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Impact of Uncertainty, Duration of Waiting, and Export Cutoff on Export Productivity

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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

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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. 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.

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

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.

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 .

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

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

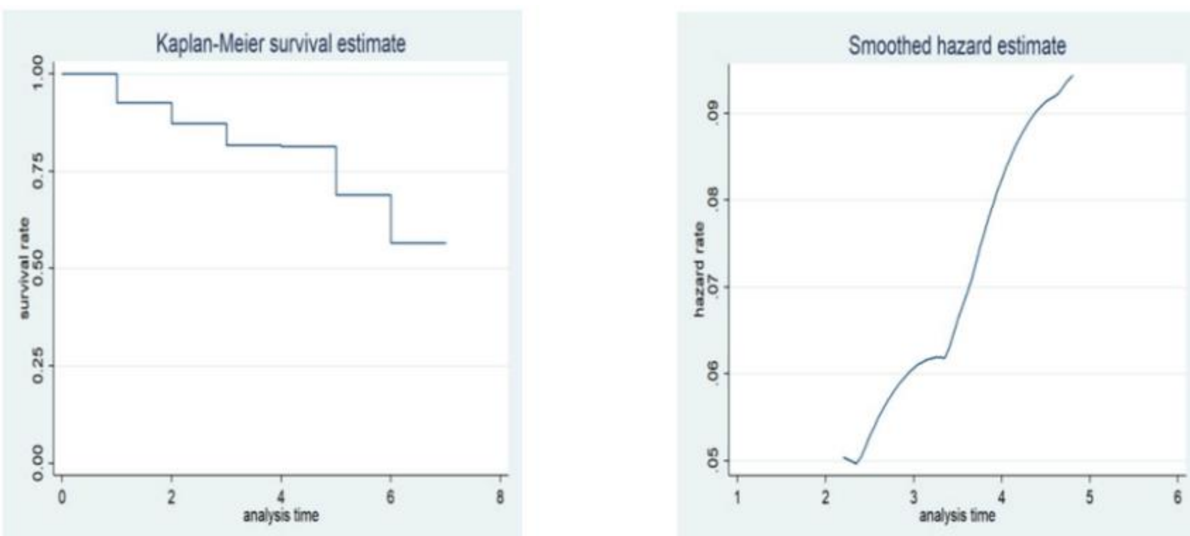
$$\widehat{h}(t) = \frac{D_k}{N_k}. \tag{4}$$

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.

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

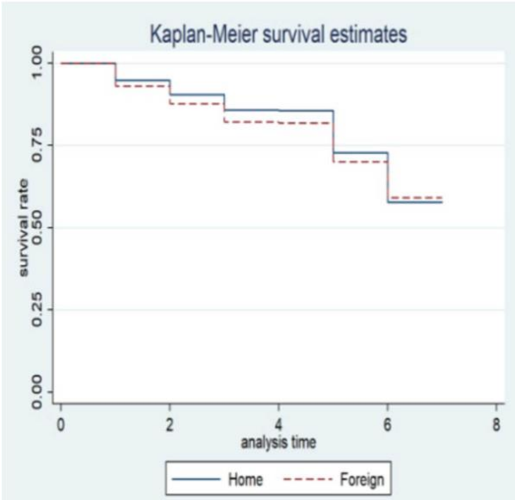


(a) (b)

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 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.

Figure 2: Survival curves by ownership.



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.

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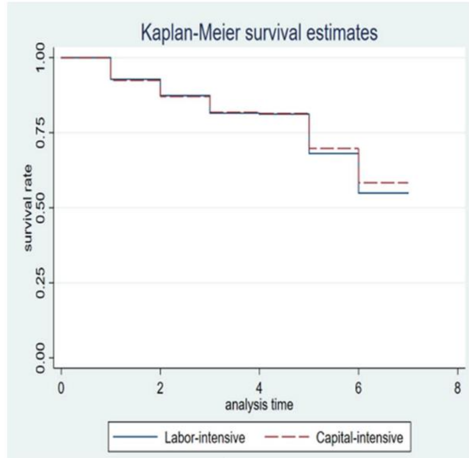
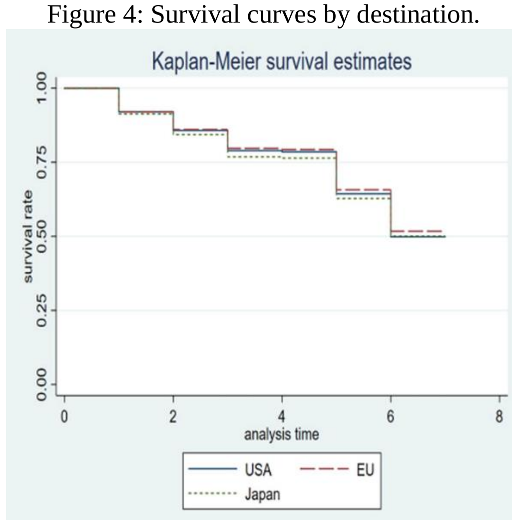
Figure 3: Survival curves by industry.



3.4 Results by Destination

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

Figure 4: Survival curves by destination.



