An International Comparison of Economic Development, S&T Input and S&T Output

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Abstract: At present, China has taken the construction of science and technology as an important strategy. Although China's innovation strength has been improved rapidly since we entering the 13th five-year plan, the ability of creation is still unbalanced. At the moment of entering the 14th five-year plan, we still face the problem of insufficient independent innovation. China has not yet become a strong power of innovation in the world. From the perspective of international comparison of the scientific and technological development, this paper discusses the problem of China's investment in R&D by comparing relevant data of major countries in the world, and puts forward some suggestions.

1. Introduction

In May 2018, General Secretary Xi proposed at the academician's conference of the Chinese Academy of Sciences and Chinese Academy of Sciences, "Science and technology have never profoundly affected the country's future, and have never profoundly affected the people's well-being." "To innovate, strengthen the confidence of innovation, and focus on enhancing independent capability of innovation" "To deepen scientific and technological exchanges and cooperation internationlly, promote independent innovation at a higher point, to deploy proactively and use international innovation resources actively, and strive to build a win-win partnership." In year 2018, China’s science and technology contribution rate has reached 58.5%, and China’s science and technology development is already at the forefront of the world in some areas, scientific and technological power has important influence in the world.

Throughout the world, China and the United States, Japan, the European Union and other major developed countries have all attach great importantce to innovation, and investments in science and technology are increasing in these countries. However, compared with the traditional developed countries, China's independent innovation capability still lacks.

2. Resarch review

As early as 1991, Rome proposed in the theory of endogenous growth that R & D is an endogenous variable of economic growth and is used to measure the change in the amount of technological input. Luo Feng (2013) studied the correlation between Japanese scientific and technological investment and economic development, and believed that Japan's scientific and technological development experience is worth learning for our country. Li Fangyi and Zheng Chuiyong (2015) analyzed the experience of R&D funding management in the United States, Germany, Japan, and South Korea, and gave suggestions on, increasing basic research investment, broadening funding sources, and improving performance of R&D funding management. Ma Lin (2016), based on data from 2003 to 2012, compared the technological competitiveness of high-tech industries in major countries, and found that there is a large gap between China and other countries in technological competitiveness of high-tech industries, and proposed that we should optimize the proportion of investment in scientific research and increase export of high-tech products. Zhang

Xianen et al. (2017) compared the basic research input of major countries and found that the proportion of basic research in China's R&D expenditure is relatively low. They believe that China must increase investment in basic research if it wants to be the froefront of innovative countries. Ye Shujun et al. (2019) believe that although China's total investment in science and technology has increased significantly, key problems such as attach much more importance to experimentation, R&D and quantity than foundation, conversion and quality are still restricting the improvement of China's innovation capacity. Therefore, we must not only increase the scale of investment, but also optimize thestructure and improve the mechanism.

This paper compares China ’s technological input, output, and economic development with those of other countries in recent years, and makes relevant suggestions of promoting economic development from the perspective of science and technology.

3. International comparison of economic development

This article selects some typical developed countries, which are the United States, the United Kingdom, Germany, Japan, South Korea, and India, Russia, and China, three BRICS countries as sample, and selects data from 1996 to 2016 for comparative analysis. All data comes from China's economic and social big data research platform. Among them, some graphic lines are interrupted due to incomplete data,especially for India.The figure below shows the per capita GDP values of the eight countries in the sample converted into dollars according to purchasing power parity (PPP).

