

Endogenous Growth Theory and Extension in China

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Abstract: Against the background of global economic challenges, China's economic operation still presents many bright spots. This paper hopes to explore the momentum of China's economic growth by establishing an endogenous economic growth model in line with China's national conditions. This paper discusses the process of classical economic growth theory evolving into endogenous economic growth theory and introduces the variable of government public capital to establish an endogenous growth model including government investment in infrastructure. By solving the steady state of economy growth, we find that increasing the proportion of government public capital expenditure can promote economic growth.

1. Introduction

In 2018, the global economy is facing many challenges, showing a slowing trend of economic growth. The gradual differentiation of policy paths and development processes among major economies, the looming debt crisis in countries with fiscal imbalances, and the huge industrial changes caused by the digitization all indicate that economic globalization and multilateralism are being hit. This series of changes have limited the momentum of global economic synergistic development. Global economic growth has begun to stagnate at the current level. At the same time, there are obvious differences in the level of economic growth among countries, and the number of countries with economic expansion has gradually decreased.

Faced with the global economic shocks, in order to safeguard multilateralism and create opportunities for global economic development, China has expanded the opening-up scale by introducing a series of policies and measures to share the achievements of reform and tap its own development potential. Under the pressure of external environment, China maintained steady economic growth in the first two quarters of 2018, and its economic operation showed many highlights. Therefore, the purpose of this paper is to explore the engine of economic growth, and the way to maintain the growth of new momentum so that the economy can reach a higher stage of development, and Chinese wisdom that can be applied to the global economy. Based on the endogenous growth theory, this paper establishes a model to analyze the relationship between

economic growth and investment in infrastructure construction of the Chinese government and proves that government-led investment driven economy can ensure sustained economic growth.

2. Literature Review

2.1. Theoretical Background

Whether a country can continuously improve its national living standard depends on its actual economic growth rate, and a small difference in economic growth rate is worth paying attention to. Therefore, the growth of GDP and per capita GDP has always been a matter of great concern to economists.

From 1776 to 1870, it laid an important foundation for modern economic growth theory to analyze the process of economic growth in the period of classical economics. Since Adam Smith, the issue of economic growth has become one of the most concerned topics in macroeconomics. Smith's analysis of economic growth in *An Inquiry into the Nature and Causes of the Wealth of Nations* is based on three basic concepts: (1) the definition of national wealth (2) Homo Economics Hypothesis (3) social division of labor. Smith believes that national wealth is measured by the exchangeable value of the land and annual production [1], and assumes that each individual who takes part in economic activities will seek to attain very specific and predetermined goals to the greatest extent with the least possible cost. In addition, Smith attaches great importance to the study of social division of labor. He believes that division of labor has three advantages: (1) sophisticated workers; (2) saving time that caused by changing different kinds of jobs; (3) the invention of specialized machinery and equipment can improve production efficiency while achieving labor simplification. In brief, with the accumulation of capital, the trade demand increased, and the division of labor gradually began, and relevant systems have emerged to ensure a more detailed social division. On the one hand, workers' skills are enhanced. On the other hand, labor-saving machinery and equipment emerge at the historic moment, and social production efficiency is gradually improved. Just then, Adam Smith has realized that technological advances will lead to economic growth.

After Adam Smith, David Ricardo made a systematic analysis of economic growth. Unlike Adam Smith, he emphasized the key position of capital accumulation in economic growth. The profit of producer is the only source of capital [2]. Therefore, he examined economic growth through the process of income distribution. Against the background of the British Industrial Revolution, Ricardo realized that the fate of leading industrial nation, like Britain, was entirely controlled by industrial capital. The greater influence the capital has, the more workers could be employed, and the more production equipment could be improved. Thus, labor productivity could be increased, which was embodied in capitalist reproduction on extended scale.

The publication of Marshall's book *Principles of Economics* in 1890 marked the formation of neoclassical economics. On the basis of classical economic school, Marshall demonstrates the influence of the quantity and efficiency of labor force and capital accumulation on economic growth, but he goes beyond the classical school's theoretical explanation, introduces mathematical models to analyze, and the rudiment of Solow Model comes into being. In the process of argumentation, he noticed that the efficiency of workers could be improved through education and training. Therefore, he concluded that good education was as important as material wealth, and it was also a substantial means of material wealth creation. In addition, Marshall observed that due to the rapid progress of technology and the rapid expansion of capital accumulation, there was a trend of increasing return to scale. In order to explain this phenomenon, he creatively distinguished the

external economy from the internal economy and believed that technological progress should be contact to the internal situation of specific departments instead of being treated as a general phenomenon, which turned the analysis of economic growth to the micro-perspective [3].

