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Research Article

Lianjie Duan*

Export Cutoff Productivity, Uncertainty and Duration of Waiting for Exporting

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Abstract: Using China's transaction-level trade data and firm-level production data during 2000–2006, this study first estimates the duration of Chinese industrial enterprises' waiting for exporting. The results show that the average duration of waiting for exporting is 4.7 years and the median is 5 years. Besides, the hazard rate of export entry has the prominent positive duration dependence. Then, this study uses Cox proportional hazard model to analyse the impact of export cutoff productivity on the duration of waiting for exporting. The result indicates that the rise in the productivity threshold will significantly prolong the duration of waiting for exporting, and this conclusion is supported by a variety of robustness tests. In addition, the estimation result of hazard ratio shows that every 1% increase in productivity threshold will lead to a 0.1261% decrease in hazard rate of enterprises' export entry. Moreover, the heterogeneity test indicates that the effect of export cutoff productivity on duration of enterprises' waiting for exporting has the significant ownership and industry heterogeneity, but does not have the destination heterogeneity. Further, this study finds that China's accession to the World Trade Organisation helps to weaken the threshold effect of export cutoff productivity on the duration of Chinese enterprises' waiting for exporting, while the rise in the uncertainty will aggravate this effect. This study indicates that it should be the focus of government to actively promote the establishment of bilateral and multilateral free trade zones, to create a stable business environment for enterprises and to reduce the market uncertainty.

Keywords: export cutoff productivity, duration of waiting for exporting, heterogeneity, uncertainty

*** Corresponding author: Lianjie Duan,** School of Tourism & Business, Guangzhou Panyu Polytechnic, No. 1342 Shiliang Road, Guangzhou, 511483, China, e-mail: duanlj5@163.com, tel: +86-13751866156

1 Introduction

With the rise and development of new-new trade theory represented by Melitz (2003), the dynamics of enterprises' export entry and exit have gradually become a hot topic in the field of empirical research of international economics. At present, there are two main directions for the research on the dynamics of enterprises' export entry and exit. The first one is the research on the decision-making of enterprises' export entry and exit. The second one is the research on the duration related to enterprises' export behavior. The research on the decision-making of enterprises' export entry and exit has been very mature. The existing literature have discussed it from various perspectives. However, the research on the duration related to enterprises' export behavior is still a relatively new direction. Further, this new direction can be divided into two sub-directions. The first one is the research on the duration required for enterprises to enter the export market, i.e. the duration of enterprises' waiting for exporting. The second one is the research on the duration of enterprises' export. In the existing literature, more studies are about the duration of enterprises' export. The representative papers include Albornoz et al. (2016), Brenton et al. (2010), Esteve-Pérez et al. (2013), Peterson et al. (2018), Sui and Baum (2014), Straume (2017), Zhou et al. (2019), etc. But the studies on the duration of enterprises' waiting for exporting are relatively rare. Ilmakunnas and Nurmi (2010) and Lemessa et al. (2018) are the two representatives of a few papers focusing on this issue. However, only in few papers focusing on the duration of enterprises' waiting for exporting, there is still a lack of discussion from the perspective of export cutoff productivity. According to Melitz (2003), the exporting of micro-enterprises shows the "productivity threshold effect." Specifically, only those enterprises whose productivity is above the export cutoff productivity can engage in export trade, while those whose productivity is between the domestic cutoff productivity and the export cutoff productivity can only engage in the domestic sales, and those with lower productivity will have to be eliminated by the market. Obviously, the core idea of new-new trade theory means that the level of export cutoff productivity (i.e. productivity threshold) plays an important role in deciding the export entry of enterprises and then the duration of their waiting for exporting. Therefore, discussing the duration of enterprises' waiting for exporting from this perspective will enrich and perfect the research on the dynamics of enterprises' export entry. In addition, the Sino-US trade war has lasted for more than 4 years since March 2018. Obviously, in this context, it is also necessary to discuss the impact of export threshold on the export behavior of micro-enterprises.

In fact, the main reason why the perspective of productivity threshold has been lacking for a long time is the lack of effective methods to estimate enterprises' export cutoff productivity. Specifically, none of the main methods for estimating the threshold, such as those reported by Chan (1993), Caner and Hansen (2004), Gao et al. (2013), Hansen (1999, 2000), Seo and Linton (2007), etc., is applicable to the case where the dependent variable is a dummy one. However, fortunately, receiver operating characteristic (ROC) method provides us with an effective way to estimate the productivity threshold. At present, ROC method is widely applied in medicine, machine learning, and natural science. Its application in economics and management is very limited. The application is basically limited to the performance evaluation of classification models, such as those reported by Banasik and Crook (2007), Blanco et al. (2013), Buckinx and Van den Poel (2005), Crook and Banasik (2004), Cubiles-De-La-Vega et al. (2013), Chen et al. (2012), Verbeke et al. (2012), etc. Therefore, this study also contributes to the extended application of ROC method.

However, when the Non-Parametric ROC method is used for estimating enterprises' export cutoff productivity, a problem that should be noticed is the performance loss caused by the possible productivity paradox. Many empirical studies by authors, such as Dai et al. (2016), Gao and Yin (2013), Lu (2010), Lu et al. (2010), Yang and He (2014), etc., all show that the productivity of China's export enterprises is lower than that of its domestic-oriented enterprises. This means that there is a productivity paradox. At present, the preponderant explanation for productivity paradox is that China has a large number of enterprises engaged in processing trade (Dai et al., 2016; Gao & Yin, 2013). Yu (2015) argues that processing trade is China's most important export mode. The generally low productivity of processing trade enterprises lowers the average productivity level of China's export enterprises, which thus makes the productivity of export enterprises be lower than that of domestic-oriented enterprises. Thus, the productivity paradox arises. As is known to all, the export of processing trade enterprises mainly depends on the low wage of China's labor force, rather than their productivity level. Hence, it is meaningless to measure the export cutoff productivity of this part of the enterprises. At the same time, the classification performance of export cutoff productivity under the whole sample will be reduced if these enterprises are included. In view of this, this study excludes the pure processing trade enterprises from the sample.

The marginal contributions of this study are mainly as follows. First, this study explores the impact of export cutoff productivity on the duration of enterprises' waiting for exporting, which enriches the research on dynamics of enterprises' export entry. Second, this study examines the heterogeneity of impact of productivity threshold on duration of enterprises' waiting for exporting. Third, this study investigates the impact of China's accession to the World Trade Organisation (WTO) on the threshold effect that the duration of Chinese enterprises' waiting for exporting shows. Fourth, this study discusses the influence of the rising of uncertainty on this effect. Fifth, this study provides a novel threshold estimation method, which can be used for reference by other peers.

The remainder of the study is organised as follows. Section 2 gives the data source and processing. Section 3 describes the Non-Parametric estimation of the duration of Chinese industrial enterprises' waiting for exporting. Section 4 gives the setup of econometric model and the selection of explanatory variables. Section 5 depicts the classification performance of export cutoff productivity under the whole sample. Section 6 investigates the impact of productivity threshold on duration of enterprises' waiting for exporting, including benchmark estimation and a variety of robustness tests. Section 7 further examines the ownership, industry, and destination heterogeneity of impact of productivity threshold on enterprises' export entry dynamics. Section 8 explores whether China's accession to the WTO weakens the productivity threshold effect. Section 9 discusses whether the rising of uncertainty aggravates the productivity threshold effect. Section 10 gives the conclusion.

2 Data

The duration of waiting for exporting that this study defines is how long it takes for the enterprises to start exporting. It is called "failure event" or "failure" that enterprises start to enter the export market. Before the survival analysis is carried out, the censoring problems should be dealt with, including left-censoring and right-censoring. Since the data set used in this study covers the period from 2000 to 2006, it is impossible to know whether enterprises export outside the sample period. If an enterprise exports in 2000, the year when it starts to enter the export market cannot be accurately confirmed. If this is ignored, the duration of enterprises' waiting for exporting will be underestimated, which thus results in the left-censoring problem. If there is no failure event during a certain period, that is, an enterprise is always a non-exporter during the period, it is considered that the right-censoring problem has arisen. Since the survival analysis is still valid in the presence of right-censoring, this problem does not need to be worried about. As for the left-censoring problem, the processing of this study is that if an enterprise exports in 2000, the corresponding duration of waiting for exporting is replaced by a missing value. For example, if an enterprise exports in 2000, does not export during 2001–2004, and exports again in 2005, the corresponding processing is that the duration of waiting for exporting in 2000 is set to a missing value, and that in 2001–2004 is calculated normally, which means that the enterprise enters the export market again after 4 years. One problem that needs to be explained is that the starting year used for measuring the duration of waiting for exporting is the certain one during the sample period rather than the establishment one of an enterprise. The reason for this is that one of the databases in this article, Chinese Industrial Enterprises Database, sets a threshold for non-state-owned enterprises to enter the survey. Specifically, only the non-state-owned enterprises with annual sales of RMB 5 million or more can be included in this database. Therefore, if the establishment year of an enterprise is taken as the starting one for measuring the duration of waiting for exporting, it is very much likely to overestimate the duration of waiting for exporting. In fact, this processing is consistent with Ilmakunnas and Nurmi (2010).

This study is based on two groups of highly disaggregated firm-level data. The first group of data is the firm-level production data from Chinese Industrial Enterprises Database constructed by China's National Bureau of Statistics. The second group of data is the transaction-level trade data from China's General Administration of Customs. The sample used in this study is obtained from the matching of these two groups of data. When using the matching data to examine the enterprises' export behavior, the sample period of the existing literature is usually from 2000 to 2006 (Cui & Liu, 2018; Dai et al., 2016; Fan et al. 2018; Rodriguez-Lopez & Yu, 2017; Schminke & Van Biesebroeck, 2013; Tian & Yu, 2015; Yu, 2015). In view of this and the data availability, this study also adopts the sample during the same period to carry out the research. So, the duration required for enterprises to enter the export market should be between 1 and 7 years. This study merges the two groups of data using the method of Dai et al. (2016). Finally, the sample obtained in this study covers 607,282 observations. The number of successfully matched observations is 52,206, and among them, the yearly results are 4,505, 5,573, 6,463, 8,050, 12,474, and 15,141, respectively. Furthermore, the successfully matched yearly exporters are 2,057, 2,539, 2,938, 3,716, 5,604, and 6,751, respectively.[1] For the detailed cleaning and matching of two groups of data, refer to the study by Duan (2022).

