NBER WORKING PAPER SERIES

# HOW YOU EXPORT MATTERS: EXPORT MODE, LEARNING AND PRODUCTIVITY IN CHINA

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Working Paper 21164
http://www.nber.org/papers/w21164

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
May 2015

Krishna is grateful to the Cowles Foundation at Yale and to the Economics Department at NYU for support as a visitor. The authors are grateful to the National Natural Science Foundation of China (NSFC) for support under Grant No. 71203114. We thank the China Data Center at Tsinghua University for access to the datasets. We are extremely grateful to Mark Roberts for his intellectual generosity and for sharing his codes with us. We also thank Andrew Bernard, Paula Bustos, Russell Cooper, Paul Grieco, Wolfgang Keller, Amit Khandelwal, Jicheng Liu, Chia Hui Lu, Nina Pavcnik, Joel Rodrigue, Daniel Trefler, James Tybout, Neil Wallace, Shang Jin Wei, Adrian Wood, Stephen Yeaple, and Jing Zhang for extremely useful comments on an earlier draft. We would like to thank participants at the Penn State-Tsinghua Conference on the Chinese Economy, 2012, the CES-IFO Area Conference on the Global Economy, 2012, the Midwest International Trade Meetings, 2012, the Tsinghua-Columbia Conference in International Economics, 2012, the Yokohama Conference, 2012, the NBER ITI spring meetings, 2013, the Penn State JMP conference, 2013, the Cornell PSU Macro Conference, 2013, ERWIT, 2013, InsTED, 2013, Princeton Summer Workshop, 2013 and the Yale International Trade workshop 2013, NBER Chinese Economy Meeting 2014, Barcelona GSE Summer Forum 2014 for comments. We are also grateful to seminar participants at the University of Virginia, Toronto, Toulouse, Paris, Namur, Kentucky, Brock, Auckland, and the City University of Hong Kong for comments. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

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NBER Working Paper No. 21164
May 2015
JEL No. F13,F14,L1


## ABSTRACT

This paper shows that how firms export (directly or indirectly via intermediaries) matters. We develop and estimate a dynamic discrete choice model that allows learning-by-exporting on the cost and demand side as well as sunk/fixed costs to differ by export mode. We find that demand and productivity evolve more favorably under direct exporting, though the fixed/sunk costs of this option are higher. Our results suggest that had China not liberalized its direct trading rights when it joined the WTO, its exports and export participation would have been 30 and 37 percent lower respectively.



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# 1 Introduction

Firms can choose how they export: directly or indirectly through intermediaries. What are the costs and benefits of such choices? On the one hand, intermediaries provide smaller firms the opportunity to engage in foreign trade without incurring the many costs associated with direct exporting. On the other hand, indirect exporters face lower variable profits because intermediaries take a cut. The existing literature on heterogeneous firms focuses on this static trade-off between exporting directly and indirectly. What about the dynamic trade-offs that could occur with different learning-by-exporting effects for direct versus indirect exporters? Learning-by-exporting refers to the mechanism whereby firms improve their performance (productivity and/or demand) after entering export markets. Case study evidence points to the importance of learning through buyer-seller relationships.[1] Hence, direct exporters, who engage in frequent contact with foreign buyers, may have more opportunities to improve than indirect ones. Consequently, firms' current export mode choices can affect their future profits. These dynamic considerations can be vital in shaping the effects of policy.

Governments have long had a tendency to intervene in markets, often with what they see as the best of reasons. However, such interventions can have unanticipated, and often, detrimental effects.[2] Before 2004, a large share of domestically owned Chinese firms were not allowed to trade directly. They had to export only through intermediaries unless their registered capital was quite large.[3] These restrictions were part and parcel of China's being a planned economy.[4] If direct exporters learn

[1] See Egan and Mody (1992) for some examples.

[2] For example, the Multi Fibre Agreement which set bilateral and product-specific quotas on textile, yarn and apparel exported by the majority of less developed countries in most of the last sixty years left the implementation of these quotas up to the developing country exporter. However, many of these countries implemented the quotas in ways that created further distortions instead of just having tradable quota licenses. See Krishna and Tan (1998) for more on this.

[3] Registered capital is also known as the authorized capital. It is the maximum value of securities that a company can legally issue. This number is specified in the memorandum of association when a company is incorporated.

[4] Part of the concern was that unrestricted exporting would result in unrestricted importing as exports earn foreign exchange. In planned economies, access to foreign exchange is usually restricted as the exchange rate is not market driven. Mr. Long Yongtu, head of the Chinese delegation, described the removal of such restrictions as "revolutionary" at the third working party meeting on

more than indirect ones, then limiting the ability to export directly could have had significant adverse effects. We estimate a structural dynamic model that allows us to quantify the static and dynamic trade-offs and evaluate the cost of the restrictions on direct trading. We recover not only the sunk and fixed costs of exporting according to mode, but also the evolution of productivity and demand under different export modes. We find that the evolution of both demand and productivity is more favorable under direct exporting. Our counterfactuals suggest that China's restrictions on direct exporting reduced Chinese export growth considerably. Exports would have been 30 percent lower and the export participation rate would have been 37 percent lower had there been no liberalization of trading rights.

Our work is most closely related to the literature on firm export decisions and learning by exporting.[5] Our work builds on Aw, Roberts and Xu (2011) who estimate a dynamic structural model of producers' decision rules for R&D investment and exporting, allowing for endogenous productivity evolution. It also builds on insights in Ahn, Khandelwal and Wei (2011) who use a static heterogeneous firm setting with costs of exporting that vary by mode. We extend their model to be dynamic, incorporate additional heterogeneity on the demand and cost side, and allow for learning by exporting that can vary by export mode.

We also build on recent work on intermediation which has become a topic of growing interest. The literature on intermediaries has focused on their role in facilitating trade as they help match firms with potential trade partners and reduce information asymmetries and trade costs.[6] Our focus is not on modeling the intermediation process. We treat it as just one technology of exporting with associated costs. Our paper is also related to a literature that tries to explain China's remarkable export growth as the result of policy reform.[7] Another strand of literature looks

China's accession to the WTO.

[5] See Dixit (1989a,b), Das, Roberts and Tybout (2007) and Aw, Roberts and Xu (2011), among others for export hysteresis and dynamic structural model of export decisions. See Clerides, Lach and Tybout (1998), Bernard and Jensen (1999) and De Loecker (2007), for learning-by-exporting.

[6] See, for example, Rubinstein and Wolinsky (1987), Feenstra and Hanson (2004), and Akerman (2010).

[7] For example, Handley and Limão (2013) argues that $22-30\%$ of the growth in exports after China joined the WTO could be due to the reduction of uncertainty in tariff after China gaining its permanent MFN status. Also see Pierce and Schott (2012) for effects of China's permanent MFN status on US employment.

at the effect on productivity of greater access to intermediate inputs.[8] We contribute to both strands of the literature on the factors behind China's growth of productivity and exports by looking at a hitherto unstudied reform, namely the removal of restrictions on direct trading.

The rest of the paper is organized as follows. In the following section we describe the data and the background of the restrictions of direct trading. In Section 2 we lay out the basis for firms' dynamic decisions over modes of exporting. Section 3 describes the estimation method. Section 4 summarizes the parameter estimates. We conduct counterfactual exercises to examine the costs and benefits of the trading right liberalization and different trade policies in Section 5. We conclude in the last section.

# 2 Data and Background

This analysis utilizes two Chinese data sets that have been matched. The first consists of firm-level data from the Annual Surveys of Industrial Production from 1998 through 2007 conducted by the Chinese government's National Bureau of Statistics. This survey includes all State-Owned Enterprises (henceforth SOEs) and non-SOEs with sales over 5 million Chinese Yuan (about $600,000$ US dollars). The data contains information on the firms' industry of production, ownership type, age, employment, capital stocks, and revenues, as well as export values. The second data set is the Chinese Customs transaction-level data. We observe the universe of transactions by Chinese firms that participated in international trade over the 2000-2006 period. This data set includes basic firm information, the value of each transaction (in US dollars) by product and trade partner for 243 destination/origin countries and $7,526$ different products in the 8-digit Harmonized System.[9]

We infer firms' exporting modes as follows. Firms from the Annual Survey are tagged as exporters if they report positive exports, and as direct exporters if they

[8] See Goldberg, Khandelwal, Pavcnik and Topalova (2010) for evidence regarding India, and Amiti and Konings (2007) for Indonesia. For structural work on this issue see Kasahara and Lapham (2013) and Kasahara and Rodrigue (2008) and Zhang (2013).

[9] Details of this matching are given in Table A.2 and Table A.3 in the Appendix.

are also observed in the customs data set.[10] The fact that we observe the universe of transactions through Chinese customs allows us to tag the remaining exporting firms (those which are not observed in the customs data set) as indirect exporters. Firms that report exports larger than their exports in the customs data are exporting both directly and indirectly and are tagged as direct exporters in this paper. We would like to emphasize that our classification of firms according to export mode is not based on a survey question as this question is rarely asked; export mode is inferred.[11] We perform a number of checks to convince the reader and ourselves that we are not mis-classifying firms. These results are provided in the Appendix.

In recent work, Bernard, Blanchard, Van Beveren and Vandenbussche (2012) argue that carry-along trade is important in the data. This refers to firms who export for other firms, thereby acting as intermediaries. In this paper we do not distinguish between such firms and those that export only their own products. We also drop pure producer intermediaries, those who show up in the customs data but do not report exporting in the survey data. As processing trade is very different from ordinary trade,[12] sunk cost and learning opportunities could be very different for processing trade. For this reason we exclude processing firms from our main sample.[13]

## 2.1 The Restrictions on Direct Trading

The restrictions on direct trading were eliminated over the period 2000-2004, at different rates for different regions, industries and types of firms, as part of the accession agreement for joining the WTO. The details of the rules governing the ability to trade directly in the period 1999-2004 are laid out in Table A.1 in the Appendix. 56.1 percent of the firms in the sample were not eligible for direct trading rights in 2000. This number dropped to 45.5 percent the next year, 6.2 percent in 2003, and all firms became eligible in 2004.

[10] According to the survey documentation, export value includes direct exports, indirect exports, and all kinds of processing and assembling exports.

[11] The Ghana Manufacturing Enterprise Survey Dataset used by Ahn et al. (2011) does asks firms to identify themselves as direct or indirect exporters and has a panel, but this seems to be the only such example.

[12] See Feenstra and Hanson (2005) for details.

[13] See the Appendix for robustness checks when including processing firms.

We leverage the institutional features that are present, namely eligibility variations, and look at firms below and above the threshold of eligibility. We find these are indeed different in terms of their probability of exporting, export and revenue growth. We also find that there is evidence that the restrictions were binding to begin with, and became less so as they were relaxed, see Bai and Krishna (2014).

To study the choice of export modes (direct versus indirect) we distinguish between firms that were eligible to trade directly and the ones that were not eligible. We assume that firms are fully informed about policy changes now and in the future and incorporate this into their calculations. We restrict their export option sets when they are ineligible to account for the policy. Consequently, indirect exporting will be less attractive to a constrained non-exporter than to an unconstrained one since the former does not have the option of becoming a direct exporter in the future.

## 2.2 Summary Statistics

In this section, we document patterns in the data that drive our modeling choices. We focus on one industry: Manufacture of Rubber and Plastic Products (2-digit ISIC Rev3 25).[14] We abstract from modeling firms' entry and exit decisions since the main focus of our study is firms' choice of export modes. Table 1 provides a summary of firms' export status and their modes of export over the sample years. Note that the share of direct exporters has risen over time and that the numbers are in line with those for other large countries.

Table 2 summarizes and compares firm size, measured in employment, capital stock, domestic sales and export sales among different types of exporters. On average, direct exporters are larger in all these dimensions than indirect exporters who

[14] We choose this industry for two reasons. First, it was not subject to other restrictions on trading (for example, state trading or designated trading only) before the accession to the WTO. Second, this industry has a fairly low R&D rate (on average 7.1 percent of the firms have positive R&D expenditure). The latter is important as our model does not incorporate R&D decisions. If R&D was important, and high R&D firms tended to export directly, our estimate on the evolution of productivity and demand shocks of direct exporters could be biased upwards. We have also done robustness checks by allowing R&D activities to affect productivity evolution, using a shorter panel that has R&D information. The results are in line with the patterns we find in our baseline estimation and are presented in the Appendix.

We have also estimated the evolution of productivity for a number of other industries. These results are given in Table 5 below.

are larger than non exporters. This makes sense as firms need to be large and/or productive enough to cover the sunk costs and fixed costs of direct exporting.

The correlation between capital stock and export value is 0.674, and that of domestic sales and exports is 0.595. Thus, success in the domestic market does not necessarily translate into success in the foreign market. This suggests multi-dimensional heterogeneity: productivity *and* other persistent firm-level differences are needed to explain the data. We call this factor foreign demand shocks and they represent differences in product-specific appeal across destinations of all kinds. We see from Table 2 that the distributions of firm sizes and firm sales are highly skewed with a right tail for exporting firms (as the mean is significantly more than the median), and even more so among firms that export indirectly. In order to explain the existence of many small exporters, we assume that fixed and sunk costs are randomly drawn in each period.[15]

## 2.3 Empirical Transition Patterns

Before estimating the model, we first describe the dynamic exporting patterns which lie behind estimated parameter values. Table 3 reports the average transition of export status and export modes over the sample period among all eligible firms.[16] The patterns reported here highlight the importance of distinguishing between indirect and direct exporters in studying their cost structures. Column 1 shows the export mode of a firm in year $t-1$, and columns 2–4 show the three possible export modes in year $t$. The high persistence of non-exporting (96.1%) suggests the existence of significant sunk export costs that prevent firms from starting to export. The fact that more non-exporting firms start exporting indirectly than directly suggests that starting to export directly requires a higher sunk entry cost that less productive firms may not wish to cover.

