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# Micro-mechanisms and Effects of Exporting to Promote the Improvement of Enterprises' Basic Research Capability

## — Micro Evidence from Zhongguancun Enterprises

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**Abstract**

In the era of globalization, unilateralism and trade protectionism are on the rise, leading to more complex market environments and heightened competitive pressures for enterprises. Basic research, a key component of scientific and technological innovation, is crucial for long-term growth and competitiveness. This study explores the link between export activities and basic research capabilities. It uses panel data from enterprises at Zhongguancun in Beijing between 2005 and 2015, employing the PSM-DID model. The findings give three main insights: (1) Exports can drive companies to improve their basic research. This is evident in the increase in their scientific publications. (2) The impact of exports varies across enterprises of different technological proficiency and ownership. Two types of enterprises, non-state-owned ones and those of high technological capabilities, experience a greater enhancement in their basic research capabilities as a result of exports; while another two types, the state-owned enterprises, and enterprises with low technological capabilities see less significant improvements in their basic research capabilities. (3) Exports influence enterprises' basic research through knowledge absorption and available capital. They help companies acquire international knowledge, fueling demand for basic research and innovation. Moreover, exports increase revenue and profits, providing funds for research investment. This enhances the efficiency and quality of R&D efforts.

**Keywords**

Export activities; Enterprises' basic research; Micro-mechanisms; Knowledge absorptive capacity

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## 1. Introduction

Basic research is a research activity that involves comprehending natural phenomena, elucidating the laws of nature, and garnering fresh knowledge, principles, and methodologies (Liu and Sun, 2022). It is the foundational element of the innovation value chain (Xie *et al*., 2023) and underpins scientific and technological advancements. Basic research also plays a pivotal role in enhancing the competitive edge of a nation's scientific and technological prowess. During a collective study of the Political Bureau of the Central Committee of the Communist Party of China on July 31, 2023, General Secretary Xi Jinping underscored the imperative of bolstering basic research to achieve high-level scientific and technological autonomy and to pave the way for establishing global scientific and technological leadership. Despite notable progress and original achievements in China's basic research over the years, significant disparities and deficiencies persist when juxtaposed against international benchmarks and national strategic imperatives. Particularly at the enterprise level, challenges such as inadequate investment, limited capabilities, and suboptimal translation of research outcomes pose pronounced hurdles in advancing basic research (Wen *et al*., 2023; Xu and Liu, 2020). Against the backdrop of a dynamic global landscape and mounting competitive pressures, a critical task for China lies in devising mechanisms to enhance enterprises' basic research capabilities, fostering independent innovation, and surmounting developmental bottlenecks.

Exports, as a crucial gateway to domestic and international markets and information, exert a meaningful influence on enhancing enterprises' basic research competencies. Theorized pathways through which exports can shape firms' basic research capabilities encompass financial backing, knowledge assimilation, and human capital development. Zhou *et al*. (2021) used Chinese A-share listed companies to demonstrate that exports increase firms' revenues and profits by capitalizing on economies of scale. This amplifies the sources of funding and resources available for basic research initiatives, which can elevate the efficiency and caliber of firms' research and development endeavors. Simultaneously, exports facilitate enterprises' engagement with international markets and technological frontiers, enabling them to access new insights, information, and experiences that can kindle the impetus and appetite for basic research and original innovation (Xie and Ding, 2018). Furthermore, the enrichment of human capital empowers enterprises to assimilate cutting-edge technology and managerial acumen from a global spectrum, propelling the exchange of diverse production factors and optimizing resource allocation. Through leveraging international technology and capital, enterprises can harness these assets to enhance their basic research capabilities (Zheng and Wang, 2017).

Scholars have extensively examined the effects of exporting on enterprise innovation development through various lenses, including enterprise heterogeneity (Li and Xin, 2019), income disparity (Tao *et al*., 2020), intellectual property rights protection, and trade expenses (Huang and Qing, 2021). Existing literature indicates that the influence of exports on enterprise innovation primarily manifests in two dimensions: total factor productivity and innovation performance. The investigation into the impact of exports on enterprise productivity dates back to 1995 when Bernard and Jensen conducted a study using data from U.S. firms to compare exporting and non-exporting entities (Bernard *et al*., 1995), sparking academic interest in the topic. Subsequently, Melitz (2003) introduced neoclassical economic theories to analyze the relationship between enterprise exports and productivity, leading to the proposal of the heterogeneous enterprise trade model. In China, research on this subject emerged in 2008, with scholars like Zhang *et al*. (2008) examining the heterogeneous effects of enterprise exports on total

factor productivity in Jiangsu Province's manufacturing enterprises. The following year, Zhang *et al*. (2009) confirmed the positive impact of enterprise exports on productivity using data from Chinese manufacturing firms. Later, Qian *et al*. (2011) distinguished between the self-selection effect and export learning effect when analyzing the correlation between corporate exports and total factor productivity. Recent studies by Zhang *et al*. (2021) have further delved into the discrepancies between the self-selection effect and export learning effect in relation to exports' impact on productivity.

Research on the influence of firms' exports on their innovation has largely been concentrated on empirical investigations. These studies have explored the link between exports and firms' innovation either from a national perspective or through a specific lens, scrutinizing their intricate interactions. Internationally, the investigation into this research theme emerged towards the end of the previous century. In 1991, Grossman and Helpman introduced the innovation-driven endogenous growth model. Subsequently, studies on firms from countries like France, the UK, Germany, Italy, Spain, and Central and Eastern European nations (Cintio *et al*., 2020; Fassio, 2018; Aghion *et al*., 2018) have verified the positive impact of firms' exports on innovation. Furthermore, scholars have examined the varying effects of exporting on innovation across different firms from multiple angles, such as business environment (Verena, 2022) and human capital (Liu *et al*., 2017). Within China, research by Yao *et al*. (2016) using industrial enterprise data confirmed that the scope and scale of exporting influence the innovation capacity of different enterprise types to varying degrees. Additionally, Xu and Xia (2022) explored the positive influence of exporting on innovation in Chinese firms from a global standpoint, using the Brexit event as a focal point. Moreover, Xie *et al*. (2023) conducted a detailed analysis of the heterogeneous impact of export intensity on firms' innovation structures based on resource-based theory.