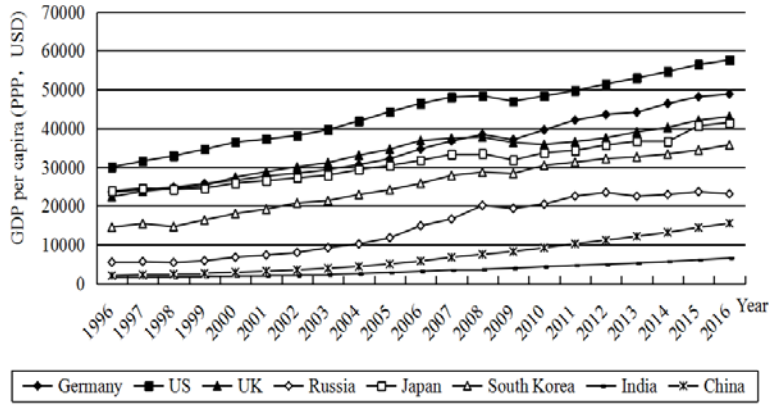

Fig. 1 Comparison of GDP per capita

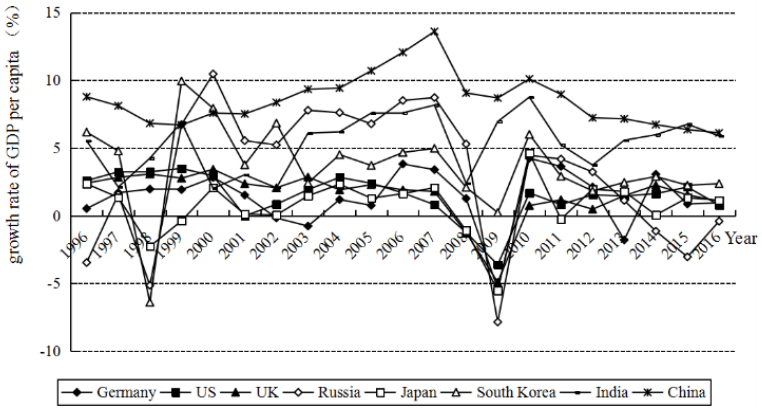

Fig. 2 Comparison of GDP per capita growth rates

Among the countries in the world, China’s overall economic level is unquestionably second only to that of the United States. However, in terms of GDP per capita, there’s still a large gap between China and the United States, Japan, Germany, and Britain. China still belongs to developing countries. On the other hand, Figure 2 shows comparison of the growth rate of per capita GDP in the past two decades. We can see that China's economic development rate has surpassed developed

countries such as the United States, Japan, Britain, Germany, and South Korea, and has also surpassed Russia and India. In the period when other countries suffered from economic crises such as the Southeast Asian financial crisis and the subprime mortgage crisis, which led to ups and downs of economic development, China's growth rate of GDP per capita has maintained a medium to high level, and the economy has always been steadily moving forward, thus providing solid foundation for scientific and technological investment.

4. International comparison of science and technology input-output

4.1 Technology input

The scale of R&D is usually used to reflect a country's scientific and technological input, including basic research, applied research, and experimental development. At present, the countries with the strongest overall economic strength in the world are the countries with the most investment in science and technology. The R&D expenditure of a country as a percentage of the country's GDP is also used to indicate the strength of the country's scientific and technological input. Figure 3 shows the developing trend of the intensity of scientific and technological input among the eight countries in the sample:

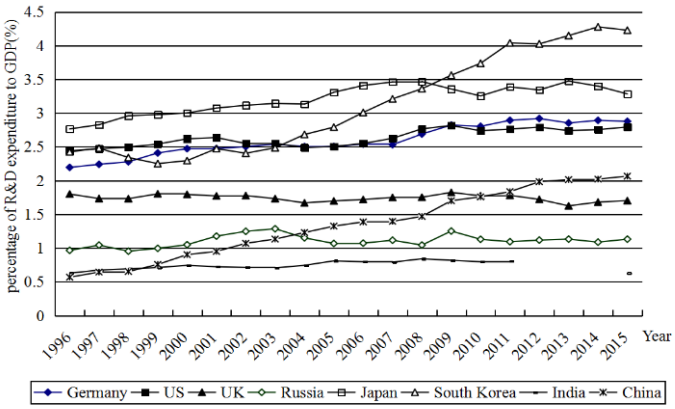

Fig. 3 Comparison of S&T Investment Intensity

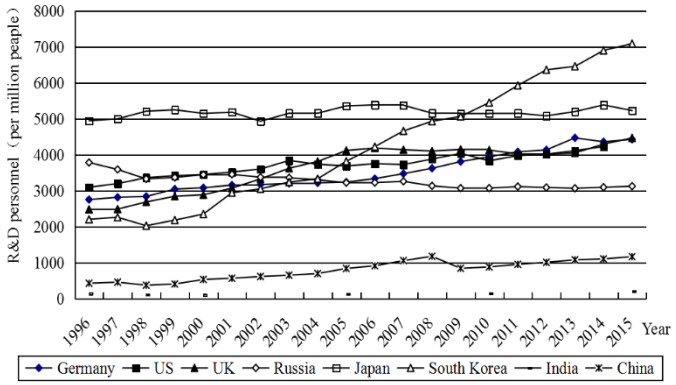

Fig 4. Comparison of researchers number

China's R&D expenditure has increased year by year over the past two decades. At present, R&D expenditure accounts for more than 2% of GDP. However, the ratios in the United States, Germany, Japan, and South Korea have all exceeded 2% in S&T investment intensity in 1996, and in an increasing trend. South Korea evenexceeded 4% in 2011. It indicats that in the past two decades, these countries have strengthened their investment in S&T earlier than China. Since the economy development usually lags behind R&D for a long time, the time for China to promote economic development with independent innovation will inevitably lag behind those developed countries. However, this indicator of China has surpassed Russia and India, and even surpassed the United

Kingdom in recent years, and it has been increasing year by year and is rapidly catching up with the technologically advanced countries such as the United States, Japan, and Germany.

The total number of R&D personnel is anothe factor that affects the scientific and technological strength of a country. In absolute terms, that number in China has reached 4.18 million in 2018, ranking first in the world. However, in terms of relative value, China is not outstanding. Figure 4 shows a comparison of the development trend of R&D personnel in the eight countries. Among them, Germany, the United States, Britain, Japan, South Korea, and Russia have far more scientific researchers per million people than China. Until 2015, the number in China was 1,176, these developed countries exceeded 4,000, and the number was even more than 7,000 in South Korea. This tells that the proportion of scientific research workers in the labor force in China is not enough, and the layout of China's R&D personnel is still at an early stage compared with developed countries.

