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Analysis of Policy of Investment in Science and Technology based on CGE Model

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Abstract: Investment in science and technology is not only a significant indicator to reflect a regional scientific and technological strength and core competitiveness, but also important to technical progress and technology innovation. Investment in science and technology will affect the entire economy through technology innovation. In this paper, we analyze the impact of Beijing's investment in science and technology on regional economic development and build a Beijing regional CGE model with an econometric module that links the investment in science and technology with technological progress. We found that Investment in science and technology will increase the Beijing GDP , and promote economic structural adjustment. When the real investment in science and technology, increase of 1%, 2%, 3%, Beijing GDP, will respectively increase 0.93, 1.22, 1.51. From the perspective of resident's income, when investment in science and technology increase by 3%, the level of resident's income will increase by 3.24 percentage points. In view of the structure perspective of different sector's investment in science and technology, different investment in sectors will lead to different impact of economic growth and structure, results show that: when the priority of Beijing's investment of different sector in science and technology is tertiary sectors, agricultural sector, industry sectors, it is conducive to economic growth and industry structure adjustment.

Keywords: Investment of Science and Technology; CGE; Economic Growth

0 Introduction

The core economic competition between countriesis science and technology therefore, the scientific advances will decide a country's future. Beijing as the centre of technology in China, technology innovation is playing an important role to the economy. Beijing R & D investment in 2010 was 82.18 billion Yuan, which is 5.3 times that of 2000, and the average annual increase by 18.1% . And R&D investment intensity has been achieved 5.8 percent, which increased 0.90 percentage points compared to 2000, and was also 4.06 percentage points above the native average. Therefore, the study of the impact of Beijing's total investment in science and technology and structure changes on economic growth, can provide the basis for the adaptation and implementation of Beijing's investment in science and technology policy, and has great significance for improving the level of technological development in Beijing.

Recent theories of economic growth draw attention to endogenous technological change to explain the growth patterns of economies. The technological progress is considered as the most determinant factor of economic growth, and innovation that based on R&D, is considered as the continuous power of economic growth sustained(Romer,1990;Aghion,Howitt,1992; Grossman, Helpman,1991). Many researchers focus on the foundation of the theoretical model of endogenous economic growth, analyze the influence of investment in science and technology and related policies on economic growth, such as Le Bas(2000) used macroeconomic model to analyze the investment in science and technology policy on economic, results show that the R&D investment had short-run effects on economic growth, and the long-term effects is relatively weak, and especially the short-term effects in the manufacturing sector is also relatively large. Archibald and Pereria（2003）using VAR model analyzed the impact of government and private R&D investment in U.S 1956-1988, on the total output of the civil , and the private and government investment in research and development . Zhu Pingfang(1999) analyzed the relationship between the Public investment in science and technology and domestic GDP in Shanghai, found that Shanghai's investment in science and technology have a significant positive correlation with GDP. Chen Zhiang and Hu Xianlong(2011) based on the investment in science and technology and economic growth variables of China in 1953-2009, using the unit root test, co-integration test and Granger causality test method, empirically analyzed the relationship between investment in science and technology and economic development, the result shows that there is a highly closed positive correlation between China's investment in science and technology and economic growth. Most of the previous studies has a limit of partial equilibrium analysis method, it lacks the basis of general equilibrium. CGE model is a popular policy analysis tool in the international, which is based on the theory of general equilibrium, reflecting the overall economic activity in a set of mathematical equations form, it can be said to be a microcosm of the economic society. So CGE model research literature has emerged both at home and abroad, such as Garau and Lecca(2007), Bor(2010), etc. Chen Sisi(2010) quantitatively analyzed the influence of financial investment on the long-term and short-term economy in China. Hu Zongyi and Liu Yiwen(2011) based on the dynamic CGE model-MCHUGE model ,studied the impact of scientific and technological progress of China's macroeconomic. But the above research on the relationship between investment in science and technology and economic growth, is focus on the impact of China's total investment in science and technology to economic growth, and ignored the science and technology investment structure. we study the effects of the total amount and the structure of investment in science and technology on economic society development by building the CGE model of Beijing with a reasonable set of scenarios, intended to provide basis of decision making for setting up rational and comprehensive investment in science and technology policy, and promotion of innovation-oriented city.