3 Non-Parametric Estimation of Duration of Enterprises' Waiting for Exporting

The survival and hazard functions are often used to describe the distribution characteristics of duration in survival analysis. Let T denote the duration of enterprise's maintaining its non-export status, and take a value of t. The duration is complete if the enterprise has a transition from non-export state to export state over a period of time, which is denoted as $c_j = 1$. The duration is right-censoring if there is no failure event over a period of time, which is denoted as $c_j = 0$. The survival function of enterprise i is given as follows:

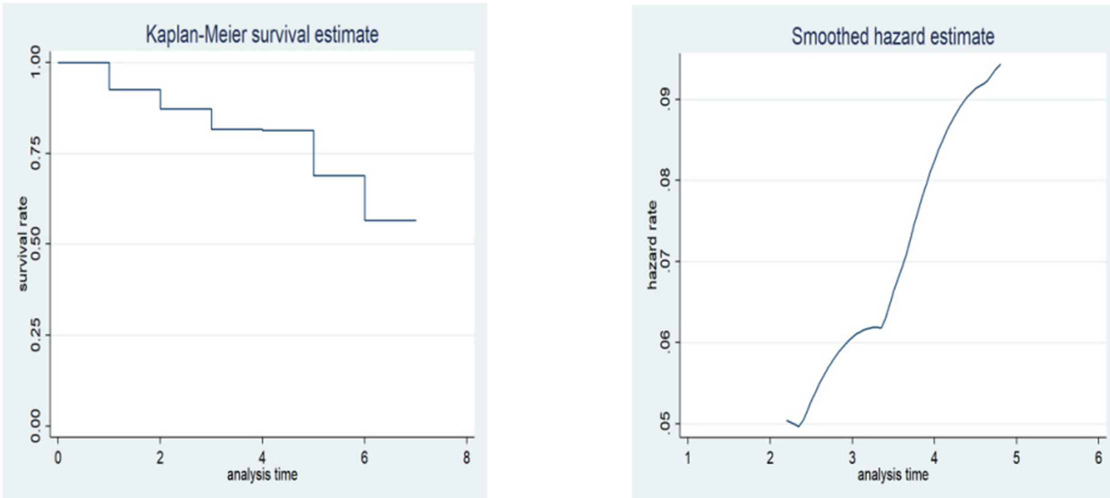
$$S_i(t) = \Pr(T_i > t). \tag{1}$$

The Non-Parametric estimation of survival function can be obtained through KM product limit estimator.

$$\hat{S}(t) = \prod_{k=1}^{t} \frac{N_k - D_k}{N_k}, \tag{2}$$

where N_k refers to the number of durations of waiting for exporting at risk when the length of duration is k. D_k refers to the number of "failures" observed in the same duration, i.e. the number of enterprises that start to enter the export market.

1 The calculation of export cutoff productivity is based on total observations, while the survival analysis is only based on successfully matched observations. In addition, due to the lack of key indicators for measuring total factor productivity, the observations in 2004 cannot be applied to the subsequent regression analysis, and thus the result of data matching of this year is not reported. The interested readers can ask the author for it.



(a) (b)

Figure 1: Survival and hazard curves for duration of waiting for exporting. (a) Survival curve. (b) Hazard curve.

The hazard function represents the probability that an enterprise changes from a non-export state in period $t-1$ to an export state in period t.

$$h_i(t) = \Pr(t-1 < T_i \le t | T_i > t-1) = \frac{\Pr(t-1 < T_i \le t)}{\Pr(T_i > t-1)}. \tag{3}$$

The Non-Parametric estimation of hazard function can be obtained through

$$\hat{h}(t) = \frac{D_k}{N_k}. \tag{4}$$

Based on the Non-Parametric estimators of survival and hazard functions, this study has carried out the overall estimation, the sub-ownership estimation, the sub-industry estimation, and the sub-destination estimation in turn.

3.1 Overall Results

Figure 1 shows the KM survival and hazard curves. The survival curve in Figure 1a indicates that with the prolonging of duration of waiting for exporting, the survival rate of enterprises gradually declines. The KM estimate shows that the average duration required for the enterprises to enter the export market is 4.7 years, and the median is 5 years. The proportion of enterprises that take more than 1 year to enter the export market is 92.61%, and that taking over 5 years is 68.91%. The hazard curve in Figure 1b indicates that with the prolonging of duration, the hazard rate gradually increases, that is, the possibility of enterprises' starting to enter the export market gradually increases. Therefore, the hazard function of duration of waiting for exporting shows a significant positive duration dependence. This indicates that the enterprises will make various efforts over time to gradually cultivate their export capacities, including conducting an investigation on international market, producing high-quality products that meet the needs of international market, carrying out advertising, and so on, so as to improve the possibility of their own export participation and shorten the duration of waiting for exporting.

3.2 Results by Ownership

Figure 2 shows the KM survival curves by ownership, including home and foreign enterprises.[2] This figure indicates that the survival rate of home enterprises is higher than that of foreign enterprises, which means that it is more difficult for home enterprises to enter the export market than foreign enterprises. The possible reason is that foreign enterprises usually have better international market channels and more rich export experiences. Compared with home enterprises, it is easier for foreign enterprises to enter the export market. The KM estimate shows

2 Home enterprises include state-owned enterprises and private enterprises, while foreign enterprises include foreign-invested enterprises and Hong Kong, Macao, and Taiwan-invested enterprises.

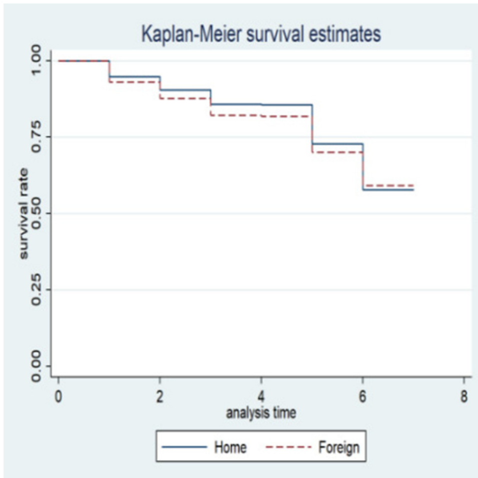


Figure 2: Survival curves by ownership.

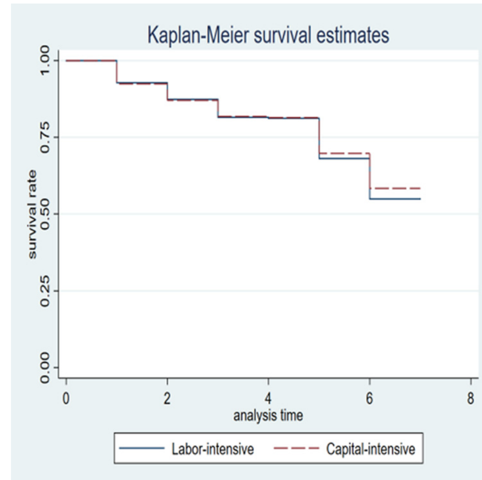


Figure 3: Survival curves by industry.

that the average duration required for home enterprises to enter the export market is 5.13 years, while 4.63 years for foreign enterprises. In addition, the median duration for home enterprises is 6 years, which is higher than 5 years for foreign enterprises. Furthermore, 94.77% of home enterprises take more than 1 year to enter the export market and 72.79% take more than 5 years, while the corresponding proportions of foreign enterprises are 93.06 and 70.03%, respectively. Besides, it can be found that the proportion of home enterprises that take more than 6 years to enter the export market is slightly lower than that of foreign enterprises. The possible reason is that home enterprises, especially state-owned ones, can benefit from more export incentive policies than foreign enterprises, which may be conducive to shortening the duration of their waiting for exporting to no more than 6 years.

3.3 Results by Industry

Figure 3 shows the KM survival curves by industry, including labor-intensive and capital-intensive industries.[3] This figure shows that when the duration of waiting for exporting is less than 4 years, the survival rate of labor-intensive enterprises is almost the same as that of capital-intensive ones. However, when the duration exceeds 5 years, the survival rate of labor-intensive enterprises will be significantly lower than that of capital-intensive ones. This indicates that in the first few years, both labor-intensive and capital-intensive enterprises face almost the same difficulties in exploiting the international market, but after a period of efforts, the labor-intensive enterprises are more likely to enter the export market earlier and become exporters. The possible reason is that the labor-intensive enterprises mainly rely on the low-cost advantage based on cheap labor to participate in the export competition, while the capital-intensive enterprises mainly rely on the technological advantage based on a large amount of R&D expenditures to participate in the export competition. Generally speaking, it is much more difficult to achieve technological breakthroughs than to reduce labor costs, especially for developing countries. Hence, the labor-intensive enterprises are more likely to take the lead in entering the international market to participate in the export competition. The KM estimate shows that the proportion of labor-intensive enterprises that take more than 4 years to enter the export market is almost the same as that of capital-intensive ones. The former is 92.80%, followed by 92.43% for capital-intensive enterprises. However, 58.33% of capital-intensive enterprises need more than 6 years to enter the export market, while the proportion for labor-intensive enterprises is 54.89%, significantly lower than the former.

