

How You Export Matters: Export Mode, Learning and Productivity in China

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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 26 and 33 percent lower respectively.

Keywords. Export modes, Productivity evolution, Learning-by-exporting, Dynamic discrete choice

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. However it neglects the dynamic trade-offs that might exist if there were different learning-by-exporting effects for direct versus indirect exporters.

Learning-by-exporting refers to the mechanism whereby firms improve their performance (on the productivity and/or demand side) after entering export markets. Case study evidence points to the importance of learning about cost-cutting technologies and profit-boosting product designs through buyer-seller relationships. Egan and Mody (1992) give some examples of how direct engagement with buyers enhances learning. They say “*importers are also more likely to employ designers, engineers, and marketing experts who can provide technical assistance to suppliers*” and point to Schwinn, a well known brand in the US bicycle market, which provided technical assistance to its Chinese supplier to help it access the US market (see page 324). Regarding the footwear industry, they say that “*Buyers may assist sellers...by providing marketing information as to what products are selling in a particular season and product specifications*” (see page 328). Since firms who export through intermediaries usually do not engage in direct contact with their foreign buyers and do not maintain employees in foreign markets, the pass-through of knowledge may be less effective than that of direct exporters. Hence, firms who export directly 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.

In theory, learning effects could be bigger for indirect exporters than for direct ones: for example, it could be that indirect exporters acquire the cumulative knowledge of the intermediaries they are using. This may be particularly relevant in terms

of learning to deal with customs procedures and learning the ins and outs of how to get things done in settings where procedures are less transparent. Also, intermediaries like Costco and Walmart may also provide significant input into what sorts of products to produce. These large intermediaries have vast experience about what sells and often conduct a lot of market research that others could not. Thus, the question is an empirical one and one of the contributions of the paper is to see what seems to hold in the data, at least for China.

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.¹ Before 2004, a large share of domestically owned Chinese firms were not allowed to trade directly,² but these restrictions were relaxed as part of joining the WTO. Prior to the reform, they had to export only through intermediaries unless their registered capital was quite large.³ If direct exporters learn more than indirect ones, then limiting the ability to export directly could have had significant adverse effects. We use this reform as a natural experiment and 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 26 percent lower and

¹For 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.

²These restrictions were part and parcel of China's being a planned economy. 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 China's accession to the WTO.

³Registered 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.

the export participation rate would have been 33 percent lower had there been no liberalization of trading rights.

This paper is most closely related to the literature on firm export decisions and learning by exporting. The work of Dixit (1989a,b) and Baldwin and Krugman (1989), among others, drew attention to the hysteresis created by the sunk costs of entering the export market. Das, Roberts and Tybout (2007) develop a dynamic structural model of export decisions, which embodies uncertainty, firm heterogeneity in export profits, and sunk entry costs. They quantify the sunk entry costs and obtain estimated sunk costs in Colombian industries that are large.

Most studies find little or no evidence of improved productivity as a result of beginning to export. Clerides, Lach and Tybout (1998) studied export participation and the effect of exporting on learning, and find no evidence of learning-by-exporting using Colombian data. Bernard and Jensen (1999) find evidence among U.S. firms that the more productive firms select into exporting rather than exporting raising productivity. However, recent research finds some evidence of productivity improvement after entry. Van Biesebroeck (2005) and De Loecker (2007) find evidence that exporting firms have an advantage in productivity growth after entry into the export market among Saharan African and Slovenian firms. Aw, Roberts and Xu (2011) estimate a dynamic structural model of producers' decision rules for R&D investment and exporting, allowing for an endogenous productivity evolution path. They quantify the linkages between the export decision, R&D investment and endogenous productivity growth. They find that firms that select into exporting and/or R&D investments tend to already be more productive than their domestic counterparts, and the decisions to export and/or to invest in R&D raise exporters' productivity levels further in turn. This paper builds on their work.

Our work is also related to a recent literature on intermediation which has become a topic of growing interest. There is substantial evidence suggesting that intermediaries facilitate international trade. About 80 percent of Japanese exports and imports in the early 1980s were handled by 300 trade intermediaries (Rossman, 1984). In 2005, roughly half of exporting firms in Sweden were wholesalers (Akerman, 2010). U.S. wholesalers and retailers account for approximately 11 and 24 percent of exports and imports, respectively (Bernard, Jensen, Redding and Schott,

2007). In China, at least 35 percent of exports in 2000 and 22 percent in 2005 went through intermediaries (Ahn, Khandelwal and Wei, 2011). In some countries, like Columbia, there are few intermediaries or middlemen, and concern has been expressed that this has discouraged potential exporters and suppressed exports (Roberts and Tybout, 1997).

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 (Rubinstein and Wolinsky, 1987; Biglaiser, 1993). Feenstra and Hanson (2004) find evidence of intermediaries' role in quality control in the context of China's re-exports through Hong Kong between 1988 and 1993. More recent work has either focused on the network and matching process between buyers and sellers (Antràs and Costinot, 2011; Blum, Claro and Horstmann, 2009, 2010) or has extended the model of Melitz (2003) and modeled intermediation as involving lower fixed costs than exporting directly, but lower variable profits as the intermediary takes his cut (Ahn et al., 2011; Akerman, 2010). An insight that emerges is sorting in the cross-sectional distribution of firms across the modes of exporting: the most productive firms choose to export directly, less productive firms export through intermediaries, and the least productive firms sell only to the domestic market. (Blum et al., 2009, 2010) show that the data is consistent with a model of heterogeneous importers and exporters and that most importer exporter pairs involve at least one large firm, which is often an intermediary, and this is particularly so in smaller markets. Thus, they argue, intermediaries play a critical role in allowing niche products to penetrate smaller markets.

We build on Ahn et al. (2011) who use a standard static heterogeneous firm setting with costs of exporting that vary by mode. They show that for China, firms sort into export modes based on productivity; that exports by intermediaries are more expensive; and that countries that are harder to access (higher trade costs or smaller market sizes) have relatively more intermediated trade.⁴ We extend their

⁴In contrast, Akerman (2010) models wholesalers as having economies of scope as they can spread the fixed cost of exporting over more than one good. In order to cover their fixed cost, wholesalers charge a markup over the manufacturer's price resulting in higher prices and lower revenue abroad than direct exporters. The economies of scope in fixed costs and the markup over domestic price cause productivity sorting among producers as regards export mode. Using Swedish

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. Our focus is not on modeling the intermediation process. We treat it as just one technology of exporting with associated costs.

It is worth noting that much of this work looks for correlations between variables as predicted by theory, i.e., does reduced form analysis rather than structural estimation. In contrast, we estimate a dynamic discrete choice model of firms choosing export modes. This allows us to estimate the structural parameters of interest (like fixed and sunk costs of different modes of exporting and the process of productivity and demand shock evolution) rather than just verify that the patterns in the data are consistent with their existence. It also allows us to do counterfactual exercises.

A tangential but related literature in trade looks at the effects of other policy reforms. One strand looks at the effect of lower export tariffs. It is well understood that China already had de facto MFN treatment for its exports to most countries by the time it joined the WTO. Joining the WTO just made it more certain. For example, China obtained MFN status in 1980 from the US and never lost it after that. Even adverse events like Tiananmen square and the Rare Earths controversy did not result in MFN status being revoked, though it may well have come close. Losing MFN status could have been significant as the alternative tariff could have been much higher. Handley and Limão (2013) make the point that “in 2000 for example, the average U.S. MFN tariff was 4% but if China had lost its MFN status it would have faced an average tariff of 35% with about one fifth of product tariff lines going up to at least 50%.” They show that, consistent with this idea, products where the difference in the alternative tariff and the MFN tariff was high also tended to grow the most after China joined the WTO. Using data on Chinese exports by industry at the HS 6 level, along with a model that captures how such uncertainty might operate to reduce the willingness to invest by firms, they argue that 22-30 percent of the growth in exports after China joined the WTO could be due to this one feature. Pierce and Schott (2012) use US Census data to show that the plants in industries where trade policy uncertainty declined more, had greater employment

cross-sectional data, he finds evidence to support the main prediction of his model that wholesalers export less per firm within a product category than do producers.

losses, especially of low skilled workers, as these plants substituted towards human and physical capital. They also show using firm level US trade data that products with higher gaps in the alternative and MFN tariffs exhibit larger increases in import value from China relative to all other U.S. trading partners. Their firm level evidence confirms the chilling effect of uncertainty.⁵

Another branch of the literature looks at the effect on productivity of greater access to intermediate inputs. China did drop its import tariffs quite significantly as part of joining the WTO and this may have also had positive consequences. Access to a greater variety of intermediate inputs could affect productivity as in Ethier (1979, 1982), where greater variety reduces unit costs of production. Recent work suggests that a reduction in tariffs on intermediate goods can raise domestic productivity and expand product scope and exports by allowing firms access to high quality inputs essential for exporting. See Goldberg, Khandelwal, Pavcnik and Topalova (2010) who show that this seems to be the case for India, and Amiti and Konings (2007) for similar results for Indonesia, and Feng, Li and Swenson (2016) for China. The latter also show that a fall in tariffs on final goods raises productivity but by half as much. Kasahara and Lapham (2013) use a dynamic structural model to argue that taxing imports destroys exports because policies that inhibit the import of foreign intermediate inputs also have a large adverse effect on the export of final goods. Kasahara and Rodrigue (2008) estimate a dynamic model that incorporates the choice of using imported intermediates using plant-level Chilean manufacturing panel data and show that plant productivity improves by doing so. Zhang (2013), using Colombian plant-level data, performs a similar exercise and further decomposes the gains from importing into a static effect and a dynamic effect with the latter predominating. We contribute to this literature on the factors behind China's growth of exports by looking at a less well-understood, but important reform on which there is, to our knowledge, no formal work: namely the removal of restrictions on direct trading.

⁵They seem to argue that changes in the direct trading rules do *not* affect US employment. They show that US employment did not fall by more in industries where more firms were constrained by these rules in 1999. There are two problems with this: first they do not use information on the temporal variation in the rules and their impact on US employment, only on cross sectional variation. Second, the effect may have been limited if US products were not close substitutes for Chinese ones.

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 3 we lay out the basis for firms' dynamic decisions over modes of exporting. Section 4 describes the estimation method. Section 5 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 6. We conclude in the last section.

2 Data and Background

This analysis utilizes two Chinese data sets that we have 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 revenue 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.⁶

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 are also observed in the customs data set.⁷ 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 taken to be exporting both directly and indirectly and are tagged as direct exporters in

⁶Details of this matching are given in Table A.2 and Table A.3 in the Appendix.

⁷According to the survey documentation, export value includes direct exports, indirect exports, and all kinds of processing and assembling exports.