Based on the above analysis, enterprises' basic research serves as the starting point for innovation activities and logically may be influenced by enterprise export activities. However, existing literature lacks empirical research on the relationship between exports and enterprises' basic research capabilities. Most studies have only focused on the impact of exports on enterprise productivity or innovation performance. Additionally, due to a lack of reliable data sources and appropriate measurement methods, it is difficult to accurately quantify enterprise basic research capabilities. This study aims to contribute to this field by utilizing micro-survey data encompassing Zhongguancun enterprises over the span of 2005 to 2015 to construct a panel dataset that contains information on enterprise exports, scientific publication output, and other relevant variables. The study employs PSM-DID model to identify the causal effect of exports on enhancing enterprise basic research capabilities.

The research objective of this study is to explore the micro-mechanisms and effects through which exports promote the enhancement of enterprise basic research capabilities, taking into account the heterogeneity of enterprise technological levels and sizes. The marginal contributions of this research are threefold: (1) enriching the literature on the relationship between exports and enterprise innovation, particularly by examining the impact mechanisms and effects of exports on enterprise basic research capabilities at the micro level, considering the heterogeneity of enterprise technological levels and sizes, thereby further enriching the empirical analysis of existing literature; (2) using scientific publication output as a proxy variable for enterprise basic research capabilities effectively distinguishes between basic and applied research, providing more accurate and detailed indicators for this study; (3) from a heterogeneity perspective, exploring the moderating effects of enterprise technological levels and ownership on the relationship between exports and enterprise basic research capabilities.

The structure of this paper is as follows: the second part reviews existing studies and presents

research hypotheses; the third part introduces data sources, variable definitions, and conducts descriptive statistical analysis; the fourth part introduces empirical methods and results, along with robustness tests; the fifth part performs mediating effects tests and heterogeneity analysis; the sixth part summarizes the main findings and insights of this study, and proposes policy recommendations.

## 2. Literature Review and Hypothesis Formulation

The focal point of this study is to investigate the causal mechanism through which exports influence the fundamental research capabilities of enterprises. To enhance the elucidation of the research standpoint and rationale, this study integrates the theoretical underpinnings of external economic effects, resource allocation effects, and learning effects of exports. Moreover, it introduces the notion of knowledge absorptive capacity, and formulates a comprehensive impact model comprising exports, capital income, knowledge absorptive capacity, and enterprise fundamental research capabilities, as illustrated in Fig. 1.

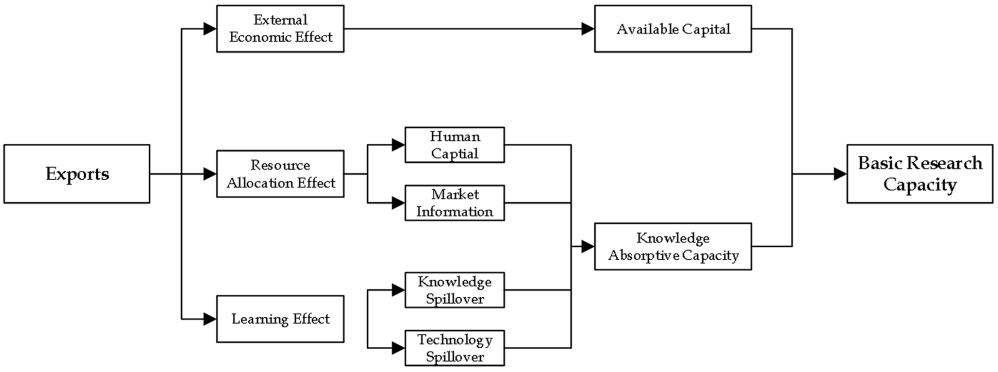


**Fig. 1.** A model of the mechanism of export impact on enterprises' basic research capacity.

Export serves as a vital transmission mechanism for disseminating foreign knowledge and technology to exporting enterprises and their affiliates, as highlighted by Liu and Long (2022). Previous studies have identified three main effects through which export impacts the basic research capacity of enterprises. Firstly, the external economic effect. As described by Feder (1982), it suggests that expanding export trade can enhance enterprise scale, leading to increased remuneration for basic research and fostering motivation for further research. Secondly, the resource allocation effect, outlined by Grossman and Helpman (1991). On the one hand, if the products exported by enterprises are human capital intensive, export trade will lead to scarce and expensive human capital, thus increasing the cost of basic research and inhibiting the investment in basic research. On the other hand, if the products exported by firms are technology-intensive, then export trade will bring more external knowledge and innovation stimulus, thus promoting the output of basic research. Thirdly, the export learning effect. It encompasses knowledge and technology spillover effects according to Zhao (2021). They can enable exporting firms to swiftly learn from international competitors and partners, thereby leveraging external knowledge and innovation stimuli for their own basic research endeavors.

According to the model of the influence mechanism of exporting on the basic research capacity of enterprises constructed in this paper, combined with the theoretical and literature analysis, the following hypotheses are proposed:

H1: Exporting enterprises have stronger basic research capacity than non-exporting enterprises.