3.4 Results by Destination

Figure 4 shows the KM survival curves by destination, including the Unites States, the European Union, and

3 The industrial sectors with more than median capital intensity are classified as capital-intensive industry, otherwise, they are classified as labor-intensive one. The measurement of capital intensity *KL ratio* is shown in Section 4.2. Furthermore, the 2-digit codes related to labor-intensive industry include 17–21, 24, 29, 34–35, 39–43. The 2-digit codes related to capital-intensive industry include 6–11, 13–16, 22–23, 25–28, 30–33, 36–37, 44-46.

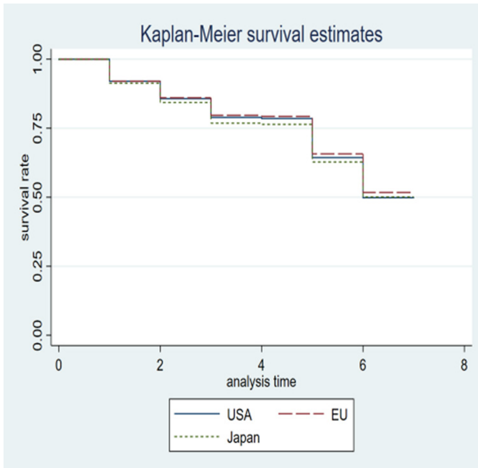


Figure 4: Survival curves by destination.

Japan.[4] This figure indicates that the survival rate of enterprises that export to Japan is relatively lower, while that of enterprises that export to the USA and the EU is relatively higher. Obviously, this fact is consistent with what Melitz (2003) expects. According to Melitz (2003), the transportation cost is an important component of export cutoff productivity, and has a positive correlation with it. The enterprises exporting to Japan only need to bear lower transportation costs due to short geographical distance, while those exporting to the USA and the EU have to bear relatively higher transportation costs due to long geographical distance. This means that the enterprises that export to the USA and the EU have to cross the higher productivity threshold, while those that export to Japan face the lower productivity threshold. Hence, the duration of enterprises' waiting for exporting to Japan is relatively shorter, while that of enterprises' waiting for exporting to the USA and the EU is relatively longer. In addition, it can be found that the survival rate of enterprises exporting to the EU is slightly higher than that of the USA. The possible reason is that EU still enjoys the retention clauses until 2004 after China's accession to the WTO. That is to say, it can continue to impose quantitative restrictions or high tariffs on import products from China during the period. As a result, compared with enterprises exporting to the USA, those exporting to the EU will take longer to enter its market. The KM estimate shows that 79.67% of enterprises exporting to the EU take more than 3 years to enter its market, followed by 78.91% of those exporting to the USA and 76.84% of those exporting to Japan. The proportions of enterprises that take more than 5 years to enter the target market are 65.70, 64.36, and 62.76%, respectively.

4 The EU consists of 25 member states in 2004, including France, Germany, Italy, Netherlands, Belgium, Luxembourg, Denmark, Ireland, UK, Greece, Spain, Portugal, Austria, Finland, Sweden, Poland, The Czech Republic, Hungary, Slovakia, Slovenia, Cyprus, Malta, Latvia, Lithuania, and Estonia.

4 Econometric Model and Variables

4.1 Econometric Model

Considering the extensive application of Cox proportional hazard model in survival analysis and its good flexibility and robustness that the specific form of baseline hazard function does not need to be presupposed, this study uses this model to analyse the effect of export cutoff productivity on the duration of waiting for exporting. Specifically, Cox proportional hazard model assumes that the enterprises face various kinds of risk shocks, and let $h(t, X_i)$ is the hazard rate of enterprise i with the risk vector X_i. When the duration is t, the hazard function can be expressed as follows:

$$h(t, X_i) = h_0(t) g(X_i'\beta), \tag{5}$$

where $h_0(t)$ is the baseline hazard function, depending on duration t but not on risk vector X_i. Thus, it is the same for each individual in the population. The risk vector $X_i' = (X_1, X_2, \cdots, X_p)$ contains p covariates and is a set of all explanatory variables. $\beta = (\beta_1, \beta_2, \cdots, \beta_p)$ is the parameter vector. $g(X_i'\beta)$ represents the heterogeneity of enterprise i and is usually expressed as an exponential form as follows:

$$g(X_i'\beta) = \exp(X_i'\beta). \tag{6}$$

Substituting equation (6) in equation (5) yields the following:

$$h(t, X_i) = h_0(t) \exp(X_i'\beta). \tag{7}$$

Suppose that there are two enterprises, i and j, whose risk vectors are X_i and X_j, respectively. Obviously, the hazard ratio between i and j is as follows:

$$\frac{h(t, X_i)}{h(t, X_j)} = \frac{h_0(t) \exp(X_i'\beta)}{h_0(t) \exp(X_j'\beta)} = \exp[(X_i - X_j)'\beta], \tag{8}$$

where the hazard ratio is independent of duration t, but only depends on $X_i - X_j$. This feature makes it unnecessary to assume the specific form of baseline hazard function $h_0(t)$. Cox regression based on partial likelihood estimation can provide consistent and asymptotically normal parameter estimators.

4.2 Variables

4.2.1 Control Variables

Total Factor Productivity (*TFP*). Melitz (2003) points out that only enterprises with high productivity can enter the export market, while those with middle productivity can only operate in the domestic market, and those with low productivity will have to be eliminated by the market. In view of this, this study expects that the estimated coefficient of total factor productivity will be greater than 1, which means that the higher the productivity, the higher the probability of occurrence of failure event. So, higher productivity is more helpful for enterprises to shorten the duration of their waiting for exporting. This study adopts the method suggested by Ackerberg et al. (2015) for estimating enterprises' productivity. This method is more precise than those proposed by Levinsohn and Petrin (2003) and Olley and Pakes (1996), solving the endogeneity and collinearity problems effectively.

Scale. There are three main measurement indicators for scale of enterprises in the existing literature – sales revenue, total assets, and number of employees. Sun and Li (2011) point out that using different indicators to measure scale of enterprises has no significant impact on the result of empirical estimation. In view of this, this study selects the logarithm of number of employees to represent the scale of enterprises. This study expects that the estimated coefficient of enterprises' scale will be greater than 1, which means that with the expansion of enterprises' scale, the duration of their waiting for exporting will be shortened.

Capital Intensity (*KL ratio*). According to the factor endowment theory, the abundant factors in a country are relatively cheaper, while the scarce ones are relatively more expensive. Therefore, as a country with abundant labor, China's comparative advantage in exports lies in labor-intensive products. The increase in capital intensity means that more capitals that are relatively more expensive are used in production, inevitably increasing the cost of products and reducing the competitiveness. Thus, the increase in capital intensity will reduce the hazard rate of enterprises' entry into export market and prolong the duration required for the start of exporting. In view of this, this study expects the estimated coefficient of capital intensity to be less than 1. This study uses the logarithm of ratio of real net fixed-asset balance to the number of employees as capital intensity. The real net fixed-asset balance is obtained by deflating the current balance using the price index of fixed-asset investment (2,000 = 100).[5]

Profit Margin (*PS ratio*). This study defines the profit margin as the ratio of profit to sales revenue. Generally speaking, the enterprises with higher profit margin are able to invest more in the exploiting of international market, and are more likely to take the lead in breaking through the fixed export cost to shorten the duration required for the start of exporting. So, this study expects the estimated coefficient of profit margin to be greater than 1. This means that with the increase in the enterprises' profit margin, the hazard rate of their starting to enter the export market will also increase, and thus the enterprises with higher profit margin are more likely to enter the export market earlier.

Output value of new products (*New*). The production and sales of new products usually originate from the R&D investment and innovation of enterprises. The higher output value of new products means stronger innovation ability and higher production efficiency, which is more conducive to enterprises' exploiting in the international market. This study expects that the estimated coefficient of output value of new products will be greater than 1, which means that the higher the output value of new products, the higher the hazard rate of their starting to enter the export market. Thus, with the increase in the output value of new products, the duration of enterprises' waiting for entry into export market will be shortened. Since the output value of new products of many enterprises are 0, in order to avoid a large number of missing values when taking logarithm, this study uses the logarithm of real output value of new products plus 1 as the output value of new products. The real output value of new products is obtained by deflating the current output value using the producer price index (2,000 = 100).[6]

Age. The older enterprises often tend to accumulate more experiences in production and sales and have better reputation. Therefore, the older enterprises are more likely to enter the export market earlier. In view of this, it is necessary to introduce this factor into the econometric model. This study expects the estimated coefficient of enterprises' age to be greater than 1, which means that the older the enterprises, the higher the hazard rate of

5 The price index of fixed-asset investment is sourced from http://www.stats.gov.cn/.

6 The producer price index is sourced from http://www.stats.gov.cn/.

their starting to enter the export market. This study uses the difference between the current year and the year when the enterprises were established to measure their age.

Ownership dummies, year and region fixed effects. a. *Ownership dummies* (*SOE* and *foreign*). If an enterprise is a state-owned one, the value of SOE is 1, otherwise, 0. If an enterprise is a foreign-invested one, the value of *foreign* is 1, otherwise, 0. Generally speaking, the state-owned enterprises are sheltered by the planned economic system for a long time, lack of incentives for technological learning and innovation, and of low production and operation efficiency, which makes it difficult to open up the international market. Unlike the state-owned enterprises, the foreign-invested ones tend to have better management performance and more advanced production technology (Helpman et al., 2004; Keller & Yeaple, 2009), which makes it easier for them to enter the export market. This study expects the estimated coefficient of *SOE* to be less than 1 and that of *foreign* to be greater than 1, which indicates that compared with other types of enterprises, the hazard rate of state-owned enterprises' entering the export market is relatively low, and that of foreign-invested enterprises is relatively high. Therefore, the duration required for state-owned enterprises to enter the international market is usually long, while that for foreign-invested enterprises is usually short. b. *Year fixed effects* (*year dummies*). The introduction of year fixed effects is mainly to control the changes in external macroeconomic environment and the changes in enterprises in the time dimension. c. *Region fixed effects* (*region dummies*). The region fixed effects involve 31 provincial dummies.

