# Research on Stage Effect of Technological Innovation of Manufacturing Government R&D Subsidies and Enterprise R&D Investment

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## Abstract

**This paper examines the difference between the effects of government subsidies in manufacturing and corporate R&D at the stage of technological development and transformation of technological achievements. Based on Chinese manufacturing data, the thesis uses patent decision equations and new product decision equations and systematic GMM estimation methods to empirically study the effects of government subsidies and enterprise R&D technology innovation. Technology innovation is divided into two stages: technology development and technology achievement transformation. The study found that the R&D investment of enterprises in the stage of technological achievement transformation is more effective, and the government subsidies in the stage of technology development are more effective. Accordingly, the paper believes that the government should increase subsidies at the stage of technological development to promote the improvement of technological innovation.**

## Keywords

**Effect of technological innovation, Government subsidies, R&D investment of enterprises.**

## 1. Introduction

China has entered a new stage of high-quality economic development. The fundamental way of high-quality economic development is innovation, especially technological innovation. The quality of industrial products represents the social productivity level of a country, and technological innovation in manufacturing is particularly important. China has entered a stage of rapid growth in innovation. In 2011, 172,113 invention patents were granted, 359,316 invention patents were granted in 2015, and 432,147 invention patents were granted in 2018. China's R&D investment accounted for a continuous increase in GDP, which was 2.19% in 2018. The intensity of China's R&D investment is still far behind the US (2.79%) and Japan (3.21%). Innovation is the soul of the development of science and technology, and innovation is a new combination of new production factors and new production conditions.

Enterprise R&D investment is the "engine" of the enterprise's innovation ability, and government subsidies are the "booster" to promote innovation. Based on this, this paper will comprehensively consider the impact of government R&D subsidies and enterprise R&D investment on manufacturing technological innovation.

## 2. Research Design

### 2.1 Variable selection and basis

#### 2.1.1 The explained variable

In order to study the technological innovation effect of government R&D subsidies and enterprise R&D investment in manufacturing industry, by distinguishing technological innovation performance into two stages of technological development and transformation of technological achievements, the thesis evaluates technological innovation performance of manufacturing enterprises from technological innovation achievements and economic benefits . The patent reflects the enterprise's technological competitiveness and technological innovation output capacity in this field. It is a direct result of the enterprise's technological innovation. New products are the final result of enterprise technological innovation, and the sales revenue of new products is a direct reflection of the actual innovation capability and potential output of manufacturing enterprises, and can be used as an important indicator to measure the performance of technological innovation (Zhang Huixin,2015; He Zhengchu,2016). The thesis selects invention patent (Pat) and new product sales revenue (Pro) as the explanatory variables to measure and measure the technological innovation performance of manufacturing enterprises.

### 2.1.2 Explanatory variables

(1) Enterprise R&D investment (PK). Liu Wei et al. (2011) found that R&D investment is the main driving factor for regional technological innovation (new product revenue). Financial innovation support, financial innovation support, and foreign investment technology spillovers have a significant impact on technological innovation. The paper selects the amount of investment used by the company for R&D activities as the R&D investment of the enterprise to explain the innovation performance of the enterprise.

(2) Government research and development subsidies (Sub). Based on the existing literature (Li Zijun, 2017; Zhao Lijun, 2017; Lin Runyi 2019), the paper selects the amount of subsidies that the government directly issues to R&D activities to explain the innovation performance of enterprises.

(3) Market concentration (mc). When the market concentration is high, it is more difficult for companies to carry out large-scale technological innovation due to the lack of competitor threats. When the market concentration is low, corporate competition will stimulate corporate innovation. This article draws on previous literature practices and uses the proportion of sample industry sales as a percentage of total industry sales as a measure (Zhang Ying, 2016; Wang Lichao, 2019).

(4) Profitability (profit). Profitability is the guarantee of corporate funds. Corporate innovation activities are inseparable from the support of large amounts of funds. Therefore, corporate innovation activities are affected by corporate profitability. This paper draws on the methods of Li Lianshui et al. (2015) and uses profit sales rate to measure corporate profitability. The profit sales rate refers to the ratio of the total profit of the enterprise to the main business income of the enterprise.