The second row shows the transition rates of indirect exporters. The high entry

[15]These random costs of exporting are meant to capture situations such as a relative moving to country X which makes it cheaper to export there. Arkolakis (2010) chooses to account for small firms by allowing fixed/sunk costs to depend on the size of the market the firm chooses to reach.

[16]It is reasonable to exclude ineligible firms for this table because part of the ineligible firms were bound by the policy when export decisions were made and including them would complicate the patterns observed.

into and exit from indirect exporting suggests that the sunk cost of entry may not be quite as high as that of direct exporting. The much higher rate of starting direct exporting as indirect exporters is consistent with firms self-selecting into different export modes based on their productivity levels. It is also possible that intermediaries help small firms learn about foreign markets, reducing the cost of market research, promoting matching with potential buyers, and facilitating their entry into foreign markets directly in later years at lower costs.

The last row shows quite different transition rates for firms that exported directly in the previous period. Among exporting firms, the average exit rate of indirect exporters is ten times higher than that of direct exporters. The high turnover in indirect exporting and the high persistence in direct exporting reflect very different sunk/fixed costs for the two modes. This churning may also come from different long-run payoffs generated by different learning-by-exporting effects. High sunk costs of entry and large learning-by-exporting in direct exporting would provide a substantial incentive for direct exporters to remain as such even if they are making short-run losses. The existing theoretical and empirical literature shows that indirect exporters on average tend to be less productive than direct exporters, and thus, more vulnerable to bad demand shocks. This higher productivity of direct exporters would also help explain their lower exit from exporting.[17]

# 3 The Model

Our model is based on Das et al. (2007), Aw et al. (2011), and Ahn et al. (2011). Heterogeneous firms (who differ in costs and demand shocks) engage in monopolistic competition in segmented domestic and foreign markets. In addition to always serving the domestic market, they can choose - not to export, export through intermediaries, and export by themselves ($d_{it}^m = \{0,1\}$, $m$=*H*ome, *I*ndirect, *D*irect). Firms also face different entry costs and fixed costs of exporting. Based on its current and expected future value, a firm chooses whether or not to export, and the mode in which to export. These decisions in turn affect the future productivity and

[17] The Ghanian data has similar patterns in terms of order, though persistence as a direct or indirect exporter is much lower. See Ahn et al. (2011)

demand shocks making the problem dynamic.

An advantage of exporting through intermediaries could be to avoid some of the sunk start-up costs and fixed costs of exporting.[18] Such costs may include those generated by establishing and maintaining a foreign distribution network, learning about and dealing with bureaucratic procedures, and so on. Firms need to be large to make it worth their while to export directly. On the other hand, firms exporting indirectly must pay for the services provided by intermediaries.[19] As a result, firms receive lower variable revenue from indirect exports than from direct exports.[20]

## 3.1 Static Decisions

Each firm supplies a single variety of the final consumption good at a constant marginal cost. Firms set their prices in each market by maximizing profits from that market, taking the price index as given, and do not compete "strategically" with other firms. Firms' domestic sales are not perfectly correlated with export sales as there are firm and market specific demand shocks.

### 3.1.1 Demand Side

We assume consumers in both domestic and foreign markets have CES preferences with elasticity of substitution $\sigma^H$ and $\sigma^X$, respectively, and where $\sigma^H$ and

[18] In order to get a better idea of the export cost structure of manufacturing firms and trading intermediaries, we interviewed a small number of firms including both manufacturing exporters and trading intermediaries. From our survey we found that the major costs manufacturing firms face to export directly come from market research, searching for foreign clients, setting up and maintaining foreign currency accounts, hiring specialized accountants and custom declarants, and finding financing. Small manufacturers may find some of these activities cost more than what they wish to bear and choose to export through trading intermediaries. On the other hand, wages, warehouse rents, and marketing costs constitute some of the major costs of trading intermediaries.

[19] Intermediary firms provide services such as matching with foreign clients, dictating quality specifications required in foreign markets, repackaging products for different buyers, consolidating shipments with products from other firms, acting as customs agents, etc., and are paid for these services by some sort of a commission.

[20] Ahn et al. (2011) document that intermediaries' unit values are higher than those of direct exporters and that this difference is not related to proxies for the extent of differentiation as it would be if intermediaries were acting as quality guarantors.

$\sigma^X$exceed unity. The utility functions in the home and foreign markets are:

$$U_t^H = \left(U_t^{HH}\right)^a \left(U_t^{XH}\right)^{1-a}, \tag{1}$$

$$U_t^{HH} = \left[\int_{i\in\Omega^H} \left(q_{it}^H\right)^{\frac{\sigma^H-1}{\sigma^H}} di\right]^{\frac{\sigma^H}{\sigma^H-1}}, \tag{2}$$

$$U_t^X = \left(U_t^{XX}\right)^b \left(U_t^{HX}\right)^{1-b}, \tag{3}$$

and

$$U_t^{HX} = \left[\int_{i\in\Omega^X} \left(q_{it}^X\right)^{\frac{\sigma^X-1}{\sigma^X}} \exp\left(z_{it}\right)^{\frac{1}{\sigma^X}} di\right]^{\frac{\sigma^X}{\sigma^X-1}}, \tag{4}$$

where $H$ denotes the home market and $X$ the foreign market, $i$ denotes the firm that provides variety $i$, and $\Omega^H$ $\left(\Omega^X\right)$ denotes the set of total available varieties in market $H$ $(X)$. Home utility has two components: the part that comes from consuming domestic goods ($U_t^{HH}$) and the part that comes from consuming foreign goods ($U_t^{XH}$). Consumers at home spend a given share ($\alpha$) of their income on domestic goods and the remainder on imports. Substitution between domestic goods is parametrized by $\sigma^H$ which differs from that between foreign goods parametrized by $\sigma^X$. We assume that the demand in the foreign market for each firm is also subject to a firm-specific demand shock $z_{it}$.[21] Foreign utility is analogously defined. Demand for Chinese goods comes from home consumers who substitute between Chinese goods according to $\sigma^H$ and from foreign consumers who substitute between them according to $\sigma^X$ as Chinese goods are exports for them.

The corresponding price indices in each market for Chinese goods are given by

$$P_t^H = \left[\int_{i\in\Omega^H} \left(p_{it}^H\right)^{1-\sigma^H} di\right]^{\frac{1}{1-\sigma^H}}, \tag{5}$$

[21] Note that the demand shock can be interpreted as something that affect exports differently from the domestic market, or as a shock to foreign demand relative to that in the domestic market.

and

$$P_t^X = \left[ \int_{i \in \Omega^X} \left( p_{it}^X \right)^{1-\sigma^X} \exp\left( z_{it} \right) di \right]^{\frac{1}{1-\sigma^X}}, \tag{6}$$

where $p_{it}^H$ ($p_{it}^X$) is the price firm $i$ charges at time $t$ in market $H$ ($X$). Let the expenditure in market $H$ ($X$) on Chinese goods be $Y_t^H$ $\left( Y_t^X \right)$. The firm-level demand from these two markets are:

$$q_{it}^H = \left( \frac{p_{it}^H}{P_t^H} \right)^{-\sigma^H} \frac{Y_t^H}{P_t^H}, \tag{7}$$

and

$$q_{it}^{Xm} = \left( \frac{p_{it}^{Xm}}{P_t^X} \right)^{-\sigma^X} \frac{Y_t^X}{P_t^X} \exp(z_{it}),\ m = I, D, \tag{8}$$

where the demand for direct exports $q_{it}^{XD}$ and demand for indirect exports $q_{it}^{XI}$ depend on their prices $p_{it}^{XD}$ and $p_{it}^{XI}$ and a firm-market specific shock $z_{it}$, which captures firm-level heterogeneity other than productivity that affects a firm's revenue and profit. Persistence in this firm-market specific shock introduces a source of persistence in a firm's export status and mode in addition to that provided by firm-level productivity and the sunk costs of exporting.

### 3.1.2 The Intermediary Sector

As in Ahn et al. (2011), we assume the intermediary sector is perfectly competitive. We do not focus on modeling the intermediation process in international trade but treat the intermediation as one technology of exporting. Intermediaries purchase goods from manufacturers at $p_{it}^I$ and sell them at price $p_{it}^{XI} = \lambda p_{it}^I$. Thus, $(\lambda - 1)$ is the commission rate charged by the intermediary and the corresponding demand is $q_{it}^{XI} = \left( \frac{p_{it}^{XI}}{P_t^X} \right)^{-\sigma^X} \frac{Y_t^X}{P_t^X} \exp(z_{it})$ from equation (8). The intermediary's cut can be thought of as a service fee or it can be any per-unit cost associated with re-packaging and re-labeling at the intermediary sector. Consequently, the price of indirectly exported goods is higher than that of the same good had it been directly exported. In order to start to export indirectly, firms must pay a sunk cost. They also need to pay an ongoing fixed cost which could be very low.

Manufacturing firms set the price they charge intermediaries, $p_{it}^I$, taking into

account that intermediaries take their cut so that the price facing consumers is $\lambda p_{it}^I$, $\lambda > 1$. Thus, they maximize

$$\max_{p_{it}^I} \pi_{it}^{XI} = \left(p_{it}^I - mc_{it}\right)\left(\frac{\lambda p_{it}^I}{P_t^X}\right)^{-\sigma^X} \frac{Y_t^X}{P_t^X} \exp(z_{it}), \tag{9}$$

where $mc_{it}$ denotes the firm's marginal cost of production, which we assumed to be constant and the same for servicing local and foreign markets, and $P_t^X$ is the aggregate price index in the export market. Thus, the price the manufacturer charges the intermediary is [22]

$$p_{it}^I = \frac{\sigma^X}{\sigma^X - 1} mc_{it}. \tag{10}$$

### 3.1.3 Supply Side

We assume as in Aw et al. (2011) that short-run marginal costs are given by:

$$\ln mc_{it} = \ln\left(c(\boldsymbol{w}_{it})e^{-\omega_{it}}\right) = \beta_0 + \beta_k \ln k_{it} + \beta_t D_t - \omega_{it}. \tag{11}$$

They depend on firm-time specific factor prices, $\boldsymbol{w}_{it}$, and the firm-time specific productivity levels, $\omega_{it}$. Since we do not have data on firm-time specific factor prices, we use a time dummy, $D_t$, to capture them. The capital stock, $\ln k_{it}$, can be thought of as a firm-level cost shifter as only factor prices enter the cost function.[23] Short-run cost heterogeneity can come from differences in scale of production, and this is captured by the firm's capital stock. Constant marginal costs of production allow firms to make their static decisions separately for the two markets.

Firms choose their prices for each market after observing their demand shocks and marginal costs. They charge constant mark-ups so that $p_{it}^H = \frac{\sigma^H}{\sigma^H - 1} mc_{it}$, $p_{it}^{XD} = \frac{\sigma^X}{\sigma^X - 1} mc_{it}$, while the price of indirectly exported goods is $p_{it}^{XI} = \lambda \frac{\sigma^X}{\sigma^X - 1} mc_{it}$.

[22] As $\lambda^{-\sigma^X}$ multiplies the whole expression, the profit maximizing price is not affected by the intermediary's cut and the usual markup rule for pricing applies. Another way of seeing this is that as an indirect exporter's variable profit is a monotonic transformation of his profits had he chosen to be a direct exporter, the price charged by a firm is unaffected by his export mode.

[23] We could also replace capital with size dummies to capture the fact that firms with different scales of production may utilize different technology in their production processes or have access to different factor prices.

Let $a^j = \left(1-\sigma^j\right)\ln\left(\frac{\sigma^j}{\sigma^j-1}\right)$ and $\Phi_t^j = \frac{Y_t^j}{\left(P_t^j\right)^{1-\sigma^j}}$, $j = H, X$. Then revenues for home markets, exporting indirectly, and exporting directly are as follows:

$$\ln r_{it}^H = a^H + \ln\Phi_t^H + \left(1-\sigma^H\right)\left(\beta_0 + \beta_k k_{it} + \beta_t D_t - \omega_{it}\right), \tag{12}$$

$$\ln r_{it}^{Xm} = a^X + \ln\Phi_t^X + \left(1-\sigma^X\right)\left(\beta_0 + \beta_k k_{it} + \beta_t D_t - \omega_{it}\right) + z_{it} - d_{it}^I \sigma^X \ln\lambda \tag{13}$$

where $m = I, D$. The last term of equation (13) $\left(\sigma^X \ln\lambda\right)$ is positive $(\lambda > 1)$ when the firm is indirectly exporting ($d_{it}^I = 1$). Firms' revenues in each market depend on the aggregate market conditions[24] (captured by $\Phi_t^H$ and $\Phi_t^X$), the firm-specific productivity, and capital stock, while the revenue in the foreign market also depends on firms' choices of export modes. The log-revenue from exporting indirectly is less than that from exporting directly by the amount of $\sigma^X \ln\lambda$.