4.2.2 Core Explanatory Variable: Export Cutoff Productivity

According to Melitz (2003), the export cutoff productivity is essentially the productivity boundary between the exporters and non-exporters, which means that when an enterprise's productivity is above the export cutoff productivity, it is an exporter, otherwise, a non-exporter. The ROC method is a Non-Parametric statistical technique that effectively estimates the optimal boundary of the test variable. When estimating export cutoff productivity using this method, the export dummy *exdum* needs to be set as the state variable and the *TFP* needs to be set as the test variable. The optimal boundary, i.e. the export cutoff productivity, is identified by using Youden's (1950) J statistic that is also known as Youden index. Specially speaking, the productivity threshold that maximises the Youden index is the optimal productivity threshold, i.e. the export cutoff productivity. Thus, the ROC method is the simple and effective one for estimating the export cutoff productivity. Since the export cutoff productivity proposed by new-new trade theory is the industry-level productivity boundary, this study follows this definition to examine the impact of productivity threshold on the duration of enterprises' waiting for exporting. In this study, the export cutoff productivity is denoted as $Cutoff_{jt}$, i.e. the export cutoff productivity of industry j in the t-th year. With the rising of export cutoff productivity, the productivity required for enterprises to enter the export market is also improved, which makes it more difficult for them to enter the export market. So, the hazard rate of enterprises' starting to enter the export market will be reduced and the duration of their waiting for exporting will be prolonged. In view of this, this study expects the estimated coefficient of export cutoff productivity to be less than 1. For a detailed introduction to ROC method, refer to the study by Duan (2022).

5 Description of Export Cutoff Productivity Based on the Whole Sample

Figure 5 indicates that the export cutoff productivity under the whole sample is 6.302, the sensitivity and specificity of which are 0.685 and 0.673, respectively. When hypothesizing all the enterprises satisfying $tfp_{it} \geq 6.302$ to be exporters, the ratio of correctly classified exporters

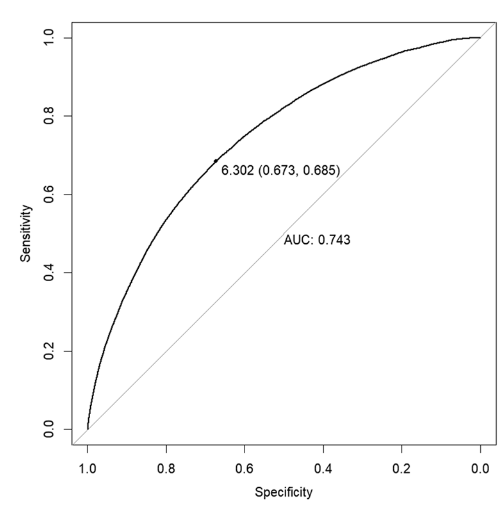


Figure 5: ROC curve based on the whole sample.

(i.e. true positives) is 68.5%. When hypothesizing all the enterprises satisfying $tfp_{it} < 6.302$ to be non-exporters, the ratio of correctly classified non-exporters (i.e. true negatives) is 67.3%. Furthermore, the accuracy of 0.6734 means that 67.34% of total enterprises are correctly classified. In addition, the calculation shows that the quantile that corresponds to the export cutoff productivity is 65.86%. This means that the top 34.14% of total enterprises may be more likely to become exporters. However, it has to be pointed out that none of sensitivity, specificity, accuracy and AUC is very high. The possible reason is that there are many factors that could determine enterprises' export participation. The productivity is not the only factor although it plays a major role. As a result, some enterprises with high productivity may operate only in the domestic market, while some enterprises with low productivity may engage in exports instead.

6 Impact of Export Cutoff Productivity on Duration of Enterprises' Waiting for Exporting

6.1 Benchmark Results

In Cox regression, there are two points to be noted. First, the test of proportional hazard assumption should be implemented. Second, the tied failures should be dealt with. The partial likelihood function is independent of exact failure time, and only related to the sequence of failure events. Therefore, if the failure events of two or more individuals occur at the same time, i.e. the tied failures occur, it is not determined that which individual's failure event first occurs. As a result, the risk set at the failure time could not be accurately identified. In addition, if the proportional hazard assumption is not satisfied, the application of Cox proportional hazard model is inappropriate. The Breslow's (1974) method is used to deal with the tied failures and this method is an approximation of exact-marginal calculation. As for the proportional hazard assumption, this study adopts the graphic method to test it. To be specific, the fitting plot of every covariate's Schoenfeld residual against time will be drawn to examine whether its slope is 0. The results of test of proportional hazard assumption are shown in Figure 6.

Figure 6 shows that all the slopes are very close to 0, which indicates that the correlation between each Schoenfeld residual and time is not significant after proportional adjustment. So, the proportional hazard assumption is satisfied and adopting Cox proportional hazard model for survival estimation is appropriate.

The column (1) of Table 1 reports the benchmark results. The estimated coefficient of export cutoff productivity (*Cutoff*) is less than 1 and statistically significant at a 1% level, which is in line with the expectation. This indicates that the improvement in export cutoff productivity does reduce the hazard rate of enterprises' starting to enter the export market, and thus prolongs the duration of their waiting for exporting. The rising of export cutoff productivity improves the productivity level required for the enterprises to enter the export market, which means that it is more difficult for them to enter the export market. So, the hazard rate of enterprises' starting to enter the export market will be reduced and thus the duration of their waiting for exporting will be prolonged. Obviously, this conclusion strongly supports the self-selection hypothesis proposed by the new-new trade theory. In addition, the hazard ratio of 0.8739 indicates that for every 1% increase in export cutoff productivity, the hazard rate of enterprises' starting to enter the export market will decrease by 0.1261%.[7]

Among control variables, the estimated coefficient of *TFP* is significantly greater than 1 at a 1% level, which is consistent with the expectation of this study and indicates that the higher the productivity, the higher the hazard rate of enterprises' starting to enter the export market. Thus, the improvement in the total factor productivity could help to shorten the duration of their waiting for exporting. As expected, the estimated coefficient of enterprises' scale is also greater than 1 and statistically significant at a 1% level. This shows that the expansion of enterprises' scale will shorten the duration of their waiting for exporting. The estimated coefficient of capital intensity (*KL ratio*) is significantly less than 1 at a 1% level, which is in line with the expectation. The capital factor of China, as a country with abundant labor, is relatively more scarce and more expensive. Thus, when using more and more capitals in production, the cost of products is bound to rise and thus, the competitiveness will be weakened. So, with the increase in the capital intensity, the hazard rate of enterprises' entering the export market will be reduced, and the duration required for their starting exporting will be prolonged. Contrary

7 Here is the original export cutoff productivity, not the logarithmic.

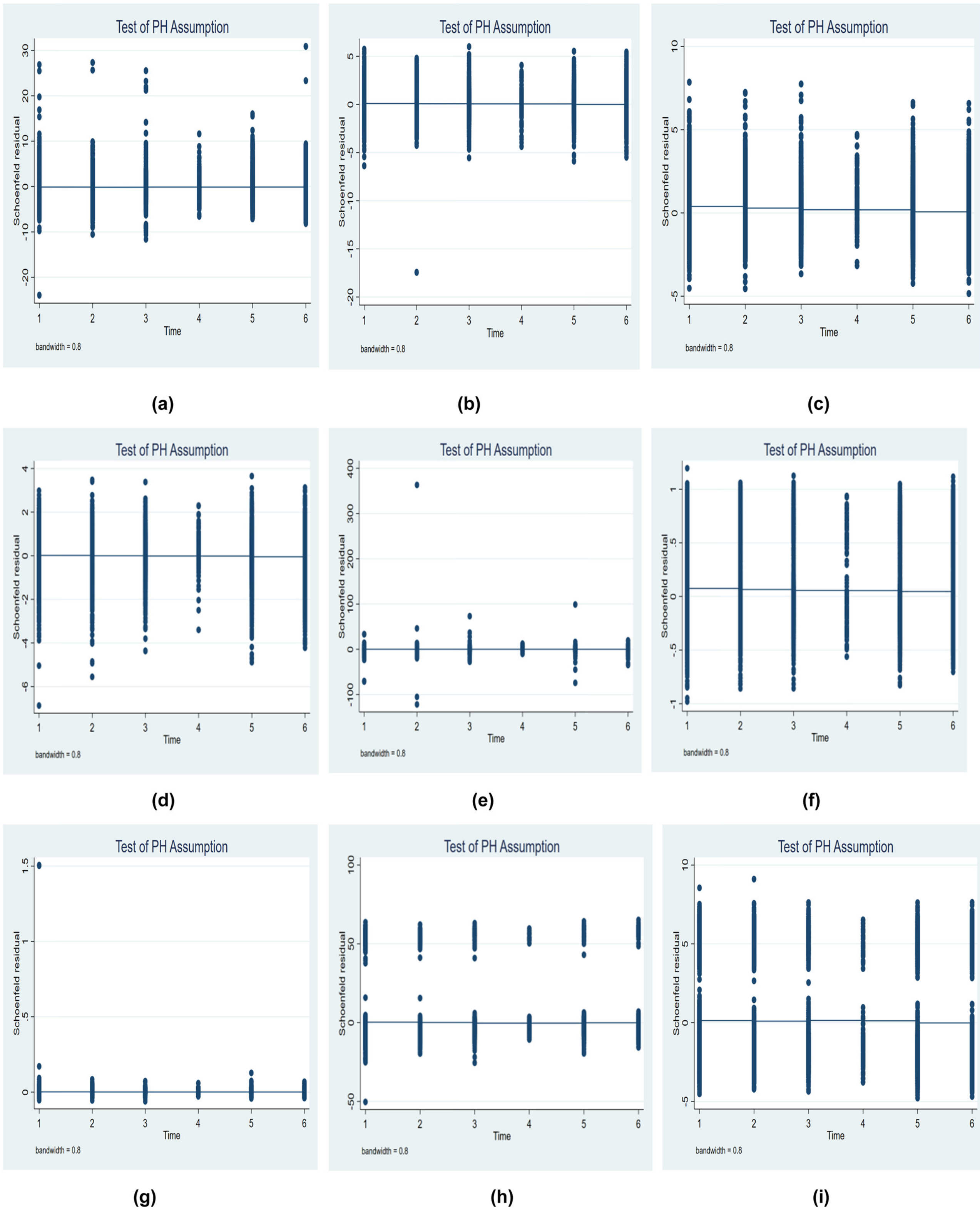


Figure 6: Test of proportional hazard assumption. (a) Cutoff, (b) TFP, (c) Scale, (d) KL ratio, (e) PS ratio, (f) New, (g) Age, (h) SOE, and (i) Foreign.