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.⁸ If we did a poor job matching the customs and survey data, then we would be at risk of classifying unmatched direct exporters as indirect ones. We perform a number of checks to convince the reader and ourselves that we are not doing this.⁹

Moreover, intermediaries can operate in China or outside China. For example, intermediaries in China could buy from Chinese producers and sell to foreign buyers. In this case, the producers would be labelled as indirect exporters in our paper. Alternatively, Chinese producers could sell to intermediaries outside China who serve as importing intermediaries in the destination country, as suggested by Blum et al. (2009, 2010). Here the intermediary abroad would buy directly from Chinese producers. In our paper such exporters would be labelled as direct exporters even though they are also working through intermediaries. This could bias our results.

However, if intermediaries in China operated in the same way as those operating abroad, this mis-classification would bias our estimates of productivity and demand shock evolution for direct exporters downward as we would be mis-classifying indirect exporters as direct ones, and work against finding direct exporters having a more favorable evolution of productivity and demand shocks. Of course, if intermediaries in China differed from those outside in terms of their learning effects, this could work against the results we find. Head, Jing and Swenson (2014) do examine the role of procurement centers set up by western multinationals. They find that current retailer presence is associated with enhanced city export capability. They take this as an indication that such procurement centers may serve the same role as intermediaries in the promotion of exports. Unfortunately, we do not have information on the importing country side, so we cannot directly test the learning effects from exporting via foreign intermediaries.

⁸The Ghana Manufacturing Enterprise Survey Dataset used by Ahn et al. (2011) does ask firms to identify themselves as direct or indirect exporters and has a panel, but this seems to be the only such example.

⁹The basic idea is to predict the probability of each firm at each time of being classified as a direct exporter. If our classification is accurate, this predicted probability should be higher for firms we do classify as direct exporters relative to other groups. This is exactly what we see. Details are provided in the Appendix.

In recent work, Bernard, Blanchard, Van Beveren and Vandebussche (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,¹⁰ sunk cost and learning opportunities could be very different for processing trade. For this reason we exclude processing firms from our main sample.¹¹

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.

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.

¹⁰See Feenstra and Hanson (2005) for details.

¹¹See the Appendix for robustness checks when including processing firms.

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).¹² 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 revenue and export revenue among different types of exporters. On average, direct exporters are larger in all these dimensions than indirect exporters who 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 revenue 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 revenue 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

¹²We 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.

randomly drawn in each period.¹³

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.¹⁴ 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 (96.2%) 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 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

¹³These 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.

¹⁴It 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.

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.¹⁵

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 ($d_{it}^m = \{0, 1\}$, $m=Home, Indirect, Direct$). 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 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.¹⁶ 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

¹⁵The Ghanaian data has similar patterns in terms of order, though persistence as a direct or indirect exporter is much lower. See Ahn et al. (2011)

¹⁶In 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.

indirectly must pay for the services provided by intermediaries.¹⁷ As a result, firms receive lower variable revenue from indirect exports than from direct exports.¹⁸

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 revenue are not perfectly correlated with export revenue 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 σ^H and σ^X , respectively, and where σ^H and σ^X exceed unity. The utility functions in the home and foreign markets are:

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

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

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

and

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

¹⁷Intermediary 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.

¹⁸Ahn 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.

where H denotes the home market and X the foreign market, i denotes the firm that provides variety i , and Ω^H (Ω^X) 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 (α) of their income on domestic goods and the remainder on imports. Substitution between domestic goods is parametrized by σ^H which differs from that between foreign goods parametrized by σ^X . We assume that the demand in the foreign market for each firm is also subject to a firm-specific demand shock z_{it} .¹⁹ Foreign utility is analogously defined. Demand for Chinese goods comes from home consumers who substitute between Chinese goods according to σ^H and from foreign consumers who substitute between them according to σ^X as Chinese goods are exports for them.

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

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

and

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

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 (Y_t^X). The firm-level demand from these two markets are:

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

and

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

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

¹⁹Note that the demand shocks 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 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 $q_{it}^{XI} = \left(\frac{p_{it}^{XI}}{P_t^X}\right)^{-\sigma^X} \frac{Y_t^X}{P_t^X} e^{z_{it}}$ 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 λp_{it}^I , $\lambda > 1$. Thus, they maximize

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

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 ²⁰

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

²⁰As $\lambda^{-\sigma^X}$ 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.

3.1.3 Supply Side

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

$$\ln mc_{it} = \ln(c(\mathbf{w}_{it})e^{-\omega_{it}}) = \beta_0 + \beta_k \ln k_{it} + \beta_t D_t + \beta_s D_s + \beta_l D_l - \omega_{it}. \quad (11)$$

Since we do not have data on firm-time specific factor prices, \mathbf{w}_{it} , these are proxied for by the time, industry and location dummies D_t , D_s , and D_l . D_t is a year dummy and D_s denotes the dummy at the 4-digit industry level. D_l is a dummy for location (inland v.s. coastal provinces).²¹

Firm-time specific productivity levels are given by ω_{it} . The capital stock, $\ln k_{it}$, can be thought of as a firm-level cost shifter as only factor prices enter the cost function.²² 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 $p_{it}^{XI} = \lambda \frac{\sigma^X}{\sigma^X - 1} mc_{it}$.

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

$$\ln r_{it}^H = a^H + \ln \Phi_t^H + (1 - \sigma^H) (\beta_0 + \beta_k k_{it} + \beta_t D_t + \beta_s D_s + \beta_l D_l - \omega_{it}) \quad (12)$$

$$\begin{aligned} \ln r_{it}^{Xm} &= a^X + \ln \Phi_t^X + (1 - \sigma^X) (\beta_0 + \beta_k k_{it} + \beta_t D_t + \beta_s D_s + \beta_l D_l - \omega_{it}) \\ &\quad + z_{it} - d_{it}^I \sigma^X \ln \lambda \end{aligned} \quad (13)$$

where $m = I, D$. The last term of equation (13) ($\sigma^X \ln \lambda$) is positive ($\lambda > 1$) when

²¹We could have included dummies at a more detailed level, for example, for provinces as the results were similar. However, they increase the state space and make second stage estimation much more complicated.

²²We 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.

the firm is indirectly exporting ($d_{it}^I = 1$). Firms' revenues in each market depend on the aggregate market conditions²³ (captured by Φ_t^H and Φ_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:

$$\pi_{it}^H = \frac{1}{\sigma^H} r_{it}^H (\Phi_t^H, \mathbf{w}_{it}, \omega_{it}), \quad (14)$$

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

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

and

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

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 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. In interpreting the demand and productivity shocks, it is important to realize that we call all shocks that affect both the domestic and foreign revenue as productivity shocks because in our model, productivity shocks affect costs and impact both domestic and foreign revenues. Shocks that operate in the foreign market alone are called demand shocks. We also assume these shocks are independent. To the extent that foreign and domestic demand shocks are positively correlated, we would be picking up part of the demand shocks in what we call productivity shocks.

²³Market conditions could vary by period. However, in the estimation we assume that they are fixed at the average level.

3.2 Transition of State Variables

In each period, firms observe their current productivity, foreign market demand shocks, and previous period mode of exporting²⁴ before they make their decisions. This section describes the transitions of these state variables. We assume productivity ω_{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.

$$\begin{aligned}\omega_{it} &= g(\omega_{it-1}, d_{it-1}) + \xi_{it} \\ &= \alpha_0 + \sum_{k=1}^3 \alpha_k (\omega_{it-1})^k + \alpha_4 d_{it-1}^I + \alpha_5 d_{it-1}^D + \xi_{it}\end{aligned}\quad (17)$$

where $d_{it-1}^m = \{0, 1\}$, $m = I, D$, 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.²⁵ Note that if firms expect their productivity to grow quickly with direct exporting, they may choose to export directly even though it is not profitable in the static sense.²⁶ ξ_{it} is an i.i.d. shock with mean 0 and variance σ_ξ^2 that captures the stochastic nature of the evolution of productivity. ξ_{it} is assumed to be un-correlated with ω_{it-1} and d_{it-1} . It is also well known that more-productive 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

²⁴The 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.

²⁵De 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.

²⁶Of course, if firms differ not just in their productivity, but also in terms of the growth of productivity, there could still be bias. We check for this later on in Section 5.5.

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.

$$z_{it} = \psi_1 d_{it-1}^I + \psi_2 d_{it-1}^D + \eta_z z_{it-1} + \mu_{it}, \quad \mu_{it} \sim N(0, \sigma_\mu^2). \quad (18)$$

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 Φ_t^H and Φ_t^X 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,

$$s_{it} = (\omega_{it}, z_{it}, \mathbf{d}_{it-1}, \Phi_t^H, \Phi_t^X, \mathbf{w}_{it})$$

which includes its current productivity and demand shocks (ω_{it}, z_{it}) and its past decision regarding which markets to serve and its export mode (\mathbf{d}_{it-1}) . Firm i observes the price indices in the markets (Φ_t^H, Φ_t^X) as well as the firm-time specific factor prices it faces, \mathbf{w}_{it} . We will suppress $\mathbf{w}_{it}, \Phi_t^H, \Phi_t^X$, as these are not chosen by the firm and call the state space $s_{it} = (\omega_{it}, z_{it}, \mathbf{d}_{it-1})$ 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

²⁷A 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.

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. We assume firms draw from distributions of fixed and sunk costs rather than having common values of these. Without this assumption, firms that look alike in terms of mode, productivity and demand shocks would make the same decisions in entering/exiting markets and changing modes. These fixed and sunk costs are drawn from separate independent distributions G^l .²⁸ For example, firm i faces the sunk cost γ_{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 γ_{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 pair-wise 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 γ_{it}^{DF} drawn from G^{DF} for direct exporters and γ_{it}^F 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 sunk costs, can be written as the integral over these costs when the firm chooses the best option today (it maximizes over $\mathbf{d}_{it} = (d_{it}^H, d_{it}^I, d_{it}^D)$) and optimizes from the

²⁸ l can take the value HDS when the draw is for the Sunk cost to be incurred by a *Home* firm looking to become a *Direct* 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.

²⁹As 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 γ_{it}^{IDS} tends to be far smaller than γ_{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.

next period onwards:

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

where $u(\mathbf{d}_{it}, s_{it} | \boldsymbol{\gamma}_{it})$ is the current period payoff and depends on the choice of export status and mode, \mathbf{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, $\boldsymbol{\gamma}_{it}$:

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

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 π_{it}^H from the domestic market and π_{it}^{XD} from exporting directly and has to pay the sunk cost of direct exporting γ_{it}^{IDS} so that his current period payoff is $u(\mathbf{d}_{it}, s_{it} | \boldsymbol{\gamma}_{it}) = \pi_{it}^H + \pi_{it}^{XD} - \gamma_{it}^{IDS}$.

