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The impact of trade with pure exporters

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Abstract

We extend the Melitz model to include pure exporters and study how they influence economic performance. We find that the presence of pure exporters lowers the productivity premium of exporters. Moreover, if there is a large portion of pure exporters, then international trade lowers the average productivity, but not welfare. Moreover, we explore how trade liberalization in form of lower entry cost into foreign markets and lower variable export cost influences the distribution of firms between pure exporters, ordinary exporters and non-exporters.

KEYWORDS

pure exporters, firm heterogeneity, trade liberalization, productivity premium

JEL CLASSIFICATION

F12; L1

1 | INTRODUCTION

Firms can be split into non-exporters, ordinary exporters, and pure exporters where pure exporters have been somewhat overlooked. We study how the presence of pure exporters can be rationalized in a theoretical model and how they influence economic performance. In our model, on average pure exporters are less productive than ordinary exporters. As a consequence, the productivity premium of exporters in the presence of pure exporters is lower than the premium in the absence of pure exporters. Moreover, if there is a large portion of pure exporters, then international trade lowers the average productivity.

To allow for the existence of pure exporters, we extend the basic Melitz (2003) model by introducing heterogeneity in productivity as well as in both entry cost and demand in foreign markets. What is important for all firms in their choices about which markets to serve is the combination of entry cost and demand versus productivity. Based on their characteristics, demand-adjusted entry cost versus productivity, firms choose to be pure exporters, ordinary exporters, non-exporters, or non-active. The present paper builds a general equilibrium model with non-exporters, ordinary exporters and pure exporters that provides a series of analytical results about the impact of trade on the average productivity, welfare, and the distribution of incumbent firms in the presence of pure exporters.

In our model, pure exporters face lower demand-adjusted foreign entry cost than demand-adjusted domestic entry cost, and their productivities allow them to make profits in the foreign market, but not in the domestic market. It is the reverse for non-exporters. Ordinary exporters make profits in both markets because their productivities allow them to afford demand-adjusted entry cost in both markets. Non-active firms cannot make profits in any market. In equilibrium, pure exporters, ordinary exporters, and non-exporters co-exist. On average, pure exporters are less productive than ordinary exporters. As a result, the productivity premium of exporters in the presence of pure exporters is lower than the premium in the absence of pure exporters. Moreover, in our model, it turns out that pure exporters can be less productive than non-exporters. As a consequence, in Theorem 2, we show quite surprisingly that if there is a large portion of pure exporters, then the average productivity of exporters can be lower than the average productivity of non-exporters. Hence, the productivity premium of exporters could be negative in the presence of pure exporters.

To explore the impact of trade on equilibrium we compare autarky and trade. Trade, on one hand, pushes 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 trade can lower the average productivity compared with autarky as we show in Theorem 3. The results indicate that studying the impact of trade without considerations of pure exporters can be misleading. Moreover, we show in Theorem 4 that trade increases welfare independently of whether it decreases the average productivity.

We study the effects of trade liberalization interpreted as changes of the conditional distribution of foreign entry cost or of variable export cost. A decrease in foreign entry cost increases the minimum productivity needed to serve both domestic and foreign markets. Therefore, among firms with any given value of demand-adjusted foreign entry cost, the least productive firms are forced out of the market. The least productive ordinary exporters become pure exporters or non-exporters depending on their demand-adjusted foreign entry cost as described in Theorem 5. A decrease in variable export cost increases the minimum productivity needed to serve the domestic market and decreases the minimum productivity needed to serve the foreign market. Hence, some firms become pure exporters and some non-exporters are pushed out of the market or become ordinary exporters as described in Theorem 6.

At first sight, it can appear puzzling that firms can have lower demand-adjusted foreign entry cost than demand-adjusted domestic entry cost. There are at least two possible sources: relatively low foreign entry cost or relatively high foreign demand. Take China as an example. Provinces and in some cases even cities compete with each other and build barriers 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 cost because of their experiences or networks with foreign firms (Dai et al., 2016). Relatively high demand in foreign markets can be the case for firms located in small or developing countries (Defever & Riaño, 2017b).

Pure exporters are nontrivial, especially in the developing countries. As described in Defever and Riaño (2019), around 10% of firms and 35% of exporters in China are pure exporters. In our empirical analysis, we find that pure exporters account for at least 30% of all exporters in around 40% industries and account for at least 20% of all exporters in around 55% industries. Moreover, Defever and Riaño

(2017a) show that pure exporters account for more than 30% of firms in almost half of the 20 largest developing and transition countries. Additionally, Defever and Riaño (2017b) document that in many countries there is a high concentration of exporters with high export intensity. There are few theoretical models explaining the existence of pure exporters. In Defever and Riaño (2017a), subsidies with export share requirement are used to explain the existence of pure exporters. However, as shown in Defever and Riaño (2017a,2017b), pure exporters and exporters with high export intensity are still pervasive even in the countries without government's policy support. This suggests that factors other than government's policy support also play an important role in explaining pure exporters.

In the present paper, firm heterogeneity in productivity as well as in both entry cost and demand in the foreign market makes firms select into pure exporters, ordinary exporters, and non-exporters. Our model is very compatible with Lu et al. (2014) and Defever and Riaño (2017b). The former paper shows that firms sort into pure exporters and ordinary exporters based on their heterogeneity in productivity only when there is a sufficiently large demand in foreign markets. The latter paper introduces firm heterogeneity in domestic and foreign demand to explain the high export intensity in some exporters, including pure exporters. Departing from firm heterogeneity in demand shocks, in Lu (2010), pure exporters can exist in the sectors in which the home country has a strong comparative advantage. Moreover, being processing exporters could also partly explain the existence of pure exporters. However, in our model, all firms produce final products by use of labor leaving no role for processing firms which usually produce final products or intermediaries for other firms. Nevertheless, we believe that our model is important for two reasons. First, although pure exporters and processing exporters are empirically related, they are not identical. In Defever and Riaño (2019), it is found that 51.62% of processing exporters are pure exporters and 37.0% of pure exporters are processing exporters (see Table A1 in Appendix A.1). Second, the logic underlying the choice to become processing exporters should be the same as the logic underlying the choice to become pure exporters, ordinary exporters, non-exporters, or non-active, namely profit maximization. If being processing exporters provides them low demand-adjusted foreign entry cost, firms choose to be processing exporters given their combinations of productivity and demand-adjusted entry cost.

The model in the present paper is very flexible and able to reconcile the existing empirical evidence on pure exporters. For example, Lu et al. (2014) and Defever and Riaño (2019) find that pure exporters are less productive than ordinary exporters. Additionally, Dai et al. (2016) show that the processing exporters are less productive than non-processing exporters. Due to high-dimensional firm heterogeneity, these productivity patterns can be reconciled by our model. Moreover, our model is also able to reconcile the empirical pattern that exporters can be less productive than non-exporters. For example, Feenstra et al. (2014) find that exporters are less productive than non-exporters, that is, the productivity premium of exporters is negative, in around one-third of sectors in China. In our empirical analysis, we find similar results using more disaggregated sectors. Additionally, we find that the premium is lower in the sectors with more pure exporters. These empirical results are compatible with our model in which pure exporters can be less productive than ordinary exporters and even can be less productive than non-exporters. As a result, the premium is negatively related to the share of pure exporters and can even be negative provided there is a large portion of pure exporters.

The basic Melitz model has been extended in several dimensions. In many papers, heterogeneity in entry cost is considered (Arkolakis, 2010; Das et al., 2007; Jørgensen & Schröder, 2008; Kasahara & Lapham, 2013; Krautheim, 2012). Compared with these papers, we add heterogeneity in productivity and demand to allow for pure exporters. In Eaton et al. (2011), the same dimensions of heterogeneity as we consider are introduced. Compared with Eaton et al. (2011), we allow for pure exporters. Moreover, we focus on the choice of which markets to serve and study the impact of trade on aggregate productivity and firm exit and entry in the presence of pure exporters.

In numerous papers, productivity of exporters and productivity of non-exporters are compared empirically. An established literature has found that exporters are more productive than non-exporters (e.g. Bernard & Jensen, 1999; Bernard et al., 2003; Bustos, 2011; De Loecker, 2007; Lileeva & Trefler, 2010). Moreover, in some papers, it is found that trade forces the least productive firms to exit markets and thereby increases overall productivity (e.g. Bernard et al., 2011; Mayer et al., 2014; Melitz, 2003; Melitz & Ottaviano, 2008; Pavcnik, 2002; Trefler, 2004). Our model is compatible with these findings provided that the distribution of firm characteristics does not result in a large portion of pure exporters.

The rest of this paper is organized as follows. Section 2 is the setup of the model. In Section 3, we describe the equilibrium. In Section 4, we explore the effects of trade liberalization. In Section 5, we provide some empirical evidence of the model. Section 6 is the conclusion.

2 | THEORETICAL 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 domestic market, foreign market, both markets, or stay non-active. Firms have to pay entry costs 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.

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

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

The solution to the consumers' 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

There is a continuum of active firms. Let Ω be the set of active firms with $\omega \in \Omega$. Firm ω can produce good ω by use of labor. 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 is the domestic entry cost; F_x is the foreign entry cost; A_d is the demand shock in the domestic market; and A_x is the demand shock in the foreign market. Therefore, a firm is characterized by its productivity, market entry cost and demand shock $(\varphi, F_d, F_x, A_d, A_x)$.

We aim at building a model in which pure exporters, ordinary exporters and non-exporters co-exist. To achieve this aim, we need firm heterogeneity in at least one parameter of (F_d, F_x, A_d, A_x) in addition to the heterogeneity in productivity φ. In the main model, we assume that entry cost and demand shock in the foreign market, that is, F_x and A_x, are heterogeneous while assuming entry cost and demand shock in the domestic market, that is, F_d and A_d, are fixed. More specifically, we assume that the parameters (φ, F_x, A_x) are drawn from a common probability distribution with density ξ and cumulative distribution Ξ. As shown in the later analysis, what matters in firms' decision on which market to serve is the combination of productivity and demand-adjusted foreign entry cost. In Supporting Information S.3, we extend the model to firm heterogeneity in entry cost and demand shock in the domestic market, that is, F_d and A_d. It is shown that the results derived from the main model are robust in the extended model.

