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THE QUANTUM LEAP OF COMPUTING: CATALYZING A PARADIGM SHIFT IN INDUSTRIAL ROBOT ADOPTION WITHIN FIRMS

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Annotation. With the establishment of supercomputing centers in various regions and countries, the leap in computational power has become a reality. As a typical sign of firms' move towards intelligence and digitalization, firms' application of industrial robots holds significant importance in firm development. To explore the logic of industrial robot applications and the role of supply chain finance in them, utilizing the OLS fixed-effect model and drawing on the theories of technological innovation and resource-based view, and using the data of Chinese A-share listed companies from 2007 to 2023, the impacts of computational power leap on the application of industrial robots in firms were examined. Results indicate that the leap in computational power significantly enhances the application level of industrial robots in firms. Further analysis reveals that the leap in computational power can significantly boost firms' intelligence levels, thereby promoting the application of industrial robots. Additionally, effective supply chain finance support can further strengthen the positive relationship between computational power leaps and the application of industrial robots in firms. The conclusions not only enrich the studies on firm intelligence development but also provide important empirical evidence for fully leveraging the value effect of computational power leaps and accelerating the intelligent process of firms.

Keywords: computational power leap, Industrial robots, Intelligence level, supply chain finance.

JEL classification: D21, G30, O30.

Introduction

The application of industrial robots, as a key element in the intelligent and digital transformation of firms, together with investment and innovation, constitutes the driving force for firm development and upgrading. According to Markets and Markets "Global Industrial Robot Market Forecast 2029" report, the global industrial robot market size is projected to grow from USD 16.89 billion in 2024 to USD 29.43 billion by 2029, with a compound annual growth rate of 11.7%. Against the backdrop of the global manufacturing industry's accelerated shift towards intelligence, the widespread application of industrial robots has become an important way for firms to enhance their core competitiveness and achieve high-quality development (Zhu, 2023).

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Computational power, as a core productive force in the digital economy era, has a profound impact on the intelligent development of firms (Mammela, Anttonen, 2017). Establishing supercomputing centers in various regions has turned the leap in computational power from a theoretical concept into reality (Dhiaf, 2024). However, the impact of this significant change on the application of industrial robots by micro-firms has received little attention in previous research. The enhancement of computational power brings new opportunities and possibilities for firms in data processing, algorithm optimization, and intelligent decision-making, which will likely affect the application level of industrial robots and promote the intelligent transformation of firms.

Firms, as the main body of industrial robot applications, have a significant impact on their development (De, 1997). The application of industrial robots helps firms increase production automation, reduce dependence on labor, alleviate labor shortages and promote technological innovation and industrial upgrading (Chen *et al.*, 2024). At the same time, firms can better participate in market competition and enhance their products' added value and market share by applying industrial robots. Existing literature has mainly analyzed the factors affecting the application of industrial robots from the perspectives of technological innovation, cost-benefit (Zheng *et al.*, 2016), policy support (Wade, 2016), market demand (Şahin, 2020), industrial chain collaboration (Wang *et al.*, 2024), industry competition (Zafar, 2024), and capital investment (Toquica, 2022). It can be seen that the existing literature has mainly analyzed the factors affecting the application of industrial robots in terms of technology, cost, and policy. The application of industrial robots is an important way for firms to achieve intelligent development (Mohan *et al.*, 2024).

However, a notable research gap exists in the current literature. While previous studies have examined multiple aspects of industrial robot applications, the specific influence of computational power on these applications has been largely overlooked. There is a lack of in-depth exploration of how augmented computational power can reshape the adoption, performance, and scope of industrial robots within firms. This study draws on two theoretical frameworks to bridge this gap. The technological innovation theory will be utilized to analyze how advancements in computing technology, which enhance computational power, drive innovation in industrial robot applications. It can elucidate how new algorithms and software-enabled by increased computational power facilitate more precise and efficient operations of industrial robots. The resource-based view will help explore how firms can leverage internal resources related to data management, IT infrastructure, and skilled personnel to better capitalize on the benefits of enhanced computational power for industrial robot applications.

Firms can achieve more precise control, more efficient scheduling of industrial robots, and deep integration with other intelligent devices by enhancing computational power. The leap in computational power can also impact firms' intelligence levels. Against the backdrop of increasingly fierce firm intelligence competition, this study will analyze how the leap in computational power affects the application of industrial robots in firms and the role of supply chain finance based on the theories of technological innovation and resource-based view. The theory of intelligence development explains understanding the behavior of industrial robot applications by firms and improving the intelligence level of firms. At the same time, the resource-based view theory also provides a basis for emphasizing the support of capital elements in firms' application of industrial robots (Das, 2024). This study will focus on the following questions: (1) the relationship between firm computational power enhancement and industrial robot application; (2) from the perspective of the advantages of supply chain finance, systematically examine the interactive effects of the leap in computational power and supply chain finance on the application of industrial robots in firms. The study will better guide firms in applying industrial robots and promote the intelligent development of firms.