The hypothesis posits that exporting enterprises benefit from a confluence of three effects: the external economic effect, resource allocation effect, and export learning effect. External economies of scale enable exporting enterprises to enjoy the advantages brought by economies of scale, thereby reducing the marginal costs of basic research and enhancing marginal returns, strengthening the motivation and capability of enterprises to engage in basic research. The resource allocation effect facilitates the attraction and retention of skilled human capital within the export enterprises, thereby enhancing the quality and quantity of their basic research endeavors. Additionally, the export learning effect enables exporting enterprises to access knowledge and technology from the global market, thereby enriching their basic research with innovative insights and reference points. Consequently, it is contended in this study that the basic research capabilities of exporting enterprises surpass those of non-exporting counterparts.

H2: Exporting can positively affect enterprises' basic research capacity by increasing available capital.

The theory posited in this exposition is predicated upon the direct influence of external economic factors. Engaging in export activities can serve as a lucrative avenue for enterprises to procure substantial financial resources, thereby furnishing them with the necessary monetary backing for their foundational research endeavors. Various scholarly investigations have substantiated the notion that participation in export trade significantly bolsters corporate profitability (Cintio *et al*., 2020; Fassio, 2018). Through the exportation of goods or services, companies can accrue revenues from international markets. These earnings not only cover the expenses associated with export operations but also yield surplus profits for the organization (Aghion *et al*., 2018). The said profits emanate from the price differentials in export transactions or the expansion of market share, which in turn serve as a financial reservoir for the firm's internal investments and research and development initiatives (Verena, 2022). Against the backdrop of intense global competition, enterprises are compelled to continually enhance their technological prowess to align with consumer needs, with basic research standing as the linchpin for achieving technological advancements. With a secure financial footing, companies can escalate their investment in basic research, thereby augmenting their overall research capabilities. Consequently, this study posits that exports can exert a favorable influence on enterprises' fundamental research capacities by bolstering capital inflows.

H3: Exporting can improve enterprises' basic research capacity by contributing to their knowledge absorptive capacity and, consequently, their basic research capacity.

This study posits a hypothesis centered on the indirect influence of the resource allocation effect and the export learning effect. According to the effect of resource allocation, exporting enables companies to gain a better understanding of the dynamic demands of the global market, thereby facilitating the precise allocation of production resources such as human capital to reduce inefficiencies. This adjustment leads to an acceleration in the turnover rate of resources, providing financial support for reinvestment or expansion of production scale, thus optimizing resource allocation. Through the learning effect of exporting, companies can access advanced technologies and management experiences in the international market, benefiting from knowledge spillovers and technological advancements from industry leaders. The absorption of knowledge is a key factor in transforming externally acquired knowledge into innovation capabilities, influenced by a company's internal resources, knowledge, and technology (Xu and Xia, 2022). By cultivating their knowledge absorption capabilities, companies can timely identify, learn, and assimilate external knowledge to enhance innovation performance and improve basic research capabilities (Wen *et al*., 2024). Therefore, this study suggests that exporting enhances enterprises' basic research capabilities by promoting the improvement of their knowledge absorption capabilities.

## 3. Data Sources and Variable Definitions

*3.1. Data source*

The region known as Zhongguancun, often referred to as the "Silicon Valley of China," stands as the largest hub of high-tech industries in this country, with its enterprises playing a significant role in representing the development of China's high-tech industry. Contrary to companies in other parts of China, those in Zhongguancun place greater emphasis on factors such as innovative mechanisms, technological talent, and funding, demonstrating heightened sensitivity to the series of reactions triggered by their export activities, thus facilitating a more rapid advancement in the fundamental research of enterprises. Therefore, this study selects enterprises from Zhongguancun during the period from 2005 to 2015 as the initial research sample. The data used comes from the annual survey database of Zhongguancun enterprises. The dataset encompasses comprehensive details on the enterprises' fundamental financial indicators, export activities, workforce composition, and research and development endeavors, which are pertinent to the study's objectives. After obtaining the raw data, this study excluded enterprises that met any of the following conditions: (1) with intermittent export activities during the sample period; (2) with export activities throughout the period from 2005 to 2015 or first-time exports in 2015; (3) with any of their key data such as total revenue, number of employees, fixed assets, intangible assets, and asset-liability ratio, is zero, negative, or absent/unavailable; or (4) with total export amount exceeding total sales revenue. Finally, the study culminated in a dataset comprising 3,520 enterprises and 38,720 individual sample observations.

*3.2. Definition of variables*

(1) Explained variable: enterprises' basic research capability. Scholarly works, such as scientific and technical papers, serve as indicators of enterprises' involvement and scholarly contributions in the realm of basic research (Haeussler and Assmus, 2021; Kou *et al*., 2022). Furthermore, these papers signify the research competency and innovative prowess of enterprises, showcasing their ability to consistently generate academically significant research outcomes. As a result, this study employs domestically and internationally published scientific and technical papers as a metric to evaluate enterprises' basic research capability. Additionally, the quantity of patents granted is indicative of enterprises' proficiency in innovation, technological acumen, market competitiveness, and technology transfer. Therefore, in the subsequent analysis, the number of patents authorized will be utilized as a proxy measure for enterprises' basic research capability to ensure the robustness of the findings.

(2) Explanatory variable: exports. This study employs the actual export value of enterprises as the metric for assessing their engagement in export trade. Specifically, if an enterprise's export transaction value exceeds zero, it is categorized as having engaged in exports during the same year. The study categorized the sample into two groups based on firms' export behavior: the first group comprises new exporting firms, defined as those entering the export market in a specific year between 2005 and 2015 and continuously exporting thereafter; the second group consists of non-exporting firms, which are companies that did not engage in any export activities throughout the sample period.

