The Influence of Industrial Robot Investment on Enterprise Labor Productivity is Analyzed Based on Econometric Model

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Abstract. The International Federation of Robotics (IFR) released the statistics of global robots in 2020. According to the statistics, the cumulative installation of industrial robots in China has reached 783000, ranking first in Asia. As an intelligent product, industrial robots can replace labor to complete many difficult and dangerous production activities, so as to greatly improve production efficiency. In this context, this paper analyzes the impact of industrial robots on enterprise labor productivity, constructs an econometric model of the impact of industrial robot investment on enterprise labor productivity, and makes descriptive statistics and regression analysis with the help of the panel data at the product level from 2019 to 2020 provided by the General Administration of Customs of China, The results show that the investment of industrial robots has a positive impact on enterprise labor productivity, and the impact is different from the perspective of regional heterogeneity.

Keywords: Industrial Robot · Labor Productivity · Econometric Model · Regression Analysis

1 Introduction

Industry plays an important role in China's national economy. The change of its labor productivity will directly affect the quality and speed of economic development and the improvement of competitive advantage, and directly determine the level of China's technological and economic development. However, in recent years, some scholars have found that at the macro level, the growth of labor productivity in many countries shows signs of slowing down. The average annual growth rate of the United States was 2.8% from 1995 to 2004, while the average annual growth rate of labor productivity in the United States was only 1.3% from 2005 to 2016. In addition, many countries have experienced similar deceleration. Since the reform and opening up, China's traditional manufacturing industry has actively integrated into the global economy with the advantages of labor cost and resource endowment, realized the "growth miracle", and the labor productivity level of manufacturing industry has also been rapidly improved [6]. However, China's economic growth is mainly driven by capital, and the investment rate has been above 30%, reaching a peak of 47.33% in 2011 [7]. Due to the investment driven

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characteristics of China's economy, the contribution rate of technological progress to China's economic growth is relatively small, and China's long-term total factor productivity growth does not have an advantage [5]. In recent years, as the latest representative of intelligence, informatization and technological progress, robot is an important factor to promote the transformation of China's investment drive into innovation drive and technology drive. Its wide use may become one of the important driving forces to improve the labor productivity of China's manufacturing enterprises.

2 Analysis of the Current Situation of Industrial Robots in China

2.1 Total Market Analysis

Market demand promotes the development of China's industrial robot industry. From 2004 to 2019, the sales of industrial robots in the Chinese market in the past 16 years are shown in Fig. 1. As can be seen from the figure, the sales volume of industrial robots in the Chinese market shows a trend of rapid growth: in 2004, the annual sales volume of China's industrial robot market was only 3493 units, with a cumulative ownership of 7096 units; However, in 2019, the annual sales volume of China's industrial robot market reached 140500 units, and the cumulative ownership reached 783000 units. It can be concluded that the sales volume of industrial robots in the Chinese market continues to rise.

2.2 Import Analysis

According to the data released by China Customs, the import quantity and import amount of China's industrial robots from 2004 to 2019 are shown in the figure. As can be seen from Fig. 2, the number of imported industrial robots increased from 9993 in 2004 to 60722 in 2019, and the import amount increased from US $29615300 in 2004 to US $989855100 in 2019. From 2001 to 2019, the number and amount of industrial robots imported by China showed a basically consistent rapid growth trend.

