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Re-evaluation of Economic Efficiency of Infrastructure investment in China

중국 기반시설 투자의 경제적 효율성에 대한 재평가

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Abstract

China is the largest developing country in the world and one of the fastest developing countries. To sustain rapid economic growth, governments across China have been ramping up investment in infrastructure (Social Overhead Capital) in recent years. However, due to the scarcity of social wealth, unreasonable infrastructure investment will make the whole society burden heavy opportunity cost. Therefore, scientific evaluation of infrastructure investment in each region is excessive or insufficient has become a topic of concern to researchers all over the world in recent years. Based on the infrastructure investment of 31 provinces in China from 1997 to 2015, this paper evaluates the efficiency of infrastructure investment in China by referring to the model proposed by Achauer (2000) and the improvement results of the model by Young Sung Lee (2012). It turns out that infrastructure in central and eastern China is already inadequate, and that the west, while currently adequate, will soon be inadequate as well. In general, compared with the level of social and economic development, the Chinese government still needs to continue to increase investment in infrastructure, and infrastructure investment can still effectively promote China's economic development.

Keyword : Evaluation, Infrastructure, investment, Efficiency, Economic, SOC

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Chapter 1. Introduction

1.1. Study Background

At present, China's economic growth rate is gradually slowing down. In the future, China's economic growth will face very big challenges, but there are also many opportunities. Lin Yifu (2015) pointed out that infrastructure construction is still one of the important favorable factors for economic growth【1】. Although China's inter-city infrastructure construction has been saturated, the intra-city infrastructure construction is far below the level of developed countries, and the historical lack. There are still many accounts. Urban rail transit, public transportation systems, and road construction are seriously inadequate, and traffic congestion is becoming more and more serious; underground pipe networks are seriously aging, and urban waterlogging disasters occur from time to time; environmental pressure is increasing, energy saving, emission reduction and pollution control are urgent; urban emergency. The system is not sound, and the response to disasters is slow. Therefore, it is foreseeable that the Chinese government will continue to increase investment in infrastructure for a long period of time in the future.

In addition to solving the above-mentioned problems and improving people's quality of life, infrastructure facilities also become a favorable factor for the country's economic development because of its own economic attributes. Infrastructure includes narrow and broad meanings. The narrow infrastructure generally refers to economic infrastructure, and specifically refers to engineering facilities such as water, gas, heating, roads, and public transportation that provide common conditions for residents' lives. Is the basic conditions and facilities for urban development, and in a broad sense, in addition to basic facilities, infrastructure also includes urban social service facilities, that is commercial, service industry, culture, education and health, urban housing, and

administrative management facility. All the components of the general infrastructure have a certain degree of commonality, so that we can generally call them the infrastructure or infrastructure of the city.

Infrastructure is also called social overhead capital in economics【2】. These two terms are usually used equivalently, but because the term infrastructure is easier to understand, it is more commonly used. According to the analysis of economics, social overhead capital is the basis of production activities and economic development. They have the external benefit function of enhancing the general welfare of society. It is the basic factor to promote the economic activities of various sectors. Therefore, from this perspective, in order to stimulate further economic development, the Chinese government will continue to invest in infrastructure in the future. However, no matter how important social overhead capital is, because social resources are limited, we cannot increase our investment in social overhead capital indefinitely. This is because the increase in social overhead capital investment (mainly relying on taxation) reduces the ability to invest in the private sector, and our society must bear perhaps unnecessary opportunity costs【3】. Therefore, the key question we need to face is, to what extent should we invest in social overhead capital to maintain or improve the functions and roles that social overhead capital should have in its original role, without increasing the burden on the private sector?

So far, without a rigorous theory, many previous studies in China tend to focus on confirming the positive effects of social overhead capital investment, and most of them use the method of calculating output elasticity to evaluate the positive effects of infrastructure investment effect. At this point, Aschauer (2000) proposed a new evaluation method. The model he proposed can estimate the optimal ratio of social overhead capital stock to private capital stock by measuring the maximum long-term economic growth rate. In Aschauer (2000), the optimal ratio in the United States should be 0.6 to 0.8 (that is, 60% to 80%). However, because the US's social

overhead capital stock is relatively small compared to the actual private capital stock, he believes that the US's social overhead capital stock is insufficient. Using this model and performing statistical processing on this model, Young Sung Lee (2012) measured the economic efficiency of social overhead capital in various regions of South Korea, and obtained reasonable results.

In the second chapter of this paper, Jin Ge (2016) uses the estimated data of China's infrastructure capital stock and non-infrastructure capital stock from 1997 to 2015 as the basic data of the model (see below for details) 【4】. Then refer to the mathematical model proposed by Aschauer (2000) and the optimization results of Young Sung Lee (2012) to re-estimate the economic efficiency of the infrastructure stock of each province in China from 1997 to 2015 (for the time selection basis refer to the following). Chapter 3 will perform GIS visualization and chart processing on the calculation results to make the results easy to identify and analyze. In summary, this research will be able to judge whether the social overhead capital in various regions of China is surplus or insufficient, and it can also reasonably judge the future social overhead capital investment strategies of various provinces based on the trend of changes from 1997 to 2015.

1.2. Literature review

As early as the 1960s, Rosto (1962) had recognized the important role of infrastructure investment in the economic take-off stage. Rosto (1962) believes that certain conditions are required for economic take-off, one is higher capital accumulation, and the other is the leading sector for take-off【5】. With the rise of the new growth theory in the 1980s, scholars represented by Barro, Lucas, and Romer discovered that human capital investment, R&D investment and infrastructure capital accumulation directly affect productivity【6】. Later, with the rapid development of western

economic growth and infrastructure, the role of infrastructure has been more and more affirmed, and there are more and more documents on the elasticity of infrastructure capital.

Arrow and Kurz (1970) were the first to separate infrastructure capital from total capital, and separately calculated the contribution of infrastructure to economic growth, and found that infrastructure had a significant positive effect on economic growth【7】. Costa et al. (2006) adopted tranlogarithmic function to conduct cross-section analysis of 48 states of the United States in 1972, and found that the output elasticity of public capital was between 0.16 and 0.26. Duffy-deno and Elberts (1991) used Cobb-Douglas production function to analyze 28 standard statistical metropolitan areas in the United States from 1980 to 1984, and found that the elasticity of public infrastructure to local total output was 0.08. Aschauer (1989) analyzed the contribution of public capital to economic growth by using the time series data of the United States from 1945 to 1985, and found that the output elasticity of public capital was as high as 0.39, and the effect of core infrastructure stock on economic growth was particularly significant, with the output elasticity reaching 0.24【8】. However, scholars generally believe that the output elasticity of infrastructure measured by Aschauer (1989) is on the high side, which is generally believed to be between 0.15 and 0.25 at the national level of the United States. Tatom (1991) believed that Aschauer (1989) ignored the time series characteristics of the data in the analysis, so the obtained infrastructure elasticity was high, and the output elasticity was only 0.14 after the first-order difference processing of the data. Munnell (1991), Finn (1993), Moomaw et al. (1995) calculated results of 0.1, 0.16, and 0.11 respectively【9】. Stephan (2001) calculated the data from 1980, 1986 and 1988 in large cities in Germany, Picci (1999) calculated the data from 20 regions from 1970 to 1991 in Italy, and Everaert and Heylen (2004) calculated the panel data from 1953 to 1996 in Belgium, and the estimated results were 0.082, 0.08 ~ 0.43 and 0.29 respectively【10】. It can be judged from these results that the output elasticity of infrastructure is

between 0.08 ~ 0.30 on the whole. From the perspective of literature development, studies on the output elasticity of infrastructure mainly focus on the United States, but are not fully carried out in other countries. This is mainly because of the availability of data, and the U.S. Department of Commerce provides a relatively complete set of infrastructure capital stock data.

China is a typical big developing country, and infrastructure plays an extremely important role in China's economic growth【11】. A large number of scholars at home and abroad have conducted in-depth studies on the output and growth effect of China's infrastructure. At present, the researches related to the optimal scale of infrastructure input in China are mainly based on two methods, the production function method represented by The Barrow model and the behavior method represented by the tranlogarithmic cost function【12】. The production function method is mainly to add infrastructure input into the factor setting of production function, and the optimal scale is estimated by the output elasticity of infrastructure input. The behavioral approach is to analyze the optimal scale of infrastructure investment by using a profit function (maximizing profits) or a cost function (minimizing costs).

Wang Renfei and Wang Jinjie (2006) based on the aggregate production function analysis of the Chinese infrastructure output elasticity of the optimal scale problem, using data from 1981 to 2000 in China were analyzed, and estimate the infrastructure capital increase 1%, can make the labor productivity and output growth of 0. 297%, China's infrastructure capital in 2000, has yet to reach the optimal size. 【13】

Ding Jianxun (2007) estimated the optimal infrastructure stock by using the Chinese data from 1985 to 2004, and calculated the optimal scale of infrastructure investment through the endogenous growth model as the proportion of infrastructure investment in GDP was 6.24%【14】. However, the data showed that China's infrastructure had exceeded the optimal scale from 1999 to 2004. [3] and Yang liu feng-ming qin (2009) using data analysis of 15

countries, including China, the relationship between infrastructure stock level and income, that raising the level of per capita income will drive the continued growth of the total infrastructure requirements, in the future should increase resource infrastructure construction, investment should sustain average growth of 15% ~ 24%. Guangnan Zhang (2011) research based on the marginal output of infrastructure and the optimal size analysis framework, adopt various provinces panel data from 1996 to 2008 for empirical research, calculate China's "electricity, gas and water production and supply industry", "transportation, warehousing and postal and telecommunication services", "water resources, environment and public facilities management" and so on the various infrastructure and government with a total investment of the marginal output of respectively 5. 765, 2. 520, 1. 420 and 1. 276【15】. The optimal scale is 4.66%, 3.29%, 5.02% and 20.95%, respectively believing that the actual investment in China's infrastructure is all lower than the optimal scale. As well as: Ma Shucai et al. (2001), Fan Jiuli et al. (2004A, 2004b), Guo Qingwang and Jia Junxue (2006), Qu Jiafeng and Li Jing (2006), Wang Renfei and Wang Jinjie (2007), Liu Shenglong and Hu Angang (2010), Zhang Guangnan et al. (2010), Zhang Xueliang (2007, Li Qiang and Zheng Jiangjun (2012), Demurger(2001), Fan &Zhang(2004), Sahoo et al. (2012), Zhang(2013), et al., Fan Jiuli and Bai Viola (2004) used the inter-provincial panel data from 1996 to 2000 to calculate that the elasticity of infrastructure capital was 0.187【16】. Fan Jiuli et al. (2004) analyzed the national time series data from 1981 to 2001, and found that the output elasticity of infrastructure capital was 0.54. Fan Jiuli et al. (2004) used the mixed data of 29 provinces and municipalities in China from 1996 to 2000, and found that the output elasticity of infrastructure investment was 0.19. Based on the above literature research, Ge Gin (2016) concluded that the output elasticity of economic infrastructure capital was 0.12~0.13. Xue Guizhi (2018) showed that the output elasticity of capital stock of urban infrastructure was 0.06~0.11. It can be seen that due to different statistical calibrations and different measurement methods,

there are large gaps in the research results of different scholars.
Then select several papers to carry out the existing research methods.