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4. ECONOMETRIC MODEL AND VARIABLES

4.1. Econometric Model

Considering the extensive application of Cox proportional hazard model in survival analysis and the flexibility and robustness without presupposing the specific form of baseline hazard function, this paper 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 if $h(t, Xi)$ is the hazard rate of enterprise i with the risk vector Xi at duration t , the hazard function can be expressed as

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

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:

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

Substituting Eq. (6) into Eq. (5) yields:

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

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

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

where the ratio of hazard rates does not change over duration t , but only depends on $X_i - X_j$. This feature makes it unnecessary to assume the specific form of baseline hazard function $h_0(t)$. Using the partial likelihood estimation, we can obtain the consistent and asymptotically normal estimators of parameters through Cox regression.

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. Based on this, this paper expects that the estimated coefficient of total factor productivity will be greater than 1, which means that the higher the productivity is, the higher the probability of occurrence of failure event will be. So, the higher productivity is more helpful for enterprises to shorten the duration of their waiting for exporting. Considering the possible synchronization bias and selectivity bias when using the traditional OLS method to measure enterprises' productivity, this paper adopts the semi-parametric method of Olley & Pakes (1996) for estimating enterprises' productivity. This method is characterized by using investment as an adjustment variable when enterprises are hit by productivity.

Scale (scale). The new trade theory represented by Krugman (1979) argues that the larger the scale of enterprises is, the more likely it is for them to achieve economies of scale, and then to gain the cost advantage to engage in export trade. Therefore, this paper 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 shorten. There are three main measurement indicators for scale of enterprises in the existing literature — sales revenue, total assets and number of employees. Sun & Li (2011) point out that using the different indicators to measure scale of enterprises has no a significant impact on the result of empirical estimation. In view of this, this paper selects the logarithm of number of employees to represent scale of enterprises.

Capital Intensity (klratio). According to the factor endowment theory, a country should produce and export products that use its abundant factors intensively and import products that use its scarce factors intensively. As a country with abundant labor, China's comparative advantage in exports lies in labor-intensive products. Therefore, the increase of capital intensity will reduce the hazard rate of enterprises' entry into export market and prolong the duration required for starting exporting. In view of this, this paper expects the estimated coefficient of capital intensity to be less than 1. This paper uses the logarithm of ratio of real net fixed-asset balance to 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 (2000=100).

Profit Margin (psratio). This paper 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 development of international market, and are more likely to take the lead in breaking through fixed export cost to shorten the duration required for starting exporting. So, this paper expects the estimated coefficient of profit margin to be greater than 1. This means that with the increase of 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 very likely to enter the export market earlier.

Output Value of New Products (new). The production and sales of new products usually come from the R&D investment and innovation of enterprises. The higher output value of new products means the stronger innovation ability and the higher production efficiency, which is more conducive to enterprises' development in international market. This paper 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 is, the higher the hazard rate of their starting to enter the export market will be. Thus, with the increase of output value of new products, the duration of enterprises' waiting for entry into export market will be shorten. Since many of output values of new products are zero, in order to avoid a large number of missing values when taking logarithm, this paper 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 (2000=100).

Age (age). The older enterprises often tend to accumulate more experiences in production and sales and have the better reputation. Therefore, the older the enterprises are, the more likely it is for them to enter the export market earlier. In view of this, it is necessary to introduce this factor into the econometric model. This paper expects the estimated coefficient of enterprises' age to be greater than 1, which means that the older the enterprises are, the higher the hazard rate of their starting to enter the export market will be. This paper uses the difference between the current year and the year in which 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 the state-owned one, the value of soe is 1, and otherwise, the value is 0. If an enterprise is the foreign-invested one, the value of foreign is 1, and otherwise, the value is 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 enterprises tend to have the better management performance and the more advanced production technology (Helpman et al., 2004; Keller & Yeaple, 2009), which makes it easier for them to enter the export market. This paper 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 for 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 of external macroeconomic environment and the changes of enterprises in the time dimension. c. Region Fixed Effects (region dummies). The region fixed effects cover the 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 exporters and non-exporters, which means that when an enterprise's productivity is above the export cutoff productivity, it is an exporter, and otherwise, it is a non-exporter. The ROC (receiver operating characteristic curve) method is a non-parametric statistical technique that effectively estimates the optimal boundary of test variable. For the purpose of this paper, the export dummy exdum is taken as the state variable and the total factor productivity tfp as the test variable for the non-parametric ROC analysis. The

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optimal boundary, i.e. the export cutoff productivity, is defined by using Youden's (1950) J statistic that is also known as Youden index. The productivity threshold that maximizes 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 in new-new trade theory is the productivity boundary between exporters and non-exporters in a certain industry, this paper follows this definition to examine the impact of productivity threshold on duration of enterprises' waiting for exporting. In this paper, 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 improvement of export cutoff productivity, the productivity required for enterprises to enter the export market is also improved, which makes it 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 paper expects the estimated coefficient of export cutoff productivity to be less than 1. In order to make readers understand the ROC method more clearly, some concepts and tools closely related to the method are introduced below, mainly including confusion matrix, sensitivity, specificity and ROC curve.

4.2.2.1. Confusion Matrix and Main Performance Evaluation Indicators

Table 1 Confusion matrix

		True Class: P	True Class: N
Hypothesized Class	P′	True Positives	False Positives
	N′	False Negatives	True Negatives

Note: The table is based on Fawcett (2006).