Table 1: Definition and calculation of variables

| Variable | Symbol | Variable definitions | Variable calculation |
|---|---|---|---|
| Explain--ed variable | lnPat | Technology Innovation Performance | The number of patent applications for manufacturing is taken as natural logarithm |
| | lnPro | | The sales revenue of patented new products in manufacturing industry takes natural logarithm |
| Core explana--tory variable | lnPK | Enterprise R&D investment | R&D investment in manufacturing takes natural logarithm<br>Government R&D subsidies take natural logarithm |
| | lnSub | Government R&D subsidies | Government R&D subsidies take natural logarithm |
| | Lnmc | Market concentration | The proportion of sales in this industry to the total sales of all industries is taken as the natural logarithm |
| | lnprofit | Profitability | Profit logarithm takes natural logarithm |
| | lnR | Number of researchers | The number of scientific researchers in manufacturing industry is taken as natural logarithm |
| Control variable | in | Manufacturing industry segments | virtual variable |
| | year | years | virtual variable |

(5) Number of scientific researchers (R). Technical innovation is the result of scientific research activities of scientific researchers. The number of scientific researchers affects the technological innovation of enterprises. The stronger the technological human capital, the higher the innovation

vitality and success rate of enterprises (Liu Hong, 2012). The thesis selects the number of scientific research personnel as the scientific and technological human capital to explain the effect of technological innovation.

The effect of technological innovation varies greatly in different industries. Different years have different policies, and the effects of technological innovation are different. The thesis uses dummy variables to deal with industry and year. The definition and calculation caliber of each variable are shown in Table 1.

### 2.2 Model establishment

The knowledge production function has a similar form to the traditional material production function. Based on the improved Cobb-Douglas production function, this paper builds a production function model of manufacturing technology innovation, enterprise R&D investment, and government R&D subsidies. However, due to the endogenous problems caused by the reverse causality in real economic phenomena, we use a dynamic panel estimation method-system GMM for regression, to a certain extent, to eliminate the endogenous problems of the model. At the same time, according to the industry classification of the national economy in 2002, this article selects the data from 2001 to 2017. Because the data time span is short, the effect of differential GMM is poor, so the system GMM method is used for regression. In order to eliminate the influence of possible heteroscedasticity, the original logarithm of all variables is taken in this paper. The following are the technical development decision equation and technical achievement transformation decision equation.

$$\mathrm{lnPat}_{it} = \beta_0 + \beta_1 \sum_{j}^{\alpha_j} \mathrm{nPat}_{it-j} + \beta_2 \mathrm{lnPK}_{it} + \beta_3 \mathrm{lnSub}_{it} + \beta_4 \mathrm{Var}_{it} + \mu_i + \nu_{it} + \eta_t \qquad (1)$$

$$\mathrm{lnPro}_{it} = \beta_0 + \beta_1 \sum_{j}^{\alpha_j} \mathrm{nPro}_{it-j} + \beta_2 \mathrm{lnPK}_{it} + \beta_3 \mathrm{lnSub}_{it} + \beta_4 \mathrm{Var}_{it} + \mu_i + \nu_{it} + \eta_t \qquad (2)$$

$\beta_0$, $\beta_1$, $\beta_2$, $\beta_3$, and $\beta_4$ are the regression coefficients of the corresponding variables, i and t represent the respective sub-sectors and time, $\mu_i$ represents the individual trait effect that does not change with time, $\eta_t$ represents the time effect that does not change with individual, $\nu_{it}$ represents random Disturbance. Var represents a collection of other variables that affect manufacturing technology innovation.

### 2.3 Data description

The data in this article comes from "China Science and Technology Statistical Yearbook" (2002-2018), "China Industrial Statistical Yearbook" (2002-2017), "China Statistical Yearbook" (2002-2018) and the State Intellectual Property Office database. According to the industry classification of the national economy in 2002, due to the serious lack of data in the three sub-sectors of comprehensive utilization of waste resources, metal products, machinery and equipment repair, the paper selects the data of 28 sub-sectors for the research and development subsidies of the Chinese manufacturing government, Empirical research on the effect of enterprise R&D investment on technological innovation performance.

## 3. Empirical analysis

When performing regression estimation, first use the individual effect F statistic to test whether the model has individual effects. The test results show that the sample data has individual effects, so the variable intercept model is selected. However, due to the endogenous problems between technological innovation performance and explanatory variables, the use of variable intercept models alone will cause bias in the estimation results. For this reason, based on the systematic GMM estimation method, this paper adds the patent application (L.lnPat) and the new product sales revenue (L.lnPro) that are one phase behind to the model to study the impact of R&D investment and government subsidies on technological innovation performance Through the method of gradually adding core explanatory variables, this paper obtains the models 1-4 in turn, and the regression results are shown in Table 2 and Table 3.