A. Gu Xiaoyun (2014) aimed at the problems existing in the existing literature, and try to improve in the following aspects【17】. First, in Barro (1990), based on the model and conclusions beyond the logarithmic function model is adopted instead of c-d function, the analysis framework of optimal scale, build infrastructure model considering human capital, private capital and infrastructure capital influence on each other, so as to estimate whether the infrastructure to achieve the optimal scale. Second, in terms of data processing, the capital stock data and human capital data of China from 1978 to 2008 were re-estimated, and human capital data were used as labor data to overcome the deficiency of most studies that only employed people were used for research. The final research results show that from 1980 to 2008, the marginal output value of infrastructure capital is higher than the marginal output value of private capital, which indicates that China's infrastructure capital has not reached the optimal scale and the supply of infrastructure services is insufficient. As a developing country, China still has much room for improvement in the urbanization process and infrastructure construction. The phenomenon of expressway congestion, high train attendance, technology and cultural venues being fully filled in every holiday also shows that China's infrastructure construction lags behind and is insufficient compared with people's consumption demand. China's economy is still in a state of high growth rate, and the ownership of private cars and buses and trucks is increasing rapidly year by year. For transportation facilities and other types of infrastructure, a certain degree of forward-looking investment can leave enough room for long-term development in the future. Compared with the huge size of population and economy, the supply of infrastructure services in China still needs to be further strengthened.

B. Xue Guizhi (2018) made an overall evaluation of the economic

efficiency of infrastructure from the perspective of cities. In her view, economic growth is a complex economic and social phenomenon, caused by both immediate and fundamental causes. Variables related to the basic causes of economic growth are those that have an impact on the economy's ability to accumulate production factors and invest in knowledge production. In Xue Guizhi's study (2018), only the direct causes of economic growth are discussed for the time being【18】. Xue Guizhi (2018) constructed the urban production function to analyze this problem. Denison, an American economist, divided economic growth factors into two categories: the first is the increase of input of factors of production, and the second is the improvement of total factor productivity. Production factors including labor, capital and land, the traditional solow model tends to output as production function of labor and capital and land are often seen as constant. Xue Guizhi (2018) argues that urban economic growth is the result of many factors, in the case of data available. Xue Guizhi (2018) to build an extension of the solow model, using cobb-douglas function to analyze the problem. In terms of time, 2009~2014 was selected. After analysis, Xue Guizhi (2018) found that at the national level, the output elasticity of infrastructure capital was 0.059, but there were obvious differences in urban infrastructure construction in eastern, central and western regions, so the output elasticity of infrastructure capital in different regions might be different. According to the operation idea of national panel data from 2009 to 2014, Xue Guizhi (2018) conducted individual time bidirectional fixed effect regression analysis on urban production functions in eastern, central and western regions respectively【19】. According to the calculated result, the eastern part of the output elasticity is 0.032, but has no significant, in central and western regions of output elasticity are 0.061 and 0.110 respectively, and explain the eastern part of the city infrastructure construction level has been gradually perfect, the effects of economic growth is no longer obvious, and the Midwest urban infrastructure construction is relatively backward, infrastructure capital stock's contribution to

the city's economic growth is more obvious. Xue Guizhi (2018) also carried out regression analysis on urban production functions of 18 cities at or above the sub-provincial level and 199 prefecture-level cities respectively【20】. Among them, the output elasticity of infrastructure capital of cities at or above the sub-provincial level is not significant, indicating that the infrastructure construction level of cities at or above the sub-provincial level has been relatively perfect, and the economic growth effect of infrastructure investment is no longer obvious. However, the output elasticity of infrastructure capital of prefecture-level cities is 0.062 and significant, indicating that the infrastructure construction level of prefecture-level cities is still relatively backward and its economic growth effect is relatively obvious. Therefore, in the future, the focus of urban infrastructure investment should be in the central and western regions and prefecture-level cities.

C. JinGe (2016) estimated the output elasticity of different types of capital by using the estimation results of national inter-provincial economic, social infrastructure capital and non-infrastructure capital stock from 1997 to 2012, and calculated the contribution of different factors to economic growth by using growth accounting method【21】. Given that infrastructure capital to a large extent has the nature of public capital and enters the production function in the form of a production externality, the overall economy may exhibit the nature of increasing returns to scale. According to Mr (2016), whether the production function in China shows an increasing return to scale or a constant return to scale needs to be further tested. For this reason, Mr (2016) estimated the output elasticity coefficients of each factor under the two assumptions of the unconstrained model and the constrained (constant return to scale) model respectively, and made a choice on the model setting through Wald test. Using the above data, some valuable findings have been made. First, through Wald test, Mr (2016) rejected the null hypothesis that China's total production function has constant returns to scale. Mr (2016) also finds that the output elasticity of infrastructure

capital, non-infrastructure capital and labor totals between 1.05 and 1.07, indicating that China's total production function has the nature of slight increasing returns to scale【22】. Among them, the output elasticity of non-infrastructure capital is between 0.55 -- 0.57, and that of infrastructure capital is about 0.19 -- 0.23. Within infrastructure, the output elasticity of economic and social infrastructure capital is between 0.12 -- 0.13 and 0.10 -- 0.12, respectively.

D. Cao Yuequn et al. (2019) studied the multi-dimensional impact of infrastructure investment on regional economic growth from the perspectives of efficiency, heterogeneity and space. Cao Yuequn (2019) pointed out that under the realistic background of China's economy entering the "new normal" and infrastructure accumulation moving towards a higher level, capturing and further playing the important role of infrastructure in regional economic growth is crucial to ensure economic operation in a reasonable range and achieve high-quality development. Cao Yuequn (2019) empirically tested the multi-dimensional impact of infrastructure on regional economic growth and its mechanism from the perspective of efficiency, heterogeneity and spatial 3d, using the provincial panel data of China from 1993 to 2016 and using spatial Dubin model and other methods【23】. Empirical analysis shows that: first, although infrastructure capital promoted regional economic growth significantly on the whole during the sample period, the output elasticity values of point infrastructure and network infrastructure were 0.172 and 0.042 respectively. Second, however, infrastructure investment has an inverted u-shaped impact on regional economic growth, and the output elasticity value of network infrastructure has exceeded the "inflection point", dropping from 0.163 in 2000-2011 to 0.085 in 2012-2016【24】. However, the output elasticity value of point infrastructure is still in the growth trend after the economy enters the "new normal", indicating that it is still quite far from the "inflection point" and has relatively large investment potential and good investment income. Thirdly, in different regions, the output

elasticity values of infrastructure are successively from high to low in western, central and eastern regions. In terms of the differences of specific structure types, the output elasticity values of the two types of facilities in the eastern region are relatively close, the network infrastructure in the central region is relatively high, and the point infrastructure in the western region is relatively high. Fourth, in terms of spatial influence, the whole infrastructure and point infrastructure have robust negative spillover effect, while network infrastructure has positive spillover effect on the whole. However, there is also evidence of negative spillover effect in 2012-2016 and the central and western regions【25】. Fifth, industrial agglomeration and employment growth are two important transmission channels through which infrastructure investment affects regional economic growth. Sixth, the accumulation of human capital and urbanization and other factors affecting regional economic growth can not be ignored. Based on the realistic background, yue-qun cao (2019) the enlightenment is: first, in view of the infrastructure to still have significant positive role in promoting regional economic growth, so the government should continue to infrastructure investment as an important means of active fiscal policy, focus on its board and weaknesses field increasing investment, such as municipal facilities, such as ecological environmental protection infrastructure, to ensure the economic operation in a reasonable range. At the same time, the investment strategy of infrastructure should be optimized according to local conditions and the regional differences in infrastructure construction should be narrowed. The eastern region will continue to adhere to the practice of balanced development of the two types of infrastructure, and pay more attention to the improvement of the quality of the two types of infrastructure on the basis of proper improvement of the infrastructure stock. In the central region, the focus of investment should be tilted to the field of network infrastructure, actively promote the construction of modern transportation and communication infrastructure in the region, and promote the full flow and employment of labor force within the

region; In the western region, we should make up for the shortage of infrastructure and accelerate the construction of municipal infrastructure such as urban water supply, urban roads and public transport.

1.3. Research methods

As can be seen from the above summary, Chinese scholars tend to use the measurement of output elasticity to evaluate the economic efficiency of infrastructure. The paper then argues that it makes sense to use output elasticity to judge the economic efficiency of infrastructure, but this is not a strict criterion.

First, even if the same amount of money is invested in different areas, the changes in economic indicators will be different. Secondly, the employment creation effect predicted by industry correlation analysis does not necessarily mean the net increase of employment opportunities, because it is also related to the background of The Times and the overall social and economic environment. If you invest in social overhead capital at a time when unemployment is high, the unemployed can find new jobs, but if unemployment is not as high as it is in China, then people working elsewhere will be redistributed. This is why the chain effect of industry correlation analysis is not included in the cost-benefit analysis. In addition, according to Young Sung Lee (2009b), industry correlation analysis cannot accurately predict the increase of actual employment opportunities. Therefore, this study adopts the mathematical model proposed by Aschauer (2000) to determine the standard of whether the social overhead capital is too much (or not enough), and calculates the ratio of the social overhead capital stock to the private capital stock.

This article draws on the research results of Aschauer (2000), who proposed a mathematical model to determine whether social overhead capital is too much (or not enough). In his model, the government obtains taxes and invests in social overhead capital, restricts private investment and consumption, and then, in this case, finds the economic growth rate that maximizes the utility of representing consumers in a long-term equilibrium. The ratio of the stock of social overhead capital to the stock of private capital at that time can be regarded as the ideal ratio of the two, and this process

can be calculated mathematically. Due to the complexity of the original calculation process, Young Sung Lee (2012) was used to summarize the original process to summarize the calculation process of Aschauer (2000).

In equation (1), "y" is the output of the economy, k is the private capital stock, and kg is the social overhead capital stock (all three variables are calculated per employee). α_k and α_kg indicate the percentage of output elasticity corresponding to the increase of y when k and kg increase by 1%.

$$y=k^{\alpha_k}kg^{\alpha_{kg}} \quad (1)$$

In the government budget constraint formula (2), the left side is the stock of social overhead capital in the first year and the present value of social overhead capital investment in subsequent years. On the right is the current value of overhead capital that the government levies at a total tax rate of θ on gross output value and invests in society.

$$kg_0 + \int_0^\infty \dot{k}g\, e^{-rt}dt = \int_0^\infty \theta \cdot ye^{-rt}dt \quad (2)$$

Equation (3) obtained from (2) and (1). The private capital stock is accumulated by excluding after-tax consumption. r is the interest rate, k is the rate of change of the private capital stock. Equation.

$$\dot{k} = (1-\theta)k^{\alpha_k}kg^{\alpha_{kg}} - c \quad (3)$$

Equation (4) is a utility function representing consumers, where V is the overhead utility function, c is consumption, σ is the elasticity of the marginal utility of consumption, and ρ is the time preference rate.

$$V = \int_0^\infty \frac{c^{1-\sigma}-1}{1-\sigma} e^{-\rho t}dt \quad (4)$$

In order to solve the dynamic optimization problem that maximizes the service life of representative consumers, the long-term equilibrium economic growth rate (y) is shown in equation (5), where ⌀ is the ratio of social overhead capital to private capital stock.

$$\gamma = \frac{1}{\sigma}\left[(1-\theta)\left(1-\alpha_{kg}\right)\emptyset^{\alpha_{kg}} - \rho\right] \quad (5)$$

Differentiate the formula (5) to obtain formula (6), calculate and find α_kg in formula (1), and substitute it into equation (6) to obtain the ideal social overhead capital to private capital ratio ⌀^max. (Refer to Aschauer, 2000 for details)

$$\emptyset^{max} = \frac{\alpha_{kg}}{(1-\alpha_{kg})^2} \quad (6)$$

The method of Aschauer (2000) has several characteristics. First, it shows how all resources should be allocated to private capital and social overhead capital to maximize long-term economic growth. To this end, the social overhead capital stock is evaluated by comparing it with the private capital stock. In his theory, the lack of social overhead capital is not an absolute shortage, but whether the state is short compared to private capital. If the results show that the social overhead capital stock is too small, it means that too much resources have been allocated to the private sector. On the contrary, if there are too many overhead social capital stocks, it means that too much resources have been allocated to the public sector, but private sector investment and consumption are restricted, so the entire society needs to bear more opportunity costs. Second, the stocks of private and public capital he refers to are not limited to specific facilities, but are widely covered. This is different from common related research that focuses on estimating the needs of each facility or evaluating supply and demand. Third, the engineering cost of facilities under construction is also included in the investment amount for the year. This is because the focus of the research is how the public sector should allocate total investment resources between private capital and social overhead capital, rather than whether these projects have been completed (Young Sung Lee, 2012).