The continuation value is

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

where $dF(\omega' | \omega_{it}, \mathbf{d}_{it})$ and $dF(z' | z_{it}, \mathbf{d}_{it})$ are the evolutions of productivity and demand shocks 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 $E_t V_{it+1}^m = E_t V(s_{it+1} | d_{it}^m = 1)$, $m = H, I, D$. 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

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

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

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

For example, if a firm was an indirect exporter last period, it will choose to become a direct exporter today if this is its best option. The options facing an indirect exporter are laid out pictorially in Figure 1. An indirect exporter will become a direct exporter if it is more profitable than either staying an indirect exporter or becoming a non-exporter.³¹ The probability of this event is

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

Thus, these marginal benefits pin down the probability of switching given the distributions of costs.³²

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, $\delta (E_t V_{it+1}^D - E_t V_{it+1}^I)$, captures the dynamic part.

Intuitively, higher fixed costs of exporting (directly or indirectly) will reduce the

³⁰ ΔHI_{it} , ΔHD_{it} , and ΔID_{it} could be similarly defined but simple calculations show that they are merely the negative of ΔIH_{it} , ΔDH_{it} , and ΔDI_{it} .

³¹The probability that becoming a direct exporter is the best option for a previous indirect exporter is

$$P_{it}^{ID} = \Pr[(\pi_{it}^H + \pi_{it}^{XD} - \gamma_{it}^{IDS} + \delta E_t V_{it+1}^D \geq \pi_{it}^H + \delta E_t V_{it+1}^H) \& (\pi_{it}^H + \pi_{it}^{XD} - \gamma_{it}^{IDS} + \delta E_t V_{it+1}^D \geq \pi_{it}^H + \pi_{it}^{XI} - \gamma_{it}^{IF} + \delta E_t V_{it+1}^I)].$$

³²More details on constructing unconditional and conditional choice probabilities are provided in the Appendix.

continuation value of being an exporter and thus decrease the marginal benefits of being an exporter versus not exporting, i.e., ΔIH_{it} or ΔDH_{it} fall. However, higher sunk costs will decrease the continuation value of being a non-exporter, and thereby increase ΔIH_{it} or ΔDH_{it} . Similarly, better learning-by-exporting effects increase ΔIH_{it} and ΔDH_{it} , and if firms learn more through direct exporting or the service fee λ rises, ΔDI_{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.

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, σ^H and σ^X , the home market size intercept Φ_t^H , the marginal cost parameter β_k , the productivity evolution function $g(\omega_{it-1}, d_{it-1})$, and the variance of transient productivity shocks σ_ξ^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.³³ Parameters of G^γ (the distribution of sunk and fixed costs), the parameters η_z , σ_μ , ψ_1 , ψ_2 of Markov process z_{it} followed by the demand shock, and the foreign market size intercept Φ_t^X are also recovered in the second stage.

³³Recall, we normalize these costs to be zero for non-exporters.

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

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

The first line in equation (25) is an identity. The second comes from using the model to substitute for marginal costs in terms of price. In the estimating equation, we add an error term which reflects measurement error in variable costs. As total variable costs and revenues are data we can estimate equation (25) by OLS to recover the elasticities of substitution.

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:

$$\begin{aligned} \ln r_{it}^H &= \phi_0^H + \sum_{t=1}^T \phi_t^H D_t + \sum_{s=1}^S \phi_s^H D_s + \sum_{l=1}^L \phi_l^H D_l \\ &\quad + (1 - \sigma^H) (\beta_k \ln k_{it} - \omega_{it}) + u_{it}, \end{aligned} \quad (26)$$

where $\phi_0^H = (1 - \sigma^H) \ln \left(\frac{\sigma^H}{\sigma^H - 1}\right) + (1 - \sigma^H) \beta_0$, $\phi_t^H = \ln \Phi_t^H + (1 - \sigma^H) \beta_t$ which captures the time varying factor prices and the home market size, $\phi_s^H = (1 - \sigma^H) \beta_s$ and $\phi_l^H = (1 - \sigma^H) \beta_l$. k_{it} denotes the firm's capital,³⁴ ω_{it} is productivity, and u_{it} is an i.i.d. error term reflecting measurement error.³⁵

As in Levinsohn and Petrin (2003), we proxy for unobserved productivity using

³⁴We convert book values of capital stock into real capital stock following the perpetual inventory method used in Brandt, Van Biesebroeck and Zhang (2012).

³⁵We 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.

the fact that more productive firms will use more materials. Thus we can replace $(1 - \sigma^H)(\beta_k \ln k_{it} - \omega_{it})$ with $h(k_{it}, m_{it})$. We estimate the function (26) using ordinary least squares and approximate $h(k_{it}, m_{it})$ by a third-degree polynomial of its arguments. This gives us estimates of ϕ_0^H , ϕ_t^H and the values of $\hat{h}(k_{it}, m_{it})$.³⁶ Thus we can rewrite productivity as follows:

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

We know $-\left(\frac{1}{1 - \sigma^H}\right) \hat{h}(k_{it}, m_{it})$ and $\ln k_{it}$, but still have to estimate β_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 ω_{it} and ω_{it-1} using equation (27) into the above equation, we can estimate the remaining parameters ($\alpha_i, i = 0, \dots, 5$ and β_k), using non-linear least squares. The variance of ξ_{it} is pinned down by the sample variance of the residual.³⁷

So far we have estimates of ϕ_0^H and ϕ_t^H , which capture the home market condition, ϕ_s^H and ϕ_l^H for 4-digit industry and location specific effects on factor prices, elasticities σ^H and σ^X , the marginal cost parameters β_k , the productivity evolution function $g(\omega_{it-1}, d_{it-1})$, and the variance of transient productivity shocks σ_ξ^2 . What remains to be estimated are the parameters of the distributions of the sunk and fixed costs, i.e., of G^γ , for each mode, the demand shocks and their evolution, and the foreign market size intercept Φ_t^X .

³⁶Note that for the purposes of solving the model, we only need $\phi_0^H + \phi_t^H$, not the separate components. The Ψ^H reported in Table 5 is the average $\phi_0^H + \phi_t^H$ over all time periods. The same holds for Ψ^X reported in Table 6. These average variables are used in the second stage estimation. We could allow them to change over time and to reach steady state at the end of the period for which we have data so that we could solve for the dynamic problem. As we have a short panel, after controlling for 4-digit industry and location dummies, it does not make much difference if we do this or do what we have done as a shortcut, namely just set them to be constant. The estimates on 4-digit industry and location dummies (β_s and β_l) are not reported in the tables to conserve space.

³⁷We 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.

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.³⁸

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.

Without additional data we have no way to pin down intermediation cost. For this reason we assume the intermediary market is relatively competitive and set the commission rate obtained by the intermediary at 1% of the export revenue. Thus, $\lambda = 1.01$.³⁹ 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. Note that the level and evolution of demand shocks is reflected in the level and behavior of export revenue for firms in a given export mode. The sunk and fixed costs are identified by the patterns in transitions in export

³⁸We 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.

³⁹Intermediaries 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.

modes. 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 revenue (which boils down to observing a particular demand shock). The level of each firm's export revenue provides information on the demand shocks once we know the firm's industry and location, productivity, capital stock (a cost shifter) and market sizes. For the exporter to sell the amount he has, the demand shocks must have taken a particular value. We can back out this value from the data given the estimated parameters from the first-stage estimation and the foreign market condition which is to be estimated in the second stage. This information goes into the likelihood function which we maximize to obtain our parameter estimates. This information is only observable conditioning on exporting. Hence the demand shock distribution is censored so that we do not observe the demand shocks of non-exporters. We follow Das et al. (2007) and Aw et al. (2011) to infer the unconditional distribution for the demand shocks based on the conditional distribution given the functional form assumptions. Based on the first-stage parameter estimates and productivity estimates, we can write firm i 's contribution to the likelihood function as

$$P(\mathbf{d}_i, r_i^{Xm} | \omega_i, k_i, \Phi) = P(\mathbf{d}_i | \omega_i, k_i, \Phi, z_i^+) f(z_i^+) \quad (28)$$

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. The technical details are in the Appendix.

To provide some idea of how this works, consider an indirect exporter who be-

comes a direct one and sells a particular amount. The probability of an indirect exporter becoming a direct exporter is given in equation (25). This requires knowledge of the distribution of γ^{IDS} and γ^{IF} as well as ΔDH_{it} and ΔDI_{it} . We assume that the γ 's are drawn from exponential distributions. The values of ΔDH_{it} and ΔDI_{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 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.

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.⁴⁰ 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.

⁴⁰Derivation of these choice probabilities is available upon request.

The elasticities of substitution imply markups of 27 percent in home market and 29 percent in foreign market. The coefficient on log capital implies that the marginal costs are lower for larger scale. The coefficients α_1 , α_2 and α_3 imply a non-linear and positive marginal effect of lagged productivity on current productivity. α_4 and α_5 , the coefficients on previous export modes, are critical parameters.⁴¹ Previous indirect exporters have a 0.7 percent higher productivity relative to previous non-exporters, while previous direct exporters have productivity that is 2.5 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).⁴² 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 2 shows the kernel density and cumulative 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.

In addition, if direct exporters have an advantage in terms of productivity evo-

⁴¹Recall that ω is the natural log of productivity. Thus, α_4 and α_5 are the percentage change in productivity when exporting indirectly and directly.

⁴²These 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.

lution, we should observe that direct exporters have actually experienced a larger improvement in productivity than that of indirect exporters and non-exporters. To check if this is indeed present in the data, in Figure 3 we look at firms who were present in the period 2001-2006 and never switched export mode. In the top panel we depict the productivity distributions of non-exporters in these two years, in the middle and lower panels we do the same for indirect and direct exporters respectively. The vertical lines give the means of the distributions. It is clear to the naked eye that the distributions move to the right over time in each panel. The increase in the mean for direct exporters is significantly higher than that for indirect exporters and non exporters. However, there is no significant difference in the increase in the means of indirect exporters and non-exporters.

5.3 Dynamic Estimates

First, the estimate of Ψ^X in Table 6 (which proxies for average foreign market size) is smaller than that for the domestic market, Ψ^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 γ^{HIS} , γ^{HDS} , γ^{IDS} , γ^{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 γ^{HDS} is much higher than γ^{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. γ^{IDS} is also much lower than what γ^{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 (γ^{DIS}) indicates that it is much easier for a direct exporter to become an indirect exporter.

