Does Export Promote R&D and Innovation in Enterprises? Empirical Evidence from Chinese Industrial Enterprises

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Abstract

In order to reveal the relationship between export and R&D innovation and improve the R&D innovation effect of Chinese enterprises' export. This paper used the method of Propensity Score Matching to study on the data of 20394 enterprises in database China's industrial enterprises from 2005 to 2007. The results show that export has significant R&D and innovation effects, such effects are the strongest in the year of export and gradually reduce over time. Large scale enterprises have stronger export R&D innovation effect. The effect of domestic enterprises is stronger than that of foreign enterprises. These results suggest that China should vigorously support enterprises to go abroad, encourage enterprises to take the path of independent innovation, so as to give full play to the R&D innovation effect of exports.

Keywords: Export R&D, Innovation Effect Propensity Score Matching

Introduction

After decades of "growth miracle", China's economy has entered a "new normal". It has attracted significant attention concerning how China will reshape its economic growth to achieve long-term stable and sustained growth. Although China has become the world's second-largest economy after years of fast economic growth, it still lags far behind the U.S., Japan, Germany, and other developed countries in terms of technological innovation. As Chinese President Xi Jinping (2017: 126) pointed out, "A large economy is not equal to the economic power. A country's long-term backwardness is ultimately due to its technological backwardness rather than the size of its economy". Economic theories and international experience also indicate that innovation is the source of economic growth. China's foreign trade witnessed rapid growth after it joined the WTO in 2001 and became the world's largest exporter in 2009. However, rapid growth in international trade doesn't help China achieve economic transformation, and upgradings like Japan and South Korea. Instead, it gradually makes China remain at the low-end of the international industrial chain. Does this mean that

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China, unlike most other countries, fails to enjoy the benefits of technology spillovers from international trade? Or do Chinese enterprises gain R&D and innovation effects from their exports? From the micro perspective, the study on the relationship between export and R&D and innovation is related to the sustainable development of an enterprise. On the other hand, from the macro perspective, it is associated with the sustainable growth of a country. Particularly, China is in the dilemma that it is losing its external export advantages while its internal domestic demands have not been fully fostered. The answer to this question will have significant reference value concerning whether China will continue to expand its exports in the short term. By analyzing the data of the Chinese Industrial Enterprises Database using the propensity score matching (PSM), this paper attempts to answer this question.

In this paper, there are two marginal contributions as follows. Firstly, based on the real data of Chinese industrial enterprises and the quasi-natural experiments by adopting the propensity score matching method, it helps to solve the prevailing problems of existing studies such as sample selection bias and endogeneity. Secondly, it creates indicators to measure the R&D and innovation of enterprises from four dimensions: innovation input decision-making, innovation input intensity, innovation output decision-making, and innovation output intensity.

Literature Review

1. Export enhances the R&D and innovation capacity of enterprises through the learning effect. Export enterprises continue to learn while maintaining constant exchanges and cooperation with foreign enterprises and manufacturers. These inspire enterprises to improve productivity such that it is an ultimate result of enterprise innovation. Therefore, export is a driving factor for R&D and innovation in enterprises. Salomon & Shaver (2010: 431-460) noted that exporters often have access to different knowledge that is lacking in the domestic market, and bringing such experience back to the country for learning will result in innovation effect. For this purpose, they made empirical studies on Spanish manufacturing enterprise data from 1990 to 1997 using the nonlinear generalized method of moments (GMM) to support their views. Jacques & Wu (2019: 123-138) found that exports create more jobs by stimulating innovation to achieve output growth while studying the employment-driven role of exports. Given the heterogeneity of Chinese enterprises, the study by Li, Yue & Chen (2016: 72-94) showed that the learning effect of export is significant only in medium and high-tech industries. Sang & Fan (2017: 39-49) examined the learning effect of export for enterprises from both product and market perspectives. Their results showed that the learning effect of export was not obvious for enterprises with diverse export markets in the year of export, and such a learning effect emerged in the second and third years after export. The learning effect became significantly noticeable for multi-product export enterprises, the third year after the export.