### 3.1 Technology development stage

Table 2： Regression results of systematic GMM estimation equations of patent applications

| Variable | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| L.lnPat | 0.334(0.295)*** | 0.617(0.35)*** | 0.57(0.412)*** | 0.757(1.334)*** |
| lnPK | 0.102(0.0427)** | 0.0646(0.0399)** | 0.0423(0.027)** | 0.0937(0.0529)** |
| lnSub | 1.931(0.0931)*** | 1.202(0.152)*** | 0.515(0.13)*** | 0.497(0.13)*** |
| Lnmc | | 0.46(0.383)*** | 0.286(0.459)*** | 0.309(0.0621)*** |
| lnprofit | | | 0.734(0.0864)*** | 0.76(2.0892)*** |
| lnR | | | | 0.418(0.2636) |
| C | -14.46(-1.112)*** | -11.13(-1.086)*** | -14.2(-0.809)*** | -14.46(-0.84)*** |
| AR(1) | 0.028 | 0.0012 | 0.009 | 0.0427 |
| AR(2) | 0.616 | 0.281 | 0.824 | 0.756 |
| Sargan | 1.0000 | 1.0000 | 1.0000 | 1.0000 |

**Note:** *** p <0.01, ** p <0.05, * p <0.1 means that the significance test of 1%, 5%, and 10% is passed, and the t value is in brackets.

Table 2 shows the regression results of the equations at the stage of technology development. First of all, the patent application variable with one lag is added to the system GMM estimation equation. The research results show that there is a significant positive correlation between the number of patent applications with one lag and the current patent application. Current patent applications increase by 1%, and future patent applications will increase by 0.334%. With the addition of variables such as R&D investment and government subsidies, the estimated regression coefficients of patent applications that lag one period and current patent applications gradually increase. Secondly, Model 1 only considers the variable of enterprise R&D investment capital investment to study the impact of enterprise R&D investment and government R&D subsidies on manufacturing technology innovation performance. The results show that for every 1% increase in enterprise R&D investment, the number of patent applications increases by 0.12%. For every 1% increase in government R&D subsidies, the number of patent applications increased by 1.931%. Both government R&D subsidies and enterprise R&D investment have passed the 1% significance test. Government subsidies reduce the risks and costs of enterprise R&D investment and make up for market failures in the process of enterprise innovation. Therefore, in the stage of technology development, government R&D subsidies have a stronger incentive for enterprise technology innovation.

Based on model 1, model 2 adds the market concentration variable. The results show that market concentration has an incentive effect on technology development. For every 1% increase in market concentration, patent applications will increase by 0.46%, which may be attributed to Large enterprises and oligarchs have strong basic research capabilities, and their technology development efficiency and success rate are higher. Model 3 adds profitability variables. Technology development is inseparable from financial support, and profitability is an indicator of corporate funds. The results are consistent with the analysis. This variable promotes technology development. For every 1% increase in profitability, patent applications will increase by 0.734%. Model 4 adds the number of scientific researchers. The results show that the number of scientific researchers can greatly increase the number of patent applications. When the scientific research personnel increases by 1%, the number of patent applications will increase by 0.418%.

### 3.2 Achievement transformation stage

Table 3 shows the regression results of the equation in the stage of achievement transformation. First, the new product sales revenue lagging one period is added to the system GMM estimation equation. The research results show that there is a significant positive correlation between the new product sales revenue lagging one period and the current new product sales revenue. Current sales revenue of new products will increase by 1%, and future sales revenue of new products will increase by 0.149%.

Secondly, Model 1 only considers the variable of enterprise R&D investment capital investment to study the impact of enterprise R&D investment and government R&D subsidies on manufacturing technology innovation performance. The results show that for every 1% increase in corporate R&D investment, new product sales revenue increases by 0.052%, for every 1% increase in government R&D subsidies, new product sales revenue increases by 0.0285%. Government subsidies have no significant effect on the transformation of results, and the enterprise R&D investment variable passed the 10% significance test. Since the production and sales expenses of new products have become a key factor influencing the transformation of results, at this time, the investment of the company's own funds has played an important role. Compared with the results in Table 2, the regression coefficient of the company's R&D investment becomes smaller, which may be due to the fact that the sales of new products are not only affected by capital investment, but also related to the market demand of the product, product popularity, and the quality of sales personnel.