Given the assumption on the Dixit-Stiglitz form of consumer preferences and monopolistic competition, firm's home market profits can be written as:

$$\pi_{it}^H = \frac{1}{\sigma^H} r_{it}^H\left(\Phi_t^H, \boldsymbol{w}_{it}, \omega_{it}\right), \tag{14}$$

and profits from the foreign market if the firm exports indirectly and directly are:

$$\pi_{it}^{XI} = \frac{1}{\sigma^X} r_{it}^{XI}\left(\Phi_t^X, \boldsymbol{w}_{it}, \omega_{it}, z_{it}, \lambda\right), \tag{15}$$

and

$$\pi_{it}^{XD} = \frac{1}{\sigma^X} r_{it}^{XD}\left(\Phi_t^X, \boldsymbol{w}_{it}, \omega_{it}, z_{it}\right). \tag{16}$$

The short-run profits together with firms' draws from the sunk costs and fixed costs distributions and the future evolution of productivity determine firms' decisions to export and their choices of export modes.

Note that productivity enters both domestic and export revenue while demand

[24]Market conditions could vary by period. However, in the estimation we assume that they are fixed at the average level.

shocks enter only export revenue. This is how the impact of productivity is separated from that of demand shocks: productivity shocks are anything that affect revenue in both domestic and export markets, while demand shocks only affect export revenue.

## 3.2 Transition of State Variables

In each period, firms observe their current productivity, foreign market demand shocks, and previous period mode of exporting [25] before they make their decisions. This section describes the transitions of these state variables. We assume productivity $\omega_{it}$ evolves over time as a Markov process that depends on the previous period's productivity and the firm's export decision - export or not, and if yes, what mode of export to use. We use a cubic polynomial to approximate this evolution.

$$\begin{aligned} \omega_{it} &= g\left(\omega_{it-1}, d_{it-1}\right) + \xi_{it} \\ &= \alpha_0 + \sum_{k=1}^{3} \alpha_k \left(\omega_{it-1}\right)^k + \alpha_4 d^I_{it-1} + \alpha_5 d^D_{it-1} + \xi_{it} \end{aligned} \tag{17}$$

where $d^m_{it-1} = \{0,1\},\ m = I,D$, are dummy variables that indicate firm $i$'s export mode at period $t-1$. We assume exporting firms either export directly or indirectly. If $\alpha_4 < \alpha_5$, then productivity will grow faster with direct exporting than with indirect exporting.

By allowing the choice of export modes to endogenously affect the evolution of productivity, we can separate the role of learning-by-exporting and the sorting by productivity.[26] This is important because firms that expect their productivity to grow quickly with direct exporting may choose to export directly even though it is not profitable in the static sense. $\xi_{it}$ is an i.i.d. shock with mean 0 and variance $\sigma^2_\xi$ that captures the stochastic nature of the evolution of productivity. $\xi_{it}$ is assumed to be un-correlated with $\omega_{it-1}$ and $d_{it-1}$. It is also well known that more-productive

[25] The assumption is that the firm does some test marketing to see how well its product would be received. As a result, it knows its demand shock.

[26] De Loecker (2013) points out that if the evolution of productivity is not allowed to depend on previous export experience, then the estimates obtained would be biased. Of course, this criticism does not apply to us.

firms self-select into export markets. When estimating productivity with learning-by-exporting, the concern is that when we compare an exporter to a non-exporter, we would attribute the future productivity differences to the act of exporting, although they merely reflect selection. Under the model's structure, productivity differences that might have existed prior to the entry into export markets are controlled for through the inclusion of lagged productivity in the productivity evolution. Thus, potential self-selection into export markets is controlled for.[27]

The firm's export demand shock is assumed to be a first-order Markov process with the constant terms dependent on the firm's previous export status and mode. This allows possible different mean values of the AR(1) process for demand shock evolutions of different export modes, which captures the different learning-by-exporting effects on the demand shocks.

$$z_{it} = \psi_1 d^I_{it-1} + \psi_2 d^D_{it-1} + \eta_z z_{it-1} + \mu_{it}, \;\; \mu_{it} \sim N\left(0, \sigma^2_\mu\right). \tag{18}$$

This source of persistent firm-level heterogeneity allows firms to perform differently in local and export markets, and together with stochastic firm-level entry costs and fixed costs, allows for imperfect productivity sorting into export modes. For computational simplicity, we assume firms' sizes, captured by capital stocks $k_{it}$, do not change over time and we capture the market sizes $\Phi^H_t$ and $\Phi^X_t$ by time dummies, which we also treat as fixed over time in the estimation.

## 3.3 Dynamic Decisions

At the beginning of each period, firm $i$ observes the current state,

$$s_{it} = \left(\omega_{it}, z_{it}, \boldsymbol{d}_{it-1}, \Phi^H_t, \Phi^X_t, \boldsymbol{w}_{it}\right)$$

which includes its current productivity and demand shocks $(\omega_{it}, z_{it})$ and its past decision regarding which markets to serve and its export mode $(\boldsymbol{d}_{it-1})$. Firm $i$ observes the price indices in the markets $(\Phi^H_t, \Phi^X_t)$ as well as the firm-time specific

[27] A possible extension might be to allow selection and learning to vary across observables and unobservables. Another extension could allow learning to vary by productivity by incorporating interactions.

factor prices it faces, $\boldsymbol{w}_{it}$. We will suppress $\boldsymbol{w}_{it}, \Phi_t^H, \Phi_t^X$, as these are not chosen by the firm and call the state space $s_{it} = (\omega_{it}, z_{it}, \boldsymbol{d}_{it-1})$ from now on. It then draws its fixed and sunk costs for all the relevant options open to it and then chooses whether to sell only domestically, export indirectly, or export directly. Ineligible firms can only choose whether to stay domestic or export indirectly, and their export dynamic problems are adjusted accordingly. We omit the detailed equations here since this is merely a special case. How these costs vary by firm is explained below.

We allow the *distributions* of the costs, both fixed and sunk, of exporting to differ depending on the firm's past exporting status and mode. These fixed and sunk costs are drawn from separate independent distributions $G^l$.[28] We allow the distribution of the sunk start-up cost of a mode to differ depending on the previous mode. For example, firm $i$ faces the sunk cost $\gamma_{it}^{HDS}$ drawn from the distribution $G^{HDS}$ if it did not export last period and is looking to export directly today, while it draws $\gamma_{it}^{IDS}$ from the distribution $G^{IDS}$, if it was already exporting indirectly.[29] All this is summarized in Table 4. We assume that all sunk costs are paid in the current period. Since choices will involve comparing the difference in payoffs from pairwise options as explained below, we will not be able to pin down all the elements of the table. We can only identify their relative sizes and so assume zero sunk costs associated with exiting exporting.

Exporters also have to pay a fixed cost to remain in the export market. We denote these costs by $\gamma_{it}^{DF}$ drawn from $G^{DF}$ for direct exporters and $\gamma_{it}^{IF}$ for indirect exporters. Firms pay only the sunk costs (not the fixed costs) when switching and only the fixed costs (not the sunk costs) when not switching modes. For this reason, the fixed costs have only two letters in the superscript.

Knowing $s_{it}$, the firm's value function in year $t$, before it observes its fixed and

[28] $l$ can take the value *HDS* when the draw is for the *S*unk cost to be incurred by a *H*ome firm looking to become a *D*irect exporter (hence the *HDS* label). Thus, the first letter defines the firm's past status (*H*, *I*, *D*) and the second defines where it might transition to (*H*, *I*, *D*) with the understanding that there are no sunk costs for staying put. Thus we have the labels *HIS*, *IDS*, *DIS* as other possibilities. We normalize the sunk costs of exiting exports, the *IHS*, *DHS* cases, to be zero.

[29] As intermediaries could help small firms lower their future entry cost into direct exporting (say by providing a match with foreign clients the firm can use to export directly later on) it could be that $\gamma_{it}^{IDS}$ tends to be far smaller than $\gamma_{it}^{HDS}$ so that the means of these distributions would differ. Intermediaries can also provide information on adjusting product characteristics or packaging style to meet foreign market standards which may also reduce sunk costs of exporting directly.

sunk costs, can be written as the integral over these costs when the firm chooses the best option today (it maximizes over $\boldsymbol{d}_{it} \triangleq (d_{it}^H, d_{it}^I, d_{it}^D)$) and optimizes from the next period onwards:

$$V(s_{it}) = \int \max_{\boldsymbol{d}_{it}} \left[ u(\boldsymbol{d}_{it}, s_{it} | \boldsymbol{\gamma}_{it}) + \delta E_t V(s_{it+1} | \boldsymbol{d}_{it}) \right] dG^{\boldsymbol{\gamma}}, \tag{19}$$

where $u(\boldsymbol{d}_{it}, s_{it} | \boldsymbol{\gamma}_{it})$ is the current period payoff and depends on the choice of export status and mode, $\boldsymbol{d}_{it}$, the state $s_{it}$ (which includes last period's demand and productivity draws as well as export status and mode of exporting) and the relevant sunk and fixed cost shocks drawn, $\boldsymbol{\gamma}_{it}$:

$$\begin{aligned} u(\boldsymbol{d}_{it}, s_{it} | \boldsymbol{\gamma}_{it}) &= \pi_{it}^H + d_{it}^I \left[ \pi_{it}^{XI} - \left( d_{it-1}^H \gamma_{it}^{HIS} + d_{it-1}^I \gamma_{it}^{IF} + d_{it-1}^D \gamma_{it}^{DIS} \right) \right] \\ &+ d_{it}^D \left[ \pi_{it}^{XD} - \left( d_{it-1}^H \gamma_{it}^{HDS} + d_{it-1}^I \gamma_{it}^{IDS} + d_{it-1}^D \gamma_{it}^{DF} \right) \right]. \end{aligned} \tag{20}$$

For example, if firm $i$ exported indirectly last period (so that $d_{it-1}^I = 1$) and decides to export directly this period (so that $d_{it}^D = 1$), then he gets $\pi_{it}^H$ from the domestic market and $\pi_{it}^{XD}$ from exporting directly and has to pay the sunk cost of direct exporting $\gamma_{it}^{IDS}$ so that his current period payoff is $u(\boldsymbol{d}_{it}, s_{it} | \boldsymbol{\gamma}_{it}) = \pi_{it}^H + \pi_{it}^{XD} - \gamma_{it}^{IDS}$.

The continuation value is

$$E_t V(s_{it+1} | \boldsymbol{d}_{it}) = \int_{z'} \int_{\omega'} V\left(s'\right) dF\left(\omega' | \omega_{it}, \boldsymbol{d}_{it}\right) dF\left(z' | z_{it}, \boldsymbol{d}_{it}\right), \tag{21}$$

where $dF\left(\omega' | \omega_{it}, \boldsymbol{d}_{it}\right)$ and $dF\left(z' | z_{it}, \boldsymbol{d}_{it}\right)$ are the evolutions of productivity and demand shock as defined in equations (17) and (18).

For any state vector, denote the choice-specific continuation value from choosing $d_{it}^m = \{0,1\}$, as $E_t V_{it+1}^m \triangleq E_t V(s_{it+1} | d_{it}^m = 1)$, $m = H, I, D$. Firms' export decisions depend on the difference in the pair-wise marginal benefits between any two options and the associated sunk/fixed costs. The marginal benefits of being an indirect exporter versus being a non-exporter, the marginal benefits of being a direct exporter versus not exporting, and the marginal benefits of being a direct exporter versus being an indirect one, are defined in equations (22), (23) and (24) respec-

tively.[30]

$$\Delta IH_{it} = \pi_{it}^{XI} + \delta\left(E_t V_{it+1}^{I} - E_t V_{it+1}^{H}\right), \tag{22}$$

$$\Delta DH_{it} = \pi_{it}^{XD} + \delta\left(E_t V_{it+1}^{D} - E_t V_{it+1}^{H}\right), \tag{23}$$

$$\Delta DI_{it} = \pi_{it}^{XD} - \pi_{it}^{XI} + \delta\left(E_t V_{it+1}^{D} - E_t V_{it+1}^{I}\right). \tag{24}$$

Thus, these marginal benefits pin down the probability of switching given the distributions of costs.[31]

The benefit an indirect exporter gains from choosing to export directly compared to exporting indirectly can be decomposed into the static and the dynamic parts. The static part is the difference between the current period payoffs from these two modes of exporting, $(\pi_{it}^{XD} - \gamma_{it}^{IDS}) - (\pi_{it}^{XI} - \gamma_{it}^{IF})$. The difference between the discounted future payoff from these two modes of exporting, $\delta\left(E_t V_{it+1}^{D} - E_t V_{it+1}^{I}\right)$, captures the dynamic part.

Intuitively, higher fixed costs of exporting (directly or indirectly) will reduce the continuation value of being an exporter and thus decrease the marginal benefits of being an exporter versus not exporting, i.e., $\Delta IH_{it}$ or $\Delta DH_{it}$ fall. However, higher sunk costs will decrease the continuation value of being a non-exporter, and thereby increase $\Delta IH_{it}$ or $\Delta DH_{it}$. Similarly, better learning-by-exporting effects increase $\Delta IH_{it}$ and $\Delta DH_{it}$, and if firms learn more through direct exporting or the service fee $\lambda$ rises, $\Delta DI_{it}$ will be larger, *ceteris paribus*. Firms make draws from the sunk and fixed costs distributions each period independently, but the marginal benefit of one option over another has some persistence due to the persistence in productivity and demand shocks.