2. Export improves the R&D and innovation capacity of enterprises through scale development. Enormous international market demands help export enterprises achieve scale development. On the one hand, this reduces the cost of innovation. On the other hand, the reduced cost helps to improve the profitability of enterprises. It provides them with more resources to invest in research and development and thus enhances the innovation capacity of enterprises. Paula et al. (2011: 36-58) and Roberts & Vuong (2013: 185-205) constructed a model based on heterogeneous firm trade theory and stated that the channel for the scale effect of export-induced innovation and the scale development enables enterprises to benefit from product innovation input through reduced unit cost and improved product quality. This will encourage enterprises to invest more in research and development, and the export-induced innovation as the result of scale development will strengthen as the tariffs decrease. The study

by Aghion et al. (2018: 15-25) on French manufacturing showed that there is an interaction between export-induced innovation and scale development. Export-induced innovation will promote scale development through increased market share, and scale development will be more conducive to achieving innovation for export enterprises.

3. Export improves the R&D and innovation capacity of enterprises through competition. Export enterprises face increased competition from the international market. To survive in the competitions, export enterprises have to increase investment in R&D and improve independent innovation to make their products meet international demands to seize international market share. Gorodnichenko, Svejnar & Terrell (2014: 954-969) used individual enterprises survey data from 27 transition countries and concluded that the internationalization of export-oriented enterprise plays a significant role in promoting product innovation. Export provides many potential opportunities for enterprises in emerging market countries in terms of innovation and competitiveness. Imppullitti & Licandro (2018: 189-229) pointed out that trade liberalization stimulates competition by reducing variable markups and creating more stringent enterprise screening mechanisms, which helps to improve innovation in enterprises.

Methodology

1. Hypotheses

Export is likely to play a role in R&D and innovation in enterprises from three channels based on existing research literature. Therefore, this paper further proposes the following hypothesis:

H_1: Export can promote the R&D and innovation capacity of Chinese enterprises. That is to say, and export does show R&D and innovation effect in Chinese enterprises.

Given that enterprises are different in terms of production behaviors, export decision-making, and R&D and innovation activities due to the heterogeneity of enterprises. This paper further puts forward the following hypothesis:

H_2: The R&D and innovation effect are different among the enterprises of different sizes and ownership.

2. Propensity Score Matching

This paper aims to analyze the impact of export on R&D and innovation of enterprises. In other words, it attempts to investigate whether there is a causal relationship between enterprise export and its R&D and innovation. One issue that cannot be avoided in the actual analysis is that: It is not random concerning an export enterprise. They may have more substantial R&D and innovation capacity before export than other enterprises that do not export, so it is easier for them to go abroad. If the R&D and innovation capacities of export enterprises are higher than those of non-export enterprises, it may not be the result of export. Instead, export enterprises already show more substantial R&D and innovation capacities over non-export ones. Ignoring the endogenous problem caused by this sample selection bias, the direct estimation results by OLS will become biased. To solve this problem, this paper adopts the propensity score matching (PSM) method to eliminate the sample selection bias. Its basic idea is to compare the differences in R&D and innovation of the same enterprise under "export scenario" and "non-export scenario". Because it compares the difference of the same enterprise in two different scenarios, it is confirmed that such a difference is caused by export.

Where $innov^1$ and $innov^0$refer to the R&D and innovation variable under export and non-export scenarios respectively. *s* represents whether or not it is an enterprise export, with 1 set as export enterprise and 0 non-export one. *i* and *t* stand respectively for enterprise and year. Thus, the average treatment effect on treated (ATT) of export on R&D and innovation in the enterprise is as follows:

$$ATT = E(innov_{it}^{1} - innov_{it}^{0}|s_{it} = 1) = E(innov_{it}^{1}|s_{it} = 1) - E(innov_{it}^{0}|s_{it} = 1) \quad (1)$$

$$ATT = E(innov_{it}^{1} - innov_{it}^{0}|s_{it} = 1) = E(innov_{it}^{1}|s_{it} = 1) - E(innov_{it}^{0}|s_{it} = 0) \quad (2)$$

where $E(innov_{it}^{1}|s_{it} = 1)$ refers to the R&D and innovation of an enterprise after export. $E(innov_{it}^{0}|s_{it} = 1)$ represents the R&D and innovation of the enterprise without export. The challenge lies in that $E(innov_{it}^{0}|s_{it} = 1)$ is unobservablely non-factual, and the solution is to construct a "counter-factual" variable and find a non-export enterprise (control group) that is "similar" to the export enterprise (treatment group). Therefore, after the R&D and innovation of the enterprise in the control group $E(innov_{it}^{0}|s_{it} = 0)$ is used to replace that of the export enterprise (treatment group) $E(innov_{it}^{0}|s_{it} = 1)$ in the non-export scenario, then the calculation is as follows:

$$ATT = E(innov_{it}^{1} - innov_{it}^{0}|s_{it} = 1) = E(innov_{it}^{1}|s_{it} = 1) - E(innov_{it}^{0}|s_{it} = 0) \quad (3)$$

