Correlative Analysis on R&D Investment Structure and Economic Growth with Transnational Data

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Abstract: With the correlative analysis based on transnational data, we examined the ISP framework of R&D investment proposed in this paper. Results showed that in current development stage, China should set a reasonable R&D input structure to improve efficiency as the basic point, and increase R&D intensity gradually. In view of R&D input structure, the principle position of enterprise must be established nationally and independent innovation should be persisted and R&D input field should be cleared by government.

Keywords: R&D; structure; economic growth; correlation

1 Problems and research status

Nowadays, R&D investment is an important research topic that drew great attention of the international organizations and administrative sectors of China, the quantitative analysis of the effect of R&D investment on economic growth is also a research subjects in Economics.

The literatures on R&D and economic growth unfolded from various aspects: Solow etc. (1956) from physical capital accumulation aspect[1-2], Lucas etc. (1988) from human capital accumulation aspect[3-5], Romer etc. (1986) from knowledge accumulation aspect[6-7], Romer(1990) and Grossman etc.(1991) from research and development (R&D) aspect[8-9] and so on, the sustained growth of economic system has been well explained with descriptive methods. The research of these areas can be summarized as the neoclassical growth theory and the new growth theory, both of which stress on the consideration of technological influence.

Scholars in China also studied the relationship of R&D and economic growth. Wang Dahui and Li Honggang (2005) pointed out that the economic growth fluctuated due to characteristics of R&D, and it would make the economy grow rapidly and stably when appropriate choice between physical capital accumulation and R&D investment made [10]. Zhang Haixing(2004) made the co-integration test and Granger causality test to the correlation of the public goods capital investment, public human capital investment, R&D investment and economic growth [11]. Lai Mingyong etc. (2005) discussed the internal mechanism of the effects of human capital, technology spillovers of domestic and foreign R&D on economic growth in open economy condition [12]. Zhu Chunkui(2004) established the error correction model to reveal the dynamic equilibrium relation between R&D investment and the economic growth of Shanghai [13].

In summary, the present researches, in theoretical study, are often studied with economic growth model based on production function expansion; in empirical study, the economic growth model is mainly estimated with the econometric methods. However, the existing literatures have seldom studied the R&D investment structure. This paper attempts to extend the existing literatures from three aspects: first, to discuss the relationship between R&D investment and economic growth; second, to make empirical analysis of the relationship between R&D structure and economic growth with transnational data; third, we jump out of the production function framework, make empirical analysis with correlation analysis method.

2 The theoretical hypothesis of R&D investment structure and economic growth

R&D investments from source sectors and executive sectors have different effects on economic growth, but the existing literatures haven't had enough understanding about the relationship between R&D structure and economic growth. This paper proposes the framework of "Intension-structure-performance" to analyze the performance of R&D activity.

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R&D investment has two core structures——the source structure and the executive structure, and between which exists complex cross-relationship. The R&D investment from the industry will not only be invested in the industry, but also in the government public R&D, academia and other sectors; the R&D investment of the academia and other executive sectors can also come from the industry, the government or abroad.

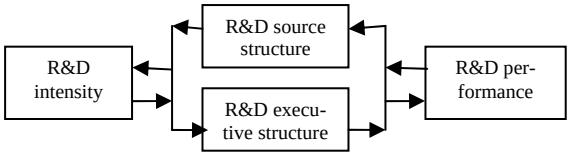

Figure 1. The ISP framework of R&D investment

Suppose that there exists a circular relationship among R&D intensity, structure and performance, Figure 1 describes this relationship clearly. On one hand, the R&D intensity determines the R&D executive structure. If the intensity remains unchanged, the executive structure will change as the adjusting of R&D investment direction. If the intensity increases, and the allocation in the executive sectors increases, the executive structure will also change. And the changes of executive structure will cause changes of R&D performance. On the other hand, R&D performance determines R&D source structure. If a sector achieves good performance in the prior period, it will enlarge the current investment scale. The sector which achieves bad performance will adjust the investment structure or reduce investment scale. These behaviors will change R&D source structure. Therefore, it forms a linear operating path: "Investment scale—Executive structure—Performance—Source structure—Investment scale". The intensity is the aggregation of all sectors; the three factors——intensity, structure and performance form a circular causality system.