The contributions of this study are reflected in the following aspects: First, it is the first to explore the factors affecting the application of industrial robots from the perspective of computational power leap, providing new evidence and perspectives for understanding the behavior of industrial robot application by firms and improving the intelligence level of firms. Second, existing literature mainly analyzes the behavior of industrial robot applications from a single perspective. At the same time, this study simultaneously introduces the technical aspect of "computational power leap" and the financial aspect of "supply chain finance" to examine the interactive effects of different elements, enriching the research on supply chain finance theory. Third, this study further examines the impact of supply chain finance and finds that effective supply chain finance support can strengthen the positive relationship between the leap in computational power and the application of industrial robots in firms. This conclusion not only enriches the research in the field of computational power leap but also provides evidence for the practical community on how firms can use the leap in computational power and supply chain finance to promote the application of industrial robots.

The remaining structure is arranged as follows. Section 2 presents the theoretical analysis and hypothesis development. Section 3 introduces the data and methods. Section 4 presents the results analysis. Section 5 discusses the results. Section 6 concludes the study with implications.

1. Theoretical Analysis and Hypothesis Development

1.1 The Impact of Computational Power Leap on the Application of Industrial Robots in Firms

The application of industrial robots by firms refers to the behavior of firms introducing industrial robots into production and operation links to replace or assist manual labor in completing related tasks. This is a key manifestation of firms' intelligent and digital development, involving transformations in production models and management methods. The application of industrial robots by firms is part of the strategy for firms to enhance their competitiveness (Dai *et al.*, 2024), and it is of great significance for firms to improve production efficiency and product quality, reduce production costs, and expand market space. Moreover, firms' application of industrial robots is also important in promoting industrial upgrading, high-quality economic development, and enhancing national manufacturing competitiveness (Lin *et al.*, 2022; Guo *et al.*, 2024).

The theoretical basis for applying industrial robots includes the principles of intelligent production and competitiveness enhancement, emphasizing the improvement of production intelligence level and market competitiveness of firms through introducing industrial robots. Therefore, firms' application of industrial robots will be affected by many factors. From the perspective of the external technological environment, technological development level (Ajwad *et al.*, 2014), technological policy orientation (Karintseva *et al.*, 2018), and industrial, technological ecosystem (Stanescu *et al.*, 2008) will all affect the application of industrial robots by firms. From the perspective of capital support, financial institutions' loan support (Li *et al.*, 2025) and the government's special fund subsidies (Lee *et al.*, 2022) are also conducive to promoting the application of industrial robots by firms. From the perspective of internal firms, innovation ability (Kodaira, 2016), management decision-making ability (Bard, 1986), and corporate strategic planning (Kuo *et al.*, 2016) are also important factors affecting the application of industrial robots by firms.

The leap in computational power refers to the process in which the computational power that firms can obtain and utilize is significantly enhanced due to the construction of supercomputing centers and the application of advanced computing technologies (Sun *et al.*, 2018; Hua *et al.*, 2023). This concept not only means the acceleration of computing speed but also includes improvements in data processing capabilities and algorithm optimization. The leap in computational power can enhance the intelligence level of firms (Deng, 2018). With strong computational power, firms can quickly analyze and process production data, thereby achieving the automation and intelligence of production processes. At the same time, the leap in computational power, through precise allocation of production resources and intelligent monitoring of production processes, helps firms improve production efficiency and product quality. With the enhancement of computational power, firms can more quickly carry out technological innovation and product upgrades, and enhance market competitiveness.

The leap in computational power can enhance the application level of industrial robots in firms in the following ways: First, according to the theory of intelligent production, improving the intelligence and automation level of production can promote the application of industrial robots (Hentout *et al.*, 2019). The leap in computational power can improve the operation efficiency of industrial robots. Enhancing the intelligence level and data processing capabilities of firms can significantly improve the operation accuracy and speed of industrial robots and enhance firms' application ability of industrial robots (Arents, Greitans, 2022). Second, enhancing the ability of firms to respond to market changes is also an important aspect of improving firm competitiveness. Faced with the uncertainty of market demand, the leap in computational power helps firms quickly analyze market data and adjust production strategies, making industrial robots better adapt to production changes and improving the production flexibility and adaptability of firms. Third, the operating costs of firms should be reduced. The computational power-based intelligent management system can reduce firms’ costs in the maintenance and scheduling of industrial robots. Fourth, promoting the technological innovation and upgrading of firms. The leap in computational power can accelerate the research and development and application of new types of industrial robots, and enhance the competitiveness of firms in the application of industrial robots.

In summary, the leap in computational power provides new impetus and opportunities for the application of industrial robots by firms. It helps firms gain a more favorable competitive position in intelligent development and can effectively improve the application level of industrial robots in firms. Therefore, the following hypothesis is proposed:

Hypothesis 1: The leap in computational power can significantly improve the application level of industrial robots in firms.

1.2 The Mediating Role of Intelligence Level

The theory of intelligence development suggests that the intelligence level of firms is a core factor affecting their production efficiency, innovation capability, and market competitiveness (Wang *et al.*, 2024). The leap in computational power can enhance the intelligence level of firms by improving data processing capabilities, optimizing decision-making processes, and promoting technological innovation. An enhanced intelligence level, in turn, can facilitate the application of industrial robots by providing better infrastructure, more efficient management systems, and more advanced technological support (Jin, 2024).