Control variables encompass factors such as enterprise size, age, and elements associated with basic research. Enterprise size is gauged by the number of employees, in line with common research practices, while enterprise age is determined by the number of years since establishment. Employees holding postgraduate degrees are valued for their specialized knowledge and theoretical expertise, making them pivotal in enterprise basic research. Hence, the paper uses the proportion of postgraduate degree holders to evaluate enterprise human resources.

(3) Mediating variables: available capital and knowledge absorptive capacity. Available capital is assessed through enterprise profit, while knowledge absorptive capacity is primarily informed by the findings of Wei and Ma (2021) and Alia and Park (2016), among others. The measurement of knowledge absorptive capacity is comprehensive, considering the ratio of technicians, postgraduates, research and development investment, and intangibles. The entropy method is utilized to calculate the index of knowledge absorption capacity.

(4) Control variables. The main consideration is the size of the enterprise, age and factors related to basic research, including firm size, firm age, human resources, industry-university-research cooperation, and the level of indebtedness. Firm size is gauged by the number of employees, in line with common research practices, while enterprise age is determined by the number of years since establishment. Employees with postgraduate degrees are valued for their specialized knowledge and theoretical expertise, making them pivotal in enterprise basic research. Hence, the paper uses the proportion of them to evaluate enterprise human resources.

**Table 1**
Variable definition table.

| Variable category | Variable | Variable code | Variable interpretation |
|---|---|---|---|
| Explained variable | Enterprises' basic research capability | Pub | Number of scientific and technical papers published by the enterprise in the current period |
| | | Pat | Number of patents granted to the enterprise in the current period |
| Explanatory variable | Export | DID | Interaction terms for exports |
| Intermediary variable | Available capital | Pro | Profit of the enterprise at the end of the period |
| | Knowledge absorptive capacity | KAC | Technical Staff Ratio, Proportion of Postgraduate Degree Holders, R&D Investment Ratio and Intangible Asset Ratio |
| Control variable | Firm size | Size | Number of employees employed by the enterprise at the end of the period |
| | Firm age | Age | Current year - year of establishment of the enterprise + 1 |
| | Human Resources | TR | Percentage of postgraduate degree holders to active employees in the enterprise |
| | Industry-university-research cooperation | IUR | Total expenditure on domestic universities and R&D institutions |
| | The level of indebtedness | Lev | Current enterprise gearing ratio |

*3.3. Descriptive statistics and correlation analysis*

The statistical data pertaining to the variables can be found in Table 2. Analyzing the basic research capability of enterprises, a significant divergence between the mean and median values of new exporting enterprises and non-exporting enterprises is evident, suggesting that the act of exporting exerts a notable impact on the fundamental research proficiency of enterprises. In terms of human resource management, new exporting enterprises prioritize the recruitment of highly educated individuals to infuse innovative vigor into their basic research endeavors. Examining the realm of industry-university-research collaborations, the metrics associated with new exporting enterprises surpass those of non-exporting counterparts, underscoring the heightened technological innovation prowess and market competitiveness

of the former. Regarding the financial landscape, new exporting enterprises exhibit a marginally higher asset-liability ratio compared to non-exporting entities, potentially indicative of the increased financing requirements and elevated business risks faced by exporting enterprises.

**Table 2**
Descriptive statistics of main variables.

| Variable | New exporters | | | | | Non-exporters | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | P50 | SD | Min | Max | Mean | P50 | SD | Min | Max |
| Pub | 3.637 | 0 | 37.660 | 0 | 968 | 0.645 | 0 | 6.516 | 0 | 317.000 |
| Pat | 6.609 | 0 | 36.910 | 0 | 914 | 0.802 | 0 | 9.195 | 0 | 923.000 |
| Pro | 5.505 | 7.750 | 6.456 | -14.102 | 14.769 | 3.425 | 5.364 | 6.079 | -15.279 | 15.9 |
| KAC | 0.047 | 0.027 | 0.073 | 0 | 1.000 | 0.041 | 0.022 | 0.052 | 0 | 1.000 |
| Size | 4.586 | 4.489 | 1.422 | 0 | 9.709 | 3.487 | 3.434 | 1.382 | 0 | 10.18 |
| Age | 10.960 | 10.000 | 5.333 | 2 | 27 | 10.310 | 10.000 | 5.036 | 2 | 27.000 |
| TR | 0.130 | 0.074 | 0.158 | 0 | 1.000 | 0.106 | 0.053 | 0.147 | 0 | 1.000 |
| IUR | 0.658 | 0 | 2.127 | 0 | 14.22 | 0.258 | 0 | 1.302 | 0 | 14.100 |
| Lev | 0.485 | 0.458 | 0.321 | 0.001 | 1.928 | 0.473 | 0.432 | 0.347 | 0.001 | 1.928 |
| N | | | 286 | | | | | 3,234 | | |

The correlation matrix presented in Table 3 illustrates the relationships between the variables across the firms under study. The data reveals a favorable correlation between the research capabilities of enterprises and their export endeavors, size, longevity, workforce composition, collaboration in industry-university-research, and debt levels. Notably, the initial five variables exhibit a significant correlation at the 1% level, while the indebtedness variable demonstrates significance at the 5% level. This suggests that engaging in export activities can enhance the research capabilities of enterprises, thereby confirming the research hypothesis posited in this study. Additionally, it is noteworthy that a negative correlation exists between a company's debt levels and its human resources as well as its involvement in industry-university-research collaborations. This implies that companies facing less financial strain are more likely to attract skilled employees and engage in collaborative research efforts with academia and industry partners.