The coefficients γ^{IF} and γ^{DF} are relatively small compared to the sunk costs of starting such exporting. This is what creates hysteresis. γ^{IF} is also smaller than γ^{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.⁴³ Table 7 presents these numbers for firms at the mean productivity levels of a non-exporter, indirect exporter and direct exporter respectively.⁴⁴

The last four parameters describe the evolution of foreign market demand shocks, z_{it} . The parameters η_z and σ_μ 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 ψ_1 is positive but not significant, while the parameter on the dummy of direct exporting ψ_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

⁴³For 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.

⁴⁴It 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, $1.393 + 1.492 > 2.228$ 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.

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 γ^{HDS} and γ^{HIS} . The model slightly overestimate the fixed costs of two modes of exporting and thus under predicts the persistence of indirect and direct exporters.

5.5 Robustness Checks

We check on the robustness of our first stage estimates. As the second stage is very computationally intensive, we cannot do the same for it. The complete set of robustness checks are in the Appendix. We present them in four tables. In Table A.4, we look at the evolution of productivity estimated in a variety of ways. Column 1 is our benchmark. Most important is Column 2 which follows Brandt et al. (2012) which uses the same data set as ours. We match the technology parameters to input shares, thereby backing out productivity firm by firm and estimating its evolution allowing learning by exporting. Other variations are described in the the remaining columns, but the thing to note is that in each case, the evolution of productivity is more favorable for direct exporters than for indirect ones.

Table A.5 in the appendix looks at productivity evolution when alternative definitions of export modes are considered. This alleviates concerns about our definitions and enriches the results in a number of dimensions. First, 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 allowing for such delays and find this makes no

difference, see Column 2. Second, there may also be producers who say they did not export in the survey data and show up in the customs data.⁴⁵ We interpret this to mean that such firms exported on someone else's behalf, making them "producer intermediaries". These firms were 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 even faster than direct exporters, see Column 3. Third, we performed the same exercise in Column 4 for processing firms whom we originally dropped. Processing firms' learning is in between that of indirect and direct exporters which makes sense as they have less control over their product. Finally, in Column 5, 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.

Next we focus on whether productivity evolution differs according to destination and product type. One might expect there is more to learn from exporting to rich countries than poor ones as they are likely to be ahead in technology and have more sophisticated consumers. 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). Neither of these seem to matter once export mode is controlled for. The results are in Columns 2 and 3 of Table A.6 in the Appendix.

One might also suspect that direct exporters export different products than do indirect exporters. For example, it is well understood (see Ahn et al. (2011)) that intermediaries are used to sell differentiated goods. By classifying firms as being in differentiated goods sectors, or not, using the Rauch classification, we can explore this idea. However, we find that controlling for type of product (differentiated or not) in estimating productivity evolution does not seem to have an effect. 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 Columns 4 and 5 of Table A.6 in the Appendix.

It is also natural to ask if we could use eligibility as an instrument in the choice

⁴⁵These comprise about 4 percent of the observations in the survey data.

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. However, we could run our productivity evolution regression on eligible firms only to see if the results differ. As is evident in Column 2 of Table A.7, the pattern is unchanged. It could also be that firms that know they are on a good productivity evolution path self select into exporting so that the usual problem of causation reappears. To deal with this, we restrict our attention to firms that exported through out and never switched export mode in Column 3. Note that the patterns are unchanged. Omitting other firm decisions that could be affecting productivity may also 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 as is evident in Columns 4 and 5 in Table A.7 in the Appendix. Direct exporters have a more favorable evolution of productivity in each of the columns of Table A.7, and what is more, this is so year by year as shown in Column 6.

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, ex-

port 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 revenue 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 0.1 percent, but negative for revenue and participation which fall by 10 and 36 percent respectively over 15 years. This comes from the weaker firms dropping out of exporting market and the stronger ones becoming direct exporters so that the effect on export revenue is smaller than that on participation. This also confirms the important role of intermediaries in facilitating trade, especially for China. When direct exports are banned as in the third case average

productivity falls by 0.6 percent over the 15 years. Export participation and export revenue fall by 33 and 26 percent respectively.

Had there been no learning-by-exporting effects, shutting down the intermediary sector would have decreased export revenue and participation by much more as there are fewer benefits from exporting directly. In the same vein, without learning-by-exporting, the decreases in export revenue and participation from banning direct exports would have been much smaller. This suggests that the effects via learning-by-exporting are critical. It is worth pointing out that this liberalization of direct trading rights was “revolutionary” (see footnote 2) given where China was coming from. In sum, the counterfactuals show that liberalizing direct trading rights was important and exports would have been roughly a third lower had this not been done. Our estimates have direct exporters have productivity growing at 2.5 percent compared to 0.7 percent for indirect exporters, see Table 5. De Loecker (2013) shows that across all sectors, exporting and investing raises future productivity per annum from 1 to 8 percent and our estimates are of a similar magnitude.

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.⁴⁶ We also simulate the effect of a 25 and 50 percent reduction in fixed or sunk costs of exporting. In addition, we

⁴⁶This 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.

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 4.7 percent and export revenue by 12.1 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 ratio 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	3270	82.1%	387	9.7%	326	8.2%	3983
2001	4617	82.5%	524	9.4%	454	8.1%	5595
2002	5054	81.5%	599	9.7%	551	8.8%	6204
2003	5410	81.1%	604	9.1%	657	9.8%	6671
2004	7703	80.1%	763	7.9%	1149	12.0%	9615
2005	8544	79.1%	886	8.2%	1369	12.7%	10799
2006	7660	79.0%	781	8.1%	1254	12.9%	9695

Table 2: Summaries of Firm Size

	Employee	Capital	Home Revenue	Export Revenue
	Non-Exporter			
Mean	120.177	0.792	2.667	0.000
Median	73	0.262	1.306	0.000
	Indirect Exporter			
Mean	280.316	2.858	8.539	2.138
Median	120	0.375	1.989	0.538
	Direct Exporter			
Mean	379.454	4.506	10.857	4.038
Median	178	1.016	3.719	1.270

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

Table 3: Transitions of Export Modes: All Eligible Firms

Export Status Time $t - 1$	Time t		
	Non-Exporter	Indirect Exporter	Direct Exporter
Non-Exporter	0.962	0.029	0.009
Indirect Exporter	0.227	0.662	0.111
Direct Exporter	0.020	0.062	0.918

Table 4: Costs of Exporting

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

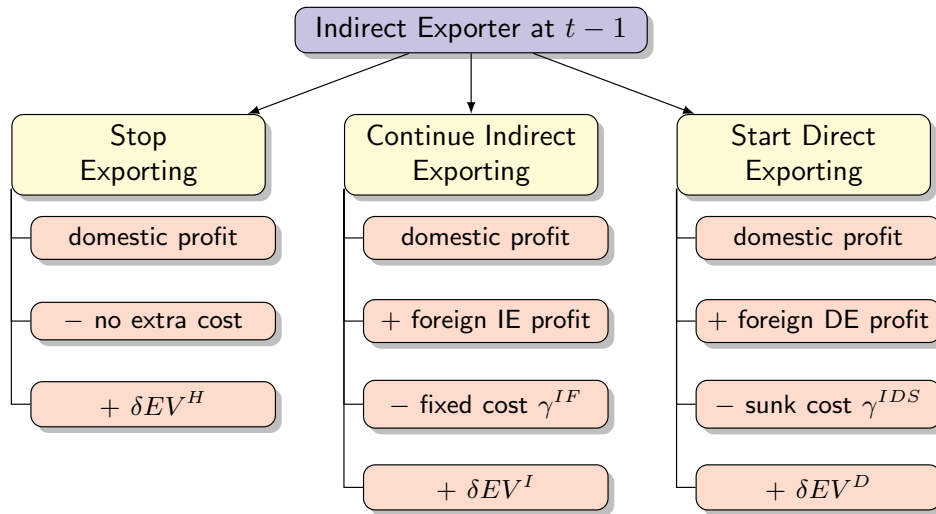


Figure 1. Example of a Firm's Dynamic Decisions

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

Parameters		Rubber & Plastic	Chemical	Machinery & Eqpt	Furniture
Domestic Elasticity	σ^H	4.679*** (0.003)	5.506*** (0.002)	5.401*** (0.002)	5.539*** (0.006)
Foreign Elasticity	σ_X	4.405*** (0.008)	3.530*** (0.009)	4.581*** (0.004)	7.059*** (0.010)
Capital	β_k	-0.070*** (0.002)	-0.057*** (0.001)	-0.057*** (0.001)	-0.043*** (0.002)
Constant	α_0	0.542*** (0.032)	0.515*** (0.017)	0.323*** (0.014)	-0.273*** (0.093)
	ω_{t-1}	0.303*** (0.068)	0.188*** (0.041)	0.549*** (0.034)	1.730*** (0.172)
	ω_{t-1}^2	0.264*** (0.050)	0.398*** (0.034)	0.206*** (0.027)	-0.488*** (0.104)
	ω_{t-1}^3	-0.028** (0.012)	-0.061*** (0.008)	-0.032*** (0.007)	0.096*** (0.020)
Indirect Export $_{t-1}$	α_4	0.007*** (0.002)	0.004*** (0.001)	0.006*** (0.001)	-0.001 (0.002)
Direct Export $_{t-1}$	α_5	0.025*** (0.002)	0.017*** (0.001)	0.019*** (0.001)	0.014*** (0.002)
	Ψ^H	2.392	2.161	1.799	0.072
	σ_ω	0.129	0.115	0.116	0.104