4.2 Scientific and technological output

The number of patent applications and the number of science papers are generally used as indicators for measuring scientific and technological achievements. In recent years, China'ssupport for scientific research from finance and market has increased, leading to a leap in quantity and quality of scientific research results. Figures 5 and 6 below describe the changes in the S&T output of the eight countries over the past two decades.

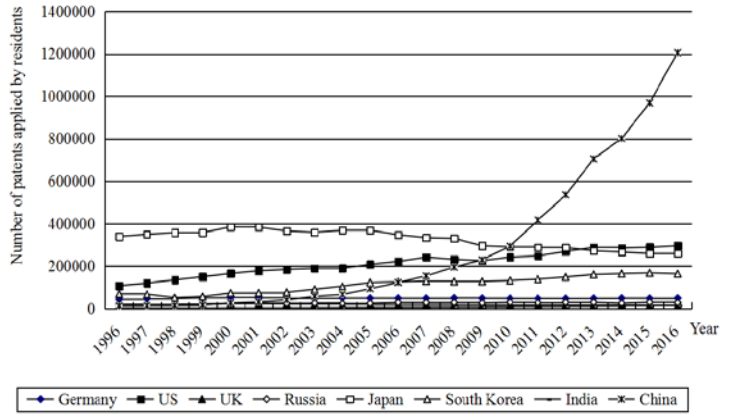

Fig 5. Comparison of patent applications number

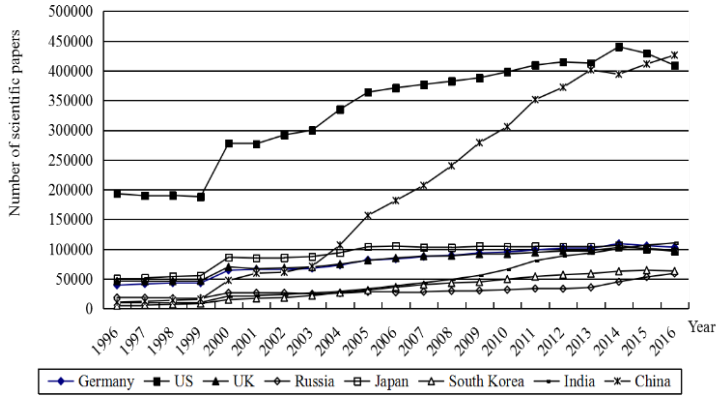

Fig 6. Comparison of scientific papers number

Seen form Figure 5, after China entered 2010, the number of patent applications has increased rapidly. In 2011, it has surpassed other countries, and by 2016, it has far exceeded all other countries. This is inseparable with the "Twelvth Five-Year Plan" which proposed specifically to increase independent innovation capability, build an innovative country. During theses year, the whole society of China attaches great importance to scientific and technological development, and support from public finance and preferential policies have promoted scientific and technological progress.

As can be seen from the Figure 6, the number of scientific papers in China has increased significantly. In recent years, that number has approached that of the United States and far exceeds

the other six countries. This is the compex result of the country's increasing emphasis on scientific and technological development, policy encourages the launch of scientific research results and the quality and quantity of scientific research workers' output are constantly increasing.

5. Conclusion

For China's economic development trend, after the implementation of supply-side reforms in 2016, it maintained a medium-to-high-speed development level, making the macroeconomic development and technological innovation on a virtuous circle.

As for S&T investment, there is still a gap in the intensity compared with developed countries. According to Rostow's theory of economic development stages, in the 1980s and 1990s when developed countries developed science and technology, China was still at the early stage of economic development, and government investment was mainly concentrated in infrastructure construction. Only in the past two years, China entered into a period of high-quality development. The structure of investment from public finance and market has gradually changed. That is to say, China was surely to start S&T investment later than the developed countries which mainly caused the lag at present.

On the other hand, there is a large gap in the proportion of scientific researchers, which may be another reason for the weakness on scientific research force in China. It is hard to accomplish innovation if there is only funding but no strong team. Therefore, it is urgent to accelerate the construction of S&T innovation talents. The government should expand the scale of training in high-quality scientific researchers, encourage high-level talents to engage in scientific research, and provide relevant policy support, so as to enhance the core competitiveness of innovation.

For S&T output, China is surpassing developled countries in terms of quantity. This shows an effect of investment and policies to support for innovation. However, economic development cannot directly been promoted by patents, but relies on the conversion from patents to products. Therefore, government should help to establish a platform for basic research departments and markets to make the conversion eadier, and promote the cooperation between research institutes and enterprises, and even participate in the conversion as a main department by itself.

In general, China's S&T innovation has already got obvious achievements, but still lags in certain aspects compared with developed countries. We need to make adjustments and catch up vigorously for the aim of becoming a leading scientific and technological power in the world earlier.

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