The key process to identify the non-export enterprises (control group) that are "similar" to the export enterprises (treatment group) is called matching. The matching process requires both the treatment group and the control group to be as close as possible in all dimensions. This paper uses the PSM method for matching on an annual basis and constructs a virtual variable of whether or not it is an export enterprise (export enterprise = 1, non-export enterprise = 0) as the explained variable. Several covariates are selected as explanatory variables to predict the probability values of enterprise export Pr using the Logit/Probit model (export decision-making model). If the tested results meet both the common support assumption and the balancing assumption, then the export enterprises (treatment group) and non-export enterprises (potential control groups) will be matched based on the similarity of Pr, and the final control group will be selected from the potential control groups. During the propensity matching process, the selection of covariates (matching variables) is related to the effect of matching. The matching variables of this paper include: labor productivity, size of the enterprise, fixed asset, financing constraint, enterprise profit, foreign investment, government subsidy, industrial added value, and government relationship. Innovation variable *innov* will be measured from two aspects: innovation input and innovation output. Each aspect will include two dimensions: innovation decision-making and innovation intensity. All the value indicators were reduced using the corresponding price index with 2005 as the baseline year. The definitions and measures of each matching variable and innovation variable are shown in Table 1.

Table 1 Definitions and Measures of Variables

Variables		Name	Type	Variable specification
Innovation variables	*dRAD*	Innovation input decision-making	Dummy variable	Set as 1 for R&D input and 0 for without R&D input
	innew	Innovation input intensity	General	R&D input/Main business revenue
	dnpdcvlu	Innovation output decision-making	Dummy variable	Set as 1 for new product and 0 for no new product

Table 1 Definitions and Measures of Variables (Cont.)

Variables		Name	Type	Variable specification
Innovation variables	*outnew*	Innovation output intensity	General	New product output value/Total industrial output value
Matching variables	*tfp*	Labor productivity	General	Total industrial output value/Average number of employees per year
	forien	Foreign investment	General	Foreign investment/Paid-in capital
	lyedemply	Size of enterprise	Logarithmic	Average number of employees per year
	lcpastyb	Fixed asset	Logarithmic	Average annual balance of net fixed assets
	rz	Financing constraint	General	Interest payments/Main operating costs
	dtotlpft	Enterprise profit	Dummy variable	Set as 1 for with profit and 0 without profit
	subsidy	Government subsidy	General	Subsidized income/Main business revenue
	lpdcvlue	Industrial added value	Logarithmic	Industrial added value
	sbjct	Government relationship	General	Ownership of enterprises: Central, provincial, municipal and county-level and other kinds of enterprises are assigned respectively as 5, 4, 3, 2 and 1. Their relationship with the government also declines from high to low.

3. Data Description

This paper uses the Chinese industrial enterprises data collected by the National Bureau of Statistics for 2005-2007[3]. We screened the samples based on consolidating data set to satisfy the research needs: (1) excluding the samples with key variables less than 0 or missing; (2) excluding the samples with fewer than 10 employees; and (3) excluding the samples with total assets less than net fixed assets, sales income less than export delivery value, paid-in capital less than or equal to 0 for their non-compliance with the accounting principles. After the treatment, 20, 394 out of 60, 136 effective sample data of enterprises were analyzed in this paper. The data were treated and analyzed by using Stata14.0 software.

[3]The Chinese industrial enterprises data cover the period 1998-2013. The reason why this paper chose 2005-2007 as the sample interval is that the data of enterprise R&D investment were not included until 2005, and the data of this interval is more consistent and are mostly used in similar studies.