**Table 3**
Correlation analysis.

| Variable | Pub | DID | Size | Age | TR | IUR | Lev |
|---|---|---|---|---|---|---|---|
| Pub | 1.000 | | | | | | |
| DID | 0.082*** | 1.000 | | | | | |
| Size | 0.118*** | 0.198*** | 1.000 | | | | |
| Age | 0.045*** | 0.102*** | 0.207*** | 1.000 | | | |
| TR | 0.094*** | 0.032*** | -0.006 | -0.039*** | 1.000 | | |
| IUR | 0.161*** | 0.077*** | 0.154*** | 0.049*** | 0.080*** | 1.000 | |
| Lev | 0.011** | 0.006 | 0.047*** | 0.114*** | -0.049*** | -0.024*** | 1.000 |

*Note: t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1, as below.*

## 4. Empirical Analysis

### *4.1. Modeling approach*

The prevailing research approach in heterogeneous firm trade involves conducting regression analysis on cross-sectional or panel data to determine the premium of exporting firms over non-exporting firms, yet endogeneity issues and selection bias are unavoidable challenges with such methods. Therefore, this study draws upon the methodology of Zou and Feng (2017) to employ the PSM-DID model in examining the impact of exports on firms' fundamental research capabilities.

In order to minimize the impact error caused by variables other than the core explanatory variables in the sample data when enterprises export and do not export, this paper adopts the Logit model to estimate the propensity score of enterprises' choosing to export, and then according to their scores, seeks for the experimental group (new exporters) to find the control group sample (non-exporters) with similar propensity scores. The specific operation is as follows, first use the following Logit model to estimate the propensity score of enterprises to choose exports.

$$Pr\{Export_{i,t}=1 \mid X_{i,t}\}=\Phi[g(X_{i,t})] \tag{1}$$

Where $X_{it}$ contains the firm characteristics of firm $i$ in the export current period, including covariates such as innovation performance. In this paper, the nearest neighbor matching is applied to match the experimental group and the control group, and a total of 8,693 sets of valid data are obtained, which is used to calculate the average disposition effect of disposition. Meanwhile, the kernel matching is further used as a robustness test.

After the export of the enterprise, the level of the enterprise's basic research capacity will rise compared with the pre-export. Based on this, this paper constructs the following equations according to the multi-period double difference model to test the effect of export activities on the level of the enterprise's basic research capacity:

$$Pub_{it}=\beta_0+\beta_1\times(t_i\times treated_t)+\sum\beta_2\times\text{controls}_{i,t}+\mu_t+\tau_t+\xi_{i,t} \tag{2}$$

where $Pub_{it}$ denotes the basic research output of firm $i$ in year $t$; $t_i\times treated_t$ denotes the cross-multiplier term—DID in the double difference mode, and the coefficients of this term are the firm's export learning effects; and $\mu$, $\tau$, $\xi$ are the individual fixed effects, the time fixed effects, and the error term, respectively.

### *4.2. Prior preparation inspection*

The foundation of utilizing DID model lies in the parallel trend test, which necessitates establishing similar trends between the treatment and control groups prior to employing the model. In the context of the enterprises examined in this study, due to their asynchronous export activities, a dynamic effect test was employed. Analysis depicted in Figure 2 reveals that before the commencement of exporting activities, no notable distinction existed between the treatment (new exporters) and control (non-exporters) groups. However, post-exportation, a substantial variation emerged between the treatment and control groups, indicating a persistent effect of enterprises' export endeavors on their fundamental research outputs. To enhance the study's reliability, a placebo test was conducted, involving the random selection of 286 experimental groups. Specifically, 286 firms were chosen at random as the pseudo experimental group, with the remaining firms serving as the pseudo control group, after 500 iterations of random sampling and regression analysis. As depicted in Fig. 3, the majority of estimated coefficients clustered around zero with non-significant regression outcomes, emphasizing a stark contrast with the genuine regression coefficients. This highlights the notable influence of export activities on enterprises' basic research.

