Science and Technology Policy: Model of Chinese National Science and Technology Input-output Relationship Analysis

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Abstract

Science and technology policy development is a sequence of political events, each of which contributes to modern science and technology developments. In this paper, the scientific output of national policies was reviewed, which focused on the development and input-output of science and technology in China. In retrospect, the hierarchical cluster analysis was used to select the indicator to represent the output of Chinese S&T policy, and the input-output model of Chinese science and technology policy was built based on the analysis of input and output variables relationship. The review resulted in four broad recommendations for Chinese policy action.

1. Introduction

There are no right answers in policy development, only a continuing flow of compromises between groups, resulting in a changing environment and ambiguous series of decisions, where ambition compete evidently with knowledge and wisdom [1].
It is widely acknowledged that the attributes of science and technology is extraordinarily complex, and it is the same with the policy processes that Chinese use to judge the researches and subsequently make investments in science and technology development. It is of great significance to understand the complexities toward appreciating deeply the role of S&T-based policy in the science and technology policy development. In this paper, we conduct a detailed analysis of Chinese policy for fostering the development of science and technology. hinese science and technology policy development as a process
Policy development in the public sector can be viewed in a number of ways, the most common of which is to regard it as a process--a sequence of political events that result in important policy outcomes [2-5].
From the beginning of 1990's, Chinese science and technology policy began to attach importance to innovation research, for which Chinese government formulated a series of measures successively, including *211 Project* in 1993, *Technology Innovation Project* in 1996, and *National Technology Innovation Congress* in 1998. In 2001, the Chinese

Ministry of Science & Technology pointed out that it was important to cultivate science and technological mid-small-scale enterprise. Meanwhile, in order to strengthen the macroscopic management of science and technology research, the *National Science and Technology Conference* in 2004 proposed the emphasis on the criterion of science and technical research.

2. Analysis of Chinese R&D activities compared with overseas countries

2.1. R&D expenditure in selected countries

In 2003, calculated by the current exchange rate, the R&D expenditure of the first five countries in the world were American (292.4 billion US dollars), Japan (135.3 billion US dollars), Germany (60.1 billion US dollars), France (39.0 billion US dollars) and England (34.0 billion US dollars). The Chinese 2003 annual R&D expenditure amounted to 18.6 billion US dollars, which took over sixth place of the world. Comparing with the data of 2000, the gap of R&D expenditure between China and the first five developed countries reduced obviously. In 2000, the R&D expenditure of China was respectively 4 percent of American total amount, 8 percent of Japan, and about 30 percent of German, French and British general level. While in 2003, the corresponding proportion enhanced nearly to 6 percent, 14 percent and 48 percent.

Analyzing the R&D expenditure growth situation of the first 10 countries of the world, from 1991 to 2003, the total amount of America grew 131.8 billion US dollars, that of Japan was 33.1 billion US dollars. For China, the R&D expenditure reached 15.6 billion US dollars during the 12 years, which took third place in the world and the average 16.2 percent growth rate of the 12 years was far beyond other nations, which moved into the first place in the world.

2.2. R&D expenditure in selected countries by character of work

According to the OECD announcement of the basic research expenditure of 25 countries in 2003, the amount of Chinese basic research investment was in the medium level of the world. This indicator of America, Japan and France reached respectively 55.9 billion, 17.6 billion and 6.9 billion US dollars. During the same period, the basic research investment of China is 1.06 billion US dollars, which was 1.9 percent of the American basic research investment, 6.0 percent of Japan, 15.4 percent of France. while the total amount of R&D investment of China respectively reached 6 percent of America, 13 percent of Japan and 49 percent of France, which indicated that the Chinese basic research investment was insufficient obviously.

Since the total quantity of Chinese R&D expenditure grew quickly, the basic research investment of China paced back and forth continuously at the level of 5 percent of the entire research and development investment. On the contrary, the basic research investment of the majority of OECD countries is 10 percent at least, and that of many developed countries has reached about 20 percent. The structure of research investment and activity of China has a huge difference compared to the developed countries.

The total amount of Chinese research and development investment has reached the level of the developed countries on the whole, but the basic research expenditure is deficient because the investment of it was far inferior to super developed countries, as percentage of total R&D expenditure was still less 10 percent. That will restrict sustaining development of science and technology of China.