When firms have a higher intelligence level, they are better equipped to integrate industrial robots into their production processes. This is because a higher intelligence level implies better data analysis, process optimization, and system integration capabilities (Liu *et al.*, 2024). For example, firms with advanced data analytics capabilities can more effectively monitor and control the performance of industrial robots, thereby improving production efficiency and product quality. Additionally, a higher intelligence level can lead to more innovative applications of industrial robots, such as in developing new products or improving existing production lines.

Therefore, the intelligence level of firms is expected to mediate the relationship between the leap in computational power and the application of industrial robots. Specifically, the leap in computational power is hypothesized to enhance the intelligence level of firms, which in turn will facilitate the application of industrial robots.

Hypothesis 2: The intelligence level of firms mediates the relationship between the leap in computational power and the application of industrial robots.

1.3 The Moderating Role of Supply Chain Finance

Supply chain finance refers to the financial services and solutions that support the flow of goods and services within a supply chain. It plays a crucial role in providing the necessary capital for firms to invest in new technologies and equipment, including industrial robots. By optimizing the allocation of financial resources, supply chain finance can enhance firms' operational efficiency and competitiveness (Wu, 2024).

The application of industrial robots requires significant capital investment, both in terms of purchasing the robots and in the associated costs of installation, maintenance, and training. Supply chain finance can provide the necessary funding to support these investments (Zaman *et al.*, 2024), thereby facilitating the adoption of industrial robots. Moreover, supply chain finance can also help firms manage their cash flow more effectively, reducing the financial risks associated with such investments (Ng *et al.*, 2023).

When firms have access to effective supply chain finance, they are more likely to invest in advanced technologies like industrial robots, which can lead to improved production efficiency and competitiveness. Therefore, supply chain finance is expected to moderate the relationship between the leap in computational power and the application of industrial robots. Specifically, it is hypothesized that the positive effect of the leap in computational power on the application of industrial robots will be stronger when firms have better access to supply chain finance.

Hypothesis 3: Supply chain finance moderates the relationship between the leap in computational power and the application of industrial robots, enhancing the positive effect of the leap in computational power on the application of industrial robots.

2. Methodology

2.1 Data Source and Sample Selection

This article examines the impact of computing power leap on firm industrial robots, taking the establishment of national supercomputing centers in different cities in China as an opportunity, and selects China's Shanghai and Shenzhen A-share listed companies from 2007 to 2023 as research samples for analysis. To ensure the reliability of the empirical results, the initial samples are screened as follows: (1) ST samples are eliminated; (2) financial and insurance industries are eliminated; (3) samples with missing data are eliminated; (4) the main continuous variables are winsorized at the 5% and 99% percentiles. The computing power leap data was obtained by manual sorting, and other data came from the CSMAR and CNRDS databases.

2.2 Variable Settings and Descriptions

Robot application (*Robot*). The explanatory variable of this study is the logarithm of the number of industrial robots in firms. Research on robots generally uses data from the World Federation of Robotics (IFR). Still, this database only publishes robot stock data at the industry level in various countries and cannot reflect the application of robots at the firm level. This study refers to the practice of existing research (Ren, Li, 2025). It uses Python software to analyze the robot usage data published in the quarterly and annual reports, social responsibility reports, environmental reports of listed companies, and sustainable development reports published by government departments. Combined with manual inspection and proofreading, some outliers are identified and eliminated. Samples that meet the requirements are extracted to determine the number of robots installed by the firm in that year, and 1 is added to take the logarithm.

Computing power leap (*NSC*). Establishing the National Supercomputing Center can reflect the leap in computing power to a certain extent. According to the differences in the time points of the establishment of national supercomputing centers in different cities (Tang, 2022), during the research sample period, if the company under the registered city is located after the establishment of the National Supercomputing Center, the NSC value is 1. The value is 0 in other cases. Since this study will use time series differences to characterize the leap in computing power, the fixed effects at the company level will be used in the empirical regression.

Table 1. Connotation and definition of main variables

Variable type	Variable code	Variable definition
Dependent variable	*Robot*	The number of robots installed by the firm in the current year, plus 1 to take the logarithm.
Independent variable	*NSC*	If the registered city of the firm is after the establishment of the National Supercomputing Center, the NSC value is 1, otherwise the value is 0.
Mediating variable	*IM*	Using the text mining method, the keyword frequency is used to build the measurement index of intelligent manufacturing.
Moderating variable	*SCF*	(Short-term loans + notes payable)/total assets
Control variable	*SIZE*	Natural logarithm of total assets.
	LEV	The firm's total short-term and long-term debt is divided by total assets.
	ROA	Net income divided by total assets.
	GROWTH	Operating income growth rate.
	TOP1	The shareholding ratio of largest shareholders.
	OUTR	Number of independent directors divided by number of board members.
	BSIZE	The natural logarithm of the number of board members.
	DUAL	An indicator variable that equals 1 if the chairman and general manager are both appointed, otherwise it is 0.
	AGE	Natural logarithm of the company's establishment years.
	Year	Year represents the year-fixed effect.
	Firm	Firm represents the firm fixed effect.