The output of each region required in equation (1) uses the GRDP amount of each province (GRDP reduction), and the labor input selects the total number of employed populations in each province. Convert equation (1) to statistical estimation equation (7), where i is the region, t is time, and k is the subscript of the independent variable and its coefficient (Young Sung Lee 2012).

$$y_{it} = \sum_{k=1}^{p} X_{itk}\beta_k + u_{it} \quad (7)$$

The advantage of the panel model is that time series data and cross-sectional data can be used at the same time, but the autocorrelation of time series data and the heteroscedasticity of

cross-sectional data need to be noted, and they can appear at the same time. Young Sung Lee's (2012) research found that the regional GDP (GRDP), the number of employees and the capital stock in the region have a strong autocorrelation. Therefore, Young Sung Lee (2012) has also dealt with some of these problems (for details, refer to Young Sung Lee, 2012), and after formula (8) is obtained, the model calculation is performed.

$$y_{it}^{*} = \sum_{k=1}^{p} X_{itk}^{*}\beta_k + u_{it}^{*} \quad (8)$$
$$(y_{it}^{*} = y_{it} - \hat{p}_i y_{it-1}, X_{itk}^{*} = X_{itk} - \hat{p}_i X_{it-1k})$$

This study will refer to the model of Aschauer (2000) and Young Sung Lee (2012). First, we will look for reliable data on social overhead capital stocks and private capital stocks, and then use these data to calculate formula (1) and find ⌀^max in formula (6) (private when the long-term economic growth rate is maximized The ratio of capital stock to social overhead capital stock), combined with the ratio of the province's infrastructure stock to the private capital stock for a comprehensive investigation.
In terms of the scope of the data, this research will sort out the panel data of infrastructure capital stock and residential capital stock according to China's 31 provinces (municipalities and autonomous regions). And the time range of the panel data is from 1997 to 2019 (for details, please refer to the data section below).

Chapter 2. Research process

2.1. Data selection

In order to calculate the economic output in equation (1), firstly, regional GDP data and employment population data are needed. These data are available from the National Bureau of Statistics of China.

Next, this research needs data on social overhead capital stock and private capital stock. Aschauer (1989) used a set of complete data on the capital stock of US public infrastructure provided by the Bureau of Economic Analysis (BEA) of the US Department of Commerce. Kamps (2006) used the perpetual inventory method to estimate the public capital stock data of OECD countries from 1960 to 2001. Since government investment in OECD countries is mainly in the field of infrastructure, this set of data can be regarded as the public infrastructure capital stock data of OECD countries. However, China lacks a complete set of infrastructure capital stock data (provided by the government). Therefore, the existing research on China's infrastructure and economic growth can only adopt certain alternatives, and therefore there are some shortcomings, mainly In the following three aspects:

(1) Use physical infrastructure or usage indicators as indicators to measure infrastructure

(2) Use the current year's infrastructure investment (flow) indicators

(3) Using the infrastructure capital stock index calculated by the researcher

Jin Ge (2012) made a detailed estimation of the capital stock of economic infrastructure in the country and various regions, and provided a relatively complete set of data on the capital stock of economic infrastructure, which made up for the above-mentioned research flaws to a certain extent. However, Jin Ge (2012) only

provided data on the capital stock of economic infrastructure, but did not provide data on the capital stock of social infrastructure (intangible infrastructure such as health, culture, and education, which is also an important part of social overhead capital). According to the authoritative definition of World Bank (1994), all infrastructure includes economic infrastructure and social infrastructure. If the latter is ignored, it is still difficult for researchers to make more accurate estimates of infrastructure and private capital stock. Then it is impossible to make a more accurate evaluation of the economic effects of the two.

In view of the above-mentioned problems of Jin Ge (2012), Jin Ge (2016) has a detailed analysis of the economic infrastructure, social infrastructure and non-infrastructure capital stocks at the national level (1981-2015) and 31 provincial administrative regions (1997-2015). A complete and detailed re-estimation was performed. Jin Ge (2016) uses the Perpetual Inventory Method (PIM) commonly used by domestic and foreign researchers to separately measure the time series data of economic infrastructure capital, social infrastructure capital, and non-infrastructure capital stock. The calculation formula is:

$$K_{jt+1} = K_{jt}(1 - \delta_j) + I_{jt} \quad (9)$$

Among them, the subscript t represents time, and the superscript j represents the type of capital (respectively three types of economic, social and non-infrastructure capital); Kjt represents the capital stock of the j capital type at the beginning of year t (ie t - 1 year-end capital stock); Ijt represents the investment flow of the j capital type in year t; δj represents the economic depreciation rate of the j capital type, and assumes that the depreciation rate does not change over time.

Jin Ge (2016) divides the total fixed capital of the whole society into infrastructure capital and non-infrastructure capital; among them, infrastructure capital is further divided into economic infrastructure capital and social infrastructure capital. This part can be considered as public capital stock. That is, the stock of social overhead capital. In terms of the statistical scope of economic,

social infrastructure and non-infrastructure investment, Jin Ge (2016) combined the historical "China Fixed Assets Investment Statistical Yearbook" (including "China Fixed Assets Investment Statistics 1950-2000") on fixed asset investment Industry classification defines the statistical scope of fixed asset investment in economic infrastructure as the entire society's use of "electricity, gas and water production and supply", "geological survey, water conservancy management" and "transportation, storage, post and telecommunications" Industry" (2002 and previous years), or "electricity, gas and water production and supply industry", "transportation, storage and post industry", "information transmission, computer service and software industry" and "water conservancy , Environment and public facilities management industry" four industries (2003 and later years) fixed asset investment.

Regarding asset depreciation rates, Jin Ge (2016) referred to Zhang Jun et al.'s (2004) assumptions about the useful life of different types of capital economy and the estimated results of corresponding depreciation rates, using the urban fixed asset investment provided by the "Statistical Yearbook of Fixed Asset Investment in China" over the years. According to the data of different industries and economic types, the average proportions of three different types of investment, namely "construction", "equipment" and "other expenses" in the economic, social infrastructure and non-infrastructure investment from 2003 to 2011, were calculated, and then weighted On average, the comprehensive depreciation rate of economic, social infrastructure and non-infrastructure capital is calculated, and the calculation base year is 1997. Based on the above calculation methods and basis, Jin Ge (2016) estimated the economic, social infrastructure and non-infrastructure capital stock data of 31 provinces (municipalities) across the country from 1997 to 2015. This is the key data cited in this study. . The specific estimation results are shown in Table (1)

According to relevant existing research, how to decompose capital is a difficult problem, that is, how to determine the boundary

between public capital stock and private capital stock and what should be included. According to the context of the existing literature review and related academic definitions, the boundary of public capital stock is relatively clear, that is, social overhead capital, and strictly speaking, it includes not only tangible infrastructure, but also intangible health care, education, etc. Of capital stock. However, the research on private capital stock is relatively rough. Generally, the fixed asset investment capital construction expenditure in the budget is used as a representative of public capital, and the rest is used as private capital (Zhang Yong, 2010). In Chen Zhiguo's (2015) study, a similar approach was adopted, that is, the stock of fixed assets in the whole society was subtracted from public capital, and the difference obtained was regarded as private capital.

Jin Ge (2016) not only estimated public capital stock (infrastructure capital stock), but also estimated the stock of social assets. According to the above relationship, we can easily obtain the private capital stock. Since these data are all calculated by Jin Ge alone, they are consistent and stable in the choice of statistical caliber and the selection of correlation coefficients such as depreciation rate. Therefore, we believe that both of them adopt Jin Ge (2016) estimated data to have higher reliability. Secondly, Jin Ge (2016) calculated the social infrastructure together on the basis of the economic infrastructure, which fully covers the types of assets that the infrastructure (social overhead capital) should include. The data is more accurate, and the resulting private capital The stock is also more reliable than the data obtained through other channels, which is also an important reason why Jin Ge (2016) is selected for this study.

The data on the stock of social capital obtained in this study is obtained by subtracting the stock of public capital from the stock of fixed capital in the whole society, and is not obtained by adding up relevant survey data. Therefore, it is necessary to make a clear division of which parts of the private capital stock are mainly included. Because if we do not understand the components of social

private capital, it will be difficult to analyze and judge the economic significance of these capital types in more detail, and it will be impossible to comprehensively analyze how infrastructure and social private capital stock interact.

First, the stock of social private capital is composed of the private property and capital of all citizens in society. According to Article 92 of the Criminal Law of the People's Republic of China on the scope of citizens' private property, citizens' private property includes:

(1) Citizens' legal income, savings, housing and other means of living;

In detail, "legal income" refers to individual citizens' wages, labor income, and various other incomes obtained in accordance with the law, such as property obtained by accepting inheritance and gifts. "Savings" refers to citizens depositing their legal beneficiaries in banks, credit unions and the interest they receive. "House" refers to a residence privately owned by citizens. "Other means of living" mainly refers to the various daily necessities of citizens, such as furniture and transportation.

(2) Production materials owned by individuals and families in accordance with the law;

In detail, this item includes various labor tools and labor objects, such as tractors, rice transplants and other machinery and equipment, cultivated crops, livestock used for farming, poultry and livestock raised, self-planted trees and other production Raw materials, etc.

(3) The legal property of self-employed and private enterprises;

Self-employed households are individuals or families as their production units and engage in commodity operations in accordance with regulations, and their legal property belongs to the individual or family in accordance with the law. The "Private Enterprise Regulations" stipulates: "Private enterprise refers to a for-profit

economic organization that has privately owned assets and employs more than eight people." It includes four categories: (1) Sole proprietorship refers to an enterprise that is exclusively invested and operated; (2)) A partnership enterprise refers to an enterprise in which two or more people invest, operate jointly, and share profits and losses in accordance with an agreement; (3) A limited liability company refers to a number of individual investors who are responsible to the company with their capital contributions, and the company uses all its assets to owe the company's debts Responsible company; (4) A company limited by shares refers to an enterprise that is funded by a number of individuals in accordance with the law, and the company is liable for the company's debts with all its assets. The legal property of a private enterprise should belong to the investor or controlling shareholder.

(4) Shares, stocks, bonds and other property owned by individuals in accordance with the law.