In Table 1, P is the total number of positives and N is the total number of negatives. So, P + N represents the whole sample. In this paper, P is the total number of exporters and N is the total number of non-exporters. P is the total number of hypothesized positives and N is the total number of hypothesized negatives. In this paper, P is the total number of hypothesized exporters and N is the total number of hypothesized non-exporters. The true positives are the correctly classified exporters and the number of them is denoted as TP . The false positives are the incorrectly classified non-exporters and the number of them is denoted as FP . The false negatives are the incorrectly classified exporters and the number of them is denoted as FN . The true negatives are the correctly classified non-exporters and the number of them is denoted as TN .

Based on the confusion matrix, the main performance evaluation indicators shown in Table 2 can be obtained.

Table 2 Main performance evaluation indicators in ROC analysis

Indicator	Calculation	Description
Sensitivity	$TPR=\frac{TP}{P}=\frac{TP}{TP+FN}$	Ratio of correctly classified exporters to total exporters
Specificity	$TNR=\frac{TN}{N}=\frac{TN}{TN+FP}$	Ratio of correctly classified non-exporters to total non-exporters
Miss rate	$FNR=\frac{FN}{P}=\frac{FN}{FN+TP}=1-TPR$	Ratio of incorrectly classified exporters to total exporters
Fallout	$FPR=\frac{FP}{N}=\frac{FP}{FP+TN}=1-TNR$	Ratio of incorrectly classified non-exporters to total non-exporters
Accuracy	$ACC=\frac{TP+TN}{P+N}$	Ratio of correctly classified exporters and non-exporters to total exporters and non-exporters

Note: The table is based on Fawcett (2006) and Powers (2011).

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4.2.2.2. ROC Curve

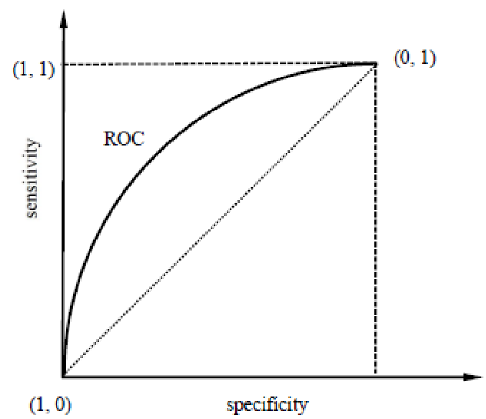
The ROC curve is the trajectory of combinations of sensitivity and specificity. The horizontal axis represents specificity and the vertical axis represents sensitivity.① Each point on ROC curve corresponds to each cutoff value that is actually each value of test variable. In this paper, each cutoff value is each value of total factor productivity tfp_{ijkt} . Among a series of cutoff values, the optimal productivity threshold, i.e. export cutoff productivity, is the one that maximizes the Youden index.

The formula for calculating the Youden index is

$$J = TPR + TNR - 1 \tag{9}$$

where the Youden index = sensitivity + specificity - 1, which indicates that the optimal productivity threshold or the export cutoff productivity is the one that maximizes the sum of sensitivity and specificity.ss

Figure 5 ROC curve



In Figure 5, the horizontal axis represents specificity and the vertical axis represents sensitivity. The specificity gradually decreases from left 1 to right 0 and the sensitivity gradually increases from bottom 0 to top 1. When the specificity is 0, the proportion of correctly classified non-exporters is 0, and when the specificity is 1, the completely accurate prediction for non-exporters is made. When the sensitivity is 0, the proportion of correctly classified exporters is 0, and when the sensitivity is 1, the completely accurate prediction for exporters is made. Therefore, the upper-left point (1, 1) represents the optimal prediction, at which the accuracy is equal to 1, which means that the completely accurate prediction for the whole sample is achieved. Figure 5 shows that the specificity decreases with the increase of sensitivity. So, there exists a cutoff value that maximizes the sum of sensitivity and specificity, and this cutoff value is the optimal productivity threshold, i.e. the export cutoff productivity.

The area under an ROC curve is denoted as AUC and it is the most commonly used indicator for evaluating the prediction capability of ROC curve with range 0 to 1. The ROC curve of perfect classification model will coincide with the left and top sides of unit square, and the corresponding AUC is 1. The ROC curve of classification model without any prediction capability will coincide with the diagonal reference line, i.e. the 45^0 line, and the corresponding AUC is 0.5. A reasonable ROC curve should be above the 45^0 line. The closer it is to the upper-left point (1, 1), the larger the AUC is, which indicates that the prediction capability of classification model is stronger. When the AUC is above 0.9, the model has the high prediction capability. When the AUC is between 0.7 and 0.9, the model has the medium prediction capability. When the AUC is between 0.5 and 0.7, the model has the weak prediction capability. When the AUC is equal to 0.5, the model has no any prediction capability. When the AUC is below 0.5, there is no any practical significance.