Source: created by the authors.

Intelligence level (*IM*). Intelligent manufacturing can reflect the intelligence level of a firm to a certain extent. Referring to the practice of existing research (Wen *et al.*, 2022), the text mining method is used to construct the measurement index of intelligent manufacturing using keyword frequency. This study will measure the intelligence level through the following three steps: (1) Calculate the ratio of the keyword combination frequency of the sample company to the total number of words of the sample company; (2)

Calculate the ratio of the proportion of the sample company to the total proportion of the sample companies in the same industry in the same year; (3) Multiply the ratio by 100 to measure the intelligence level of the sample company. If the keyword does not appear in the annual report of the sample company, the intelligence level of the sample company in that year is assigned a value of 0.

Supply chain finance (*SCF*). Supply chain finance reflects the borrowing and lending of funds between supply chains. This study mainly analyzes the impact of supply chain financial support. Therefore, drawing on the practice of existing literature (Ng *et al.*, 2023), (short-term loans + notes payable)/total assets are used to measure the degree of supply chain financial support. The larger the value, the higher the supply chain financial support degree.

Control Variables: Firm size (*SIZE*), financial leverage (*LEV*), profitability (*ROA*), growth opportunities (*Growth*), major shareholder shareholding ratio (*TOP1*), board characteristics (*OUTR*; *BSIZE*; *DUAL*), years of establishment (*AGE*), year and firm fixed effects.

The definitions of the above variables are listed in *Table 1*.

2.3 Model Construction

To test the hypotheses, the following models were specified:

$$Robot = \alpha_0 + \alpha_1 NCS + Controls + Year + Firm + \varepsilon \tag{1}$$

In model (1), the explained variable is robot application (Robot), and the explanatory variable is computing power leap (*NSC*). Since the establishment of the National Super Computing Center differs in different cities, this study will use the double difference model for analysis. The company fixed effect will be controlled at this time, and the expected computing power leap (*NSC*) regression coefficient is significantly positive.

$$IM = \alpha_0 + \alpha_1 NCS + Controls + Year + Firm + \varepsilon \tag{2}$$

$$Robot = \alpha_0 + \alpha_1 NCS + \alpha_2 IM + Controls + Year + Firm + \varepsilon \tag{3}$$

To examine the mediating role of the level of firm intelligence, the three-step method will be used to test the mediating effect, and the regression results of models (1)-(3) will be analyzed.

$$Robot = \alpha_0 + \alpha_1 NCS + \alpha_2 SCF + \alpha_3 NCS \times SCF + Controls + Year + Firm + \varepsilon \tag{4}$$

To examine the moderating role of supply chain financial support, model (4) will be used for analysis. The coefficient of the interaction term of expected computing power leap (*NSC*) and supply chain finance (*SCF*) is significantly positive.

3. Results Analysis

3.1 Descriptive Statistics

Table 2 shows the descriptive statistical results.

Table 2. Descriptive statistics of main variables

Variable	Obs	Mean	S.d.	Min	Median	Max
Robot	35,055	3.247	1.499	0.000	3.693	7.460
NSC	35,055	0.213	0.178	0.000	0.000	1.000
IM	35,055	0.115	0.319	0.000	0.089	0.827
SCF	35,055	0.186	0.081	0.012	0.146	0.730
SIZE	35,055	22.137	1.263	20.219	21.961	24.887
LEV	35,055	0.458	0.209	0.118	0.452	0.841
ROA	35,055	0.043	0.055	-0.088	0.040	0.152
GROWTH	35,055	0.143	0.289	-0.338	0.105	0.872
TOP1	35,055	0.340	0.141	0.130	0.319	0.617
OUTR	35,055	0.389	0.079	0.250	0.375	0.556
BSIZE	35,055	2.249	0.264	1.792	2.197	2.773
DUAL	35,055	0.221	0.415	0.000	0.000	1.000
AGE	35,055	2.832	0.314	2.197	2.890	3.332

Source: own calculations.

The mean of Robot Application (*Robot*) is 3.247, the maximum is 7.460, the minimum is 0.000, and the standard deviation is 1.499. The large standard deviation indicates that there are obvious differences in the amount of robot installation among different firms. The mean of Computing Power Leap (*NSC*) is 0.213. The mean intelligence level (*IM*) is 0.115. Combined with its definition, the text mining method is used to construct the intelligent manufacturing measurement index using the keyword frequency. The larger the value is, the higher the level of intelligence. It can be seen that the level of intelligence among firms is uneven. The mean of Supply Chain Finance (*SCF*) is 0.186, which reflects the degree of financial support firms receive in the supply chain. The mean of 0.186 indicates that the overall support level of sample firms in supply chain finance is at a medium level.

3.2 Correlation Analysis

The correlation coefficient between *NSC* and *Robot* is 0.098, and is significant at the 1% level, indicating that *NSC* can improve the application level of firm robots (*Table 3*).

