x)(\lambda(f_x \mid \varphi, A_d, A_x) - \lambda'(f_x \mid \varphi, A_d, A_x))\mathrm{d}f_x \\
&= (f_x^*(P,\varphi,A_x) - f_x)(\Lambda(f_x \mid \varphi, A_d, A_x) - \Lambda'(f_x \mid \varphi, A_d, A_x))|_0^{f_x^*(P,\varphi,A_x)} \\
&\quad - \int_0^{f_x^*(P,\varphi,A_x)} (-1)(\Lambda(f_x \mid \varphi, A_d, A_x) - \Lambda'(f_x \mid \varphi, A_d, A_x))\mathrm{d}f_x \\
&= \int_0^{f_x^*(P,\varphi,A_x)} (\Lambda(f_x \mid \varphi, A_d, A_x) - \Lambda'(f_x \mid \varphi, A_d, A_x))\mathrm{d}f_x
\end{aligned}$$

With property of LEFC, i.e. $\Lambda(f_x \mid \varphi, A_d, A_x) \geq \Lambda'(f_x \mid \varphi, A_d, A_x)$, $\Delta\pi(P \mid \varphi, A_d, A_x) \geq 0$. Therefore $\pi(P \mid \varphi, A_d, A_x)$ becomes higher.

Appendix 5: Innovation

In order to analyse the effects of an increase in productivity, we assume that for two distributions of characteristics, the conditional distributions of productivity φ can ranked by first-order stochastic dominance:

Higher Productivity (HP) *For two distributions of characteristics λ and λ', λ has higher productivity than λ' provided $\Lambda(\varphi \mid \eta) \leq \Lambda'(\varphi \mid \eta)$ for all (φ, η).*

With HP satisfied, the effects of an innovation will be the same effects as a decrease of foreign entry cost in Theorem 5, i.e., innovation pushes some pure exporters and non-exporters out of the market and some ordinary exporters to become pure exporters or non-exporters.

Rearrange equation (7) to get:

$$k(x) = \int_x^\infty \left(\left(\frac{\varphi}{x} \right)^{\sigma - 1} - 1 \right) \lambda(\varphi \mid \eta)\mathrm{d}\varphi$$

With property HP innovation will increase $k(x)$. To see this, let $\lambda'(\varphi \mid \eta)$ denote the conditional distribution of productivity and $\lambda(\varphi \mid \eta)$ denote the conditional distribution with innovation. $\Lambda'(\varphi \mid \eta)$ and $\Lambda(\varphi \mid \eta)$ are the corresponding cumulative distributions. The change of $k(x)$ is:

$$
\begin{aligned}
\Delta k(x) &= \int_x^{\infty}\left((\frac{\varphi}{x})^{\sigma-1}-1\right)\left(\lambda(\varphi\,|\,\eta)-\lambda'(\varphi\,|\,\eta)\right)\mathrm{d}\varphi \\
&= \left((\frac{\varphi}{x})^{\sigma-1}-1\right)(\Lambda(\varphi\,|\,\eta)-\Lambda'(\varphi\,|\,\eta))\,|_x^{\infty}-\int_x^{\infty}\frac{(\sigma-1)\varphi^{\sigma-2}}{x^{\sigma-1}}(\Lambda(\varphi\,|\,\eta)-\Lambda'(\varphi\,|\,\eta))\mathrm{d}\varphi \\
&= -\int_x^{\infty}\frac{(\sigma-1)\varphi^{\sigma-2}}{x^{\sigma-1}}(\Lambda(\varphi\,|\,\eta)-\Lambda'(\varphi\,|\,\eta))\mathrm{d}\varphi
\end{aligned}
$$

With property of HP, i.e. $\Lambda(\varphi\,|\,\eta)\leq\Lambda'(\varphi\,|\,\eta)$, $\Delta k(x)\geq 0$. Therefore $k(x)$ is increased.

Therefore, $k(\varphi_d^*(P,f_d,A_d))$ and $k(\varphi_x^*(P,f_x,A_x))$ become higher. According to equation (8), $\pi(P,\varphi\,|\,\eta)$ becomes higher, so does the expected profit $\Pi(P)$. Therefore, price level is decreased, leading to the same effects as a decrease of foreign entry cost in Theorem 5. The effects of innovation are channelled through active firms. The distribution of non-active firms, i.e. firms with productivity lower than $\varphi_d^*(P,f_d,A_d)$ and $\varphi_x^*(P,f_x,A_x)$, makes no difference to the results.