[30] $\Delta HI_{it}$, $\Delta HD_{it}$, and $\Delta ID_{it}$ could be similarly defined but simple calculations show that they are merely the negative of $\Delta IH_{it}$, $\Delta DH_{it}$, and $\Delta DI_{it}$.

[31] For example, the probability that a previous indirect exporter chooses to become a direct exporter is

$$P_{it}^{ID} = \Pr[\gamma_{it}^{IDS} \leq \min\left\{\Delta DH_{it}, \gamma_{it}^{IF} + \Delta DI_{it}\right\}].$$

# 4 Estimation

Following Das et al. (2007) and Aw et al. (2011), we estimate the model using a two-stage approach. In the first stage of the estimation, we estimate the firms' static decisions regarding production to obtain estimates of the domestic revenue function and of the productivity evolution process. The following parameters are recovered: the elasticities of substitution in the two markets, $\sigma^H$ and $\sigma^X$, the home market size intercept $\Phi_t^H$, the marginal cost parameter $\beta_k$, the productivity evolution function $g(\omega_{it-1}, d_{it-1})$, and the variance of transient productivity shocks $\sigma_\xi^2$. In the second stage, we exploit information on firms' discrete choices regarding export market participation modes, and the productivity estimates obtained in the first stage of the estimation procedure, to obtain the parameters on the sunk and fixed costs of two exporting modes.[32] Parameters of $G^\gamma$ (the distribution of sunk and fixed costs), the parameters $\eta_z$, $\sigma_\mu$, $\psi_1$, $\psi_2$ of Markov process $z_{it}$ followed by the demand shock, and the foreign market size intercept $\Phi_t^X$ are also recovered in the second stage.

## 4.1 Stage 1: Elasticities and Productivity Evolution

### 4.1.1 Elasticities

To estimate the elasticity of substitution in each market we use the approach in Das et al. (2007). Each firm's total variable cost can be written as

$$\begin{aligned} TVC_{it} &= mc_{it} q_{it}^H + mc_{it} q_{it}^{Xm} \\ &= \left(\frac{\sigma^H - 1}{\sigma^H}\right) p_{it}^H q_{it}^H + \left(\frac{\sigma^X - 1}{\sigma^X}\right) \left[d_{it}^D p_{it}^{XD} q_{it}^{XD} + d_{it}^I p_{it}^I q_{it}^{XI}\right]. \end{aligned} \tag{25}$$

As total variable costs and revenues are data we can estimate equation (25) by OLS to recover the elasticities of substitution.

[32] Recall, we normalize these costs to be zero for non-exporters.

### 4.1.2 Productivity and Productivity Evolution

We can rewrite equation (12) as being made up of a part that does not vary over time, a part that does, and a part that varies by firm and time as follows:

$$\ln r_{it}^H = \phi_0^H + \sum_{t=1}^{T} \phi_t^H D_t + \left(1-\sigma^H\right)\left(\beta_k \ln k_{it} - \omega_{it}\right) + u_{it}, \tag{26}$$

where $\phi_0^H = \left(1-\sigma^H\right)\ln\left(\frac{\sigma^H}{\sigma^H-1}\right) + \left(1-\sigma^H\right)\beta_0$ and $\phi_t^H = \ln\Phi_t^H + (1-\sigma^H)\beta_t$ which captures the time varying factor prices and the home market size. $k_{it}$ denotes the firm's book value of capital, $\omega_{it}$ is productivity, and $u_{it}$ is an i.i.d. error term reflecting measurement error.[33][34]

As in Levinsohn and Petrin (2003), we proxy for unobserved productivity using the fact that more productive firms will use more materials. Thus we can replace $\left(1-\sigma^H\right)\left(\beta_k \ln k_{it} - \omega_{it}\right)$ with $h\left(k_{it}, m_{it}\right)$. We estimate the function (26) using ordinary least squares and approximate $h\left(k_{it}, m_{it}\right)$ by a third-degree polynomial of its arguments. This gives us estimates of $\phi_0^H$, $\phi_t^H$ and the values of $\hat{h}\left(k_{it}, m_{it}\right)$. Thus we can rewrite productivity as follows:

$$\omega_{it} = -\left(\frac{1}{1-\sigma^H}\right)\hat{h}(k_{it}, m_{it}) + \beta_k \ln k_{it}. \tag{27}$$

We know $-\left(\frac{1}{1-\sigma^H}\right)\hat{h}(k_{it}, m_{it})$ and $\ln k_{it}$, but still have to estimate $\beta_k$ and the parameters for the evolution of productivity. Recall that productivity evolves according to

$$\omega_{it} = \alpha_0 + \sum_{k=1}^{3} \alpha_k \omega_{it-1}^k + \alpha_4 d_{it-1}^I + \alpha_5 d_{it-1}^D + \xi_{it}.$$

Thus, if we substitute for $\omega_{it}$ and $\omega_{it-1}$ using equation (27) into the above equation, we can estimate the remaining parameters ($\alpha_i, i = 0, ..., 5$ and $\beta_k$ ), using non-linear least squares. The variance of $\xi_{it}$ is pinned down by the sample variance of the

[33] We could have estimated the model separately for different kinds of firms. However, given that we estimate the model industry by industry, this would reduce the size of our sample a lot.

[34] Note that for the purposes of solving the model, we only need $\phi_0^H + \phi_t^H$, not the separate components. The $\Psi^H$ reported in Table 5 is the average $\phi_0^H + \phi_t^H$ over all time periods. The same holds for $\Psi^X$ reported in Table 6. These average variables are used in the second stage estimation.

residual.[35]

So far we have estimates of $\phi_0^H$ and $\phi_t^H$, which capture the home market condition, elasticities $\sigma^H$ and $\sigma^X$, the marginal cost parameters $\beta_k$, the productivity evolution function $g(\omega_{it-1}, d_{it-1})$, and the variance of transient productivity shocks $\sigma_\xi^2$. What remains to be estimated are the parameters of the distributions of the sunk and fixed costs, i.e., of $G^\gamma$, for each mode, the demand shocks and their evolution, and the foreign market size intercept $\Phi_t^X$.

One might think that we could take the same approach as above and estimate demand shocks from the export revenue data given our estimates of productivity and its evolution. However, not all firms export in all years, resulting in censored data. Thus a different approach is needed here: we will be able to estimate demand shocks jointly with the dynamic discrete choice component in the second stage.[36]

## 4.2 Stage 2: Dynamic Estimation

We exploit information on the transitions of export modes and export revenues of exporting firms to estimate a dynamic multinomial discrete choice model. Intuitively, sunk entry costs of an export mode are identified by the persistence in the mode and the frequency of entry into the mode across firms, given their previous exporting mode. High sunk costs make a firm less willing to enter, and once it has entered, less willing to exit. Given sunk cost levels, the variable export profit levels at which firms choose to exit from being indirect or direct exporters help to identify the fixed costs of different export modes. Firms tend to stay in their current exporting mode if the sunk cost of exporting in that export mode is high and the fixed cost is relatively low. Ceteris paribus, we would observe frequent exits from a particular mode of exporting if the fixed cost was high.

We fix the commission rate obtained by the intermediary at 1% of the export rev-

[35] We also experimented with incorporating additional firm specific factors in marginal costs such as the wage bill, location by province, and ownership (domestic, foreign or SOE). This did not change the patterns in the evolution of productivity we focus on below.

[36] We do not consider entry and exit or attempt to estimate their costs. This is not the focus of this paper. In addition, since the survey data covers all SOEs and all non-state firms above a certain size (5 million Yuan in annual revenue), we cannot distinguish exit from the industry and exit from the data, though we do observe firm's age and hence its entry date.

enue. Thus, $\lambda = 1.01$.[37] Given productivity and capital stock, the export revenues of both types of exporters provide information on foreign market demand shocks when firms choose to export. We observe a firm's choice of export modes and its export revenue *only* if it exports. Variable profits and revenues are tightly linked in the model so that once we have revenues and demand elasticities, we have variable profits. These profits play a key role in the dynamic estimation below. Given variable profits and the remaining parameters of the model, the value functions can be found as a solution to a fixed point problem.

We estimate the rest of the model (export demand shocks and their evolution by mode of exporting and the various levels of fixed and sunk costs) by maximizing the likelihood function for the observed participation and modes of exporting along with the observed export sales (which boils down to observing a particular demand shock). Since firm export revenue is determined by firm productivity, capital stock (a cost shifter), market size and the foreign market shocks, we can write firm $i$'s contribution to the likelihood function as

$$P\left(\boldsymbol{d}_i, r_i^{Xm} | \omega_i, k_i, \Phi\right) = P\left(\boldsymbol{d}_i \left| \omega_i, k_i, \Phi, z_i^+\right.\right) f\left(z_i^+\right) \tag{28}$$

where $f(\cdot)$ is the marginal distribution of $z$ and $z_i^+$ is the series of foreign market demand shocks in the years when firm $i$ exports. In the evaluation of the likelihood function, we followed Das et al. (2007) and Aw et al. (2011) to construct the density $f(\cdot)$ and simulate the unobserved export market shocks.

To provide some idea of how this works, consider an indirect exporter who becomes a direct one and sells a particular amount. The probability of an indirect exporter becoming a direct exporter is given in equation (31). This requires knowledge of the distribution of $\gamma^{IDS}$ and $\gamma^{IF}$ as well as $\Delta DH_{it}$ and $\Delta DI_{it}$. We assume that the $\gamma's$ are drawn from exponential distributions. The values of $\Delta DH_{it}$ and $\Delta DI_{it}$ as defined in equations (23) and (24) depend on variable profits from exporting directly (which from equation (16) we know depend on parameters estimated in the first stage and the ones remaining to be estimated) and on the value functions

[37] Intermediaries tend to have thin margins and make up for them in terms of volume. A one percent cut is not out of line with observed contracts.

for exporting directly, indirectly, and not exporting. For every guess of the parameters remaining to be estimated, we can calculate these value functions by essentially solving a fixed point problem, and then obtain the probability of an indirect exporter becoming a direct exporter.

For the exporter to sell the amount he has, the demand shock must have taken a particular value which we can back out from the data given our choice of parameters. This will then give the probability of seeing this shock. Such elements are what go into the likelihood function which we maximize to obtain our parameter estimates.

Thus, by assuming that the export sunk costs and fixed costs for each firm and year are i.i.d. draws from separate independent exponential distributions, we can write the choice probabilities of each export status and mode in a closed form.[38] It is worth reiterating that these choice probabilities are conditional on the firm's state.

# 5 Estimation Results

First, we report the estimates of demand, marginal cost and productivity evolution in the Rubber and Plastic industry as well as a number of other industries. We then confirm the pattern of productivity sorting regarding different export modes. Following this, we report the results of the dynamic estimation, summarize the marginal returns to different modes of exporting and the hidden costs of being constrained from direct trading, and analyze the model fitness. Finally, we conduct some robustness checks.

## 5.1 Productivity Evolution

The revenue estimates as well as the productivity evolution are reported in Table 5. In the first column, we report our estimates for the Rubber and Plastic industry. The elasticities of substitution imply markups of 25 percent in home market and 28 percent in foreign market. The coefficient on log capital implies that the marginal

[38] Derivation of these choice probabilities is available upon request.

costs are lower for larger scale. The coefficients $\alpha_1$, $\alpha_2$ and $\alpha_3$ imply a non-linear and positive marginal effect of lagged productivity on current productivity. $\alpha_4$ and $\alpha_5$, the coefficients on previous export modes, are critical parameters.[39] Previous indirect exporters have a 0.5 percent higher productivity relative to previous non-exporters, while previous direct exporters have productivity that is 2.3 percent higher. This confirms the dynamic trade-off between direct and indirect exporting in terms of learning-by-exporting. This long-run benefit gives firms an incentive to stay in the direct exporting mode even if they are making short-run losses.

In columns 2–4 of Table 5, we also report our estimates of the productivity evolution process in three other industries - Chemicals and Chemical Products (2-digit ISIC Rev3 24), Machinery and Equipment (2-digit ISIC Rev3 29), and Furniture (2-digit ISIC Rev3 36).[40] Direct exporting always has larger effects on firm productivity than indirect exporting in all these industries.

## 5.2 Productivity Sorting

When we look at the productivity distributions for non-exporters, indirect exporters and direct exporters separately, we have a clear pattern of productivity sorting. The Kolmogorov-Smirnov test affirms that non-exporters, indirect exporters and direct exporters are significantly different from each other. Moreover, the distribution for direct exporters first order stochastically dominates that of indirect exporters which first order stochastically dominates that of non-exporters. Figure 1 shows the kernel density estimates of these three distributions. The randomness of sunk and fixed costs of different exporting modes and the persistence of the firm-level heterogeneous foreign demand shocks predict that the productivity sorting will not be a strict hierarchy just as observed here.

[39] Recall that $\omega$ is the natural log of productivity. Thus, $\alpha_4$ and $\alpha_5$ are the percentage change in productivity when exporting indirectly and directly.

[40] These industries are important in China's exports in terms of both export revenue and number of exporters. Other industries are presented in the working paper version of the paper.

