Public Infrastructure Investment in the Transforming Chinese Economy: A Dynamic General Equilibrium Analysis

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1. Introduction

Although China survived the economic turnmoil that stuck South-east Asia in the second half of 1997 in relatively good shape, the economy was not able to keep the remarkable record in 1998 and 1999.[1] According to the recent release of statistical data, the economy is reported to slow down in 1998: 1) The growth rate of China's GDP was 8.8 percent in 1997 and it was 7.8 percent in 1998; 2) The growth rate of China's export was more than 20 percent in 1997 but it was decreased to 0.5 percent in 1998; and 3) the deflationary pressure is evidented by the negative growth rates of both retail price index (0.8 percent in 1997 and -2.6 percent in 1998) and consumer price index (2.8 percent in 1997 and -0.8 percent in 1998).[2]

Facing the deficiency in internal and external demand,[3] Minister Xiang admitted in a policy address that an active fiscal policy by which spending on infrastructure would be used to stabilize domestic demand (People Daily, August 31, 1998). In his report to the People Congress in March 1999, he stated that PRC would continue to pursue an expanded government spending policy in 1999 to stimulate the economy (Public Finance in China, April 1999 in Chinese). The government was expected to finance the increased spending by issuing tresury bonds. Specifically, half the speical 100 billion Chinese Yuan (US$ 12 billion) bond issue approved by the National People's Congress Standing Committee in August 1998 was used in the first two quarters of 1999 to fund infrastructure developemnt. Another 60 billion Chinese Yuan of state debt was issued in the second half of 1999 to fund additional investment. The State Development Planning Commission estimated that debt-funded investment spending reached 200 billion Chinese Yuan in 1999 and contributed two percentage points to GDP growth (Business China, "Whatever it takes", Jan 17, 2000).

The contribution of public investment in infrastructure has been received attention by economists in the literature. Empirical testing of the significance of public investment has been conducted the literature, Aschauer (1989)(using U.S. states data), Morrison and Schwartz (1996) (also using U.S. states data), Canning and Fay (1993) (using data from 95 developing countries), Datt and Ravallion (1998) (using Indian states data), Lau and Sin (1997) (using U.S. aggregate time series data), and Crihfield and Panggabean (1995) (using U.S. states and metropolitan areas data), showing that public infrastructure plays an important role in economic growth and productivity improvement. Given its importance, analytical models are formulated to investigate the implications of public infrastructure in a dynamic framework. Barro (1990) derives the effect of tax-financed government services that affect production or utility by using an endogenous growth model. An increase in utility-type expenditure is shown to increase the growth rate while an increase in productive government expenditure can only initially increase the growth rate. Buffie (1995) investiagtes the short- and long-run effects of cutting investment in social infrastructure in a simple perfect foresight model. He shows that the private capital stock always declines in the long run although the reduction in public investment may be partly offset by a surge in private investment in the short

[1] Recession in the region significantly affects the economy's export performance and her capital inflow because of two reasons. First, two-fifths of China's exports are to other parts of Asia and three-fifths of of foreign investment in China comes from within the region (see Economist, v.346, p15, "China's coming recession"). Second, China has decided not to devalue the yuan while currencies in the rest of Asia have collapsed. A strong yuan decreases the competitiveness of China's export but increase the cost of investment in China.

[2] It is reported that (Far Eastern Economic Review, Jun 10, 1999, "Deflationary Drift") China's retail price index declined 3.1 percent in the first four months of 1999, compared with a year earlier. Rising inventories and sinking corporate profits have sparked price wars in serval industroes.

[3] A sharp cut in interest rate may not be feasible in China. As the big four state banks are technically insolvent because of the poor quality of bank loans to state-owned enterprises, decreasing lending rates without cutting deposit rates would further damage their profitability. Lowering deposit rates may tempt depositors to take their money out of the banking system (see Economist, "Let it slide", Jan 9, 1999).

run. On the other hand, he further shows that inflation rate may decrease in the short run while it is likely to increase in the long run when the productivity of social infrastructures is comparable to or above that of private capital. Rioja (1999) derives the gorwth and welfare implications when additional resources are devoted to infrastructure investment and concludes that public investment in infrastructure can payoff in terms of sizable increases in GDP and private investment.

The objective of this paper is to derive the implications of a debt-financed public investment in infrastructure in China. To provide an analysis of the policy issue, we follow the methodology adopted by Byrd (1989), Bennett and Dixon (1995 and 1996), Brandt and Zhu (1995), Fung, Ho, and Zhu (2000), to build a macrotheoretic model based on the existing analytical framework in such a way that it sufficiently characterizes the Chinese economy in transition. To carry out the intended analysis, we modify the framework by incorporating three important institutional features of the Chinese economy. First, there is a dual system in commodity production: a group of efficient private firms and a group of inefficient state-owned enterprises. The state sector is relatively large, measured either by the number of emplyees or the amount of resources it commands. However, when compared with the non-state sector, it is extremely inefficient.[4] Second, the financial sector is dominated by the state-banking system which are being heavily regulated in terms of setting interest rates and allocating bank loans(Allsopp, 1995). Third, the state banking system in China serves as a quasi-fiscal institution which effectively taxes depositors and subsidizes the state-owned enterprises (Naughton, 1995).

Utilizing a dynamic general equilibrium model, we study the implications of public investment in infrastructure in the transforming Chinese economy. We show that an increase in debt-financed public investment in infrastructure is not necessarily growth enhancing in the long run. As the public investment is financed by government bonds, the amount of investment funds avaliable to both state and non-state sectors is reduced. This crowding out effect reduces the capital invetsment in both state and non-state sector and then the output growth rate of the economy may not be increased by this debt-financed public investment although more availability of infrastructure has a positive effect on the economy wide productivity.