The economic growth is the ultimate measurement of R&D performance. The R&D performance is affected by the demand of source sectors and the supply of executive sectors. This paper attempts to discuss the relationship between the structure and the performance, and tries to find out the R&D source sectors and executive sectors which have the closest relations with economic growth.

3 Research design

According to the theoretical analysis, there must be some relevance among GDP, R&D and the source structure and executive structure of R&D. This paper uses correlation analysis and partial correlation analysis in the empirical study.

Data of this paper is from the *Global R&D Report 2009* which is provided by R&D Magazine、Battelle、OECD、World Bank etc. There are 40 countries or regions in the report, considering the completeness of data, we select 32 of them as the sample, and they are: Japan, Germany, France, Korea, UK, Canada, Italy, Taiwan, Spain, Australia, Sweden, Netherlands, Israel, Switzerland, Austria, Belgium, Finland, Singapore, Denmark, South Africa, Czech Republic, Poland, Norway, Argentina, Ireland, Portugal, Greece, Romania, New Zealand, Slovenia, Slovakia and Iceland. The data in the report is the cross-section data in 2007, and the per capita GDP data is from the report of IMF in 2007.

This paper employs SPSS 13.0 for Windows to make the correlation analysis and partial correlation analysis for the 32 countries and regions so as to analyze quantitatively the relationship between GDP and R&D investment structure.

4 Empirical analyses of the R&D investment structure and economic growth

4.1 The correlation analysis of R&D investment and GDP

Basic hypothetical proposition 1: ① There is a significantly positive correlation between R&D investment and GDP; ② There is a significantly positive correlation between R&D/GDP and GDP per capita; ③ The higher the R&D/GDP of the economies is, the higher the correlation between R&D investment and GDP will be; ④ The higher GDP of the economies is, the higher the correlation between R&D investment and GDP will be.

Table 1 presents the results of correlation tests. The correlation coefficient between R&D investment and GDP reaches 0.943; the correlation coefficient between R&D/GDP and per capita GDP is relatively low, which is only 0.383; both of them are significant. We consider that the low correlation between R&D/GDP and per cap-

ita GDP is mainly due to R&D investment scale is not enough which leads to insufficiency of R&D intensity.

Table 1. The Pearson correlation coefficients of R&D and GDP

Variable	GDP	Per capita GDP
R&D	0.943（0.000）	——
R&D/GDP	——	0.383（0.031）

Note: The numbers in brackets are the 2-tailed test results of correlation (the same hereinafter).

Table 2. The Pearson correlation coefficients of R&D and GDP based on the classification

Variable	GDP			
R&D	R&D/GDP ＜1.5%	R&D/GDP ＞1.5%	GDP＜330	GDP＞330
	0.973	0.966	0.531	0.944
	（0.000）	（0.000）	（0.034）	（0.000）

According to the classification criteria of national industrialization process by UNESCO, the R&D/GDP equals to 1.5% is the main characteristic that the first stage transforms to the second stage of industrialization. We classify 32 economies into two classes from two dimensions: the first dimension is R&D/GDP, we regard that R&D/GDP equals to 1.5% as the demarcation point of the industrialization stage; the second dimension is GDP, we regard that GDP equals to 330 billions as the demarcation point of all sample economies.

Table 2 shows the correlation test results between R&D and GDP after classification. For the classification of R&D/GDP, there is no significant difference between the economies higher than 1.5% and those lower than 1.5%, so hypothesis ③ is not confirmed. The correlation coefficient of the economies with GDP higher than 330 billions is bigger than those with GDP lower than 330 billions, which shows that there is a more close relation between R&D and GDP in large scale economies.

4.2 The correlation analysis of R&D structure and GDP

Basic hypothetical proposition 2: ① No matter what the aspect of the R&D source sectors or the R&D executive sectors is, the correlation between industry R&D and GDP is most significant; ② The higher GDP of the economies is, the higher the correlation between source and executive R&D capital of industry and GDP is; ③ The opening degree of R&D resources of the economies with lower GDP is higher than those with higher GDP.