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

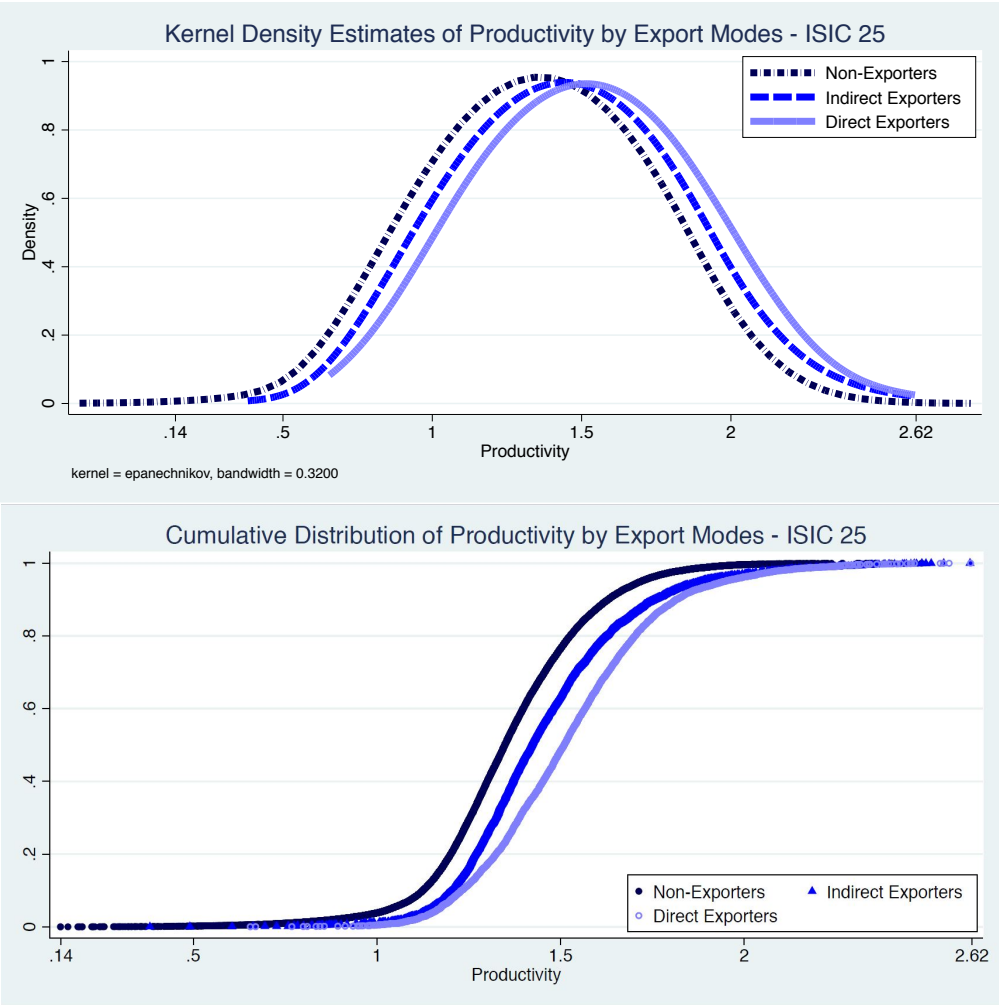


Figure 2. Productivity Distributions by Export Modes

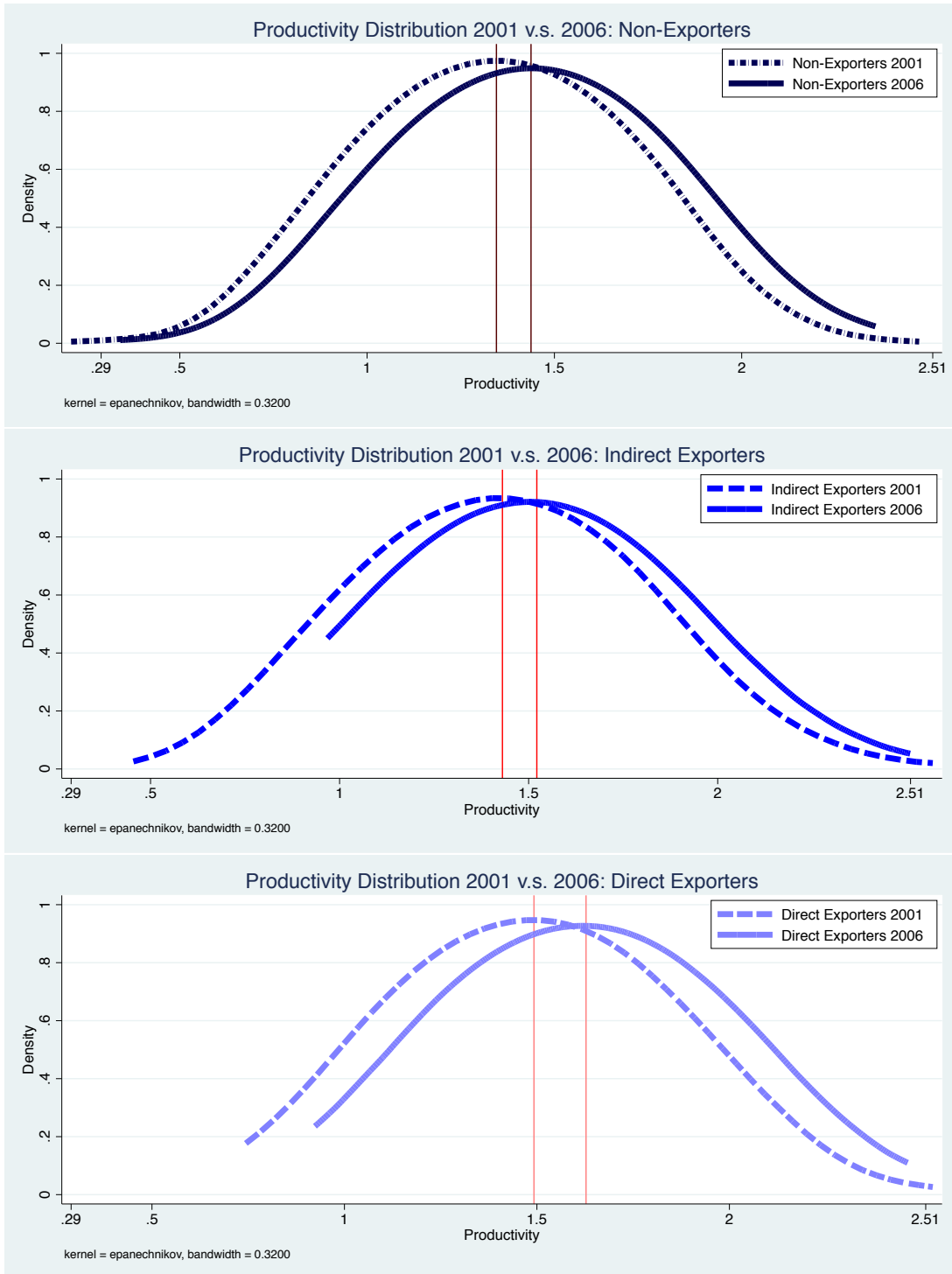


Figure 3. Evolution of Productivity Distributions: 2001 & 2006

Table 6: Dynamic Parameter Estimates

Export Market Size	Ψ^X	1.663***	(0.019)
Sunk Export Costs			
Home → Indirect	γ^{HIS}	32.555***	(0.542)
Home → Direct	γ^{HDS}	140.544***	(6.055)
Indirect → Direct	γ^{IDS}	25.886***	(0.719)
Direct → Indirect	γ^{DIS}	0.979***	(0.031)
Fixed Export Costs			
Indirect	γ^{IF}	0.830***	(0.015)
Direct	γ^{DF}	1.527***	(0.023)
Demand Shock			
	η_z	0.825***	(0.004)
	$\log(\sigma_\mu)$	-0.176***	(0.007)
Indirect	ψ_1	0.003	(0.002)
Direct	ψ_2	0.007***	(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	ω_{it}	Indirect Exporter	Direct Exporter	
Non-Exporter	1.359		1.393 (0.265)	2.228 (0.406)	
Indirect Exporter	1.455		0.441 (0.060)	1.492 (0.195)	
Direct Exporter	1.523		0.063 (0.060)	1.061 (0.111)	

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	1.336	1.354	1.381	1.379	1.397	1.445
	Model	1.363	1.378	1.392	1.385	1.390	1.412
Indirect Exporter	Data	0.094	0.097	0.091	0.079	0.082	0.081
	Model	0.093	0.096	0.093	0.088	0.082	0.091
Direct Exporter	Data	0.081	0.088	0.098	0.120	0.127	0.129
	Model	0.088	0.102	0.115	0.125	0.127	0.139

Simulation reports average results from thirty simulations.

Table 9: Model Prediction of Transition Rates

Export Status Time $t - 1$	Time t			
	Non-Exporter	Indirect Exporter	Direct Exporter	
Non-Exporter	Data	0.962	0.029	0.009
	Model	0.942	0.038	0.020
Indirect Exporter	Data	0.227	0.662	0.111
	Model	0.247	0.616	0.137
Direct Exporter	Data	0.020	0.062	0.918
	Model	0.065	0.066	0.869

Simulation reports average results from thirty simulations.

Table 10: Firm Response Under Different Liberalization Scenarios

Policy Regimes Years since 2000	Learning			No Learning		
	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	-0.1	0.0	0.0	0.0
No Liberalization	-0.1	-0.4	-0.6	0.0	0.0	0.0
	Export Participation					
No Restriction	0.3	0.0	0.0	0.1	0.0	0.0
No Intermediary	-34.6	-35.2	-35.8	-51.0	-53.7	-53.3
No Liberalization	-21.3	-30.6	-33.4	-5.8	-6.8	-6.7
	Export Revenue					
No Restriction	0.2	0.1	0.0	0.0	0.0	0.0
No Intermediary	-21.1	-17.6	-9.7	-23.1	-23.3	-21.0
No Liberalization	-13.5	-21.6	-25.7	-3.4	-3.6	-3.7

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	1.0	3.865	1.9	5.1	5.175	2.4	5.8	4.849
10%	1.0	1.4	1.872	3.9	10.4	4.951	4.7	12.1	4.742
Fixed Cost Subsidy									
25%	6.6	1.1	2.053	10.1	2.7	1.246	13.7	2.9	2.355
50%	21.3	2.7	3.123	27.5	6.4	2.047	33.3	6.4	4.287
Sunk Cost Subsidy									
25%	4.6	2.1	2.547	2.3	1.4	1.240	8.1	3.1	1.389
50%	20.4	8.9	4.756	9.1	5.6	2.109	30.4	10.8	2.585

- (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.

Appendix

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

A Details on Second-Stage 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 recovered the following parameters using data on total variable cost, domestic revenue, export revenue, capital size, intermediate materials, export modes, year, industry and location: the elasticities of substitution in the two markets (σ^H and σ^X), the home market size intercept (Φ_t^H), the marginal cost parameter (β_k), the productivity evolution function ($g(\omega_{it-1}, d_{it-1})$), and the variance of transient productivity shocks (σ_ξ^2).

In the second stage, based on the estimates from the first stage, we construct and estimate the dynamic discrete choice problem to obtain the parameters on the foreign market size (Φ_t^X), demand shock evolution ($\eta_z, \sigma_\mu, \psi_1, \psi_2$) and the distribution of both sunk and fixed costs (G^γ). In the following sections, we provide details on the construction and estimation of the dynamic discrete choice problem.