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5. DESCRIPTION OF EXPORT CUTOFF PRODUCTIVITY BASED ON THE WHOLE SAMPLE

Figure 6 ROC curve based on the whole sample

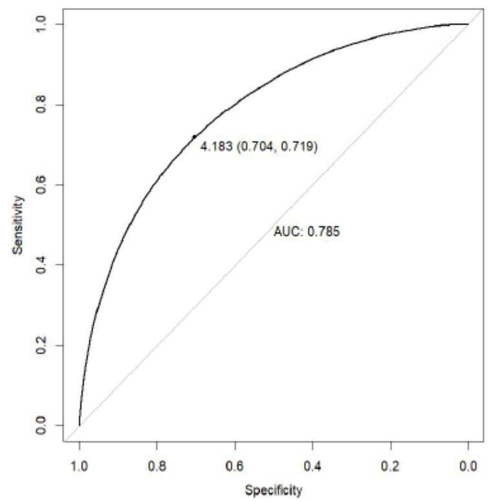

Figure 6 shows that the export cutoff productivity based on the whole sample is 4.183, and the corresponding sensitivity and specificity are 0.719 and 0.704 respectively. When all the enterprises satisfying $tfp_{it} \geq 4.183$ are hypothesized to be exporters, the ratio of correctly classified exporters (i.e. true positives) to total exporters is 71.9%. When all the enterprises satisfying $tfp_{it} \geq 4.183$ are hypothesized to be non-exporters, the ratio of correctly classified non-exporters (i.e. true negatives) to total non-exporters is 70.4%. In addition, the accuracy is 0.7042, which means that the ratio of correctly classified exporters and non-exporters to total exporters and non-exporters is 70.42%. Furthermore, it is found through calculation that the export cutoff productivity of 4.183 corresponds to a quantile of 68.71%, which indicates that on the whole, the top 31.29% of enterprises may be more likely to become exporters. However, it has to be pointed out that any of sensitivity, specificity, accuracy and AUC is not very high. There are two possible reasons for this. First, there are many factors that could determine the export participation of enterprises. Although the productivity plays a major role, it is not the only factor. Second, in practice, some enterprises with higher productivity may not engage in export trade, while some enterprises with lower productivity may engage in export trade.

6. IMPACT OF EXPORT CUTOFF PRODUCTIVITY ON DURATION OF ENTERPRISES' WAITING FOR EXPORTING

6.1. Benchmark Results

Figure 7 Test of proportional hazard assumption

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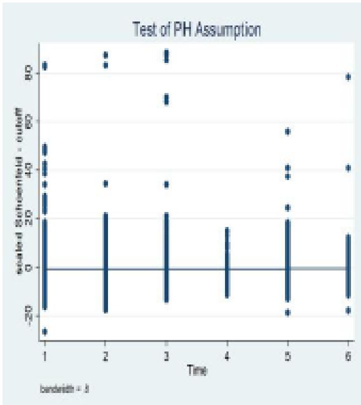
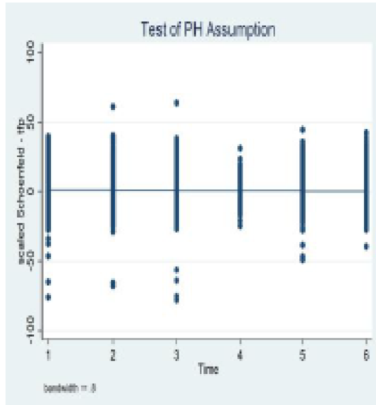
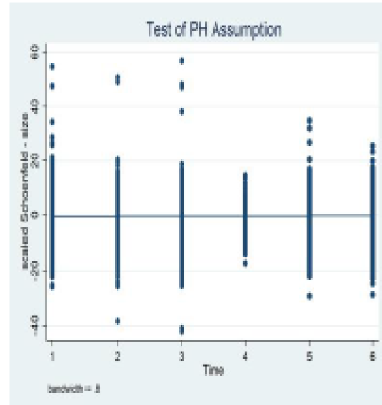


