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Research on the Impact of Human Capital and R&D Investment on Manufacturing Technology Innovation

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Abstract

The development of China's economy towards high quality requires that the manufacturing industry must speed up the pace of structural adjustment, carry out technological innovation and master the core technology. This paper constructs the knowledge production function in the form of double logarithm linear, studies the relationship between human capital, R&D investment and manufacturing technology innovation through the patent determination equation and new product determination equation, and divides the technology innovation process into two stages: technology development and technology achievement transformation. The empirical results show that the promotion effects of human capital and R&D investment in manufacturing technology development and technological achievements transformation are different. In the process of technology achievement transformation, R&D investment has a better promotion effect, while in the technology development stage, human capital has a better promotion effect. After adding control variables, the regression results of human capital and R&D investment are still robust. On the basis of theoretical assumptions and empirical analysis, this paper puts forward relevant countermeasures and suggestions for manufacturing technology innovation.

Keywords

Manufacturing; Technological Innovation Human Capital; R&D Input.

1. Introduction

The manufacturing industry is the main body of the industrial economy, the support of the service economy, and the important foundation for the development of the national economy. However, the phenomenon of "large but not strong" in China's manufacturing industry still exists, and it is difficult to get rid of low-end manufacturing products because of the resource trap. Therefore, in the context of the new normal, China must improve the innovation ability of the manufacturing industry, rely on technological innovation of the manufacturing industry, build high-end manufacturing industry, and accelerate the cultivation and development of the manufacturing industry. Technological innovation can promote the rationalization and upgrading of the advantageous industrial structure, contribute to the sustainable growth of the national economy and the optimization and upgrading of traditional industries, give play to the advantages of backwardness, form new driving forces and new growth, and promote the high-quality development of China's economy.

China is a big manufacturing country in the world, but it is not a strong manufacturing country. The manufacturing industry is "big but not strong" in terms of value-added rate, production of key components, proportion of high-end industries and product quality. China's manufacturing industry lacks the ability to transform innovative achievements and has not yet mastered core technologies. The leading scientific and technological innovation ability and innovation achievements transformation ability enable developed countries to control the commanding

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heights of industrial technology. For example, the transformation rate of scientific and technological achievements in developed countries has reached more than 80%, while that in China is only about 25%. To this end, China needs to urgently improve the level of technological innovation in the manufacturing industry, achieve major technological breakthroughs, maximize the transformation of innovation achievements, and promote the high-quality development of China's economy.

At present, there are many researches on the influencing factors of technological innovation in China's manufacturing industry. Most scholars only study the influencing factors in the manufacturing industry's technological development stage, or the influencing factors in the technology transformation achievement stage, and few study the specific effects of the two stage influencing factors on improving technological innovation. Therefore, based on the existing research, this paper discusses the relationship between R&D funds, human capital and technological innovation in manufacturing industry.

Schumpeter (1912) put forward the concept of innovation. He believed that innovation includes process innovation, product innovation, resource development and utilization innovation, market innovation, system and management innovation, and that process innovation and product innovation are closely linked, which is the recombination of production factors [1]. Later, the concept of innovation gradually expanded, especially technological innovation became an important thrust to optimize and upgrade the industrial structure of the manufacturing industry. Xiang Gang et al. (2004) studied technological innovation in an early stage and believed that technological innovation was the whole process from the establishment of a new concept to the formation of material productivity (new products) and the entry of new products with profit margins into the market [2]. Wu Youjun (2010) believes that the technological innovation ability of enterprises in the industry affects the industrial technological innovation ability. The strength of technological innovation ability is related to the organizational structure, environment, policies, etc. of enterprises, and its purpose is to ultimately promote industrial development through the development or introduction of new technologies [3]. Li Dawei et al. (2011) believed that technological innovation is a cyclic process of technological research and development, new technology application and production, and new products being put into the market [4].

The research on R&D investment is earlier at home and abroad. Scherer (1965) used patent applications as enterprise innovation performance. In the technology development stage, the number of patent applications will change with the change of R&D investment. The empirical research results show that R&D investment has a significant positive effect on industrial innovation performance [5]. Liu Wei et al. The empirical results show that R&D investment is the main driving factor for regional technological innovation (new product income), and there are obvious regional differences in the impact of financial innovation support, financial innovation support and foreign investment technology spillovers on technological innovation [6]. Li Lianshui (2015) used the provincial panel data of China's manufacturing industry from 2001 to 2011 to study the driving factors of China's manufacturing technology innovation capability. The results show that R&D investment has a significant difference in the improvement of innovation capability in the technology development and technology transformation achievement stages, and R&D investment has a better promotion effect in the technology development stage [7].