Results

1. Basic Characteristic Facts

We divide the enterprises into export enterprises (treatment group) and non-export enterprises (potential control group) based on the value of enterprise export delivery in the Chinese Industrial Enterprises Database. Table 2 shows the characteristics of R&D and innovation in two kinds of enterprises before propensity score matching. For each year within the sample period, the number of export enterprises is significantly lower than that of non-export enterprises. However, the R&D and innovation of export enterprises are better than those of non-export enterprises in terms of innovation input decision-making, innovation input intensity, innovation output decision-making or innovation output intensity. To take innovation input decision-making as an example, the proportion of export enterprises with R&D input in the year of 2005, 2006 and 2007 accounted for 37.4%, 40.4% and 42.8% respectively, while the proportion of non-export enterprises was 12.7%, 13.5% and 13.9% respectively over the same period, showing an obvious difference. The analyses of simple characteristic facts reveal that export enterprises have higher R&D and innovation capacity, which provides a preliminary basis for our subsequent analysis. However, as mentioned above, this does not prove the causal relationship between export and the R&D and innovation capacity of enterprises. Because the difference in R&D and innovation between these two kinds of enterprises is probably the result of the reason that export enterprises already have relatively strong R&D and innovation capacity, or it may be indeed that export promotes the R&D and innovation capacity of the enterprises.

Table 2 Comparison of R&D and Innovation (Mean Value) between Export and Non-export Enterprises

Types of Companies	Year	Number of enterprises	Innovation input decision-making	Innovation input intensity	Innovation output decision-making	Innovation output intensity
Export Enterprises	2005	3235	37.40%	0.60%	42.40%	11.40%
	2006	3190	40.40%	0.70%	42.10%	11.90%
	2007	2907	42.80%	0.80%	36.80%	12.80%
Non-export Enterprises	2005	16828	12.70%	0.20%	7.30%	2.60%
	2006	16882	13.50%	0.20%	7.90%	2.70%
	2007	17094	13.90%	0.20%	7.80%	2.70%

2. Estimation of Export Decision-making Model

According to the requirement of propensity score matching, the probability value of export should be calculated for each enterprise. Therefore, we conducted Probit and logit regression to construct the export decision-making model, and the estimation are shown in Table 3. Whether it is in the Probit model or in the logit model, the covariates (matching variables) are relatively significant, indicating that the variable set in this paper is reasonable.

Based on the estimation results of the export decision-making model in Table 3, there are systematic differences in many characteristics between export enterprises and non-export enterprises. On the one hand, these differences help to identify which enterprises are more inclined to export. More importantly, the differences remind us to take into account the pre-export sample selection bias in analyzing the real impact of exports on the R&D and innovation of enterprises. Otherwise, it will confuse the existing R&D and innovation capacity of an

enterprise and the innovation effect as the result of export. The following PSM analysis in this paper will be based on the estimation results of the Probit model.

Table 3 Estimation Results of Probit Model and logit Model (Explained Variable: whether or not the enterprise exports)

	Probit model		**Logit model**	
	Coefficient	**Z value**	**Coefficient**	**Z value**
Foreign investment	1.4183***	25.61	2.3986***	25.65
Size of enterprise	0.1802***	13.67	0.3186***	12.84
Fixed asset	0.0188**	2.28	0.0271*	1.80
Industrial added value	0.1060***	9.14	0.1967***	8.93
Government relationship	0.0374***	5.26	0.0670***	5.30
Labor productivity	-0.0001***	-5.91	-0.0002***	-5.60
Financing constraint	-1.0813***	-4.45	-0.4107***	-4.10
Enterprise profit	-0.0477**	-2.31	-0.0919**	-2.44
Government subsidy	-2.1328***	-6.11	-4.8006****	-6.24
Year	control		control	
Region	control		control	
Constant term	-3.4615***	-47.98	-6.0801***	-45.29
Log likelihood	-17104		-17102	
Pseudo R2	0.0964		0.0965	
N	60134		60134	

Notes: *, ** and *** means being significant under 10%, 5% and 1% scenario respectively.

3. Matching and Matching Quality Assessment

The traditional PSM model is based on sectional data, while this paper uses non-balanced panel data for three consecutive years. To avoid the same enterprise over different periods being regarded as different enterprises and thus being mutually matched. This paper conducts the matching according to the year. The accuracy of PSM testing depends to a large extent on whether the enterprises in the control group can well replace those in the treatment group that do not export. In other words, there should be no significant difference in covariates after matching between export enterprises and non-export enterprises. Therefore, a balance test is required.