Other than the effect of an increase in public investment on the economy, we derive how the allocation of public investment in infrastructure among state and non-state sectors affects the macroeconomic performance of the economy. Given the dual structure in production in China, the type or location of public investment may be sector specific, e.g. public investment in heavy inductry or in the Western/Northeastern part of the country may benefit state sector more while public investment in light industry or in the Southern/Coastal region of the country may benefit private sector more. Accordingly, we assume that public capital goods are classified into three groups. The first type of public capital supplies public intermediate inputs to both state and private sectors while the other two types supply public intermediate inputs to state and private sectors repsectively. Under this assumption, we derive the effects of reallocation of public investment between the two sectors. As the financial markets in China are only partially reformed, most of the financial resources are chanelled to state setor. We show that this institutional feature significantly affects how the reallocation of public investment may affect the economy. Although it is suggested that government should give less support to the less efficient state sector, we show that a reduction in the allocation of public investment in infrastructure to state sector sector may be growth enhancing when entrepreneurs in non-state sector are not facing binding internal financial constraints. It is the case because entrepreneurs can invest more as the wage rate is reduced by this policy change.

[4]Between 1979 and 1993, the real growth rate of the gross output in the non-state sector averaged 18.7 percent, about two times higher than that observed in the state sector. Moreover, total factor productivity growth in the non-state sector for the same period was also significantly faster than that estimated for the state sector (see Brandt and Zhu, 1995).

However, the same policy may reduce the output growth rate of the economy when the entrepreneurs cannot increase their capital investment because of binding internal financial constraints. We also derive the effects of an increase in the allocation of public investment in infrastructure to non-state sector. We show that this policy change necessarily increases the output growth rate and reduces the inflation rate when the entreprenuers in the sector are not facing binding internal financial constraints. However, it may not be the case if the entrepreneurs in non-state sector cannot invest more because of those binding internal financial constraints.

The rest of the paper is organized as follows. In section 2 the model is specified. Section 3 chacterizes the agents' optimization problems, the general equilibrium, and the balanced growth path of the model economy. Section 4 provides the major results and intuitions. Some concluding remarks are provided in Section 5. The derivations of our analytical results are in the appendix.

2. The Model

2.1. Agents, Preferences, and Production Technology

Consider an economy inhabited by an infinite sequence of overlapping generations of individuals. Time is discrete and indexed by $t = 0, 1, 2, 3, \cdots$. At the beginning of each period, a set of individuals of measure one are born. Each individual lives for three periods. When young, each individual is endowed with a single unit of labor and inelastically supplies it to a perfectly competitive labor market. Let W_t denote the nominal wage rate prevailing in the labor market in period t.[5] Using the labor income earned, at the end of the first period of their lives, the young individuals make their portfolio decisions. At the end of the second period of their lives, the middle-aged individuals collect returns from their portfolios. When they are old, the individuals do nothing but consume their saving.

The individuals of the same generation are heterogeneous in their ability in organizing production processes (i.e., setting up and managing individual firms for commodity production). There are two types of individuals in each generation: a measure of θ individuals are endowed with the production-organizing ability, and the rest do not possess such ability. Hereafter, the first type will be referred to as the entrepreneurs (indexed by a superscript e), and the second type will be referred to as the non-entrepreneurs (indexed by a superscript n).

The individuals of all generations have identical preferences about consumption. For simplicity, it is assumed that individuals value consumption only when they are old.[6] The preferences of an individual of generation t are characterized by the utility function

$$U^{t,i}(C_t^{t,i}, C_{t+1}^{t,i}, C_{t+2}^{t,i}) = C_{t+2}^{t,i}, \qquad i = e, n, \qquad \forall\, t \geq 1. \tag{1}$$

Note that the first superscript indicates which generation the individual belongs to, the second superscript indicates his type, and the subscript indicates which period the individual lives in. Since the individuals value consumption only when old, they save their labor income earned in the first period of their lives by holding money, bank deposits, government bonds, and/or the regular capital good in the second period of their lives. In addition, as consumption must be paid in cash, the old individuals finance their consumption by the cash balances carried over from the second period of their lives.

[5] Even though in the state sector wage rates are determined administratively, they can be viewed as if they are determined by the market. This is because since 1979 the growth rates of wages in the state sector have been maintained at the same level as those in the non-state sector, which are determined in the labor market. See Brandt and Zhu (1995) for detailed discussion as to how and why.

[6] This assumption is required to simplify the problem so that analytical solutions can be obtained. With this simplifying assumption, the consumption-saving decision of individuals are assumed away. As for how changing this assumption affects our results, see the appendix for a detailed discussion.

There are three types of commodities being produced in the economy: a non-storable consumption good, a regular capital good and public capital goods. Firms which have access to the production technology can produce the consumption good by combining the services of labor and the regular capital good, and the public intermediate inputs. The two types of capital goods are produced according to the same investment technology which converts one unit of the current-period consumption good into one unit of the next-period capital good without using the inputs of labor effort. It is assumed that every individual has access to the investment technology that produces the regular capital good, but only the government has access to the investment technologies that produces the public capital goods. The regular capital good is excludable which can be used in the production of the consumption good of an individual firm (a private firm or a state-owned firm) only. All public capital goods can promote the improvement of the economy-wide technological level and thus benefit all firms. However, among the public capital goods, some of them can generate sector-specific public intermediate inputs supplied to the production of the state-owned enterprises and the private firms, respectively. The use of the public intermediate inputs are nonrival and nonexcludable among the firms within the same sector. For simplicity, it is assumed that both the regular and public capital goods depreciate completely after the production processes of the consumption good have completed.

The markets for trading the consumption good and the regular capital good are perfectly competitive. Let P_t and P_t^k denote respectively the market-determined nominal prices of the consumption good and the regular capital good. As the use of the regular capital good is exclusive and it depreciates completely after the completion of the production of the consumption good, the nominal prices of the regular capital good and the consumption good are identical, $P_t = P_t^k$. Since the public capital goods are nonrival and nonexcludable, there is no market for the public capital goods, and they are provided by the government to its residents free of charge, Given the investment technology, the cost of constructing a unit of the public good is equal to P_t.