1 Data and Model
1.1 Basic Data and SAM Format

In this paper we use the data from 2007 input-output tables of Beijing, we also merge data from Beijing Statistical Yearbook 2008, China Finance Statistics Yearbook 2008, China Tax Yearbook 2008, China Foreign Economic and Trade Yearbook 2008, China Population and Labor Employment Yearbook, also made reference to the Beijing census data , and the Beijing economic Census data. And we prepared the 2007 Beijing Social Accounting Matrix (SAM). It is established based on the Beijing 2007 input-output table in which production sector and government, residents, business, and other parts of the country, foreign tax, transfer payment, income distribution, etc. were expanded. In fact, SAM provides a consistent and complete accounting framework. It gets related traffic data together, provides a data base for the calibration and operation of the CGE model. The key parameter of the model, especially the various elasticity of substitution and income elasticity was obtained mainly by reference to the experience of the World Bank model and retrieve relevant literature; others mainly by shift and share parameters, that is, according to the base year data and exogenously give key parameter we got the parameters by calibration method.

1.2 The CGE Model

The analytical framework applied in this study is a dynamic Computable General Equilibrium (CGE) model, in which scenario set was used to simulate the impact of investment in science and technology policy options for economic growth, people's lives and changes in industrial structure, and then on this basis we compared the different policy options.

CGE as a macroeconomic model is characterized by describing the economic cycle of production generate income, income induced demand, demand lead to production, which reflected the economic change process of factor markets and commodity markets led to price changes due to the imbalance of supply and demand, and then it resulted in the relationship between supply and demand tend to balance. Based on the consistent national accounts, SAM simulated the macroeconomic performance.

In the description of the production and factor markets, all departments were assumed constant returns of scale and cost minimization, and production is modeled by nested, linear homogeneous CES production functions. The market structure is subjected to perfect competition and manufacturers determine the level of output by making the marginal cost equal to the market price. In terms of foreign trade, first Beijing exports and import from other areas of the world, and second transferred between Beijing and the rest of the country. Beijing is considered as a small open economy in import markets where foreign import prices are determined in world markets. Import demand is modeled using the Armington to reflect the different between Beijing and foreign products. Exports are demanded according to constant elasticity demand curves for most of commodities, in which infinite price elasticity is used to reflect that exports in Beijing, does not have an impact on the international market price. The domestic trade portrayed follow above assumes. Constant elasticity of transformation (CET) is used to describe the distribution of products in manufacturing departments between domestic and

imported sources. Considered that oversees trade is not the focus of this paper, foreign trade system is not distinguished, also there is no depth characterization between import and export taxes and subsidies.

This CGE model was improved on the basis of the National CGE model (DRC_CGE),developed by the State Council Development Research Center, and which is widely used in the policy simulation analysis, also offers plenty of adopted recommendations in China. The model includes 42 sectors, including 1 agriculture sector, 24 manufacture sectors, 1 construction sector and 16 service sectors. Production factors mainly include two categories of labor and capital, the labor subdivided into agricultural labor, industrial workers and technicians, and land was divided from capital; Residents subdivided into rural and urban residents; Government subdivided into central government and local government, as well as extra-budgetary sector; Taxes subdivided into value-added tax, business tax and other production taxes; Foreign trade objects include domestic and other areas of foreign; addition to capital and inventory accounts.

Build the Beijing CGE model; we also need to know how to reflect the investment in science and technology variables in the model. Judging from the existing literature, there are basically two mechanisms. Introduce the investment in science and technology straight into the production function that the investment of science and technology is one of the basic elements of production which is equal to capital and labor factors and so on, which we called “direct mechanism” ,widely used in the econometric analysis. Another method, introduce the science and technology input variables into the CGE model through the total factor productivity variables, which we called “indirect mechanism”, and can be detailed into two steps: Fist, show the relationship of between science and technology investment and TFP by econometric analysis. Second, introduce the TFP growth rate into CGE model as exogenous variables. By indirect mechanisms, this paper introduces science and technology inputs into CGE model, sheds lights on the impact of three industries’ investment in science and technology on the total factor productivity in their respective industries, then embeds the econometric equation in the CGE model, so that we can analyze the impact of t total amount of science and technology investment and structural changes to Beijing area macroeconomic. Then this paper sheds lights on the view that how to introduce the science and technology investment into the CGE model under the perspective of data model.

First, analyze the effects of the investment in science and technology on TFP growth rate using the Solow residual method and the mathematical expression is given by:

$$tfp_t = a_t + \beta \cdot tr_t$$

Where, tfp accounts for the total factor productivity growth rate，tr accounts for the growth rate of the stock of research investment.

The above equation shows that, a linear relation between the growth rate of TFP（tfp_t）and the investment in scientific research stock of each year, was founded. Weather tfp_t is high or low, depends closely not only on the size of the growth rate but also on the size of the output elasticity of the stock of investment in scientific research, that the faster the growth rate and the bigger the output elasticity of the stock of investment in science research, the faster the growth of tfp_t.