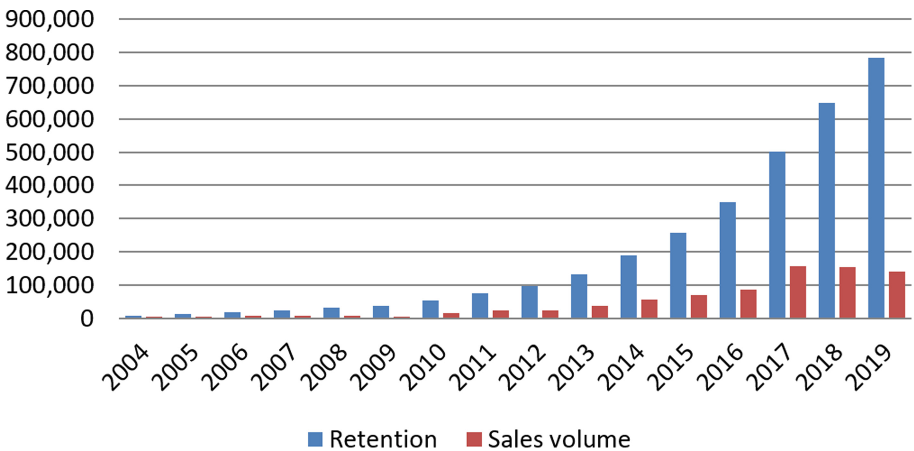

Fig. 1. Analysis of total industrial robot market.

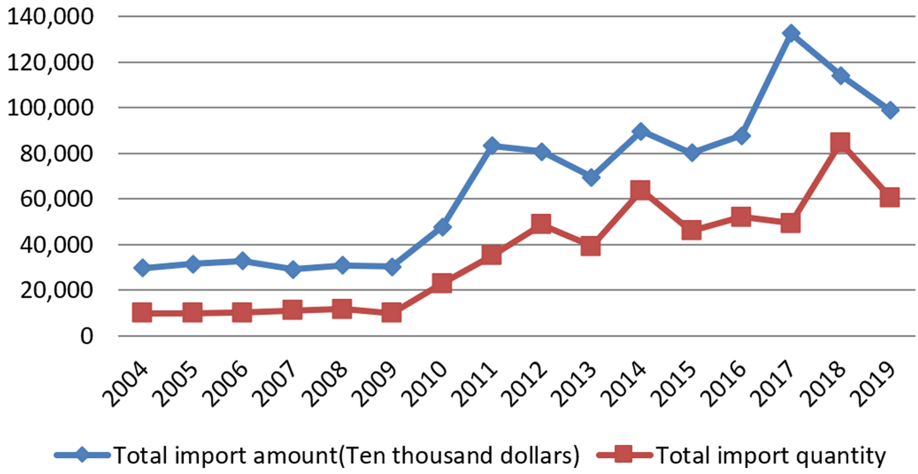

Fig. 2. Analysis on the import of industrial robots.

3 Analysis on the Influence of Industrial Robot Investment on Enterprise Labor Productivity

Enterprise labor productivity is the ratio of enterprise industrial added value to the average number of employees. Therefore, when studying the influencing factors of enterprise labor productivity, this paper starts from two aspects: industrial GDP and labor demand.

3.1 Influence of Industrial Robot Investment on Industrial GDP

Gross industrial output value is the total amount of industrial products sold or available for sale produced by industrial enterprises in a certain period of time. Capital accumulation and technological progress are the key factors affecting the total industrial output value of enterprises. At the same time, they are interrelated and inseparable [8]. Only new production technology can catalyze new production equipment, and the investment of a large number of new equipment capital will also accelerate the efficiency of technological progress. According to Cobb Douglas function, when the labor input remains unchanged, with the improvement of enterprise technology and the increase of capital input, the total output of the enterprise will be higher and higher, so as to improve its labor productivity. In enterprises, robots, as the representative of technological progress and capital, will eventually improve the labor productivity of enterprises by increasing the gross domestic product of enterprises.

3.2 Influence of Industrial Robot Investment on Labor Force

In the 1970s, some economists believed that with the progress of science and technology, some of our jobs would eventually be completed by machines, but we lost our jobs, leading to an increase in unemployment. After the 1980s, some scholars believe that with the continuous progress and development of artificial intelligence, the comparative advantages between human and machine are gradually emerging, and its automation will further reduce the labor demand. Lordan and Neumark believe that workers in low skill fields are more likely to be replaced by machines than workers in medium and high skill fields [2]. However, Acemoglu and Restrepo have different views. They have built a new framework. Labor force and new technology interact. New technology can replace workers to complete tasks, but at the same time, new tasks will be generated. Workers have more advantages to complete these new tasks than their automatic completion. If there are obvious advantages and new tasks continue to appear, Then, even with the continuous development of automation, employment and labor share will maintain a relatively stable state [1]. It can be seen that foreign studies in this regard believe that robots will replace the labor force of enterprises to a certain extent, and this substitution occurs more in low skill fields. However, the development status of different countries is different, and the impact is also different. For China, the cost of robots is much higher than the labor cost. The investment of robots will not reduce the labor force, but is the way for enterprises to expand their scale. Therefore, the investment of robots is still helpful to improve the labor productivity of enterprises.

