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A Study on the Dynamic Evolution and Regional Differences of Public Capital and Return to Capital in China

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Abstract: Public capital plays a key role in national economic production in developing countries, and it has become the focus of factor reform in China. This paper aims at studying the dynamic characteristics of China's public capital and the return rate. To this end, this paper inventories the public capital stock from 1978 to 2017; constructs a two-sector model to derive the necessary condition for optimal investment related to the return rate, and empirically tests it; estimates the output shares of the two sectors and calculates the rate of return to capital; and illustrates the dynamic evolution of public capital and the return rate from the time and regional dimensions. The study shows that, first, public capital has grown significantly. The portion of public capital held in the form of state-holding is increasing year by year. However, the proportion of public capital to total capital has decreased from 81% to 35%. Second, the growth of public capital has effectively balanced the gap of capital between regions. Third, the rate of return to capital has been decreasing, with two sectors' return rates having converged in 1981 and in 2010–2013. This paper measures the stock of public capital and its return rate, which is beneficial for formulating the policy of public capital in economic production and distribution, as well as exploring the path to achieving common prosperity.

Keywords: public capital; return; inventory; state-owned; stock

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1. Introduction

The main focus of this paper is to elaborate the accumulation process of public capital and the dynamic evolution of its return rate in time and regional dimensions.

As a major component of the capital factor, public capital plays a central role in the national economic production of developing countries. It has become the focus of factor reform under the Chinese market economy. Public capital participates in the production and distribution of the market economy. It is also an accumulated stock of wealth that influences income disparity. Many scholars have confirmed that public capital promotes economic growth, mostly from the perspective of the size of capital investment [1]. However, the sustainable development of the economy cannot only rely on the continuous input of production factors. The economy should also focus on the improvement of economic efficiency [2]. If public capital fails to achieve the corresponding level of return to capital and obtain a certain income, it not only shows over-investment in the economy, but also increases the debt burden of the government. Therefore, the study of public capital and its rate of return is particularly important.

On the other hand, public capital plays a role in economic distribution, and the study of public capital and its rate of return can contribute to the exploration of the path to narrowing the income gap. Regarding the division of capital factor income between the public and non-public sectors (same as "private sector" in this paper), whether to "give benefits to the people" or "save wealth for the country" is an issue, which needs capital income adjusted at the macro level on the basis of reasonable and scientific measurement

of capital scale and the estimation of the rate of return to capital. In addition, public capital also has the stock effect of wealth. With the development of economy, the wealth gap caused by capital stock becomes more and more obvious. How big is the capital stock gap between the public sector and the non-public sector? Compared with non-public capital (same as "private capital" in this paper), public capital is owned by the state, and its ownership is separated from its use. Public capital is subject to regulatory compliance in the process of capital operation, which results in the cost of monitoring the use of funds and a certain degree of efficiency impairment. How large is the gap between the two sectors, and does this gap change as the stock increases? Since the scale of accumulated public capital affects the capacity for policy implementation and regional development, do public capital and its rate of return vary across spatial regions? Numerous scholars have focused on public capital as a factor of production attribute, with an emphasis on the study of capital productivity. However, few have bothered to measure the return to capital and measure these differences. Not only that, but there are also still some problems in the existing studies, such as unclear definition of public capital, confusion between productivity of capital and return to capital, and the mixing of stocks and flows. On the basis of clarifying the above problems, this study attempts to assess the temporal and spatial characteristics of China's public capital and its return rate.

2. Related Literature

Current studies on public capital mainly focus on the role of public capital or public investment on economic growth; the effect of public capital on private capital, substitution, crowding out, spillover; and the efficiency of public capital utilization, among which is an essential part is the inventory of public capital; and most of the studies use national-level data, while relatively few studies are conducted at the provincial level.

Additionally, the size of the data on public capital varies widely among researchers, which leads to a lack of comparability and in-depth continuity in the study of public capital. The reason is that the definitions of public capital are different. Many scholars, including [3–5], have defined public capital as capital that is formed by government investment in the public sector. Under such a definition framework, researchers have selected several industries as public sectors to estimate the public capital stock. However, the selection of some public sectors may ignore the fact that private for-profit capital is continuously pouring into these sectors, which leads to an overestimation of the volume and size of public capital. On the other hand, as reforms advance, more and more public capital is involved in the operation of non-public sectors in the form of shares, which may lead to an underestimation of public capital. Based on the classification criteria of government expenditures and their accounting caliber, [6] takes capital construction expenditures, excavation and renovation expenditures, and enterprise working capital and agricultural expenditures, within both on-budget and off-budget capital expenditures, as the accounting caliber of public capital. However, the fiscal data published after 2007 only have functional expenditure classification and no economic classification. In fact, not all investments have entered the actual projects, with the existence of human remuneration and other costs. Since that, ignoring the economic classification exaggerates the scale of public capital. In addition to accounting for public capital from the perspective of government investment, [2] and [7] argue that investment by Chinese SOEs (state-owned enterprises) is closer to a government action, and thus, they include SOEs within the investment body of public capital at the same time.

It can be seen that public capital is closely related to its investment subject, the public sector. Different definitions of the public sector by researchers will result in different definitions of public capital. Only after a clear and explicit definition of the public sector can the definition of public capital be effectively grasped, and public capital be accurately accounted for.

To this end, this paper defines the public sector according to the definition of the public sector in the System of National Accounts 2008 (SNA 2008) [8]. The public sector

includes: general government units (government units, government-controlled non-profit institutions, and state-owned enterprises not treated as corporations), and state-owned enterprises and their subsidiaries that are controlled by the government. From the perspective of ownership, public capital is defined as all the net assets of capital accumulated by the public sector through investment activities. At the same time, this paper considers that the "state-owned economy and state-holding investment" in the inventory of public capital, as the investment sequence not only covers budgetary and extra-budgetary expenditures, but also includes state-owned economy and state-holding investment, which can better fit the definition of public capital.

After clearly defining the concept of public capital, it is necessary to distinguish between two concepts: "productivity of capital" and "return to capital". The two concepts are often confused in many studies on the efficiency of output and return to public capital. According to the OECD Handbook on Productivity Measurement [9], the productivity of capital is physical and is part of the productivity measure, which is usually defined as the ratio of a set of output indicators to a set of input indicators. Return to capital is a return measure that links the return to capital to the value of the capital stock. The distinction between the two concepts provides a good grasp of the focus of scholars' research. For example, [2] explored the changing trends, regional differences, and influencing factors of public capital input efficiency, based on data envelopment analysis. [10,11] used "public output capital ratio" or "public capital output ratio" to measure the investment efficiency of public capital. These are all studies of capital productivity. Few studies of the return to public capital exist, the most representative of which is [12].

Reference [12] measured China's net public capital assets from 1978–2015 according to sectors based on national accounts, surveys, income data, fiscal data, and balance sheets. The balance sheets referred to Li Yang's CNBS team, Cao Yuanzheng team, and Ma Jun team [13–16]. Reference [12] then used the fund flow statement to calculate the capital return at the national level of China, thus calculating the level of return to capital.

Reference [12] is noteworthy, but we find three points worth exploring by analyzing the data. The first is with regard to the construction of the balance sheet, which is the basis of [12]. There has been very little research on the measurement of public capital returns because the Chinese government does not have uniform public balance sheet data. Three research teams, Li Yang, Cao Yuanzheng, and Ma Jun, started to compile the national balance sheet of China at the end of 2011. Apart from the fact that the national balance sheet was constructed in a later year, the structure and data results of the compilation showed great differences, which may lead to doubts regarding the accuracy of the data in [12]. Second, the data sources used in the capital and return measurement are complicated and of different calibers. Many assumptions are made in the calculation process. Hence, the comparability of the data and the reasonableness of the results in the article are subject to verification. The third is with regard to the division and definition of assets, and the liabilities of each sector by [12]. In one country, the net assets should belong to the wealth of each national sector, and whether they can be inducted in another country. With the development of time and economic changes, we must ask whether these assets should be adjusted and perfected? These issues are the focus of international discussion. Reference [17] have made a comparison between the wealth estimation results of Piketty et al. and CNBS's balance sheet by sectors. Reference [17] found the existence of differences in the division of accounting subjects, different categories of assets accounted for, different ratios of intersectoral division of assets, etc., in the study. Therefore, the applicability of these differences in China are worth further exploration and demonstration.

In addition, due to the lack of data on capital stock or the difficulties in accounting, public capital flows (i.e., public investment, public expenditure, etc.) are often used instead of public capital stock in existing studies involving public capital returns, with the implicit assumption that the efficiency of public investment is not correlated with public capital stock. However, according to the theory of diminishing marginal returns, an increase by one unit of public capital results in a smaller output outcome when the public capital

stock is larger. Reference [18] also argue that investment decisions may depend both on new public investment and on the existing stock of public capital. The stock often reflects the perfection of existing infrastructure. In conclusion, using the public capital stock to calculate the return to public capital gives a better picture of changes in capital efficiency.

Based on the above literature, this paper uses the perpetual inventory method to calculate the scale of public capital stock at the national and provincial levels from 1978 to 2017 and compares it with the state-owned assets data of liquidated state-owned assets; constructs a two-sector model, derives the necessary condition for optimal investment related to the return rate and empirically tests the necessary condition; regresses the estimated output shares of the two sectors; calculates the return to capital, and investigates the time–space difference characteristics of the accumulation process of public capital and the dynamic evolution of the rate of return to public capital.

The innovations of this paper include the following: (1) Defining a framework for the public sector in China and conducting a comparative analysis of the investment series of public capital. (2) Measuring public capital returns at the provincial level, linking optimal public investment rules to capital returns, testing whether optimal public investment conditions have existed in China over the past 40 years, and finding a convergence of returns between 1981, 2010, and 2013. (3) In the study, the state-owned assets data of the inventory and verification statistics are introduced, and the public capital in inventory is benchmarked against it. (4) A detailed analysis of the total capital and regional data reveals the role of public capital in stabilizing the market, boosting the economy, and balancing regional differences in capital.

The article is organized as follows: Section 3 constructs a two-sector model to obtain the optimal investment necessary condition related to the rate of return, Section 4 presents how to calculate the rate of return to public capital, Section 5 inventories the public capital, Section 6 conducts an empirical analysis, and finally, Section 7 concludes, indicates limitations, and shows possible research directions.