The economic theory of neoclassical school cannot answer the question of economic growth perfectly. In 1928, Allyn A. Young focused on division of labor again. On the basis of Smith's theory, he put forward that, the extent of the market determined the division of labor, and in turn the division of labor decided the market maturity, which reflects the interaction between production and division of labor.

Joseph Alois Schumpeter elaborated on the relationship between economic growth and technological progress. He followed Marshall's thought and introduced the concept of biology, viewing the economic changes of capitalism as a process called The Creative Destruction of Capitalism [4]. He believed that the introduction of new technology can stimulate economic growth, but the stimulus was dynamic and unbalanced, and reflected in the cyclical fluctuations of the economy. In consideration of that economic growth was related to the economic cycle, the economic fluctuation brought about by technological progress actually is economic growth.

2.2. Development of Endogenous Growth Theory

In 1939, against the backdrop of the Great Depression, economist Roy Forbes Harold put forward the dynamic economic theory on the basis of the static macroeconomic system established by Keynes, which marked the beginning of the development of the theory of economic growth in modern times. Evsey David Domar, a Polish economist, followed and adopted Leontief production function and Saving-Investment Identity; however, the economic growth models of Harold and Dow are essentially identical, so they are collectively called Harold-Domar Model. This model considers that a country's growth rate is in proportional to its savings and points out that it is almost impossible to achieve long-term economic growth. Because of the discontinuity of the production function, the equilibrium in the model is very unstable, so the economic growth path simulated by Harold-Domar Model is also called "economic growth on the blade".

In order to overcome the shortcomings of Harold-Domar Model, the neoclassical economic growth theory, which emerged in the 1950s, assumes that the capital and the labor are perfect substitutes. It also introduces continuous production functions that enable economists to find a stable path of economic growth. This theory roughly contains two models, Solow Model and Ramsey-Cass-Koopmans Model. Both of them take capital accumulation as the core and consider the law of diminishing marginal efficiency of capital as the basic assumption and provide highly refined models to analyze the complex process of economic growth. The difference between them lies in the interpretation of capital accumulation. In Solow Growth Model, saving ratio is constant, while in Ramsey-Cass-Koopmans Model the optimal savings rate is depended on representative households and firms [5]. The basic conclusion of these neoclassical economic growth theories is the same, that is, under the hypothesis of diminishing marginal efficiency of capital, the momentum of economic growth decreases gradually, and only exogenous technological progress can achieve sustained economic growth. In addition, it is also given that government policy has only horizontal effect, but no growth effect.

Like any economic model, the neoclassical growth model should also be tested by empirical data. There are some contradictions between the reality and the prediction. Initially, under the hypothesis of diminishing marginal efficiency of capital, economy will only converge to its own equilibrium growth path and per capita output will not continue to grow unless there is exogenous technological progress. On the contrary, the data shows that the growth rate of output per capita is

increasing rather than decreasing. Secondly, according to the neoclassical growth model, when the savings rate and population growth rate of different countries are the same, the per-capita income converges to the same fixed value but the cross-sectional data does not reflect the economic convergence described in the model. What's more, there is no reasonable explanation for the huge difference of per-capita income between different countries and regions. Finally, the defects of the neoclassical growth model are about ways of dealing with other possible sources of income disparity. The one is to consider income gap as an exogenous variable. The other is to exclude consideration directly. Thus, the model does not fully interpret technological progress, positive externalities of capital or effective labor.