The research on human capital at home and abroad was relatively mature at the end of the 20th century. Jvaorick (2004) believed that the technological innovation process of different industries in China's manufacturing industry was significantly different [8]. Glass A. J. et al. (2007) believed that, in addition to the differences in R&D investment, the main reason for the differences in technological innovation in different industries of the manufacturing industry was the accumulation of human capital of technicians. Technicians have different experience

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accumulation and learning abilities, which affect technological innovation in different industries [9]. Sun Wenjie (2009), from the perspective of the technology development stage, conducted an empirical study through the random frontier method, and the results showed that: technological innovation efficiency was different in different industries. China's large and medium-sized enterprises had high technological innovation efficiency, and there was a significant threshold effect on the accumulation of human capital of domestic enterprises' technicians [10]. Guo Bing (2014) believed that the efficiency of technological innovation in China's manufacturing industry has a great relationship with industrial human capital [11]. Yu Maojian (2016) believed that specialized human capital is an important source of enterprise innovation ability, and there is a significant positive correlation between specialized human capital and enterprise R&D investment and new product income [12].

2. Model and Variables

2.1. Model

The knowledge production function has a similar form to the production function in the traditional material field. This paper adopts the improved Cobb Douglas production function. Build the production function model of manufacturing technology innovation. In order to eliminate the influence of possible heteroscedasticity, natural logarithms are taken for the primitives of all variables to obtain the double logarithmic linear form of the knowledge production function, which is expressed by the patent decision equation and the new product decision equation respectively:

$$lnPat_{it} = \beta_0 + \beta_1 lnPR\&D_{it} + \beta_2 lnH_{it} + \beta_3 lnControl_{it} + \mu_i + \nu_{it} + \eta_t \quad (1)$$

$$lnPro_{it} = \beta_0 + \beta_1 lnPR\&D_{it} + \beta_2 lnH_{it} + \beta_3 lnControl_{it} + \mu_i + \nu_{it} + \eta_t \quad (2)$$

Where, β_0, β_1, β_2, β_3 is the regression coefficient of the corresponding variable, i and t represent each industry segment and time respectively, or represent each region and time, μ_i represents the individual trait effect that does not change over time, η_t represents the time effect that does not change with the individual, ν_{it} represents the random disturbance term. $Control_{it}$ represents the set of other control variables that affect technological innovation in the manufacturing industry.

2.2. Variables

2.2.1. Interpreted Variable

Patent for invention (Pat) and sales revenue of new products (Pro) are important indicators to measure technological innovation. Patent is an important indicator to reflect the transformation of R&D resources into technology development, and the sales revenue of new products can fully reflect the important measurement of technical achievements into economic benefits. Therefore, this paper selects the logarithm of patent authorization amount and the logarithm of new product sales revenue as important indicators to reflect China's manufacturing technology development capability and technology transformation capability.

2.2.2. Core Explanatory Variables

(1) R&D expenditure. This paper uses R&D investment to measure R&D investment.

(2) Human capital (H). Human capital usually refers to the sum of knowledge, technical skills, ability and quality that can create economic and social value and agglomerate on workers through education, training and learning. It is the main factor affecting industrial upgrading and economic growth. Since the measurement of technological innovation is related to the technical

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maturity of technicians, but cannot be completely measured by education background, the number of R&D technicians can highlight the accumulation and transformation of new knowledge. Therefore, this paper uses the number of R&D technicians to measure human capital.

2.2.3. Control Variables

(1) Market competition. In industries or fields with complementary technologies, the degree of information sharing of joint ventures will be relatively large, while in industries with direct competition, the degree of information sharing will be relatively small. This paper uses the number of enterprises (CM) as a measurement index to measure the degree of market competition.

(2) Profitability. This paper uses the scholar's point of view to express the economic strength of enterprises or industries by profit sales rate (Pr).

(3) Government support. This paper uses the view of this scholar to measure the government expenditure by government research and development funding (gov).