2.3.1 | 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 cost. In the sequel, we use amortized per date market entry cost and calculate profit per date rather than market entry cost and expected lifetime profit. Clearly the density λ on productivity, amortized entry cost, and demand shock in the foreign market is defined by $\lambda(\varphi, f_x, A_x) = \xi(\varphi, f_x/\delta, A_x)$ with cumulative distribution $\Lambda(\varphi, f_x, A_x) = \Xi(\varphi, f_x/\delta, A_x)$.

In order to supply $q > 0$ units of good ω to domestic market, the firm with productivity φ uses $f_d + q/\varphi$ units of labor. There is a variable export cost $\tau \geq 1$. Therefore, in order to supply $q > 0$ units of the good to foreign market, the firm with productivity φ uses $f_x + q\tau/\varphi$ units of labor. For given price and quantity indices, every firm faces the demand function described in Equation (1). The firm serving the domestic market maximizes its profit:

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

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

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

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

2.3.2 | Behavior

Firms can be non-active firms, non-exporters, ordinary exporters, or pure exporters. The cut-off productivities are determined by $\pi_i(\varphi) = 0$ in which $i \in \{d,x\}$. Therefore for $\Theta = (\sigma/R)^{1/(\sigma-1)}/\rho$, the cut-off productivities are:

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

Hence the behavior of a firm (φ, f_x, A_x) can be characterized as follows:

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

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

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

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

Ordinary exporter: A firm is an ordinary exporter provided

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

Pure exporter: A firm is a pure exporter provided

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

For a pure exporter, $\varphi_x^*(f_x, A_x) < \varphi_d^*$ means $\tau f_x^{1/(\sigma-1)}/A_x < f_d^{1/(\sigma-1)}/A_d$. Therefore, a pure exporter 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 market $A_x > A_d$. Take China as an example. Provinces, and in some cases, even cities compete with each other 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 cost because of their experience or networks with foreign firms (e.g. Dai et al., 2016). Relatively high demand in foreign market can happen when firms are located in a small or developing country (e.g. Defever & Riaño, 2017b). When a firm has relatively higher foreign demand than domestic demand, it may still have lower demand-adjusted foreign entry cost than demand-adjusted domestic entry cost even if 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. An ordinary exporter earns profit in both markets given its productivity and a non-active firm cannot make profit in any market.

Let $Z_d = f_d^{1/(\sigma-1)}/A_d$ be the fixed value of demand-adjusted domestic entry cost. Let $z_x = f_x^{1/(\sigma-1)}/A_x$ be demand-adjusted foreign entry cost, which is heterogeneous across firms. Equation (2) shows that cut-off productivity in domestic market is fixed while cut-off productivity in foreign market is linear in demand-adjusted foreign entry cost. Figure 1 illustrates different kinds of firm behavior in the space of productivity and demand-adjusted foreign entry cost. The two lines of cut-off productivity divide the space into four parts: non-exporters (NE), ordinary exporters (OE), pure exporters (PE) and non-active firms (N). For a given value of demand-adjusted domestic entry cost, pure exporters are characterized by low productivity and low demand-adjusted foreign entry cost.

2.3.3 | 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, dead firms are replaced by new firms. Therefore, entry and exit do not affect the distribution of firms.

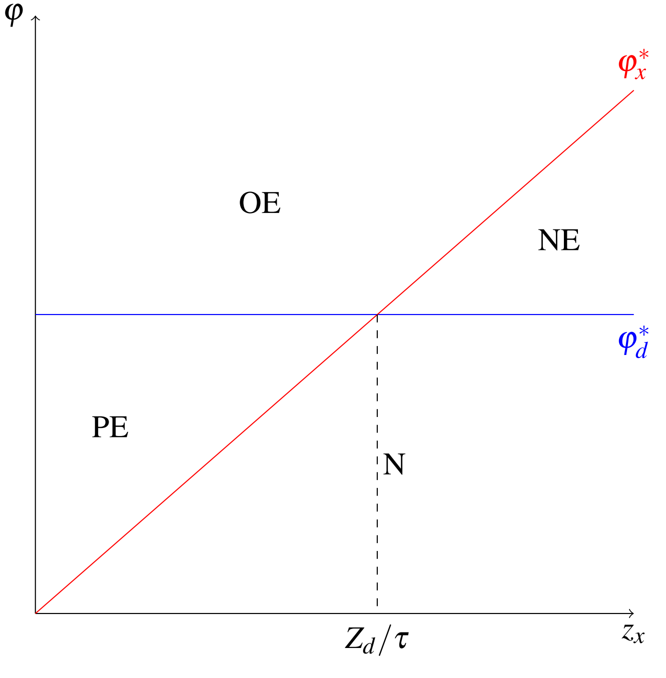

FIGURE 1 Firm behavior based on productivity and demand-adjusted foreign entry cost

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 $\eta = (f_x, A_x)$ 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 $\pi_d(P, \varphi) = R(PA_d\rho\varphi)^{\sigma-1}/\sigma - f_d$ and profit from the foreign market $\pi_x(P,\varphi,\eta) = R(PA_x\rho\varphi/\tau)^{\sigma-1}/\sigma - f_x$:

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

Therefore, for Φ and k 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 of productivity, the expected profit conditional on η is

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

Then we prove that $\Pi(P)$ is an increasing function of P. From Equations (6) and (7), $k\prime(x) = (1-\sigma)\int_x^{\infty}\varphi^{\sigma-1}\lambda(\varphi\,|\,\eta)\,\mathrm{d}\varphi/x^{\sigma} < 0$. According to Equation (2), the derivatives of the cutoff productivities with respect to P are negative, that is, $\partial\varphi_d^*/\partial P < 0$ and $\partial\varphi_x^*(f_x,A_x)/\partial P < 0$. Hence $\pi\prime(P\,|\,\eta) > 0$ 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. All other endogenous variables are determined in equilibrium (see Appendix A.2 for full details).

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

Given the distribution $\lambda(\varphi,\eta)$ where $\eta = (f_x, A_x)$, firms which can afford both demand-adjusted domestic and foreign entry cost will become ordinary exporters. 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 are present due to either relatively lower foreign entry cost than domestic entry cost and (or) higher foreign demand than domestic demand. Figure 1 illustrates all the combinations of parameters for different firm behavior. The share of pure exporters depends on the distribution of firms. Therefore, different distributions of firms generate different shares of pure exporters.

Figure 1 shows that 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 *The average productivity of exporters, consisting of pure exporters and ordinary exporters, can be lower than the average productivity of non-exporters.*

Proof To quantitatively show that the average productivity of exporters can be lower than the average productivity of non-exporters, we simplify the calculation using a specific form of firm distribution. Assume a distribution $\lambda(\varphi,\eta)$ such that: (1) density distribution of productivity φ is $g(\varphi)$, and (2) demand-adjusted foreign entry cost z_x is under distribution $\gamma(z_x)$. As widely used, productivity distribution is Pareto distribution $g(\varphi) = \theta\underline{\varphi}^{\theta}\varphi^{-\theta-1}$ with support on $(\underline{\varphi},\infty)$, where $\underline{\varphi}$ is assumed very small. We also assume that $\gamma(z_x) = \alpha {Z_x}^{\alpha} z_x^{-\alpha-1}$ with support on (Z_x,∞). In Appendix A.3, we show that the ratio between the average productivity of exporters Ψ_e and the average productivity of non-exporters Ψ_{ne} in the presence of pure exporters is:

$$\frac{\Psi_e}{\Psi_{ne}} = \frac{\theta}{\theta-1}\left(\frac{\tau Z_x}{Z_d}\right) \text{ provided } \frac{\tau Z_x}{Z_d} \leq 1$$

for $\theta > 1$. It can be verified that:

$$\frac{\Psi_e}{\Psi_{ne}} < 1 \text{ provided } \frac{\tau Z_x}{Z_d} < \frac{\theta-1}{\theta}$$

As shown in Appendix A.3, the share of pure exporters is negatively related to $\tau Z_x/Z_d$. Therefore, the average productivity of exporters is lower than the average productivity of non-exporters when there is a large portion of pure exporters.

Theorem 2 is surprisingly different from the studies that neglect pure exporters. In our model, on average pure exporters are less productive than non-exporters. When demand-adjusted foreign entry cost is lower than demand-adjusted domestic entry cost, then some low-productivity firms can only survive as pure exporters, leading to lower average productivity of pure exporters. As a result, the productivity premium of exporters is negatively related to the share of pure exporters. Therefore, when there is a large portion of pure exporters, the average productivity of exporters can be lower than the average productivity of non-exporters.

Whether there is a large portion of low-productivity pure exporters depends on the distribution of firms. In Appendix A.3 using Pareto distributions of productivity and demand-adjusted foreign entry cost, we show that when demand-adjusted foreign entry cost is high ($\tau Z_x/Z_d > 1$), there are no pure exporters and the average productivity of exporters is higher than the average productivity of non-exporters. This is consistent with the Melitz model. However, when the distribution of firms skews to low demand-adjusted foreign entry cost, for example, the minimal demand-adjusted foreign entry cost Z_x is very small ($\tau Z_x/Z_d < 1$), some low-productivity firms will be able to survive as pure exporters. As Z_x is lower, there are more low-productivity pure exporters. As a result, the average productivity of exporters is more likely to be lower than the average productivity of non-exporters. Moreover, the productivity distribution parameter θ affects how many low-productivity firms there are. A larger value of θ means that the distribution of firms skews to low-productivity firms. As a result, there will be a larger portion of low-productivity pure exporters, leading to lower average productivity of exporters compared with non-exporters.

It is worth noting that the average productivity of exporters (non-exporters) is a simple average of productivity across exporters (non-exporters). This measure of average productivity is consistent with the empirical analysis on the productivity premium of exporters, in which usually firms' productivities are regressed on a dummy variable being one (zero) if firms are exporters (non-exporters). However, this measure does not take into consideration that firms with higher productivity have larger revenue and thereby should have higher weights in the calculation of average productivity. In Supporting Information S.1, we provide additional analysis with alternative measures of average productivity. More specifically, we investigate the aggregate productivity as in Melitz (2003) and the revenue-weighted average productivity as widely used in empirical analysis when calculating the industry-level productivity (e.g. Pavcnik, 2002). The results are robust in that the average productivity of exporters is lower than the average productivity of non-exporters when there is a large portion of pure exporters.