Obviously, exogenous technological progress cannot further explain the internal mechanism of economic growth, so enriching the connotation of technological progress becomes the point of endogenous economic growth theory. The neoclassical growth theory is an exogenous growth model rest with the hypothesis of diminishing marginal efficiency of capital. The endogenous growth model revises this hypothesis. One way is to give up the hypothesis of diminishing marginal efficiency of capital directly, and the other way is to consider that there is a mechanism in the economy to slow down the rate of the diminishing marginal returns. The former is exactly the way of adopted by AK model. Its core assumption is that output is a linear function of capital stock and knowledge is understood as a kind of capital. The progressiveness of AK model is embodied in that it expands the meaning of capital and proves that when, the marginal revenue of the factors of production are the constant, it does not need exogenous technological progress to promote sustained economic growth and can be achieved by endogenous savings rate; however, AK model still does not discuss the inherent mechanism of technological progress. If we do not abandon the hypothesis of diminishing marginal efficiency of capital, we should discuss the internal mechanism of technological progress or knowledge accumulation to slow down the trend that marginal return on capital declines too fast with the increase of capital stock. For one thing, we consider technological progress as an unconscious by-product of the positive externality of economic activities, so this kind of model is collectively called externality model. For another thing, we consider that knowledge accumulation is a conscious R&D behavior of enterprises, so technology progress is explicitly introduced into the model that is two-sector model. Most endogenous growth models are based on these two ideas.

In 1986, inspired by Arrow's thought of "learning by doing", that is, technological progress is a by-product of capital accumulation, Paul M. Romer put forward a model of knowledge spillover in which he assumed that technological progress is achieved through investment in knowledge. Because knowledge is classified as public product that is non-competitive and non-exclusive, unlike other production factors, it will produce strong positive externalities when they are put into production, which will lead to increasing returns to scale. In 1988, Lucas explained the internal driving force of economic growth by introducing the positive externality of human capital accumulation. In 1990, Romer took the Dixit-Stiglitz utility function as the production function and introduced the dominant R&D department to illustrate the endogenous source of technological progress. Both of them follow predecessors' ideas and strengthen the explanatory power of economic growth model to realistic data. Firstly, the idea knowledge internalization is greatly inspired by Allyn A. Young' theory [6], the relationship between the market and the division of labor. Subsequently, in the endogenous growth theory, the revision of the total production function and the core hypothesis in the neoclassical growth theory make the increase in return to scale possible. Ultimately, it provides a reasonable explanation for the differences of output per capita in different countries.

Generally speaking, endogenous growth theory emphasizes the long-term impact of endogenous variables such as human capital and technological progress on the economy, and these variables are sensitive to government policies; however, most theories, based on the national conditions of western developed countries, focus on the institutional basis of strengthening human capital and promoting technological progress, which is not applicable. In fact, China needs to formulate effective policies according to the endogenous growth theory to guide China's economic development. The sudden change of domestic and foreign economic environment also requires us to actively explore new driving forces for economic growth. Consumption, investment and export have always been regarded as the three carriages driving China's economic growth. Owing to slumping consumption and exogenous export, investment is the key of re-understanding the source of China's economic growth. In addition, China's state-sponsored investment is mainly divided into infrastructure investment, manufacturing investment, real estate development investment and other investment. Among them, according to the data of the National Bureau of Statistics, only the investment in infrastructure construction has increased, by nearly 4 percentage points, since 2015. Therefore, this paper discusses the relationship between infrastructure investment and China's economic growth.

3. Endogenous Growth Model Including Government Investment in Infrastructure

This model introduces government infrastructure investment, a key variable of government activities, into the endogenous growth model. Because of the delay of government financial behavior, this paper considers the social public capital stock as an endogenous factor of production when establishing the growth model.

Let's assume that there are two sectors in an economy, one is the production sector that produces products, and the other is the R&D sector that provides technology for the production sector. Capital and labor are allocated between the two sectors.

Suppose that the proportion of labor force used in R&D department is a_L , so the proportion of labor force used in product production department is $1 - a_L$. Among them, a_L is exogenously given and remains unchanged. If the time is continuous, the total output of the period t is as follows.

$$Y_t = K(t)^\alpha [A(t)(1 - a_L)L(t)]^{1-\alpha} \quad (1)$$

The production function meets the law of constant returns to scale. Then, we hold that new knowledge is created by the R&D department, which depends on the amount of capital invested by the government, the amount of labor and the level of knowledge available.

$$\dot{A}(t) = K_g(t)^\beta A(t)^\theta, \quad \beta \geq 0, \quad 0 \leq \theta \leq 1 \quad (2)$$