2.3. Analysis of R&D personnel proportion

According to the statistical data of China Science and Technology Statistic, in 2003, the R&D personnel of China reached 1.1 million FTEs, which was more than that of Japan, Germany, France, Russia and Korea. On the other hand, the R&D personnel per 10000 labor force of Japan reached 132 FTEs. This indicator of Germany, France, Russia and South Korea reached respectively 120 FTEs, 127 FTEs, 135 FTEs and 81 FTEs, which is much higher than that of China.

Although the R&D personnel of China is more than that of some developed countries, the R&D personnel per 10000 labor force of China is much lower than that of the developed high-tech countries.

3. Input-output model of Chinese science and technology activities

As shown in Table 1, four indicators are used to evaluate the R&D output of Chinese S&T policy, including number of patent applications, S&T papers catalogued by SCI, ISTP and EI, exports of high-tech products and high-tech products share in total exports, which are represented by dependent variable Y_i.

Table 1: Output indicator data of China.

Year	1998	1999	2000	2001	2002	2003	2004
Number of patent applications (case)	121989	134239	170682	203573	252631	308487	353807
S&T papers catalogued by SCI, ISTP and EI	35003	46188	49678	64526	77395	93352	111356
Exports of high-tech products (USD 100 million)	202.5	247	370.4	464.5	678.6	1103.2	1655.4
Share in total exports	11.0	12.7	14.9	17.5	20.8	25.2	27.9

Source: China Science and Technology Statistics

The hierarchical cluster analysis is used to select one of the four indicators to represent the output of Chinese S&T policy. The result is shown in Fig. 1. According to the result of hierarchical analysis, Y_3 is the most suitable indicator to evaluate the output of Chinese S&T policy.

Fig. 1: The hierarchical cluster analysis of Chinese S&T policy output.

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                 Rescaled Distance Cluster Combine
 CASE    0       5       10      15      20      25
 Label   Num  +---------+---------+---------+---------+---------+
 Y3       3  Ú°ÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚ¯
 Y4       4  Ú˜                     ˘ÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚ¯
 Y1       1  ÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚ˜                     Û
 Y2       2  ÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚÚ˜
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where Y_1 is the number of patent applications (case), Y_2 is the S&T papers catalogued by SCI, ISTP and EI, Y_3 is the exports of high-tech products (USD 100 million), and Y_4 the share in total exports

Table 2: Input indicator data.

Year	1998	1999	2000	2001	2002	2003	2004
GERD (100 million RMB)	551.1	678.9	895.7	1042.5	1287.6	1539.6	1966.3
Govt. S&T appropriation (100 million RMB)	438.6	543.9	575.6	703.3	816.2	975.5	1095.3
Percentage of total govt. expenditure (%)	4.1	4.1	3.6	3.7	3.7	4.0	3.8

Source: China Science and Technology Statistics

GERD, Govt. S&T appropriation and percentage of total government expenditure as input indicators used to evaluate the R&D input of Chinese S&T policy, which is presented by independent variable X_i.

The input-output model of dependent variable Y_3 and independent variable X_i can be achieved as follows:

$$\log(Y_3) = 3.343\log(X_1) + 2.043\log(X_2) + 0.363X_3 - 2.960$$

where X_1 stands for the GERD (100 million RMB), X_2 is the government S&T appropriation (100 million RMB), and X_3 is the percentage of total government expenditure (%)

Table 3: Model Summary.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.991	0.982	0.979	4.843E-02
2	0.997	0.993	0.990	3.312E-02
3	1.000	0.999	0.998	1.328E-02

4. Recommendations

Four broad recommendations are proposed based on the above analysis. Firstly, in the future, the Chinese R&D investment management should be enhanced, and more focus need to put on the quality of the R&D expenditure growth. Secondly, considering the overall situation of national economy, the intensity of R&D investment and the proportion of basic research expenditure should be improved. Thirdly, more effective policy is necessary to guarantee the R&D expenditure, and the development of science and technology should be promoted by law, which should come into being institution. Finally, improving the government S&T appropriation and the percentage of total government expenditure are also active factors to accelerate the development of S&T.

5. Conclusions

From 1990 to 2004, Chinese science and technology policy developed quickly. The Chinese government played an especially important role in policy development, which attached importance to S&T studies all the while, especially the development of high-tech industry, and it affected the advancement of S&T remarkably. According to the analysis and models in this paper, the further development of Chinese science and technology can be achieved when certain policy is carried out.

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