Table 3. Pearson correlation coefficient matri

	Robot	*NSC*	*IM*	*SCF*	*SIZE*	*LEV*	*ROA*	*GROWTH*	*TOP1*	*OUTR*	*BSIZE*	*Dual*
Robot	1											
NSC	0.098***	1										
IM	0.588***	0.094***	1									
SCF	-0.145***	-0.045***	-0.096***	1								
SIZE	0.204***	0.013**	0.133***	0.036***	1							
LEV	-0.094***	-0.013**	-0.060***	0.509***	0.421***	1						
ROA	-0.050***	-0.002	-0.039***	-0.299***	0.009*	-0.380***	1					
GROWTH	-0.045***	0.012**	-0.041***	-0.039***	0.062***	0.005	0.297***	1				
TOP1	-0.084***	-0.011**	-0.058***	-0.034***	0.197***	0.032***	0.147***	0.028***	1			
OUTR	-0.056***	0.027***	-0.042***	-0.012**	-0.059***	-0.051***	0.040***	0.001	0.026***	1		
BSIZE	0.109***	-0.012**	0.070***	0.016***	0.267***	0.163***	-0.083***	-0.039***	-0.026***	-0.189***	1	
DUAL	0.116***	0.062***	0.080***	-0.019***	-0.175***	-0.149***	0.025***	0.024***	-0.039***	0.020***	-0.095***	1
AGE	0.497***	0.101***	0.339***	-0.065***	0.203***	0.091***	-0.090***	-0.085***	-0.166***	-0.072***	0.133***	-0.032***

Notes: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively.

Source: own calculations.

The correlation coefficient between *IM* and *Robot* is also significantly positive, indicating that a higher level of intelligence can improve the application of firm robots. The VIF values of other control variables are all less than 5, indicating that the model design is good.

3.3 Basic Regression Analysis

The leap in computing power can provide stronger technical support for various firms' business operations. Establishing the National Supercomputing Center enables regional firms to obtain massive computing resources and advanced algorithm support. For industrial robot applications, powerful computing power helps to optimize the programming control of robots, making their operation more accurate and efficient; it can quickly process a large amount of sensor data, enabling robots to perceive and respond flexibly to complex production environments in real-time. It can also use computing power to simulate and simulate, test, and optimize robots before deployment, reducing costs and risks. Therefore, from a theoretical logic point of view, the leap in computing power has a driving effect on the improvement of the application level of industrial robots in firms.

Table 4. The impact of the leap in computing power on industrial robot applications

Variable	(1)	(2)
	Robot	***Robot***
NSC	0.035*** (14.192)	0.021*** (23.033)
SIZE		-0.000 (-0.535)
LEV		-0.000 (-0.156)
ROA		-0.001 (-0.110)
GROWTH		0.001 (1.193)
TOP1		0.005* (1.832)
OUTR		-0.001 (-0.298)
BSIZE		-0.002 (-1.106)
DUAL		-0.001 (-0.737)
AGE		0.001 (1.109)
Constant		4.356*** (3.537)
Year Effect	Yes	Yes
Firm Effect	Yes	Yes
N	35,055	35,055
A-R2	0.031	0.875

Notes: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively; the values in brackets represent robust standard errors.

Source: own calculations.

Table 4, column (1) is the baseline regression result. The coefficient of the leap in computing power (*NSC*) is significantly positive, indicating that the leap in computing power can improve the robot application of firms. Column (2) controls the relevant factors. At this time, the regression coefficient of the leap in computing power (*NSC*) is 0.021. This shows that when the computing power of the firm in the region increases due to the establishment of the National Supercomputing Center (*NSC*) value changes from 0 to 1, the firm's industrial robot application level (*Robot*) will increase significantly by 0.021. The regression results prove that increased computing power can improve the firm's industrial robot application level.

3.4 Robustness Test

3.4.1 Hysteresis regression model

In the hysteresis regression model of *Table 5*, column (1) shows the impact of the variable computing power leap (*NSC*) on the next period of robot application (*Robot*). From the results, the regression coefficient of NSC is still 0.021, which means that even considering the time lag factor, when the computing power leap occurs in the region where the firm is located, the firm's industrial robot application level in the next period will still increase significantly by 0.02. Overall, the results after adopting the hysteresis model are consistent with the previous ones, indicating robust research conclusions.

3.4.2 Control the economic level of the region

Column (2) controls the regional economic level (expressed as GDP per capita, i.e., natural logarithm). The regression coefficient of the variable computing power leap (*NSC*) on the robot application (Robot) is 0.022, which is significant at the 1% level), which shows that after incorporating the regional economic level factor, the computing power leap still has a significant effect on improving the level of industrial robot application. At the same time, the coefficient of the GDP variable is 0.001. It is significant at the 5% level, indicating that the regional economic level also has a certain impact on the application of industrial robots.