4 | TRADE LIBERALIZATION

4.1 | From autarky to trade

In autarky, all firms are non-exporters by definition. Therefore, demand shock and entry cost in the foreign market play no roles in firms' profit and cut-off productivity. Autarky could also be considered as the limit case where the variable export cost is infinite. When variable export cost is decreased, trade happens. In order to do comparative study from autarky to trade, we first prove a unique equilibrium in autarky and lower price index with trade than in autarky. The average profit of firms in autarky conditional on η is determined as:

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

where P_a is the price level and φ_d^{*a} is the cut-off productivity in autarky. The expected profit in autarky $\Pi(P_a)$ is:

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

Since $k(\varphi_d^{*a})$ is monotonically decreasing in φ_d^{*a} and φ_d^{*a} is monotonically decreasing in P_a in autarky, $\Pi(P_a)$ 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 Π 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 as shown in Figure 2. From Figure 2, we see that trade not only forces the least productive firms with relatively high demand-adjusted foreign entry cost ($z_x > Z_d/\tau$) out of the market, as shown in O area, but also induces less productive firms with relatively low demand-adjusted foreign entry cost ($z_x < Z_d/\tau$) to enter the market as pure exporters, as shown in PE area. As a result, the effect of trade on average productivity can be positive or negative. In particular, if there is a large portion of pure exporters, the effect can be negative.

Theorem 3 *Compared with autarky, trade can lower the average productivity.*

Proof Using the same distributions of productivity and demand-adjusted foreign entry cost as in the proof in Theorem 2, in Appendix A.4, we show that the ratio between the average productivity under trade Ψ and the average productivity in autarky Ψ_a is:

$$\frac{\Psi}{\Psi_a} = \frac{\left(\frac{\tau Z_x}{Z_d}\right)^{\theta-\sigma} + \frac{\alpha\tau^{1-\sigma}}{\alpha+\theta-\sigma}}{\left(\frac{\tau Z_x}{Z_d}\right)^{\theta-\sigma+1} + \frac{\alpha\tau^{1-\sigma}}{\alpha+\theta-\sigma+1}} \left(\left(\frac{\tau Z_x}{Z_d}\right)^{\theta} + k\left(\frac{\tau Z_x}{Z_d}\right)^{\sigma-1}\right)^{\frac{1}{\theta}}$$

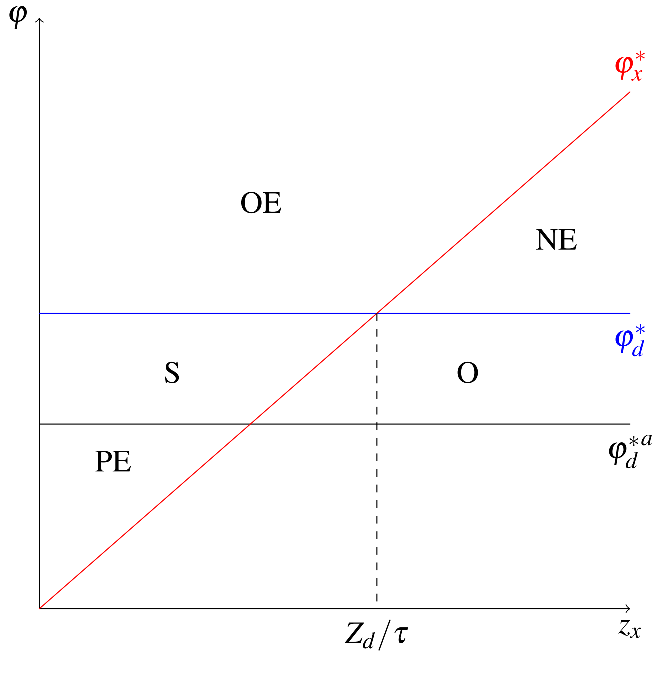

FIGURE 2 Firm behavior from autarky to trade

in which $\theta > \sigma$ and k is a positive constant. The term in the bracket is an increasing function of $\tau Z_x/Z_d$. In Appendix A.4, it is shown that when $\tau Z_x/Z_d$ is very small, the fractional term is also an increasing function of $\tau Z_x/Z_d$. Therefore, Ψ/Ψ_a is an increasing function when $\tau Z_x/Z_d$ is small. Moreover, it can be verified that:

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

As a result, Ψ/Ψ_a is less than one when $\tau Z_x/Z_d$ is small. Therefore, compared with autarky, trade can lower the average productivity when there is a large portion of pure exporters.

Theorem 3 is a surprise indicating that the impact of trade without considerations of pure exporters can be misleading when there is a large portion of pure exporters. 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 2, 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 the 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 to enter the market as pure-exporters (PE). Compared with autarky, the effect of trade on average 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. Take the Pareto distributions of productivity and demand-adjusted foreign entry cost used in Appendix A.4 as an example. When demand-adjusted foreign entry cost is high ($\tau Z_x/Z_d > 1$), there are no pure exporters under trade. As shown in Appendix A.4, trade will increase average productivity, which is consistent with the Melitz model. When minimal demand-adjusted foreign entry cost Z_x is lower, there are more firms with low demand-adjusted foreign entry cost. As a result, trade will induce more low-productivity pure exporters into the market. Hence, it is more likely that trade will lower the average productivity compared with autarky.

Here, we prove Theorem 3 using the revenue-weighted average productivity. This measure is widely used to study how the overall productivity is affected in the empirical analysis (e.g. see Pavcnik (2002) and Appendix D.3 of Melitz (2003)). In Supporting Information S.2, we provide additional analysis with alternative measures: simple average productivity and aggregate productivity as in Melitz (2003). The results are robust that trade can lower average productivity when there is a large portion of pure exporter.

Theorem 4 *Compared with autarky, 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 is:

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

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

The effect of trade on the average productivity can be positive or negative, but the welfare gains from trade are positive. This indicates that the dominant source of trade gains here is the access to more varieties as in Melitz (2003).

4.2 | A decrease in foreign entry cost

Trade liberalization in form of lower foreign entry cost can be interpreted as a change in the conditional distribution of foreign entry cost. An example is the enlargement of EU in 2004 whereby the regulatory environment for a lot of European firms became standardized leading to lower foreign entry cost. Figure 3 illustrates an example of a decrease in foreign entry cost.

In order to analyze the effects of a decrease in foreign entry cost, we assume that for two distributions of characteristics, the conditional distributions of foreign entry cost on (φ, 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 $\Lambda(f_x \mid \varphi, A_x) \geq \Lambda'(f_x \mid \varphi, A_x)$ for all (f_x, φ, A_x).*

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

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

Proof Instead of cut-off productivities φ_d^* and $\varphi_x^*(f_x, A_x)$, $\pi_d(\varphi) = 0$ and $\pi_x(\varphi) = 0$ can alternatively determine cut-off market entry cost $f_d^*(\varphi) = (PA_d\varphi/\Theta)^{\sigma-1}$ and $f_x^*(\varphi, A_x) = (PA_x\varphi/(\Theta\tau))^{\sigma-1}$. 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 $\pi_d(\varphi) = f_d^*(\varphi) - f_d$ and $\pi_x(\varphi, f_x, A_x) = f_x^*(\varphi, A_x) - f_x$, respectively.

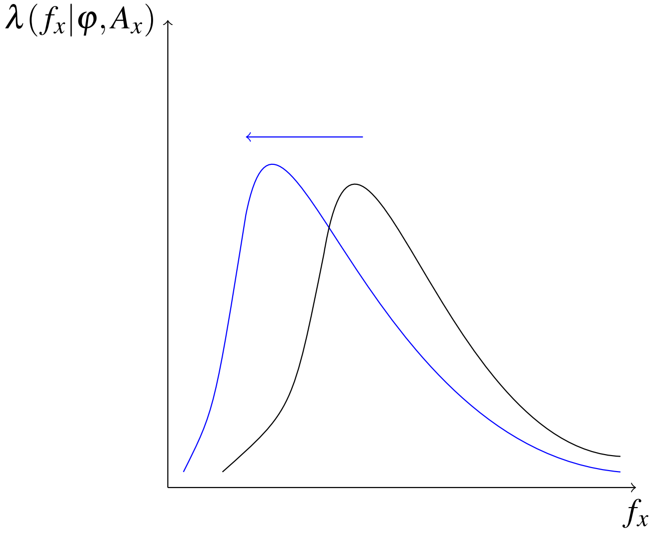

FIGURE 3 Shift of distribution under a decrease in foreign entry cost

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

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

Let $\lambda(f_x \mid \varphi, A_x) = \lambda(\varphi, \eta)/\lambda(\varphi, A_x)$ be conditional distribution of foreign entry cost.

$$\pi(P \mid \varphi, A_x) = \max\{f_d^*(\varphi) - f_d, 0\} + \int_0^{f_x^*(\varphi, A_x)} (f_x^*(\varphi, A_x) - f_x)\lambda(f_x \mid \varphi, A_x)\,\mathrm{d}f_x$$

Here a decrease in foreign entry cost will shift conditional distribution $\lambda(f_x \mid \varphi, A_x)$ while leaving $\lambda(\varphi, A_x)$ unchanged. With LFEC, the decrease of foreign entry cost will increase the conditional profit $\pi(P \mid \varphi, A_x)$ (see Appendix A.5). As a result, $\Pi(P)$ is higher. We have shown that $\Pi(P)$ is a monotonically increasing function. Therefore, the price level P is decreased, leading to higher cut-off productivity for both domestic and foreign market. As shown in Figure 4, some firms are pushed out of the market while some 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 the real wage is increased. As a result, the least productive firms for any value of demand-adjusted foreign entry cost are pushed out of the market. More specifically, as shown in Figure 4, pure exporters in area I, ordinary exporters in area II, and non-exporters in area III are pushed out of the market. The ordinary exporters with low demand-adjusted foreign entry cost in area IV are pushed out of the non-profitable domestic market to become pure exporters while those with