## 5.3 Dynamic Estimates

First, the estimate of $\Psi^X$ in Table 6 (which proxies for average foreign market size) is smaller than that for the domestic market, $\Psi^H$, which we estimated in the first stage. This is in line with what we see in Table 2 that exporters on average sell 63 to 75 percent less in the foreign market than in the domestic market.

The coefficients $\gamma^{HIS}, \gamma^{HDS}, \gamma^{IDS}, \gamma^{DIS}$ reported in Table 6 are the mean parameters of the exponential distributions for, respectively, the sunk costs of a non-exporter to start indirect and direct exporting, the sunk cost of an indirect exporter to become a direct one and that of a direct exporter to start to export indirectly. Note that $\gamma^{HDS}$ is much higher than $\gamma^{HIS}$. This is consistent with the observed transition patterns in the data and suggests that on average, it is much less costly to enter the indirect exporting market than the direct exporting market. $\gamma^{IDS}$ is also much lower than what $\gamma^{HDS}$. This indicates that using an intermediary to export in the previous period helps firms to start direct exporting in the current period by lowering their sunk costs. Moreover, we can see that on average, climbing the export ladder by starting off as an indirect exporter and then moving into direct exporting is cheaper than exporting directly to begin with. The relatively small average sunk costs of starting indirect exporting as a direct exporter ($\gamma^{DIS}$) indicates that it is much easier for a direct exporter to become an indirect exporter.

The coefficients $\gamma^{IF}$ and $\gamma^{DF}$ are relatively small compared to the sunk costs of starting such exporting. This is what creates hysteresis. $\gamma^{IF}$ is also smaller than $\gamma^{DF}$ confirming the cost advantage of exporting through intermediaries.

What do firms actually pay? Firms with high cost draws do not avail of the option to export. Table 7 gives average costs *incurred* and the ratio of these costs to average export revenues earned (in brackets). These costs are measured as the truncated mean of the exponential distributions incorporating the fact that only favorable draws result in a firm exporting.[41] Table 7 presents these numbers for firms at the mean productivity levels of a non-exporter, indirect exporter and direct ex-

[41] For each combination of the state variables, the mean fixed and sunk costs of the firms that choose to export are the truncated means of the corresponding exponential distributions with truncation point given by the pairwise marginal benefits.

porter respectively.[42]

The last four parameters describe the evolution of foreign market demand shocks, $z_{it}$. The parameters $\eta_z$ and $\sigma_\mu$ characterize the serial correlation and standard deviation of $z_{it}$ which is assumed to evolve as a first-order Markov process. The high serial correlation shows the persistence in firm-level demand shocks, which also induces persistence in firms' export status and export revenue. The parameter on the dummy of indirect exporting $\psi_1$ is positive but not significant, while the parameter on the dummy of direct exporting $\psi_2$ is significantly positive. These two parameters give the growth in the demand shocks if firms were indirectly or directly exporting last period, compared to non-exporters.

## 5.4 Model Fit

Using our estimates in Table 5 and Table 6 we simulate the model thirty times to assess its performance. Specifically, we use the actual data in the initial year of each firm observed in the sample and simulate their evolutions of productivity and decisions of export modes in the following years based on simulated draws of foreign market demand shocks and export costs. Table 8 compares the actual and simulated average productivity and the participation rates of each mode of exporting. Overall, the model predicts the average productivity and the participation rates of two export modes well. In Table 9, we report the actual and simulated transitions between each export status and mode. The simulated transitions for non-exporters which account for 81 percent of the sample are very close to the actual transition rates, indicating that our model performs well in estimating the sunk costs of starting two modes of exporting as non-exporter, specifically $\gamma^{HDS}$ and $\gamma^{HIS}$. The model slightly overestimate the fixed costs of two modes of exporting and thus under predicts the

[42] It is worth noting that one of the main points made above, namely that it is "cheaper to climb the ladder than jump a rung" does not on first glance look like it holds in Table 7. For example, $0.827 + 1.338 > 1.500$ so that the actual costs incurred by a non-exporter to export directly after exporting indirectly are actually more than that of exporting directly to begin with. This is not surprising: though the mean of the sunk costs of exporting directly for a non-exporter is higher, costs actually incurred could be lower if the option is exercised only for low cost draws. In other words, the numbers in Table 7 come partly from selection and partly from the the distributions costs are drawn from and so cannot be interpreted in the same way as those in Table 6 in terms of climbing the ladder versus jumping a rung.

persistence of indirect and direct exporters.

## 5.5 Robustness Checks

We check the robustness of our first stage estimates. As the second stage is very computationally intensive, we cannot do the same for it. The details are in the Appendix. It is also natural to ask if we could use eligibility as an instrument in the choice of export mode. This is not as easy as it seems. If firms choose to become indirect exporters on the way to exporting directly, eligibility would both make firms more likely export indirectly as well as directly. This would make eligibility a poor instrument and this is exactly why we are unable to exploit this institutional feature. Here we sketch what we found.

First, we address concerns about the definition of indirect and direct exporters. Recall that we infer export modes as firms are not directly asked about their mode of export. Hence, mis-reporting in the survey and errors or mismatches in the process of merging the two data sets could create errors in our classification.[43] For example, some firms may say they did not export because they did not realize the intermediary they sold to was exporting their goods. Consequently, we could have mis-classified indirect exporters as non-exporters. This is unlikely as exporting intermediaries have names that clearly differentiate them from domestic ones as made clear in Ahn et al. (2011). In any case, this mis-classification would work in our favor as it would reduce growth of demand shocks and productivity of exporters relative to non-exporters. We also look at whether there is any evidence that non matched exporters are mistakenly classified as indirect ones. In the appendix, in section C, we show that this does not seem to be the case.

There may also be producers who say they did not export in the survey data and show up in the customs data.[44] We interpret this to mean that such firms exported on someone else's behalf, making them "producer intermediaries" . These firms are dropped in our baseline estimation. To check if this made a difference we ran the first stage of the estimation including them as a separate type of export mode. This did not affect the estimates of productivity evolution and these firms seemed to learn

[43] Evidence on match quality is discussed in the second section of the Appendix.

[44] These comprise about 4 percent of the observations in the survey data.

even faster than direct exporters. We performed the same exercise for processing firms whom we originally dropped. Processing firms' learning is in between that of indirect and direct exporters. These results are reported in Table A.4 of the Appendix.

We also checked the robustness of our results to alternative definitions of export modes. For example, if there is a delay in customs in recording export shipments at the end of a calendar year, a firm could report positive exports in year $t$ while its shipment only show up in year $t+1$. In this case, we could have mis-classified direct exporters as indirect exporters. To deal with this we reclassify firms as described in the Appendix and find it makes no difference. We also estimate the evolution of productivity allowing it to differ by the share of direct exports and not just classify firms as one or the other. We find that the higher the share of direct exports, the greater the learning gains.

In this vein, there is also a concern that exports to Hong Kong may actually be mis-classified as direct since Hong Kong often acts like an intermediary and re-exports to the final destination, see Feenstra and Hanson (2004). To see if our results are robust to this concern, we allow exporters to Hong Kong to have different learning patterns. However, the coefficients are not significant. These results are in Table A.4 of the Appendix.

Firms may also differ in other dimensions in terms of their exporting behavior and this could be what lies behind our results. For example, it is well understood (see Ahn et al. (2011)) that direct exporters access different markets and export different products than do indirect exporters. Direct exporters sell 10 to 15 percentage points more overall to the top ten destinations than do intermediaries, consistent with the idea that intermediaries are used to access smaller, less desirable destinations and sell differentiated goods (which are a greater share of expenditure in rich countries). However, when we control for destination and product in estimating the productivity evolution they do not seem to affect the evolution of productivity. Similarly, when we control for the propensity of a shipment to be sold by an intermediary, we find no significant change in the patterns of the coefficients of interest. These results are reported in Table A.5 of the Appendix.

Omitting other firm decisions that could be affecting productivity may confound

our results. For example, if direct exporters tend to import intermediate inputs and due to this have a better productivity evolution, our results could be spurious. Other dimensions in which firms may differ include their behavior in investing in R&D or actively increasing their registered capital to obtain direct trading rights. Adjusting for such variations in our first-stage estimation does not change the learning-by-exporting patterns we have in our baseline estimation. Table A.6 in the Appendix reports these results.

To ensure that the differential learning-by-exporting effects by modes are robust to different productivity measures, we allow firms in different provinces or with different ownership structures to face different factor prices. In addition to log capital, log wage rate is also used to capture the firm-time level cost shifters. We also estimated productivity evolution in an alternative manner following De Loecker (2013). Specifically, we used both total revenue and value-added as measures of total output. These results can be found in Table A.7 in the Appendix.

# 6 Counterfactuals

In this section we use our estimated model to conduct some counterfactual experiments. These include liberalization of restrictions on direct exports and subsidy policies of different kinds.

## 6.1 Direct Trading Liberalization

Using our estimates, we compare firms' growth under different liberalization scenarios. As described above, the liberalization of direct trading rights that took place was gradual and expected. We simulate firms' growth in average productivity, export participation and export revenue under the following three scenarios. First, we assume that the liberalization was immediate and all firms were free to choose their export modes from the year 2000 onwards. Second, we look at banning indirect exports. This is similar to what would happen in the absence of a well-developed intermediary sector. Third, we look at what would happen if all domestic firms were forced to export through intermediaries, i.e., we eliminate direct exports for them.

This scenario is a bit more extreme than what would have happened without the liberalization of direct trading rights that did occur. In addition, we also compare how firms react under these three scenarios when productivity evolution is completely exogenous and there are no learning-by-exporting effects. To compare the effects, we use the first year of the data as given and simulate firms' optimal export decisions for the next five, ten and fifteen years. In each of the three cases, firms perceive the changes made as being permanent when evaluating their options. We repeat the simulation thirty times and report the average effects in Table 10. The numbers reported here are the percentage changes relative to the current situation.

First look at columns 1–3 of the table where there are learning-by-exporting effects. As we can see from the first row of each horizontal panel, the first case, where the liberalization was immediate, is closest to the current trade regime. There is no effect on average productivity, though export participation and export revenue would have been slightly higher than under the status quo. This is both because the liberalization process only took four years, and because it was perfectly expected by firms in the economy. In the second row of each panel, we report the relative effects when indirect trading was not an option. Restricting indirect exporting moves small firms who would have been indirect exporters into the non-exporter group. This reduces sales and productivity. However, it also moves larger indirect exporters into exporting directly which has the opposite effect. The net effect is close to zero for productivity which falls by 0.3 percent, but negative for sales and participation which fall by 11 and 13 percent respectively over 15 years. When direct exports are banned as in the third case average productivity falls by 1.2 percent. Export participation and export sales fall by 37 and 30 percent respectively. Had there been no learning-by-exporting effects, all these effects would be much smaller. This suggests that the effects via learning-by-exporting are critical. In sum, the counterfacutals show that liberalizing direct trading rights was important and exports would have been roughly a third lower had this not been done.

## 6.2 Subsidies

A variety of trade policies have been used to encourage exports in developing countries. The most commonly used tools include direct subsidies based on firms' export performances, such as export revenue subsidies and duty-free access to imported inputs in export processing zones. Both of these tools have been used intensively by the Chinese government. This type of subsidy targets incumbent exporters and affects exports on the intensive margin. At the same time, it increases exporters' survival rates and encourages entry just like a fall in variable costs. Other subsidies, like those to fixed and sunk costs, directly focus on reducing the cost of exporting and encourage net entry.

In this section, we simulate the effects of such subsidies. First, we simulate the effect of a 5 and 10 percent subsidy on exports.[45] We also simulate the effect of a 25 and 50 percent reduction in fixed or sunk costs of exporting. In addition, we target the subsidies to different types of exporters. We take the first year of the data and simulate trajectories of firm performance for future years. We compare all the results to the case with no subsidies. In each of the three cases, firms perceive the policy to be permanent when evaluating their options.

Table 11 presents the results of this exercise ten years after the policy was introduced. We compare three measures of the effects of the subsidy: the increase in export participation, export revenue and the ratio of increases in export revenue to the subsidy costs. The last is the benefit to cost ratio and we focus on this.

First, we see that a 10 percent subsidy on exports increases the export participation rate by 2.9 percent and export revenue by 11.4 percent. The difference suggests that this type of subsidy mainly operates through the intensive margin of exports. In contrast, subsidizing the costs of exporting has a larger effect on increasing export participation than on export revenue. This is because subsidizing costs operates through the entry-exit of firms into exporting. It is worth noting that the benefit-cost ratio of the export subsidy is higher when targeting direct exporters. This makes sense as they tend to be more productive. However, the benefit-cost ra-

[45] This can also be interpreted as the effect of a lower variable transportation cost or the development of transportation technologies or/and port facilities (as costs are of the iceberg variety) or VAT rebates. This is because revenues are multiplicatively related to productivity and costs in our setting.

tio of cost subsidies is higher for indirect exporters as the costs of indirect exporting are lower.

# 7 Conclusion

Massive amounts of money has been allocated to "Aid for Trade" initiatives in developing countries. The aim is to help developing countries overcome "trade-related constraints" and to bring growth and reduce poverty. Yet, little is known about where the constraints are. Our paper has little to say about this and work in this area is sorely needed.