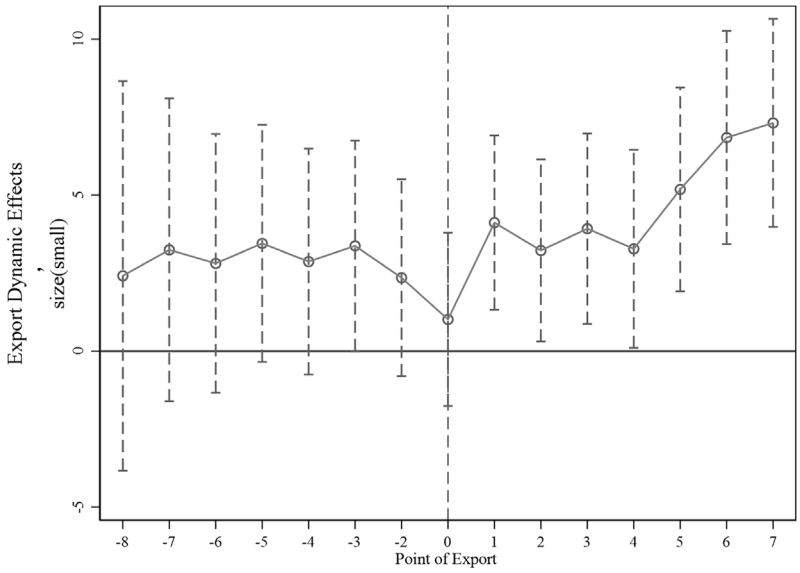


**Fig. 2.** Dynamic trend test results.

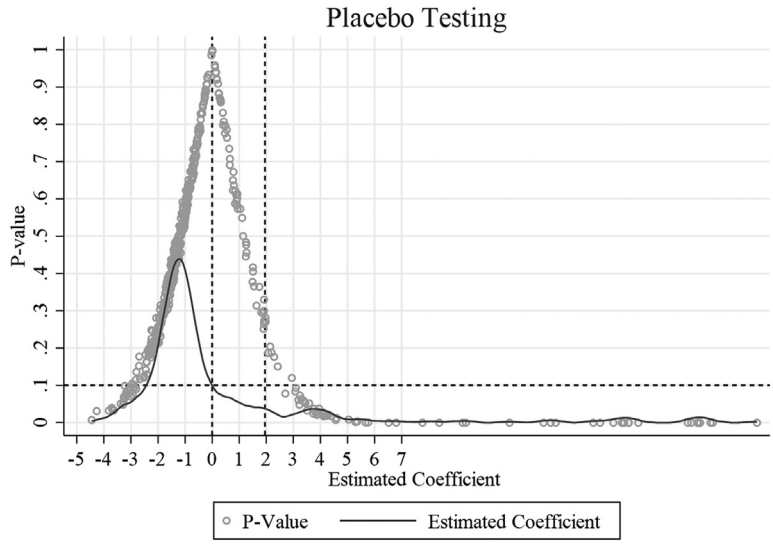


**Fig. 3.** Placebo test results.

*4.3. Base regression analysis*

The study examines the impact of exports on enterprises' basic research capabilities through an empirical analysis utilizing model (2). By incorporating year and individual fixed effects, the regression analysis isolates the baseline regression outcomes showcased in column (1) of Table 4, while columns (2–6) present the regression outcomes when considering control variables. The examination reveals that the coefficient denoting the influence of export activities on enterprises' basic research diminishes with the rise of factors affecting basic research. Nonetheless, the impact remains noteworthy, underscoring the significance of export activities on enhancing enterprises' basic research. Export ventures can furnish firms with expanded global market opportunities, along with heightened competition that might prompt firms to amplify investments in basic research to secure a stronger technological edge, thereby

affirming hypothesis one. Furthermore, findings indicate a negative and substantial relationship between enterprise age and debt levels with enterprises' basic research capacity. This is likely attributed to nascent enterprises' inclination towards market adaptation through innovation and contemporary technology utilization to swiftly enhance their basic research capability, whereas highly indebted enterprises may encounter fiscal challenges hindering adequate support for basic research endeavors, thus inhibiting advancements in their basic research capabilities.

**Table 4**
Analysis of benchmark regression results.

| Variable | (1) Pub | (2) Pub | (3) Pub | (4) Pub | (5) Pub | (6) Pub |
|---|---|---|---|---|---|---|
| DID | 2.610***(2.802) | 2.410***(2.583) | 2.321**(2.487) | 2.138**(2.291) | 2.049**(2.220) | 1.950**(2.111) |
| Size | | 1.186***(2.941) | 1.177***(2.918) | 1.532***(3.719) | 1.320***(3.237) | 1.308***(3.208) |
| Age | | | -0.787***(-2.712) | -0.776***(-2.677) | -0.724**(-2.527) | -0.747***(-2.606) |
| TR | | | | 9.669***(4.131) | 9.210***(3.978) | 9.254***(3.999) |
| IUR | | | | | 1.603***(12.032) | 1.596***(11.981) |
| Lev | | | | | | -2.730**(-2.500) |
| Constant | 1.426***(5.345) | -3.417**(-2.048) | 5.265(1.459) | 2.410(0.657) | 1.996(0.550) | 3.615(0.981) |
| Year | YES | YES | YES | YES | YES | YES |
| Code | YES | YES | YES | YES | YES | YES |
| Observations | 8,693 | 8,693 | 8,693 | 8,693 | 8,693 | 8,693 |
| $R^2$ | 0.622 | 0.622 | 0.623 | 0.624 | 0.632 | 0.632 |

*Note: t-values in parentheses, below.*

*4.4. Robustness analysis*

Furthermore, in an effort to elevate result reliability and diminish errors, the paper transitions from the propensity score matching method to kernel matching for matching new exporters with non-exporters. This transition yields 34,393 sets of experimental data, significantly expanding the sample size. The findings in column (3) show the resilience of core variables' coefficients and their significance levels.

(1) Replace explanatory variables. In addition to the quantity of enterprise scientific and technical papers as a proxy, the number of enterprise invention patent applications serves as another significant indicator. This study performs a robustness test by substituting variables, with the outcomes displayed in column (1) of Table 5. The positive coefficient of the export activities interaction term, alongside the consistent negative impacts of enterprise age and debt level on basic research, affirm the steadfastness of the research findings.

(2) Shrink the tail at the 5% level. To enhance the integrity of the research outcomes, the study opts to truncate the tails at the 5% level to diminish the influence of outliers. The results in column (2) of the table demonstrate the sustained robustness and dependability of the benchmark regression outcomes.

(3) Replace propensity score matching method. In the benchmark regression, this paper uses the near-neighbor matching method with put-back to match new exporters and non-exporters, which results in fewer firms ultimately participating in the regression analysis. In an effort to elevate result reliability

and diminish errors, the paper transitions from near-neighbor matching method to kernel matching for matching new exporters with non-exporters. This transition yields 34,393 sets of experimental data, significantly expanding the sample size. The findings in column (3) show the resilience of core variables' coefficients and their significance levels.