Table 5. Robustness test

Variable	*(1)*	*(2)*
	Robot $_{t+1}$	***Robot***
NSC	0.021*** (18.830)	0.022*** (21.839)
GDP		0.001** (2.297)
SIZE	-0.001 (-1.203)	-0.000 (-0.996)
LEV	0.001 (0.514)	0.001 (0.307)
ROA	0.015* (1.895)	-0.000 (-0.011)
GROWTH	-0.000 (-0.321)	0.001 (1.152)
TOP1	0.003 (1.258)	0.004* (1.656)
OUTR	0.003 (0.505)	-0.003 (-0.584)
BSIZE	-0.000 (-0.319)	-0.002 (-1.046)
DUAL	-0.000 (-0.417)	-0.001 (-0.966)

Table 5 (*continuation*). Robustness test

Variable	*(1)*	*(2)*
	Robot$_{t+1}$	***Robot***
AGE	-0.000 (-0.125)	0.001 (0.872)
Constant	4.419*** (6.475)	4.354*** (8.400)
Year Effect	Yes	Yes
Firm Effect	Yes	Yes
N	30,512	35,055
A-R2	0.854	0.879

Notes: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively; the values in brackets represent robust standard errors.

Source: own calculations.

The results show that even if the regional economic level is controlled, the findings remain robust.

3.5 Analysis of Impact Mechanisms

The leap in computing power has injected a strong impetus into the intelligent transformation of firms. The ultra-high computing power brought by the National Supercomputing Center can help firms quickly process massive amounts of data, which is crucial for building intelligent production systems, accurately analyzing market demand, and optimizing firm operation processes. Through efficient data processing and analysis, firms can more accurately formulate intelligent development strategies, accelerate the research and development and application of intelligent technologies, and thus significantly improve the intelligence level of firms. A higher level of intelligence will prompt firms to introduce more advanced industrial robots in the production process, realize the automation and intelligent upgrade of the production process, and match the overall intelligent development direction of the firm, forming a virtuous cycle in which the leap in computing power promotes intelligence. Intelligence drives the application of industrial robots.

Table 6. Analysis of impact mechanisms

Variable	**(1)**	**(2)**
	IM	***Robot***
NSC	0.004** (2.144)	0.021*** (23.023)
IM		0.002** (2.239)
SIZE	-0.001 (-0.638)	-0.000 (-0.542)
LEV	0.007 (0.591)	-0.000 (-0.149)
ROA	-0.016 (-0.366)	-0.001 (-0.114)
GROWTH	-0.013* (-1.737)	0.001 (1.172)
TOP1	0.013 (0.892)	0.005* (1.843)
OUTR	0.001 (0.032)	-0.001 (-0.297)

Table 6 (*continuation*). Analysis of impact mechanisms

BSIZE	-0.013 (-1.542)	-0.002 (-1.125)
DUAL	-0.001 (-0.200)	-0.001 (-0.740)
AGE	0.007 (0.839)	0.002 (1.119)
Constant	1.319*** (19.369)	4.358*** (9.115)
Year Effect	Yes	Yes
Firm Effect	Yes	Yes
N	35,055	35,055
A-R2	0.401	0.875

Notes: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively; the values in brackets represent robust standard errors.

Source: own calculations.

Observing the regression results in *Table 6*, in column (1), the regression coefficient of the leap in computing power (*NSC*) on the intelligent level (*IM*) is 0.004. It is significant at the 5% level, with a t value of 2.144, which shows that the leap in computing power has a significant positive effect on the intelligence level of firms. In column (2), after the intelligent level (*IM*) variable is included, the regression coefficient of computing power leap (*NSC*) on robot application (*Robot*) is still 0.021 and significant at the 1% level. At the same time, the regression coefficient of intelligent level (*IM*) on robot application (*Robot*) is 0.002, and the t value is 2.239. This shows that computing power leap directly promotes the application of industrial robots on the one hand and further promotes the application of industrial robots through the intermediate mechanism of improving the intelligence level of firms on the other hand, which fully verifies the view that computing power leap can promote the application of industrial robots by improving the intelligent level of firms.

3.6 Impact of Supply Chain Finance

The leap in computing power provides a technical foundation for the intelligent development of firms. It can help firms achieve upgrades in production, management and other aspects, thereby promoting the application of industrial robots. As an important means of financial support, supply chain finance can provide necessary financial guarantees for firms in the process of intelligent transformation and industrial robot application. When firms obtain good supply chain financial support, they are more capable of investing resources to utilize computing power advantages, conduct intelligent technology research and development, and purchase, install, and maintain industrial robots. Therefore, supply chain finance can strengthen the role of computing power leaps in improving the application of industrial robots in firms.

Table 7. The impact of supply chain finance

Variable	*Export*
NSC	0.022*** (16.854)
SCF	0.002 (0.454)
*NSC*SCF*	0.001** (2.147)

Table 7 (*continuation*). The impact of supply chain finance

Variable	*Export*
SIZE	-0.000 (-0.492)
LEV	-0.001 (-0.400)
ROA	-0.000 (-0.056)
GROWTH	0.001 (1.196)
TOP1	0.005* (1.841)
OUTR	-0.001 (-0.305)
BSIZE	-0.002 (-1.093)
DUAL	-0.001 (-0.760)
AGE	0.002 (1.124)
Constant	4.355*** (3.770)
Year Effect	Yes
Firm Effect	Yes
N	35,055
A-R2	0.875

Notes: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively; the values in brackets represent robust standard errors.