The policy conclusions we wish to highlight from our results are straightforward. First, learning-by-exporting is important and is dramatically different across export mode. Direct exporters seem to learn more about how to produce and what to produce than indirect ones. For this reason alone, policies that encourage direct exporting might be worth considering. We make the case that a hitherto less studied policy, that of removing controls on direct exporting, had a significant effect on promoting Chinese export growth. Of course, all the other policies that changed also had an effect. In future work we hope to better understand the extent to which China's domestic reforms, tariff reforms, and tariffs it faced, as well as its selective encouragement of sectors by fine-tuning VAT rebate levels, contributed to its export growth.

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**Table 1:** Composition of Firms

| Year | Non-Exporter | | Indirect Exporter | | Direct Exporter | | Total |
|---|---|---|---|---|---|---|---|
| 2000 | 3,244 | 83.1% | 362 | 9.3% | 299 | 7.6% | 3,905 |
| 2001 | 4,599 | 83.5% | 488 | 8.9% | 419 | 7.6% | 5,506 |
| 2002 | 5,046 | 82.5% | 557 | 9.1% | 514 | 8.4% | 6,117 |
| 2003 | 5,415 | 81.9% | 579 | 8.8% | 615 | 9.3% | 6,609 |
| 2004 | 7,697 | 80.9% | 732 | 7.7% | 1,085 | 11.4% | 9,514 |
| 2005 | 8,509 | 79.8% | 863 | 8.1% | 1,292 | 12.1% | 10,664 |
| 2006 | 7,627 | 79.7% | 758 | 7.9% | 1,183 | 12.4% | 9,568 |

**Table 2:** Summaries of Firm Size

| | Employee | Capital | Home Sales | Export Sales |
|---|---|---|---|---|
| | Non-Exporter | | | |
| Mean | 119.787 | 0.796 | 2.660 | 0 |
| Median | 73 | 0.263 | 1.304 | 0 |
| | Indirect Exporter | | | |
| Mean | 282.892 | 2.968 | 8.789 | 2.176 |
| Median | 120 | 0.400 | 2.089 | 0.482 |
| | Direct Exporter | | | |
| Mean | 388.856 | 4.707 | 11.237 | 4.139 |
| Median | 180 | 1.070 | 3.806 | 1.270 |

Notes: Capital, domestic sales and exports are in 10 millions of Chinese Yuan.

**Table 3:** Transitions of Export Modes: All Eligible Firms

| Export Status | Time t | | |
|---|---|---|---|
| Time $t-1$ | Non-Exporter | Indirect Exporter | Direct Exporter |
| Non-Exporter | 0.961 | 0.030 | 0.009 |
| Indirect Exporter | 0.231 | 0.655 | 0.115 |
| Direct Exporter | 0.022 | 0.058 | 0.920 |

**Table 4:** Costs of Exporting

| Export Status | Time $t$ | | |
|---|---|---|---|
| Time $t-1$ | Non-Exporter | Indirect Exporter | Direct Exporter |
| Non-Exporter | 0 | $\gamma_{it}^{HIS}$ | $\gamma_{it}^{HDS}$ |
| Indirect Exporter | 0 | $\gamma_{it}^{IF}$ | $\gamma_{it}^{IDS}$ |
| Direct Exporter | 0 | $\gamma_{it}^{DIS}$ | $\gamma_{it}^{DF}$ |

**Table 5:** Demand Elasticities, Marginal Cost, and Productivity Evolution

| Parameters | | Rubber & Plastic | Chemical | Machinery & Eqpt | Furniture |
|---|---|---|---|---|---|
| Domestic Elasticity | $\sigma^H$ | 4.902*** | 5.818*** | 5.740*** | 5.844*** |
| | | (0.003) | (0.001) | (0.002) | (0.007) |
| Foreign Elasticity | $\sigma^X$ | 4.550*** | 3.776*** | 4.357*** | 5.930*** |
| | | (0.008) | (0.010) | (0.004) | (0.009) |
| Capital | $\beta_k$ | -0.036*** | -0.030*** | -0.033*** | -0.025*** |
| | | (0.001) | (0.000) | (0.000) | (0.001) |
| Constant | $\alpha_0$ | 0.637*** | 0.559*** | 0.338*** | -0.140* |
| | | (0.036) | (0.017) | (0.014) | (0.081) |
| $\boldsymbol{\omega}_{it-1}$ | $\alpha_1$ | 0.194*** | 0.167*** | 0.528*** | 1.440*** |
| | | (0.071) | (0.039) | (0.034) | (0.151) |
| $\boldsymbol{\omega}_{it-1}^2$ | $\alpha_2$ | 0.309*** | 0.383*** | 0.200*** | -0.315*** |
| | | (0.046) | (0.030) | (0.026) | (0.094) |
| $\boldsymbol{\omega}_{it-1}^3$ | $\alpha_3$ | -0.034*** | -0.053*** | -0.026*** | 0.062*** |
| | | (0.010) | (0.007) | (0.006) | (0.019) |
| Indirect Export$_{t-1}$ | $\alpha_4$ | 0.005** | 0.005*** | 0.006*** | -0.000 |
| | | (0.002) | (0.001) | (0.001) | (0.001) |
| Direct Export$_{t-1}$ | $\alpha_5$ | 0.023*** | 0.016*** | 0.017*** | 0.012*** |
| | | (0.002) | (0.001) | (0.001) | (0.001) |
| Home Market Size | $\Psi^H$ | 2.627 | 2.382 | 2.146 | -0.000 |
| | $\boldsymbol{\sigma}_\omega$ | 0.123 | 0.111 | 0.108 | 0.095 |

$^{***}$,$^{**}$ and $^{*}$ indicate significance at the 1%, 5% and 10% levels, respectively.

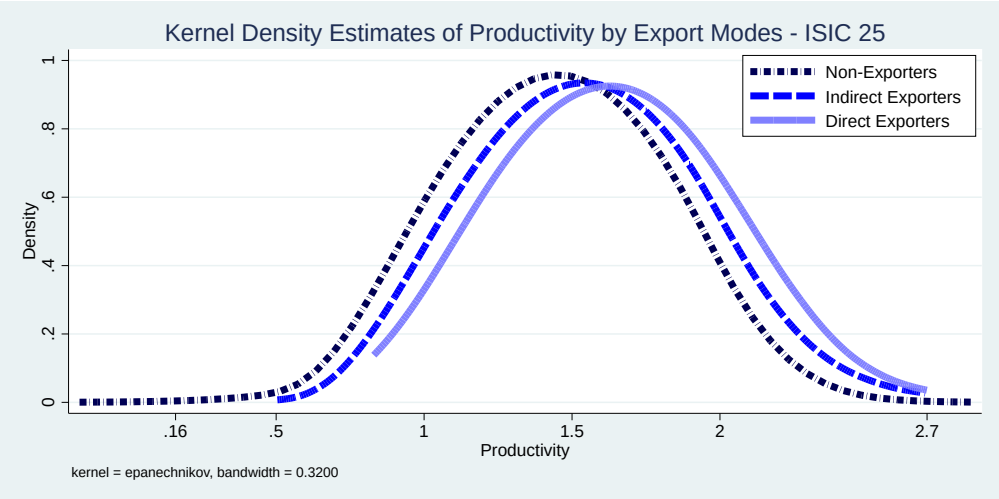


**Figure 1.** Productivity Distributions by Export Modes

**Table 6:** Dynamic Parameter Estimates

| | | | |
|---|---|---|---|
| Export Market Size | $\Psi^X$ | 1.574*** | (0.018) |
| Sunk Export Costs | | | |
| Home $\rightarrow$ Indirect | $\gamma^{HIS}$ | 26.149*** | (0.531) |
| Home $\rightarrow$ Direct | $\gamma^{HDS}$ | 123.079*** | (3.634) |
| Indirect $\rightarrow$ Direct | $\gamma^{IDS}$ | 32.336*** | (0.725) |
| Direct $\rightarrow$ Indirect | $\gamma^{DIS}$ | 1.116*** | (0.031) |
| Fixed Export Costs | | | |
| Indirect | $\gamma^{IF}$ | 0.780*** | (0.020) |
| Direct | $\gamma^{DF}$ | 1.544*** | (0.035) |
| Demand Shock | | | |
| | $\eta_z$ | 0.836*** | (0.007) |
| | $\log(\sigma_\mu)$ | -0.200*** | (0.003) |
| Indirect | $\psi_1$ | 0.003 | (0.002) |
| Direct | $\psi_2$ | 0.008*** | (0.001) |

***,** and * indicate significance at the 1%, 5% and 10% levels, respectively.

**Table 7:** Average Costs of Exporting

| Export Status | | Time t | | | |
|---|---|---|---|---|---|
| Time t-1 | $\omega_{it}$ | Indirect Exporter | | Direct Exporter | |
| Non-Exporter | 1.448 | 0.827 | (0.253) | 1.500 | (0.438) |
| Indirect Exporter | 1.558 | 0.385 | (0.079) | 1.338 | (0.264) |
| Direct Exporter | 1.638 | 0.052 | (0.008) | 1.111 | (0.165) |

Values of costs are in 10 millions of Chinese Yuan.
Numbers in brackets are the ratio of the costs to the gross export revenue.

**Table 8:** Model Prediction of Productivity and Participation Rates

| | | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|
| Productivity | Data | 1.447 | 1.456 | 1.475 | 1.471 | 1.480 | 1.520 |
| | Model | 1.462 | 1.472 | 1.482 | 1.470 | 1.471 | 1.493 |
| Indirect Exporter | Data | 0.089 | 0.091 | 0.088 | 0.077 | 0.081 | 0.079 |
| | Model | 0.086 | 0.086 | 0.083 | 0.079 | 0.072 | 0.077 |
| Direct Exporter | Data | 0.076 | 0.084 | 0.093 | 0.114 | 0.121 | 0.124 |
| | Model | 0.079 | 0.088 | 0.101 | 0.114 | 0.115 | 0.123 |

Simulation reports average results from thirty simulations.

**Table 9:** Model Prediction of Transition Rates

| Export Status | | Time $t$ | | |
|---|---|---|---|---|
| Time $t-1$ | | Non-Exporter | Indirect Exporter | Direct Exporter |
| Non-Exporter | Data | 0.963 | 0.029 | 0.008 |
| | Model | 0.951 | 0.031 | 0.017 |
| Indirect Exporter | Data | 0.234 | 0.660 | 0.107 |
| | Model | 0.271 | 0.619 | 0.110 |
| Direct Exporter | Data | 0.022 | 0.058 | 0.920 |
| | Model | 0.086 | 0.053 | 0.861 |

Simulation reports average results from thirty simulations.

**Table 10:** Firm Response Under Different Liberalization Scenarios

| Policy Regimes | Learning | | | No Learning | | |
|---|---|---|---|---|---|---|
| Year | 5 | 10 | 15 | 5 | 10 | 15 |
| Average Productivity | | | | | | |
| No Restriction | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| No Intermediary | 0.0% | -0.1% | -0.3% | 0.0% | 0.0% | 0.0% |
| No Liberalization | -0.2% | -0.6% | -1.2% | 0.0% | 0.0% | 0.0% |
| Export Participation | | | | | | |
| No Restriction | 0.9% | 0.3% | 0.2% | 0.1% | 0.0% | 0.0% |
| No Intermediary | -10.3% | -12.6% | -13.0% | -0.7% | -2.9% | -1.0% |
| No Liberalization | -29.8% | -35.8% | -36.9% | -7.2% | -8.9% | -8.9% |
| Export Revenue | | | | | | |
| No Restriction | 0.3% | 0.2% | 0.8% | 0.0% | 0.0% | 0.0% |
| No Intermediary | -9.3% | -9.8% | -10.8% | 11.0% | 3.4% | 8.2% |
| No Liberalization | -15.0% | -22.3% | -29.7% | -3.7% | -4.4% | -4.2% |

Numbers in the table represent the percentage change compared to the current scenario.

**Table 11:** Firm Response to Alternative Subsidy Plans

| | Indirect Exporter | | | Direct Exporter | | | Both Types | | |
|---|---|---|---|---|---|---|---|---|---|
| Rates | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) |
| Export Revenue Subsidy | | | | | | | | | |
| 5% | 0.5% | 0.9% | 1.222 | 0.9% | 4.9% | 1.128 | 1.3% | 5.7% | 1.124 |
| 10% | 1.0% | 1.6% | 0.643 | 2.0% | 9.8% | 1.112 | 2.9% | 11.4% | 1.126 |
| Fixed Cost Subsidy | | | | | | | | | |
| 25% | 5.0% | 1.3% | 1.698 | 12.8% | 4.2% | 0.604 | 17.3% | 5.4% | 0.697 |
| 50% | 14.3% | 3.2% | 1.378 | 38.1% | 9.5% | 0.496 | 49.6% | 11.5% | 0.550 |
| Sunk Cost Subsidy | | | | | | | | | |
| 25% | 4.6% | 1.9% | 2.216 | 5.1% | 2.0% | 0.800 | 9.6% | 3.9% | 1.167 |
| 50% | 11.2% | 4.1% | 1.556 | 13.3% | 5.7% | 0.706 | 23.9% | 9.1% | 0.924 |

(1) Percentage change in export participation rate compared to no subsidies.
(2) Percentage change in export revenue compared to no subsidies.
(3) Ratio of the gain in export revenue to the total subsidy costs.

For Online Publication

# Appendix

This appendix provides supplemental information on the restrictions on direct trading rights in China, the data sets used in this paper and robustness checks for the model.