Note that although the Cobb-Douglas function is also used for the production of new knowledge, it is not assumed that returns to scale remains unchanged. Assuming that the depreciation rate is zero, the savings rate of private capital is s , and the savings rate of public capital is τ . Therefore, the private capital accumulation can be described as

$$\dot{K}(t) = sY(t), \quad s \leq 1 \quad (3)$$

The public capital accumulation can be described as

$$K_g \dot{(t)} = \tau Y(t), \tau \leq 1 \quad (4)$$

In this model, we do not consider the negative population growth, so population growth is expressed as

$$L \dot{(t)} = nL(t), \quad n > 0 \quad (5)$$

The technological progress rate is

$$g_{A(t)} = \frac{A \dot{(t)}}{A(t)} = K_g(t)^\beta A(t)^{\theta-1} \quad (6)$$

In equation 6, we simply take its log and then differentiating the logarithmic expression obtained with respect to time. Hence, the expression of the growth rate of $g_{A(t)}$ is

$$\frac{g_{A(t)} \dot{(t)}}{g_{A(t)}} = \beta g_{K_g(t)} + (\theta - 1)g_{A(t)} \quad (7)$$

Multiply both ends of the formula by $g_{A(t)}$, and get

$$g_{A(t)} \dot{(t)} = \beta g_{K_g(t)} g_{A(t)} + (\theta - 1)[g_{A(t)}]^2 \quad (8)$$

Similarly, the growth rate of private capital is

$$g_{K(t)} = \frac{K \dot{(t)}}{K(t)} = sK(t)^{\alpha-1} [A(t)(1 - a_L)L(t)]^{1-\alpha} \quad (9)$$

In equation 9, we simply take its log and then differentiating the logarithmic expression obtained with respect to time. Hence, the expression of the growth rate of $g_{K(t)}$ is

$$\frac{g_{K(t)} \dot{(t)}}{g_{K(t)}} = (1 - \alpha)[g_{A(t)} + n - g_{K(t)}] \quad (10)$$

In the same way, the growth rate of public capital is

$$g_{K_g(t)} = \frac{K_g \dot{(t)}}{K_g(t)} = \frac{\tau K(t)^\alpha [A(t)(1 - a_L)L(t)]^{1-\alpha}}{K_g(t)} \quad (11)$$

In equation 9, we simply take its log and then differentiating the logarithmic expression obtained with respect to time. Hence, the expression of the growth rate of $g_{K_g(t)}$ is

$$\frac{g_{K_g(t)} \dot{(t)}}{g_{K_g(t)}} = \alpha g_{K(t)} + (1 - \alpha)[g_{A(t)} + n] - g_{K_g(t)} \quad (12)$$

Let the right side of equation 7, 10 and 12 be zero and establish equations as

$$\begin{cases} \beta g_{K_g(t)} + (\theta - 1)g_{A(t)} = 0 \\ (1 - \alpha)[g_{A(t)} + n - g_{K(t)}] = 0 \\ \alpha g_{K(t)} + (1 - \alpha)[g_{A(t)} + n] - g_{K_g(t)} = 0 \end{cases} \quad (13)$$

By solving the simultaneous equations 13, we can get

$$g_{A(t)} = \frac{n}{\frac{1-\theta}{\beta} - 1} \quad (14)$$

$$g_{K(t)} = \frac{(1-\theta)n}{1-\theta-\beta} \quad (15)$$

$$g_{K_g(t)} = \frac{(1-\theta)n}{1-\theta-\beta} \quad (16)$$

In order to have a further study in the relationship between public capital and technological progress, it is necessary to analysis the influence of changes in β on g_A . Formula 6 shows that the initial value of g_A is depended on the initial values of K_g and A and other parameters, and Formula 8 describes the subsequent changes of g_A . Obviously, when $g_A \rightarrow 0_+$, $\dot{g}_{A(t)} \rightarrow 0_+$; when $g_A \rightarrow +\infty$, $\dot{g}_{A(t)} < 0$. Because the function determined by formula 8 is continuous, there must be a point that makes $\dot{g}_{A(t)} = 0$. That is to say, given any K_g and A , there must be a point that makes g_A converge to g_A^* . Let the right side of equation 8 be zero, that is, $\beta g_{K_g(t)} g_{A(t)} + (\theta - 1)[g_{A(t)}]^2 = 0$, and we could get