In detail, "individually owned shares" refers to shares subscribed by citizens with their own capital. The shares subscribed by citizens with their own capital are personal property. "Stocks" refer to securities issued by joint stock limited companies in accordance with the law that indicate the rights of shareholders. "Bonds" are marketable securities issued by the state or enterprises in accordance with the law and agreed to repay the principal and interest to the holders when they expire. "Individually owned stocks and bonds" refer to stocks and bonds that are purchased by citizens and issued to the public in accordance with the law. Stocks and bonds that are legally purchased by citizens or obtained legally through inheritance, gifts, etc., are also privately owned properties of citizens.

Through the above analysis, we can already know what kind of property is included in the components of social private capital. The above parts can be distinguished according to tangible fixed assets and intangible assets. Among them, citizens' legal income, savings, houses and other means of living are the production materials

owned by individuals and families according to law, and the legal property of self-employed individuals and private enterprises is tangible assets. Shares, stocks, bonds and other property owned by individuals are intangible assets. The inventory of tangible fixed assets can be calculated using the Perpetual Inventory Method (PIM), and the results are as calculated by Jin Ge (2016) cited in this paper. The calculation of intangible capital is more tricky. Therefore, when studying such issues, it has become a tradition in the academic world to focus on tangible assets. For example, Young Sung Lee (2012) only focused on tangible fixation in the study of Korean SOC economic efficiency. The asset part finally achieved reasonable results. Moreover, Jin Ge (2016) cited in this research is all fixed assets. Therefore, in this research, there will be no more discussion on intangible assets.

Then, by dividing whether the assets belong to tangible fixed assets, and combining the definition of the above types of social private capital, we can see that the tangible fixed social private capital stock includes residential or other houses owned by individuals or families, fixed assets of self-employed and private enterprises, As well as labor tools, automobiles and other transportation tools required for production activities. Referring to Young Sung Lee's (2012) research on South Korea, the social private capital stock data he collected mainly include residential capital stock, capital stock of manufacturing factories, and construction capital stock of office buildings, shopping malls, etc. Because the statistical caliber of the country's data is different, it may lead to different titles of the same essential data. Here, we need to carefully judge whether the asset type obtained by the above decomposition process is reasonable.

In detail, the first is the residential assets held by individuals or families. Can the housing capital stock be regarded as a factor in regional economic production activities? On this issue, industry association analysis provides important clues. The "closed model" widely used in regional economics regards the household sector as an independent industry that earns income at the cost of production

and supply of labor, and maintains and supplies labor with income consumption. In the United States, the household sector accounts for more than 70% of the entire economy. The family sector also accounts for a large proportion of the Chinese economy, so if the family sector is excluded, regional economic trends may be distorted. And in the household sector, the core capital item that supplies labor is housing, and this is particularly prominent in China. According to the "2018 China Urban Family Wealth and Health Report" (2018), the proportion of residential assets in total household assets in China is as high as 77.7 %, residential assets have become a pillar asset category for Chinese families. Therefore, in this study, it is a reasonable choice to include residential capital stock in the calculation of private capital stock.

Next are the fixed assets of self-employed and private enterprises, as well as the labor tools and vehicles needed for production activities. Combining with the reality of life, we can know that the core parts of the fixed assets of self-employed and private enterprises are the factories, machinery used in production, automobiles and other assets of various production enterprises. In addition, it also includes the shopping malls and stores owned and operated by individual or private enterprises. Office buildings, etc. According to Young Sung Lee's research, these types of capital can correspond to the fixed assets of manufacturing factories, office buildings, shopping malls, and other construction capital stocks he said. Therefore, through the above process to divide and understand the components of private capital, we can think that although the social private capital stock data used in this study is obtained in a rough but relatively common way, the data obtained can be Think it is reasonable.

2.2. Calculation results

According to the GDP data and employment population data

published by China's national statistical agency, using SPSS software and the previously cited statistical models from Aschauer (2000) and Young Sung Lee (2012), the results are as follows.

Variable	Average	SD	Minimum	Maximum
Number of employees (10,000)	73228	5944	65254	82791
GRDP	29398	14678	11416	57374
SOC	15723	11161	3359	42640
Private capital stock	36259	27730	10058	105556

(Unit: $100 million)

Chart 1. Statistical results

The final statistical results are briefly introduced. The coefficient of per capita private capital stock and per capita SOC are 0.385 and 0.242 respectively. Through the above formula, we can know that the optimal ratio of social private capital stock to SOC in China from 1997 to 2015 should be 0.421. Using this result to make a conclusion analysis, if the ratio of a certain region in a certain year is greater than 0.421, SOC capital stock is surplus, and negative infrastructure investment strategy should be adopted. If the ratio is equal to 0.421, the SOC capital stock is in good condition. If the ratio is less than 0.421, it indicates that the SOC capital stock is insufficient, so the region should increase SOC investment.

Variable	Coefficient value
Interceptions	1.996 (<0.001)
ln (private capital stock per employee)	0.385 (<0.001)
ln (social overhead capital stock per employee)	0.242 (<0.001)
R2	0.936
$\emptyset^{max}$ (Desirable ratio of social overhead capital stock to private capital stock)	0.421

Chart 2. Regression analysis

Chapter 3. Research result

3.1. Result Explanation

This research is different from the previous method of calculating output elasticity to evaluate economic efficiency. This research uses the comparison of social overhead capital stock and private capital stock to evaluate social overhead capital stock. This is a process of drawing conclusions through dynamic fluctuations and comparison between the two. Even if the final conclusion is the lack of social overhead capital, it is not an absolute shortage, but whether it is a shortage compared with the state of private capital. Therefore, before adopting the final chart analysis, it is necessary to once again deeply understand and discuss the nature of social public capital and social private capital, because if you do not know the true nature of these two types of capital, you will not be able to understand their mutual relationship in the whole society. The process of action, which will make the conclusions of this study not thorough enough, nor can it fully understand the economic development characteristics of the changes in the ratio of social public capital stock and social private capital stock in different regions in different years (hereinafter referred to as the "ratio"). Next, by analyzing the economic characteristics of these two types of capital, combined with temporal changes, we will provide a "thinking template" for understanding the changes in the ratio of the two dimensions of time and space.

As mentioned, many times in the previous article, although social overhead capital stock, infrastructure stock, and social public capital stock are three different names, the core of the three is mainly tangible social infrastructure such as roads, ports, water and sewage. The reason why people use the term "infrastructure" more often is because this type of capital is a prerequisite for urban and regional economic development and the "foundation" of local social progress. Therefore, for the convenience of dissemination and

understanding, people often use " "Infrastructure". It is precisely because of the important position that this type of investment occupies in the process of regional economic development, so usually this type of capital is the investment that the government needs to consider and implement in advance. If it is assumed that a piece of land does not originally contain any property or capital, and the government wants to carry out construction and development activities on this piece of land, usually from the perspective of investment order and time point, such infrastructure will be invested and constructed first. Or compared with other types of capital such as factories, office buildings, etc., it will not lag far behind, otherwise the regional economy will not be able to maintain healthy development. Secondly, combined with the history of urban planning and construction, infrastructure is usually invested by the national government, which is one of the reasons why infrastructure capital is public capital. Although in recent years, countries in the world, including China, have been working hard to promote innovative infrastructure investment and construction such as the PPP model, and continue to encourage private capital to join infrastructure investment, but due to the obvious public and capital-heavy nature of the infrastructure itself Characteristics: Government fiscal expenditure is still the most important force in infrastructure investment, that is, infrastructure investment is still dominated by the government, and the main investor can be regarded as the government.

Next, analyze social private capital. From the above division of private capital stock. Private capital stock mainly includes residential or other houses owned by individuals or families, fixed assets of self-employed individuals and private enterprises, as well as labor and transportation required for production activities. Generally speaking, when the overall economic development momentum of a certain area is upward, economic progress is rapid, production and commercial activities are active, and there are many production enterprises, then the personal wealth of residents in the area is more likely to be rapidly increased and accumulated, that is,

private Capital stock can accelerate growth. Conversely, if the regional economic development declines or there is insufficient motivation, the growth of private capital stock will be slower or even decline. Therefore, it can be seen from these asset types that in addition to reflecting the personal wealth of residents in the region, the rate of growth of private capital can also reflect the vitality of regional economic development.

In urban and regional economics, many variables interact with each other and change together. According to various production function theories and traditional cognitions widely used in economics, the growth of regional economy is closely related to production factors such as capital, labor, technology, and land. According to the theory of agglomeration economy in urban economics, when these basic production factors are agglomerated, regional economic growth is usually active. In detail, when the investment in a certain area increases, and the labor force with skills and talents and entrepreneurs and other human resources gather, the regional economy can be more dynamic. Of course, if you want to make these production factors gather or circulate freely, while temporarily eliminating the influence of policies and other human factors, just from the regional hardware configuration, a good infrastructure must be the prerequisite and the first determining factor.

In summary, infrastructure investment is usually at the forefront in the process of promoting regional economic development, and so far, in most cities and regions, especially in China, the government is still the main investor. The growth of social private capital is based on the conditions of healthy economic development and capital accumulation in the region. Therefore, compared with the front-end infrastructure investment and stock growth in a certain region's economic development, the growth of social private capital in this region will be in a slightly lagging position. It can be said that the accumulation of infrastructure in the early stage will become the "key" that triggers the increase of social private capital in the future. It is precisely because of the slight difference in the time of

occurrence of the two that when judging the economic efficiency of social overhead capital by studying the changes in the ratio of the two, data with longer time series is more conducive to observing more results. This study uses time panel data from 1997 to 2015 for a total of 19 years, which is the longest time series involved in previous related studies, which is also one of the important significances of this study.

Aschauer (2000) believes that regional economic growth comes from two aspects: economic growth caused by the investment of social overhead capital and economic growth caused by the investment of private capital. These two types of capital investment and stock are an interactive and dynamic relationship that fluctuates in real time, and they work together on the overall growth of the regional economy. In the long-term fluctuations, by bringing national data into formula (1), the economic growth rate that maximizes the utility of representing consumers can be obtained, then the ratio of the stock of social overhead capital to the stock of private capital at this time can be seen It is the ideal ratio of the two within a certain corresponding period of time and a certain geographic range. The next analysis will start from here, comparing the difference between the ratios of China's provinces and the optimal ratio from the two dimensions of time and space, and analyze the calculation results. At the same time, Young Sung Lee (2012) has also used this model to analyze the social overhead capital in South Korea, and finally compares the results of China and South Korea to find similarities and differences.

3.2. National analysis

The time range of the panel data used in this study is from 1997 to 2015. Compared with previous researchers, there have been great breakthroughs and extensions in the time series. This helps us

understand and extend the time series from a longer time frame. Study the changes in the economic efficiency of China's SOC capital. In order to more intuitively see the changes in the ratio of the social overhead capital stock to the social private capital stock in different years in various provinces, a 3D method is used to draw the map, and the result is shown in Figure (1).

By observing Figure (1), we can clearly see the changing trend of the ratio between the social overhead capital stock and the social private capital stock (hereinafter referred to as the "ratio") of all provinces and regions in China. By observing the change of color visually, we can divide the change trend of color into three stages, namely:

The first stage: from 1997 to 2005, the ratio of China's provinces gradually increased, and social overhead capital turned from insufficient to surplus.

As shown in Figure (1), from 1997 to 2005, the ratios of all provinces in China have almost the same trend of change, all of which are rising. Combining the analysis of the meaning represented by the comparison value in the previous article, that is, between 1997 and 2005, the social overhead capital stock of China's provinces increased more than that of private capital. According to the statistical model calculation, the optimal ratio of China is 0.4222. Comparing this ratio, it can be found that in 1996, the ratio of most provinces in the country was less than 0.4222, that is, the social overhead capital stock was insufficient. In the last year of this stage, that is, in 2006, the ratio of most provinces in the country was greater than 0.4222, that is, the social overhead capital stock is sufficient and there is some surplus.