## A Restriction on Direct Trading Rights

China began to open up its economy in the late 1970s. Before a series of trade policy reforms, Chinese trade was dominated by a few Foreign Trade Corporations (FTC) with monopoly trading rights. By the end of 1978, there were less than 20 such FTCs and around 100 subsidiaries of these FTCs controlled by the central government. The Foreign Trade Law adopted in 1994 formalized the so called "approval system" of foreign trade rights. Restrictions on direct trading rights applied only to domestically-owned firms while foreign-invested firms automatically had direct trading rights. In 1998, the State Council approved the issuing of direct trading rights to private domestic entities whose registered capital, sales, net assets, and exports exceeded certain threshold levels.[46] The thresholds were reduced and the restrictions eliminated over the period 2000 to 2004 as part of the accession agreement for joining the WTO. The details of the rules governing the ability to trade directly in the period 1999-2004 are laid out in Table A.1 below. Before 2001, private domestic firms faced multiple threshold requirements as explained above, but after 2001, they only needed to qualify in terms of their registered capital. Until

[46] Registered capital is also known as the authorized capital. It is the maximum value of securities that a company can legally issue. This number is specified in the memorandum of association (or articles of incorporation in the US) when a company is incorporated. It is also called authorized stock, nominal capital, nominal share capital. Registered capital may be divided into (1) issued capital: par value of the shares actually issued; (2) paid up capital: money received from the shareholders in exchange for shares; (3) uncalled capital: money remaining unpaid by the shareholders for the shares they have bought. By law, in China, a firm's paid up capital should be equal to its registered capital.

2001, they needed to formally apply for approval while after 2001, approval was automatically given.

Before 2001, State or Public-owned enterprises and firms in Special Economic Zones faced thresholds only on registered capital. In 2001, the requirements were made homogeneous across all types of firms, other than those in SEZs, whose requirements were less restrictive. In the middle of 2001 and then again later on, this common threshold for registered capital was lowered. By July 2004, the Chinese government removed all restrictions on direct trading rights.

Firms in Pudong were only treated differently from other firms (of the same type) in that the registered capital requirement was reduced for them in 2002, a year and a half before it was reduced for other firms.

# B Data Matching

This section provides detailed information on the quality of the match between the firm-level survey data and the transaction-level customs data used in this paper. The difficulty of matching these two data sets lies in the fact that the firm identification codes used in the two data sets are completely different. Thus we matched the data on the basis of firm name, region code, address, legal representative, and other information that identifies the firm. Firms were matched in multiple dimensions and a score was assigned which increased with the dimensions in which the records matched. All matches above a cutoff score were accepted. Below the cutoff, each case was manually examined.

Table A.2 and Table A.3 provide information on the percentage of the total number of exporters and total value of exports matched based on the customs data. In each of these two tables, the first horizontal panel shows the number of exporters or the value of exports accounted for by intermediaries. Below this is their share of the total. As in Ahn et al. (2011), we identify intermediaries in the customs data based on their names. For example, in 2004, intermediaries account for 18.1 percent of the total number of exporters. This means that in 2004, 81.9 percent of the total exporters are producing exporters, matched, unmatched, and unsurveyed.

The second horizontal panel of these two tables shows the number of exporters

or the value of exports that have been matched. Below this is their share in the total. From the second panel of A.2, we can see that 46.8 percent of the total number of exporters observed in the customs data are matched with the firm-level data in 2004.

The third horizontal panel then shows the share of exporters that are unmatched or unsurveyed or the exports that are accounted for by these exporters. Below this is their share in the total. We can see that we have matched about 50 percent of the data in terms of the number of producing exporters and about 80 percent in terms of export values that belong to these producing exporters.

We can better understand the third panel by looking at the Census data. Based on the Census data from 2004, 39 percent of the producers who export are below the Census threshold and account for 2 percent of the total export value.

# C Inferred Export Modes

This section examines the robustness of our definition of indirect and direct exporters by comparing the ever matched and never matched indirect exporters. Ever matched indirect exporters are the inferred indirect exporters who have been matched at least once with the customs data. Once these exporters are matched, we know their identification number in the customs data and are able to track their export modes over time. They are the ones who we can see switching between indirect and direct export modes. Never matched indirect exporters are the ones who could be wrongly labeled as indirect exporters, just because they are not matched with the customs data in any sample year. Could these never matched indirect exporters actually be *unmatched* direct exporters? This is what we want to check.

We estimate the predicted probability of each firm-time observation being (observed as) a direct exporter using a probit model.

$$e_{it} = \mathbf{1}\left[\beta e_{it-1} + \eta D_{omt} + X_{it}\phi + \nu_{it} > 0\right]$$

$e_{it}$ equals one if exporter $i$ is directly exporting (or being matched with the customs data) at time $t$. $D_{omt}$ is a set of ownership, industry and time dummies and $X_{it}$ in-

cludes other firm-time level covariates such as log capital, log employee, eligibility of direct trading rights, log revenue, previous export modes, etc. Figure A.1 compares the distribution of the predicted probability of being a direct exporter for firms we classify as direct exporters, ever matched indirect exporters, never matched indirect exporters and non-exporters.

From these histograms we can see that the distribution of the never matched looks like it lies between that of non-exporters and ever matched indirect exporters, which makes them closer to indirect exporters than to direct exporters. This gives us some confidence that we are not mis-classifying firms. We further examine the robustness of our model to alternative definitions of export modes in the next section.

# D Robustness Checks

In this section, we re-estimate the first stage of our model with alternative definitions of export modes. For example, we treat processing and producer intermediaries as alternative modes. These are dropped in our baseline estimation. We also allow for differences in the evolution of productivity according to product exported and the destination of exports. We also control for other firm decisions, like importing intermediates and doing R&D that may affect productivity.

## D.1 Definition of Export Modes

In Table A.4, we report the estimates of productivity evolution based on five variations. The baseline estimation is given in the first column. The second column shows the estimates reclassifying which firms are direct versus indirect exporters. An issue that could arise is that delays in the customs could make us wrongly classify firms. For example, a firm exporting at the end of a calendar year could report positive exports though its shipments only show up in the following year. Such firms would be wrongly classified as indirect exporters though they are really direct ones. To deal with this we redefine firms that report positive exports in year $t$ who do not show up in the customs data and have records of exporting in the customs

data during the first two months in year $t+1$ as direct exporters in $t$.[47] Column 2 in Table A.4 shows that this reclassification does not change the estimates of the productivity evolution.

The third column shows the results when we include "producer intermediaries" as a separate type of export mode. "Producer intermediaries" are firms that do not report exports in the survey data and show up in the customs data. They comprise about 4 percent of the observations in the survey data. As we can see from column 3, producer intermediaries have a slightly better productivity evolution than do direct exporters. We also do the same exercise for processing firms and report the results in column 4. Processing firms are somewhere in between indirect and direct exporters in their productivity evolution. Also note that the coefficients on direct and indirect exporters are pretty stable across all the first four columns.

The fifth column shows the estimates when we use the ratio of direct exports to all exports (i.e., the exports in the customs data relative to the survey data) as a continuous measure of export mode instead of the dummy variables we used originally. The positive and significant coefficient on this variable confirms our results that the more the firm exports directly, the larger are the learning-by-exporting effects.

In the last column, we show the estimates on productivity evolution when we differentiate direct exporters who export to Hong Kong and those who do not. Since Hong Kong often acts like an intermediary for Chinese exports, it is possible for us to mis-classify indirect exporters who exports to a Hong Kong intermediary as direct exporters. We can see that the coefficient on direct exporters exporting to Hong Kong is not significant. In fact, our baseline patterns still hold even if we classify all direct exporters who export to Hong Kong as indirect exporters.

## D.2 Other Dimensions and Firm Activities

Firms may also differ in other dimensions in their exporting behavior. Could this be what lies behind our results? For example, direct exporters tend to sell to easier (i.e., rich and close) markets. If sales grow faster in such markets, we could be spuriously obtaining our results. Direct exporters are differentiated by their exports

[47] Other possible cases of such types of mis-identifications are also checked and not discussed here.

to rich markets, and the goods they export. Firms that export more than 50 percent to rich and close countries are seen as selling to rich destinations. Goods that are handled primarily ($> 50\%$) by intermediaries are called intermediated products. Columns 2 and 3 in Table A.5 show that direct exporters who sell intermediated products or sell to easier markets have the same productivity evolution as others. Column 4 shows the estimates when we control for the propensity for a shipment to be sold by an intermediary, aggregated to the firm level. We find no significant change in the patterns of the coefficients of interest. Thus, though direct exporters do sell different products and to different countries than do indirect ones, this is not what lies behind their difference in productivity growth.

In Table A.6 we examine the effects of other controls on productivity evolution. Firms can be actively increasing their registered capital to obtain direct trading rights and in turn affecting their productivity. Column 2 shows the estimates when we drop firms who are ineligible to export directly from the data. Columns 3 and 4 add controls for firms in investing in R&D or importing.[48] We see that R&D has positive effects on the evolution of productivity as in Aw et al. (2011). The smaller effects of learning-by-exporting are possibly due to the short time series of the data. Nonetheless, we still find that direct exporters experience better learning-by-exporting effects on productivity. Being an importer is not significant in the evolution of productivity. Column 5 controls for the propensity of being a direct exporter in the previous period. This is also irrelevant. Note also that the learning-by-exporting patterns we see in the baseline estimation are robust throughout.

## D.3 Other Productivity Measures

All previous robustness checks are based on the model assumptions that consumers have CES preferences while firms compete monopolistically and produces at constant marginal cost. We also used time dummies and log capital stock to capture time-varying and firm-time varying cost shifters. These productivity measures are identified within the model from firms' domestic revenue function. Table A.7 shows the productivity evolution using alternative productivity measures. Column 1 shows

[48] Column 3 uses a shorter panel of data given the unavailability of R&D information in the earlier years of the data set.

the estimates from the benchmark model. In column 2, we allow the marginal cost of production to be dependent on firm ownership and province-level locations. In column 3, we add log wage rate to the benchmark model to capture the firm-time level cost shifters. In columns 4 and 5, we show the estimates of productivity evolution where the productivity is estimated from a Cobb-Douglas production *á la* De Loecker (2013). Specifically, we use total revenue and value-added as measures of total output respectively. Note that direct exporters productivity evolution is always more favorable than that of indirect exporters who tend to have productivity evolve more favorably than non-exporters.

**Table A.1:** Policy and Changes 1999-2004

| Time | 1999 - 2000 | 1/2001 - 6/2001 | 7/2001 - 12/2001 | 1/2002 - 8/2003 | 9/2003 - 6/2004 |
|---|---|---|---|---|---|
| SEZ | •Reg.K $\geq$ 2M<br>•Register | •Reg.K $\geq$ 2M<br>•Register | •Reg.K $\geq$2M<br>Reg.K $\geq$1M if M&E<br>•Register | •Reg.K $\geq$2M<br>Reg.K $\geq$1M if M&E<br>•Register | •Reg.K $\geq$0.5M<br>•Register |
| Pudong New Area | No difference from the rest of China | No difference from the rest of China | No difference from the rest of China | •Reg.K$\geq$0.5M<br>•Register | •Reg.K $\geq$0.5M<br>•Register |
| State or Public Owned Domestic Firm | •Reg.K $\geq$5M<br>Reg.K $\geq$3M if MW<br>Reg.K $\geq$2M if M&E<br>Reg.K $\geq$2M if Inst.<br>•Register | •Reg.K $\geq$5M<br>Reg.K $\geq$3M if MW<br>Reg.K $\geq$2M if M&E<br>Reg.K $\geq$2M if Inst.<br>•Register | •Reg.K $\geq$3M<br>Reg.K $\geq$2M if MW<br>Reg.K $\geq$1M if M&E<br>Reg.K $\geq$1M if Inst.<br>•Register | •Reg.K $\geq$3M<br>Reg.K $\geq$2M if MW<br>Reg.K $\geq$1M if M&E<br>Reg.K $\geq$1M if Inst.<br>•Register | •Reg.K $\geq$0.5M<br>•Register |
| Private Owned Domestic Firm | •Reg.K $\geq$8.5M<br>Net Assets $\geq$8.5M<br>Sales $\geq$50M for 2 yrs<br>Export$\geq$1M USD<br>Sales$\geq$30M if M&E<br>•Apply for Approval | •Reg.K $\geq$5M<br>Reg.K $\geq$3M if MW<br>Reg.K $\geq$2M if M&E<br>Reg.K $\geq$2M if Inst.<br>•Apply for Approval | •Reg.K $\geq$3M<br>Reg.K $\geq$2M if MW<br>Reg.K $\geq$1M if M&E<br>Reg.K $\geq$1M if Inst.<br>• Register | •Reg.K $\geq$3M<br>Reg.K $\geq$2M if MW<br>Reg.K $\geq$1M if M&E<br>Reg.K $\geq$1M if Inst.<br>• Register | •Reg.K $\geq$0.5M<br>•Register |

Source: Ministry of Commerce of China;

M: Million Chinese Yuan; SEZ: Special Economic Zones; Reg. K: Registered Capital; M&E: Mechanical and Electrical products; MW: Midwest; Inst.: Research Institution;

**Table A.2:** Data Match: Number of Exporters

| Match Status | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Total |
|---|---|---|---|---|---|---|---|---|---|
| (1) | Number | 8,116 | 8,931 | 10,657 | 14,520 | 21,813 | 29,367 | 41,543 | 134,947 |
| | Percentage | 12.9 | 13.0 | 13.6 | 15.2 | 18.1 | 20.5 | 24.3 | 18.2 |
| (2) | Number | 23,708 | 27,704 | 32,383 | 38,425 | 56,313 | 58,537 | 63,209 | 300,279 |
| | Percentage | 37.8 | 40.5 | 41.2 | 40.2 | 46.8 | 40.8 | 37.0 | 40.6 |
| (3) | Number | 30,900 | 31,824 | 35,531 | 42,685 | 42,239 | 55,682 | 65,941 | 304,802 |
| | Percentage | 49.3 | 46.5 | 45.2 | 44.6 | 35.1 | 38.8 | 38.6 | 41.2 |
| Total | Number | 62,724 | 68,459 | 78,571 | 95,630 | 120,365 | 143,586 | 170,693 | 740,028 |

Source: Chinese Customs 2000-2006.
Match status: (1) Intermediaries; (2) Matched producers; (3) Unsurveyed and unmatched producers.