Table 1: Benchmark results and robustness tests based on alternative samples

	Full sample	First spell	One spell only	Gap-adjusted
Cutoff	0.8739***	0.8680***	0.8734***	0.8709***
	(−5.88)	(−5.69)	(−5.22)	(−5.76)
TFP	1.0558***	1.0415***	1.0441***	1.0470***
	(5.67)	(4.01)	(4.02)	(4.62)
Scale	1.2320***	1.1927***	1.1916***	1.2054***
	(22.23)	(17.65)	(16.82)	(19.26)
KL ratio	0.9745***	0.9589***	0.9505***	0.9652***
	(−3.78)	(−5.83)	(−6.66)	(−5.03)
PS ratio	1.0460	1.0037	0.9586	1.0314
	(1.27)	(0.11)	(−1.26)	(0.78)
New	1.0639***	1.0634***	1.0631***	1.0646***
	(25.88)	(23.63)	(22.45)	(25.04)
Age	1.0009***	1.0008***	1.0009***	1.0009***
	(4.13)	(3.56)	(3.16)	(3.73)
SOE	1.0423	1.0068	1.0329	1.0133
	(0.65)	(0.10)	(0.41)	(0.20)
Foreign	1.0552**	1.0403*	1.0602**	1.0523**
	(2.42)	(1.69)	(2.39)	(2.23)
Year dummies	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes
Log likelihood	−159634.63	−138375.97	−110238.17	−146822.76
Observations	44,248	40,948	37,632	43,011

Note: ***, **, and * denote the significance at a 1, 5, and 10% level, respectively. The z-statistics in parentheses are based on robust standard errors (corrected for clustering at firm-level).

to the expectation, the regression coefficient of profit margin (*PS ratio*) is not statistically significant. The possible reason is that although the profit margin increases, the enterprises use a large amount of profits for shareholder's dividend, and thus the growth of funds for exploiting the international market is limited. As expected, the regression coefficient of output value of new products (*New*) is greater than 1 and statistically significant at a 1% level. This shows that the increase in output value of new products could improve the hazard rate of enterprises' entering the export market, thus helping to shorten the duration of their waiting for exporting. The estimated coefficient of enterprises' age is significantly greater than 1 at a 1% level, which is consistent with the expectation. This indicates that the older enterprises can enter the export market earlier by virtue of more experience and better reputation accumulated over a long period. Unexpectedly, the regression coefficient of dummy for state-owned enterprises (*SOE*) is not statistically significant. The possible reason is that although the production and operation efficiency of state-owned enterprises is low, they can usually enjoy various preferences and subsidies from the government. The former is not conducive to the exploiting of international market, while the latter is helpful for enterprises to enter the export market early. Under the interaction of two opposite forces, it is not surprising that the regression coefficient is not statistically significant. In line with the expectation, the estimated coefficient of dummy for foreign-invested enterprises (*Foreign*) is significantly greater than 1 at a 5% level. The estimation results indicate that the hazard rate of foreign-invested enterprises is 5.52% higher than that of other types.

6.2 Robustness Tests

6.2.1 Robustness Test I: Alternative Samples

The benchmark results are based on the full sample with multiple spells.[8] In order to examine the robustness of benchmark results, this study investigates the sub-sample only with the first spell, the sub-sample with single spell and the gap-adjusted full sample, respectively. For example, an enterprise is a non-exporter during the period 2000–2001, starts to enter the export market in the year 2002 and keeps exporting until 2003, exits from the export market in the year 2004, and then reenters the export

8 The multiple spells refer to a period of time in which a non-export enterprise becomes an exporter after a period of efforts, and then is forced to withdraw from the export market. Furthermore, after another waiting duration, it reenters the export market.

market in the year 2005 and keeps exporting until 2006. So, the duration 2000–2001 is the first spell. Obviously, the only spell is the first one, but the first spell is not necessarily the only one. As for the gap-adjusted full sample, this study does not regard a 1 year gap between two adjacent spells as the real exit from export market, and therefore, connects these two spells and adjusts the spell length accordingly. In the above example, the enterprise waits only 1 year when it reenters the export market in the year 2005. After the gap adjustment, the enterprise continuously exports during the period 2002–2006. Hence, the original multiple spells are transformed into a single spell. There are two main reasons for a 1 year gap adjustment. First, it is likely that the trade transactions of certain year are not recorded in time. Second, it is also likely that the enterprise is not included in the database because its annual sales of that year are less than RMB 5 million, but in fact, it is still exporting (Mao & Sheng, 2013). The columns (2–4) of Table 1 report the estimation results of sub-sample only with first spell, sub-sample with single spell, and gap-adjusted full sample, respectively. The results show that the estimated coefficients of export cutoff productivity are always less than 1, all significant at a 1% level, and all very close to that of benchmark results. Therefore, this again indicates that the rising of productivity threshold does reduce the hazard rate of enterprises' entering the export market, and then prolongs the duration of their waiting for exporting. Among control variables, the sign, significance, and size of estimated coefficient of any other variable except for profit margin are very consistent with the benchmark results. Hence, the benchmark results of this study are very robust.

6.2.2 Robustness test II: Alternative Methods for Estimating TFP

In addition to Ackerberg et al. (2015), Levinsohn and Petrin (2003), Olley and Pakes (1996), and Wooldridge (2009) also propose their own methods for estimating TFP. In order to examine the robustness of benchmark results more broadly, this section presents the estimation results based on TFP_OP, TFP_LP, and TFP_WRDG, respectively. Naturally, when using another method to estimate TFP, the export cutoff productivity will be also re-estimated. The export cutoff productivities corresponding to TFP_OP, TFP_LP, and TFP_WRDG are denoted as Cutoff_OP, Cutoff_LP, and Cutoff_WRDG, respectively. Table 2 reports the estimation results using alternative methods for estimating TFP. The results show that the regression coefficients of export cutoff productivity are always significantly less than 1 at a 1% level, which is completely consistent with the benchmark results. Hence, the basic conclusion of this study still holds. That is, the rising of export cutoff productivity will reduce the hazard rate of enterprises' starting to enter the export market and prolong the duration of their waiting for exporting. Among the control variables, the sign and significance of regression coefficients of a part of them only in the model based on TFP_OP are different from the benchmark results, while the estimation results based on TFP_LP and TFP_WRDG are fully consistent with the benchmark results. Thus, on the whole, the regression results of control variables in the benchmark estimation are still robust.

6.2.3 Robustness Test III: Newly Established Enterprises

As mentioned above, the survival analysis using raw data directly will face the censoring problems, including left-censoring and right-censoring. The right-censoring problem does not need to be worried about, while the left-censoring problem should be dealt with. In fact, the left-censoring includes two situations in this study. First, it is impossible

Table 2: Regressions using alternative methods for estimating TFP

	Cutoff_OP + TFP_OP	**Cutoff_LP + TFP_LP**	**Cutoff_WRDG + TFP_WRDG**
Cutoff	0.7173***	0.9137***	0.8995***
	(−8.46)	(−3.80)	(−4.42)
TFP	2.1358***	1.0542***	1.0551***
	(10.03)	(5.51)	(5.58)
Scale	0.7424***	1.1748***	1.1720***
	(−5.98)	(15.65)	(15.07)
KL ratio	0.8564***	0.9774***	0.9781***
	(−9.74)	(−3.34)	(−3.26)
PS ratio	1.0885***	1.0469	1.0456
	(3.14)	(1.31)	(1.28)
New	1.0643***	1.0641***	1.0639***
	(26.26)	(25.96)	(25.89)
Age	1.0014***	1.0010***	1.0010***
	(6.42)	(4.54)	(4.52)
SOE	1.7689***	1.0350	1.0352
	(6.76)	(0.54)	(0.54)
Foreign	0.9413**	1.0541**	1.0535**
	(−2.40)	(2.37)	(2.34)
Year dummies	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes
Log likelihood	−159585.15	−159645.02	−159641.67
Observations	44,248	44,248	44,248

Note: ***, **, and * denote the significance at a 1, 5, and 10% level, respectively. The *z*-statistics in parentheses are based on robust standard errors (corrected for clustering at firm-level).

to determine whether the year 2000 is the initial one for enterprises to enter the export market when they have the positive exports in 2000. Second, it is impossible to know whether the enterprises start waiting for exporting in 2000 when they do not export this year. Actually, this study only deals with the first kind of left-censoring. The reason why the second kind of left-censoring is ignored is mainly to avoid a large loss of samples. If the enterprises that do not export in 2000 are deleted from the sample, a large number of observations will be lost. In this way, the sample that consists of only the newly established enterprises during 2000–2006 will be very small, and the authority of regression results may be questioned. In fact, ignoring the second kind of left-censoring in this study follows Ilmakunnas and Nurmi (2010). However, inadequate dealing with left-censoring is imperfect after all. In view of this, this section performs the robustness tests using the sample consisting of only the newly established enterprises during 2000–2006. Obviously, using it can avoid all the left-censoring problems although this sample is quite small. Table 3 presents the corresponding estimation results. All the results show that the sign and significance of the estimated coefficients of both the core variable and control variables are in line with the benchmark results. This indicates that the benchmark results in this study are still valid under the incomplete dealing with left-censoring.