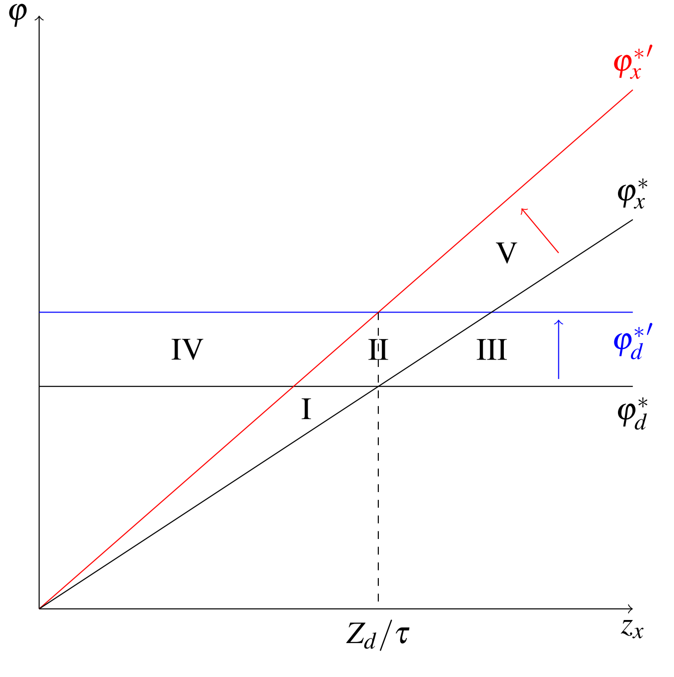

FIGURE 4 The impact of a decrease in foreign entry cost

high demand-adjusted foreign entry cost in area V are pushed out of the non-profitable foreign market to become non-exporters. 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 A.6). Innovation can be interpreted as a change of the conditional distribution of productivity. An example is the digitization starting in the 1980s. Innovation increases the average productivity of incumbents and the average profit, thereby intensifying the competition for labor. The real wage is increased as well. Therefore, the effects are the same as a decrease in foreign entry cost.

4.3 | A decrease in variable export cost

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

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

Proof As variable export cost τ decreases, the profit from the foreign market $\pi_x(P, \varphi, f_x, A_x)$ increases. Therefore, the conditional profit $\pi(P|\eta)$ in Equation (5) increases. It is follows that $\Pi(P)$ increases. We have shown that $\Pi(P)$ is a monotonically increasing function. Hence the price index decreases. This raises cut-off productivity in the domestic market.

To see the effect of a decrease in the variable export cost on cut-off productivity for the foreign market, we let $r = P/\tau$. Then Equation (2) becomes $\varphi_d^* = \varphi_d^*(r) = (\Theta/(r\tau))f_d^{1/(\sigma-1)}/A_d$ and $\varphi_x^*(f_x, A_x) = \varphi_x^*(r, f_x, A_x) = (\Theta/r)f_x^{1/(\sigma-1)}/A_x$. Equilibrium determination (3) can be written as $\Pi(r, \tau) = F_e\delta$. Hence we have $\mathrm{d}r/\mathrm{d}\tau = -(\partial\Pi(r, \tau)/\partial\tau)/(\partial\Pi(r, \tau)/\partial r)$.

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

$$\frac{\partial\pi(r, \tau|\eta)}{\partial\tau} = f_d k'(\varphi_d^*(r))\frac{\partial\varphi_d^*(r)}{\partial\tau} > 0$$
$$\frac{\partial\pi(r, \tau\mid\eta)}{\partial r} = f_d k'(\varphi_d^*(r))\frac{\partial\varphi_d^*(r)}{\partial r} + f_x k'(\varphi_x^*(r, f_x, A_x))\frac{\partial\varphi_x^*(r, f_x, A_x)}{\partial r} > 0$$

Hence $\partial\Pi(r,\tau)/\partial\tau > 0$ and $\partial\Pi(r,\tau)/\partial r > 0$ so $\mathrm{d}r/\mathrm{d}\tau < 0$. Therefore, the cut-off productivity for the foreign market is reduced by a decrease in variable export cost. As shown in Figure 5, some firms become pure exporters while some non-exporters become ordinary exporters or non-active.

A decrease in variable export cost will increase profits for exporters causing an increase in the demand for labor. The real wage will be higher. As a result, the cut-off productivity for the domestic market is higher. However, even though the real wage is higher, exporters still benefit from a lower variable export cost, leading to lower cut-off productivity for the foreign market. As shown in Figure 5, non-active firms in area I, non-exporters in area II and ordinary exporters in area IV become pure exporters. The least productive non-exporters as shown in area III are pushed out of the market while the most productive non-exporters as shown in area V become ordinary exporters.

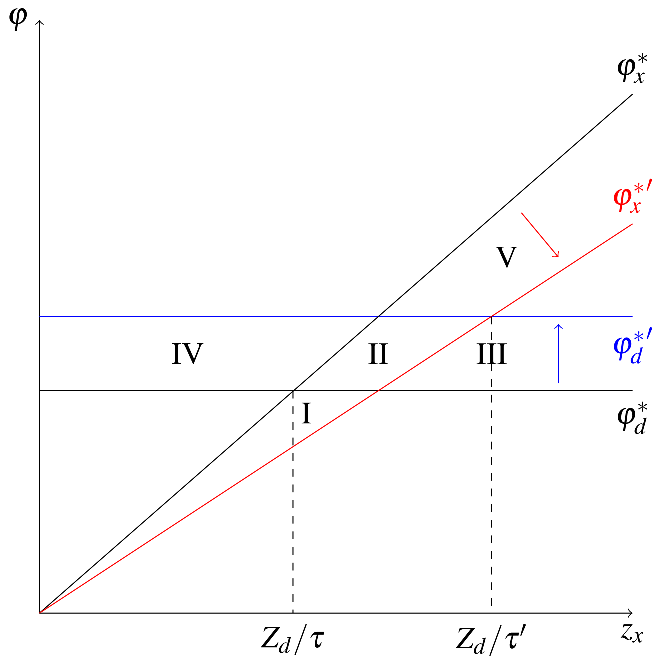

FIGURE 5 The impact of a decrease in variable export cost

5 | EMPIRICAL VALIDATION

In this section, we provide empirical evidence to validate the model. More specifically, we show that (a) pure exporters are prevalent across industries, (b) pure exporters can be less productive than non-exporters, and (c) exporter premium of an industry can be negative and is negatively related to the share of pure exporters in the industry. These results are consistent with our model of pure exporters: because pure exporters can be less productive than non-exporters, exporter premium is negatively related to the share of pure exporters; as a result, exporter premium can be negative when there is a large share of pure exporters.

5.1 | The prevalence of pure exporters

As shown in Table A1, pure exporters account for around 33.58% of all exporters in China. Using data of the Chinese annual survey of manufacturing firms in 2007, we calculate the share of pure exporters in all exporters for 422 disaggregated 4-digit industries. Then we plot the distribution of the share of pure exporters in Figure 6. As shown in Figure 6, pure exporters account for at least 30% of all exporters in around 40% of the industries and account for at least 20% of all exporters in around 55% of the industries. Moreover, in around 80% of the industries, the share of pure exporters is larger than 10%. Therefore, pure exporters are prevalent across industries.

As shown in Figure A1, pure exporters account for at least 50% (25%) of total export value in around 40% (60%) of the industries. Moreover, pure exporters account for at least 25% (10%) of total output and asset of exporters in around 35% (60%) of the industries. We also find that pure exporters account for at least 25% (10%) of total employment of exporters in around 45% (65%) of the industries. Therefore, pure exporters play a non-trivial role in the economy.

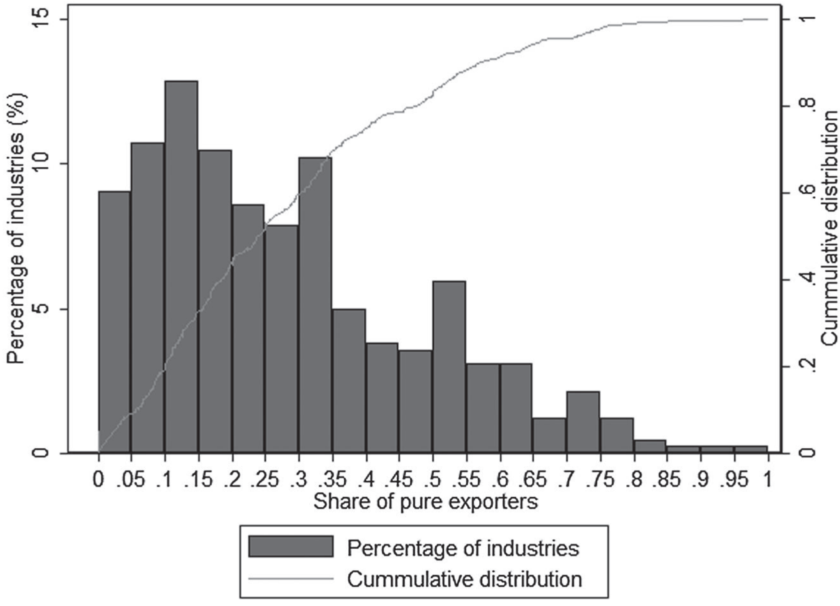

FIGURE 6 The prevalence of pure exporters across industries

5.2 | The productivity of pure exporters

To compare the productivity of pure exporters and non-exporters, we estimate the following equation:

$$\ln\varphi_i = \beta + \nu Pure\_exporter_i + \varrho Ord\_exporter_i + \varsigma_r + \varepsilon_i$$

where φ_i is total factor productivity (TFP) of firm i. To provide robustness, we estimate TFP using Levinsohn and Petrin (2003) approach (LP approach), Olley and Pakes (1996) approach (OP approach) and Ackerberg et al. (2015) approach (ACF approach). We use the sector-wide price index as in Brandt et al. (2012) to deflate the output, capital, investment and material for all estimations of TFP. $Ord\_exporter_i$ is a dummy variable that takes the value one if firm i is an ordinary exporter (serving both domestic and foreign markets) and $Pure\_exporter_i$ is a dummy variable that takes the value one if firm i is a pure exporter. ς_r denotes region fixed effects and r denotes the region in which firm i is located. In our database, the 6-digit postcode of firm's location is recorded. We estimate the equation using both the first 3 digits (close to cities) and 4 digits (close to counties) of postcode to denote regions. ε_i is the error term.