The second stage: from 2006 to 2009, the changes in the ratio of China's provinces tend to be flat, and social overhead capital is surplus.

As shown in Figure (1), from 2006 to 2009, the ratio of China's

provinces changed from a gradual increase in 1997 to 2005 to a flat or even a slight decline. This is an important turning point in the changing trend of the ratio, which means that the increase in the stock of social overhead capital in China's provinces is equal to the increase in the stock of social private capital. In the previous article, the characteristics of social overhead capital and social private capital investment and accumulation are that the accumulation of infrastructure in the early stage will become the "key" that triggers the increase of social private capital in the future, compared with the front-end infrastructure in the economic development of a certain region With the growth of investment and stock, the growth of social private capital in the region will lag behind. Therefore, it can be considered that between 1997 and 2005, the social overhead capital stock of China's provinces has been rapidly invested and accumulated, even to a slight surplus, but the infrastructure investment at this stage has begun to stimulate the regional economy from 2006 to 2009 The role of growth is that between 2006 and 2009, the stock of social private capital experienced rapid growth. In terms of ratio, during this period, the growth of social private capital stock closely followed the growth of social overhead capital stock, and the gap between the two did not continue to widen as it did during 1997-2005. However, comparing the optimal ratio of 0.4222, it can be found that with the exception of a few regions (such as Liaoning and Shanghai), during this period, the stock of social overhead capital in most provinces in China was still in excess.

The third stage: From 2010 to 2015, the ratio of China's provinces gradually declines, and social overhead capital turns from surplus to insufficient.

As shown in Figure (1), from 2010 to 2015, the ratio of most provinces in China began to drop significantly. This study is affected by the scope of the data. The situation after 2015 is temporarily unknown, but looking at the chart, we can It is found that almost no provinces show a trend of recovery, so we tend to

think that the trend of changes in the ratio after 2015 is also gradually decreasing. Combining the analysis of the previous two stages, we can think that based on the sufficient or surplus infrastructure capital stock before 2010, China's social private capital stock has experienced rapid growth since 2010, and the ratio has changed. It can be seen that the growth rate is far greater than that of the social overhead capital stock. Based on the previous analysis, we already know that the growth of social private capital stock means the accumulation of capital, labor and other factors of production and the improvement of social productivity. It also means that the economy of the provinces across the country has developed faster during this period. Comparing with the optimal ratio of 0.4222, it can be found that after several years of rapid economic development and an increase in private capital stock, as of 2015, most provinces in China have had their social overhead capital stock changed from surplus to insufficient.

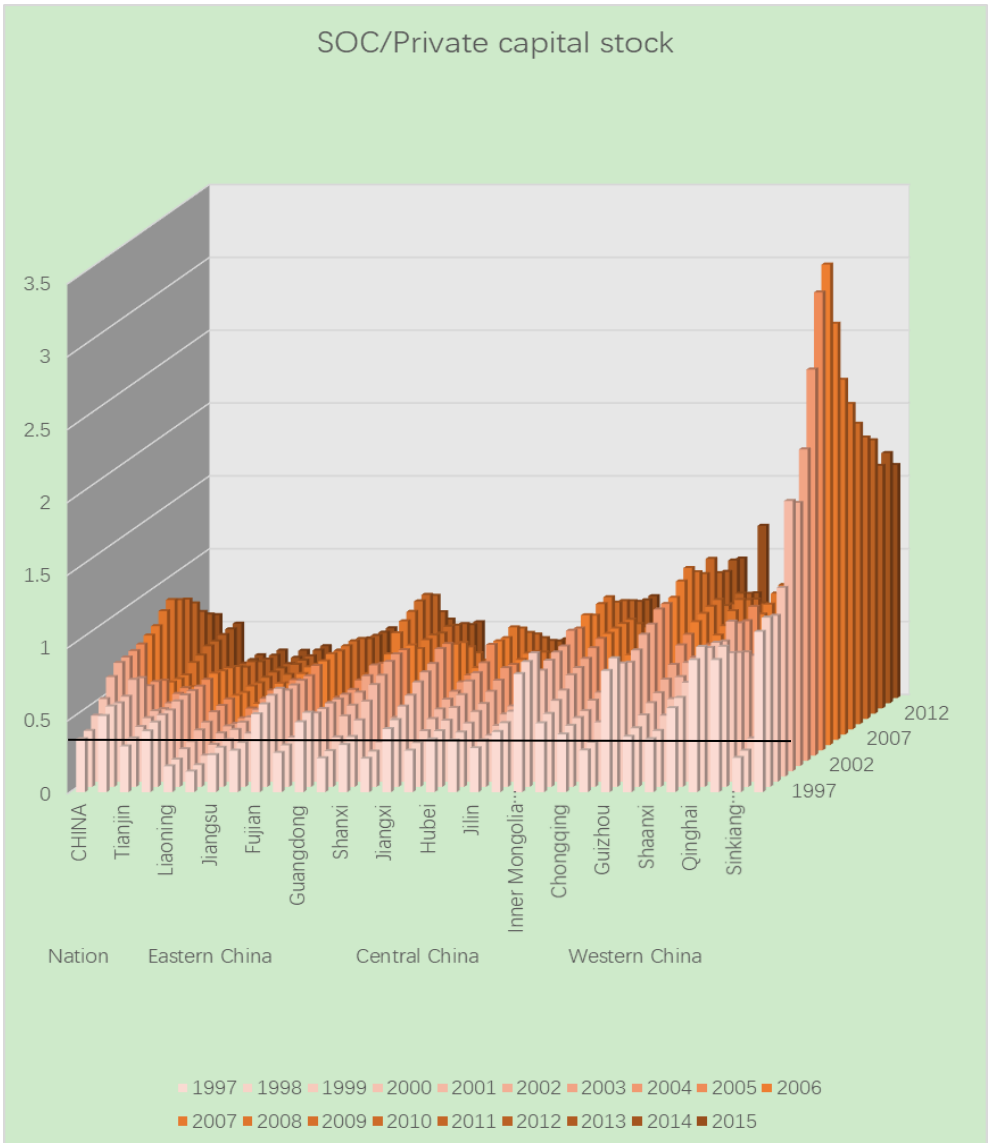

Figure 1 SOC/Private capital stock(3D)

Figure (2) shows the total GDP of China from 1997 to 2019. According to the aforementioned three phases with 2006 and 2009 as the time nodes, it can be observed that the growth of GDP can be roughly divided into three phases. In contrast to the changes in the total GDP, the changes in the ratios of the above three stages are summarized:

The first stage: from 1997 to 2005, the ratio of China's provinces gradually increased, and social overhead capital turned from insufficient to surplus. It can be considered that China was in the

stage of infrastructure accumulation during this period. In terms of the amount of GDP in the region, the growth was relatively small, and the economic vitality was not released in a large amount compared with the later period.

The second stage: from 2006 to 2009, the changes in the ratio of China's provinces tended to be flat, and the growth of social private capital stock and social overhead capital stock was about the same, and there was no significant change. Comparing Figure (2), we can find that the GDP growth has become larger.

The third stage: From 2010 to 2015, the ratio of China's provinces gradually decreases, and the growth of social private capital stock is greater than that of social overhead capital stock. Comparing the graph of changes in the total GDP, we can clearly see that the economy developed rapidly during this period, and the growth of the total GDP was greater than the previous two stages. Regarding the situation after 2015, due to the lack of data after 2015 in this study, after observing the growth of the total GDP after 2015, it can be considered that after 2015, GDP has continued to grow rapidly, and the stock of social private capital has The growth rate should be greater than the growth rate of social overhead capital stock, that is, the ratio of the two continues to decrease, and social overhead capital is insufficient.

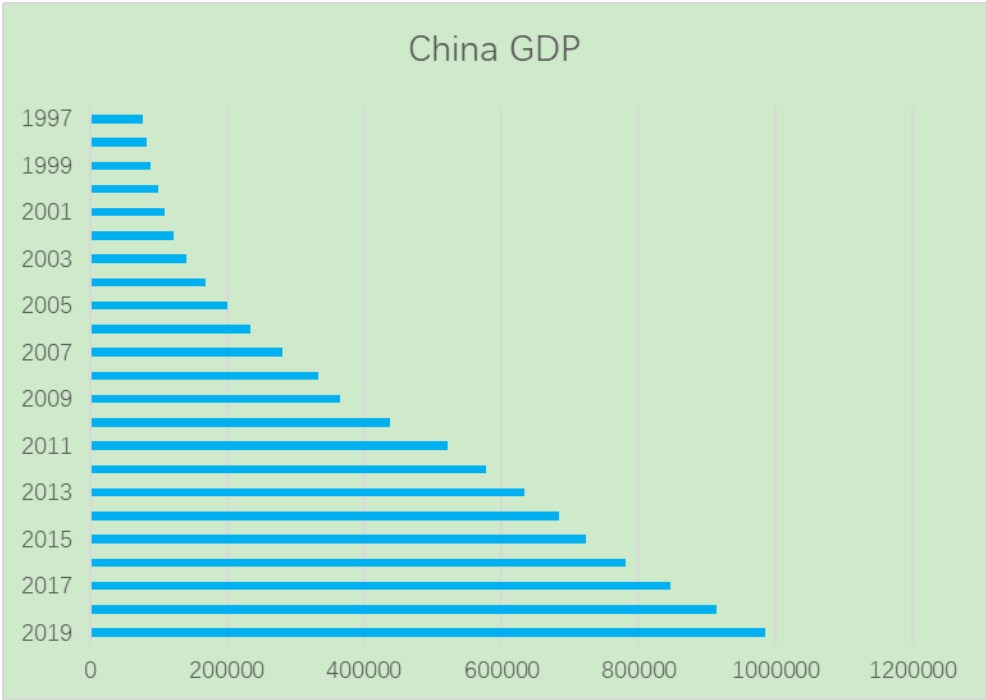

Figure 2 China GDP (1997~2019)

3.3. Regional Analysis

The previous article introduced the changes of the national unit ratio over time. But at present, China is a country with uneven development, with obvious differences in economic development and social living standards among different regions and provinces. In-depth understanding and exploration of the changes in social overhead capital and social private capital in various provinces in China from 1997 to 2015 will help us understand the economic development and future trends of each province, and achieve more accurate and efficient investment in infrastructure. Therefore, in this study, the data of all provinces and all years are shown in the graph in 2D, and the results are shown in Figure (3).

According to the definition of the National Bureau of Statistics, China is divided into 23 provinces, 5 autonomous regions (Inner Mongolia, Guangxi, Tibet, Ningxia, Xinjiang), 4 municipalities (Beijing, Tianjin, Shanghai, Chongqing) and 2 special administrative

regions (Hong Kong and Macao). Individual analysis of all provinces in turn, although we can understand the changes in each province from a more specific perspective, we will not do this in the following analysis. The main reasons are as follows. First of all, China has a vast land area and many provinces. If all of them are analyzed separately, more space is required. Secondly, different provinces in China are located in different regions in space, and the geographical conditions of different regions are important decisive factors for the development level of social economy and other aspects. Therefore, it can be understood that, in many cases, the social development levels of provinces in similar regions and geographical conditions are also similar. Such thinking is also in line with the common understanding of many scholars on the development of various regions in China. Therefore, in combination with the above reasons, this study will try to find a way to divide China's many provinces spatially, and then conduct classification research. This not only makes the analysis process more efficient, but also helps to judge changes at a national level.