7 Heterogeneous Analysis

In order to investigate the heterogeneity of impact of productivity threshold on the duration of enterprises' waiting for exporting, this study provides the sub-ownership results, the sub-industry results and the sub-destination results, respectively.

7.1 Sub-Ownership Results

Table 4 reports the sub-ownership results. The results show that the improvement in export cutoff productivity not only reduces the hazard rate of home enterprises' starting to enter the export market but also reduces that of foreign enterprises' starting to enter the export market. Therefore, both the duration of home enterprises' waiting for exporting and that of foreign enterprises' waiting for exporting will be prolonged. But at the same time, it is found that the increase in productivity threshold has a stronger inhibition effect on foreign enterprises' export entry. Specifically, first, the estimated coefficient of foreign enterprises is more significant than that of home enterprises. Second, the estimated coefficient of foreign enterprises is lower than that of home enterprises. In fact, this is also supported by Chow test that is used for testing

Table 3: Estimations using newly established enterprises during 2000–2006

	Full sample	First spell	One spell only	Gap-adjusted
Cutoff	0.9214**	0.9005***	0.8901***	0.9114**
	(−2.30)	(−2.81)	(−3.06)	(−2.54)
TFP	1.0780***	1.0746***	1.0879***	1.0758***
	(4.76)	(4.43)	(5.17)	(4.57)
Scale	1.2461***	1.2128***	1.2144***	1.2238***
	(14.17)	(12.21)	(12.14)	(12.90)
KL ratio	0.9709***	0.9625***	0.9585***	0.9645***
	(−2.86)	(−3.63)	(−3.97)	(−3.47)
PS ratio	0.9677	0.9481	0.8962	0.9413
	(−0.28)	(−0.43)	(−0.85)	(−0.50)
New	1.0615***	1.0585***	1.0565***	1.0598***
	(14.88)	(13.87)	(13.40)	(14.39)
Age	1.0509***	1.0245**	1.0240**	1.0357***
	(4.99)	(2.44)	(2.34)	(3.53)
SOE	0.7523	0.7790	0.7998	0.7569
	(−1.19)	(−1.03)	(−0.91)	(−1.18)
Foreign	1.0636*	1.0605*	1.0855**	1.0600*
	(1.85)	(1.74)	(2.41)	(1.74)
Year dummies	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes
Log likelihood	−48579.31	−45404.32	−40519.54	−46593.43
Observations	15,507	14,814	14,217	15,290

Note: ***, **, and * denote the significance at a 1, 5, and 10% level, respectively. The z-statistics in parentheses are based on robust standard errors (corrected for clustering at firm-level).

Table 4: Sub-ownership results

	Home	Foreign
Cutoff	0.9198*	0.8086***
	(−1.93)	(−6.64)
Control variables	Yes	Yes
Year dummies	Yes	Yes
Region dummies	Yes	Yes
Log likelihood	−37949.30	−70828.43
Observations	11,883	22,690

Note: ***, **, and * denote the significance at a 1, 5, and 10% level, respectively. The *z*-statistics in parentheses are based on robust standard errors (corrected for clustering at firm-level).
Due to space limitation, Table 4 does not report the results of sub-sample only with first spell, sub-sample with single spell, and gap-adjusted full sample. The interested readers can ask the author for them.

the significance of coefficient difference between the groups. Chow test indicates that the *p*-value of coefficient of interaction term *Domestic* × *Cutoff* is 0.001, which shows that the coefficient difference of *cutoff* between home and foreign enterprises is statistically significant at a 1% level. Here *Domestic* is a dummy, which equals to 1 if an enterprise is a home enterprise, otherwise, 0. The heterogeneity of estimated coefficients of export cutoff productivity means that when the productivity threshold increases, the foreign enterprises may have to wait longer to enter the export market than the home enterprises. The possible reason is that the home enterprises, especially the state-owned ones, can usually enjoy various subsidies and preferences from government when they engage in export trade, which helps to weaken the restriction effect of productivity threshold on their export entry.

7.2 Sub-Industry Results

Table 5 reports the sub-industry results. The results show that the improvement in the export cutoff productivity has a significant inhibition effect on the hazard rate of entering the export market of both the labor-intensive and capital-intensive enterprises, thus making the duration of waiting for exporting of all types of enterprises be prolonged.

However, it can be seen that the inhibition effect has the significant industry heterogeneity. Specifically, the inhibition effect is stronger in capital-intensive industry, followed by labor-intensive industry. Chow test also confirms this conclusion. The test result shows that the *p*-value of coefficient of interaction term *Industry* × *Cutoff* is 0.068. So, the null hypothesis that the coefficients of *Cutoff* have no difference between the two groups can be rejected at

Table 5: Sub-industry results

	Labor-intensive	Capital-intensive
Cutoff	0.9218**	0.8809***
	(−2.12)	(−4.36)
Control variables	Yes	Yes
Year dummies	Yes	Yes
Region dummies	Yes	Yes
Log likelihood	−77118.39	−71467.33
Observations	22,098	22,150

Note: ***, **, and * denote the significance at a 1, 5, and 10% level, respectively. The *z*-statistics in parentheses are based on robust standard errors (corrected for clustering at firm-level).
Due to space limitation, Table 5 does not report the results of sub-sample only with first spell, sub-sample with single spell, and gap-adjusted full sample. The interested readers can ask the author for them.

the 10% significance level. The dummy *Industry* is equal to 1 if an enterprise is capital-intensive, otherwise, 0. A reasonable explanation for industry heterogeneity is that compared with capital-intensive industry, it is less difficult for labor-intensive industry to improve the productivity level. This is because the main production factor in labor-intensive industry is labor, and the promotion of labor productivity can be achieved through strengthening of business management, increase in staff training investment, and so on. Hence, when the productivity threshold rises, it is more likely for labor-intensive industry to leap over higher productivity threshold. So, the improvement in productivity threshold has a small inhibition effect on labor-intensive industry. However, it is more difficult to improve the productivity of capital as main production factor in capital-intensive industry. The improving of capital productivity mainly depends on the updating of production equipment based on technological breakthroughs. Obviously, this is very difficult.

7.3 Sub-Destination Results

Table 6 reports the sub-destination results. The United States, European Union, and Japan are China's three most important export markets except Hong Kong during the sample period. Taking 2006 as an example, these four markets account for 65.27% of China's total exports, and the other three markets excluding Hong Kong accounts for 49.23%. The main reason why Hong Kong is excluded is that Hong Kong mainly engages in entrepot trade, and its imports do not reflect the real local market demand. Table 6 indicates that the improvement in export cutoff productivity has a significant inhibition effect on hazard

Table 6: Sub-destination results

	USA	EU	Japan
Cutoff	0.9005***	0.9097***	0.8848***
	(−3.19)	(−3.29)	(−3.59)
Control variables	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes
Log likelihood	−69554.13	−87645.88	−61465.25
Observations	18,152	23,093	16,599

Note: ***, **, and * denote the significance at a 1, 5, and 10% level, respectively. The z-statistics in parentheses are based on robust standard errors (corrected for clustering at firm-level).
Due to space limitation, Table 6 does not report the results of sub-sample only with first spell, sub-sample with single spell, and gap-adjusted full sample. The interested readers can ask the author for them.

rate of enterprises' exporting to any market. That is to say, the increase in productivity threshold will prolong the duration of enterprises' waiting for exporting to any market. However, it seems that there is no significant heterogeneity among markets, because all the regression coefficients of export cutoff productivity are very close. In fact, this conclusion is also supported by Chow test. The test results are as follows. First, when taking USA as the benchmark group, both the regression coefficient of interaction term $EU \times Cutoff$ and that of interaction term $Japan \times Cutoff$ are not statistically significant, and the corresponding p-values are 0.235 and 0.334, respectively. Second, when taking EU as the benchmark group, the regression coefficient of $Japan \times Cutoff$ is not statistically significant, and its p-value is 0.984. The dummy EU equals to 1 if an enterprise exports to EU, otherwise, 0. The dummy $Japan$ equals to 1 if an enterprise exports to Japan, otherwise, 0. Thus, the coefficients of $Cutoff$ have no significant difference among the three markets. The possible reason is that the three regions have similar levels of economic development and similar market demands. Hence, the inhibition effect of export cutoff productivity on enterprises' waiting for exporting has no significant heterogeneity among markets.

8 Does China's Accession to the WTO Weaken the Productivity Threshold Effect?

On November 10, 2001, China finally joined the WTO after 15 years of hard work. This means that China can enjoy the same rights as other WTO members and have the fair-trade opportunity. Obviously, China's accession to the WTO creates a convenient and fair-trade environment for Chinese enterprises. China's exports have been growing rapidly after its accession to the WTO, and since 2009, China has jumped from the sixth largest exporter in 2001 to the largest exporter, thus playing an important role in the world trade. In order to investigate whether the accession to the WTO weakens the threshold effect of export cutoff productivity on duration of Chinese enterprises' waiting for exporting, this section constructs the following econometric model:

$$\begin{aligned} h(t, x, \beta) = h_0(t)g(&\beta_1 Cutoff_{jn} + \beta_2 WTO_n \\ &+ \beta_3 WTO_n \times Cutoff_{jn} \\ &+ \sum_{l\geq 4} \beta_l Control^l_{ijkn} + \upsilon_n + \upsilon_k + \varepsilon_{ijkn}), \end{aligned} \tag{9}$$

where WTO_n is the dummy related to accession to the WTO. If $n \geq 2002$, its value is 1, otherwise, 0. $WTO_n \times Cutoff_{jn}$ is the product of dummy WTO_n and productivity threshold $Cutoff_{jn}$, and $Control^l_{ijkn}$ represents some control variable. The control variables in expression (9) are the same as those in expression (5). υ_n and υ_k represent the year and region fixed effects, respectively. ε_{ijkn} is the random disturbance term. i, j, k, and n denote the enterprise, industry, region, and year, respectively.