We estimate the equation for each industry using Chinese annual survey of manufacturing firms in 2007 and collect coefficients ν and ϱ for more than 400 industries. Table 1 summarizes the sign and significance of coefficients ν and ϱ. A positive (negative) ν suggests that the productivity of pure exporters is higher (lower) than the productivity of non-exporters. If the coefficient is statistically significant at least at 10% level, the productivity of pure exporters is significantly higher or lower than the productivity of non-exporters. From panel A of Table 1, on average pure exporters are not significantly more productive than non-exporters in 77% of the industries across different measures of TFP. Moreover, as shown in panel A, on average the productivity of pure exporters is (significantly) lower than the productivity of non-exporters in 39.3% (9.4%) of the industries. As a comparison shown in panel B, on average the productivity of ordinary exporters is (significantly) higher than the productivity of non-exporters in 71.9% (36.9%) of the industries across different measures of TFP. Therefore, the phenomenon that pure exporters are less productive than non-exporters is nontrivial.

TABLE 1 The productivity of pure exporters

	(1)	(2)	(3)	(4)	(5)	(6)
	LP approach		OP approach		ACF approach	
Panel A: the coefficient ν						
Negative ν	17.3%	18.0%	48.0%	46.2%	53.9%	52.4%
Significantly negative ν	3.2%	3.7%	9.3%	7.9%	16.8%	15.2%
Positive ν	82.7%	82.0%	52.0%	53.8%	46.1%	47.6%
Significantly positive ν	45.3%	47.6%	9.6%	11.3%	10.4%	13.8%
Panel B: the coefficient ϱ						
Negative ϱ	4.6%	5.5%	39.0%	33.8%	45.9%	40.0%
Significantly negative ϱ	0.7%	1.5%	4.9%	4.0%	7.1%	8.2%
positive ϱ	95.4%	94.5%	61.0%	66.2%	54.1%	60.0%
Significantly positive ϱ	78.0%	74.6%	18.8%	18.9%	14.9%	15.9%
Region fixed effects:						
3-digit region	Yes	No	Yes	No	Yes	No
4-digit region	No	Yes	No	Yes	No	Yes

Notes: The table summarizes the percentage of industries with negative/positive ν and ϱ. The results presented in the table are estimated using data of the Chinese annual survey of manufacturing firms in 2007. The results are robust when using data of other years, using TFP estimated from value added function and using different definitions of pure exporters.

5.3 | Exporter premium

To study whether there is negative productivity premium of exporters, we estimate the following equation for every industry:

$$\ln\varphi_i = \beta + \vartheta Exporter_i + \varsigma_r + \varepsilon_i$$

where φ_i is the TFP of firm i. $Exporter_i$ is a dummy variable that takes the value one (zero) if firm i is an exporter (a non-exporter). ς_r denotes region fixed effects and r denotes the region in which firm i is located. ε_i is the error term. We estimate the equation for each industry using Chinese annual survey of manufacturing firms in 2007 and collect coefficients ϑ for more than 400 industries. If ϑ is positive (negative) for an industry, the average productivity of exporters is larger (lower) than the average productivity of non-exporters, that is, there is positive (negative) productivity premium of exporters in the industry. If ϑ is significant at least at 10% level, the premium is significant. As shown in Table 2, on average negative (positive) premium exists in around 28.3% (71.7%) of the industries and is significant in around 4.5% (36.1%) of the industries across different TFP measures. Being consistent with Feenstra et al. (2014), this exercise suggests that the productivity premium of exporters can be negative.

To show exporter premium is negatively related to the share of pure exporters, we estimate the following equation:

$$\ln\varphi_{is} = \beta + \iota Exporter_i + \kappa Exporter_i \times Share_s + \varsigma_s + \varsigma_r + \varepsilon_{is}$$

where the additional variable $Share_s$ is the share of pure exporters out of all exporters in industry s. The coefficient κ of the interaction term $Exporter_i \times Share_s$ measures the relationship between exporter premium and the share of pure exporters at the industry level. A negative κ suggests that exporter premium is lower in the industry with larger share of pure exporters. As shown in Table 3, the coefficients of the interaction term across different measures of TFP are all significantly negative, suggesting that exporter premium is negatively related to the share of pure exporters.

The negative relationship between exporter premium and the share of pure exporters across industries is also visually shown in Figure A2, in which exporter premium (ϑ) is plotted against the share of pure exporters. Figure A2 also suggests that exporter premium tends to be negative when the share is large. Using the results from Table 3, we can approximately calculate the required share of pure exporter for a negative exporter premium. For example, in the specification of column (2), the positive premium is cancelled when the share is 100%. In specifications of columns (1) and (3)–(6), the required share of pure exporters has to be larger than 96%, 84%, 96%, 36% and 44%, respectively.

TABLE 2 The productivity premium of exporters

	(1)	(2)	(3)	(4)	(5)	(6)
	LP approach		**OP approach**		**ACF approach**	
Negative premium (negative ϑ)	4.6%	6.2%	37.8%	34.4%	45.0%	41.6%
Significantly negative premium	1.0%	1.2%	3.9%	3.2%	10.7%	7.2%
Positive premium (positive ϑ)	95.4%	93.8%	62.2%	65.6%	55.0%	58.4%
Significantly positive premium	75.8%	74.8%	17.2%	18.1%	14.3%	16.3%
Region fixed effects:						
3-digit region	Yes	No	Yes	No	Yes	No
4-digit region	No	Yes	No	Yes	No	Yes

*Notes*The table summarizes the percentage of industries with negative/positive ϑ. The results presented in the table are estimated using data of the Chinese annual survey of manufacturing firms in 2007. The results are robust when using data of other years and using TFP estimated from value added function.

TABLE 3 The productivity premium of exporters and the share of pure exporters

	(1)	(2)	(3)	(4)	(5)	(6)
	LP approach		**OP approach**		**ACF approach**	
Exporter	0.382	0.378	0.021	0.022	0.026	0.028
	(0.005)***	(0.005)***	(0.003)***	(0.003)***	(0.003)***	(0.003)***
Exporter	−0.397	−0.378	−0.025	−0.023	−0.072	−0.064
× Share of pure exporters	(0.011)***	(0.011)***	(0.006)***	(0.006)***	(0.008)***	(0.008)***
Fixed effects:						
4-digit industry	Yes	Yes	Yes	Yes	Yes	Yes
3-digit region	Yes	No	Yes	No	Yes	No
4-digit region	No	Yes	No	Yes	No	Yes
Adj. R^2	0.882	0.886	0.338	0.363	0.937	0.939
# observations	295,378	295,166	295,378	295,166	295,378	295,166

Notes: The results are estimated using data of the Chinese annual survey of manufacturing firms in 2007. The results are robust when measuring the share of pure exporters as the share of pure exporters in all firms, using data of other years, using TFP estimated from value added function and using different definitions of pure exporters. Standard errors are clustered at the firm level and stated in parentheses below point estimates. ***, **, and * mean 1%, 5% and 10% significance levels respectively.

A simple average across all columns suggests that exporter premium tends to be negative when the share of pure exporters is larger than 76%. Therefore, exporter premium can be negative when there is a large share of pure exporters.

6 | CONCLUSION

In the present paper, we build a general equilibrium model in which pure exporters, ordinary exporters and non-exporters co-exist. Our model can reconcile the empirical findings on pure exporters in the literature. For example, pure exporters can have lower average productivity than ordinary exporters and productivity premium of exporters can be negative. With the model, we have studied what makes firms become pure exporters, ordinary exporters and non-exporters. We have also investigated the impact of trade on average productivity and welfare as well as how trade liberalization pushes firms to change the markets they serve in the presence of pure exporters.

Our paper suggests that taking pure exporters into consideration is important in the analysis of the impact of trade, especially when there is a large number of pure exporters. For example, the average productivity of exporters consisting of pure exporters and ordinary exporters can be lower than the average productivity of non-exporters. In the presence of pure exporters, trade, on the one hand, pushes firms with low productivity out of the market, and on the other hand, induces firms with even lower productivity to enter the market as pure exporters. Therefore, compared with autarky, trade can lower average productivity in the presence of a large number of pure exporters.

In this 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 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.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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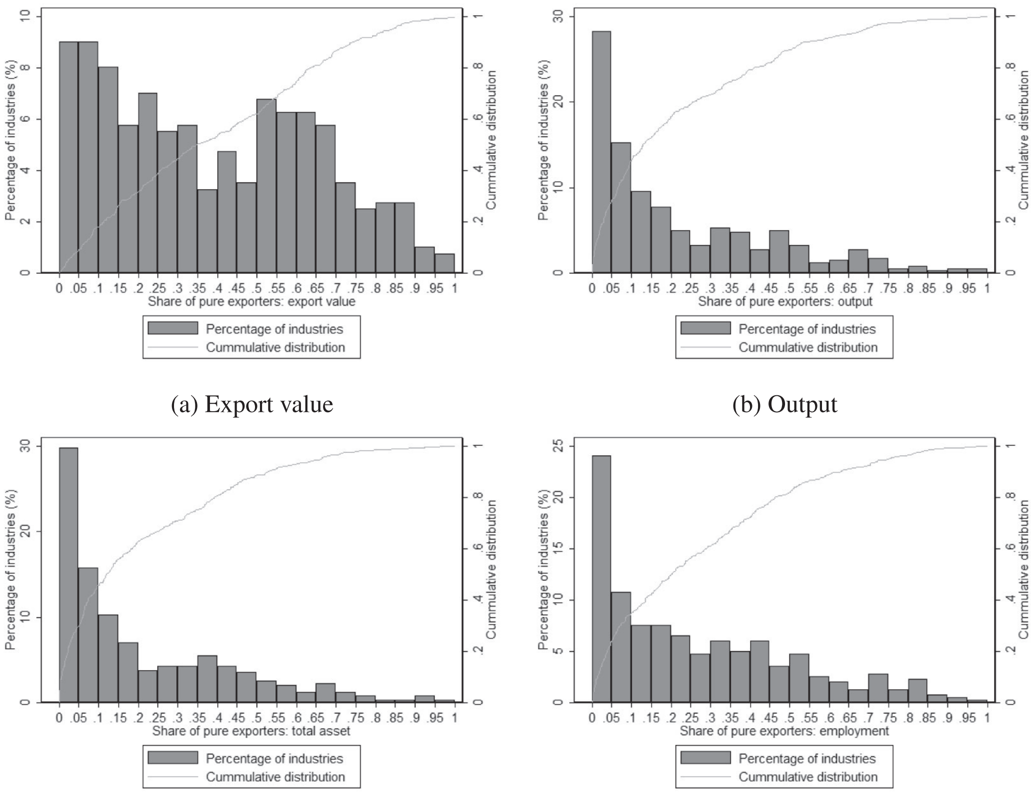
SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