3. Construction of the Model

This paper builds a two-sector endogenous growth model, including the public sector and the private sector, with the reference of [19], and links the optimal public investment conditions with the return to capital, to obtain a new optimal public investment condition. The model refers to [20], and adopts the central planner model. Capital depreciation is not considered in the basic model.

3.1. Social Output

Consider only two factors of production, the private sector capital and the public sector capital. The production function is:

$$y(t) = f\big(k_p(t), k_g(t)\big). \tag{1}$$

Here follows the assumption commonly adopted in the study of the relationship between public capital and economic growth to unitize the population, which has no substantial impact on the conclusion, as follows. Here, $y(t), k_p(t),\ k_g(t)$ are the output per capita, private capital per capita, and public capital per capita, respectively. The production function is concave and homogeneous for both private and public capital. At the same time, it is assumed that the production function satisfies Inada Condition and strictly increases for each variable. $f_{k_p(t)}$ and $f_{k_g(t)}$ are the partial derivatives of the production function with respect to $k_p(t)$ and $k_g(t)$, respectively. Hence, $f_{k_p(t)}$, $f_{k_g(t)}$ have the following mathematical properties: $\lim_{k_p \to 0} f_{k_p(t)} = \infty$, $\lim_{k_p \to \infty} f_{k_p(t)} = 0$, $\lim_{k_g \to 0} f_{k_g(t)} = \infty$, $\lim_{k_g \to \infty} f_{k_g(t)} = 0$, $f_{k_p(t)} > 0$ and $f_{k_g(t)} > 0$.

3.2. Households

Assuming that the number of households is N, with homogeneous and infinite survival and no population growth, households obtain utility from consumption and maximize their own utility. The total intertemporal utility can be expressed as follows:

$$U(t) = \int_0^\infty u(c(t))e^{-\rho t}dt, \tag{2}$$

where $c(t)$ denotes the representative household consumption at time t, ρ is the time preference rate, and u denotes the utility function, which is increasing, strictly concave, and twice-continuous differentiability.

The representative household supplies one unit of labor to earn wages, has an initial capital $k_p(0) > 0$, and accumulates capital by investing to earn rental income from capital.

In each period, the household makes a choice between $\{c(t), I_p(t)\}_{t=0}^{\infty}$, i.e., consumption and investment in the current period, to maximize the discount flow of total utility.

3.3. Public Sector

The government provides public capital through public investment, and the public capital accumulation equation is:

$$\dot{k}_g(t) = I_g(t), \tag{3}$$

where $k_g(t)$ and $I_g(t)$ denote public capital and public investment per capita, respectively. $\dot{k}_g(t)$ is shorthand for $dk_g(t)/dt$. The initial public capital is noted as $k_g(0)$.

In order to maximize social welfare U, the government distributes output in order to exploit the optimal performance of capital factors in each sector. As a result, the capital constraint equation faced by the private sector is:

$$\dot{k}_p(t) = y(t) - I_g(t) - c(t). \tag{4}$$

3.4. Optimal Public Investment Rule

So, for the government, the problem is to find the optimal growth path for the variables c, I_g, I_p that can maximize the total intertemporal utility Equation (2) under the constraints Equations (3) and (4).

This optimization problem is solved using the Hamiltonian system by constructing the Hamiltonian function.

$$H(t) = u(c(t)) + \lambda\left[f\left(k_p(t), k_g(t)\right) - I_g(t) - c(t)\right] + \mu I_g(t). \tag{5}$$

According to the concave function property of u and f, the H function is concave for the variables c, I_g, k_p, k_g, satisfying the first-order condition and the sufficiency of the transverse intercept condition. To solve the first-order optimal condition, the following equation can be obtained:

$$f_{k_g(t)} = f_{k_p(t)}. \tag{6}$$

Equation (6) is the optimal investment rule, and its economic implication is that the marginal output of public capital is equal to the marginal output of private capital.

Now, assume that the production function is Cobb–Douglas production function:

$$y(t) = f\left(k_p(t), k_g(t)\right) = Ak_p^{\alpha}(t)k_g^{\beta}(t), \tag{7}$$

where α and β are the output elasticities of private and public capital, respectively. Take the partial derivative of the production function, and it is easy to obtain:

$$f_{k_g(t)} = \frac{\beta y(t)}{k_g(t)},\ f_{k_p(t)} = \frac{\alpha y(t)}{k_p(t)}. \tag{8}$$

According to the optimal investment rule Equation (6), the two partial derivatives on the optimal steady path are equal, so the optimal ratio of public capital and private capital is:

$$z^* = \frac{k_g(t)}{k_p(t)} = \frac{\beta}{\alpha}. \tag{9}$$

That is, z^* is the output elasticity of capital or the ratio of capital shares.

Continue to consider output and capital prices on the basis of Equation (6) and assume that the depreciation rate of public and non-public capital is $\delta(t)$.

Both sides of $\frac{\beta y(t)}{k_g(t)} = \frac{\alpha y(t)}{k_p(t)}$ are simultaneously multiplied up and down by $P_y(t)$ and $P_k(t)$, respectively, and simultaneously subtracted from $\delta(t)$ to obtain:

$$\frac{\beta P_y(t) y(t)}{P_k(t) k_g(t)} - \delta(t) = \frac{\alpha P_y(t) y(t)}{P_k(t) k_p(t)} - \delta(t). \tag{10}$$

According to [21], this is the formula for calculating the return to capital for public and private capital, i.e.,

$$r_g(t) = r_p(t). \tag{11}$$

This means that to achieve the optimal investment ideal state, the necessary condition is that the rate of return to public and private capital are equal. This paper uses this conclusion to test whether optimal investment conditions have ever existed in China between the two sectors since the reform and opening up.

4. The Measurement of Return to Capital

From the progress of research on macro-accounting return to capital, the existing studies are based on the capital rent formula of [22], and the framework of capital return measurement constructed by [21]. The main improvements and optimizations are only the local facilitation or adjustment of the measurement indicators, such as the deduction of indirect taxes borne by workers, and the correction study of the bias of the depreciation rate [23]. Therefore, in this paper, referring to [21], the rate of return to capital r, when capital and output are at comparable prices, is

$$r(t) = \frac{\alpha(t) P_Y(t) Y(t)}{P_K(t) K(t)} - \delta(t), \tag{12}$$

where $\alpha(t)$ is the share of capital output, $P_Y(t)$ and $P_K(t)$ are the prices of output and capital, respectively, and $\delta(t)$ is the depreciation rate of capital.

To obtain the share $\alpha(t)$ in Equation (9), it is assumed that the factors of production are the production functions of public capital $K_{pub}(t)$, private capital $K_{pri}(t)$, and labor $L(t)$, as:

$$Y(t) = A_0 K_{pri}^{a_1}(t) K_{pub}^{a_2}(t) L^{a_3}(t). \tag{13}$$

Taking the logarithm of both sides is:

$$ln\, Y(t) = lnA_0 + a_1 lnK_{pri}(t) + a_2 lnK_{pub}(t) + a_3 lnL(t). \tag{14}$$

However, the output elasticity of labor is found to be negative by the regression, which is due to the more prevalent labor surplus in the production sector in China. The negative effect of labor surplus on output efficiency is difficult to peel off. It is consistent with the findings of [24], who studied the production function of the Chinese national economy. For this reason, this paper makes an adjustment to remove labor compensation from output to obtain the real output $Y_K(t)$ brought by capital, and then regresses $Y_K(t)$ on capital in both

sectors. The corresponding regression equations of capital output and production function are Equations (15) and (16), respectively.

$$Y_K(t) = \frac{(Y_{IA}(t) - CE(t)) \times \frac{Y_{PA}(t)}{Y_{IA}(t)}}{GDPdeflator(t)}, \tag{15}$$

$$lnY_K(t) = lnA_0 + b_1 lnK_{pri}(t) + b_2 lnK_{pub}(t) + \varepsilon, \tag{16}$$

where Y_K denotes the real capital output; $Y_{IA}(t)$, $Y_{PA}(t)$, and $CE(t)$ denote income method GDP, production method GDP, and labor compensation, respectively, with all three in current year prices; ε is the disturbance term and follows the normal distribution with the mean value of 0.

Here, assuming constant returns to scale, the regressions yield the output shares of each factor as below.

Labor share:

$$a_3 = \frac{CE(t)}{Y_{IA}(t)}. \tag{17}$$

Share of private capital output in total output:

$$a_1 = b_1(1 - a_3). \tag{18}$$

Share of public capital output in total output:

$$a_2 = b_2(1 - a_3). \tag{19}$$

The return to capital can be calculated by bringing Equations (18) and (19) and output, capital after inventory, and depreciation rate into Equation (12).

5. Inventory of Capital

This study assumes that the market is a two-sector economy, and that the capital elements include public capital and non-public capital. Capital K_t is inventoried using the perpetual inventory method, and the capital inventory formula is:

$$K_t = (1 - \delta)K_{t-1} + I_t \tag{20}$$

The key data involved are: base period capital stock, investment sequence I_t, investment price index, and depreciation rate δ. Both the total and public capital are inventoried using the investment sequences, while non-public capital is obtained by subtracting the public capital from total capital after inventory.

5.1. Base Period Capital Stock

For the estimation of total capital stock in the base period, 1952 and 1978 are generally used. In view of the availability of public capital investment series, many domestic studies choose the base period as 1978, 1980, or even after 1980. Generally speaking, the earlier the base period selected, the less impact it will have on the measurement of capital in subsequent years. Therefore, the base year is set to 1978 in this paper.

In China's domestic literature, there are two approaches to calculating the base period capital: one is to use the base period investment amount divided by 10% as the base period capital in 1952, as in [25], with reference to [26]. In [26], this base period is stated as "The capital in 1952 is calculated by dividing the actual investment in 1952 by 0.06 (depreciation rate) and adding the annual average growth of the actual investment from 1952 to 1957 by 0.04." It is clear that the 10% ratio is only applicable to 1952, but many scholars still use this ratio to calculate the base period in 1980 [5] and 1985 [2]. The results obtained are obviously unrealistic. Another approach considers that the annual increase in investment is partly used for a certain percentage of capital increase and is partly used to cover the capital depreciation of the previous year. Therefore, when calculating the base period

capital, "real investment in the following year / (capital growth rate + capital depreciation rate)" is used as the base period data. In order to obtain the growth rate of capital, it is assumed that the growth rate of stock capital is equal to the growth rate of investment in the case of economic steady state ($\frac{\Delta K}{K} = \frac{\Delta I}{I}$) [27]. Hence, we use investment growth rate instead of capital growth rate for the calculation. In fact, this is basically consistent with [26]. Therefore, this paper uses "actual investment in 1979/(investment growth rate + capital depreciation rate)" as the base period data in 1978. The average growth rate of investment in the five-year period from 1978 to 1983 is chosen as the growth rate of the article, which is calculated as 13%.