As there are four innovation variables in this paper (innovation input decision-making, innovation input intensity, innovation output decision-making, and innovation output intensity), the balance test should be carried out separately from these four dimensions. Due to limited space, this paper only reports the balance test result of innovation input intensity (The balance test results of the other three dimensions are all consistent with this result).

The test results from Table 4 to 6 showed that export enterprises and non-export enterprises have significant differences in most covariates before matching, and there is a "self-selection effect" in enterprises for their export activities. After matching, there is no statistically significant difference in the covariates between the treatment group and the control group. Therefore, the matching of samples satisfies the balance requirements, and the selection of covariates and matching methods is appropriate in this paper.

Table 4 Balance Test (2005)

Variables	Before matching		t value	After matching		t value
	Treatment group	Potential control group		Treatment group	Potential control group	
Labor productivity	427.32	388.15	1.73*	427.32	413.39	0.76
Foreign investment	0.083	0.018	27.1***	0.083	0.079	0.64
Financing constraint	0.021	0.024	-1.94*	0.021	0.024	-1.61
Size of enterprise	5.888	5.196	33.36***	5.888	5.918	-0.94
Fixed asset	10.268	9.229	32.43***	10.268	10.32	-1.12
Enterprise profit	0.782	0.786	-0.54	0.782	0.791	-0.91
Government subsidy	0.006	0.007	-2.26**	0.006	0.007	-1.13
Industrial added value	11.358	10.541	31.65***	11.358	11.366	-0.21
Government relationship	2.212	1.799	18.78***	2.212	2.184	0.85

Notes: *, ** and *** stands for significant effect under 10%, 5% and 1% scenario respectively.

Table 5 Balance Test (2006)

Variables	Before matching		t value	After matching		t value
	Treatment group	Potential control group		Treatment group	Potential control group	
Labor productivity	487.69	462.92	0.81	487.69	474.32	0.63
Foreign investment	0.086	0.018	28.27***	0.086	0.087	-0.17
Financing constraint	0.022	0.023	-0.41	0.022	0.024	-0.66
Size of enterprise	5.887	5.174	34.07***	5.887	5.886	0.06
Fixed asset	10.308	9.261	32.18***	10.308	10.338	-0.64
Enterprise profit	0.795	0.792	0.35	0.795	0.795	-0.03
Government subsidy	0.004	0.007	-2.98***	0.004	0.005	-1.97
Industrial added value	11.479	10.651	31.14***	11.479	11.456	0.57
Government relationship	2.166	1.786	17.12***	2.166	2.177	-0.34

Notes: *, ** and *** stands for significant effect under 10%, 5% and 1% scenario respectively.

Table 6 Balance Test (2007)

Variables	Before matching		t value	After matching		t value
	Treatment group	Potential control group		Treatment group	Potential control group	
Labor productivity	560.98	534.45	0.97	560.98	528.26	1.48
Foreign investment	0.09	0.018	28.83***	0.09	0.087	0.56
Financing constraint	0.019	0.024	-1.26	0.019	0.02	-0.89
Size of enterprise	5.959	5.155	36.66***	5.959	5.996	-1.05
Fixed asset	10.43	9.295	33.1***	10.43	10.461	-0.62
Enterprise profit	0.819	0.801	2.23**	0.819	0.821	-0.2
Government subsidy	0.003	0.007	-4.48***	0.003	0.004	-1.66
Industrial added value	11.722	10.756	33.58***	11.722	11.707	0.34
Government relationship	2.174	1.79	16.63***	2.174	2.168	0.17

Notes: *, ** and *** stands for significant effect under 10%, 5% and 1% scenario respectively.

4. Innovation Effect of Export

Table 7 summarizes the test results of the R&D and innovation effect for export enterprises. It can be seen that the ATT of sample enterprises in each year is significantly greater than 0, whether being measured from innovation input or innovation output. This confirms that export has a positive incentive effect on the R&D and innovation in enterprises, and thus the hypothesis H_1 is verified. By taking the year 2005 as an example, if the enterprise innovation is measured by its investment in R&D (innovation input), export made its innovation decision-making increase by 17.87 percentage point. Also, if enterprise innovation is measured by the sale of new products (innovation output), export made its innovation decision-making increase by 31.787 percentage point. In addition, export also made the enterprise's R&D intensity and output intensity of its new product increase by 0.43 and 8.34 percentage points respectively. By comparing the ATT values, it is found that export has more obvious incentive effect on innovation output than innovation input for the enterprises.