Source: own calculations.

Observing the regression results in *Table 7*, the regression coefficient of computing power leap (*NSC*) on robot application (*Robot*) is 0.022, and it is significant at the 1% level, indicating that computing power leap has a significant positive impact on firm robot application. The coefficient of the interaction term *NSC*SCF* between computing power leap and supply chain finance is 0.001. It is significant at the 5% level, meaning that supply chain finance can enhance the effect of computing power leaps on the application of industrial robots in firms. That is, with the support of supply chain finance, the effect of computing power leaps on promoting firm intelligence and industrial robot applications will be more significant, which verifies the hypothesis.

4. Discussions

In the context of the accelerated integration of digitalization and intelligence, firms use of computing resources and intelligent upgrading have become key development paths. The leap in computing power and the improvement of the level of intelligence will affect firms' production decisions and technological innovation. In the context of increasingly fierce market competition, can the leap in computing power help firms better improve their level of intelligence, thereby promoting the application of industrial robots to enhance the market competitiveness of firms? What role does supply chain finance play in this process? These issues need to be explored in depth. The empirical results of this study show that the leap in computing power can significantly improve the level of intelligence of firms, thereby promoting the application of industrial robots, and supply chain finance can strengthen the role of the leap in computing power in improving the application of industrial robots in firms. At this point, all the problems mentioned in the introduction have been solved. The specific discussion is as follows:

The leap in computing power will have a significant impact on the level of intelligence of firms and the application of industrial robots, which is manifested in that the leap in computing power can significantly improve the level of intelligence of firms, thereby promoting the application of industrial robots. Starting from the theory of technological innovation and production upgrading, this study finds that firms can bring themselves technological advantages and production efficiency advantages through computing power leaps, making firms more competitive in the production link. This shows that the application of industrial robots by firms will not only be affected by production costs, and technical difficulties but also by the leap of computing power and intelligence level of firms. The conclusion of this study also supports the research of (Che *et al.*, 2024) on the impact of computing power improvement on the development of firm intelligence because, in production activities, a higher level of intelligence is an important basis for improving firm competitiveness and promoting the application of industrial robots. On the other hand, the test results also show that the improvement of the application of industrial robots in firms also depends on technological innovation capabilities. The test results are consistent with the research results of (Guo, Su, 2023), indicating that stronger technological innovation capabilities can promote the application of industrial robots in firms.

The effect of computing power leaps on the application of industrial robots in firms varies under different supply chain financial support levels. The study found that compared with the situation with low supply chain financial support, the effect of computing power leaps on the application of industrial robots in firms is more significant when the supply chain financial support is high. Supply chain financial theory points out that supply chain finance can affect firms' capital flow and resource allocation, and good supply chain financial support can motivate firms to use technical resources more effectively and improve production efficiency. Based on the supply chain financial theory, this study analyzes the differential impact of computing power leaps under different levels of supply chain financial support, and the research conclusion enriches the relevant research on supply chain financial theory. As discussed in (Liu *et al.*, 2015), under different supply chain financial environments, there will be differences in the motivation for technology investment and the effect of production upgrade. Then, firms with higher levels of supply chain financial support are more capable of taking advantage of the advantages of computing power leaps and effective internal intelligent upgrades, which can have a more positive impact on the application of industrial robots in firms.

Supply chain finance plays a regulatory role in the relationship between Computing Power Leap and the application of industrial robots in firms; that is, when the level of supply chain financial support is high, it will strengthen the role of Computing Power Leap in promoting the application of industrial robots in firms. Starting from the theory of supply chain finance, this study verifies the positive role of supply chain finance as a resource allocation factor in applying industrial robots in firms. Higher supply chain financial support can achieve synergy with the leap in computing power; thereby better promoting firms' application of industrial robots. This conclusion is consistent with the research conclusion of (Wang, 2016), indicating that supply chain finance has played a positive role in the production upgrade of firms. On the other hand, it also shows that the application behavior of firms for industrial robots will be affected by many factors (Kopp *et al.*, 2021). In addition to the leap in computing power, supply chain financial factors also play an important role in applying industrial robots in firms. They can also strengthen the role of computing power leaps in promoting the application of industrial robots in firms.

Conclusions and recommendations

Main Findings

This study explores the impact of computing power leap on its industrial robot application and examines the role of intelligence level, and supply chain finance, the following conclusions can be drawn: (1) based on the perspective of market competition theory, it is found that computing power leap can significantly improve the application level of firm industrial robots, and the conclusion still holds after robustness test. (2) The impact mechanism test shows that computing power leaps can improve the intelligence level of firms, thereby promoting the application of industrial robots. (3) From the perspective of financing theory, it is found that supply chain finance can strengthen the role of computing power leaps in improving the application of firm industrial robots.