5.2. Investment Sequence

This paper needs to inventory total capital and public capital, so it involves two investment sequences of capital.

5.2.1. Total Capital Investment Series

Regarding the inventory of total capital, the investment data used in different studies mainly include fixed asset investment data [28], fixed capital formation data [25], accumulation data [29,30], and new fixed asset data [31]. Reference [28] started from the methodology of the perpetual inventory method and analyzed the concept and coverage of each investment data. They concluded that retirement and depreciation should not be considered in the investment sequence. In their paper, the accumulated amount of fixed assets is equal to the fixed capital formation minus depreciation, and the fixed capital formation is equal to the fixed asset investment minus the value of retired capital goods, plus the land improvement investment. They believed the data of new fixed asset investment are more appropriate. However, due to the long construction period of the project and the different price indexes across the years, it is difficult to calculate the new fixed assets formed by the project. Considering the availability of data, it is found that after 1993, the government no longer published the income accumulation data, and the published official data from 1952 to 1992 did not subdivide the economic type. The new fixed assets of the provincial panel from 1978 to 1995 are not directly available. They need to be approximately calculated by adding the new fixed assets of capital construction and renovation, while ignoring the new fixed assets invested by other fixed assets.

In contrast, fixed asset investment data and fixed capital formation data are often used to inventory capital data. Fixed asset investment includes expenditure on land purchase, and the purchase of old machinery and buildings. Comparatively, fixed capital formation is subtracted from fixed asset investment data by land use rights fees and the purchase value of old machinery and buildings, plus some uncounted investment projects [27]. However, [32] argued that under the background of China's land finance and land finance, the two methods of land transfer income and land mortgage loan have relaxed the government's budget constraints, which were important drivers to the formation of capital and have revitalized the currency circulation required for China's economic growth. Therefore, this paper's perspective is that using the fixed asset investment series to inventory capital is more appropriate to the reality.

5.2.2. Public Capital Investment Series

Given the availability of data, there are four selections for using the fixed asset investment series to inventory public capital.

First, from the source of funds for fixed asset investment, [11] used indicators from government budgetary funds. However, a large part of public investment comes from extra-budgetary government funds, as well as state-owned enterprises.

Second, [30] considers the amount of national income accumulation as the net increase in capital stock, but this investment series data are not available after 1985.

Thirdly, by referring to the National Economic Classification, some subjectively identified industries are selected as public sector industries. On the one hand, the identification

possesses a certain degree of arbitrariness. On the other hand, with the entry of private capital, some industries cannot be defined as being pure public sector. Therefore, public capital is often overvalued [2].

Fourth, from the perspective of the enterprise registration type of fixed assets investment, the amount of investment in the "state-owned economy" is selected as the investment sequence. Reference [7] argues that public capital investment comes from government budgetary funds, extra-budgetary funds, and funds from state-owned enterprises. This is basically consistent with the indicator of a "state-owned economy" in fixed asset investment. However, in addition to the state-owned economy, there are various types of enterprise registration, such as collective economy, joint venture economy, and shareholding economy. The government often enters many types of enterprises by injecting capital into them, and its investment forms part of the public capital. This approach therefore underestimates the size of public capital, and the underestimation will grow larger as the new round of SOE reforms progresses in 2003.

In summary, the fourth method of selecting data from the type of investment enterprises is consistent with the definition of public capital, and more in line with the reality. However, this paper believes that changing the registered type of investment into the holding type of investment enterprise can define public investment and public capital more comprehensively. It is a pity that the data of state-holding only appeared after 2003. Given that the difference between "state-owned economy and state-holding" and "state-owned economy" investment accounted for a relatively small proportion of capital before 2003, we use the amount of investment in "state-owned economy" from 1978 to 2002 and the data of "state-owned economy and state-holding" enterprises in fixed asset investment after 2003 to estimate provincial public capital. At the same time, this paper uses the amount of investment in the "state-owned economy" for comparative measurement.

5.2.3. Fixed Asset Investment Price Index

The National Bureau of Statistics published the price index of fixed asset investment from 1991, and the studies before that were constructed by scholars in various ways. With the supplementation and perfection of the data, the *Historical Data of China's GDP Accounting (1952–1995)* published the price index of fixed capital formation at the national and provincial levels. Reference [25] and [27] used this data to calculate the investment price deflator before 1991. "Compare the calculated index for each province from 1991 to 1995 with the provincial fixed capital investment price indices published in the *China Statistical Yearbook* for this period, you will find that they were basically consistent" [25]. Following this approach, this paper calculates the implicit investment price deflator from 1978 to 1990 and uses the fixed capital investment price index published by the National Bureau of Statistics after 1991. The formula used to calculate the investment price deflator is (using 1980 as an example):

$$\begin{aligned} &Investment\ price\ deflator\ in\ 1980\ (1978=1)\\ &=(gross\ fixed\ capital\ formation\ in\ 1980\ (current\ year\ prices)\\ &/\ gross\ fixed\ capital\ formation\ in\ 1978(current\ year\ prices)\\ &/\ gross\ fixed\ capital\ formation\ index\ in\ 1980\ (1978=1). \end{aligned} \tag{21}$$

5.2.4. Depreciation Rate

Based on different data series and statistical methods, scholars vary in calculating depreciation. Some scholars use the accumulation data as the net increase in capital stock in the investment series [29,30,33], and the data have deducted the depreciation amount, but the investment series data are available for a limited period of time. Some scholars directly calculate the depreciation amount, avoiding the calculation of depreciation rate. For example, [34] uses the depreciation of fixed assets in Equation (22) as follows:

$$Y_{IA}(t) = CE(t) + DEPFA(t) + NPT(t) + OS(t), \tag{22}$$

where $Y_{IA}(t)$, $CE(t)$, $DEPFA(t)$, $NPT(t)$, and $OS(t)$ denote income method GDP, labor compensation, depreciation of fixed assets, net production tax, and operating surplus respectively.

Reference [35] uses Equation (23) to calculate the annual depreciation amount from 1978 to 1993; however, this is prone to inconsistency between the depreciation part and the investment series.

$$Dep(t) = Y(t) - NI(t) + SSD(t) - INDTX(t), \tag{23}$$

where *Dep(t)*, $Y(t)$, $NI(t)$, $SSD(t)$, and $INDTX(t)$ denote depreciation, GDP, national income, subsidies, and indirect taxes respectively.

Some other scholars have calculated the depreciation rate. Reference [25] assume that the replacement rate and the depreciation rate of assets are equal under the mode of geometric decline in the relative efficiency of capital goods. They set the service life of assets, calculate the proportion of three types of fixed assets, and then obtain the comprehensive depreciation rate of capital of 9.6%. Reference [36] uses the same method to calculate the comprehensive depreciation rate of 9.2% for infrastructure. However, the problem that can exist in the calculation is that it is not possible to obtain the proportion of construction, equipment, and other costs in the amount of public sector fixed assets investment [2]. Then it is not possible to determine the asset life. Thus, the asset life and the proportion of assets are set empirically. Reference [11] obtained a public capital depreciation rate of 9.28% to estimate the public capital stock, based on the DSGE model. On the other hand, [5] chose a depreciation rate of 9.5% to inventory the public capital, based on a summary of scholars' studies. In summary, referring to the previous research results, this paper adopts a depreciation rate level of 9.28%.

6. Empirical Evidence and Analysis of Results

6.1. Total Capital and Public Capital

6.1.1. Capital Overview

After determining the base period capital stock, investment sequence, investment price index, and depreciation rate according to the perpetual inventory method introduced in Section 4, this paper inventories the total capital, public capital, and non-public capital at the national and provincial levels (see Figure 1 for national data), then calculates the annual growth rate of capital (Figure 2) and the ratio of the two types of capital to total capital (Figure 3). The data sources of the investment series used are: total investment series used for social fixed asset investment, and "state-owned economy" fixed asset investment sequences used for inventorying public capital for 1978–1982, from the "Compilation of Statistical Information on Fifty Years of New China (1949–1999)", 1983–2017, from *China Statistical Yearbook* of the corresponding year. The fixed asset investment sequence of the "state-owned economy and state-holding" used in the inventory of public capital (2003–2017) is from *China Fixed Asset Investment Yearbook*, and the average value of 2012 and 2014 is calculated by interpolation method to fill the 2013 data, due to the data vacancy in 2013. In accordance with the research practice, data from Hong Kong, Macao, and Taiwan are excluded; and data from Tibet are excluded; data from Hainan before 1988 are excluded from Guangdong, and data from Chongqing before 1997 are excluded from Sichuan. Missing data are found from the provincial statistical yearbooks. The capital stock in this article has been converted to the 1978 prices, and the capital amounts involved in this article are reported in 1978 prices.

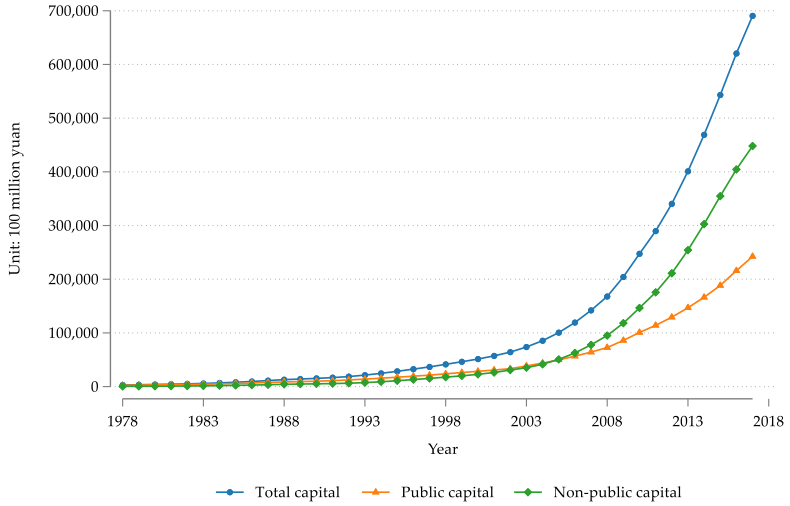


Figure 1. Overview of inventory capital.