Table 7 ATT Results of Different Years: R&D and Innovation Effect of Export

Year	Innovation input		Innovation output	
	Innovation decision-making	**Innovation intensity**	**Innovation decision-making**	**Innovation intensity**
2005	0.1787*** （0.01201）	0.0043*** （0.00058）	0.3178*** （0.01095）	0.0834*** （0.00482）
2006	0.1975*** （0.01256）	0.0044*** （0.00040）	0.3179*** （0.01120）	0.0864*** （0.00503）
2007	0.1875*** （0.01353）	0.0052*** （0.00056）	0.2542*** （0.01165）	0.0906*** （0.00557）

Notes: *** stands for significant effect under 1% scenario and the value in the bracket represents standard error.

The estimation results in Table 7 show that export can promote R&D and innovation in enterprises. However, does the R&D and innovation effect of export only appear in the year of the export or continue to sustain every year? To examine the lag effect and the cumulative effect of export on R&D and innovation, we tested the R&D and innovation effect in the year of export, the second and third years after export respectively, as shown in Table 8. The R&D and innovation effect of export is the strongest in the year of export and gradually decreases over time. This conclusion is consistent with the study results of Damijan, Kostevc & Polanec (2010: 374-398). After the analysis, the reasons may lie in: First, the enterprises have access to advanced technologies after entering the international market and decide immediately to imitate them to improve their own technologies. This is the immediate incentive effect of export on R&D and innovation. However, after absorbing these advanced technologies, the enterprises may encounter technological bottlenecks and difficulties in innovation. The marginal effect of innovation will decline over time, and what they could learn from it will also gradually decrease. Second, some enterprises need to do lots of preparatory work to overcome technological barriers in importing countries to enter international market, such as making the active investment in R&D, improving their ability to absorb advanced international technologies, improving the quality of products and launching new products to meet the needs of export markets. These preparations and adjustments indirectly improve the R&D and innovation capacity of the enterprises, which is reflected in the actual observation that the R&D and innovation effect is the strongest in the year of export. This also inspires us to distinguish different types of export enterprises to further to confirm whether or not the improvement in R&D and innovation capacity of enterprises is the result of incentive and sustained interaction of export markets.

Table 8 R&D and Innovation Effects of Different Years after Export

Time	Innovation input		Innovation output	
	Innovation decision-making	**Innovation intensity**	**Innovation decision-making**	**Innovation intensity**
Year of export	0.2185*** （0.00878）	0.0050*** （0.00040）	0.3917*** （0.00771）	0.1086*** （0.00361）
2nd year of export	0.2108*** （0.01045）	0.0049*** （0.00034）	0.3257*** （0.00929）	0.0949*** （0.00441）
3rd year of export	0.1953*** （0.01464）	0.0052*** （0.00067）	0.2550*** （0.01280）	0.0881*** （0.00617）

Notes: *** stands for significant effect under 1% scenario and the value in the bracket represents standard error.

Discussion and Conclusion

Based on the statistical data of Chinese industrial enterprises from 2005 to 2007, this paper makes an in-depth analysis of the impact of export on the R&D and innovation in enterprises. The innovation capacity of enterprises is measured by four dimensions such as innovation input decision-making, innovation input intensity, innovation output decision-making, and innovation output intensity. The propensity score matching method is used to address the problem of sample selection bias. The research results show that: First, export does have significant R&D and innovation effect in enterprises. The analyses on the full samples, or sub-samples categorized by the size and ownership of enterprises confirm that export has a significant positive effect on the innovation of enterprises in four different dimensions. Second, the impact of export on R&D and enterprises' innovation gradually decreased over time. The immediate effect of export on R&D and innovation is the largest in the year of export and gradually decreases in the next two or three years. Third, there are significant differences in the effects of export on R&D and innovation for different sizes of enterprises. Though export has obvious R&D and innovation effect for different sizes of enterprises, such effects are stronger for large scale enterprises. Fourth, in terms of ownership of enterprises, the effects of export on R&D and innovation are the strongest for state-owned enterprises, followed by private enterprises and the weakest for foreign enterprises. In other words, export has a stronger R&D and innovation effect for domestic enterprises than foreign-invested enterprises. Such a consequence no longer exists for foreign-invested enterprises in the third year after export. The conclusions of this paper show good stability among different sample selections and in different matching methods.