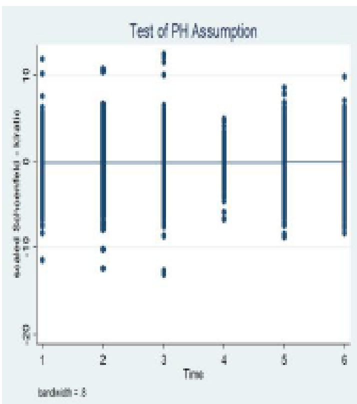
(a) cutoff



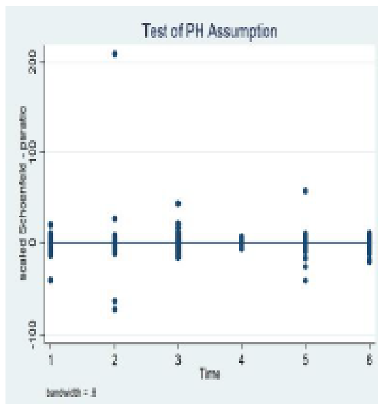
(b) tfp



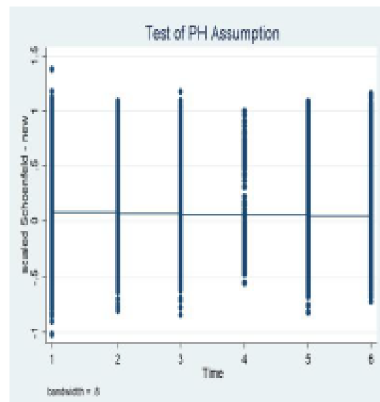
(c) scale



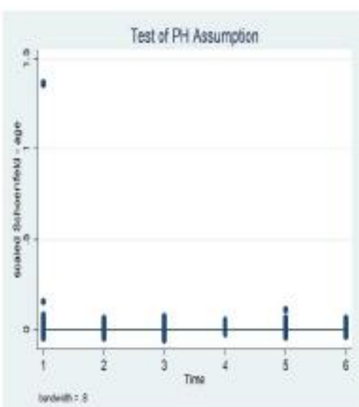
(d) klratio



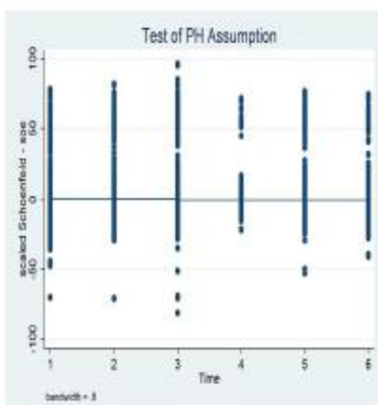
(e) psratio



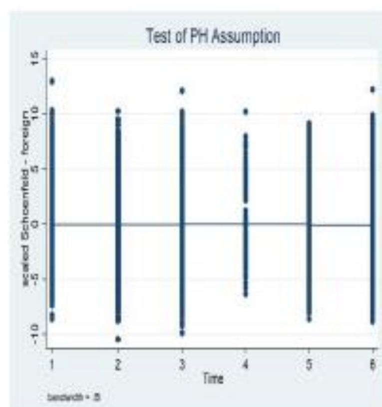
(f) new



(g) age



(h) soe



(i) foreign

In the partial likelihood estimation of Cox proportional hazard model, there are two points to be noted. First, the test of proportional hazard assumption should be firstly 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

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is not satisfied, the application of Cox proportional hazard model to estimate 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 paper 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 is shown in Figure 7.

Figure 7 show 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 3 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 of 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 improvement of export cutoff productivity improves the productivity required for 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 new-new trade theory. In addition, the hazard ratio of 0.7173 indicates that for every 1% increase in export cutoff productivity, the hazard rate of enterprises' starting to enter export market will decrease by 0.2827%.

Table 3 Benchmark results and robustness tests

	Full sample	First spell	One spell only	Gap-adjusted
	(1)	(2)	(3)	(4)
cutoff	0.7173***	0.7310***	0.7191***	0.7286***
	(-8.46)	(-7.51)	(-7.51)	(-7.79)
tfp	2.1358***	2.0017***	2.0114***	2.0010***
	(10.03)	(8.75)	(8.43)	(8.95)
scale	0.7424***	0.7524***	0.7494***	0.7594***
	(-5.98)	(-5.45)	(-5.29)	(-5.39)
klratio	0.8564***	0.8501***	0.8424***	0.8568***
	(-9.74)	(-9.76)	(-9.83)	(-9.48)
psratio	1.0885***	1.0380	0.9853	1.0698*
	(3.14)	(0.97)	(-0.42)	(1.95)
new	1.0643***	1.0634***	1.0633***	1.0649***
	(26.26)	(23.81)	(22.72)	(25.32)
age	1.0014***	1.0012***	1.0013***	1.0013***
	(6.42)	(5.50)	(4.88)	(5.66)
soe	1.7689***	1.6385***	1.6895***	1.6445***
	(6.76)	(5.47)	(5.24)	(5.65)
foreign	0.9413**	0.9345***	0.9517*	0.9467**
	(-2.40)	(-2.56)	(-1.79)	(-2.12)
year dummies	Yes	Yes	Yes	Yes
region dummies	Yes	Yes	Yes	Yes
Log likelihood	-159585.15	-138338.56	-110205.84	-146784.31
Observations	44248	40948	37632	43011

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Note: ***, ** and * denote 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).