**Table A.3:** Data Match: Value of Exports

| Match Status | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Total |
|---|---|---|---|---|---|---|---|---|---|
| (1) | Value | 87.8 | 86.9 | 98.8 | 121.2 | 151.5 | 183.4 | 229.8 | 959.2 |
| | Percentage | 35.3 | 32.6 | 30.4 | 27.7 | 25.6 | 24.1 | 23.8 | 26.7 |
| (2) | Value | 111.6 | 130.9 | 168.5 | 243.5 | 372.9 | 469.7 | 589.4 | 2086.4 |
| | Percentage | 44.9 | 49.1 | 51.8 | 55.7 | 62.9 | 61.8 | 61.0 | 58.0 |
| (3) | Value | 49.4 | 48.7 | 57.7 | 72.8 | 68.1 | 107.0 | 147.3 | 551.1 |
| | Percentage | 19.9 | 18.3 | 17.8 | 16.6 | 11.5 | 14.1 | 15.2 | 15.3 |
| Total | Value | 248.8 | 266.5 | 325.0 | 437.5 | 592.5 | 760.1 | 966.5 | 3596.7 |

Source: Chinese Customs 2000-2006. Values in Billion US dollars.
Match status: (1) Intermediaries; (2) Matched producers; (3) Unsurveyed and unmatched producers.

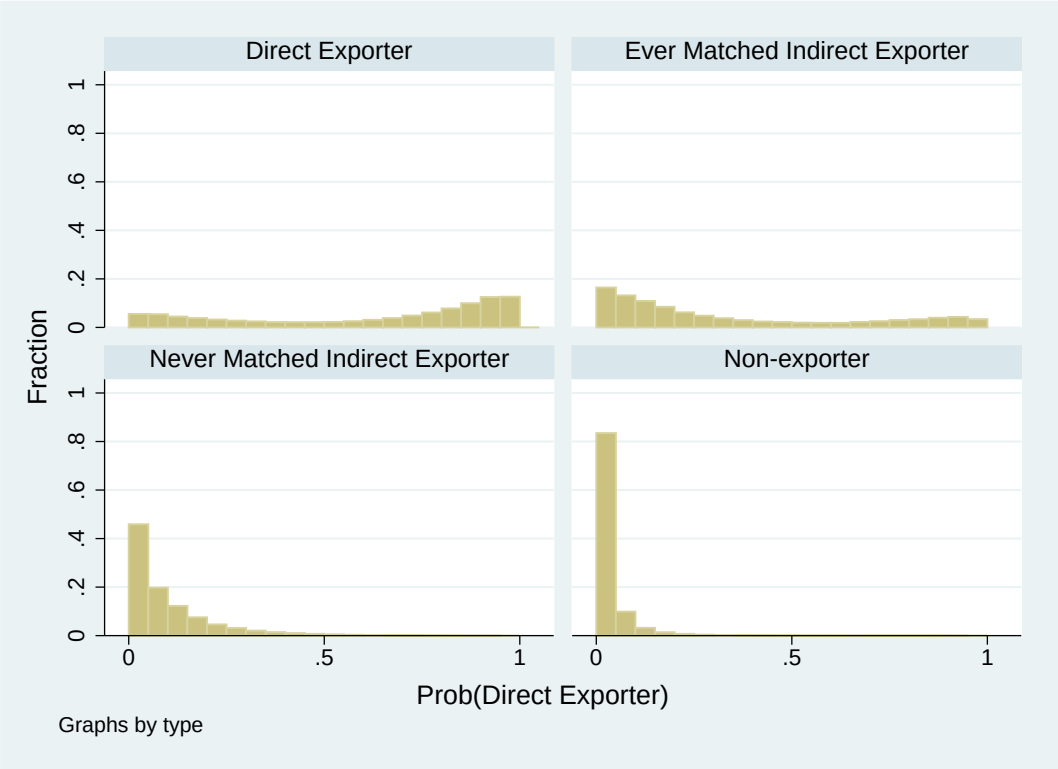


**Figure A.1.** Matched and Never Matched Indirect Exporters

**Table A.4:** Productivity Evolution: Alternative Definitions of Export Modes

| | | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|---|
| | | Benchmark | Customs Delay | Intermediary | Processing | DE Ratio | HKG |
| Constant | $\alpha_0$ | 0.637*** | 0.638*** | 0.591*** | 0.771*** | 0.573*** | 0.637*** |
| | | (0.036) | (0.036) | (0.029) | (0.046) | (0.048) | (0.036) |
| $\omega_{t-1}$ | $\alpha_1$ | 0.194*** | 0.191*** | 0.197*** | 0.108 | 0.203** | 0.194*** |
| | | (0.071) | (0.071) | (0.060) | (0.083) | (0.090) | (0.071) |
| $\omega^2_{t-1}$ | $\alpha_2$ | 0.309*** | 0.310*** | 0.334*** | 0.313*** | 0.356*** | 0.308*** |
| | | (0.046) | (0.046) | (0.042) | (0.049) | (0.056) | (0.046) |
| $\omega^3_{t-1}$ | $\alpha_3$ | -0.034*** | -0.035*** | -0.042*** | -0.032*** | -0.051*** | -0.034*** |
| | | (0.010) | (0.010) | (0.009) | (0.009) | (0.011) | (0.010) |
| Indirect Export$_{t-1}$ | $\alpha_4$ | 0.005** | 0.005** | 0.006*** | 0.006*** | | 0.005** |
| | | (0.002) | (0.002) | (0.002) | (0.002) | | (0.002) |
| Direct Export$_{t-1}$ | $\alpha_5$ | 0.023*** | 0.022*** | 0.021*** | 0.022*** | | 0.022*** |
| | | (0.002) | (0.002) | (0.002) | (0.002) | | (0.002) |
| Intermediary$_{t-1}$ | | | | 0.031*** | | | |
| | | | | (0.003) | | | |
| Processing$_{t-1}$ | | | | | 0.016*** | | |
| | | | | | (0.003) | | |
| DE Ratio$_{t-1}$ | | | | | | 0.029*** | |
| | | | | | | (0.004) | |
| Hong Kong*DE$_{t-1}$ | | | | | | | 0.002 |
| | | | | | | | (0.007) |

***,** and * indicate significance at the 1%, 5% and 10% level, respectively.

**Table A.5:** Productivity Evolution: Products and Destinations of Direct Exporting

| | | (1) | (2) | (3) | (4) |
|---|---|---|---|---|---|
| | | Benchmark | HS4 Product | GDP p/c | Prob($IE_{t-1}$) |
| Constant | $\alpha_0$ | 0.637*** | 0.637*** | 0.574*** | 0.637*** |
| | | (0.036) | (0.036) | (0.048) | (0.036) |
| $\omega_{t-1}$ | $\alpha_1$ | 0.194*** | 0.193*** | 0.201** | 0.194*** |
| | | (0.071) | (0.071) | (0.090) | (0.071) |
| $\omega^2_{t-1}$ | $\alpha_2$ | 0.309*** | 0.310*** | 0.358*** | 0.309*** |
| | | (0.046) | (0.046) | (0.056) | (0.046) |
| $\omega^3_{t-1}$ | $\alpha_3$ | -0.034*** | -0.035*** | -0.052*** | -0.034*** |
| | | (0.010) | (0.010) | (0.011) | (0.010) |
| Indirect $Export_{t-1}$ | $\alpha_4$ | 0.005** | 0.005** | 0.007*** | 0.005** |
| | | (0.002) | (0.002) | (0.002) | (0.002) |
| Direct $Export_{t-1}$ | $\alpha_5$ | 0.023*** | 0.024*** | 0.019*** | 0.023*** |
| | | (0.002) | (0.002) | (0.004) | (0.002) |
| Intermediated Product*$DE_{t-1}$ | | | -0.004 | | |
| | | | (0.004) | | |
| Rich Destination*$DE_{t-1}$ | | | | -0.001 | |
| | | | | (0.005) | |
| Prob($IE_{t-1}$)*$DE_{t-1}$ | | | | | -0.000 |
| | | | | | (0.007) |

***,** and * indicate significance at the 1%, 5% and 10% level, respectively.

**Table A.6:** Productivity Evolution: Potential Unobserved Heterogeneity

| | | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|---|
| | | Benchmark | Eligible Firms | R&D | Import | Prob($DE_{t-1}$) |
| Constant | $\alpha_0$ | 0.637*** | 0.796*** | 0.805*** | 0.573*** | 0.796*** |
| | | (0.036) | (0.056) | (0.061) | (0.048) | (0.056) |
| $\boldsymbol{\omega}_{t-1}$ | $\alpha_1$ | 0.194*** | -0.158 | 0.040 | 0.203** | -0.157 |
| | | (0.071) | (0.102) | (0.097) | (0.090) | (0.102) |
| $\boldsymbol{\omega}^2_{t-1}$ | $\alpha_2$ | 0.309*** | 0.547*** | 0.377*** | 0.357*** | 0.547*** |
| | | (0.046) | (0.062) | (0.051) | (0.056) | (0.062) |
| $\boldsymbol{\omega}^3_{t-1}$ | $\alpha_3$ | -0.034*** | -0.084*** | -0.048*** | -0.052*** | -0.084*** |
| | | (0.010) | (0.012) | (0.009) | (0.011) | (0.012) |
| Indirect $Export_{t-1}$ | $\alpha_4$ | 0.005** | 0.005** | 0.004 | 0.007*** | 0.005* |
| | | (0.002) | (0.002) | (0.003) | (0.002) | (0.002) |
| Direct $Export_{t-1}$ | $\alpha_5$ | 0.023*** | 0.017*** | 0.010*** | 0.017*** | 0.016*** |
| | | (0.002) | (0.002) | (0.002) | (0.003) | (0.005) |
| $R\&D_{t-1}$ | | | | 0.007*** | | |
| | | | | (0.004) | | |
| $R\&D_{t-1}$*$IE_{t-1}$ | | | | -0.008 | | |
| | | | | (0.011) | | |
| $R\&D_{t-1}$*$DE_{t-1}$ | | | | 0.003 | | |
| | | | | (0.007) | | |
| $Import_{t-1}$ | | | | | 0.003 | |
| | | | | | (0.004) | |
| $Import_{t-1}$*$IE_{t-1}$ | | | | | -0.001 | |
| | | | | | (0.012) | |
| $Import_{t-1}$*$DE_{t-1}$ | | | | | 0.000 | |
| | | | | | (0.006) | |
| Prob($DE_{t-1}$) | | | | | | 0.001 |
| | | | | | | (0.006) |

***,** and * indicate significance at the 1%, 5% and 10% level, respectively.

**Table A.7:** Productivity Evolution: Alternative Productivity Measures

| | | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|---|
| | | Benchmark | Ownership & Province | Wage Rate | Total Revenue | Value-Added |
| Constant | $\alpha_0$ | 0.637*** | 0.830*** | 0.596*** | -2.626*** | 0.259*** |
| | | (0.036) | (0.069) | (0.033) | (0.033) | (0.008) |
| $\boldsymbol{\omega}_{t-1}$ | $\alpha_1$ | 0.194*** | 0.145 | 0.169** | -0.124*** | 0.736*** |
| | | (0.071) | (0.111) | (0.067) | (0.036) | (0.008) |
| $\boldsymbol{\omega}^2_{t-1}$ | $\alpha_2$ | 0.309*** | 0.264*** | 0.318*** | 0.134*** | 0.069*** |
| | | (0.046) | (0.059) | (0.044) | (0.024) | (0.005) |
| $\boldsymbol{\omega}^3_{t-1}$ | $\alpha_3$ | -0.034*** | -0.023** | -0.038*** | 0.072*** | -0.005*** |
| | | (0.010) | (0.010) | (0.009) | (0.004) | (0.001) |
| Indirect Export$_{t-1}$ | $\alpha_4$ | 0.005** | 0.002 | 0.001 | 0.000 | 0.018** |
| | | (0.002) | (0.002) | (0.002) | (0.001) | (0.007) |
| Direct Export$_{t-1}$ | $\alpha_5$ | 0.023*** | 0.016*** | 0.013*** | 0.005*** | 0.074*** |
| | | (0.002) | (0.002) | (0.002) | (0.001) | (0.007) |

***,** and * indicate significance at the 1%, 5% and 10% level, respectively.