Table 3. Partial correlation coefficients of R&D structure and GDP

Source sector	Industry	Government	Academia and others	Abroad
GDP	0.574（0.020）	-0.046（0.805）	0.202（0.109）	-0.114（0.541）
Executive sector	Industry	Government	Academia and others	——
GDP	0.318（0.029）	-0.071（0.706）	-0.183（0.326）	——

Table 4. Partial correlation coefficients of R&D structure and GDP based on the classification of GDP

	Source sector	Industry	Government	Academia and others	Abroad
GDP <330 billions	GDP	-0.005（0.985）	-0.249（0.371）	0.329（0.231）	0.408（0.058）
	Executive sector	Industry	Government	Academia and others	——
	GDP	0.244（0.082）	-0.065（0.817）	0.198（0.141）	——
	Source sector	Industry	Government	Academia and others	Abroad
GDP >330 billions	GDP	0.485（0.048）	-0.096（0.735）	-0.220（0.143）	0.028（0.168）
	Executive sector	Industry	Government	Academia and others	——
	GDP	0.319（0.075）	0.088（0.755）	-0.174（0.535）	——

Table 3 shows the results of partial correlation tests. For the R&D source sectors, the correlation of industry R&D and GDP is highest, followed by Academia and others, and finally are Government and Abroad; there is a similar sort for the R&D executive sectors. Therefore, we can believe that the industry R&D performance is better than other sectors, the R&D performance of government is relatively low, and the academia plays a very small role. Then, we will classify 32 economies into two classes based on GDP and discuss the correlation of R&D structure and GDP for different economies.

Table 4 presents the correlation test results based on the classification of GDP. For the samples with GDP lower than 330 billions, in the aspect of R&D source, the correlation between R&D from abroad and GDP is highest; the correlations of other sectors are not significant. In the aspect of R&D executive sector, the industry is still the sector which has the best correlation with GDP, and the correlations of other sectors are not too significant.

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For the samples with GDP higher than 330 billions, in the aspect of R&D source, the correlation between R&D of industry and GDP is highest; the correlations of other sectors are not significant; there is a similar sort for R&D executive sector, the correlation between the industry R&D and GDP is highest, and the academia and the government are not significant.

From Table 4, we can see that whatever economic scale is large or small, the correlation between the R&D of executive sectors of industry and GDP is highest. The correlation between R&D activity of industry and GDP is higher in large scale economies than in small economies; The R&D of small economies depend more on funding from abroad; The correlation between R&D activity of academia and GDP is higher in small scale economies than in large economies; for all economies, the government is failed to play positive role in the R&D source or R&D executive aspects. We conclude that in large economies, enterprise is the main source and executive of R&D, but in small economies, the R&D activity tends to rely on the overseas capital and technology introduction.

5 Conclusions and suggestions

According to the empirical analysis, in hypothetical proposition 1, ①②④ have been proved, ③ hasn't; in hypothetical proposition 2, ①②③all have been confirmed. Based on the empirical result, we give some suggestions for R&D investment of China.

Firstly, in current development stage, China shouldn't follow the standards of developed countries blindly; it should focus on the reasonable structure and high efficiency of R&D investment, and increase R&D intensity. In the first stage of industrialization, the R&D/GDP of countries all over the world is of great difference. The R&D/GDP of US is only about 0.3~ 0.4% but the one of UK and France is nearly 2.0%, which is almost equivalent to the level of US in the second stage, while they are just in the first late stage. Therefore, China should focus on the reasonable structure and high efficiency of R&D investment.

Secondly, in the aspect of R&D investment structure, China should establish the dominant position of enterprise and insist on independent innovation, and the Government must make R&D investment fields clear. The industry R&D is the core factor to promote economic growth, so China should establish the dominant position of enterprise in the national level, making which to be the main R&D source and executive body.

Finally, although the government R&D plays a minor role in economic growth, we can not ignore its importance. On one hand, government should emphasize on these fields of fundamental research and national security which will have great impacts on human development, so it can give prominence to advanced national strategy and seize the commanding point of technology; on the other hand, the government should guide the enterprise to increase R&D investment, making the government and enterprise double subjects in the transitional period.

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