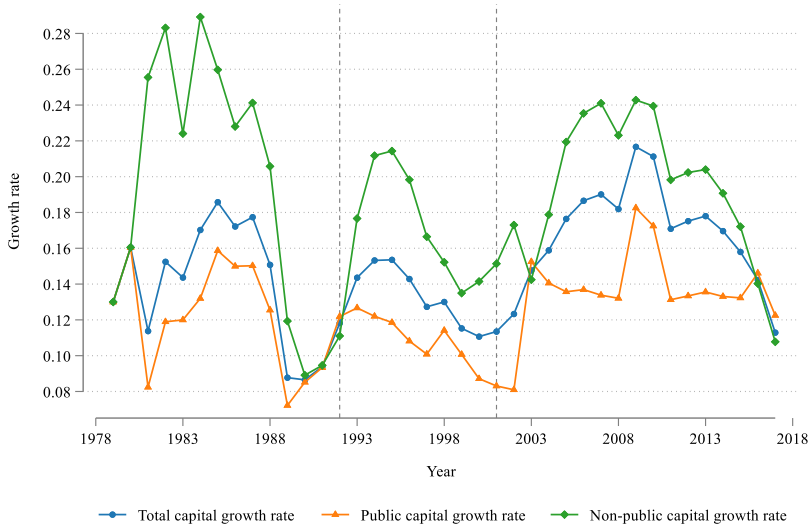


Figure 2. Capital growth rate.

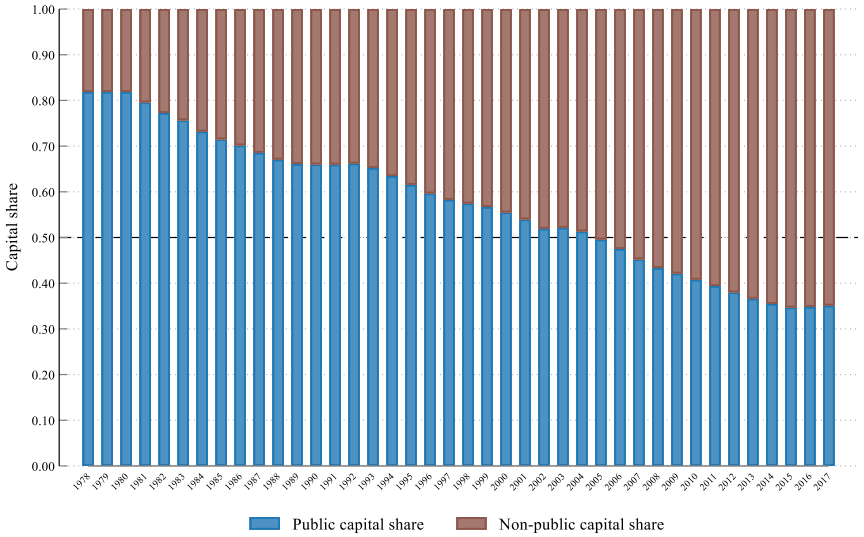


Figure 3. Analysis of capital share.

The change in China's capital followed the footsteps of reform and opening up, as well as the reform of state-owned enterprises. So, according to the timeline of reform, the period from 1978 to 2017 can be divided into "three stages".

The first stage is from 1978 to 1992; that is, from the Third Plenary Session of the Eleventh Central Committee to Deng Xiaoping's "Southern Tour". Economic development focused on releasing market vitality, improving the autonomy of state-owned enterprises, and allowing private enterprises to develop. From Figure 1, the total capital was CNY 305 billion in 1978, and increased to CNY 1,873 billion in 1992. The total capital in 1992 was 5.13 times that of 1978, and the average growth rate over 15 years was 13.83%. Looking at the composition of the two types of capital (Figure 3), in 1978, public capital occupied an absolute advantage, with CNY 250 billion, accounting for 81.88% of the total capital, while non-public capital was only CNY 55 billion, accounting for 18.11%. However, in 1992, the ratio of public capital to non-public capital dropped to about 2:1. The public capital was CNY 1,240 billion, accounting for 66.20%, while the non-public capital increased significantly to CNY 633 billion, accounting for 33.80%. In terms of the growth rate (Figure 2), the average growth rate of non-public capital was 19.01%, much higher than that of public capital, at 12.11%.

The second stage is from 1993 to 2001, when China joined the World Trade Organization (WTO). The reform of state-owned enterprises adopted the policy of "focusing on large state-owned enterprises and releasing small ones"; focusing on the operation of large, state-owned enterprises, flexibly transforming small and medium-sized state-owned enterprises, and focusing on improving the deficit of state-owned enterprises. From Figure 1, the total capital reached CNY 5723 billion by the end of 2001, with an average growth rate of 13.21% in 9 years. In this period, the situation with two kinds of capital, "national retreat and private advance" continued to play out. By the end of 2001, the scale of public capital and non-public capital was CNY 3089 billion and CNY 2633 billion, respectively, accounting for 54% and 46%, with an average growth rate of 10.67% and 17.16%.

The third stage was from 2002 to 2017. In 2003, The State Council established the State-owned Assets Supervision and Administration Commission (SASAC) to prevent the loss of state-owned assets. SASAC strived to establish a clear and definite ownership and modern enterprise system. SASAC also promoted and expanded the mixed ownership of state-owned enterprises. After China's economy entered the new normal in 2014, new issues such as the transformation from "managing assets" to "managing capital", and the optimization of capital structure have been put forward in SOE reform. The total capital reached CNY 10 trillion for the first time in 2005, and non-public capital began to exceed public capital in the same year. By 2017, the total capital volume reached CNY 69,056 billion, with an average growth rate of 16.84% in 16 years (Figures 1 and 2). As can be seen from Figure 2, the annual growth rate of capital in this stage was much higher than that in the first and second stages. Among them, the annual growth rate in 2009 was the largest, increasing by 21.67% compared with 2008, and the growth rate in 2010 was also over 20%. With the arrival of the new normal in 2014, the annual growth rate decreased year by year. The annual growth rates from 2014 to 2017 were 16.96%, 15.79%, 14.23%, and 11.29%, respectively. According to Figure 3, the compositions of the two types of capital at the end of 2017 were exactly opposite to those at the end of 1992. The ratio of public capital to non-public capital was about 1 to 2, with public capital accounting for 35.10% and non-public capital accounting for 64.89%. The average growth rate of the two types of capital was 13.74% and 19.38%. Non-public capital contributed more to the growth rate and scale of total capital because the proportion of non-public capital exceeded that of public capital.

In addition to the above-mentioned phased developments, the changes in the annual growth rates of the two capitals at the time of several economic crises are equally noteworthy (see Figure 2).

First of all, during 1988–1990, the world was faced with adverse situations, such as the collapse of Japan's bubble economy and the transmission of a crisis in 1989; the

political uncertainty brought by the economic reform of the Soviet Union, and the economic blockade of international capitalism against socialism. In China, after 10 years of exploration of reform and opening up, although the economy had achieved rapid growth, serious economic problems emerged, such as the aggravation of supply–demand, the intensification of structural contradictions, inflation, and soaring prices [37]. In such a situation, the increment of domestic capital decreased significantly, from a 15% annual growth rate in 1987 to 8.6% in 1990. Among the two types of capital, the growth rate of non-public capital dropped from 24.12% to 8.91% for a time, and the growth rate of public capital also dropped from 15.02% to 8.52%. However, the decline of public capital was significantly lower than that of non-public capital. As the share of public capital in the total capital is large, it supported the development of national economy at that time.

Second, during the 1997–1998 Asian financial crisis, the growth of non-public capital still showed a significant decrease, with the growth rate decreasing from 19.83% in 1996 to 13.49% in 1999. In contrast, public capital showed a more stable growth trend, maintaining an annual growth rate of 10.59% from 1996 to 1999, and even slightly increasing to 11.40% in 1998. This shows the role of public capital in boosting the economy in the face of economic crisis.

Then, there was the 2007–2009 U.S. subprime crisis, where similarly non-public capital growth fell by two percentage points in 2008, growing at around 24% in 2007 and 2008, while public capital growth was solid, growing at about the same rate in 2007 and 2008. The government then implemented a CNY 4 trillion investment plan in 2009 and 2010, and public capital growth remained high in 2009 and 2010, rising five percentage points from 2008 to 18.26%.

Finally, under the new normal economy in 2014, the growth rate of non-public capital decreased from 19% in 2014 to 10.77% in 2017, while the growth rate of public capital was maintained at about 13.35%, from 2014 to 2017.

In summary, it can be seen that China's capital stock grew by leaps and bounds over the period of 1978–2017. Public capital grew more slowly than non-public capital. The two capital shares changed in reverse, with the public capital share decreasing significantly from 81.88% in 1978 to 35.10% in 2017. However, the growth of non-public capital is more volatile by the market, while the change of public capital is relatively stable. In the face of the unfavorable internal and external market environments, public capital showed a counter-cyclical change in growth, which coincides with the conclusion of the public capital counter-cyclical regulation drawn by [38]. This reflects the "counter-cyclical" nature of economic policy operations and the important policy role played by the public sector in stabilizing markets and boosting the economy.

6.1.2. Inventory of Public Capital vs. Liquidation of State Capital

The public capital inventories of many researchers vary widely, and often one study is compared with another, which tends to cause selective comparisons among studies. The main reason for this is the lack of comparable data. Therefore, in order to test whether the public capital inventory is reasonable, this paper found that China had conducted an appraisal of state-owned assets during the Eighth Five-Year Plan period, covering administrative and public institutions as well as state-owned enterprises, which is in line with the public sector defined in this paper.

According to *China Yearbook of State-owned Assets*, the work of inventory verification of state-owned assets started in 1992. After basic work, trials, and nationwide implementation, by the end of 1995, the work had successfully completed the liquidation and capital verification of 1,076,000 administrative institutions, 302,000 state-owned enterprises, and 24,000 financial enterprises above the county level. It has formed a preliminary understanding of China's state-owned assets and carried out the first work since the founding of the New China. It was the first time that the number of households of enterprises and units was cleared up, property rights were defined, and land was evaluated. Additionally,

state-owned land use rights as state-owned net assets were included in the balance sheet of state-owned enterprises for the first time.