In addition, industry dummy variables and year dummy variables are added in the measurement process.

3. Empirical Results and Analysis

When making regression estimation, first use individual effect F statistics to test whether the model has individual effect. If there is no individual effect, use Pooled OLS model for analysis. If there is individual effect, choose variable intercept model. The test results show that there is individual effect in the sample data, so variable intercept model is selected, that is, fixed and random effect models are selected for regression instead of Pooled OLS. The basis for determining whether the model is a random effect model or a fixed effect model is the correlation between individual characteristics and explanatory variables. When individual characteristics are related to explanatory variables, it is called a fixed effect model. At this time, OLS estimates are inconsistent. When individual characteristics are not related to all explanatory variables, it is called random effect model. At this time, OLS estimation is consistent, but not the most effective. Under unconstrained conditions, if the P value of Hausman test statistic is less than 5% of the significance level, the original hypothesis is rejected, so the fixed effect model is selected to analyze the influence relationship between variables. Through the method of adding control variables step by step, this paper successively obtains models 1 to 4.

(1) The regression results of the patent application determination equation. Model 1 only considers the impact of R&D investment and human capital on technological innovation in manufacturing industry. The results show that R&D investment and human capital have a significant role in promoting manufacturing industry. Every 1% increase in R&D investment, industry patent applications will increase by 2.9%, and every 1% increase in human capital, industry patent applications will increase by 6.2%. It can be seen that the increase of R&D investment and human capital will greatly improve the level of technological innovation in manufacturing industry, and human capital will have a greater effect on technological innovation, which indicates that human capital plays an important role in technological innovation in manufacturing industry.

On the basis of model 1, model 2 adds market competition control variables, the regression coefficient of R&D funds and human capital increases, and the stability of model 1 is strengthened. The significant negative correlation between market competition and technological innovation in manufacturing industry shows that market competition has an inhibitory effect on technological innovation. This is because China's intellectual property protection system is not perfect enough. Once new products are developed, more enterprises

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will imitate and embezzle them. They do not need R&D funds and human capital investment, and can also obtain certain economic benefits. This leads to negative attitudes towards R&D innovation among enterprises. More enterprises will only weaken the technological innovation advantage of the manufacturing industry.

The manufacturing profitability variable is added to model 3, and the profitability has passed the 5% significance test, indicating that there is a significant positive relationship between profitability and technological innovation. Model 4 includes government support, which has passed the 10% significance test, indicating that government support can promote technological innovation in manufacturing industry.

(2) The regression results of the new product determination equation. Model 1 only considers the impact of R&D investment and human capital on technological innovation in manufacturing industry. The results show that R&D investment and human capital have a significant role in promoting manufacturing industry. Every 1% increase in R&D investment, industry patent applications will increase by 4.2%, and every 1% increase in human capital, industry patent applications will increase by 4.8%. Compared with the corresponding model, the regression coefficients of R&D investment and human capital are not significantly different. This is because in the process of transforming technological innovation into new products, production costs and sales expenses become the key factors that determine the transformation of technological innovation achievements. Therefore, R&D investment has become an important factor affecting the transformation of technological innovation achievements in the manufacturing industry.

On the basis of model 1, model 2 adds market competition control variables. As a result, the regression coefficient of R&D investment and human capital increases, and the stability of model 1 is strengthened. However, market competition has an inhibitory effect on the transformation of technological achievements, which is the same as the return result in the technological development stage. This is because in the transformation stage of technological achievements, many enterprises produce imitation products without bearing the cost of enterprise research and development, and the sales price of new products is relatively low, which leads to the reduction of economic benefits of research and development enterprises and the transformation process of technological achievements becomes difficult.

Model 3 adds the manufacturing profitability control variable, and the profitability passes the 5% significance test, indicating that there is a significant positive relationship between profitability and technological innovation. Model 4 includes government support, which has passed the 10% significance test, indicating that government support can promote the transformation of manufacturing technology achievements.