**Table 5**
Robustness test results.

| Variable | (1) Replace explanatory variables | (2) Shrink the tail at the 5% level | (3) Replace propensity score matching method |
|---|---|---|---|
| DID | 2.526***(2.916) | 1.942**(2.106) | 1.521***(5.570) |
| Size | 1.990***(5.205) | 1.347***(3.308) | 0.478***(8.720) |
| Age | -0.114(-0.424) | -0.962***(-3.892) | -0.275***(-6.872) |
| TR | 11.111***(5.119) | 8.901***(3.847) | 1.911***(5.501) |
| IUR | 0.882***(7.061) | 1.591***(11.956) | 0.165***(6.558) |
| Lev | -2.304**(-2.250) | -4.010***(-3.093) | 0.155(1.048) |
| Constant | -5.560(-1.608) | 6.222*(1.903) | 1.575***(3.249) |
| Year | YES | YES | YES |
| Code | YES | YES | YES |
| Observations | 8,693 | 8,693 | 34,393 |
| $R^2$ | 0.569 | 0.633 | 0.599 |

## 5. Mechanism Testing

*5.1. Heterogeneity test*

The present study conducts heterogeneity testing from two perspectives: enterprise technological level and enterprise ownership nature. Specific results can be found in Table 6, columns (1) and (2), as well as columns (3) and (4).

Using the mean as a reference point, the research sample is divided into groups of high technological level enterprises and low technological level enterprises for regression analysis. It is observed that export activities significantly enhance the basic research capabilities of high-technology level firms. This enhancement can be attributed to the expansion of international markets and the improvement of international competitiveness facilitated by engaging in export activities. Such activities necessitate technical exchanges and collaborations with various international partners, enabling firms to access more technological resources and garner inspiration for technological research and development (R&D) and innovation. Moreover, export activities create opportunities for international technology transfer, which includes tangible assets like technology and equipment, as well as intangible resources such as advanced management practices and market operation strategies. The integration of these resources enriches the technological reservoir of enterprises, propelling them towards greater advancements in technological innovation.

Likewise, the impact of export activities on the basic research capabilities of enterprises is influenced by the ownership structure of the companies. Throughout the process of market operations, non-state-

owned enterprises often exhibit higher market insight and innovative vitality, leading to their investments in basic research fields to gain a competitive advantage in the market. In contrast, state-owned enterprises, due to the characteristics inherent in their system and management structure, may adopt a more cautious stance towards investment in basic research. Meanwhile, non-state-owned enterprises face relatively greater market competition pressure, prompting them to focus more on technological innovation and basic research to enhance their market competitiveness. When it comes to obtaining innovation funds, non-state-owned enterprises may have more market-oriented avenues available, while state-owned enterprises may encounter more constraints in financing, which could impact their investments in basic research. Moreover, the government's incentives for innovation directed towards non-state-owned enterprises may be more favorable, further enhancing the willingness and capability of these enterprises to innovate.

**Table 6**
Heterogeneity test results.

| Variable | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | High level of technology | Low level of technology | State-owned enterprises | Non-state-owned enterprises |
| DID | 3.646**(2.101) | -0.651(-0.905) | 2.364(1.306) | 0.833**(2.368) |
| Size | 1.344(1.409) | 1.314***(4.395) | 1.321(1.402) | -0.239*(-1.708) |
| Age | -0.137(-0.241) | -0.056(-0.246) | -0.084(-0.135) | -0.157(-1.531) |
| TR | 20.144***(3.668) | 7.044***(4.305) | 19.790***(3.431) | 0.091(0.139) |
| IUR | 2.410***(10.473) | 0.133(1.127) | 1.876***(9.208) | 0.321***(3.890) |
| Lev | -6.992***(-2.843) | -0.871(-1.110) | -6.885***(-2.897) | 0.155(0.434) |
| Constant | -3.458(-0.454) | -3.527(-1.199) | -3.398(-0.377) | 2.470**(2.158) |
| Year | YES | YES | YES | YES |
| Code | YES | YES | YES | YES |
| Observations | 4,292 | 3,423 | 4,264 | 3,518 |
| $R^2$ | 0.610 | 0.808 | 0.713 | 0.519 |

*5.2. Mechanism test based on enterprises' available capital and knowledge absorptive capacity*

Based on the previous hypotheses and theoretical analysis, this study believes that the export performance of enterprises not only directly affects their basic research capacity, but also has an impact on their basic research capacity by accumulating available capital and improving knowledge absorptive capacity, so it is necessary to test the mediating effect of available capital and knowledge absorptive capacity. The corresponding regression model is shown below:

$$Pub=\alpha_1+cDID+\sum\beta_1\times Controls+\lambda_1\sum Year+\Phi_1\sum Code+e_1 \quad (3)$$

$$Pro=\alpha_2+a_1DID+\sum\beta_2\times Controls+\lambda_2\sum Year+\Phi_2\sum Code+e_2 \quad (4)$$

$$KAC=\alpha_3+a_2DID+\sum\beta_3\times Controls+\lambda_3\sum Year+\Phi_3\sum Code+e_3 \quad (5)$$

Where $a$ is the constant term of the regression equation and $e$ is the model error term. The causal stepwise regression mediation effect analysis was conducted using Stata along these lines and the results are shown in Table 7.