After the liquidation and capital verification, the state-owned assets data in 1995 and subsequent years disclosed in *China's State-owned Assets Yearbook* and *China's Fiscal Yearbook* can accurately present the actual capital scale of China's state-owned assets, which can be used as a benchmark for capital inventory comparison. However, since 2003 in the *China Fiscal Yearbook*, the data of state-owned assets has changed into the data of state-owned enterprises, which is inconsistent with the public capital in this paper. Therefore, this paper makes a comparative analysis of the data of state-owned assets in *China's State Assets Yearbook* and *China's Fiscal Yearbook from 1995 to 2002* with the public capital inventory.

Table 1 shows the difference between the public capital inventoried and the total amount of state-owned assets appraisal data, as well as the ratio of the difference to the state-owned appraisal data (all converted to 1978 prices). It can be seen that, except for the ratio of 3.05% in 1997, the rest of the difference was controlled to within 1%. This shows that the methods and results of public capital inventory in this paper reflect the real asset situation very well.

Table 1. Inventory of public capital versus liquidation of state capital over 1995–2002.

Year	Inventory of Public Capital (1978 Price)	State-Owned Assets Appraisal Data (1978 Price)	Difference ("Inventory of Public Capital" Minus "State-Owned Assets Appraisal Data") (1978 Price)	The Ratio of Difference to Appraisal Data
1995	17,537	17,363	174	1.00%
1996	19,434	19,264	170	0.88%
1997	21,394	20,760	634	3.05%
1998	23,836	23,680	156	0.66%
1999	26,236	26,306	−71	−0.27%
2000	28,522	28,279	243	0.86%
2001	30,892	31,145	−254	−0.81%
2002	33,392	33,637	−245	−0.73%

Unit: CNY 100 million.

6.1.3. Comparison of Public Capital Inventory in Different Investment Sequences after 2003

This paper uses the investment in the fixed assets of the state-owned economy and state-holding, and the investment in the fixed assets of the state-owned economy to inventory public capital after 2003, to make a comparative analysis. By Figure 4, it can be seen that the difference between the two inventories of public capital in 2003 was not large. The public capital inventoried by the state-owned economy and state-holding was CNY 3848 billion in 2003, which was CNY 216 billion more than the public capital inventoried by the state-owned economy (CNY 3632 billion), with the difference accounting for 5.62% of the former. However, as the economy advanced, the gap between the two series of inventoried capital became larger and larger. By 2017, the former was CNY 6815 billion more than the latter, accounting for 28.12% of the public capital inventoried by the state-owned economy and state-holding. This not only shows that the portion of SOEs participating with shares should be emphasized when inventorying public capital, but also shows the continued deepening of mixed ownership and shareholding reforms in the SOE reform process.

6.2. Output Shares

This section regresses capital output on public and non-public capital, using provincial panel data for 30 provinces (excluding Hong Kong, Macao, and Taiwan, and excluding Tibet, due to incomplete data) using Equation (16) in Section 4. The data of the production method GDP is sourced from *China Statistical Yearbook*. The income method GDP data is sourced from: data from 1978–1992, from *China GDP Accounting History 1952–1995*; data from 1993–2004, from *China GDP Accounting History in 1952–2004*; and data from 2005–2017, from *China Statistical Yearbook*.

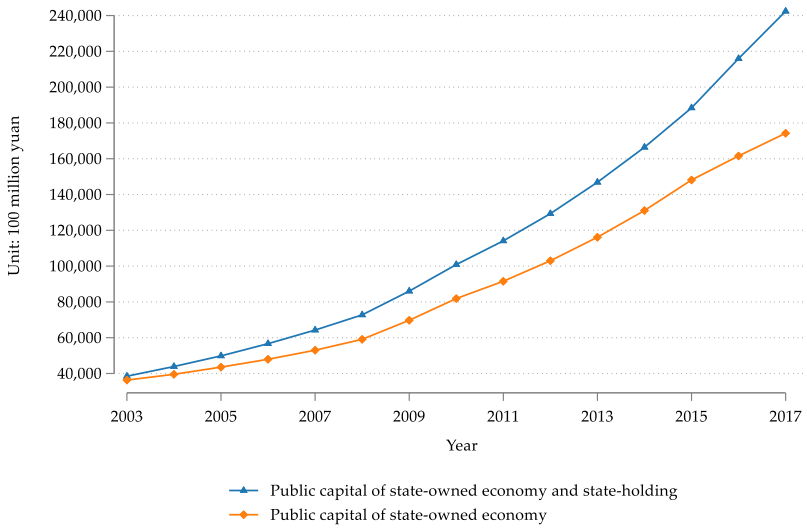


Figure 4. Public capital inventory of different investment sequences in 2003–2017.

Due to the rapid development of China's economy, the growth of capital inputs varies widely from year to year. If the regression study is conducted for the overall 40 years, it yields the expected or average result, which cannot observe the change of shares over time. Therefore, it is necessary to shorten the time window to observe the continuous evolution. If the 40-year time period is regressed in segments (e.g., using the stages of reform and opening up to segmentation), it can well reflect the characteristics of capital output over a certain period, but the regression results between time periods still show large jumps. Therefore, in order to obtain the national average production function for each year from 1978 to 2017, this paper uses cross-sectional data and conducts the regression year by year. The regression coefficient is shown in Table 2, and the output share of each factor is calculated according to Equations (17)–(19) in Section 4, as shown in Figure 5.

Table 2. Capital regression coefficients of the production function.

Year	lnKpub	lnKpri	Year	lnKpub	lnKpri
1978	0.902 ***	0.098 *	1998	0.394 ***	0.606 ***
1979	0.905 ***	0.096 *	1999	0.379 ***	0.621 ***
1980	0.869 ***	0.131 **	2000	0.358 ***	0.642 ***
1981	0.798 ***	0.202 ***	2001	0.306 **	0.694 ***
1982	0.703 ***	0.297 ***	2002	0.279 *	0.721 ***
1983	0.659 ***	0.341 ***	2003	0.287 *	0.713 ***
1984	0.620 ***	0.380 ***	2004	0.303 *	0.697 ***
1985	0.592 ***	0.408 ***	2005	0.328 *	0.672 ***
1986	0.584 ***	0.416 ***	2006	0.303 *	0.697 ***
1987	0.568 ***	0.432 ***	2007	0.314 **	0.686 ***
1988	0.570 ***	0.430 ***	2008	0.336 **	0.664 ***
1989	0.568 ***	0.432 ***	2009	0.338 **	0.662 ***
1990	0.586 ***	0.414 ***	2010	0.374 ***	0.626 ***
1991	0.565 ***	0.436 ***	2011	0.374 ***	0.626 ***
1992	0.542 ***	0.459 ***	2012	0.357 **	0.643 ***
1993	0.473 ***	0.527 ***	2013	0.333 **	0.667 ***
1994	0.455 ***	0.545 ***	2014	0.305 *	0.695 ***
1995	0.442 ***	0.558 ***	2015	0.272 *	0.728 ***
1996	0.402 ***	0.598 ***	2016	0.259 *	0.741 ***
1997	0.406 ***	0.594 ***	2017	0.277 *	0.723 ***

Note: Robust regressions. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

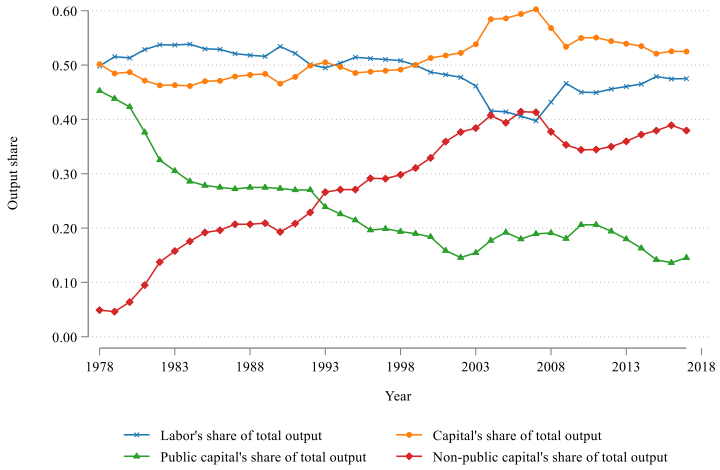


Figure 5. Share of total output.

As shown in Figure 5, during the past 40 years, the average share of labor in China's total output was 48.8%, and the average share of capital in China's total output was 51.2%. The point of divergence between the two factor shares appears in 1999. Before 1999, the labor share was 1to8 percentage points higher than the capital share, except in 1993, when the capital share was 1 percentage point higher than the labor share. After 1999, the share of capital far exceeded that of labor, by more than 20 percentage points at its peak. After entering the new normal in 2014, the two shares showed a trend toward the middle, with the average labor share at 47.3% and the average capital share at 52.7%. Much of the share of output lost to labor has gone to non-public capital. The point of divergence between public and non-public capital occurs in 1993. Before 1993, the share of public capital was larger than that of non-public capital, and the former went down, while the latter fluctuated. After 1993, non-public capital went out of the curve of large fluctuations; unlike it, public capital declined slowly before 2002, and then vibrated up and down after 2002. By 2017, in the national output, the share of public capital was 14.5% and that of non-public capital was 38%.

6.3. Rate of Return

The rate of return to capital calculated by Equation (12) is shown in Figure 6. From 1978 to 2017, the average rate of return to total capital is 19.5%, public capital is 14.41%, and non-public capital is 26.11%. From the trends of the return rates, the three rates of return to capital all show a general trend of decline over time.

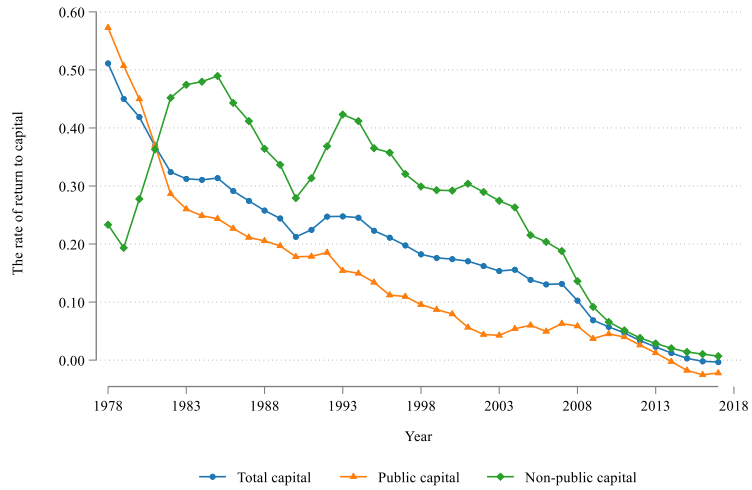


Figure 6. The rate of return to capital.