By the nature of ownership, there are two types of producers in the consumption good industry: private firms (indexed by a superscript p) owned by the entrepreneurs and state-owned enterprises (indexed by a superscript s) owned by the government. In the state sector there is a measure of one firms, whereas there is a measure of θ firms in the private sector. Production of the consumption good requires the input of the regular capital, labor effort, and the public intermediate input. Assuming that there is a time lag of one period in building up the stocks of the two types of capital goods. In order to produce the consumption good in period $t+1$, at the end of period t, each individual firm must install the regular capital good for its own use; and the government must construct the public capital good for the economy. It is assumed that the capital goods must be paid when purchases are made but workers are paid only after the production processes are completed. That is, there exists a cash-in-advance (liquidity) constraint on constructing capital but not on hiring labor.

The technology for producing the consumption good is characterized by the following production function:

$$Q_t^i = Q(k_t^i, l_t^i, H_t, k_t^g) = A^i {k_t^i}^{\sigma} {l_t^i}^{1-\sigma} H_t^{\gamma(1-\sigma)} G_t^{i(1-\gamma)(1-\sigma)}, \quad i = p, s, \quad \sigma \in (0, 1), \quad \gamma \in (0, 1), \quad (2)$$

where $A^i > 0$ is the time-invariant productivity parameter, k_t^i and l_t^i are the inputs of the regular capital good and labor of the firm, H_t is an indicator of the economy-wide technology level in period t, and G_t^i is the public intermediate input to sector i provided by the government in period t. It is assumed that $A^p = A$ and $A^s = \alpha A$, where $\alpha \in (0, 1]$. The evolution of H_t is assumed to be determined by the stock of regular capital good accumulated in the private sector and the stock of the public capital good in the economy in period t. Formally,

$$H_t = \theta k_t^p + k_t^g. \quad (3)$$

That is, only the augmentation of the regular capital good in the private sector and the public capital good can generate a positive external effect on the productivity of the whole economy.[7] For simplicity, it is assumed that they affect H_t in a linear way.

The private and state sectors are free to use the public intermediate inputs in the production of the consumption good. In period t, there are k_t^g units of the public capital good in the economy which were invested by the government at the end of period $t-1$. Some of the public capital goods are assumed to be sector-specific. The public capital goods can be classified into three groups. First, there are k_t^{gp} units of public capital that can generate $G_t^p = \delta_p k_t^{gp}$ units of public intermediate input that are for the private firms only. Second, there are k_{t+1}^{gs} units of public capital that can generate $G_t^s = \delta_s k_t^{gs}$ units of public intermediate input that can only be used by the state-owned firms. Third, the remainder $k_t^g - k_t^{gp} - k_t^{gs}$ units of the public capital goods do not generate public intermediate inputs; they do not enter the production function of any sector directly, while affecting the production of the firms through its effect on the evolution of technology of the economy. It is assumed that δ_p and δ_s are positive parameters that are constant over time.

2.2 The Financial Sector and Fiscal Arrangement

In the economy, there are three types of financial assets: money, bank deposits, and government bonds. The government monopolizes the allocation of financial resources by retaining the rights of bond-issuing and by controlling the banking system through a central bank.

At the end of period t, the government issues bonds for financing the investment of the public capital goods that will be used in period $t+1$; and the commercial banks accept the deposits from the young individuals and make loans to state-owned enterprises. Once bonds are purchased, they cannot be redeemed until the end of the next period. Similarly, once bank deposits are made, they cannot be withdrawn until the end of the next period. Since there is a cash-in-advance constraint on the purchases of the consumption good, and saving in forms of bonds and bank deposits will be illiquid for one period, at the end of period t, only the young individuals will purchase government bonds and deposit their labor income into the commercial banks.

Let B_t denote the quantity of government bonds issued at the end of period t. The investment of k_{t+1}^g units of the public capital goods is financed by the receipt from issuing the bonds, $P_t^k k_{t+1}^g = B_t$. In each period, the government determines the stock and allocation of the public capital goods which it provides to the economy. Thus, the share of the economy's aggregate supply of the consumption good purchased by the government in period t for the production of the period-$t+1$ public capital goods, $\lambda_t \equiv \frac{k_{t+1}^g}{Q_t}$, and the shares of the public capital goods allocated to the state sector and the private sector, $\lambda_{st} \equiv \frac{k_{t+1}^{gs}}{k_{t+1}^g}$ and $\lambda_{pt} \equiv \frac{k_{t+1}^{gp}}{k_{t+1}^g}$ respectively, are the choice variables of the government. It is noted that $0 < \lambda_t < 1,\ 0 < \lambda_{st} < 1,\ 0 < \lambda_{pt} < 1,$ and $\lambda_{st} + \lambda_{pt} \leq 1$.

Let D_t^e and D_t^n denote the amount of bank deposits held by the representative entrepreneur and non-entrepreneur in period t, respectively. Moreover, let $D_t = \theta D_t^e + (1-\theta) D_t^n$ denote the total amount of bank deposits held by the young individuals and L_t the total amount of bank loans made by the banking system in period t. Given that bank deposits are the only source of loanable funds of the state banking system, the liquidity constraint faced by the system is $D_t \geq L_t$.

[7] The assumption that $A^p = A$ and $A^s = \alpha A$ where $\alpha \in (0, 1]$ is made to capture the fact that in China the state-owned enterprises can be either less efficient than or equally efficient to the private firms in production. In addition, the assumption that $H_t = \theta k_t^p + k_t^g$ is made to capture the following two facts in China. First, the private firms are relatively more efficient than the state-owned enterprises in learning by doing (e.g., adapting to a fast changing environment and adopting modern technologies and advanced management techniques). Second, infrastructure investment is important to economic development. Dasgupta (1999, p.360) cited the World Bank Development Report (World Bank, 1994) that the estimated annual economic costs of inadequate transport infrastructure in China is at least 1% of its GNP.