To sum up, robots improve the labor productivity of enterprises mainly through two ways: one is to increase the industrial GDP through the improvement of technical level and the increase of capital investment, so as to improve the labor productivity of enterprises; The other is to expand the production scale through robots, so as to improve the labor productivity of enterprises.

4 Data Source, Model Setting and Variable Description

4.1 Data Source

Using the macro data provided by IFR, Kromann found that industrial robots have a significant positive impact on productivity. The study pointed out that if a country improves the automation level to the level of the country with the highest automation level, its manufacturing productivity can be greatly improved [4]. Using the macro data provided by IFR, Graetz and Michaels found that the use of industrial robots has a significant positive impact on regional labor productivity and industrial added value. [3]. Based on the Customs Trade data at the enterprise product level provided by the General Administration of Customs of China, considering the development status of some regions and the availability of data, this paper finally selects the panel data of 25 provinces, cities and autonomous regions in 2019 and 2020 for analysis.

4.2 Model Setting

In order to study the use of industrial robots in different regions and their impact on the production efficiency of enterprises, this paper sets the measurement model: $\ln LP_{ij} = \alpha + \beta_0 \ln R_{ij} + \beta_1 Z_{ij} + \mu_{ij}$

LP_{ij} is the explanatory variable of this paper, enterprise labor productivity; R_{ij} is the core explanatory variable of this paper, which represents the use status of enterprise robots, and Z_{ij} represents the collection of other factors affecting enterprise production efficiency except the use status of industrial robots, that is, the control variable set of the model; μ_{ij} is random disturbance term; α is the parameter to be evaluated. The subscript i represents the region where the enterprise is located and j represents the year.

4.3 Variable Selection Description

4.3.1 Explained Variable

The calculation formula of the explained variable LP_{ij} in the model is: $LP_{ij} = \frac{TP_{ij}}{L_{ij}}$; Where TP_{ij} is the total industrial output value of the enterprise, L_{ij} is the number of employees of enterprises, but due to the imperfect data of total industrial output value of enterprises, this paper selects the industrial added value of enterprises and the average number of employees of enterprises, and uses its ratio to reflect the production efficiency of enterprises in this region.

4.3.2 Core Explanatory Variable

R_{ij} is the core explanatory variable of this paper, which mainly reflects the use of enterprise robots. However, it is very difficult to study the use of robots from the enterprise level. Global robot suppliers began to provide data in 2004, and China robot industry alliance (CRIA) began to provide data of robot suppliers in 2013. At the same time, the data they provide are at the industrial level, and there is no relevant information at the enterprise level, so they can not directly and accurately obtain the relevant data used by robots. According to our analysis of the use of robots in China, it is found that more than 70% of the robots used in China are provided by foreign suppliers, and the statistical data of China customs provide the annual import quantity and amount of industrial robots in various provinces. Therefore, this paper uses the import data of industrial robots as an alternative variable for the stock of industrial robots. This paper analyzes the eight digit code of hs2002 in China's customs data, and then identifies the number and amount of imported robots. The robot import amount X1 and the robot import quantity x2 in the Customs Trade data are used as the proxy variables of the robot respectively, which can indirectly realize the research purpose of this paper to a certain extent.

4.3.3 Control Variable

This paper selects the average number of workers X3, total profits x4, total assets X5 and R & D expenses X6 of Industrial Enterprises above Designated Size in each region as the main control variables. The data sources are China Statistical Yearbook, China Industrial statistical yearbook, China high tech statistical yearbook, etc.