Table 7 reports the estimation results of expression (9). Considering the robustness, in addition to benchmark results based on the method reported by Ackerberg et al. (2015), Table 7 also reports the results based on the other three methods, including Levinsohn and Petrin (2003), Olley and Pakes (1996) and Wooldridge (2009). According to Table 7, the estimated coefficients of interaction term ($WTO \times Cutoff$) in the four cases are all significantly greater than 1, indicating that China' accession to the WTO does weaken the threshold effect of export cutoff productivity on the duration of Chinese enterprises' waiting for exporting. The accession to WTO enables Chinese enterprises to engage in export trade freely under the basic principles advocated by WTO, including non-discrimination, transparency, and fair competition. Obviously, this helps to weaken the threshold effect of export cutoff productivity on the duration of waiting for exporting.

9 Uncertainty and Productivity Threshold Effect

Since 2016, the world has entered a state of considerable uncertainty. The UK leaves the EU. Donald Trump, a businessman, is elected as the president of United States.

Table 7: Impact of accession to the WTO on productivity threshold effect

	Cutoff_ACF + TFP_ACF	Cutoff_OP + TFP_OP	Cutoff_LP + TFP_LP	Cutoff_WRDG + TFP_WRDG
Cutoff	0.6328***	0.6160***	0.7550***	0.7831***
	(−5.78)	(−4.11)	(−2.83)	(−3.47)
WTO × *Cutoff*	1.4244***	1.2207*	1.2179**	1.1623**
	(4.44)	(1.70)	(1.98)	(2.13)
Control variables	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes
Log likelihood	−138375.80	−110320.37	−110355.53	−138392.40
Observations	40,964	37,650	37,650	40,964

Note: ***, **, and * denote the significance at a 1, 5, and 10% level, respectively. The *z*-statistics in parentheses are based on robust standard errors (corrected for clustering at firm-level).
The reason why the regression coefficient of dummy *WTO* is not reported is that its effect on hazard rate of enterprises' entering the export market is absorbed by year fixed effects.

The refugee problem is getting worse in Europe. Turkey's foreign military expansion is escalating. Populism is emerging around the world. Coronavirus Disease 2019 (COVID-19) caused by a novel coronavirus is spreading globally. The war between Russia and Ukraine is still ongoing. The comprehensive strategic competition between China and the United States is getting more and more fierce. All of these increase the risk of the global economy. In this context, this study assumes that it is necessary to explore the impact of uncertainty on threshold effect of export cutoff productivity on the duration of enterprises' waiting for exporting. So, this section constructs the following hazard model:

$$h(t, x, \lambda) = h_0(t) g(\lambda_1 Cutoff_{jn} + \lambda_2 Uncertainty_{jn} + \lambda_3 Uncertainty_{jn} \times Cutoff_{jn} + \sum_{l \geq 4} \lambda_l Control^l_{ijkn} + v_n + v_k + \mu_{ijkn}), \tag{10}$$

where $Uncertainty_{jn}$ is the uncertainty faced by industry j in the nth year, and it is expressed by the variance of the daily closing price of listed industrial enterprises. $Uncertainty_{jn} \times Cutoff_{jn}$ is the product of uncertainty $Uncertainty_{jn}$ and productivity threshold $Cutoff_{jn}$. In addition, the control variables used in expression (10) are also the same as those in expression (5). Further, the calculation of uncertainty is as follows:

$$Uncertainty_{jn} = \sum_{i=1}^{N_{jn}} \omega_{ijn} \mathrm{var}(p_{ijnm}), \tag{11}$$

where $\omega_{ijn} = \bar{V}_{ijn}/\bar{V}_{jn}$ is the proportion of the average market value of the listed enterprise i in industry j in the $n$thyear to the average total market value of industry j in the $n$thyear, and is the weight used for measuring the uncertainty. Here $\bar{V}_{ijn} = \sum_{m=1}^{M_{ijn}} V_{ijnm}/M_{ijn}$ and $\bar{V}_{jn} = N_{jn} \times \bar{V}_{ijn}$. V_{ijnm} is the market value of enterprise i on the mth trading day of the nth year. M_{ijn} is the total number of trading days of enterprise i in the

Table 8: Impact of uncertainty on productivity threshold effect

	Cutoff_ACF + TFP_ACF	Cutoff_OP + TFP_OP	Cutoff_LP + TFP_LP	Cutoff_WRDG + TFP_WRDG
Cutoff	0.8830***	0.7747***	0.9127***	0.8873***
	(−4.18)	(−4.94)	(−2.87)	(−3.98)
Uncertainty	1.0648***	1.0390***	1.0773***	1.0495***
	(3.70)	(2.59)	(3.51)	(2.91)
Uncertainty × *Cutoff*	0.9907***	0.9915**	0.9897***	0.9935***
	(−3.57)	(−2.54)	(−3.47)	(−2.82)
Control variables	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes
Log likelihood	−122718.92	−97962.94	−97982.91	−122725.66
Observations	36,361	33,399	33,399	36,361

Note: ***, **, and * denote the significance at a 1, 5, and 10% level, respectively. The *z*-statistics in parentheses are based on robust standard errors (corrected for clustering at the firm-level).

nth year. N_{jn} is the number of listed enterprises of industry j in the nth year. Furthermore, $\mathrm{var}(p_{ijnm})$ is the variance of daily closing price of enterprise i in the nth year, and can be obtained as follows:

$$\mathrm{var}(p_{ijnm}) = \frac{\sum_{m=1}^{M_{ijn}} \left(p_{ijnm} - \frac{\sum_{m=1}^{M_{ijn}} p_{ijnm}}{M_{ijn}} \right)^2}{M_{ijn} - 1}, \tag{12}$$

where p_{ijnm} is the closing price of enterprise i on the mth trading day of the nth year. In addition, the data used for calculating uncertainty are from China Stock Market and Accounting Research (CSMAR) Database.

Table 8 reports the estimation results of expression (10). It can be seen that the estimated coefficients of interaction term *Uncertainty* × *Cutoff* in the four cases are all significantly less than 1, showing that the increase in uncertainty will aggravate the threshold effect of export cutoff productivity on the duration of enterprises' waiting for exporting. If the increase in productivity threshold is accompanied by the rise of uncertainty, the enterprises will encounter double obstacles in entering the export market. On one hand, the enterprises have to cross the higher export threshold. On the other hand, they have to bear the higher export risk. Compared with single export obstacle, the double export obstacles will make it more difficult for the enterprises to enter the export market. Therefore, the increase in uncertainty will aggravate the impact of productivity threshold on the duration of waiting for exporting.

10 Conclusion

In the existing literature on the duration related to enterprises' export behavior, more studies are about the duration of export trade, while the analyses of duration of waiting for exporting are relatively rare. Even in the few articles that focus on the duration of enterprises' waiting for exporting, there is still a lack of discussion from the perspective of export cutoff productivity. However, according to Melitz (2003), only the enterprises whose productivity is above the export cutoff productivity can engage in export trade, which indicates that the export cutoff productivity has an important impact on the duration of enterprises' waiting for exporting. So, analyzing the duration of enterprises' waiting for exporting from this perspective will enrich and perfect the research on dynamics of enterprises' export entry. This study first carries out a Non-Parametric estimation of duration of Chinese industrial enterprises' waiting for exporting. Then, based on estimation of export cutoff productivity by applying the Non-Parametric ROC method, this study uses Cox proportional hazard model to investigate the impact of productivity threshold on the duration of enterprises' waiting for exporting. In addition, this study further examines the ownership, industry, and destination heterogeneity of impact of productivity threshold on the dynamics of export entry. Furthermore, this study explores the influences of China's accession to the WTO and the uncertainty on threshold effect of export cutoff productivity on the duration of waiting for exporting. Specifically, the conclusions are as follows:

(1) The average duration of enterprises' waiting for exporting is 4.7 years and the median is 5 years. The proportion of enterprises whose duration of waiting for exporting exceeds 1 year is 92.61%, while it is 68.91% over 5 years. In addition, with the prolonging of duration, the hazard rate of export entry gradually increases, which indicates that the hazard function of duration of enterprises' waiting for exporting shows a significant positive duration dependence.

(2) The improvement in export cutoff productivity reduces the hazard rate of enterprises' starting to enter the export market, and thus prolongs the duration of their waiting for exporting. Furthermore, this conclusion is supported by a variety of robustness tests, including estimations using alternative samples, those using alternative methods for estimating TFP and those using the sample consisting of newly established enterprises during the sample period. In addition, according to the estimation result of hazard ratio, it can be found that for every 1% increase in productivity threshold, the hazard rate of enterprises' entering the export market will decrease by 0.1261%.

(3) The impact of export cutoff productivity on the duration of enterprises' waiting for exporting has the significant ownership and industry heterogeneity, but does not have the destination heterogeneity. First, the increase in productivity threshold has a stronger prolonging effect on the duration of waiting for exporting of foreign enterprises than that of home enterprises. In addition, the prolonging effect is stronger in capital-intensive industry, followed by labor-intensive industry. However, it does not have the significant destination heterogeneity.

(4) China's accession to the WTO helps to weaken the productivity threshold effect that the duration of Chinese enterprises' waiting for exporting shows, while the rising of uncertainty will aggravate this effect. In addition, this finding is rather robust and can be supported by a variety of robustness tests using alternative methods for estimating TFP.

This study gives us some important inspirations. First, making great efforts to improve the productivity is still the basic way for enterprises to shorten the duration required for opening up the international market. In addition, considering that the threshold for entry into the US market has been raised, Chinese enterprises should actively seek other alternative markets, such as European market, Southeast Asian market, and South American market. Furthermore, it should be the focus of the government to accelerate the negotiation and establishment of various free trade zones, to construct a stable business environment and to lower the market uncertainty.