This is the same as the conclusion that [39] found, where the rate of return to capital showed a trend of gradually decreasing or even turning negative. There are two points to make. First, comparing the numerous literature on return to capital studies, the levels and trends of return rates obtained from researches differ significantly, which are explained by the different estimates of the capital stock and the different scopes covered by the studies [40]. The results of [40] show that return to capital presents a very obvious inertial characteristic, with a significant decline since 2008. Reference [41] focused on the study of the return to capital of industrial enterprises, and believed that the return to capital continued to rise. According to [42], although the rate of return to industrial capital in China is very high, the overall rate of return to capital has a downward trend, which is consistent with the trend of the results calculated in this paper. Secondly, it is widely believed that China's rapid economic growth has largely depended on government investment since the reform and opening up. Therefore, it is natural for some people to wonder how capital can drive rapid economic development if the rate of return to capital continues to decline. The reason for this doubt is that the relationship between "return of capital", "the rate of return to capital", and "the rate of return to investment" has not been clarified. First of all, the decline in the rate of return to capital does not mean the decline in the return of capital. On the contrary, because of the rapid accumulation of capital, the return of capital in China still has a large increase process. Next, as capital accumulates, in general, the capital is greater than the investment in the current year, so that the rate of return to capital is usually lower than the rate of return to investment. The decline in the rate of return to capital does not mean the decline in the rate of return to investment. Rather, the rate of return to investment will still show an upward trend, corresponding to the increase in the added value brought by capital investment in the current year. When the added value of GDP is used to calculate economic growth, it will still show a trend of economic development.

According to Figure 6, we can see the change trend of the rates of return to total capital, public capital, and non-public capital. (1) From 1978 to 1983, the rate of return to total capital and public capital declined sharply, while the rate of return to non-public capital increased sharply. The possible reason for this is that at the beginning of reform and opening up, the public sector invested a large amount of money in infrastructure construction. The rate of return of the projects themselves were low, with long cycles and slow results. Further, state-owned enterprises are not ready to enter the market economy and are still in a backward state of operation. While the market needed a lot of flexible capital to enter, non-public capital could fill these needs. Especially, the nationwide household contracting system carried out in 1980 greatly promoted the accumulation of non-public capital. However, because the initial stock of non-public capital was small, the early rate of return rose sharply, and in 1981, the rate of return of public capital was the same as that of non-public capital. (2) From 1986 to 1990, the rate of return to the three kinds of capital dropped significantly, especially the rate of return to non-public capital, which dropped the most violently. The lack of experience in the exploration of reform and opening up accumulated many economic problems. The economic crisis in neighboring Japan, and the international political and economic blockade, with domestic economic problems, together caused China's national economy to face internal and external difficulties. (3) From 1993 to 1996, the second period of decline in the rate of return to non-public capital occurred, which corresponded to the small peak in the growth rate of non-public capital in Figure 2, as the rate of return declined due to the short-term excess of capital investment. (4) From 2003 to 2008, the rate of return to non-public capital declined significantly in the third paragraph. By contrast, the rate of return to public capital fluctuated around 5.5%. The new round of state-owned enterprise reform launched in 2003 played a certain role. Due to the stability of the rate of return to public capital, the return to total capital did not decrease significantly between 2003 and 2007, remaining between 13% and 15%. (5) From 2009 to 2013, the rates of return to all three types of capital continued to decline and began to converge. The order of the rate of return is as follows: non-public capital is slightly higher than total capital, and the rate of total capital is higher than public capital. The average rates of return to the three kinds of capital

from 2009 to 2013 are: 5.5%, 4.5%, and 3.2%. It is not hard to see that the trend of return rates is consistent with the reality of the CNY 4 trillion plan implemented in 2009–2010, when capital poured into the market to expand the economy, resulting in lower return rates. (6) After entering the new normal economy in 2014, economic growth slowed down. The return to capital fell to a very low level, and even the total capital and public capital showed negative returns after deducting depreciation.

It can be seen that the level of rates of return to capital is closely related to the capital accumulation caused by fiscal policies and the operation of the market economy and is affected by the global economic crisis. The rate of return to non-public capital fluctuates greatly, while the rate of return to public capital is relatively stable. On the whole, the average return to capital of non-public capital is higher than the return to public capital, and there is a convergence between the two returns to capital in 1981 and 2010–2013.

6.4. Test of the Necessary Conditions for Optimal Investment

The scale ratio and share ratio of public capital and non-public capital on both sides in Equation (9) are calculated, and the difference between the two ratios is found, as shown in Figure 7. It was found that the optimal investment condition appeared in 1981, and the difference was also very close to 0 from 2010 to 2013, which is consistent with the convergence of the rate of return to capital in 1981 and 2010–2013 in Figure 6. That is, the two necessary conditions for optimal investment were tested to be equivalent.

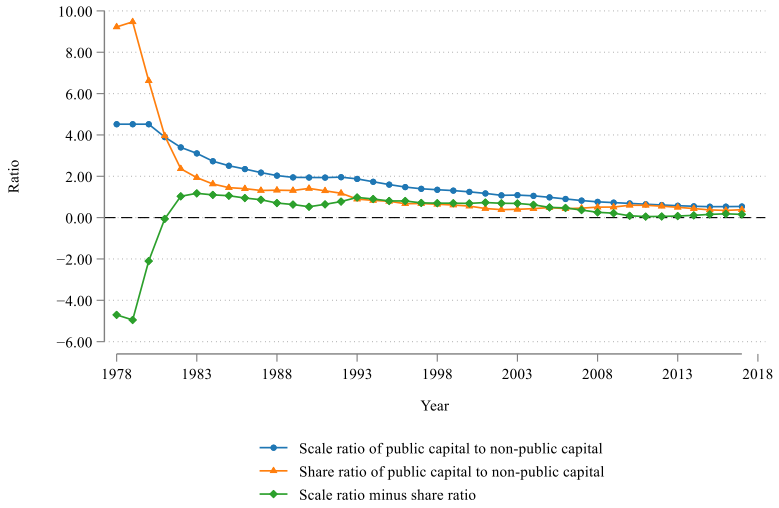


Figure 7. Test of optimal investment condition.

Comparing the two time points, we can see that the former emerged after the nationwide "land lump sum to household" policy launched in the second half of 1980, while the latter emerged after the CNY 4 trillion plan implemented in 2009–2010. The former is that institutional change revitalized the flow of capital property rights and increased the rate of return to non-public capital. The other is that the easing policy made capital abundant enough to enable the market to achieve the necessary conditions for optimal allocation between the public and non-public sectors. However, the large amount of capital accumulated from 2009 to 2013 and the rate of return to capital remained low, reflecting that capital was not fully utilized due to excess investment. The annual growth rate of total capital and non-public capital decreased significantly after 2014 (Figure 2). Economic growth, meanwhile, slowed to 7.4% in 2014 (compared with 10.64% in 2010). Thus, it can be seen that the capital allocation mode of relying on a large amount of capital factors in a short period of time is a double-edged sword. For a period of time, it can cause economic and social benefits to achieve a better state. However, if the system is not innovated and improved upon, and the efficiency of capital use and the level of production technology are not improved, the excessive accumulation of capital will reduce the rate of return, thereby reducing investment and dragging down economic growth.

6.5. Regional Differences in Capital and Return Rates between the East, Central, and West

6.5.1. Capital in the East, Central, and West

After the capital inventory, it can be seen from Figure 8 that the capital in each region increased substantially from 1978 to 2017. The ratio between public capital and private capital was reversed, from being public capital dominated to private capital predominant. The change of capital ratio was especially obvious in the Eastern region, followed by the Central region, and finally the Western region. The ratios of public capital and private capital in the Western region in 2017 were similar.

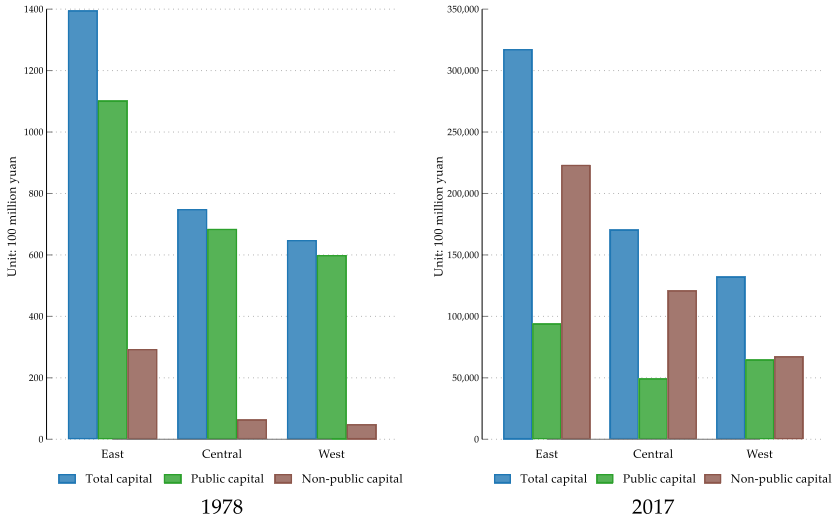


Figure 8. Capital distribution in eastern, central, and western regions.

From the perspective of regional differences in capital between Eastern China and the Midwest region of China (see Figure 9), in the first 20 years of reform and opening up, China's first policy was the rich first leading others, giving priority to the development of the Eastern coastal areas, and capital was also inclined to the Eastern region. At the beginning of 1978, the capital of the Eastern region was approximately equal to the sum of the capital of the Central and Western regions. By 1988, the difference between the total capital in the East minus the total capital in the Central and Western regions was kept within 10% of China's total capital. In 1999, the difference reached a maximum of 26.10% of the total capital in China. In 2017, the ratio dropped to 2.1%. The development of the regional capital difference ratio shows an obvious inverted U-shaped trend.