Among control variables, the estimated coefficient of total factor productivity (tfp) is significantly greater than 1 at a 1% level, which is consistent with the expectation of this paper and indicates that the higher the productivity is, the higher the hazard rate of enterprises' starting to enter the export market will be. Thus, the improvement of total factor productivity could help to shorten the duration of their waiting for exporting. The estimated coefficient of enterprises' scale (scale) is less than 1 and statistically significant at a 1% level, which is contrary to the expectation of this paper. This shows that the larger the scale is, the lower the hazard rate of enterprises' entering the export market will be. Thus, the expansion of enterprises' scale will prolong the duration of their waiting for exporting. The possible reason is that facing the unpredictable international market, the adjustment cost of product structure of larger enterprises is higher, which makes it more difficult for them to quickly adapt to the changes of international market demand. Thus, the expansion of enterprises' scale will delay their entry into the export market. On the contrary, the smaller enterprises have the lower adjustment cost, their production and operation is more flexible, and thus they are able to better adapt to the everchanging international market, which makes it possible for them to take the lead in entering the export market. The estimated coefficient of capital intensity (klratio) is significantly less than 1 at a 1% level, which is in line with the expectation. According to the factor endowment theory, the comparative advantage of China as a country with abundant labor should lie in labor-intensive products. Therefore, with the increase of capital intensity, the hazard rate of enterprises' entering the export market will be reduced, and thus the duration required for their starting exporting will be prolonged. The estimated coefficient of profit margin (psratio) is significantly greater than 1 at a 1% level, which is consistent with the expectation. This indicates that the higher the profit margin is, the higher the hazard rate of enterprises' entry into the export market will be. Thus, the increase of profit margin could help to shorten the duration of their waiting for exporting. A reasonable explanation is that the enterprises with higher profit margin will have more funds to exploit the international market, and thus they will be more likely to take the lead in entering the export market to shorten the duration of their waiting for exporting. The estimated coefficient of output value of new products (new) is greater than 1 and statistically significant at a 1% level, which is in line with the expectation. This shows that the increase of 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 (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 experiences and better reputation accumulated over a long period. The estimated coefficient of dummy for state-owned enterprises (soe) is greater than 1 and statistically significant at a 1% level. This means that compared with other types of enterprises, the state-owned ones have a higher hazard rate of export entry and are more likely to enter the export market earlier, which is contrary to the expectation of this paper. The possible reason is that the state-owned enterprises can usually enjoy various preferences and subsidies from government. Even if their production and operation efficiency is low, they are very likely to easily break through the productivity threshold and take the lead in exporting. The estimation results show that the hazard rate of state-owned enterprises is 76.89% higher than that of other types of ones. The estimated coefficient of dummy for foreign-invested enterprises (foreign) is significantly less than 1 at a 5% level, which is also contrary to the expectation of this paper. The possible reason is that the sample used in this paper excludes the pure processing trade enterprises and only includes the enterprises with ordinary trade. Generally speaking, the purpose of entry into China of foreign-invested enterprises with ordinary trade is different from that of pure processing trade enterprises. Their main motivation of entering China is not to take China as a production, processing and assembly base or then engage in export trade. In fact, they more hope that they can obtain some market shares from huge Chinese market, and even occupy the entire Chinese market by virtue of their excellent management, technology and high-quality products.

6.2. Robustness Tests

The benchmark results are based on the full sample with multiple spells. In order to examine the robustness of benchmark results, this paper analyzes the sub-sample only with 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 at the year 2002 and keeps exporting until 2003, exits from the export market at the year 2004, and then reenters the export market at 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 paper does not regard a one-year gap between spells as the exit from export market, merges the individual spells and adjusts the spell

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length accordingly. In the above example, the enterprise waits only one year when it reenters the export market at the year 2005. After the gap adjustment, the enterprise has a continuous export during the period 2002-2005. Hence, the original multiple spells are transformed into a single spell. There are two main reasons for a one-year gap adjustment. First, it is likely that trade transactions of certain year were not recorded in a timely manner. Second, it is also likely that the enterprise was not included in the database because its annual sales of that year were less than RMB 5 million, but in fact, it was still exporting (Mao & Sheng, 2013). The columns (2)-(4) 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 greater than 1, all significant at a 1% level, and all very close to that of benchmark results. Therefore, this again indicates that the improvement of productivity threshold does reduce the hazard rate of enterprises' entering export market, and then prolongs the duration of their waiting for exporting. Among control variables, the sign, significance and size of any other variable except for profit margin are very consistent with benchmark results. Hence, the benchmark results of this paper are very robust.

7. HETEROGENEOUS ANALYSIS

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

7.1. Sub-Ownership Results

Table 4 Sub-ownership results

	Home	Foreign
cutoff	0.8835* (-1.81)	0.6935*** (-6.78)
control variables	Yes	Yes
year dummies	Yes	Yes
region dummies	Yes	Yes
Log likelihood	-37948.73	-70832.34
Observations	11883	22690

Note: ***, ** and * denote 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, the results of sub-sample with single spell and the results of gap-adjusted full sample. The interested readers can ask the author for them.

Table 4 reports the sub-ownership results. The results show that the improvement of export cutoff productivity not only reduces the hazard rate of home enterprises' starting to enter export market, but also reduces that of foreign enterprises' starting to enter 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 founded that the increase of 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. 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 export market than home enterprises. The possible reason is that the home enterprises, especially the state-owned enterprises, 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's increase on their export entry.

7.2. Sub-Industry Results

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Table 5 Sub-industry results

	Labor-intensive	Capital-intensive	Technology-intensive
cutoff	0.7142*** (-5.01)	0.6936*** (-5.14)	0.5490*** (-5.99)
control variables	Yes	Yes	Yes
year dummies	Yes	Yes	Yes
region dummies	Yes	Yes	Yes
Log likelihood	-37813.53	-44003.14	-60575.06
Observations	13514	14506	16228

Note: ***, ** and * denote 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, the results of sub-sample with single spell and the results of gap-adjusted full sample. The interested readers can ask the author for them.

Table 5 reports the sub-industry results. The results show that the improvement of export cutoff productivity has a significant inhibition effect on hazard rate of entering export market of enterprises belonging to any industry, 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 strongest in technology-intensive industry, followed by capital-intensive industry and labor-intensive industry. The possible reason is that compared with capital-intensive and technology-intensive industries, it is less difficult for labor-intensive industry to improve 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 of staff training and other ways. Therefore, when the productivity threshold rises, it is more likely for labor-intensive industry to leap over higher productivity threshold. So, the improvement of 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 and that of technology as main production factor in technology-intensive industry, especially the latter. This may be the reason why the increase of productivity threshold has the strongest inhibition effect on technology-intensive industry.