APPENDIX A

Empirical figures and tables on pure exporters



(a) Export value (b) Output

(c) Total asset (d) Employment

FIGURE A1 More statistics on the roles of pure exporters across industries

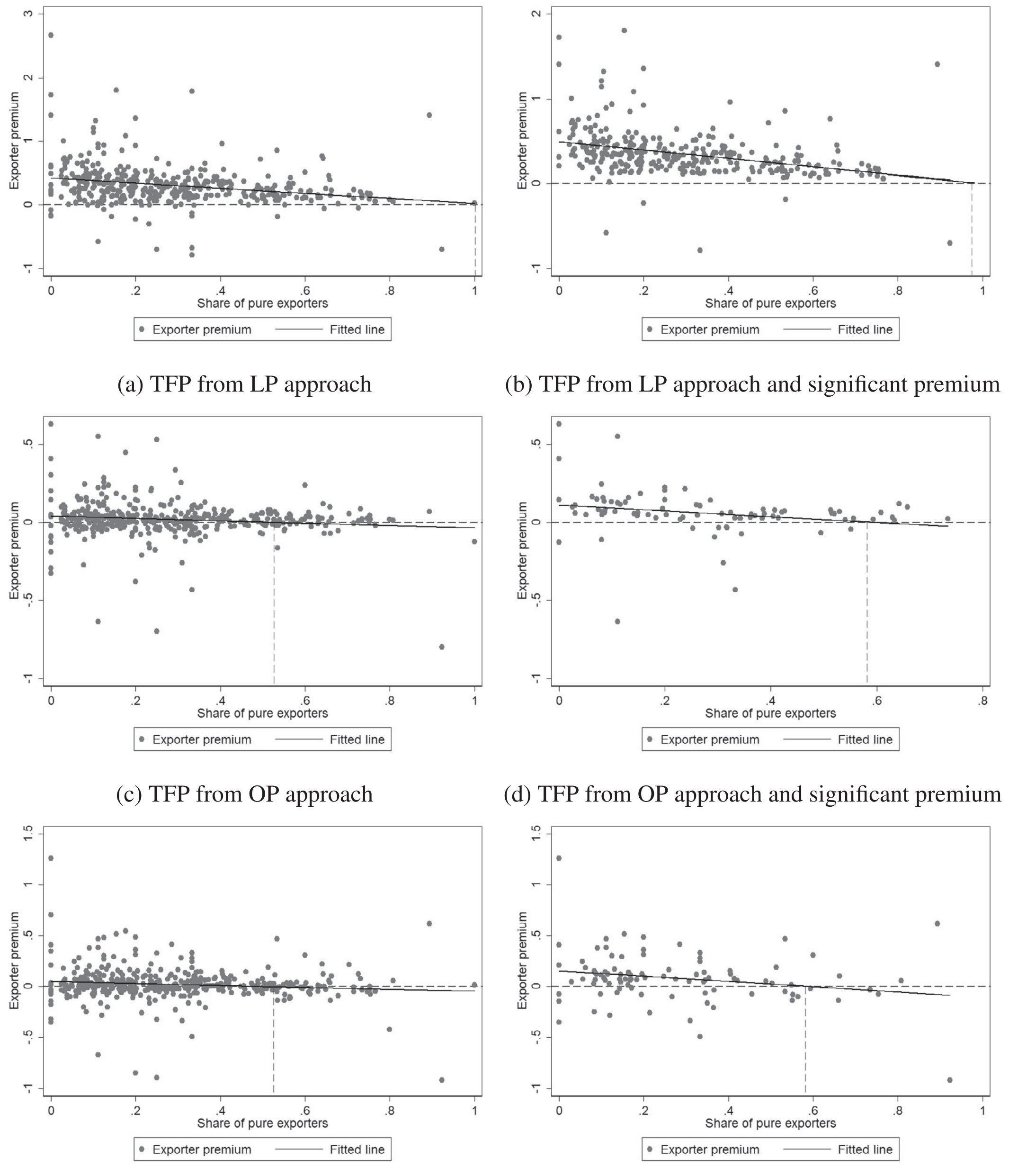
Equilibrium

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 $\varphi * (\eta) = \min\{\varphi_d^*, \varphi_x^*(f_x, A_x)\}$. It follows from Equation (2) and Figure 1 that $\varphi * (\eta) = \varphi_d^*$ if $z_x > Z_d/\tau$ and $\varphi * (\eta) = \varphi_x^*(f_x, A_x)$ if $z_x < Z_d/\tau$.

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, that is, $\Pi = \Upsilon\Pi_p$. 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 $L_e = M_eF_e$. With Equation (3), we have



(a) TFP from LP approach

(b) TFP from LP approach and significant premium

(c) TFP from OP approach

(d) TFP from OP approach and significant premium

(e) TFP from ACF approach

(f) TFP from ACF approach and significant premium

FIGURE A2 Exporter premium and the share of pure exporters across industries

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

$M\Pi_p$ 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 average market entry cost of incumbents respectively. Then $\Pi_p = \bar{r}/\sigma - \bar{f}$. It follows that $\bar{r} = \sigma(\Pi_p + \bar{f}) = \sigma(\delta F_e/\Upsilon + \bar{f})$.

TABLE A1 The composition of exporters in China

Percentage of pure exporters among all exporters				
	PTE	**FIE**	**Neither**	**All**
In a FTZ	52.63	34.67	22.49	36.04
Outside	35.56	27.85	16.85	21.93
All	51.62	33.74	20.79	33.58
The composition of pure exporters				
	PTE	**FIE**	**Neither**	**All**
In a FTZ	35.5	37.0	16.1	88.6
Outside	1.5	4.7	5.2	11.4
All	37.0	41.6	21.4	100

Notes: This table is derived from Table A1 (entitled "Percentage of Exporters and Percentage of Pure Exporters by Firm Type and Location") of Defever and Riaño (2019). PTE means processing trade enterprises, FIE means foreign invested enterprises and FTZ is free trade zone. The definition of pure exporters is the same with Defever and Riaño (2019). The table shows that pure exporters account for around 33.58% of all exporters. Moreover, it shows that 51.62% of processing exporters are pure exporters and 37.0% of pure exporters are processing exporters, suggesting that pure exporters and processing exporters are not identical.

With Υ, we can denote the distribution of incumbents as $\lambda(\varphi,\eta)/\Upsilon$. $\bar{f}$, as the average market entry cost of incumbents, is

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

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:

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

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

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

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

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

Theorem 2

As shown in Equation (2), $\varphi_d^* = (\Theta/P)Z_d$ and $\varphi_x^*(z_x) = (\Theta/P)\tau z_x$ in which $Z_d = f_d^{1/(\sigma-1)}/A_d$ is fixed and $z_x = f_x^{1/(\sigma-1)}/A_x$ is heterogeneous. Assume Pareto distributions $g(\varphi) = \theta\, \underline{\varphi}^{\theta} \varphi^{-\theta-1}$ where $\theta > 1$ and $\gamma(z_x) = \alpha \underline{Z_x}^{\alpha} z_x^{-\alpha-1}$. Assume $\underline{\varphi} < \varphi_d^*$ and $\underline{\varphi} < \varphi_x^*(z_x)$ for any value of z_x. Figure A3 shows firm behavior for different values of z_x.

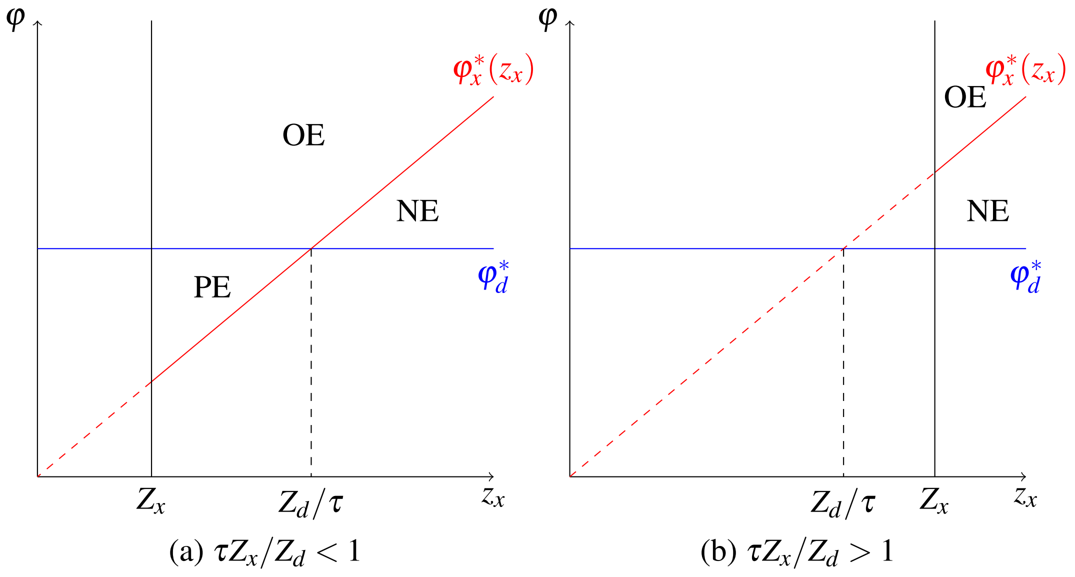


FIGURE A3 The existence of pure exporters given Pareto distributions

Given Figure A3, the probability of an entrant becoming active Υ is:

$$\Upsilon = \begin{cases} \int_{Z_x}^{Z_d/\tau} \int_{\varphi_x^*(z_x)}^{\infty} g(\varphi)\gamma(z_x)\,\mathrm{d}\varphi\,\mathrm{d}z_x + \int_{Z_d/\tau}^{\infty} \int_{\varphi_d^*}^{\infty} g(\varphi)\gamma(z_x)\,\mathrm{d}\varphi\,\mathrm{d}z_x & \text{if } \dfrac{\tau Z_x}{Z_d} \le 1 \\ \int_{Z_x}^{\infty} \int_{\varphi_d^*}^{\infty} g(\varphi)\gamma(z_x)\,\mathrm{d}\varphi\,\mathrm{d}z_x & \text{if } \dfrac{\tau Z_x}{Z_d} > 1 \end{cases}$$

The distribution of incumbents is then $g(\varphi)\gamma(z_x)/\Upsilon$. Let M be the number of incumbents.