As the financial sector is monopolized by the government, it is the central bank that sets the nominal interest rates on bonds (i_t^b), bank deposits (i_t^d), and loans (i_t^L). The nominal interest rate on bonds is set to be higher than that on bank deposits (i.e., $i_t^b > i_t^d$).[8] In this case, the young individuals would prefer bonds to bank deposits. Given that B_t is less than the desired aggregate bond holdings of the young individuals, each young individual is allowed to purchase b_t units of government bonds. In other words, the purchase of government bonds is "quantity-rationed".[9]

It is assumed that only state-owned enterprises can take loans from the commercial banks and that private firms have no access to the loanable funds.[10] The government subsidizes the state-owned enterprises by lowering their borrowing costs. The interest rate on loans, i_t^L, is lower than that on bank deposits, i_t^d.[11] In addition, it is assumed that the interest rate on loans i_t^L is set so low that there is an excess demand for bank loans. Given that the state banking system faces the liquidity constraint, $D_t \geq L_t$, it chooses $D_t = L_t$ and imposes credit rationing such that each of the state-owned enterprises can obtain L_t units of bank loans. As the investment undertaken by state-owned enterprises is financed by bank loans only, the investment level of the state sector is constrained by the quantity of loanable funds available in the banking system, D_t.

Since the nominal interest rate charged on bank loans is lower than that on bank deposits, the interest payments from the state-owned enterprises to the commercial banks, $L_t\, i_t^L$, are not sufficient to cover the commercial banks' interest payments on deposits, $D_t\, i_t^d$. The loss of the banking system in period $t+1$ is then given by $D_t\,(i_t^d - i_t^L)$. In addition to financing this loss, at the end of period $t+1$, the government must redeem the outstanding government bonds, $B_t(1+i_t^b)$. One source of government revenues is the two types of taxes levied on residents: the labor income tax and corporate income tax. The two types of nominal tax rates are denoted by τ^l and τ^c, respectively. It is assumed that only private firms are subject to the corporate income tax. The state-owned enterprises are not subject to any taxes, but they must submit all of their profits to the government. The tax revenue collected in period $t+1$ is

$$T_{t+1} = \tau^l\, W_{t+1} \,+\, \tau^c\, \theta\, \Pi_{t+1}^p, \tag{4}$$

where Π_{t+1}^p is the profit of each private firm in period $t+1$, The government's budget constraint in period $t+1$ is given by

$$\Pi_{t+1}^s \,+\, T_{t+1} + M_{t+1} \,-\, M_t \,=\, D_t\,(i_t^d - i_t^L) \,+\, B_t\,(1+i_t^b), \tag{5}$$

where Π_{t+1}^s is the total profit of the state sector, and M_t and M_{t+1} are the end-of-period money stock of the economy in period t and $t+1$, respectively.[12] If the revenues collected from the profits of the state-owned sector and taxes are not enough to cover the loss of the banking system and

[8] According to the structure of interest rates for 1989-1994 reported by World Bank (1995), the interest rate on bonds was higher than that on bank deposits in the period of study.

[9] In China, when inflation runs high, each year the government will supply a fixed amount of bonds to the public. In recent years, secondary markets have been developed for trading bonds. As modeled here, the individuals are not allowed to trade bonds in secondary markets. As discussed in the appendix, relaxing the assumption will not affect the results derived in the paper.

[10] In China, firms in the non-state sector are subject to hard budget constraints and must rely on self-financing for their investment projects. See McKinnon (1994) for a detailed discussion.

[11] It is consistent to what McKinnon (1994) reported in the period of 1980-1991. According to Brandt and Zhu (1995), for the period between 1981 and 1993, the average real interest rate for one-year working capital loans was 0.73% and for one-year fixed investment loans was 1.29%. Taking into consideration the lack of loan repayment enforcement and the possibility of loan forgiveness, the effective real interest rate on loans was even lower.

[12] The expressions for Π_{t+1}^p and Π_{t+1}^s which will be described in detail in Section 3.1.

the redemption of the government bonds, the government will finance its deficit by printing more money, $M_{t+1} - M_t$.[13]

3. Optimization, Equilibrium, and Balanced Growth

3.1. Optimization Problems

Let us consider the entrepreneurs' optimization problem first. At the end of period t, taking as given the the after-tax labor income, $(1-\tau_t^l)\,W_t$, the nominal price of the capital good, P_t^k, the nominal wage rate, W_{t+1}, the nominal price of the consumption good, P_{t+1}, the interest rates i_t^d and i_t^b, the bond subscription b_t, the tax rate τ_{t+1}^c, the economy-wide technology level, H_{t+1}, and the government's supply of the public intermediate input to the private sector, G_{t+1}^p, the representative entrepreneur of generation t chooses k_{t+1}^p, l_{t+1}^p, and D_t^e to solve the following optimization problem.

$$\max_{k_{t+1}^p, l_{t+1}^p, D_t^e} (1-\tau_{t+1}^c)\,\left[\,P_{t+1}\,Q\,(\,k_{t+1}^p,\,l_{t+1}^p,\,H_{t+1},\,G_{t+1}^p)\;-\;W_{t+1}\,l_{t+1}^p\,\right]$$

$$+[(1-\tau^l)W_t - b_t - P_t k_{t+1}^p\,](1+i_t^d) + b_t(1+i_t^b),$$

subject to

$$Q(k_{t+1}^p, l_{t+1}^p, H_{t+1}, G_{t+1}^p) = A\,{k_{t+1}^p}^{\sigma}\,{l_{t+1}^p}^{1-\sigma}{H_{t+1}}^{\gamma(1-\sigma)}{G_{t+1}^p}^{(1-\gamma)(1-\sigma)},$$

and

$$(1-\tau_t^l)\,W_t \geq b_t + D_t^e + P_t^k\,k_{t+1}^p. \tag{6}$$

Note that as reflected by the liquidity constraint (6), the representative entrepreneur has no access to the external funds and must finance the project internally. Hence, the production decision and the portfolio decision of each entrepreneur are jointly determined. Since the nominal rate of return on money is equal to zero, no young individual will hold money, and thus the liquidity constraint (6) is always binding. That is, $D_t^e = (1-\tau_t^l)\,W_t - b_t - P_t^k\,k_{t+1}^p$.