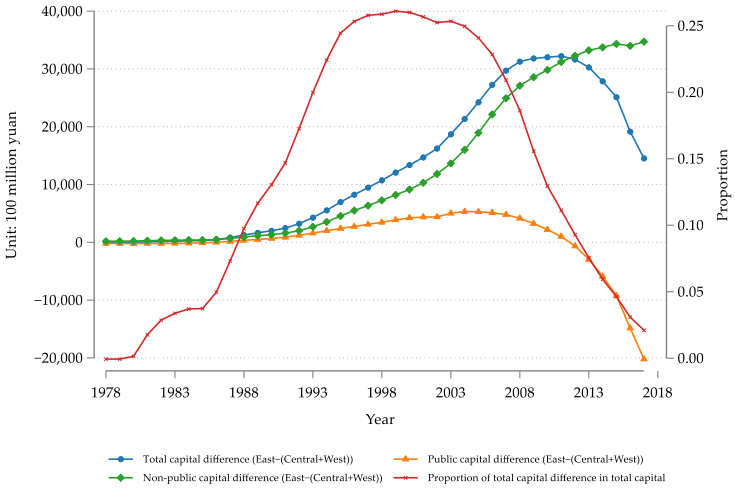


Figure 9. Capital differences (East − (Central + West)).

In terms of the absolute scale of the difference (see Figure 9), the regional difference in total capital showed an increasing trend from 1978 to 2011 and gradually declined until 2012, mainly due to the guidance of various policies. Among them, the policy with greater contribution was the drafting of the "Key points of Western Development", which greatly promoted the construction of infrastructure in Central and Western China. In addition, the Ninth Five-Year Plan for National Economic and Social Development in 2010 proposed to "place more emphasis on supporting the development of the Midwest region and actively work toward narrowing the gap". From the perspective of policy, public capital has undoubtedly played a leading role. From Figure 9, the absolute gap between the regional scale of non-public capital has been expanding, while the gap of public capital has been gradually decreasing since 2005. Until 2012, the difference in public capital between the East and the Midwest was negative, with negative differences gradually expanding over time. The corresponding total capital of the region difference grew slowly from 2005 and began to decline in 2012. This shows that China has increased its public capital investment in the Central and Western regions, and that the imbalance of public capital between regions has been effectively improved. It also means that public capital has played a leading role in balancing capital distribution.

6.5.2. The Rate of Return to Capital in the East, Central, and West

Using the two capital share ratios estimated from the national cross-sectional regression equation, the return levels for each region in the East, Central, and West are calculated using the same methodology as that used to calculate the national return rates. As can be seen from Figure 10, the trend of rates of return to capital in the East, Central, and West regions are basically consistent with the national average return. On the whole, the rate of return to non-public capital is higher than the rate of return to total capital, and the rate of return to total capital is higher than the rate of return to public capital. When the economy develops to a certain stage, the return rates tend to converge, but the differences between the regions are reflected as follows: First, the differences between the rate of return to non-public capital and the rate of return to public capital in the Midwest regions are significantly larger than that in the Eastern region. Second, the convergence of the three capital return rates occurred at different time points. The Eastern region started in 2009, the Central region after 2010, and the Western region after 2009 with still obvious differences. Third, from the perspective of the three types of capital, respectively (see Figure 11), the rate of return to total capital showed a stable phase of convergence between the regions from 1990 to 2008. Before 1990 and after 2008, the return rate of total capital is greater in the East than in the Central region, and greater in the Central region than in the West. The return rate of public capital, from beginning to end, is greater in the East than in the Central region, and greater in the Central region, than in the West, while the return rate of non-public capital is much more variable in terms of regional differences.

In summary, due to early development and a developed economy, the Eastern region has a high overall return, especially with the rate of return to public capital being the highest in the region, followed by the Central and Western regions. The return rate of non-public capital in the Western region is the highest. On the one hand, this shows that non-public capital is less than that in the Eastern and Central regions. On the other hand, it also shows that the economic potential of the Western region is huge. Since 2010, the Eastern, Central, and Western regions have shown a convergence of return to capital, which is similar to the convergence in the whole country, which proves the robustness of the conclusion.

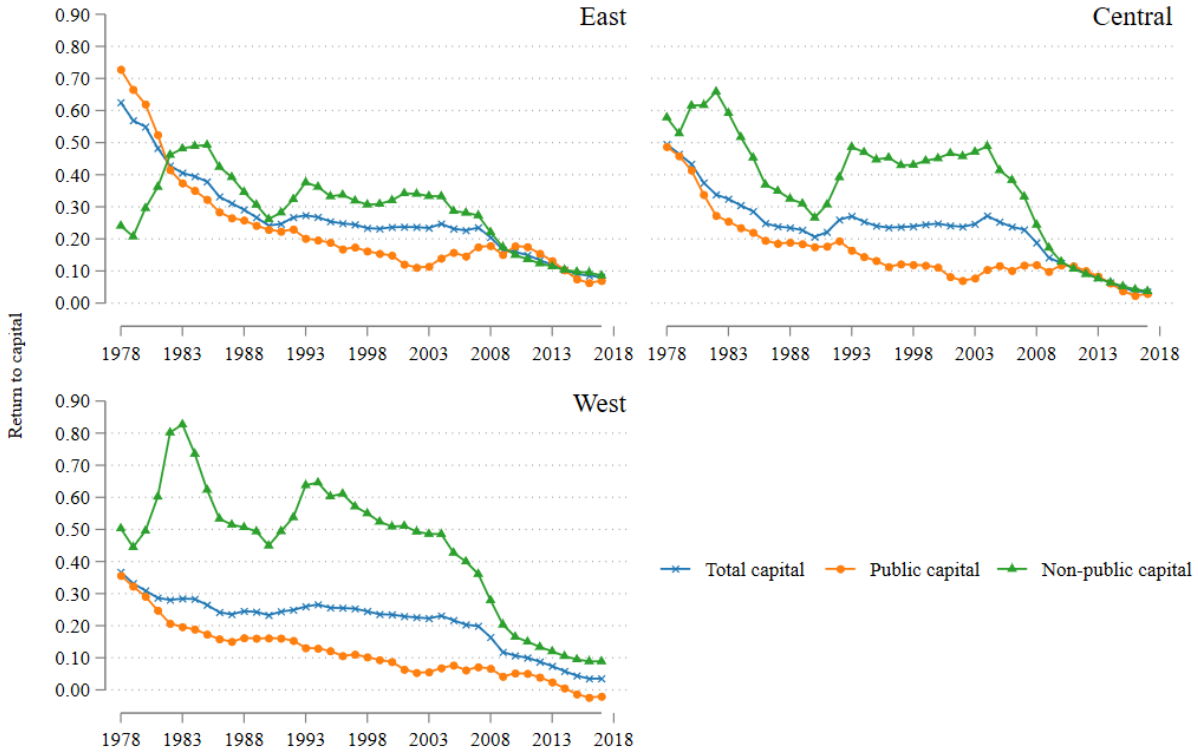


Figure 10. Return to capital in eastern, central, and western regions.

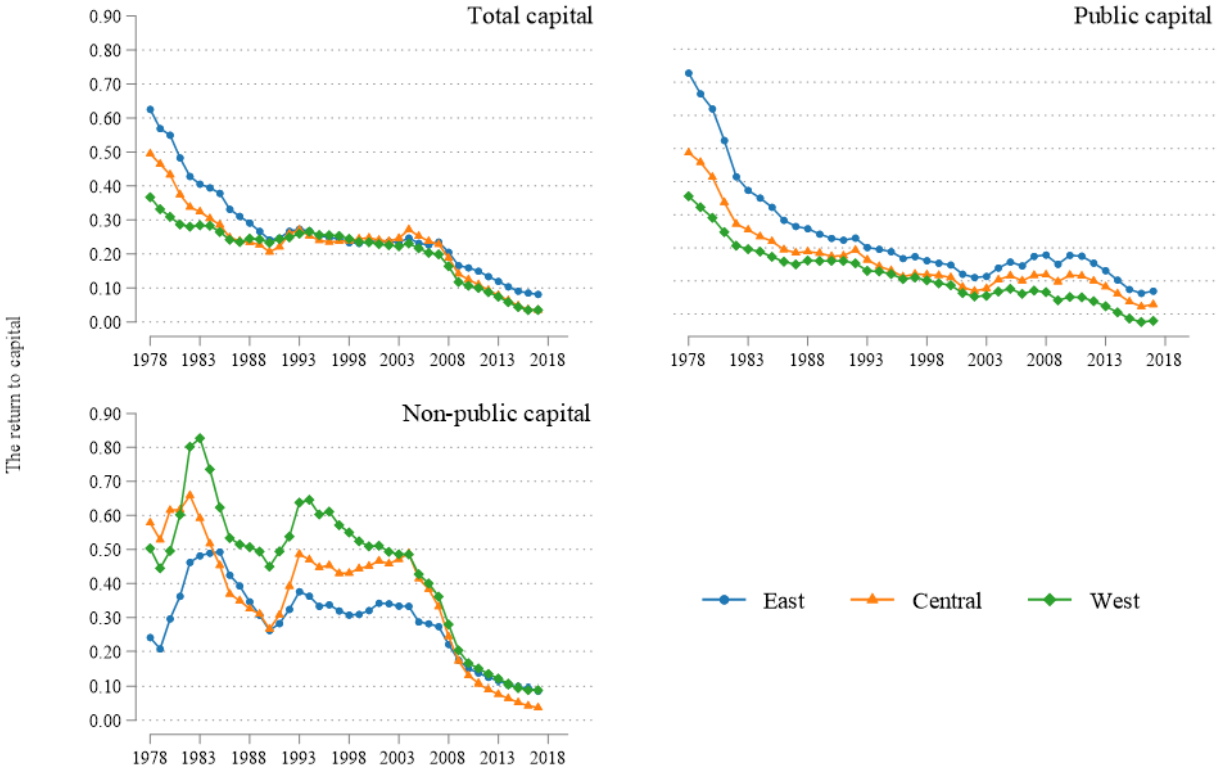


Figure 11. The return to different kinds of capital.