4. Suggestions

According to the empirical research results and the actual situation, the following suggestions are put forward on how to improve the technological innovation of manufacturing industry:

First, increase the R&D investment in the transformation stage of technological achievements, and rationally allocate the fund management in the two stages of technological innovation. At present, the development of technological innovation activities in China's manufacturing industry needs the support of R&D funds. R&D investment mainly depends on self raised funds of enterprises. Enterprises usually obtain self raised funds through financing, credit, government subsidies or other capital channels to make up for the inconvenience caused by the shortage of R&D funds. The R&D investment is the financial support and guarantee for the manufacturing industry to carry out all innovation activities. While increasing the R&D investment in the transformation of technological achievements, it is also necessary to ensure the rational use of R&D funds, develop a reasonable and effective R&D funds management system, avoid capital risks, take risk prevention measures, and ensure that the enterprise's R&D

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funds can be timely and effectively invested in the enterprise's R&D innovation activities, To ensure that R&D funds can operate well in the two stages of technology development and technology achievements transformation. Enterprises should reasonably plan and arrange the use of R&D funds to maximize the conversion into practical new products, bringing more economic benefits to enterprises.

Second, we should pay attention to the introduction of technical talents to maximize the transformation of technological achievements in the manufacturing industry. The shortage of talents is the biggest constraint to the development of technological innovation in China's manufacturing industry. The gap of high-level technological innovation talents is relatively serious, which seriously restricts the technological innovation and transformation and upgrading of manufacturing industry. The core competition of various industries in the manufacturing industry has shifted from the comparative advantage industry to the talent resources, and the competition for creative and technical talents has been launched one after another, striving to improve the core competitiveness of enterprises through talent advantages. Of course, enterprises should not only pursue simple expansion of the size of technical personnel, but also pursue the quality of technical personnel, and strictly assess and test the technical personnel employed and to be employed. In order to introduce technical personnel, enterprises must also ensure and give full play to the innovation ability of technical personnel. Therefore, enterprises must establish talent training mechanisms such as long-term innovation awards, recognize the achievements of technical personnel, and stimulate the enthusiasm and creativity of R&D personnel. The technical talents with technical background and great contribution shall be trained in theoretical knowledge, and some sports or entertainment activities shall be organized to make the technical talents feel that the enterprise attaches importance to them, retain the talents who master the core technology to the greatest extent, and realize the transformation of technical achievements.

Third, protect intellectual property rights and prevent market competition from deteriorating. China's weak awareness of intellectual property rights and inadequate laws related to intellectual property protection have led to the emergence of many enterprises that "get something for nothing", leading to economic losses for innovative enterprises. To this end, the relevant legal departments of the government should vigorously publicize the laws on intellectual property protection to enterprises, strengthen their awareness of intellectual property protection, and apply for patent protection as far as possible. If there is technical innovation that cannot apply for invention patents, they should apply for relevant legal protection to prevent other enterprises from malicious imitation and damaging the market as far as possible. In the information age, the access to resource information is more transparent, and the traditional "patent only" or "problem oriented" thinking has not met the needs of enterprises. In addition to the protection of intellectual property rights of enterprises, enterprises should also take innovation protection and business competition as the starting point, through the diagnosis of the overall business innovation of enterprises, combined with the current development trend and competition pattern of the manufacturing industry, and effectively use the means of intellectual property, information security, and enterprise legal affairs in many fields to design a complete set of rhythmic, logical, efficient and valuable enterprise innovation protection and business competition programs, Protect the innovative achievements of enterprises and prevent the deterioration of market competition.

Fourth, we should appropriately increase government support to make the manufacturing industry bigger and stronger. The government gives certain price and tax preferences to enterprises' R&D and innovation investment, and directly grants subsidies to encourage enterprises to carry out technological innovation and achieve major technological breakthroughs. Government support will greatly promote the technological innovation level of the manufacturing industry, but the government should not intervene in enterprises

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excessively, and should adhere to the market leading, and the government should guide enterprises to carry out technological innovation. The government should change the traditional "one size fits all" support mode and implement specific targeted fiscal policies for different industries and fields involved in the manufacturing industry. At the same time, we will improve the payment methods and procedures of government research and development fund subsidies, from "production side financial support" on the supply side to "production side and consumer side simultaneous support" on both sides of supply and demand, so as to expand domestic consumption demand and force enterprises to improve their technological innovation level. Through fiscal and tax policies, enterprises are encouraged to increase investment in research and development of new processes, new equipment and key technologies, improve production and manufacturing capacity, and promote the manufacturing industry to become bigger and stronger.

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