At the end of period $t+1$, the representative entrepreneur of generation t receives $(1-\tau_{t+1}^c)\Pi_{t+1}^p$ as a dividend payment, where $\Pi_{t+1}^p = P_{t+1}\,Q\,(\,k_{t+1}^p,\,l_{t+1}^p,\,H_{t+1}\,G_{t+1}^p) - W_{t+1}\,l_{t+1}^p$ is the before-tax profit of the representative private firm. Thus, the representative entrepreneur has a cash balance of

$$m_{t+1}^e = (1-\tau_{t+1}^c)\Pi_{t+1}^p + b_t(1+i_t^b) + D_t^e(1+i_t^d). \tag{7}$$

In period $t+2$, he can consume $C_{t+2}^{t\,e}$ units of the consumption good where $C_{t+2}^{t\,e} = \frac{m_{t+1}^e}{P_{t+2}}$.

In the absence of the private capital investment decision, the optimization problem for the non-entrepreneurs is degenerated. Because no young individual will hold any money, at the end of period t, the representative non-entrepreneur holds b_t units of bonds and has a deposit balance of $D_t^n = (1-\tau_t^l)\,W_t - b_t$. At the end of period $t+1$, the individual has a cash balance of

$$m_{t+1}^n = [(1-\tau_t^l)\,W_t - b_t](1+i_t^d) + b_t(1+i_t^b). \tag{8}$$

In period $t+2$, he can consume $C_{t+2}^{t,n}$ units of the consumption good where $C_{t+2}^{t,n} = \frac{m_{t+1}^n}{P_{t+2}}$.

[13] Brandt and Zhu (1995) quantitatively identify that the underlying link between the cyclical growth pattern of the Chinese economy and the behavior of the state-owned enterprises is the government's use of the financial system to transfer resources from the non-state sector to the state sector so as to equalize the benefits of economic reforms. In the process, money supply is endogenously determined by the transfer requirement, which is a function of the government's commitment to protect the state sector.

The objective of the representative state-owned enterprise is to maximize its profit subject to the technological constraint and the liquidity constraint, taking as given the market wage rate, prices of goods and the government's provision of the public intermediate input to the state sector.[14] The optimization problem of a representative state-owned enterprise in period $t+1$ is

$$\Pi^s_{t+1} \equiv \max_{k^s_{t+1}, l^s_{t+1}} \; P_{t+1}\, Q(\,\alpha,\, k^s_{t+1},\, l^s_{t+1},\, H_{t+1}\, G^s_{t+1}\,) \;-\; L_t(1+i^L_t) \;-\; W_{t+1}\, l^s_{t+1} \tag{9}$$

subject to

$$Q(k^s_{t+1}, l^s_{t+1}, H_{t+1}, G^s_{t+1}) = \alpha A {k^s_{t+1}}^{\sigma} {l^s_{t+1}}^{1-\sigma} {H_{t+1}}^{\gamma(1-\sigma)}\, {G^s_{t+1}}^{(1-\gamma)(1-\sigma)},$$

and

$$L_t = P^k_t\, k^s_{t+1}. \tag{10}$$

The strict equality in (10) implies that the cash-in-advance constraint always binds, given the existence of credit rationing. It is noted that Π^s_{t+1} is positive even though the production of the state sector is relatively less efficient than the private firms. The positive profit is created by the government's loan subsidization, $i^L_t < i^d_t$. McKinnon (1994) refers to this phenomenon as "hidden deficit". As will be described in the appendix, the hidden deficit occurs if the condition $\frac{1+i^L_t}{1+i^d_t} < \alpha^{\frac{1}{\sigma}}\delta < 1$ is satisfied. Hence, it is assumed that this condition holds hereafter.

3.2. Market Equilibrium

In equilibrium, three conditions must be satisfied in each period. First, taking as given the market prices and government policies, each agent (an individual or a firm) solves his optimization problem. Second, the government's budget constraint is balanced. Third, all markets are cleared. The market-clearing conditions for the economy in period t are

the labor market: $$l^s_t \;+\theta\, l^p_t = \; 1, \tag{11}$$

the consumption-good market: $$\theta\, C^{t-2,e}_t + (1-\theta) C^{t-2,n}_t + I_t = \theta\, Q^p_t + Q^s_t, \tag{12}$$

the capital-good market: $$\theta\, k^p_{t+1} + k^s_{t+1} + k^g_{t+1} = I_t, \tag{13}$$

the loan market: $$D_t = \theta\, D^e_t \;+\; (1-\theta)\, D^n_t = L_t = P_t k^s_{t+1}, \tag{14}$$

the money market: $$\theta\, m^e_t \;+\; (1-\theta)\, m^n_t = M_t, \tag{15}$$

the bond market: $$b_t = B_t = P_t k^g_{t+1}. \tag{16}$$

where I_t is the aggregate investment of the economy in period t.