$$g_A^* = \frac{\beta g_{K_g(t)}}{1-\theta} \quad (17)$$

Formula 17 indicates that if $g_{A(0)} < g_A^*$, then $\dot{g}_{A(t)} > 0$, which means that $g_{A(t)}$ will increase until it reaches g_A^* ; if $g_{A(0)} > g_A^*$, then $\dot{g}_{A(t)} < 0$, which means that $g_{A(t)}$ will continue to decrease until it reaches g_A^* . Once $g_{A(t)} = g_A^*$, A will grow steadily at the rate of g_A^* . In particular, the calculation results of formula 14 and 16 are in accordance with formula 17, which shows that $g_{A(t)}$ will be affected by parameter β and the economy will eventually reach a steady state. Under the stable economic growth rate, we may as well derive formula 14 with respect to β , and we will get

$$\frac{\partial [g_{A(t)}]}{\partial \beta} = \frac{n(1-\theta)}{(1-\theta-\beta)^2} \quad (18)$$

Because $0 \leq \theta \leq 1$ and $n > 0$, the first derivation is greater than zero. Evidently, when $0 \leq \beta < 1 - \theta$, or $\beta > 1 - \theta$, $g_{A(t)}$ monotonically increases with respect to β , and as shown in the figure, when $\beta \rightarrow 0_+$, $g_{A(t)} \rightarrow 0_+$, when $\beta \rightarrow +\infty$, $g_{A(t)} \rightarrow -n$, when $\beta \rightarrow (1 - \theta)_-$, $g_{A(t)} \rightarrow +\infty$, when $\beta \rightarrow (1 - \theta)_+$, $g_{A(t)} \rightarrow -\infty$, which means that when $0 \leq \beta < 1 - \theta$, with the

increased endogenous degree of public capital, the rate of technological progress increases, and technological progress accelerates; however, when $\beta > 1 - \theta$, with the increased endogenous degree of public capital, technological decline slows down. In other words, as long as the economy has enough public capital to invest in the R&D sector, total output will continue to grow, and per capita output will rise to a high level over time when capital-enhanced technology in the production sector continues to grow.

4. Enlightenment of Endogenous Growth Theory to China's Economic Development

The endogenous growth theory suggests that the breakthrough in stimulating China's economic growth lies in introducing government investment in infrastructure into the economic growth model and acting as one of the intrinsic driving forces to stimulate economic growth.

When the economy growth slows down, China usually increases infrastructure investment with the help of leverage to promote economic growth, but there are some side effects, such as the crowding-out effect of increasing investment in the short term, and weaken effect of investment. As the most objects of government investment is are non-private enterprises, bank loans tend to be unreasonably inclined, which ultimately ends up as overcapacity, and shrinking growth space of small and medium-sized private enterprises, and aggravating environmental problem. Obviously, it is difficult to sustainably and effectively promote economic growth if we rely solely on the traditional way of increasing infrastructure investment. The crux of this matter is that imperfect fiscal policies and excessive business burden reduce the enthusiasm of enterprises to invest independently.

In the current situation, the purpose of the new investment and financing mode of infrastructure construction is to guide private capital to participate in infrastructure construction. Through the adjustment of investment and financing mode, government investment becomes one of the inner agents of economic growth. The regulations are as follows: (1) attraction effect. For example, in regional construction, the government has initially injected funds into the construction of regional infrastructure, then absorbs private capital with business-friendly policies and continued to expand infrastructure construction. (2) Savings policies. To promote the development of infrastructure construction, Policy-based banks expand the lending directed at investment sectors by attracting idle social funds for investment loans. This in turn induces private capital, which makes private capital compete to provide funds to the investment sector to meet the capital needs of infrastructure construction. (3) Utilization of foreign capital. By introducing foreign advanced machinery, equipment and knowledge, the state can improve its own scientific technology and labor productivity and promote its own economic development.

To sum up, refining China's infrastructure construction investment and financing pattern is the only way to find the new driving force of economic growth. Originally, the traditional model of investment and financing restricted the development of China's economy. Thinking about the mode of investment and financing can provide inspiration for China's market-oriented reform and achieve higher achievements in economic development. Afterwards, in order to provide a fair and scientific market competition environment for social capital, the market-oriented reform has weakened the absolute position of the government in infrastructure construction; however, the government is supposed to adhere to its dominant position in infrastructure construction, which puts forward higher requirements for government management.

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