Figure 3 Regional division of China

China is divided into 23 provinces, 5 autonomous regions (Inner Mongolia, Guangxi, Tibet, Ningxia, Xinjiang), 4 municipalities (Beijing, Tianjin, Shanghai, Chongqing) and 2 special administrative regions (Hong Kong, Macau) in terms of administrative divisions. In order to better carry out regional coordination and management, both the government and the private sector have carried out various regional divisions and divisions of China. However, due to different starting points, the classification methods are also different. Among them, the more common ones are as follows: According to China's physical geography, China is divided into seven regions: East China, North China, Central China, South China, Southwest, Northwest, and Northeast China; According to economic policies, China is divided into four regions: East, Central, West and Northeast Regional, there are other regional division methods such as defense-based theater division. After selection, according to the definition of the National Bureau of Statistics of China , this study divides mainland China into eastern, central and western regions by geographical area. As shown in Figure (3), the eastern region of China includes 11 provinces (municipalities): Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan. The central region includes 8 provinces: Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan. The western region includes 12 provinces (autonomous regions and municipalities): Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang.

Following this regional division method, Figure (4) has divided the data of all provinces into national, eastern, central, and western regions. This figure can not only observe and compare the similarities and differences of the changes in the ratio of each province, but also can be divided into different regions. Understand the changes in the country at a macro level. Next, we will use the area as the scale to observe the graphs, compare them with each other, and analyze the graph changes and the situation reflected by the time series changes.

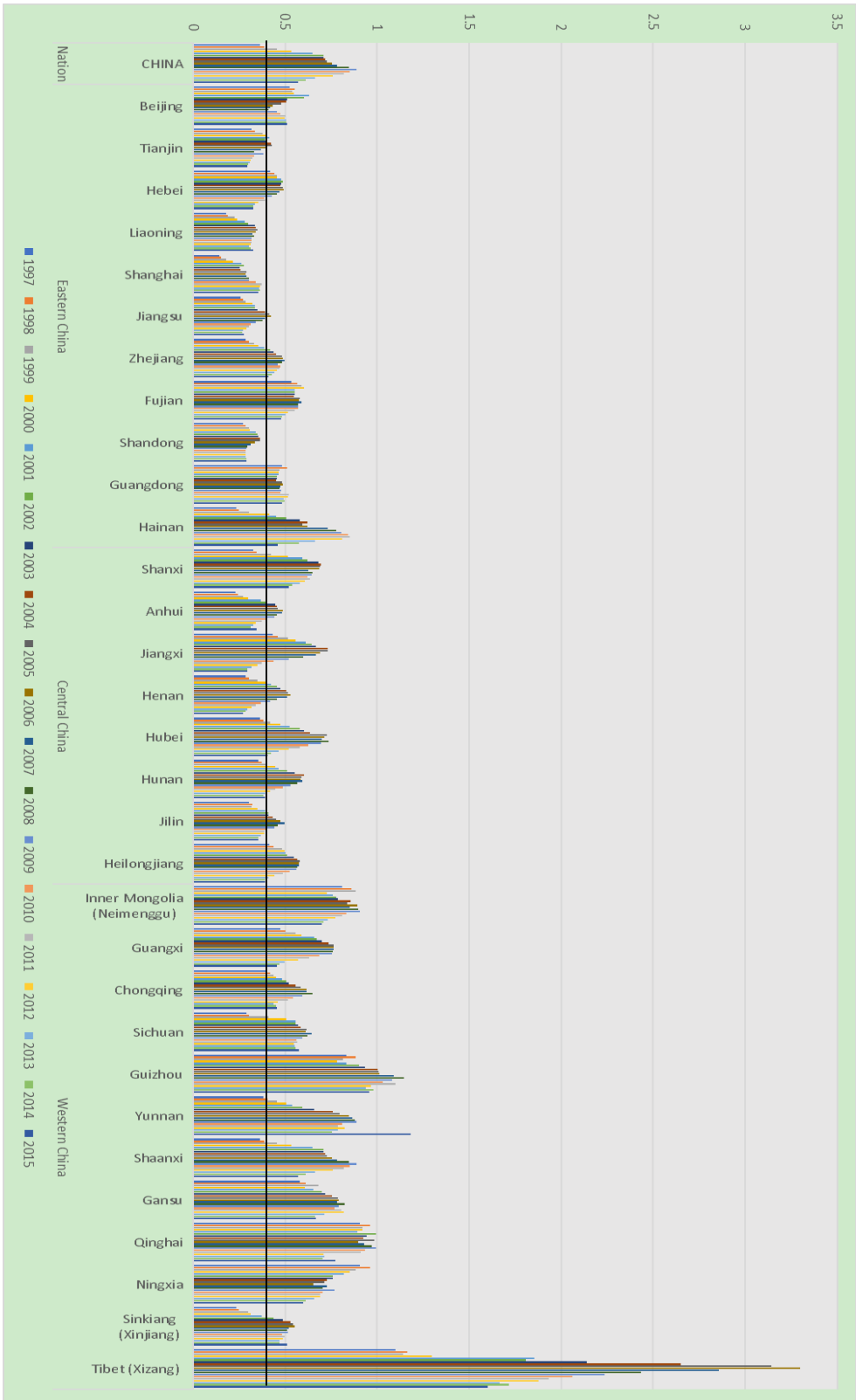

Figure 4 SOC/Private capital stock(2D)

East: insufficient infrastructure

Eastern China includes 11 provinces (municipalities directly under the Central Government): Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan. Due to the distribution of many important ports in the coastal area, dense population and good geographical conditions, and in line with the country's policy of giving priority to the development of the east, since the reform and opening up, the east has become the most economically developed region in China. Not only the most economically developed cities in China such as Beijing, Shanghai, Guangdong and Shenzhen belong to the eastern region, but also the richest provinces in China such as Zhejiang and Jiangsu. Comparing the overall height of the graphs of the provinces, except for Hainan, which is slightly higher, the ratios of the provinces in the eastern region on the overall timeline are mostly slightly lower than the optimal ratio. As of 2015, the ratio of most provinces in the east was less than the optimal ratio of 0.4222. From the perspective of the fluctuation range of the graph, compared with the central and western regions, the fluctuation range of the ratio of the eastern provinces from 1997 to 2015 is not too large.

After observing the changes in the above graphic patterns, we can judge the comparison of the social overhead capital stock and the social private capital stock of the provinces in the eastern region from 1997 to 2015. First, considering the temporal sequence of changes in social overhead capital stock and the increase in social private capital stock mentioned above, it can be known that the increase in social overhead capital stock in the eastern region after 2006 is less than the increase in social private capital stock. Secondly, although the ratio of the eastern provinces has shown a shape of rising first and then flat or falling, overall, the infrastructure of the eastern provinces is currently in a state of insufficient.

Central: insufficient infrastructure

The central region includes 8 provinces: Shanxi, Jilin, Heilongjiang,

Anhui, Jiangxi, Henan, Hubei and Hunan. The economic development level of the central region is in the middle position compared with the western and eastern regions. Observing the shape of the graphics in the central provinces, we can find that the shape of the graphics has changed dramatically since 2004, that is, the ratio has changed from increasing to decreasing. On the whole, the "inverted V" shape presented by the ratios of the central provinces is more obvious, that is, the peak is higher and the slopes on both sides are larger. From the perspective of the internal situation of the central region, the changes in the provinces are almost the same. That is, the ratio of each province continued to rise from 1997 to 2005, and the ratio of each province continued to decline from 2005 to 2015. Comparing the optimal ratio line, it can be observed that the ratio of the provinces in central China reached a peak in 2005, and was significantly greater than 0.4222, and then gradually decreased. By 2015, the ratio of the provinces in the central region was already lower than the optimal ratio or the same as the optimal ratio.

It can be seen from the above graph that the social overhead capital stock in Central China has gone through three stages of "insufficient-surplus-insufficient" between 1007 and 2015. Around 2004 and 2006 are the turning points of changes. In March 2004, the Chinese government proposed The Rise of Central China (The Rise of Central China) strategy, which is a policy of China to promote the common development of the six central provinces. The goal is to build the central region into an important national advanced manufacturing center and a new type of urbanization in the country. Key areas, core areas for the development of modern agriculture in the country, demonstration areas for the construction of national ecological civilization, and important support areas for all-round opening up are major decisions and deployments made by the Chinese government. Since 2004, the economic development of the central region has entered the "fast lane". The "Rise of Central China" policy has promoted the investment and accumulation of private social capital, promoted the flow of capital and other

production factors to the central region, and played an important role in the economic development of the central region. Of course, we cannot say here that the transition in the changes in the central region in 2004 was entirely caused by the policy, but judging from the time when the policy was promulgated and the time when the turning point appeared, the two seem to be related. This article only puts forward this view here, and the relationship between the specific policy and policy remains to be further studied in the future. Generally speaking, although the infrastructure in the central region was surplus from 2004 to 2006, after the rapid development thereafter, the current infrastructure in the central region is as inadequate as most regions in the east.

West: Infrastructure is currently surplus, but soon or will be insufficient

The western region includes 12 provinces (autonomous regions and municipalities): Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang. According to the National Bureau of Statistics, although the western region has the largest land area, compared with the eastern region, many economic and human development indicators in the western region are lower. This is due to various reasons such as local geographic conditions, historical evolution, and policy influences. Caused. From a graphical point of view, first, the ratios of the western provinces are significantly higher than the central and eastern provinces as a whole. Comparing the optimal ratio line, the ratio in the western region far exceeded 0.4222 almost all the time between 1997 and 2015. In terms of shape, the western region also presents an "inverted V" shape, but the year when the highest point appears is slightly behind the central and eastern regions. In terms of time series, from 1997 to 2009, the ratio continued to rise. Many provinces reached the highest peak in 2009, and then gradually declined from 2010, but the decline was slightly smaller than the central and eastern regions.

It can be seen from the graph of the western region that the ratio

has gradually declined since 2009. It can be considered that the growth rate of private capital stock in the western region has accelerated since 2009. From the perspective of the decline in the ratio, the decline in the western region is slightly smaller than that in the central region. This can be explained as a certain amount of total social capital stock, the proportion of social private capital stock in the central region has increased faster, that is, social and economic development is more active. Comparing the optimal ratio line, it can be judged that as of 2015, the overall infrastructure in the western region is still in excess. Tibet is particularly eye-catching. On the whole, its ratio is abnormally higher than that of other provinces. The highest peak is even more than three times the ratio of other provinces in the same period. This is affected by geographical conditions, national policies, population, national defense and security, etc. result. This means that the level of infrastructure in Tibet is seriously surplus compared to the national level.

In summary, the ratios of eastern, central, and western China all reached their maximum values around 2006-2009, and since then, almost all provinces have declined. So far, it can be known that compared with the rapid growth of private capital stock in society, the infrastructure stocks in the eastern and central regions are already facing insufficient, and the government can continue to increase investment in the public sector in the eastern and central regions. Although the infrastructure stock in the western region was in excess as of 2015, combined with the change trend in the later period, it may soon be faced with the problem of insufficient infrastructure in the future, and relevant departments should take timely measures.