7.3. Sub-Region Results

Table 6 Sub-region results

	East	Middle	West
cutoff	0.7081*** (-7.95)	0.7497** (-2.49)	0.7400* (-1.80)
control variables	Yes	Yes	Yes
year dummies	Yes	Yes	Yes
region dummies	Yes	Yes	Yes
Log likelihood	-132411.06	-11617.77	-6958.61
Observations	37350	4433	2465

Note: ***, ** and * denote 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, the results of sub-sample with single spell and the results of gap-adjusted full sample. The interested readers can ask the author for them.

Table 6 reports the sub-region results. It can be seen from Table 6 that the improvement of export cutoff

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productivity has a significant inhibition effect on hazard rate of entering export market of enterprises in all regions. That is to say, the increase of productivity threshold will prolong the duration of waiting for exporting of enterprises located in any region. However, it has to be pointed out that this inhibition effect is not very obvious in western enterprises. It can only pass the significance test at a 10% level and is not robust. The possible reason is that compared with eastern and middle regions, the intra-region competition environment of western region is relatively loose, which weakens the inhibition effect of increase of productivity threshold on hazard rate of enterprises' entering export market. Thus, the inhibition effect on western enterprises shows the lower significance and the non-robustness.

8. DOES CHINA'S ACCESSION TO THE WTO WEAKEN THE PRODUCTIVITY THRESHOLD EFFECT?

On November 10, 2001, China finally joined the World Trade Organization (WTO) after 15 years of hard work. This means that after years of discrimination, China finally enjoys the same rights as other WTO members. Obviously, China's accession to the WTO creates a convenient and fair trade environment for Chinese enterprises. China's export has been growing rapidly after its accession to the WTO, and since 2009, China has became the largest exporter in the world from the sixth largest exporter in 2001, 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 part constructs the following econometric model:

$$h(t,x,\beta)=h_0(t)g(\beta_1 cutoff_{jn}+\beta_2 WTO_n\times cutoff_{jn} + \sum_{l\geq 3}\beta_l control_{ijkn}^l+\upsilon_n+\upsilon_k+\varepsilon_{ijkn}) \qquad (10)$$

Where WTOn is the dummy related to accession to the WTO. If $n\geq 2002$, its value is 1, and otherwise, the value is 0. WTOn x cutoff jn is the product of dummy WTOn and productivity threshold cutoff jn . control1 ijkn represents some control variable, and the control variables used in expression (10) are the same with the ones 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 denotes enterprise, industry, region and year, respectively.

Table 7 reports the estimation results of expression (10). Considering the robustness, in addition to the benchmark results based on duration measured according to CIED, Table 7 also reports the results based on export cutoff productivity (cutoff _ lp) and total factor productivity (tfp _ lp) measured by applying the method of Levinsohn & Petrin (2003), the results based on duration measured according to CGAC database and the results based on the forgoing two kinds of situations.

According to Table 7, the estimated coefficients of interaction term $(WTO\times cutoff)$ in 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 duration of Chinese enterprises' waiting for exporting. The accession to the WTO makes Chinese enterprises no longer suffer from discrimination, and enables them to engage in export trade freely under the basic principles advocated by the WTO, including non-discrimination, transparency and fair competition. Obviously, this helps to weaken the threshold effect of export cutoff productivity on duration of waiting for exporting.

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

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	CIED	cutoff_lp and tfp_lp	CGAC	CGAC + cutoff_lp + tfp_lp
cutoff	0.6160*** (-4.11)	0.7605*** (-2.77)	0.6204*** (-3.95)	0.5541*** (-6.04)
$WTO \times cutoff$	1.2207* (1.70)	1.2315** (2.09)	1.2989** (2.24)	1.6570*** (5.17)
control variables	Yes	Yes	Yes	Yes
year dummies	Yes	Yes	Yes	Yes
region dummies	Yes	Yes	Yes	Yes
Log likelihood	-110320.37	-110362.91	-151190.91	-151157.22
Observations	37650	37650	25446	25446

Note: ***, ** and * denote 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).

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, was elected president of the United States. The refugee problem is getting worse in Europe. Turkey's foreign military expansion is escalating. Populism is emerging around the world. The right-wing forces are constantly coming to power all over the world. Coronavirus Disease 2019 (COVID-19) caused by a novel coronavirus is spreading globally. The comprehensive strategic competition between China and the United States is getting more and more fierce. All of these adds to the risk of the global economy. In this context, this paper thinks that it is necessary to explore the impact of uncertainty on threshold effect of export cutoff productivity on duration of enterprises' waiting for exporting. So, this part constructs the following hazard model:

$$h(t,x,\lambda) = h_0(t)g(\lambda_1 cutoff_{jn} + \lambda_2 uncertainty_{jn} + \lambda_3 uncertainty_{jn} \times cutoff_{jn} + \sum_{l \geq 4} \lambda_l control^l_{ijkn} + \nu_n + \nu_k + \mu_{ijkn}) \tag{11}$$