5 Empirical Research

5.1 Descriptive Statistics

Make descriptive statistical analysis according to the program code input by Stata software, as shown in Table 1. A brief analysis of the results shows that the labor productivity

Table 1. Decriptive statistics.

VARIABLES	(1)	(2)	(3)	(4)	(5)
	N	mean	sd	min	max
LP	50	217,946	214,098	536.3	569,835
x1	50	4,204	12,044	0	60,501
x2	50	43,488	96,315	0	514,016
x3	50	302.9	295.1	29.67	1,386
x4	50	2.563e+07	2.165e+07	1.946e+06	9.572e+07
x5	50	4.494e+08	3.498e+08	3.587e+07	1.507e+09
x6	50	5.719e+06	6.277e+06	415,733	2.500e+07

of the explained variables varies greatly among regions, the maximum value is 569835 yuan per person, the minimum value is 536.3 yuan per person, and the average value is 214098 yuan per person; The minimum value of import amount and import quantity of core explanatory variable robots is 0, indicating that there are no imported robots in some regions in a certain year, and the maximum value of import quantity is 60501, indicating that the import volume of robots in different regions varies greatly; In the variable of average number of workers, the difference between the maximum value and the minimum value is also large. The minimum value is 296700 and the maximum value is as high as 13.86 million, which is mainly caused by the difference between the western region and developed countries such as Shanghai, Guangdong and Shenzhen. It shows that due to the regional economic development, the demand for science and technology, labor demand and other factors in different regions will have a great impact on the labor productivity of local enterprises.

5.2 Basic Regression Analysis

According to the previous analysis, the import quantity and amount of industrial robots in different regions will have an impact on the labor productivity of local industrial enterprises. The table shows two regression results, model (1) and (2). Model (1) is a concise regression result containing only core explanatory variables, and the regression coefficient of core explanatory variables is positive (0.847 and 0.616), indicating that the number and amount of industrial robots have effectively improved the labor productivity of local enterprises, which is consistent with the theoretical expectation. Model (2) is the regression result after adding control variables. The regression coefficient of the core explanatory variable is still positive, but the coefficient decreases, indicating that after adding control variables such as total profit, total assets and R & D expenses, the number and amount of robots still have a significant positive impact on the labor productivity of local enterprises (Table 2).

Table 2. Basic regression analysis

VARIABLES	(1)	(2)
	y	y
x1	0.847**	0.651**
	(0.58)	(0.37)
x2	0.416**	0.465**
	(0.32)	(0.29)
x3		– 0.182**
		(0.09)
x4		– 0.01
		(0.06)
x5		– 0.007
		(0.12)
x6		– 0.014
		(0.072)
Constant	213,384.341***	226,696.689***
	(5.70)	(3.54)
Observations	50	50
R-squared	0.091	0.320

t-statistics in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

6 Conclusion and Enlightenment

Today, with the rapid development of artificial intelligence, robots are more and more widely used, especially industrial robots. Based on the panel data from 2019 to 2020, this paper analyzes the impact of the use of industrial robots on the labor productivity of local industrial enterprises, and draws the following conclusions and Enlightenment:

First, the investment in industrial robots has improved the labor productivity of enterprises. Specifically, for every 1% increase in the import quantity and amount of industrial robots, the labor productivity of local enterprises will increase by 1.26%. Second, there are many factors affecting enterprise labor productivity. The input of industrial robots affects the labor productivity of enterprises through the gross industrial product and labor demand. However, for different countries and regions, the impact of the input of industrial robots on the labor productivity of enterprises is different. We need to analyze it in detail in combination with the local economic development.

With the development of the times and the progress of science and technology, artificial intelligence will only be more and more integrated into our life and bring us great convenience. The integration of robot and artificial intelligence has just begun. With the more and more extensive application of robot in China, clarify the impact channels of robot on the labor productivity of Chinese enterprises, It is very necessary for China's economic development and industrial enterprises to clarify the pulling degree of robots to China's labor productivity.

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