Managerial Implications

Considering the profound impact of computing power leap on the intelligent development of firms and the application of industrial robots to improve the production efficiency and market competitiveness of firms, accelerate the intelligent process of firms, and promote high-quality economic development. To enable firms to seize opportunities better and cope with challenges in the context of computing power leap, the following enlightenment is proposed based on the research conclusions of this article.

Actively promote computing power leap and application. Firms should fully realize the importance of computing power leap in improving the application level of industrial robots and increase investment in computing power infrastructure, such as accessing the computing power resources of the National Supercomputing Center and upgrading the company’s computing equipment, to improve the intelligence level and competitiveness of firms in the production process. For example, manufacturing firms can optimize the operation algorithm of industrial robots by accessing the computing power of the National Supercomputing Center, realizing precise control of the production process, and thus significantly improving product quality and production efficiency.

Pay attention to the improvement of intelligence level. Firms should focus on the research development and application of intelligent technology, strengthen the collection, analysis, and utilization of data, and improve the intelligent decision-making ability of firms to give full play to the advantages of computing power leaps. Especially for those firms that plan or are using computing power leap, they should increase investment in intelligent technology so that it can be better combined with industrial robot applications. It is recommended that firms establish a dedicated, intelligent R&D team to use computing power to conduct in-depth mining and analysis of production data, provide more accurate instructions and optimization solutions for the application of industrial robots, and thus strengthen the role of computing power leap in promoting the application of industrial robots.

Strengthen supply chain financial support. Given that effective supply chain financial support can further strengthen the positive relationship between computing power leap and firm industrial robot application, financial institutions and governments should further improve the supply chain financial service system, provide firms with more convenient and efficient financial support and financial services, and alleviate the financial pressure of firms in the process of computing power investment and industrial robot application. Financial institutions can develop special loan products for firm computing power upgrades and industrial robot procurement, provide preferential loan interest rates and flexible repayment methods; the government can introduce relevant policies to encourage financial institutions to increase their support for firms, help them better realize intelligent transformation, and improve the level of industrial robot application.

Limitations and Future Directions

This study still has some limitations. First, in terms of measuring the level of industrial robot application in firms, although the current measurement of the number of robot installations reflects the degree of application of industrial robots by firms to a certain extent, it still needs to be further refined. Although this indicator can reflect firms' investment in the number of robot applications, it fails to fully cover important dimensions such as the quality, efficiency, and diversity of application scenarios of industrial robot applications. Based on the data availability of subsequent research, a more comprehensive measurement indicator system can be constructed in the future from the aspects of the use time of industrial robots, the complexity of application scenarios, and the output efficiency of robots per unit time.

In addition, the samples of this study only focus on A-share listed companies in Shanghai and Shenzhen of China. Although these companies occupy an important position in the domestic economy, and China's manufacturing industry is large in scale and plays a key role in the global industrial chain, it is representative, but there are still limitations. Significant differences in industrial structure, economic policies, technological development level, and firm operating environment exist in different countries, which may lead to limited applicability of the research conclusions in other countries or regions. Subsequent research may consider incorporating firm samples from developed countries such as Europe the United States, and other emerging economies to comprehensively examine the influencing factors of industrial robot application in firms in different countries and regions under the background of computing power leap.

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KVANTINIS ŠUOLIS KOMPIUTERIJOS SRITYJE: PARADIGMOS POKYČIO SKATINIMAS PRAMONINIŲ ROBOTŲ DIEGIMO ĮMONĖSE

Xuegong Du, Yanping Wang

Santrauka. Įvairiuose regionuose ir šalyse įkūrus superkompiuterių centrus, skaičiavimo galios šuolis tapo realybe. Pramoninių robotų taikymas įmonėse yra kaip tipiškas įmonių judėjimo link intelekto ir skaitmeninimo požymis ir labai svarbus įmonių plėtrai. Siekiant išanalizuoti pramoninių robotų pritaikymo logiką ir tiekimo grandinės finansavimo vaidmenį, pasitelkiamas OLS fiksuoto poveikio modelis, technologinių inovacijų ir į išteklius orientuotos teorijos, naudojami Kinijos A-akcijų sąraše esančių įmonių duomenys nuo 2007 iki 2023 metų. Rezultatai rodo, kad kompiuterinio galingumo šuolis žymiai padidina pramoninių robotų naudojimo lygį firmose. Tolimesnė analizė atskleidžia, kad kompiuterinio galingumo šuolis gali reikšmingai padidinti įmonių intelekto lygį ir taip skatinanti pramoninių robotų pritaikymą. Be to, efektyvi tiekimo grandinės finansavimo parama gali dar labiau sustiprinti teigiamą ryšį tarp kompiuterinio galingumo šuolio ir pramoninių robotų pritaikymo firmose. Išvados ne tik praturtina studijas apie įmonių intelekto vystymąsi, bet ir suteikia svarbių empirinių įrodymų, kaip visapusiškai panaudoti kompiuterinio galingumo šuolio vertės efektą ir spartinti įmonių intelektualų procesą.

Reikšminiai žodžiai: kompiuterinio galingumo šuolis; pramoniniai robotai; intelekto lygis; tiekimo grandinės finansavimas.