Table 3：Regression results of systematic GMM estimation equation of new product sales revenue

| Variable | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| L.lnPro | 0.149(0.416)* | 0.121(0.429)* | 0.160(0.14)* | 1.145(0.46)* |
| lnPK | 0.052(0.0314)* | 0.020(0.0354)* | 0.015(0.0203)* | 0.0401(0.0401)* |
| lnSub | 0.0285(0.0685) | 0.0072(0.135) | 0.0400(0.0977) | 0.0391(0.0988)*** |
| Lnmc | | -0.134(-0.0737)* | -0.361(-0.0445)* | -0.254(-0.0471)* |
| lnprofit | | | 0.719(0.0651)*** | 0.731(0.0677)*** |
| lnR | | | | 0.0347(0.0483)* |
| C | 2.492(0.819)*** | 3.46(0.963)*** | 0.451(0.74)*** | 0.326(0.637)*** |
| AR(1) | 0.232 | 0.144 | 0.042 | 0.351 |
| AR(2) | 0.784 | 0.796 | 0.522 | 0.788 |
| Sargan | 1.0000 | 1.0000 | 1.0000 | 1.0000 |

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ means that the significance test of 1%, 5%, and 10% is passed, and the t value is in brackets.

On the basis of Model 1, Model 2 adds the market concentration variable. The results show that the market concentration has an inhibitory effect on the results of technology conversion. Contrary to the results in Table 2, when the market concentration is high, large enterprises and oligopoly companies cater to the government's innovation strategy, and the phenomenon of "rent-seeking" appears. Although the number of patent applications increases, it does not translate into real economic benefits. Government subsidies squeezed out the original enterprise investment, making the market concentration degree inhibit the transformation of achievements. Models 3 and 4 add variables of profitability and the number of scientific researchers respectively. The results show that the profitability and the number of scientific researchers have an incentive effect on the sales revenue of new products. For every 1% increase in profitability, the sales revenue of manufacturing new products increases by 0.731%. When the scientific research staff increases by 1%, the sales revenue of manufacturing new products increases by 0.347%

# 4. Conclusions and suggetions

## 4.1 Conclusions

This article divides the technological innovation process into two stages: technology development and achievement transformation, to empirically study the relationship between government R&D subsidies, enterprise R&D investment and manufacturing technology innovation performance. The research found that: first, in the technology development stage, government R&D subsidies and enterprise R&D investment both have an incentive effect on manufacturing technology innovation performance, and government subsidies have a stronger incentive effect on technology innovation performance. Secondly, in the stage of achievement transformation, government R&D subsidies have no significant effect on technological innovation performance, and enterprise R&D investment has an incentive effect on technological innovation performance. Finally, market concentration has an incentive effect on manufacturing technology development and a restraining effect on achievement transformation. Profitability and the number of scientific researchers have a positive incentive effect on technological innovation performance.

### 4.2 Suggestions

Firstly, the government should increase research and development subsidies to stimulate innovation. The government should strengthen financial support for manufacturing companies. Government R&D subsidies have significantly eased the shortage of funds in enterprise innovation activities and stimulated the innovation vitality of enterprises. Especially in the technological development stage, the incentive effect of government R&D subsidies on technological innovation far exceeds private R&D investment. Therefore, based on the existing subsidies, the government should further expand the scope of subsidies and increase the intensity of subsidies. At the same time, the government should subsidize more funds to enterprises in the stage of technology development to maximize the promotion of government subsidies on technological innovation performance.

Secondly, enterprises should appropriately increase R&D investment and strengthen R&D project management. Enterprises should appropriately increase R&D investment, pay attention to the important role of R&D investment, and actively carry out innovation activities to improve the company's core technical level. At the same time, R&D project management should be strengthened. In the technical R&D stage, government R&D subsidies and enterprise R&D investment funds should be reasonably allocated. In the stage of product achievement transformation, the R&D achievements should be commercialized in time to bring more economic benefits to the enterprise.

Thirdly, the government should optimize the manufacturing market structure environment. The government should pay attention to the manufacturing market structure environment and issue effective industrial policies to guide enterprises with lower market power in the manufacturing industry to become bigger and stronger through reorganization and other means. By efficiently integrating and allocating resources, the manufacturing market structure is optimized to improve the performance of technological innovation. At the same time, the selection criteria for enterprise innovation achievements should be improved to promote the profitability of innovation achievements.

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