3.4. Refer to South Korea

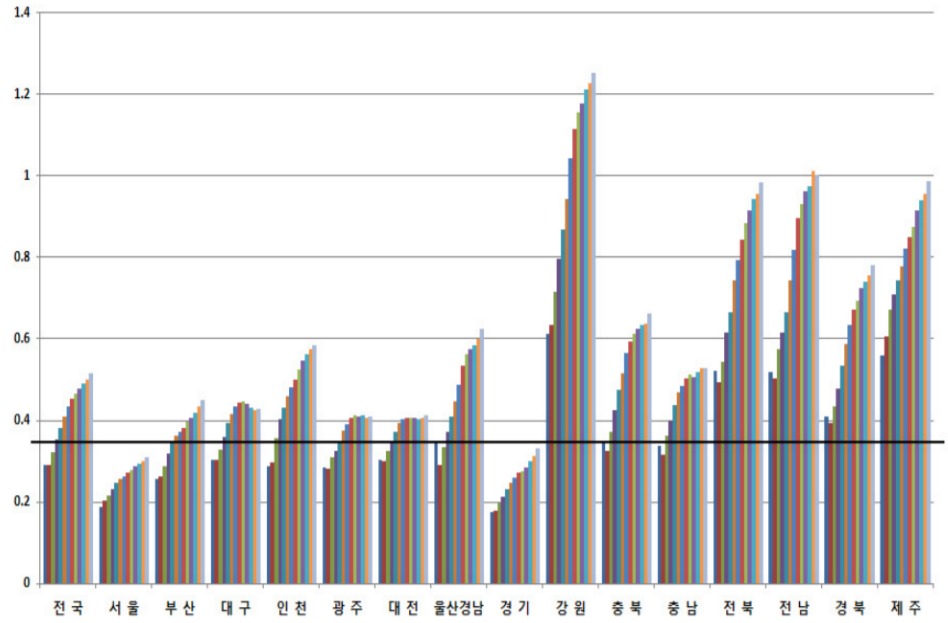

Figure 5 SOC/Private (S.Korea)

The research methods and statistical models used in this paper are based on the research results of Aschauer (2000) and Young Sung Lee (2012). In context, Aschauer (2000) first proposed the statistical model shown in formula (1), and Young Sung Lee (2012) improved the model of Aschauer (2000) to make it statistically significant. Next, referring to the change in the ratio of social overhead capital to social private capital in each region of South Korea produced by Young Sung Lee (2012), based on the above analysis of the changes in the ratio of each region in China, we will compare and discuss the differences between China and South Korea. Similarities and differences.

Figure (5) is the result of Young Sung Lee's (2012) study on South Korea. First of all, according to Young Sung Lee's (2012) interpretation of the graph, first, since 2000, South Korea's social overhead capital stock has exceeded the national average ideal level (ie the optimal ratio) proposed by Aschauer (2000). Since then, deviations from the ideal level have continued to occur. Second, from a regional perspective, there is a surplus of social overhead

capital in other regions outside the capital, and the more backward the place, the greater the excess. Third, although there are too many social overhead capital stocks in big cities, it is not so serious except for Incheon, and has always maintained a relatively stable level. And in Daegu and Gwangju, the excess of social overhead capital stock has eased in recent years. Fourth, Seoul and Gyeonggi Province are different from general expectations. Their social overhead capital stock is still insufficient. Although it has approached the ideal level in recent years, it is still insufficient. Generally speaking, the more economically backward areas are, the more surplus social overhead capital is. This implies that even if investment is made from the perspective of regional development, the material investment and other forms of flexible investment methods that have been so far must be considered in the future. In other words, although it is not visible right now, it should be invested in a way that can make a substantial contribution to regional economic development.

Observing the changes in various regions of South Korea as a whole, and comparing the changes in China, we can first find huge differences. That is, the stock of social overhead capital in most areas of China is in a state of insufficient, while the stock of social overhead capital in South Korea is in a state of surplus. At the national level, China's social overhead capital stock has undergone a phased transition of "deficiency-surplus-insufficient". In recent years, most regions have been in a state of inadequacy. This is due to the rapid economic development of China around 2009-2010, which has greatly increased the stock of private capital in society, which is more obvious than the increase in the stock of social overhead capital. In South Korea, since 2000, the stock of social overhead capital in most regions except Seoul and Gyeonggi Province has exceeded the ideal level, and the surplus has continued to deepen. This gap means that China's social overhead capital investment is still insufficient, and the pulling effect on economic development is still obvious. There is still a lot of room for growth in the private capital stock, the economic development

momentum remains, and the future can continue to increase infrastructure. Big investment. In most areas of South Korea, social overhead capital investment has been severely surplus, and the growth of private capital brought about by infrastructure investment has gradually weakened. To stimulate regional economic growth, other forms of flexible investment methods must be considered.

Observing the changes in each region of the two countries in detail, we can also find very significant similarities. In a nutshell, relative to the level of social private capital, the more economically developed a place is, the more its social overhead capital stock is insufficient, and the more economically backward a place, the more its social overhead capital stock is surplus. This phenomenon can be found in both China and South Korea. In China, the economically more developed southeast coastal provinces such as Jiangsu Province and Shanghai, the ratio of social overhead capital to social private capital is always lower than that of other regions in the same period, and even has been lower than the ideal level of the national unit, and the economically developed Even if the social overhead capital in the eastern provinces of China is higher than the ideal level, its surplus is lower than that of the central and western provinces in the same period. The western part of China is more backward than the central part, so in the western part, the gap is even more obvious. Such characteristics can also be found in Korea. In South Korea, the surplus of social overhead capital in other regions outside the capital region, such as Gangwon Province and Jeju, has continued to deepen. Although there are too many social overhead capitals in large cities, it is not so serious except for Incheon. Has maintained a relatively stable level. Especially in Daegu and Gwangju, the surplus of social overhead capital stock has eased in recent years. In Seoul and neighboring Gyeonggi Province, South Korea's most economically developed regions, the stock of social overhead capital is still insufficient. This can also reflect that the more economically backward a place is, the greater the excess of social overhead capital.

This common ground clearly shows the law of urban economic

development, that is, in a market economy, capital, labor and other factors of production prefer to gather in economically developed regions, so after a period of time, private capital in previously economically developed regions will naturally There will be more significant growth. Under such circumstances, compared with the rapid growth of private capital, the phenomenon of insufficient social overhead capital can be understood.

Chapter 4. Conclusion

4.1. Research review

Infrastructure is an important basis for regional economic development, which has become the consensus of all countries in the world. OECD countries and other developed countries have made a lot of exploration on the extent to which infrastructure can play an effective role in regional economic development. Scientific and accurate measurement results can play a vital role in reference to the government's investment in the public sector. The capital of whole society is limited, reasonable allocation and investment are the first step that drive regional economy development. However, currently there is no official statistical data in China, and in terms of methods, most traditional methods are used to measure the output elasticity of infrastructure to judge the effect of infrastructure on economic stimulation. The results obtained vary greatly with the different time sequence length and data, which makes people feel confused and unclear.

Therefore, this paper referred to Aschauer(2000) and Young Sung Lee (2012) and adopted a method that has not been used by Chinese scholars so far. In terms of data, the statistical data from Mr (2016) with the highest adoption rate and the highest recognition in relevant fields are used. In the end, this study obtained a lot of results different from the existing literature, which provided the relevant personnel with a new perspective.

Such results can be seen from the perspective of time and space. Nationally speaking, in the first stage, from 1997 to 2005, the social overhead capital in China's provinces mostly turned from insufficient to surplus. The second stage: 2006-2009, China's provinces still have excess capital, but the degree of excess has declined. The third stage: from 2010 to 2015, the ratio of Chinese

provinces gradually declined, and social overhead capital turned from surplus to insufficient. Regionally, compared with the rapid growth of social private capital stock, the infrastructure stock in eastern and central China is already facing shortage. The government can boldly continue to increase investment in the public sector in eastern and central China, which is contrary to the previous scholars' belief that the infrastructure in eastern China is already surplus. Although the infrastructure stock in the western region was in surplus by 2015, combined with the changing trend in the later period, it may soon face the problem of insufficient infrastructure in the future, which is quite different from the serious shortage of infrastructure in the western region as previously believed by scholars. According to the conclusion of this paper, relevant departments should take timely measures to deal with it.

4.2. Discussion

The conclusions of this study are different from those of previous studies on China's social overhead capital stock. In general, western China is an underdeveloped region, but from the change of ratio, social capital investment has significantly promoted the development of local economy in recent years, and even by 2015, there was a trend of insufficient social overhead capital stock. But here, too, it will be necessary to consider physical investments and other flexible investment methods in the future. Different investments must be made in a way that makes a real contribution to local economic development.

The results of this study basically imply that China still needs to invest in social indirect capital. But it needs to be maintained at an appropriate level. Because the excessive investment of social overhead capital may bring heavy burden to the economy. Social equity and balanced regional development are also valuable values that cannot be ignored. Since neither equity nor efficiency can be

given up, the academic community needs to further discuss how to invest in social overhead capital to pursue these two worthy goals in a balanced way.

This study attempts to obtain more reliable results by reestimating the stock of social overhead capital and private capital, but it should be remembered that regardless of the data used, the study of social overhead capital is inevitably incomplete, as Gramlich (1994) says. This involves both different approaches to research and more detailed work on the underlying data. Hence the need for a broader review and discussion of the "truth" of our social overhead capital stock in the future.

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Appendix

Economic infrastructure capital stock					
성도/시간	1997	2002	2007	2012	2015
베이징 北　京	696.09	1456.17	1819.14	3214.55	4022.48
천진 天　津	252.43	591.71	1040.74	2174.47	3581.74
허베이 河　北	1019.52	2183.77	3464.40	7446.82	12000.88
산시 山　西	270.15	764.30	1714.33	3965.58	6516.50
내몽골 内蒙古	294.93	587.88	2088.35	6590.76	10807.90
랴오닝 辽　宁	358.04	991.33	2099.28	5762.79	10086.88
길림 吉　林	284.12	513.83	1182.22	3796.78	5863.10
헤이룽장 黑龙江	587.94	1101.75	1826.98	3634.00	5258.03
상하이 上　海	535.81	1634.66	2468.05	4009.14	4196.34
장쑤 江　苏	1242.76	2572.13	6163.71	10698.36	16123.09
절강 浙　江	1077.55	2589.16	5768.61	9157.27	11897.35
안휘 安　徽	352.62	843.33	1728.04	3952.99	7297.58
복건 福　建	1021.08	1664.54	2324.05	4247.26	8042.96
장시 江　西	359.67	731.97	1518.23	3258.90	4735.95
산동 山　东	1122.53	2255.91	3677.32	7075.19	11486.97
허난 河　南	698.93	1570.50	3675.80	7324.34	10418.71
후베이 湖　北	588.54	1495.22	3086.91	5802.94	8084.46
후난 湖　南	408.58	983.87	1908.57	3625.51	6498.44
광동 广　东	2056.19	3400.76	5938.45	11614.05	16384.10
광시 广　西	484.37	1044.94	1747.50	3894.03	6232.74
하이난 海　南	52.35	223.44	411.50	693.96	884.40
충칭 重　庆	279.00	556.19	1384.93	2920.89	5489.83
사천 四　川	486.29	1702.28	3233.69	7471.96	13656.77
귀주 贵　州	313.75	688.27	1374.24	2879.42	5239.23
윈난 云　南	285.44	741.27	1683.79	3442.05	9587.19
티벳 西　藏	20.80	100.54	326.86	571.32	881.05
산시 陕　西	221.87	844.99	1626.53	3657.71	6089.90
간쑤 甘　肃	254.71	492.26	801.38	1895.94	3584.84
칭하이 青　海	145.83	257.39	436.66	665.59	1211.44
닝샤 宁　夏	173.20	251.04	447.00	994.04	1655.15
신장 新　疆	218.82	687.26	1316.30	2125.17	4078.43