First, we show that the share of pure exporters is a decreasing function of $\tau Z_x/Z_d$. Pure exporters only exist when $\tau Z_x/Z_d < 1$. Therefore, the share of pure exporters in all exporters is

$$Share_{pe} = \begin{cases} \dfrac{\int_{Z_x}^{Z_d/\tau} \int_{\varphi_x^*(z_x)}^{\varphi_d^*} \frac{g(\varphi)\gamma(z_x)}{\Upsilon} M\,\mathrm{d}\varphi\,\mathrm{d}z_x}{\int_{Z_x}^{\infty} \int_{\varphi_x^*(z_x)}^{\infty} \frac{g(\varphi)\gamma(z_x)}{\Upsilon} M\,\mathrm{d}\varphi\,\mathrm{d}z_x} = 1 + \dfrac{\theta}{\alpha}\left(\dfrac{\tau Z_x}{Z_d}\right)^{\theta+\alpha} - \dfrac{\theta+\alpha}{\alpha}\left(\dfrac{\tau Z_x}{Z_d}\right)^{\theta} & \text{if } \dfrac{\tau Z_x}{Z_d} \le 1 \\ 0 & \text{if } \dfrac{\tau Z_x}{Z_d} > 1 \end{cases}$$

It can be verified that the share of pure exporters is a decreasing function of $\tau Z_x/Z_d$ when $\tau Z_x/Z_d < 1$. Therefore, the smaller is $\tau Z_x/Z_d$, the larger is the share of pure exporters.

Second, we show that when $\tau Z_x/Z_d$ is small, the average productivity of exporters is lower than the average productivity of non-exporters. Let Υ_{ne} be the probability of an entrant becoming a non-exporter and M_{ne} be the number of non-exporters. We have

$$\Upsilon_{ne} = \begin{cases} \int_{Z_d/\tau}^{\infty} \int_{\varphi_d^*}^{\varphi_x^*(z_x)} g(\varphi)\gamma(z_x)\,\mathrm{d}\varphi\,\mathrm{d}z_x & \text{if } \dfrac{\tau Z_x}{Z_d} \le 1 \\ \int_{Z_x}^{\infty} \int_{\varphi_d^*}^{\varphi_x^*(z_x)} g(\varphi)\gamma(z_x)\,\mathrm{d}\varphi\,\mathrm{d}z_x & \text{if } \dfrac{\tau Z_x}{Z_d} > 1 \end{cases}$$

The distribution of non-exporters can be denoted as $g(\varphi)\gamma(z_x)/\Upsilon_{ne}$. The simple average productivity of non-exporters is:

$$\Psi_{ne} = \begin{cases} \dfrac{\int_{Z_d/\tau}^{\infty}\int_{\varphi_d^*}^{\varphi_x^*(z_x)} \varphi \frac{g(\varphi)\gamma(z_x)}{\Upsilon_{ne}} M_{ne}\,\mathrm{d}(\varphi, z_x)}{M_{ne}} = \dfrac{\Theta}{P}\dfrac{\alpha+\theta}{\alpha+\theta-1}Z_d & \text{if } \dfrac{\tau Z_x}{Z_d} \le 1 \\ \dfrac{\int_{Z_x}^{\infty}\int_{\varphi_d^*}^{\varphi_x^*(z_x)} \varphi \frac{g(\varphi)\gamma(z_x)}{\Upsilon_{ne}} M_{ne}\,\mathrm{d}(\varphi, z_x)}{M_{ne}} = \dfrac{\Theta}{P}\dfrac{\theta}{\theta-1}\dfrac{\left(\frac{\tau Z_x}{Z_d}\right)^{\theta-1} - \frac{\alpha}{\alpha+\theta-1}}{\left(\frac{\tau Z_x}{Z_d}\right)^{\theta} - \frac{\alpha}{\alpha+\theta}}(\tau Z_x) & \text{if } \dfrac{\tau Z_x}{Z_d} > 1 \end{cases}$$

Let Υ_e be the probability of an entrant becoming an exporter and M_{ex} be the number of exporters. For both $\tau Z_x/Z_d \le 1$ and $\tau Z_x/Z_d > 1$, we have

$$\Upsilon_e = \int_{Z_x}^{\infty}\int_{\varphi_x^*(z_x)}^{\infty} g(\varphi)\gamma(z_x)\,\mathrm{d}\varphi\,\mathrm{d}z_x$$

The distribution of exporters can be denoted as $g(\varphi)\gamma(z_x)/\Upsilon_e$. The simple average productivity of exporters is:

$$\Psi_e = \frac{\int_{Z_x}^{\infty}\int_{\varphi_x^*(z_x)}^{\infty} \varphi \frac{g(\varphi)\gamma(z_x)}{\Upsilon_e} M_{ex}\,\mathrm{d}(\varphi, z_x)}{M_{ex}} = \frac{\Theta}{P}\frac{\theta}{\theta-1}\frac{\alpha+\theta}{\alpha+\theta-1}(\tau Z_x)$$

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

$$\frac{\Psi_e}{\Psi_{ne}} = \begin{cases} \dfrac{\theta}{\theta-1}\left(\dfrac{\tau Z_x}{Z_d}\right) & \text{if } \dfrac{\tau Z_x}{Z_d} \le 1 \\ \dfrac{(\alpha+\theta)\left(\frac{\tau Z_x}{Z_d}\right)^{\theta} - \alpha}{(\alpha+\theta-1)\left(\frac{\tau Z_x}{Z_d}\right)^{\theta-1} - \alpha} & \text{if } \dfrac{\tau Z_x}{Z_d} > 1 \end{cases}$$

It can be verified that $\Psi_e/\Psi_{ne} > 1$ when $\tau Z_x/Z_d > 1$. Therefore, $\Psi_e/\Psi_{ne} < (>) 1$ when $\tau Z_x/Z_d < (>) (\theta-1)/\theta$. Therefore, we can conclude that when $\tau Z_x/Z_d$ is small, there are more pure exporters and thereby the average productivity of exporters is lower than the average productivity of non-exporter.

In Supporting Information S.1, we provide additional analysis with alternative measures of average productivity: aggregate productivity as in Melitz (2003) and revenue-weighted average productivity as widely used in the empirical analysis when calculating industry-level productivity (e.g. Pavcnik, 2002). The results are very robust that the average productivity of exporters is lower than the average productivity of non-exporters when there is a large portion of pure exporters.

Theorem 3

Assume Pareto distributions $g(\varphi) = \theta\underline{\varphi}^{\theta}\varphi^{-\theta-1}$ and $\gamma(z_x) = \alpha Z_x^{\alpha} z_x^{-\alpha-1}$, in which $\theta > \sigma$ and $\alpha > 1$. Assume $\underline{\varphi} < \varphi_d^{*a}$ in autarky where φ_d^{*a} is the cut-off productivity in autarky. In autarky, the probability of an entrant becoming active Υ_a is determined as:

$$\Upsilon_a = \int_{Z_x}^{\infty}\int_{\varphi_d^{*a}} g(\varphi)\gamma(z_x)\,\mathrm{d}(\varphi)\,\mathrm{d}z_x = \int_{\varphi_d^{*a}} g(\varphi)\,\mathrm{d}(\varphi)$$

The distribution of incumbents can be denoted as $g(\varphi)\gamma(z_x)/\Upsilon_a$. Let M_a be the number of firms in autarky. The revenue-weighted average productivity in autarky is:

$$\Psi_a = \frac{\int_{\varphi_d^{*a}}^{\infty} r_d(\varphi)\varphi\frac{g(\varphi)}{\Upsilon_a}M_a\,\mathrm{d}\varphi}{\int_{\varphi_d^{*a}}^{\infty} r_d(\varphi)\frac{g(\varphi)}{\Upsilon_a}M_a\,\mathrm{d}\varphi} = \frac{\Theta}{P_a}\frac{\theta-\sigma+1}{\theta-\sigma}Z_d$$

Let Υ be the the probability of an entrant becoming active as defined in A.3 and M be the number of incumbents. The distribution of incumbents is then $g(\varphi)\gamma(z_x)/\Upsilon$. Under trade, the revenue-weighted average productivity is:

$$\Psi = \begin{cases} \dfrac{\left(\begin{aligned} &\int_{Z_x}^{Z_d/\tau}\int_{\varphi_x^*(z_x)}^{\varphi_d^*} r_x(\varphi)\varphi\frac{g(\varphi)\gamma(z_x)}{\Upsilon}M\mathrm{d}\varphi\mathrm{d}z_x + \int_{Z_x}^{Z_d/\tau}\int_{\varphi_d^*}^{\infty}\left(r_d(\varphi)+r_x(\varphi)\right)\varphi\frac{g(\varphi)\gamma(z_x)}{\Upsilon}M\mathrm{d}\varphi\mathrm{d}z_x \\ &+\int_{Z_d/\tau}^{\infty}\int_{\varphi_x^*(z_x)}^{\infty}\left(r_d(\varphi)+r_x(\varphi)\right)\varphi\frac{g(\varphi)\gamma(z_x)}{\Upsilon}M\mathrm{d}\varphi\mathrm{d}z_x + \int_{Z_d/\tau}^{\infty}\int_{\varphi_d^*}^{\varphi_x^*(z_x)} r_d(\varphi)\varphi\frac{g(\varphi)\gamma(z_x)}{\Upsilon}M\mathrm{d}\varphi\mathrm{d}z_x\end{aligned}\right)}{\left(\begin{aligned} &\int_{Z_x}^{Z_d/\tau}\int_{\varphi_x^*(z_x)}^{\varphi_d^*} r_x(\varphi)\frac{g(\varphi)\gamma(z_x)}{\Upsilon}M\mathrm{d}\varphi\mathrm{d}z_x + \int_{Z_x}^{Z_d/\tau}\int_{\varphi_d^*}^{\infty}\left(r_d(\varphi)+r_x(\varphi)\right)\frac{g(\varphi)\gamma(z_x)}{\Upsilon}M\mathrm{d}\varphi\mathrm{d}z_x \\ &+\int_{Z_d/\tau}^{\infty}\int_{\varphi_x^*(z_x)}^{\infty}\left(r_d(\varphi)+r_x(\varphi)\right)\frac{g(\varphi)\gamma(z_x)}{\Upsilon}M\mathrm{d}\varphi\mathrm{d}z_x + \int_{Z_d/\tau}^{\infty}\int_{\varphi_d^*}^{\varphi_x^*(z_x)} r_d(\varphi)\frac{g(\varphi)\gamma(z_x)}{\Upsilon}M\mathrm{d}\varphi\mathrm{d}z_x\end{aligned}\right)} & \text{if } \dfrac{\tau Z_x}{Z_d}\le 1 \\[2ex] \dfrac{\int_{Z_x}^{\infty}\int_{\varphi_d^*}^{\varphi_x^*(z_x)} r_d(\varphi)\varphi\frac{g(\varphi)\gamma(z_x)}{\Upsilon}M\mathrm{d}\varphi\mathrm{d}z_x + \int_{Z_x}^{\infty}\int_{\varphi_x^*(z_x)}^{\infty}\left(r_d(\varphi)+r_x(\varphi)\right)\varphi\frac{g(\varphi)\gamma(z_x)}{\Upsilon}M\mathrm{d}\varphi\mathrm{d}z_x}{\int_{Z_x}^{\infty}\int_{\varphi_d^*}^{\varphi_x^*(z_x)} r_d(\varphi)\frac{g(\varphi)\gamma(z_x)}{\Upsilon}M\mathrm{d}\varphi\mathrm{d}z_x + \int_{Z_x}^{\infty}\int_{\varphi_x^*(z_x)}^{\infty}\left(r_d(\varphi)+r_x(\varphi)\right)\frac{g(\varphi)\gamma(z_x)}{\Upsilon}M\mathrm{d}\varphi\mathrm{d}z_x} & \text{if } \dfrac{\tau Z_x}{Z_d}> 1 \end{cases}$$

It can be rearranged as

$$\Psi = \frac{\int_{Z_x}^{\infty}\int_{\varphi_d^*}^{\infty} r_d(\varphi)\varphi g(\varphi)\gamma(z_x)\,\mathrm{d}\varphi\,\mathrm{d}z_x + \int_{Z_x}^{\infty}\int_{\varphi_x^*(z_x)}^{\infty} r_x(\varphi)\varphi g(\varphi)\gamma(z_x)\,\mathrm{d}\varphi\,\mathrm{d}z_x}{\int_{Z_x}^{\infty}\int_{\varphi_d^*}^{\infty} r_d(\varphi) g(\varphi)\gamma(z_x)\,\mathrm{d}\varphi\,\mathrm{d}z_x + \int_{Z_x}^{\infty}\int_{\varphi_x^*(z_x)}^{\infty} r_x(\varphi) g(\varphi)\gamma(z_x)\,\mathrm{d}\varphi\,\mathrm{d}z_x}$$

for both $\tau Z_x/Z_d \le 1$ and $\tau Z_x/Z_d > 1$. After solving the equation, we have

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

Therefore, we have

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

Next we express P_a/P with $\tau Z_x/Z_d$. Given the Pareto distribution of productivity, the Equations (6) and (7) mean:

$$k(x) = \frac{\underset{!!}{\varphi^{\theta}(\sigma-1)x^{-\theta}}}{\theta+1-\sigma}$$

Together with the Equations (2) and (8), we have

$$\pi(P\,|f_x, A_x) = \frac{\overline{\varphi}^{\theta}(\sigma-1)}{\theta+1-\sigma}\left(\frac{\Theta}{P}\right)^{-\theta}(f_d Z_d^{-\theta} + f_x(TZ_x)^{-\theta})$$

under trade and

$$\pi(P_a\,|f_x, A_x) = \frac{\overline{\varphi}^{\theta}(\sigma-1)}{\theta+1-\sigma}\left(\frac{\Theta}{P_a}\right)^{-\theta} f_d\left(Z_d\right)^{-\theta}$$

in autarky. With the equilibrium condition (3) and Equation (4), we have

$$\left(\frac{P_a}{P}\right)^{\theta} = \frac{f_d Z_d^{-\theta} + \int_{A_x f_x} f_x(\tau z_x)^{-\theta}\lambda(f_x, A_x)\,\mathrm{d}(A_x, f_x)}{f_d Z_d^{-\theta}}$$

In order to solve the aggregate price index in the equilibrium, we simplify the distribution $\lambda(f_x, A_x)$ such that the demand shock in foreign market is fixed as $\overline{A}_x$. Therefore, we have

$$\left(\frac{P_a}{P}\right)^{\theta} = \frac{f_d Z_d^{-\theta} + \int_{Z_x}^{\infty} \overline{A}_x^{\sigma-1} z_x^{\sigma-1}(\tau z_x)^{-\theta}\gamma(z_x)\,\mathrm{d}(z_x)}{f_d Z_d^{-\theta}} = 1 + \frac{\alpha}{\alpha+\theta-\sigma+1}\left(\frac{\overline{A}_x}{\tau A_d}\right)^{\sigma-1}\left(\frac{\tau Z_x}{Z_d}\right)^{\sigma-\theta-1}$$

After substituting P_a/P into Ψ/Ψ_a, we have

$$\frac{\Psi}{\Psi_a} = \frac{\left(\frac{\tau Z_x}{Z_d}\right)^{\theta-\sigma} + \frac{\alpha\tau^{1-\sigma}}{\alpha+\theta-\sigma}}{\left(\frac{\tau Z_x}{Z_d}\right)^{\theta-\sigma+1} + \frac{\alpha\tau^{1-\sigma}}{\alpha+\theta-\sigma+1}}\left(\left(\frac{\tau Z_x}{Z_d}\right)^{\theta} + \frac{\alpha}{\alpha+\theta-\sigma+1}\left(\frac{\overline{A}_x}{\tau A_d}\right)^{\sigma-1}\left(\frac{\tau Z_x}{Z_d}\right)^{\sigma-1}\right)^{\frac{1}{\theta}}$$

The term in the bracket is an increasing function of $\tau Z_x/Z_d$. It can be verified that when $\tau Z_x/Z_d$ is small, the fractional term is also an increasing function of $\tau Z_x/Z_d$. To see this point, the differentiation of the fractional term with respect to $\tau Z_x/Z_d$ is:

$$\frac{\left(\frac{\tau Z_x}{Z_d}\right)^{\theta-\sigma}\left(\frac{\alpha\tau^{1-\sigma}(\theta-\sigma)}{\alpha+\theta-\sigma+1}\left(\frac{\tau Z_x}{Z_d}\right)^{-1} - \left(\frac{\tau Z_x}{Z_d}\right)^{\theta-\sigma} - \frac{\alpha\tau^{1-\sigma}(\theta-\sigma+1)}{\alpha+\theta-\sigma}\right)}{\left(\left(\frac{\tau Z_x}{Z_d}\right)^{\theta-\sigma+1} + \frac{\alpha\tau^{1-\sigma}}{\alpha+\theta-\sigma+1}\right)^2}$$

Therefore, the differentiation is positive when $\tau Z_x/Z_d$ is small. As a result, Ψ/Ψ_a is an increasing function when $\tau Z_x/Z_d$ is small.As a result, Ψ/Ψ_a is an increasing function when $\tau Z_x/Z_d$ is small. Moreover, it can be verified that:

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

As a result, Ψ/Ψ_a tends to be less than one when $\tau Z_x/Z_d$ is small. Note that it can also be verified that:

$$\frac{\Psi}{\Psi_a} = \underbrace{\frac{P_a}{P}}_{>1} \underbrace{\frac{\left(\frac{\tau Z_x}{Z_d}\right)^{\theta-\sigma+1} + \frac{\alpha\tau^{1-\sigma}}{\alpha+\theta-\sigma}\left(\frac{\tau Z_x}{Z_d}\right)}{\left(\frac{\tau Z_x}{Z_d}\right)^{\theta-\sigma+1} + \frac{\alpha\tau^{1-\sigma}}{\alpha+\theta-\sigma+1}}}_{>1} > 1 \quad \text{if} \quad \tau Z_x/Z_d > 1$$

Therefore, when there are no pure exporters, it is consistent with Melitz (2003) that trade increases average productivity. As $\tau Z_x/Z_d$ becomes lower, the share of pure exporters becomes higher. When there is a large portion of pure exporters, trade can lower average productivity compared with autarky. In Supporting Information S.2, we provide additional analysis with alternative measures: simple average productivity and aggregate productivity as in Melitz (2003). The results are very robust that trade can lower average productivity when there is a large portion of pure exporter.

A decrease in foreign entry cost

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

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

With LFEC, that is, $\Lambda(f_x\,|\,\varphi, A_x) \geq \Lambda'(f_x\,|\,\varphi, A_x)$, $\Delta\pi(P\,|\,\varphi, A_x) \geq 0$. Therefore, $\pi(P\,|\,\varphi, A_x)$ becomes higher.

Innovation

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

Higher Productivity (HP) For two distributions of characteristics λ and λ', λ has higher productivity than λ' provided $\Lambda(\varphi\,|\,\eta) \leq \Lambda'(\varphi\,|\,\eta)$ for all (φ,η) in which $\eta = (f_x, A_x)$.

With HP satisfied, the effects of an innovation will be the same effects as a decrease of foreign entry cost in Theorem 5. Rearrange Equation (7) to get:

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

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

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

With HP, that is, $\Lambda(\varphi\,|\,\eta) \leq \Lambda'(\varphi\,|\,\eta)$, $\Delta k(x) \geq 0$. Therefore, $k(x)$ is increased. As a result, $k(\varphi_d^*)$ and $k(\varphi_x^*(f_x, A_x))$ become higher. According to Equation (8), $\pi(P|\eta)$ 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.