where *jn uncertainty* is the uncertainty faced by industry *j* in the *n*th year, and it is based on the variance of the daily closing price of listed industrial enterprises. *jn jn uncertainty* x *cutoff* is the product of uncertainty *jn uncertainty* and productivity threshold *jn cutoff* . In addition, the control variables used in expression (11) is also the same with those in expression (5). Further, the calculation of uncertainty is as follows:

$$uncertainty_{jn} = \sum_{i=1}^{N_{jn}} \omega_{ijn} \operatorname{var}(p_{ijnm}) \tag{12}$$

where $\omega_{ijn} = \dfrac{\overline{V}_{ijn}}{\overline{V}_{jn}}$ is the proportion of the average market value of listed enterprise i in industry j in the nth year to the average total market value of industry j in the nth year, and is the weight used for measuring uncertainty. Here, $\overline{V}_{ijn} = \sum_{m=1}^{M_{ijn}} V_{ijnm} \Big/ M_{ijn}$ and $\overline{V}_{jn} = N_{jn} \times \overline{V}_{ijn}$. V_{ijnm} is the market

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value of enterprise i on the mth trading day of the day of the nth year. M_{ijn} is the total number of trading days of enterprises i in the 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 by

$$\mathrm{var}(p_{ijnm}) = \frac{\sum_{m=1}^{M_{ijn}} \left(p_{ijnm} - \frac{\sum_{m=1}^{M_{ijn}} p_{ijnm}}{M_{ijn}} \right)^2}{M_{ijn} - 1} \tag{13}$$

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

Table 8 reports the estimation results of expression (11). It can be seen that the estimated coefficients of interaction term $(uncertainty \times cutoff)$ in four cases are all significantly less than 1, showing that the increase of uncertainty will aggravate the threshold effect of export cutoff productivity on duration of enterprises' waiting for exporting. If the increase of 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 enterprises to enter the export market. Therefore, the increase of uncertainty will aggravate the impact of productivity threshold on duration of waiting for exporting.

Table 8 Impact of uncertainty on the threshold effect

	CIED	cutoff_lp and tfp_lp	CGAC	CGAC + cutoff_lp + tfp_lp
cutoff	0.7747*** (-4.94)	0.9294** (-2.30)	0.8077*** (-3.99)	0.9320* (-1.95)
uncertainty	1.0390*** (2.59)	1.0787*** (3.58)	1.0399*** (2.71)	1.0872*** (4.20)
$uncertainty \times cutoff$	0.9915** (-2.54)	0.9896*** (-3.54)	0.9912*** (-2.70)	0.9883*** (-4.18)
control variables	Yes	Yes	Yes	Yes
year dummies	Yes	Yes	Yes	Yes
region dummies	Yes	Yes	Yes	Yes
Log likelihood	-97962.94	-97989.99	-132343.67	-132328.80
Observations	33399	33399	22670	22670

Note: ***, ** and * denote 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).

10. CONCLUSIONS

In the existing literature on 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. In only a few articles that focus on duration of enterprises' waiting for exporting, there is still a lack of discussion from perspective of export cutoff productivity. However, according to Melitz (2003), only the enterprises whose productivity is above export cutoff productivity can engage in export trade, which indicates that the export cutoff productivity has an important impact on 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 paper firstly 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 paper uses Cox proportional hazard model to investigate the impact of productivity threshold on duration of enterprises' waiting for exporting. In addition, this paper further analyzes the heterogeneity of impact of productivity threshold on dynamics of export entry by ownership, industry and region. Furthermore, this paper explores the influences of China's accession to the WTO and uncertainty on threshold effect of export cutoff productivity on 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 one is 5 years. The proportion of enterprises whose duration of waiting for exporting exceeds 1 year is 92.61% and 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 of export cutoff productivity reduces the hazard rate of enterprises' starting to enter export market, that is to say, prolongs the duration of their waiting for exporting. Furthermore, this conclusion is supported by a variety of robustness tests, including the sub-sample only with first spell, the sub-sample with single spell and the gap-adjusted full sample. In addition, according to the estimation result of hazard ratio, it can be seen that for every 1% increase in productivity threshold, the hazard rate of enterprises' entering export market will decrease by 0.2827%.

(3) There exists the significant heterogeneity in ownership, industrial and regional influences on duration of enterprises' waiting for exporting. First, the increase of productivity threshold has a stronger prolonging effect on duration of waiting for exporting of foreign enterprises than that of home enterprises. In addition, the prolonging effect is strongest in technology-intensive industry, followed by capital-intensive industry and labor-intensive industry. Furthermore, the rising of productivity threshold mainly prolongs the duration of waiting for exporting of eastern and middle enterprises, but it has no a very obvious impact on that of western enterprises.

(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, including export cutoff productivity and total factor productivity measured according to LP method, duration of waiting for exporting based on CGAC database and these two cases.

This paper gives us some important inspirations. First, making great efforts to improve the productivity is still the basic way for enterprises to shorten duration required for opening up international market. In addition, considering that the entry threshold of the U.S. 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 concern of government to accelerate the negotiation and establishment of various free trade zones, to construct a stable business environment and to lower the uncertainty in markets. Besides, the support and subsidy from government should focus more on technology-intensive enterprises, because they may be more heavily harmed by the Sino-U.S. trade war.

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