A.1 Dynamic Optimization Problem

At the beginning of each period, firm i observes the current state, $s_{it} = (\omega_{it}, z_{it}, \mathbf{d}_{it-1}, \Phi_t^H, \Phi_t^X, \mathbf{w}_{it})$ which includes its current productivity and demand shocks (ω_{it}, z_{it}) and its past decision regarding which markets to serve and its export mode (\mathbf{d}_{it-1}), the price indices in the markets (Φ_t^H, Φ_t^X) as well as the firm-time specific factor prices it faces, \mathbf{w}_{it} . We will suppress $\mathbf{w}_{it}, \Phi_t^H, \Phi_t^X$, as these are not chosen by the firm and call the state space $s_{it} = (\omega_{it}, z_{it}, \mathbf{d}_{it-1})$ 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.⁴⁷ We allow the *distributions* of the costs, both fixed and sunk, of exporting to differ depending on the firm's past and current exporting status and mode. All this is summarized in Table 4.

Knowing s_{it} , the firm's value function in year t , before it observes its fixed and sunk costs, can be written as the integral over these costs when the firm chooses the best option today (it maximizes

⁴⁷Firms that don't have direct trading rights can only choose whether to stay domestic or export indirectly, and their export dynamic problems are adjusted accordingly.

over $\mathbf{d}_{it} = (d_{it}^H, d_{it}^I, d_{it}^D)$ and optimizes from the next period onwards:

$$V(s_{it}) = \int \max_{\mathbf{d}_{it}} [u(\mathbf{d}_{it}, s_{it} | \boldsymbol{\gamma}_{it}) + \delta E_t V(s_{it+1} | \mathbf{d}_{it})] dG^\boldsymbol{\gamma}, \quad (\text{A.1})$$

where $u(\mathbf{d}_{it}, s_{it} | \boldsymbol{\gamma}_{it})$ is the current period payoff and depends on the choice of export status and mode, \mathbf{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, $\boldsymbol{\gamma}_{it}$:

$$\begin{aligned} u(\mathbf{d}_{it}, s_{it} | \boldsymbol{\gamma}_{it}) &= \pi_{it}^H + d_{it}^I \left[\pi_{it}^{XI} - \left(d_{it-1}^H \gamma_{it}^{HIS} + d_{it-1}^I \gamma_{it}^{IF} + d_{it-1}^D \gamma_{it}^{DIS} \right) \right] \\ &+ d_{it}^D \left[\pi_{it}^{XD} - \left(d_{it-1}^H \gamma_{it}^{HDS} + d_{it-1}^I \gamma_{it}^{IDS} + d_{it-1}^D \gamma_{it}^{DF} \right) \right]. \end{aligned} \quad (\text{A.2})$$

where per-period variable profits (before the sunk and fixed costs) in different markets are given by

$$\begin{aligned} \pi_{it}^H &= \frac{1}{\sigma^H} r_{it}^H = \frac{1}{\sigma^H} \left[\frac{\sigma^H}{\sigma^H - 1} \frac{c(\mathbf{w}_{it})}{e^{\omega_{it}}} \right]^{1-\sigma^H} \frac{Y_t^H}{(P_t^H)^{1-\sigma^H}} e^{z_{it}} \\ \pi_{it}^{XI} &= \frac{1}{\sigma^X} r_{it}^{XI} = \frac{1}{\sigma^X} \lambda^{-\sigma^X} \left[\frac{\sigma^X}{\sigma^X - 1} \frac{c(\mathbf{w}_{it})}{e^{\omega_{it}}} \right]^{1-\sigma^X} \frac{Y_t^X}{(P_t^X)^{1-\sigma^X}} e^{z_{it}} \\ \pi_{it}^{XD} &= \frac{1}{\sigma^X} r_{it}^{XD} = \frac{1}{\sigma^X} \left[\frac{\sigma^X}{\sigma^X - 1} \frac{c(\mathbf{w}_{it})}{e^{\omega_{it}}} \right]^{1-\sigma^X} \frac{Y_t^X}{(P_t^X)^{1-\sigma^X}} e^{z_{it}} \end{aligned} \quad (\text{A.3})$$

The continuation value is

$$E_t V(s_{it+1} | \mathbf{d}_{it}) = \int_{z'} \int_{\omega'} V(s') dF(\omega' | \omega_{it}, \mathbf{d}_{it}) dF(z' | z_{it}, \mathbf{d}_{it}), \quad (\text{A.4})$$

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

A.2 Choice Probability and Value Function

For any state vector, denote the choice-specific continuation value from choosing $d_{it}^m = \{0, 1\}$, as $E_t V_{it+1}^m = E_t V(s_{it+1} | d_{it}^m = 1)$, $m = H, I, D$. 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 (A.5), respectively.⁴⁸

$$\begin{aligned}\Delta IH_{it} &= \pi_{it}^{XI} + \delta (E_t V_{it+1}^I - E_t V_{it+1}^H) \\ \Delta DH_{it} &= \pi_{it}^{XD} + \delta (E_t V_{it+1}^D - E_t V_{it+1}^H) \\ \Delta DI_{it} &= \pi_{it}^{XD} - \pi_{it}^{XI} + \delta (E_t V_{it+1}^D - E_t V_{it+1}^I)\end{aligned}\tag{A.5}$$

Given the distribution of costs, these marginal benefits and export modes in the last period pin down the probability of switching export modes or not doing so. Specifically, for any set of realized export costs, $\boldsymbol{\gamma}_t = (\gamma_{it}^{HDS}, \gamma_{it}^{IDS}, \gamma_{it}^{DF}, \gamma_{it}^{HIS}, \gamma_{it}^{DIS}, \gamma_{it}^{IF})$, the following show the differences in life-time payoff between any two different current export modes that are unconditional on previous export mode.

$$\begin{aligned}y_{it}^{DH} &= \Delta DH_{it} - I(d_{it-1} = H) \gamma_{it}^{HDS} - I(d_{it-1} = I) \gamma_{it}^{IDS} - I(d_{it-1} = D) \gamma_{it}^{DF} \\ y_{it}^{IH} &= \Delta IH_{it} - I(d_{it-1} = H) \gamma_{it}^{HIS} - I(d_{it-1} = D) \gamma_{it}^{DIS} - I(d_{it-1} = I) \gamma_{it}^{IF} \\ y_{it}^{DI} &= \Delta DI_{it} - [I(d_{it-1} = H) \gamma_{it}^{HDS} + I(d_{it-1} = I) \gamma_{it}^{IDS} + I(d_{it-1} = D) \gamma_{it}^{DF} \\ &\quad - I(d_{it-1} = H) \gamma_{it}^{HIS} - I(d_{it-1} = D) \gamma_{it}^{DIS} - I(d_{it-1} = I) \gamma_{it}^{IF}]\end{aligned}\tag{A.6}$$

Thus, the unconditional choice probability between any two different export modes are given as

$$\begin{aligned}P(y_{it}^{DH} > 0) &= P\left[I(d_{it-1} = H) \gamma_{it}^{HDS} + I(d_{it-1} = I) \gamma_{it}^{IDS} + I(d_{it-1} = D) \gamma_{it}^{DF} \leq \Delta DH_{it}\right] \\ P(y_{it}^{IH} > 0) &= P\left[I(d_{it-1} = H) \gamma_{it}^{HIS} + I(d_{it-1} = D) \gamma_{it}^{DIS} + I(d_{it-1} = I) \gamma_{it}^{IF} \leq \Delta IH_{it}\right] \\ P(y_{it}^{DI} > 0) &= P\left[I(d_{it-1} = H) \gamma_{it}^{HDS} + I(d_{it-1} = I) \gamma_{it}^{IDS} + I(d_{it-1} = D) \gamma_{it}^{DF} \right. \\ &\quad \left. - I(d_{it-1} = H) \gamma_{it}^{HIS} - I(d_{it-1} = D) \gamma_{it}^{DIS} - I(d_{it-1} = I) \gamma_{it}^{IF} \leq \Delta DI_{it}\right]\end{aligned}\tag{A.7}$$

Hence, conditioning on the previous export mode, the probability of firm i at time t can be written as the following. This corresponds to the empirical transition matrix in Table 3. For a

⁴⁸ ΔHI_{it} , ΔHD_{it} , and ΔID_{it} could be similarly defined but simple calculations show that they are merely the negative of ΔIH_{it} , ΔDH_{it} , and ΔDI_{it} .

previous non-exporter, the probability to stay as non-exporter, to become an indirect exporter and to become a direct exporter are given as follows respectively.

$$\begin{aligned}
P_{it}^{HH} &= P(y_{it}^{IH} \leq 0 \ \& \ y_{it}^{DH} \leq 0) = P\left[\gamma_{it}^{HIS} \geq \Delta IH_{it}\right] \cdot P\left[\gamma_{it}^{HDS} \geq \Delta DH_{it}\right] \\
P_{it}^{HI} &= P(y_{it}^{IH} > 0 \ \& \ y_{it}^{DI} \leq 0) = P\left[\gamma_{it}^{HIS} < \min\left\{\Delta IH_{it}, \gamma_{it}^{HDS} - \Delta DI_{it}\right\}\right] \\
P_{it}^{HD} &= P(y_{it}^{DH} > 0 \ \& \ y_{it}^{DI} > 0) = P\left[\gamma_{it}^{HDS} < \min\left\{\Delta DH_{it}, \gamma_{it}^{HIS} + \Delta DI_{it}\right\}\right]
\end{aligned} \tag{A.8}$$

Thus, after rewriting equation (A.1), the value function for a previous non-exporter updates according to the following formula.

$$\begin{aligned}
V_{it}^H &= \pi_{it}^H + P_{it}^{HH} \cdot [\delta E_t V_{it+1}^H] \\
&+ P_{it}^{HI} \cdot \left[\pi_{it}^{XI} - E\left(\gamma_{it}^{HIS} \mid \gamma_{it}^{HIS} < \min\left\{\Delta IH_{it}, \gamma_{it}^{HDS} - \Delta DI_{it}\right\}\right) + \delta E_t V_{it+1}^I\right] \\
&+ P_{it}^{HD} \cdot \left[\pi_{it}^{XD} - E\left(\gamma_{it}^{HDS} \mid \gamma_{it}^{HDS} < \min\left\{\Delta DH_{it}, \gamma_{it}^{HIS} + \Delta DI_{it}\right\}\right) + \delta E_t V_{it+1}^D\right]
\end{aligned} \tag{A.9}$$