7. Discussion

7.1. Summary and Policy Recommendations

In order to better grasp the process characteristics of public capital since the reform and opening up, this paper inventoried the public capital stock, measured the return rate of public capital, and expounded the change process of public capital and the rate of return from the time and regional dimensions. The main conclusions are as follows: (1) From the perspective of time change, the evolution of capital in China follows the pace of reform and opening up, and the reform of state-owned enterprises. All kinds of capital have grown rapidly since the reform and opening up. The growth of public capital is slower than that of non-public capital, and the share of public capital has fallen sharply, from 81.88% in 1978 to 35.10% in 2017. Compared with the serial inventory data of a pure state-owned economy, it is found that the proportion of state-holding shares is increasing progressively, indicating that the reform of mixed ownership and shareholding system of state-owned enterprises is continuously deepening. (2) From the perspective of the regional differences, the ratio of the capital gap between the Eastern region and the Central–Western regions to the country's total capital has increased year by year from 1978 to 1999. With the policy of developing the Western region in 2001, the proportion decreased step by step, and the absolute scale difference gradually decreased after 2012. Public capital plays an important role in stabilizing the market, boosting the economy, and balancing regional capital distribution. (3) This paper draws some conclusions regarding the rate of return to capital. The average return to capital of non-public capital is higher than that of public capital, but the former fluctuates greatly under the influence of domestic and foreign economy. From 2010 to 2013, the rate of return to capital of the two types of capital converges at a low level. From the regional point of view, the difference between the return rates of non-public capital and public capital in the central-western regions is significantly larger than that in the Eastern region. Due to early development and an advanced economy, the rate of return of public capital in the Eastern region is the highest, while the return rate of non-public capital in the Western region is high, showing great economic potential.

Combined with the research of this paper, we can provide the following policy recommendations: (1) When formulating the policies related to reducing income disparity, the issue of stock or flow capital and the corresponding rate of return should be fully considered. (2) After China's economy entered the new economic normal, due to the excessive accumulation of capital, the rate of return to capital has been hovering at a low level. Only by innovating the system, allocating capital rationally, and by spending more capital on R&D to upgrade technology can China's economy really improve the efficiency of capital use and promote economic growth. (3) In recent years, the reform of state-owned enterprises has put forward the concept of "managing capital" for "managing assets". However, while carrying out this reform, we should pay full attention to the share of public capital in the total capital, giving play to the role of public capital in stabilizing the market, boosting the economy, and balancing the distribution of regional capital. (4) Economic growth points should be tapped, through the development of the Central and Western regions. Authorities should be committed to improving the investment environment in the Central and Western regions. We suggest making use of the regulations, and of talent introduction, infrastructure construction, and industrial layout, to narrow the capital gap between the regions.

7.2. Limitations and Future Directions

This paper has two main limitations. The first is the availability and integrity of data. As the work of inventory verification of state-owned assets has only been carried out for a few years, the public capital after inventory has not been fully calibrated and compared. Due to the limited time available for depreciation related data, this paper can only refer to the previous estimates to select the fixed depreciation rate. The second limitation is that the necessary condition for optimal investment related to the rate of return to capital have been obtained, but whether the condition is sufficient or not has not been verified.

Based on the existing research, this paper summarizes three possible future research directions: (1) How external factors affect the scale of public capital and the return rate of public capital? The external factors, for example, poverty alleviation policies, industrial layout, etc. (2) The impact of the change in the rate of return to public capital on the distribution of wealth and the elimination of income inequality, as well as the mechanism. (3) The impact of changes in public capital and its return rate on the scale and sustainability of government debt.

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References

1. Guo, Q.; Jia, J. The long-term economic growth effect of government public capital investment. *Econ. Res. J.* **2006**, *7*, 29–40.
2. Wu, M.; Zeng, G.; Cao, Y. The efficiency difference of public capital investment among provinces in China and its influencing factors. *J. Quant. Tech. Econ.* **2016**, *33*, 22–40.
3. Ma, S. An empirical analysis of public capital and private sector economic growth in China. *Econ. Sci.* **2000**, *6*, 21–26.
4. Yuan, D.; Han, J. Public capital, inter provincial spillover and technological progress—An Empirical Analysis Based on Panel Cointegration. *China Soft Sci.* **2011**, *2*, 80–90.
5. Chen, B.; Zhang, L.; Cao, Y. Estimation of inter provincial public capital stock and regional allocation. *Econ. Sci.* **2013**, *4*, 26–40.
6. Chen, Z. Estimation and analysis of China's public capital stock and private capital stock. *Public Financ. Res.* **2005**, *9*, 29–31.
7. Zhang, Y. Reestimation and comparative analysis of China's capital stock, public and private capital stock. *Economist* **2010**, *6*, 103–104.
8. Nations, T.U.; Commission, E. *; Organization for Economic Cooperation and Development*; Fund, I.M.; Bank, W. *2008 SNA*; China Statistics Press: Beijing, China, 2012.
9. Organization for Economic Cooperation and Development. *Productivity Measurement Manual*; Science and Technology Academic Press: Beijing, China, 2008.
10. Zhao, Z.; Lv, B. The impact of productive government expenditure on the output-capital ratio: A study based on China's experience. *Econ. Res. J.* **2005**, *11*, 46–56.
11. Zhu, J.; Yao, J. Reestimation of China's public Capital Stock and its Application: A dynamic general Equilibrium perspective. *China Econ. Q.* **2017**, *16*, 1367–1398.
12. Piketty, T.; Yang, L.; Zucman, G. Capital Accumulation, Private Property, and Rising Inequality in China, 1978–2015. *Am. Econ. Rev.* **2019**, *109*, 2469–2496. [CrossRef]
13. Li, Y.; Zhang, X.; Chang, X. *China National Balance Sheet 2013: Theory, Method and Risk Assessment*; China Social Sciences Press: Beijing, China, 2013.
14. Li, Y.; Zhang, X.; Chang, X. *China National Balance Sheet 2015: Leverage Adjustment and Risk Management*; China Social Sciences Press: Beijing, China, 2015.
15. Cao, Y.; Zhong, H.; Liao, S.; Ye, Z. Reshaping the national asset liability capacity. *Financ. Econ.* **2012**, *15*, 84–85,89–93.
16. Ma, J.; Zhang, X.; Li, Z. *Research on China's National Balance Sheet*; Social Science Literature Press: Beijing, China, 2012.
17. Li, Y.; Zhang, X.; Chang, X. *China's National Balance Sheet 2018*; China Social Sciences Press: Beijing, China, 2018.
18. Zhang, Y.; GU, M. Can Public Investment Drive Private Investment: A reappraisal of China's public investment policy. *J. World Econ.* **2011**, *34*, 119–134.
19. Jin, G.; Zhu, D. Public capital in economic growth model. *Econ. Theory Bus. Manag.* **2015**, *5*, 98–112.
20. Turnovsky, S.J.; Fisher, W.H. The composition of government expenditure and its consequences for macroeconomic performance. *J. Econ. Dyn. Control* **1995**, *19*, 747–786. [CrossRef]
21. Bai, C.-E.; Hsieh, C.-T.; Qian, Y. The Return to Capital in China. *Brook. Pap. Econ. Act.* **2006**, *2*, 61–101. [CrossRef]
22. Jorgenson, D.W.; Griliches, Z. The Explanation of Productivity Change. *Rev. Econ. Stud.* **1967**, *34*, 249–283. [CrossRef]

23. Wang, K.; Zeng, W. Further improvement and re measurement of macro accounting method of return on capital. *Stat. Res.* **2020**, *37*, 11–23.
24. Feng, X.; Zhu, Y.; Yang, Q. Research on the Production function of Chinese national Economy based on the variance of human capital distribution. *China Econ. Q.* **2012**, *11*, 559–594.
25. Zhang, J.; Wu, G.; Zhang, J. Estimation of China's inter-provincial physical capital stock: 1952–2000. *Econ. Res. J.* **2004**, *10*, 35–44.
26. Young, A. Gold into Base Metals: Productivity Growth in the People's Republic of China during the Reform Period. *J. Political Econ.* **2003**, *111*, 1220–1261. [CrossRef]
27. Shan, H. Re-estimation of China's capital stock K:1952~2006. *J. Quant. Tech. Econ.* **2008**, *25*, 17–31.
28. Sun, L.; Ren, R. Estimation of capital investment and total factor productivity in China. *J. World Econ.* **2005**, *12*, 3–13.
29. He, J. Estimation of assets in China. *J. Quant. Tech. Econ.* **1992**, *8*, 24–27.
30. Chow, G.C. Capital Formation and Economic Growth in China. *Q. J. Econ.* **1993**, *108*, 809–842. [CrossRef]
31. Xie, Q.; Luo, S.; Zheng, Y. Estimation and reliability analysis of the changing trend of China's industrial productivity since the reform. *Econ. Res. J.* **1995**, *12*, 10–22.
32. Zheng, S.; Sun, W.; Wu, J.; Wu, Y. "Make money with land, Raise land with Money"—Research on investment and Financing Mode of urban construction with Chinese characteristics. *Econ. Res. J.* **2014**, *49*, 14–27.
33. Zhang, J.; Zhang, Y. Reestimation of China's capital stock K. *Econ. Res. J.* **2003**, *7*, 35–43+90.
34. Xu, X.; Zhou, J.; Shu, Y. Estimation of capital stock of tertiary industry in China. *Stat. Res.* **2007**, *5*, 6–13.
35. Li, Z.; Tang, G. Capital Formation path and Capital Stock Adjustment Model: Based on the analysis of China's transition period. *Econ. Res. J.* **2003**, *2*, 34–42+92.
36. Jin, G. Estimation of China's infrastructure capital stock. *Econ. Res. J.* **2012**, *47*, 4–14+100.
37. Li, C. China's economy in 1988: Achievements, Difficulties and Hopes. *Financ. Trade Econ.* **1989**, *5*, 3–8.
38. Ma, W.; Dong, S. Countercyclical regulation, public capital and economic growth. *Econ. Sci.* **2021**, *2*, 5–18.
39. Schmelzing, P. Eight Centuries of Global Real Interest Rates, R-G, and the 'Suprasecular' Decline, 1311–2018. *Bank of England Staff Working Paper.* **2020**, *845*, 1–108. [CrossRef]
40. Bai, C.; Zhang, Q. Analysis of China's return on capital and its influencing factors. *J. World Econ.* **2014**, *37*, 3–30.
41. Liu, X.; Lu, F. The mystery of China's rising rate of return on capital. *China Econ. Q.* **2014**, *13*, 817–836. [CrossRef]
42. Zhang, X.; Xu, J. The remeasurement of Return on capital in China. *J. World Econ.* **2014**, *37*, 3–23.