3.3. The Balanced Growth Path

In order to analyze the balanced growth path, we define the following variables. Let g_{t+1} denote the growth rate of output in period $t+1$ ($g_{t+1} \equiv \frac{Q_{t+1}-Q_t}{Q_t}$); π_{t+1} the inflation rate in period $t+1$

[14] The state-owned enterprises are model as profit-maximizing entities for simplicity. As discussed in the introduction, the crucial assumption of our model is that the state sector is less efficient in production and learning by doing than the private sector is. Hence, any policy changes that affect the allocation of resources between the two sectors have influence on the levels of capital investment in the two sectors, the economy-wide production scale and productivity, and the government's budget deficit condition, which in turn, affect the growth rate of output, the growth rate of money supply and the inflation rate. As long as the assumption is retained, no matter how the objective function of the state sector is modeled, qualitatively equivalent results will be obtained.

($\pi_{t+1} \equiv \frac{P_{t+1}-P_t}{P_t}$); and μ_{t+1} the growth rate of money supply in period $t+1$ ($\mu_{t+1} \equiv \frac{M_{t+1}-M_t}{M_t}$). In addition, let β_t denote the fraction of each young individual's disposable income held in the form of government bonds in period t ($\beta_t \equiv \frac{b_t}{(1-\tau^l)W_t}$). Given that the purchase of government bonds is quantity-rationed, β_t is a decision variable of the government. However, once the government has decided the shate of the economy's current aggregate supply of the consumption good purchased for the production of the next-period public capital good, λ_t, the value of β_t will be pinned down, $\beta_t = \lambda_t/[(1-\tau_t^l)(1-\sigma)]$. Finally, let ϕ_t denote the propensity to invest in the private sector in period t (i.e., the fraction of each young entrepreneur's disposable income net of government bond subscription put into private investment ($\phi_t \equiv \frac{P_t^k k_{t+1}^p}{(1-\tau^l)W_t - b_t}$)). In fact, the propensity to invest in the private sector ϕ_t provides a measurement of the production share of the private sector in the economy.

With the specifications of the model, if the exogenous variables, λ, λ_s, λ_p, τ^l, τ^c, i^L, i^d, and i^b, are kept constant, the economy exhibits a deterministic balanced growth path on which the growth rate of money supply, μ, the growth rate of output, g, the inflation rate, π, and the propensity to invest in the private sector, ϕ, are all constant over time.[15] The balanced-growth equilibrium of the economy is characterized by equations (17), (18a), (19a) and (20a) in the case in which $\phi \in (0,1)$.

$$(1+g)(1+\pi) = (1+\mu), \tag{17}$$

$$1+g = (1-\sigma)A(1-\tau^l)(1-\beta)^{\sigma}\Big[\theta\phi + \alpha^{\frac{1}{\sigma}}(1-\theta\phi)\delta\Big]^{\sigma}\Big[(\beta+\theta\phi(1-\beta))^{\gamma}(\delta_p\lambda_p\beta)^{1-\gamma}\Big]^{1-\sigma}, \tag{18a}$$

$$(1-\tau^c)\sigma(1+\mu) - (1-\tau^l)(1-\sigma)(1+i^d)(1-\beta)\Big[\theta\phi + \alpha^{\frac{1}{\sigma}}(1-\theta\phi)\delta\Big] = 0, \tag{19a}$$

$$(1+\mu)^2\left[\frac{1}{(1-\sigma)(1-\tau^l)} - 1\right] - \Big[\beta(1+i^b) + (1-\beta)(1+i^d)\Big] = 0, \tag{20a}$$

where

$$\delta \equiv \left(\frac{\delta_s\,\lambda_s}{\delta_p\,\lambda_p}\right)^{\frac{(1-\gamma)(1-\sigma)}{\sigma}}.$$

In the case of $\phi = 1$, the entrepreneurs face binding internal finance constraints, the balanced-growth equilibrium of the economy in the case of $\phi = 1$ is characterized by equations (17), (18b) and (20b).

$$1+g = (1-\sigma)A(1-\tau^l)(1-\beta)^{\sigma}\Big[\theta + \alpha^{\frac{1}{\sigma}}(1-\theta)\delta\Big]^{\sigma}\Big[(\beta+\theta(1-\beta))^{\gamma}(\delta_p\lambda_p\beta)^{1-\gamma}\Big]^{1-\sigma}, \tag{18b}$$

$$(1+\mu)^2\left[\frac{1}{(1-\sigma)} - (1-\tau^l)\right] - \left(\frac{(1-\tau^c)\sigma\theta}{1-\sigma}\right)\Big[\theta + \alpha^{\frac{1}{\sigma}}(1-\theta)\delta\Big]^{-1}(1+\mu)$$
$$-(1-\tau^l)\Big[\beta(1+i^b) + (1-\theta)(1-\beta)(1+i^d)\Big] = 0. \tag{20b}$$

The derivation of these equations is presented in the appendix.

4. The Analysis

[15] Along the balanced growth path, the levels of output, consumption, saving and investment are all growing at a rate of g; and the money supply, government bonds, and wage rate are all growing at a rate of μ.

In this section, we study how changes in the total volume and allocation of the public capital goods affect the key macroeconomic aggregates. By totally differentiating the simultaneous equation systems that characterize the balanced growth equilibrium, we can derive the long-run effects of changes in β λ_s, and λ_p on the values of μ, g, π, and ϕ.[16] In the following discussion, we will present the major results of the paper and offer the intuitions behind them. In the discussion, the level effects are distinguished from the growth effects. Note that the level effect discussed here refers to the level of a variable concerned on the original balanced growth path relative to that on the new balanced growth path after a policy change.

Proposition 1: *Suppose that the government increaes the provision of the public capital to the economy, β, while maintaining the composition of the public capital goods constant (i.e. leaving λ_s and λ_p unchanged). This policy change will increase the money supply growth rate, but its effects on the growth rate of output and the inflation rate are ambiguous.*

$$\frac{dg}{d\beta} =?, \quad \frac{d\pi}{d\beta} =?, \quad \text{and} \quad \text{if} \quad i^b > i^d, \quad \frac{d\mu}{d\beta} > 0.$$

$$\frac{d\phi}{d\beta} > 0 \quad \text{for the case with} \quad \phi \in (0,1).$$

The increase in the provision of the public capital goods has two direct positive effects on the production of the consumption good. The first effect is via the increase in the supply of the public intermediate input to each sector; and the second effect is through the improvement in the economy-wide technology level. These two effects raise both the level and growth rate of aggregate output of the economy. In the case in which the entrepreneurs do not face binding internal finance constraint ($0 < \phi < 1$), the larger supply of the public intermediate input and the higher economy-wide technology level induces the private firm to increase their regular capital investment, which will reinforce the two direct positive effects on the level and growth rate of output.