Similarly, given his previous export mode, a previous indirect exporter optimizes according to the following choice probabilities

$$\begin{aligned}
P_{it}^{IH} &= P(y_{it}^{IH} \leq 0 \ \& \ y_{it}^{DH} \leq 0) = P\left[\gamma_{it}^{IF} \leq \Delta IH_{it}\right] \cdot P\left[\gamma_{it}^{IDS} \leq \Delta DH_{it}\right] \\
P_{it}^{II} &= P(y_{it}^{IH} > 0 \ \& \ y_{it}^{DI} \leq 0) = P\left[\gamma_{it}^{IF} < \min\left\{\Delta IH_{it}, \gamma_{it}^{IDS} - \Delta DI_{it}\right\}\right] \\
P_{it}^{ID} &= P(y_{it}^{DH} > 0 \ \& \ y_{it}^{DI} > 0) = P\left[\gamma_{it}^{IDS} < \min\left\{\Delta DH_{it}, \gamma_{it}^{IF} + \Delta DI_{it}\right\}\right],
\end{aligned} \tag{A.10}$$

and value function updating rule,

$$\begin{aligned}
V_{it}^I &= \pi_{it}^H + P_{it}^{IH} \cdot [\delta E_t V_{it+1}^H] \\
&+ P_{it}^{II} \cdot \left[\pi_{it}^{XI} - E\left(\gamma_{it}^{IF} \mid \gamma_{it}^{IF} < \min\left\{\Delta IH_{it}, \gamma_{it}^{IDS} - \Delta DI_{it}\right\}\right) + \delta E_t V_{it+1}^I\right] \\
&+ P_{it}^{ID} \cdot \left[\pi_{it}^{XD} - E\left(\gamma_{it}^{IDS} \mid \gamma_{it}^{IDS} < \min\left\{\Delta DH_{it}, \gamma_{it}^{IF} + \Delta DI_{it}\right\}\right) + \delta E_t V_{it+1}^D\right].
\end{aligned} \tag{A.11}$$

For a previous direct exporter, we can write the same choice probabilities and value function

iteration.

$$\begin{aligned}
P_{it}^{DH} &= P(y_{it}^{IH} \leq 0 \ \& \ y_{it}^{DH} \leq 0) = P\left[\gamma_{it}^{DIS} > \Delta IH_{it}\right] \cdot P\left[\gamma_{it}^{DF} > \Delta DH_{it}\right] \\
P_{it}^{DI} &= P(y_{it}^{IH} > 0 \ \& \ y_{it}^{DI} \leq 0) = P\left[\gamma_{it}^{DIS} < \min\{\Delta IH_{it}, \gamma_{it}^{DF} - \Delta DI_{it}\}\right] \\
P_{it}^{DD} &= P(y_{it}^{DH} > 0 \ \& \ y_{it}^{DI} > 0) = P\left[\gamma_{it}^{DF} < \min\{\Delta DH_{it}, \gamma_{it}^{DIS} + \Delta DI_{it}\}\right]
\end{aligned} \tag{A.12}$$

$$\begin{aligned}
V_{it}^D &= \pi_{it}^H + P_{it}^{DH} \cdot [\delta E_t V_{it+1}^H] \\
&+ P_{it}^{DI} \cdot \left[\pi_{it}^{XI} - E\left(\gamma_{it}^{DIS} \mid \gamma_{it}^{DIS} < \min\{\Delta IH_{it}, \gamma_{it}^{DF} - \Delta DI_{it}\}\right) + \delta E_t V_{it+1}^I\right] \\
&+ P_{it}^{DD} \cdot \left[\pi_{it}^{XD} - E\left(\gamma_{it}^{DF} \mid \gamma_{it}^{DF} < \min\{\Delta DH_{it}, \gamma_{it}^{DIS} + \Delta DI_{it}\}\right) + \delta E_t V_{it+1}^D\right]
\end{aligned} \tag{A.13}$$

A.3 Dynamic Estimation

We estimate the dynamic parameters by maximizing the likelihood function for the observed participation and modes of exporting along with the observed export revenue. The level of each firm's export revenue provides information on the demand shocks once we know the firm's industry and location, productivity, capital stock (a cost shifter), market size. This information is observable conditioning on exporting. Hence the demand shock distribution is censored so that we do not observe the demand shocks of non-exporters. We follow Das et al. (2007) and Aw et al. (2011) to infer the unconditional distribution for the demand shocks based on the conditional distribution. Based on the first-stage parameter estimates and productivity estimates, we can write firm i 's contribution to the likelihood function as

$$P(\mathbf{d}_i, r_i^{Xm} \mid \omega_i, k_i, \Phi) = P(\mathbf{d}_i \mid \omega_i, k_i, \Phi, z_i^+) f(z_i^+) \tag{A.14}$$

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.

We solve each firm's dynamic optimization problem using the following algorithm:

1. Begin with an initial guess of parameters $(\Phi_t^{X0}, \eta_z^0, \sigma_\mu^0, \psi_1^0, \psi_2^0, G^{X0})$
2. Given the parameters, backout and simulate z shocks based on observed export values, based the export profit functions (A.3) and guessed parameters $(\Phi_t^{X0}, \eta_z^0, \sigma_\mu^0, \psi_1^0, \psi_2^0)$. Then cal-

culate $F(z' | z, \mathbf{d})$ based on equations (18). $F(\omega' | \omega, \mathbf{d})$ can be calculated outside the loop based on parameters from the first-stage estimation.

3. Iterate on the following inner loop to find fixed points of value functions.

- (a) Start with a set of initial guess of value functions $V^{m0}(s), m = H, I, D$, where $s = (\omega, z, \mathbf{d}_{-1}, \Phi^H, \Phi^X, \mathbf{w})$
- (b) According to equations (A.1) and (A.4), calculate the continuation values for every export mode $EV^{m0} = \int_{z'} \int_{\omega'} V^{m0}(s') dF(\omega' | \omega, d_{it}^m = 1) dF(z' | z, d_{it}^m = 1)$, where $m = H, I, D$.
- (c) Update value functions for every export mode according to equations (A.9), (A.11) and (A.13). The choice probabilities are calculated based on equations (A.8), (A.10) and (A.12). For example, for a previous non-exporter:

$$\begin{aligned} V^{H1}(s) = & \pi^H + P^{HH} \cdot [\delta EV^{H0}] \\ & + P^{HI} \cdot [\pi^{XI} - E(\gamma^{HIS} | \gamma^{HIS} < \min\{\Delta IH, \gamma^{HDS} - \Delta DI\}) + \delta EV^{I0}] \\ & + P^{HD} \cdot [\pi^{XD} - E(\gamma^{HDS} | \gamma^{HDS} < \min\{\Delta DH, \gamma^{HIS} + \Delta DI\}) + \delta EV^{D0}] \end{aligned}$$

- (d) Iterate step (a)-(c) until $|V^{mn+1} - V^{mn}| < \varepsilon$ for every $m = H, I, D$.

4. Evaluate the likelihood function for every observation.

We followed the methods in Aw et al. (2011) to discretize the state space. For data points that are not on the grid we use the same procedure as in Aw et al. (2011).

B 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, revenue, net assets, and exports exceeded certain threshold lev-

els.⁴⁹ 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 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.

C 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

⁴⁹Registered 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.

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.

D Inferred Export Modes

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.⁵⁰ 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.

More importantly, we could be mis-classifying firms because our match of the survey to the customs data is poor. If this were the case, there would be many firms who are actually in both data sets but whom we cannot match and so end up being mis classified as indirect exporters. We examine 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.

⁵⁰Evidence on match quality is discussed in the second section C of the Appendix.

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

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

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} includes 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 misclassifying firms. We further examine the robustness of our model to alternative definitions of export modes in the next section.

E Robustness Checks

In this section, we provide robustness checks of our benchmark model in terms of productivity evolution, especially learning effects from different export modes. Specifically, we re-estimate the first stage of our model using alternative productivity measures, alternative definitions of export modes, different evolution processes of productivity. We also control for types of products, destination countries and other firm decisions.

E.1 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, industry, location 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.4 shows the productivity evolution using alternative productivity measures. In column 2, we replicate the Törnqvist index productivity measure in Brandt et al. (2012) and show the evolution of productivity allowing for learning-by-exporting. In Columns 3 and 4, we show the estimates of productivity evolution where the productivity is estimated from a Cobb-Douglas production *à la* De Loecker (2013). Specifically, we use total revenue and value-added as measures of total output respectively. In column 5, we add log wage rate to the benchmark

model to capture the firm-time level cost shifters. 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.

E.2 Definition of Export Modes

In Table A.5, we report the estimates of productivity evolution based on four 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 .⁵¹ Column 2 in Table A.5 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.

E.3 Products and Destinations

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 revenue grow faster in such markets, we could be spuriously obtaining our results. In this section, direct exporters are differentiated by their exports to rich markets, and the goods they export. In

⁵¹Other possible cases of such types of mis-identifications are also checked and not discussed here.

the second column, direct exporters that export more than 50 percent to rich and close countries are seen as selling to rich destinations. The third column shows 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. Columns 4 and 5 treat direct exporters that export different types of goods separately. The estimates in the fourth column show that even if goods that are more differentiated tend to be handled differently than more homogeneous goods in terms of the export modes, it is not biasing our results on the learning effects from different export modes. Column 5 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.

E.4 Selection and Other Firm Activities

In Table A.7 we examine the effects of other controls on productivity evolution, especially some unobserved heterogeneity that can bias our benchmark estimates. 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. Column 3 serves as a sensitivity test for self-selection into export modes, where we restrict the sample to firms that never switched export modes through out the whole period. In this way, we exclude potential selection effects that are not captured by the model's structure by excluding entry and exits. Columns 4 and 5 add controls for firms in investing in R&D or importing.⁵² 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. In the last column, we include interactions of time dummies and export modes. Note also that the learning-by-exporting patterns we see in the baseline estimation are robust throughout.

⁵²Column 4 uses a shorter panel (2005-2006) of data given the unavailability of R&D information in the earlier years of the data set.