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References

Ackerberg, D. A., Caves, K., & Frazer, G. (2015). Identification properties of recent production function estimators. *Econometrica*, *86*(3), 2411–2451. doi: 10.3982/ECTA13408.

Albornoz, F., Fanelli, S., & Hallak, J. C. (2016). Survival in export markets. *Journal of International Economics*, *102*, 262–281. doi: 10.1016/j.jinteco.2016.05.003.

Breslow, N. (1974). Covariance analysis of censored survival data. *Biometrics*, *30*(1), 89–99. doi: 10.2307/2529620.

Banasik, J., & Crook, J. (2007). Reject reference, augmentation, and sample selection. *European Journal of Operational Research*, *183*(3), 1582–1594. doi: 10.1016/j.ejor.2006.06.072.

Buckinx, W., & Van den Poel, D. (2005). Customer base analysis: Partial defection of behaviourally loyal clients in a non-contractual FMCG retail setting. *European Journal of Operational Research*, *164*(1), 252–268. doi: 10.1016/j.ejor.2003.12.010.

Blanco, A., Pino-Mejías, R., Lara, J., & Rayo, S. (2013). Credit scoring models for the microfinance industry using neural networks: Evidence from Peru. *Expert Systems with Applications*, *40*(1), 356–364. doi: 10.1016/j.eswa.2012.07.051.

Brenton, P., Saborowski, C., & von Uexkull, E. (2010). What explains the low survival rate of developing country export flows? *The World Bank Economic Review*, *24*(3), 474–499. doi: 10.1093/wber/lhq015.

Chan, K. S. (1993). Consistency and limiting distribution of the least squares estimator of a threshold autoregressive model. *The Annuals of Statistics*, *21*(1), 520–533. doi: 10.1214/aos/1176349040.

Crook, J., & Banasik, J. (2004). Does reject reference really improve the performance of application scoring models? *Journal of Banking & Finance*, *28*(4), 857–874. doi: 10.1016/j.jbankfin.2003.10.010.

Cubiles-De-La-Vega, M. D., Blanco-Oliver, A., Pino-Mejías, R., & Lara-Rubio, J. (2013). Improving the management of microfinance institutions by using credit scoring models based on statistical learning techniques. *Expert Systems with Applications*, *40*(17), 6910–6917. doi: 10.1016/j.eswa.2013.06.031.

Chen, Z. Y., Fan, Z. P., & Sun, M. H. (2012). A hierarchical multiple kernel support vector machine for customer churn prediction using longitudinal behavioral data. *European Journal of Operational Research*, *223*(2), 461–472. doi: 10.1016/j.ejor.2012.06.040.

Caner, M., & Hansen, B. E. (2004). Instrumental variable estimation of a threshold model. *Econometric Theory*, *20*(5), 813–843. doi: 10.1017/s0266466604205011.

Cui, Y. Q., & Liu, B. (2018). Manufacturing servitisation and duration of exports in China. *The World Economy*, *41*(6), 1695–1721. doi: 10.1111/twec.12614.

Duan, L. J. (2022). Estimation of export cutoff productivity of Chinese industrial enterprises. *PLOS ONE*, *17*(11), 1–16. doi: 10.1371/journal.pone.0277842.

Dai, M., Maitra, M., & Yu, Y. M. (2016). Unexceptional exporter performance in China? The role of processing trade. *Journal of Development Economics*, *121*, 177–189. doi: 10.1016/j.jdeveco.2016.03.007.

Esteve-Pérez, S., Requena-Silvente, F., & Pallardó-Lopez, V. J. (2013) The duration of firm-destination export relationships: Evidence from Spain, 1997-2006. *Economic Inquiry*, *51*(1), 159–180. doi: 10.1111/j.1465-7295.2012.00460.x.

Fan, H. C., Li, Y. A., & Yeaple, S. R. (2018). On the relationship between quality and productivity: Evidence from China's accession to the WTO. *Journal of International Economics*, *110*, 28–49. doi: 10.1016/j.jinteco.2017.10.001.

Gao, J., Tjøstheim, D., & Yin, Y. J. (2013). Estimation in threshold autoregressive models with a stationary and a unit root regime. *Journal of Econometrics*, *172*(1), 1–13. doi: 10.1016/j.jeconom.2011.12.006.

Gao, Y., & Yin, X. P. (2013). *Trade media, processing trade, and unsolved export puzzle: Theory and empirical analysis*. *Working Paper*.

Hansen, B. E. (1999). Threshold effects in non-dynamic panels: Estimation, testing and inference. *Journal of Econometrics*, *93*(2), 345–368. doi: 10.1016/S0304-4076(99)00025-1.

Hansen, B. E. (2000). Sample splitting and threshold estimation. *Econometrica*, *68*(3), 575–603. doi: 10.1111/1468-0262.00124.

Helpman, E., Melitz, M. J., & Yeaple, S. R. (2004). Export versus FDI with heterogeneous firms. *The American Economic Review*, *94*(1), 300–316. doi: 10.2307/3592780.

Ilmakunnas, P., & Nurmi, S. (2010). Dynamics of export market entry and exit. *The Scandinavian Journal of Economics*, *112*(1), 101–126. doi: 10.1111/j.1467-9442.2009.01596.x.

Keller, W., & Yeaple, S. R. (2009). Multinational enterprises, international trade and productivity growth: Firm-level evidence from the United States. *The Review of Economics and Statistics*, *91*(4), 821–831. doi: 10.1162/rest.91.4.821.

Lu, D. (2010). *Exceptional exporter performance? Evidence from Chinese manufacturing firms*. *Working Paper*.

Lu, J. Y., Lu, Y., & Tao, Z. G. (2010). Exporting behavior of foreign affiliates: Theory and evidence. *Journal of International Economics*, *81*, 197–205. doi: 10.1016/j.jinteco.2010.03.002.

Levinsohn, J., & Petrin, A. (2003). Estimating production functions using inputs to control for unobservables. *Review of Economic Studies*, *70*(2), 317–341. doi: 10.1111/1467-937x.00246.

Lemessa, S. D., Watabaji, M. D., & Yismaw, M. A. (2018). The analysis of entry of Ethiopian enterprises into the export-markets and the associated factors: The duration approach. *Journal of Small Business and Enterprise Development*, *25*(2), 241–255. doi: 10.1108/JSBED-01-2018-0003.

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, *71*(6), 1695–1725. doi: 10.1111/1468-0262.00467.

Mao, Q. L., & Sheng, B. (2013). Trade liberalization, firms' heterogeneity and dynamics of exports: Evidence from Chinese firms. Management World (*in Chinese*), *3*, 48–67.

Olley, G. S., & Pakes, A. (1996). The dynamics of productivity in the telecommunications equipment industry. *Econometrica*, *64*(6), 1263–1297. doi: 10.2307/2171831.

Peterson, E. B., Grant, J. H., & Rudi-Polloshka, J. (2018). Survival of the fittest: Export duration and failure into United States fresh fruit and vegetable Markets. *American Journal of Agricultural Economics*, *100*(1), 23–45. doi: 10.1093/ajae/aax043.

Rodriguez-Lopez, A., & Yu, M. J. (2017). *All-around trade liberalization and firm-level employment: Theory and evidence from China*. *Working Paper*.

Straume, H. M. (2017). Here today, gone tomorrow: The duration of Norwegian salmon exports. *Aquaculture Economics & Management*, *21*(1), 88–104. doi: 10.1080/13657305.2017.1262477.

Sui, S., & Baum, M. (2014). Internationalization strategy, firm resources and the survival of SMEs in the export market. *Journal of International Business Studies*, *45*(7), 821–841. doi: 10.1057/jibs.2014.11.

Sun, L. Y., & Li, R. L. (2011). Do financing constraints restrain Chinese firms' export participation?. *China Economic Quarterly* (*in Chinese*), *11*(1), 231–252.

Seo, M. H., & Linton, O. (2007). A smoothed least squares estimator for threshold regression models. *Journal of Econometrics*, *141*(2), 704–735. doi: 10.1016/j.jeconom.2006.11.002.

Schminke, A., & Van Biesebroeck, J. (2013). Using export market performance to evaluate regional preferential policies in China. *Review of World Economics*, *149*(2), 343–367. doi: 10.1007/s10290-012-0145-y.

Tian, W., & Yu, M. J. (2015). Processing trade, export intensity, and input trade liberalization: Evidence from Chinese firms. *Journal of the Asia Pacific Economy*, *20*(3), 444–464. doi: 10.1080/13547860.2015.1054169.

Verbeke, W., Dejaeger, K., Martens, D., Hur, J., & Baesens, B. (2012). New insights into churn prediction in the telecommunication sector: A profit driven data mining approach. *European Journal of Operational Research*, *218*(1), 211–229. doi: 10.1016/j.ejor.2011.09.031.

Wooldridge, J. M. (2009). On estimating firm-level production functions using proxy variables to control for unobservables. *Economics Letters*, *104*(3), 112–114. doi: 10.1016/j.econlet.2009.04.026.

Youden, W. J. (1950). Index for rating diagnostic tests. *Cancer*, *3*(1), 32–35. doi: 10.1002/1097-0142(1950)3:1<32:aid-cncr2820030106>3.0.co;2-3.

Yu, M. J. (2015). Processing trade, tariff reductions and firm productivity: Evidence from Chinese firms. *The Economic Journal*, *125*(6), 943–988. doi: 10.1111/ecoj.12127.

Yang, R., & He, C. (2014). The productivity puzzle of Chinese exporters: Perspectives of local protection and spillover effects. *Papers in Regional Science*, *93*(2), 367–384. doi: 10.1111/pirs.12035.

Zhou, D. G., Yang, J. J., & Lai, M. Y. (2019). Input trade liberalization and the export duration of products: Evidence from China. *China & World Economy*, *27*(6), 1–25. doi: 10.1111/cwe.12305.