However, in order to finance the increase in the public capital investment, the government has to issue more bonds, and therefore the bond subscription of each young individual increases. Given that all the after-tax labor income of the young generation is allocated for the purchases of the regular capital goods of the private sector and the state sector, and the public capital goods, an increase in the purchases of the public capital goods indicates a decrease in the purchases of the regular capital goods.

The larger volume of bond subscription implies a decrease in the deposit holding of each non-entrepreneur. Hence, the quantity of loanable funds channelled to the state sector by the banking system falls, the investment in the regular capital of each state-owned firm and therefore its output drop. Whehter the deposit decision of each entrepreneur is affected by the larger volume of bond subscription depends on whether the entrepreneur is facing a binding internal finance constraint. In the case in which the internal finance constraints are non-binding ($0 < \phi < 1$), the larger bond subscription will only reduce the deposit holdings of the entrepreneurs, while having no negative effect on their regular investment decisions. The decrease in the entrepreneurs' deposit holdings result in a decrease in the output of the state sector.[17] In contrast, in the case in which the internal finance constraints are binding ($\phi = 1$), the entrepreneurs have already allocated all their after-tax

[16] The derivations of our comparative statics analysis are provided in the appendix.

[17] As a result, a larger fraction of the entrepreneurs' after-tax labor income, net of government bond subscription, is allocated for the purchases of the regular capital goods for the private sector, ϕ rises. The increase in ϕ implies that when the regular capital goods allocated to the state sector falls, there will be a reallocation of labor from the state sector to the private sector.

labor income, net of bond subscription, to regular capital investment. The larger bond subscription tightens the finance constraint of each entrepreneur, reduces the purchase of the regular capital good of each private firm, and thus lowers the output of the private sector. The decrease in the regular capital investment of the private sector will further reduce the aggregate output of the economy via its negative effect on the economy-wide technology level. As discussed above, no matter whether the internal finance constraints of the entrepreneurs are binding, the increase in each young individual's government bond subscription generates negative effects on the level and growth rate of the output of the economy. Consequently, the equilibrium effect of this policy change on the growth rate of output of the economy is in general ambiguous; it depends on the relative strength of the positive effects that are induced directly from the increase in the supply of the public capital and the negative effects that result from the increase in bond issuing for financing the increase in the purchases of the public capital goods.

The increase in the issuing of government bonds for financing the purchases of public capital goods generates several effects on the government's budget. First, as the government borrows more by issuing bonds, its burden of debt repayment increases. Second, the government bonds crowd out bank deposits in the portfolios of the young and thus reduces the subsidies of the government to the state sector, which tends to reduce the budget deficit of the government. Third, since the policy change affects the output levels of the private and the state sectors, it will affect the profit submission and the revenues from labor income tax and corporate profit tax. Although the effects on the government's tax revenues and profit submission of the state sector are ambiguous, it can be shown that when the nominal interest rate on government bonds is higher than the nominal interest rate on deposits, in the new equilibrium, the government budget deficit is worsen and the government has to rely more on money financing. Hence, the growth rate of money supply is higher on the new balanced growth path. Given that the equilibrium effect on the growth rate of output is ambiguous while the money supply growth rate increases, the effect on the inflation rate is ambiguous.

Proposition 2: *Suppose that the government increaes the share of the public capital goods allocated to the state sector, λ_s, while maintaining the share of aggregate output used to construct the public capital goods and the share of public capital goods allocated to the private sector constant (i.e. leaving β and λ_p unchanged, and $\lambda_s + \lambda_p < 1$). If the entrepreneurs face binding internal finance constraints, this policy change will increase the growth rate of output and reduce the growth rate of money supply and the inflation rate. However, If the internal finance constraints of the entrepreneurs are non-binding, this policy change will reduce the propensity to invest of the entrepreneurs, lower the growth rate of output, raise the inflation rate, while leaving the money supply growth rate unchanged.*

$$\frac{dg}{d\lambda_s} > 0, \quad \frac{d\pi}{d\lambda_s} < 0, \quad \text{and} \quad \frac{d\mu}{d\lambda_s} < 0, \quad \text{for the case with} \quad \phi = 1.$$

$$\frac{d\phi}{d\lambda_s} < 0, \quad \frac{dg}{d\lambda_s} < 0, \quad \frac{d\pi}{d\lambda_s} > 0, \quad \text{and} \quad \frac{d\mu}{d\lambda_s} = 0, \quad \text{for the case with} \quad \phi \in (0, 1).$$

The increase in the share of public capital goods allocated to the state sector increases the supply of the public intermediate input to the state-owned firms. At any given levels of regular capital and labor inputs, the output of the state sector increases. In addition, the marginal product of labor schedule of the state sector shifts upward; it induces each state-owned firm to increase its demand for labor. In order to eliminate the excess demand for labor, the market wage rate rises. Hence, there is a reallocation of labor from the private sector to the state sector. For any given

allocation of the regular capital in the economy, the increase in the average productivity of labor inputs indicates increases in both the level and growth rate of output. However, as will be shown below, how the entrepreneurs respond to this initial impact of this policy change on the labor market plays an important role in the determination of the equilibrium effect on the balanaced growth path.