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	<ul style="list-style-type: none"> ●Reg.K $\geq 2M$ ●Register 	<ul style="list-style-type: none"> ●Reg.K $\geq 2M$ ●Register 	<ul style="list-style-type: none"> ●Reg.K $\geq 2M$ Reg.K $\geq 1M$ if M&E ●Register 	<ul style="list-style-type: none"> ●Reg.K $\geq 2M$ Reg.K $\geq 1M$ if M&E ●Register 	<ul style="list-style-type: none"> ●Reg.K $\geq 0.5M$ ●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	<ul style="list-style-type: none"> ●Reg.K $\geq 0.5M$ ●Register 	<ul style="list-style-type: none"> ●Reg.K $\geq 0.5M$ ●Register
State or Public Owned Domestic Firm	<ul style="list-style-type: none"> ●Reg.K $\geq 5M$ Reg.K $\geq 3M$ if MW Reg.K $\geq 2M$ if M&E Reg.K $\geq 2M$ if Inst. ●Register 	<ul style="list-style-type: none"> ●Reg.K $\geq 5M$ Reg.K $\geq 3M$ if MW Reg.K $\geq 2M$ if M&E Reg.K $\geq 2M$ if Inst. ●Register 	<ul style="list-style-type: none"> ●Reg.K $\geq 3M$ Reg.K $\geq 2M$ if MW Reg.K $\geq 1M$ if M&E Reg.K $\geq 1M$ if Inst. ●Register 	<ul style="list-style-type: none"> ●Reg.K $\geq 3M$ Reg.K $\geq 2M$ if MW Reg.K $\geq 1M$ if M&E Reg.K $\geq 1M$ if Inst. ●Register 	<ul style="list-style-type: none"> ●Reg.K $\geq 0.5M$ ●Register
Private Owned Domestic Firm	<ul style="list-style-type: none"> ●Reg.K $\geq 8.5M$ Net Assets $\geq 8.5M$ Revenue $\geq 50M$ for 2 yrs Export $\geq 1M$ USD Revenue $\geq 30M$ if M&E ●Apply for Approval 	<ul style="list-style-type: none"> ●Reg.K $\geq 5M$ Reg.K $\geq 3M$ if MW Reg.K $\geq 2M$ if M&E Reg.K $\geq 2M$ if Inst. ●Apply for Approval 	<ul style="list-style-type: none"> ●Reg.K $\geq 3M$ Reg.K $\geq 2M$ if MW Reg.K $\geq 1M$ if M&E Reg.K $\geq 1M$ if Inst. ●Register 	<ul style="list-style-type: none"> ●Reg.K $\geq 3M$ Reg.K $\geq 2M$ if MW Reg.K $\geq 1M$ if M&E Reg.K $\geq 1M$ if Inst. ●Register 	<ul style="list-style-type: none"> ●Reg.K $\geq 0.5M$ ●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 un-matched producers.

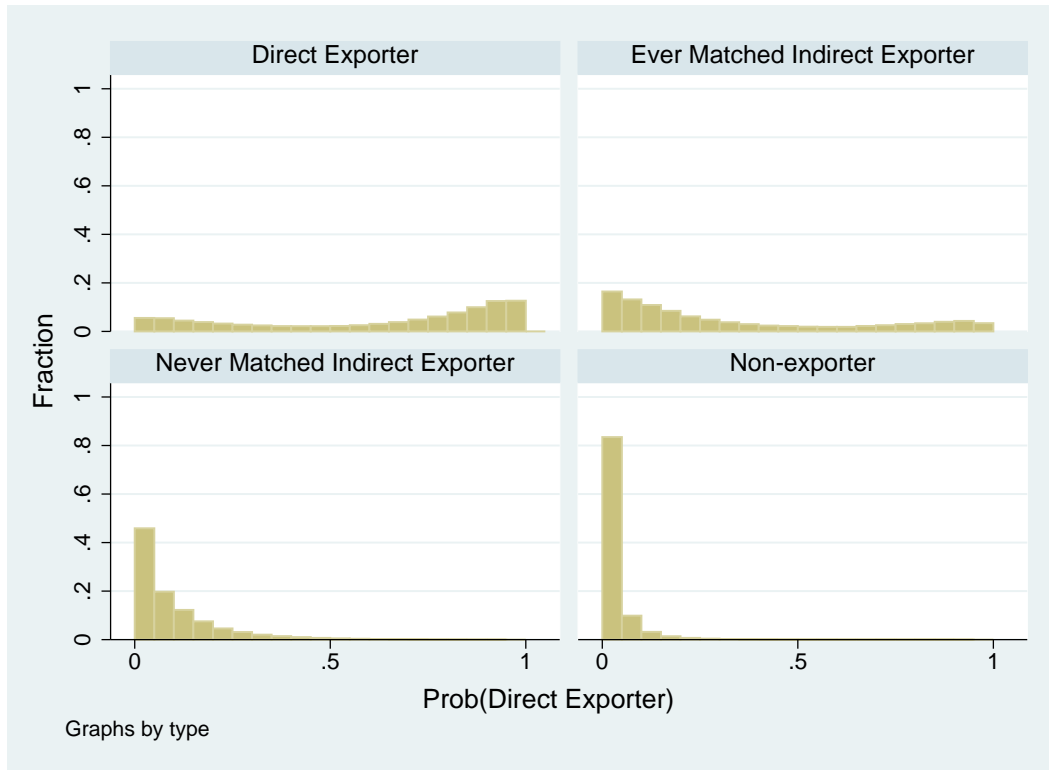


Figure A.1. Matched and Never Matched Indirect Exporters

Table A.4: Productivity Evolution: Alternative Productivity Measures

	(1)	(2)	(3)	(4)	(5)
	Benchmark TFP	Tornqvist Index	TFP _R	TFP _{VA}	TFP w/ Extra Controls
Constant α_0	0.542*** (0.032)	0.382*** (0.008)	-1.985*** (0.028)	0.223*** (0.008)	0.620*** (0.035)
ω_{t-1} α_1	0.303*** (0.068)	0.787*** (0.009)	-0.384*** (0.014)	0.781*** (0.008)	0.291*** (0.067)
ω_{t-1}^2 α_2	0.264*** (0.050)	0.039*** (0.004)	0.013 (0.008)	0.054*** (0.006)	0.243*** (0.043)
ω_{t-1}^3 α_3	-0.028** (0.012)	-0.009*** (0.001)	0.097*** (0.003)	-0.004*** (0.001)	-0.025*** (0.008)
Indirect Export _{t-1} α_4	0.007*** (0.002)	0.028*** (0.010)	-0.001 (0.001)	0.017** (0.007)	0.008*** (0.003)
Direct Export _{t-1} α_5	0.025*** (0.002)	0.093*** (0.009)	0.004*** (0.001)	0.076*** (0.007)	0.028*** (0.003)

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

Table A.5: Productivity Evolution: Alternative Definitions of Export Modes

	(1)	(2)	(3)	(4)	(5)
	Benchmark	Customs Delay	Producer Intermediary	Processing	DE Ratio
Constant	α_0	0.544*** (0.032)	0.497*** (0.026)	0.727*** (0.048)	0.542*** (0.032)
ω_{t-1}	α_1	0.301*** (0.068)	0.324*** (0.057)	0.173* (0.089)	0.305*** (0.068)
ω_{t-1}^2	α_2	0.264*** (0.050)	0.275*** (0.043)	0.282*** (0.054)	0.263*** (0.050)
ω_{t-1}^3	α_3	-0.028** (0.012)	-0.032*** (0.010)	-0.028** (0.010)	-0.028** (0.012)
Indirect Export $_{t-1}$	α_4	0.007*** (0.002)	0.007*** (0.002)	0.007*** (0.002)	
Direct Export $_{t-1}$	α_5	0.025*** (0.002)	0.024*** (0.002)	0.024*** (0.002)	
Intermediary $_{t-1}$			0.032*** (0.004)		
Processing $_{t-1}$				0.014*** (0.004)	
DE Ratio $_{t-1}$					0.039*** (0.004)

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

Table A.6: Productivity Evolution: Products and Destinations of Direct Exporting

	(1)	(2)	(3)	(4)	(5)
	Benchmark	GDP p/c	Hong Kong	Rauch	Prob(IE _{t-1})
Constant	0.542*** (0.032)	0.577*** (0.045)	0.578*** (0.045)	0.577*** (0.045)	0.577*** (0.045)
ω_{t-1}	0.303*** (0.068)	0.163* (0.086)	0.163* (0.086)	0.164* (0.086)	0.164* (0.086)
ω_{t-1}^2	0.264*** (0.050)	0.395*** (0.057)	0.395*** (0.057)	0.395*** (0.057)	0.395*** (0.057)
ω_{t-1}^3	-0.028** (0.012)	-0.061*** (0.013)	-0.061*** (0.013)	-0.061*** (0.013)	-0.061*** (0.013)
Indirect Export _{t-1}	0.007*** (0.002)	0.008*** (0.003)	0.008*** (0.003)	0.008*** (0.003)	0.008*** (0.003)
Direct Export _{t-1}	0.025*** (0.002)	0.021*** (0.004)	0.021*** (0.003)	0.014* (0.008)	0.018*** (0.003)
Rich Destination*DE _{t-1}		-0.002 (0.004)			
Hong Kong*DE _{t-1}			-0.010 (0.010)		
Differentiated Goods*DE _{t-1}				0.006 (0.008)	
Prob(IE _{t-1})*DE _{t-1}					0.008 (0.008)

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

Table A.7: Productivity Evolution: Self-Selection and Potential Unobserved Heterogeneity

		(1)	(2)	(3)	(4)	(5)	(6)
		Benchmark	Eligible Firms	Persistent Exporters	R&D	Import	Time-Dependent Learning
Constant	α_0	0.542*** (0.032)	0.233*** (0.009)	0.527*** (0.039)	1.261*** (0.085)	0.577*** (0.045)	0.546*** (0.032)
	ω_{t-1}	0.303*** (0.068)	0.437*** (0.026)	0.349*** (0.082)	-1.044*** (0.150)	0.164* (0.087)	0.298*** (0.068)
	ω_{t-1}^2	0.264*** (0.050)	0.412*** (0.032)	0.250*** (0.059)	1.101*** (0.093)	0.395*** (0.057)	0.268*** > (0.048)
	ω_{t-1}^3	-0.028** (0.012)	-0.096*** (0.014)	-0.032** (0.014)	-0.194*** (0.019)	-0.061*** (0.013)	-0.029** (0.012)
Indirect Export _{t-1}	α_4	0.007*** (0.002)	0.004* (0.002)	0.012*** (0.004)	0.004 (0.004)	0.008*** (0.003)	
Direct Export _{t-1}	α_5	0.025*** (0.002)	0.021*** (0.002)	0.029*** (0.003)	0.006* (0.003)	0.017*** (0.003)	
R&D _{t-1}					0.008 (0.006)		
R&D _{t-1} *IE _{t-1}					0.006 (0.014)		
R&D _{t-1} *DE _{t-1}					0.012 (0.010)		
Import _{t-1}						0.001 (0.004)	
Import _{t-1} *IE _{t-1}						0.001 (0.013)	
Import _{t-1} *DE _{t-1}						0.006 (0.007)	
IE _{t-1} *2001							-0.023*** (0.007)
DE _{t-1} *2001							-0.004 (0.007)
IE _{t-1} *2002							0.003 (0.006)
DE _{t-1} *2002							0.013** (0.006)
IE _{t-1} *2003							0.017*** (0.006)
DE _{t-1} *2003							0.032*** (0.006)
IE _{t-1} *2004							-0.016*** (0.006)
DE _{t-1} *2004							0.029*** (0.006)
IE _{t-1} *2005							0.012** (0.004)
DE _{t-1} *2005							0.026*** (0.004)
IE _{t-1} *2006							0.024*** (0.004)
DE _{t-1} *2006							0.029*** (0.004)

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