Secondly, in the CGE model, each department has two nested production function equation, intermediate inputs and elements increase are described as in the CES production function, and the value-added production function is described as the constant elasticity of substitution functional, included labor, capital and land elements which are alterative terms. The growth rate of total factors tfp_t in the production function is exogenous given, depending on the investment in science and technology and the level of human capital and other factors, and under the established technical level, manufacturers determine the production factors and demands of intermediate inputs according to the principle of profit maximization.

$$Qva_i = A_i^{va}(1+tfp_{it})[\sum_{f\in F}\delta_{fi}^{va}(\alpha_{fi}^{vaf}QF_{fi})^{-\rho_i^{va}}]^{\frac{1}{\rho_i^{va}}}$$

Where i denotes activity, f denotes elements，Qva_i denotes added value，QF denotes factor inputs, ρ_i^{va} denotes elasticity of output.

The increase investment in science and technology can improve the production efficiency, so that the increase on TFP that is the output increased in case of constant input factors. From the above analysis, when the production efficiency advanced, it can result on the production, consumption and trade both in this sector and other sectors, thereby affecting the whole economy. The CGE model is right to analyze these issues, and below is the macro-analytical framework model of this paper.

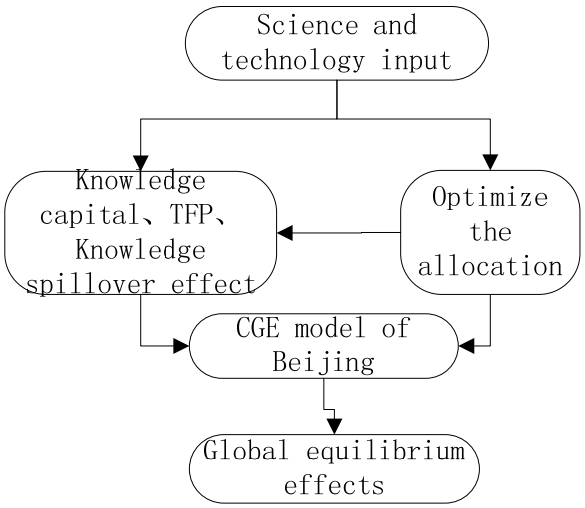

Figure 2 Macroeconomic analysis framework of investment in science and technology CGE model

2 Science and Technology investment Setup

Based on the 2007 SAM table calibration model, we made the baseline scenario be consistent with the data of 2007, using the year of 2007 as the base. On this basis, we designed two scenarios, and followed by different detailed scenarios, which aimed at study the long-term effects of the amount and structure of the investment in science and technology to the development of economic society in Beijing.

2.1 The Total Investment Amount

Assuming that the investments in science and technology of each industry are equal, that is, increase the same amount of investment (symmetry of the increase); causing the increase of TFP in different industries, then had an impact on the whole economy. The paper established the CGE model for the actual investment in science and technology, so in our simulation, we assumed the actual flow growth rate is about 2 percent (nominal growth rate is about 6.8 percent) with respect to inflation factors (4.8 percent in 2007). It requires doing some conversion between the flow and the stock of science and technology due to they are different concepts. So to compare the effects of the total investment increase in science and technology to the macroeconomic and industrial structure, we present three scenarios: in Scenario 1, the investment flows increased 1 percent; in Scenario 2, the investment flows increased 2 percent; in Scenario 3, the investment flows increased 3 percent.

2.2 The Investment Structure

In this scenario, we assumed the investment in science and technology flow increased by 3 percent than in 2007 with emphasis on their impact on economic and social development of Beijing. However, the

asymmetrical inputs among primary industry, industry, construction industry, tertiary industry, result in various increases in different sectors, so we can make sure the structural policies by analyzing which are key sectors requiring greater investment of science and technology. SR1: to increase the input in agricultural while decrease in tertiary industry; SR2: to increase the input in industrial sector while decrease in tertiary industry; SR3: to increase the input in construction industry while decrease in tertiary industry.

3 Results

Using the Beijing CGE model, which was developed by Beijing Science and Research Center, we can simulate the impact that investment in science and technology and structural changes to the economic development of Beijing.

3.1 The total investment amount analyze

The simulation shows that increasing science and technology input serves to increase GDP of Beijing. When the actual science and technology investment flows increased respectively by 1, 2, 3 percent, the CDP will increase 0.93, 1.22, 1.51 points. In terms of consumer, investment and import and export, increasing scientific and technological input help to increase consumption and investment, but it will reduce the trade surplus. If the investment in science and technology flow rate increased 3 percent, it will drive the consumption to increase 1.55 percent, investment to increase 9.54 percent in the baseline scenario while international trade surplus decrease 25.65 percent. Considered the income of residents, when the investment in science and technology flow rate increased 3 percent, it will drive the income level of residents in Beijing to increase 3.24 percent. Meantime, judging from the price index, investment in science and technology flow rate increasing 3 percent will lead to 2.25 percent increasing in CPI of Beijing, and 1.90 percent increasing in GDP deflator.