**Table 7**
Results of the mechanism test.

| Variables | (1) Pub | (2) Pro | (3) Pub | (4) KAC | (5) Pub |
|---|---|---|---|---|---|
| DID | 1.410*(1.864) | 1.443*(1.665) | 1.325*(1.755) | 0.003***(2.720) | 1.367*(1.807) |
| Pro | | | 0.046***(4.596) | | |
| KAC | | | | | 13.297*(1.793) |
| Constant | 2.956(1.063) | 16.546***(10.191) | -6.459***(-4.534) | 0.035***(8.019) | 2.493(0.893) |
| Year | YES | YES | YES | YES | YES |
| Code | YES | YES | YES | YES | YES |
| Observations | 9,875 | 9,846 | 9,846 | 9,875 | 9,875 |
| $R^2$ | 0.665 | 0.846 | 0.668 | 0.898 | 0.665 |

The results from Table 7 confirm the mediating effects of available capital and absorptive capacity on the relationship between exports and firm's basic research capabilities, thereby validating hypotheses two and three. In columns (2) and (4), the coefficients of the binary variable DID for firms' export activities exhibit a positive association at the 10% significance level. It suggests that heightened export performance leads to increased accumulation of available funds and enhancement of knowledge absorptive capacity. In columns (3) and (5), the coefficients related to firms' exports, available funds, and knowledge absorptive capacity are all notably positive. It indicates that available funds and knowledge absorptive capacity act as partial mediators between exports and enterprises' fundamental research capability. Thus, companies can optimize their financial structure and enhance capital utilization efficiency through export activities, facilitating the augmentation of available capital to support fundamental research endeavors. Furthermore, enterprises can boost their knowledge absorptive capacity by engaging in strategic partnerships with academic institutions and research organizations, as well as establishing specialized research and development platforms, thereby establishing a solid groundwork for strengthening basic research capabilities.

## 6. Conclusions and Implications

*6.1. Research conclusion*

This study examines Zhongguancun enterprises over the span of 2005 to 2015 as the research sample, integrating enterprise capital and knowledge absorption capacity into the research framework of export and basic research capacity. The following findings are drawn by utilizing the PSM-DID model to explore the impact of enterprises' export activities on their basic research capacity.

Firstly, enterprises' export activities have a direct positive impact on their basic research capacity. Export activities positively influence enterprises' basic research capacity by providing access to advanced foreign technologies and fostering collaborations with excellent enterprises or universities. These opportunities enhance innovation potential and improve basic research capabilities.

Secondly, enterprises can obtain more abundant available funds through exporting activities, thus prompting them to participate in basic research. Exporting enables enterprises to access more funds, encouraging participation in basic research. Diversified funding sources from exporting activities support

stable financial backing for long-term basic research, contributing to sustained development in well-funded enterprises.

Thirdly, knowledge absorptive capacity plays a crucial role in enhancing basic research capabilities. By absorbing knowledge from advanced domestic and foreign technologies and integrating various knowledge resources, enterprises can enrich knowledge reserves, knowledge application and innovation capabilities, and eventually improve basic research capacities in export enterprises.

Lastly, the impact of exports varies across enterprises of different technological proficiency and ownership. Concerning the enhancement of basic research capabilities, the non-state-owned enterprises and enterprises of high technological proficiency exhibit more pronounced effects than the other two categories, with the latter two showing less conspicuous improvements in basic research capabilities.

### *6.2. Policy implications*

The aforementioned findings inform some significant recommendations for enhancing enterprises' fundamental research capabilities.

Firstly, optimize the export trade environment. There is a need to optimize the export trade environment by refining export trade policies to diminish trade barriers and expenses for export-oriented enterprises, particularly those with advanced technological prowess and larger operations. It is crucial to offer enhanced policy backing and resource allocation to bolster their competitiveness in global markets, foster technological advancements, and elevate product quality. This necessitates policymakers to contemplate streamlining export procedures, reducing tariff and non-tariff obstructions, and furnishing supportive services like export credit and insurance to diminish the costs and risks associated with exporting for enterprises.

Secondly, provide financial support and incentives. Financial backing and incentives play a pivotal role in propelling basic research forward. Establishing a dedicated fund enables the government to provide stable research funding to enterprises, especially those benefiting from export endeavors, thereby fostering their research and innovation activities. Therefore, formulating an efficient financial support and incentive framework to ensure prudent fund utilization while contemplating tax benefits or incentives for enterprises with substantial basic research achievements to stimulate original innovations is a critical aspect of framing enterprises' basic research policies.

Moreover, enhance the knowledge absorption capacity of enterprises. Augmenting enterprises' knowledge absorption capacity is essential for innovation. Strengthening internal training and technological acumen can enhance employees' professional skills and innovation potential, thereby elevating overall research standards. Government intervention can complement this by offering training subsidies, organizing technology workshops, and innovation symposiums to aid enterprises in enhancing their knowledge application and transformation capabilities.

Last but not the least, develop differentiated support strategies. Diverse enterprises, characterized by varying technological proficiency and ownership structures, exhibit disparities in their enhancement of basic research capabilities. To facilitate the advancement of research capabilities across all types of enterprises, it is imperative to implement tailored support strategies. For enterprises with lower technological proficiency and those of state ownership, enhancing basic research capabilities can be facilitated through provisions such as technical consultancy and market expansion services.

Implementing the aforementioned initiatives can effectively bolster enterprises' basic research capabilities, subsequently fostering scientific and technological advancements, industrial upgrades, and

infusing fresh vigor into China's industrial economy development. These recommendations are intended to furnish guidance to the government and policymakers in formulating precise and efficacious policies to stimulate enterprise innovation and ensure sustainable and robust national economic progress.

*6.3. Shortcomings and prospects*

The study discussed in this manuscript focuses on examining the influence of export activities on the fundamental research of enterprises. However, certain constraints arise from cognitive limitations and comprehension abilities. Initially, the investigation primarily employs the Logit model and PSM-DID model as research methods, neglecting the analysis of data dynamics and individual diversity. Additionally, due to limitations in data collection, the crucial variable of enterprise basic research investment was not fully taken into account. For future research, the sample scope can be further expanded including considerations of industry, geographical location, and policy variables. It's useful to refine and dissect the micro-level impacts of export activities on enterprises' basic research across various sectors and regions.

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