Social infrastructure capital stock					
성도/시간	1997	2002	2007	2012	2015
베이징 北　京	388.13	816.61	1094.66	1411.58	1631.59
천진 天　津	108.80	194.73	319.57	653.94	1165.64
허베이 河　北	504.06	800.23	1405.50	2012.79	3157.29
산시 山　西	78.88	194.93	330.25	675.46	1074.57
내몽골 内蒙古	122.62	232.75	559.65	1433.44	2191.66
랴오닝 辽　宁	180.95	380.42228	879.29	1638.06	2826.56
길림 吉　林	88.13	271.32	640.99	1050.76	1642.58
헤이룽장 黑龙江	141.07	347.61	714.36	1291.19	2000.42226
상하이 上　海	244.41	594.66	740.70	824.96	827.02
장쑤 江　苏	507.13	950.42220	1864.85	2856.70	4671.35
절강 浙　江	391.20	770.66	1531.34	1876.66	2652.57
안휘 安　徽	180.73	387.53	724.77	1335.01	2283.82
복건 福　建	170.86	368.38	588.35	1045.84	1969.25
장시 江　西	75.50	227.36	625.45	1227.30	1707.94
산동 山　东	381.19	868.63	2165.55	4486.89	7457.70
허난 河　南	394.78	728.24	1144.42	2076.18	2765.58
후베이 湖　北	346.60	755.08	1052.95	2174.06	2869.60
후난 湖　南	261.22	506.46	902.85	1364.05	2537.34
광동 广　东	591.79	1224.49	2045.55	3085.21	3957.81
광시 广　西	116.67	251.05	463.57	962.01	1792.34
하이난 海　南	54.06	96.77	144.36	261.57	309.78
충칭 重　庆	136.39	299.51	607.30	934.41	1238.59
사천 四　川	260.51	603.55	998.12	1804.97	2719.88
귀주 贵　州	39.49	109.91	256.80	442.34	591.11
윈난 云　南	206.94	415.92	613.27	1122.51	1641.30
티벳 西　藏	29.04	61.33	159.56	281.35	412.89
산시 陕　西	127.48	255.11	645.76	1739.13	2539.49
간쑤 甘　肃	62.34	169.70	311.26	865.48	1357.42
칭하이 青　海	21.12	55.86	114.24	206.79	439.85
닝샤 宁　夏	15.53	44.05	109.40	232.31	311.82
신장 新　疆	117.27	237.15	474.73	761.18	1049.76

Social Overhead Capital Stock					
성도/시간	1997	2002	2007	2012	2015
베이징 北　京	1084.22	2272.78	2913.80	4626.13	5654.08
천진 天　津	361.23	786.44	1360.32	2828.41	4747.38
허베이 河　北	1523.58	2984.00	4869.89	9459.62	15158.17
산시 山　西	349.03	959.23	2044.58	4641.05	7591.07
내몽골 内蒙古	417.55	820.62	2648.00	8024.20	12999.56
랴오닝 辽　宁	538.98	1371.81	2978.58	7400.86	12913.44
길림 吉　林	372.25	785.15	1823.21	4847.54	7505.68
헤이룽장 黑龙江	729.01	1449.36	2541.34	4925.18	7258.49
상하이 上　海	780.22	2229.31	3208.75	4834.10	5023.36
장쑤 江　苏	1749.89	3522.53	8028.56	13555.07	20794.44
절강 浙　江	1468.75	3359.82	7299.96	11033.93	14549.93
안휘 安　徽	533.35	1230.86	2452.80	5288.00	9581.40
복건 福　建	1191.93	2032.92	2912.40	5293.10	10012.21
장시 江　西	435.16	959.33	2143.68	4486.21	6443.89
산동 山　东	1503.72	3124.54	5842.87	11562.09	18944.67
허난 河　南	1093.71	2298.73	4820.22	9400.52	13184.29
후베이 湖　北	935.14	2250.30	4139.86	7977.00	10954.06
후난 湖　南	669.80	1490.33	2811.42	4989.57	9035.78
광동 广　东	2647.98	4625.25	7984.00	14699.26	20341.90
광시 广　西	601.04	1295.98	2211.07	4856.04	8025.07
하이난 海　南	106.41	320.21	555.86	955.53	1194.17
충칭 重　庆	415.38	855.69	1992.22	3855.30	6728.42
사천 四　川	746.80	2305.83	4231.80	9276.94	16376.65
귀주 贵　州	353.24	798.17	1631.03	3321.77	5830.33
윈난 云　南	492.38	1157.18	2297.05	4564.56	11228.49
티벳 西　藏	49.84	161.87	486.42	852.68	1293.93
산시 陕　西	349.35	1100.10	2272.29	5396.84	8629.39
간쑤 甘　肃	317.05	661.97	1112.64	2761.42	4942.26
칭하이 青　海	166.95	313.26	550.90	872.38	1651.29
닝샤 宁　夏	188.73	295.09	556.40	1226.35	1966.97
신장 新　疆	336.08	924.41	1791.03	2886.34	5128.19

Private capital stock					
성도/시간	1997	2002	2007	2012	2015
베이징 北　京	2073.61	3766.91	6993.28	9330.98	11079.67
천진 天　津	1147.94	2014.98	3714.18	9083.89	16161.99
허베이 河　北	3644.59	6149.21	10348.47	26712.70	46534.86
산시 山　西	1076.06	1546.98	3277.84	7675.79	14582.60
내몽골 内蒙古	515.03	1053.32	3106.74	10382.98	18589.17
랴오닝 辽　宁	3027.39	4594.16	9228.09	23822.81	39786.52
길림 吉　林	1232.08	1916.59	3686.02	12517.94	21215.44
헤이룽장 黑龙江	1761.26	2837.96	4438.36	11160.34	18671.77
상하이 上　海	5498.65	8163.67	11100.38	13279.92	14131.17
장쑤 江　苏	6866.74	10544.91	20663.27	47202.38	75081.55
절강 浙　江	5141.48	8014.87	14663.30	24249.60	35566.93
안휘 安　徽	2317.20	3063.78	5083.47	15595.81	27925.69
복건 福　建	2227.48	3673.18	4955.62	10329.46	20912.83
장시 江　西	1004.80	1491.13	3224.98	12867.57	22064.25
산동 山　东	5574.44	8920.29	18648.39	40337.63	65573.51
허난 河　南	3836.27	5041.11	9476.19	29827.76	48403.66
후베이 湖　北	2582.81	3872.61	5925.06	15370.90	27186.81
후난 湖　南	1892.56	2922.92	4753.00	11970.76	23272.47
광동 广　东	5508.51	10127.59	16859.67	28656.85	42357.88
광시 广　西	1270.66	1926.26	2894.26	8554.56	17672.71
하이난 海　南	456.04	634.90	759.80	1181.11	2598.37
충칭 重　庆	1046.88	1698.43	3229.82	8400.42	14833.12
사천 四　川	2601.05	4154.36	6598.52	16985.91	28493.46
귀주 贵　州	424.15	885.52	1499.33	3441.93	6093.72
윈난 云　南	1291.28	1951.15	2655.51	5540.67	5960.78
티벳 西　藏	45.26	89.60	170.27	454.28	808.98
산시 陕　西	959.32	1553.55	2910.34	7131.55	15180.02
간쑤 甘　肃	549.18	947.73	1425.90	3381.72	7431.31
칭하이 青　海	184.04	315.95	593.31	1229.83	2133.48
닝샤 宁　夏	207.92	389.74	764.96	1775.02	3301.75
신장 新　疆	1427.49	2111.92	3437.49	5922.48	10079.70

SOC/Private Capital Stock					
성도/시간	1997	2002	2007	2012	2015
Nation	0.36417	0.70812	0.78076	0.75676	0.56847
Beijing	0.52287	0.60335	0.42221	0.42229	0.51031
Tianjin	0.31468	0.39030	0.36625	0.31137	0.29374
Hebei	0.42221	0.42228	0.42227	0.35412	0.32574
Shanxi	0.32436	0.62007	0.62376	0.60463	0.52056
Neimenggu	0.81072	0.77908	0.85234	0.77282	0.69931
Liaoning	0.17804	0.29860	0.32277	0.31066	0.32457
Jilin	0.30213	0.42220	0.42229	0.38725	0.35378
Heilongjiang	0.42221	0.51071	0.57259	0.42224	0.38874
Shanghai	0.14189	0.27308	0.28907	0.36402	0.35548
Jiangsu	0.25484	0.33405	0.38854	0.28717	0.27696
Zhejiang	0.28567	0.42221	0.42229	0.42225	0.42220
Anhui	0.23017	0.42220	0.42228	0.33907	0.34310
Fujian	0.53511	0.55345	0.58770	0.51243	0.42227
Jiangxi	0.42223	0.64335	0.66471	0.34864	0.29205
Shandong	0.26975	0.35027	0.31332	0.28663	0.28891
Henan	0.28510	0.42225	0.50867	0.31516	0.27238
Hubei	0.36206	0.58108	0.69870	0.51897	0.42220
Hunan	0.35391	0.50988	0.59150	0.42221	0.38826
Guangdong	0.42228	0.42225	0.42227	0.51294	0.42228
Guangxi	0.42227	0.67280	0.76395	0.56765	0.42225
Hainan	0.23333	0.50434	0.73159	0.80901	0.42225
Chongqing	0.39678	0.50381	0.61682	0.42225	0.42225
Sichuan	0.28712	0.55504	0.64133	0.54616	0.57475
Guizhou	0.83282	0.90136	1.08785	0.96509	0.95678
Yunnan	0.38131	0.59308	0.86502	0.82383	1.18195
Shaanxi	0.36417	0.70812	0.78076	0.75676	0.56847
Gansu	0.57732	0.69848	0.78031	0.81657	0.66506
Qinghai	0.90716	0.99149	0.92850	0.70935	0.77399
Ningxia	0.90775	0.75714	0.72736	0.69090	0.59573
Sinkiang(Xinjiang)	0.23544	0.42223	0.52103	0.42228	0.50876
Tibet (Xizang)	1.10129	1.80660	2.85674	1.87700	1.59945

Abstract

중국은 세계에서 가장 큰 개발도상국이며 가장 빠른 개발도상국 중 하나이다. 급속한 경제성장을 지속하기 위해 중국 전역의 정부들은 최근 몇 년 동안 인프라(사회간접자본) 투자를 늘리고 있다. 하지만 사회적 부의 결핍으로 인해 불합리한 인프라 투자는 사회 전체를 막대한 기회비용에 부담을 지게 할 것이다. 따라서 각 지역의 인프라 투자에 대한 과학적 평가가 지나치거나 미흡한 점이 최근 몇 년간에 전 세계 연구자들에게 관심 문제가 되고 있다. 본 논문은 1997년부터 2015년까지 중국 31개 성도의 인프라 투자를 바탕으로 Achauer (2000년)가 제안한 모델과 이영성(2012년)가 제시한 모델 개선 결과를 참고해서 중국 인프라 투자의 효율성을 평가하였다. 결과는 중국 중부와 동부의 기반시설은 이미 불충분하고 있으며 서구도 현재 충분하기는 하지만 곧 불충분해질 것이라는 것이 밝혀졌다. 그래서 사회·경제 발전 수준에 비해 중국 정부는 여전히 인프라 투자를 지속적으로 늘릴 필요가 있으며 인프라 투자는 여전히 중국의 경제 발전을 효과적으로 촉진할 수 있다.