Increased investment in science and technology not only can increase the total economic output, but also improve the income level and welfare of residents in Beijing, but to some extent, it will also increase the trade deficit and investment. Viewed from the model, this is because that the improvement in scientific and technological level of the industry increased the level of investment industries, which also caused the demand for imports. The mentioned phenomena are conducive to the long-term economic growth.

Table1.Impact of increased investment in science and technology on the macroeconomic

	TR1 (actual investment in science and technology flow increased by 1%)	TR2 (actual investment in science and technology flow increased by 2%)	TR3 (actual investment in science and technology flow increased by 3%)
GDP	0.93	1.22	1.51
Consumer	0.94	1.24	1.55
Fixed capital formation	6.03	7.80	9.54
Export	-2.33	-2.99	-3.60
Import	2.94	3.85	4.74
Trade surplus	-16.25	-21.03	-25.65
Resident' income	2.01	2.63	3.24

From the structure of troika (investment, exports, consumption), increased investments in Beijing Science and Technology have led to a rise in the share of the total consumption, investment (including inventory), while a fall in the share of the import and export in GDP.

Table2.Impact of increased investment in science and technology on the macro-structure

	2007 baseline scenario	TR1 (actual investment in science and technology flow increased by 1%)	TR2 (actual investment in science and technology flow increased by 2%)	TR3 (actual investment in science and technology flows increased by 3%)
Total consumption	49.07	49.41	49.51	49.60
Investment （ including inventory）	48.57	51.29	52.10	52.88
Import and Export(including transferred to the tune out)	2.36	-0.70	-1.60	-2.48
total	100	100	100	100

3.2 The investment structure simulations

The simulation results show that when reduce the science and technology investment in the tertiary industry, but increase in the first industry, industry, construction industry, the investment in the construction industry contributes to a bigger growth of GDP, which is caused by our assumptions in the model that the increase of investment in science and technology of the construction industry led to TFP increases rapidly. If all industries increased by 3 percent, the GDP growth rate will be 1.51 percent, which is higher than in the first scenario (SR1, 1.504%) and the second scenario (SR2, 1.356%). From

the three industries' contributions to the growth of GDP, the scientific and technological input order should be: the tertiary industry, primary industry, the industrial sector.

Table 3. Impact of investment in science and technology structural changes on Macroeconomic in Beijing

	SR1	SR2	SR3
GDP	1.504%	1.356%	1.567%
Consumer	1.549%	1.391%	1.622%
Fixed capital formation	9.553%	10.885%	11.070%
Export	-3.621%	-4.559%	-4.480%
Import	4.747%	5.564%	5.426%
Trade surplus	-25.724%	-31.297%	-30.644%
Resident' income	3.245%	3.611%	3.677%

From the structure of troika (investment, exports, consumption), if Beijing's investment prefers to the industrial sector, it will maximize the rate of investment growth, and improve the consumption rate, but also increase the imports which will result in a substantial increase in deficit of import and export.

Table4. Investment in science and technology structural changes in the macro-structure

	baseline scenario	SR1	SR2	SR3
total consumption	49.07%	49.61%	49.87%	49.76%
Investment(include stock)	48.57%	52.89%	53.81%	53.68%
Import &export (include transferred to the tune）	2.36%	-2.50%	-3.68%	-3.43%
total	100	100	100	100

4 Conclusion

From the simulation results of the total amount and structure of investment in science and technology point of view, the increasing of the investment will contribute to the growth of GDP, and to a certain extent, it will improve the economic structure of Beijing. The greater the amount of the investment in science and technology, the bigger the growth of GDP, and the narrower the range of the marginal increase will be. Meanwhile, because of different science and technology investment in different sectors will make different changes in GDP and economic structure, the scientific and technological input order should be: the tertiary industry, primary industry, the industrial sector, which will be better for the realization of the economic growth and structure adjusting in Beijing.

As above conclusion depends on a number of assumptions about the model and data, so we should pay attention to the use and interpretation of the impact of scientific and technological input to

macroeconomic. Fist, since CGE is the main model of this paper, the inherent limitations of CGE will affect the analytical results, such as we assumed the economic system is perfectly competitive and it can achieve balance under the price mechanism as CGE model is a balance analysis, while in the realistic economy it may be out of equilibrium, and monopolies is also exist. Secondly, this paper has introduced science and technology investment to CGE by indirect mechanism, and the quantitative relationship between science and technology investment and total factor productivity has a greater influence on model results, so if in the realistic economy there does not exist the quantitative relationship in the model, the result will not established. Hence, the empirical research and model updating need to be improved.

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