The findings of this paper not only continue and expand the existing research but also have important practical significance. Although China is a large exporting country, it still lags far behind developed countries in terms of technology development. Therefore, China should vigorously support its enterprises to go abroad to participate in international competitions, give full play to the effect of export on R&D and innovation, and encourage its enterprises for independent innovation to narrow the gap with other countries in terms of technological development. Specifically, China should make efforts in the following aspects: (1) It should create a favorable external environment for the R&D and innovation of enterprises. Only under a strong intellectual property protection system will enterprises be willing to disclose the information about their research and development. This will help to address the information asymmetry in the R&D for SMEs and private enterprises, and reduce the cost of innovation. (2) It needs to deepen the reform of production factor markets and promote the development

of its financial markets. Based on the previous analysis, we believe that financing constraint restricts the effects of export on R&D and innovation for private enterprises. The fundamental reason lies in the unsound financial market in China, particularly during this transition period when the financial sector is distracted from their intended purpose, which makes it more difficult for private enterprises to have access to finance. Therefore, more favorable policies should be introduced to encourage private sectors and financial resources to engage in and support the real economy. In addition, it needs to reform its financial management system and provide flexible and innovative financial services for small and medium-sized enterprises to ease their financing constraints to have better access to the international market. (3) It needs to change the patterns of its export trade. China's export enterprises have remained at the low end of the global industrial chain and value chain for a long time, which is very unfavorable for them to foster innovation. Therefore, subsequent export enterprises should focus more on the "quality" of export products and appropriately reduce the proportion of the export products with low added value. It should encourage enterprises to invest in R&D and improve the international competitiveness of their products to create a positive interaction between export and innovation.

References

Aghion, P., Bergeaud, A., Lequien, M. & Melitz, M. J. (2018). The Heterogeneous Impact of Market Size on Innovation: Evidence from French Firm-Level Exports. *National Bureau of Economic Research (NBER),* no 24600.

Damijan, J. P., Kostevc, C. & Polanec, S. (2010). From Innovation to Exporting or Vice Versa? *World Economy, 33*(3), 374-398.

Gorodnichenko, Y., Svejnar, J. & Terrell, K. (2014). When does FDI have positive spillovers? Evidence from 17 transition market economies. *Journal of Comparative Economics, 42*(4), 954-969.

Impullitti, G. & Omar, L. (2018). Trade, Firm Selection and Innovation: The Competition Channel. *Economic Journal, 128*(608), 189-229.

Jacques, M. & Wu, Y. (2019). Impacts of innovation, export, and other factors on firm employment growth in Chinese manufacturing industries. *Industrial and Corporate Change, 28*(1), 123-138.

Li, B., Yue, Y. & Chen, T. (2016). Export and Innovation: Empirical Evidence from Patent Data at Firm Level. *The Journal of World Economy, 12*, 72-94.

Paula, H. , Carmen, L. & Luis, F. L. (2011). The Trade-Off Between Customer and Technology Orientations: Impact on Innovation Capabilities and Export Performance. *Journal of International Marketing, 19*(3), 36-58.

Roberts, M. J. & Vuong, V. A. (2013). Empirical Modeling of R&D Demand in a Dynamic Framework. *Applied Economic Perspectives & Policy, 35*(2), 185-205.

Salomon, R. M. & Shaver, J. M. (2010). Learning by Exporting: New Insights from Examining Firm Innovation. *Journal of Economics & Management Strategy, 14*(2), 431-460.

Sang, R. & Fan, J. (2017). Retest of Learning-by-export Effect: An Empirical Analysis Based on Product and Market Perspective. *Journal of International Trade, 04*, 39-49.

Xi, J. (2017). *Excerpts of Xi Jinping's Speeches on Socialist Economic Development.* Beijing: Central Party Literature Press.