Appendix 6: Estimation of Productivity

To estimate the productivity of firms, the revenue function (sector k is omitted to ease notation) is:

$$\ln Y_{it}=\kappa_0+\kappa_1\ln L_{it}+\kappa_2\ln K_{it}+\kappa_3\ln M_{it}+\ln\varphi_{it}$$

To correct the simultaneity bias and selection bias, Olley and Pakes (1996) use investment to control the unobservable productivity and survival probability to control the firm exit. Following Amiti and Konings (2007) and Yu(2015), we add the export dummy in the investment function.

$$\ln I_{it}=I(\ln K_{it},\ln\varphi_{it},EX_{it})$$

We have data of depreciation D_{it} in our database. Thus the investment is measured as $I_{it}=K_{it}-K_{it-1}+D_{it}$. The investment is positively related to productivity. Therefore, the inverse function of investment is $\ln\varphi_{it}=I^{-1}(\ln K_{it},\ln I_{it},EX_{it})$. The production function is then:

$$\ln Y_{it}=\kappa_0+\kappa_1\ln L_{it}+\kappa_3\ln M_{it}+g(\ln K_{it},\ln I_{it},EX_{it})+\varepsilon_{it}$$

where $g(\ln K_{it},\ln I_{it},EX_{it})=\kappa_2\ln K_{it}+I^{-1}(\ln K_{it},\ln I_{it},EX_{it})$. We use third-order polynomials to approximate the $g(\cdot)$ to estimate the κ_1 and κ_3 as the first step.

$$g(\ln K_{it},\ln I_{it},EX_{it})=(\alpha_0+\alpha_1 EX_{it})\sum_{m=0}^{3}\sum_{n=0}^{3}\alpha_{mn}\ln K_{it}^m\ln I_{it}^n$$

To estimate the κ_2 requires a second step to estimate the survival probability to control for the selection bias. The survival probability in $t+1$ is estimated by third-order polynomials in $\ln K_{it}$, $\ln I_{it}$ and EX_{it}. Calculate the predicted probability $\hat{P}_{it}$. In the third step, we fit the following model by non-linear least squares to estimate κ_2.

$$\ln Y_{it} - \hat{\kappa}_1 \ln L_{it} - \hat{\kappa}_3 \ln M_{it} = \kappa_2 \ln K_{it} + \phi(\hat{g}_{it-1} - \kappa_2 \ln K_{it-1}, \hat{P}_{it}) + \varepsilon_{it}$$

where $\phi(\cdot)$ is approximated by third-order polynomials in $\hat{g}_{it-1} - \kappa_2 \ln K_{it-1}$ and $\hat{P}_{it}$. Then the productivity is calculated by $\ln \varphi_{it} = \ln Y_{it} - \hat{\kappa}_1 \ln L_{it} - \hat{\kappa}_2 \ln K_{it} - \hat{\kappa}_3 \ln M_{it}$. This estimation is used for the main analysis in the empirical section. We also provide four other methods to estimate the productivity.

The first one is to estimate of revenue function with Olley and Pakes (1996) approach and more controls in investment function (OP_revenue_2). The investment function is revised to add the dummies of pure exporters and state-owned firms: $\ln I_{it} = I(\ln K_{it}, \ln \varphi_{it}, EX_{it}, PE_{it}, SOE_{it})$. Accordingly,

$$g(\ln K_{it}, \ln I_{it}, EX_{it}, PE_{it}, SOE_{it}) = (\alpha_0 + \alpha_1 EX_{it} + \alpha_2 PE_{it} + \alpha_3 SOE_{it}) \sum_{m=0}^{3} \sum_{n=0}^{3} \alpha_{mn} \ln K_{it}^m \ln I_{it}^n$$

The survival probability in $t+1$ is estimated by third-order polynomials in $\ln K_{it}$, $\ln I_{it}$, EX_{it}, PE_{it} and SOE_{it}. We also estimate the value-added function:

$$\ln Valueadded_{it} = \kappa_0 + \kappa_1 \ln L_{it} + \kappa_2 \ln K_{it} + \ln \varphi_{it}$$

Olley and Pakes (1996) approach with controls $\ln K_{it}$, $\ln \varphi_{it}$ and EX_{it} (OP_valueadded_1) is similar to the estimation of revenue function, except that the coefficient of material is no longer estimated. Olley and Pakes (1996) approach with more controls $\ln K_{it}$, $\ln \varphi_{it}$, EX_{it}, PE_{it} and SOE_{it} (OP_valueadded_2) is similar to OP_revenue_2. We also provide the Levinsohn and Petrin (2003) approach (LP_valueadded), where the unobservable productivity is controlled by materials.

$$\ln M_{it} = M(\ln K_{it}, \ln \varphi_{it})$$

Therefore, the productivity is controlled by $\ln \varphi_{it} = M^{-1}(\ln K_{it}, \ln M_{it})$ in order to estimate κ_1. And then $\ln Valueadded_{it} - \hat{\kappa}_1 \ln L_{it} = \kappa_2 \ln K_{it} + \phi(\hat{g}_{it-1} - \kappa_2 \ln K_{it-1}) + \varepsilon_{it}$ is estimated by non-linear least squares to get κ_2. After estimating the value-added function, the productivity is calculated by $\ln \varphi_{it} = \ln Valueadded_{it} - \hat{\kappa}_1 \ln L_{it} - \hat{\kappa}_2 \ln K_{it}$.