In the case in which the entrepreneurs are facing binding internal finance constraints, this policy change does not affect the entrepreneurs' investment decisions, and therefore has no effect on the economy-wide technology level.[18] It affects the production of the private firms only through the increase in the market wage rate. As the cost of labor increases, each private firm reduces its input of labor. As a result, the output of the private sector decrease. However, as the economy-wide average productivity of labor increases, the output growth rate will be higher on the new balanced growth path.

From these effects on the output levels of the two sectors, we know that the increases in the output level of the state sector and in the market wage rate improve the government budget condition by increasing the government's revenues from the profit subm ission of the state sector and taxes on labor income increase; and that the decrease in the production of the private sector worsens the government budget deficit by reducing the corporate profit taxes. As this policy change does not alter the bond subscription faced by each young individual, it does not have any direct effect on the burden of debt repayment of the government. Although there are many opposing effects on the government budget, it can be shown that the equilibrium effect on the money supply growth rate is negative. That is, this policy change reduces the government budget deficit so that the government can rely less on money printing to finance its budget deficit. As the growth rate of output rises but the money supply growth rate falls, the inflation rate will be lower on the new balanced growth path.

In the case in which the internal finance constraints of the entrepreneurs are not binding, the decrease in the labor input to the private firms resulting from the increase in the market wage rate shifts the schedule of the marginal product of regular capital downward. Given that the nominal interest rate on deposits remains unchange, the marginal beneifit of captial investment becomes lower than its marginal cost; the entrepreneurs will reduce their captial investment and increase their holding of bank deposits. Hence, the propensity to invest of each entrepreneur drops. The decrease in the regular capital investment has two negative effects on the level and growth rate of aggregate output of the economy. First, the reallocation of regular capital investment from the private sector to the state sector reduces the aggregate output and the market wage rate of the economy because the state sector is relatively less efficient in production ($\alpha^{\frac{1}{\sigma}}\delta < 1$). Second, because the private firms are more efficient in learning by doing, the decrease in the regular capital investment of the private sector implies a slower rate of the improvement in the economy-wide technology and a drop in the level of output of each firm. These two negative effects on the growth rate of output are found to be strong enough to outweigh the positive effect so that growth rate of output is lower on the new balanced growth path.

Recall that from the discussion of the case in which the internal finance constraints of the entrepreneurs are nonbinding, the equilibrium effect on the money supply growth rate is negative. In this case, because of the adjustment of the entreprenurs' investment decision which generates further changes in the revenues and expenses of the government, the equilibrium effect on the money supply growth rate is quite different from that in the case in which the entrepreneurs face binding internal finance constraints. When the entreprenuers adjust their investment decisions, there are

[18] As long as this policy change does not induce a substantial reduction in the labor input to the private sector, the marginal product of regular capital investment of the private firms will still higher than the opportunity cost, and the entrepreneur will have no incentive to adjust their investment decisions.

additional negative effects on the output level of each firm and the market wage rate. These additional negative effects worsen the government budget condition and have an upward force on the money supply growth rate. It is shown that the positive and negative effects on the government budget condition completely offset each other, and leave the equilibrium money supply growth rate unchanged. Given that the growth rate of output is lower while the money supply growth rate is unchanged, the inflation rate is higher on the new balanced growth path.

Proposition 3: *Suppose that the government increaes the share of the public capital goods allocated to the private sector, while maintaining the share of aggregate output used to construct the public capital goods and the share of public capital goods allocated to the state sector constant (i.e. leaving β and λ_s unchanged, and $\lambda_s + \lambda_p < 1$). If the entrepreneurs face binding internal finance constraints, this policy change will increase the growth rate of output and the growth rate of money supply, but its effect on the inflation rate will be ambiguous. However, If the internal finance constraints of the entrepreneurs are non-binding, this policy change will increase the propensity to invest of the entrepreneurs, raise the growth rate of output, reduce the inflation rate, while leaving the money supply growth rate unchanged.*

$$\frac{dg}{d\lambda_p} > 0, \quad \frac{d\pi}{d\lambda_p} = ?, \quad \text{and} \quad \frac{d\mu}{d\lambda_p} > 0, \quad \text{for the case with} \quad \phi = 1.$$

$$\frac{d\phi}{d\lambda_p} > 0, \quad \frac{dg}{d\lambda_p} > 0, \quad \frac{d\pi}{d\lambda_p} < 0, \quad \text{and} \quad \frac{d\mu}{d\lambda_p} = 0, \quad \text{for the case with} \quad \phi \in (0,1).$$

The increase in the share of public capital goods allocated to the private sector increases the supply of the public intermediate input to the private firms. It follows that the output of the private sector increases for any given levels of regular capital and labor inputs. In addition, there is an upward shift in the marginal product of labor schedule of the state sector, which induces each private firm to increase its demand for labor. The excess demand for labor causes the market wage rate to rise and results in a reallocation of labor from the state sector to the private sector. If the allocation of the regular capital in the economy remains unchanged, the increase in the average productivity of labor inputs indicates increases in both the level and growth rate of output. However, as have been shown in Proposition 2, the further adjustment of the entrepreneurs' investment decisions in response to this initial impact of this policy change on the labor market plays an important role in the determination of the equilibrium effect on the balanaced growth path.

In the case in which the internal finance constraints are binding, the entrepreneurs have already invested all of their after-tax labor income, net of bond subscription, in the private firms. Although the entrepreneurs have an incentive to increase their regular capital investment, they are not able to do so. Hence, this policy change does not affect the entrepreneurs' regular capital investment, and therefore has no effect on the economy-wide technology level. The production of the private firms is affected only by two positive effects. The first one is the direct positive effect of the increase in the supply of public intermediate input to the private sector; and the second one is the induced positive effect of the reallocation of labor input from the state sector to the private sector. As the economy-wide average productivity of labor increases, the output growth rate will be higher on the new balanced growth path.

As the labor input of each state-owned firm decreases, the output level of the state sector falls. The profit submission of the state sector to the government decreases so that the government budget condition is worsen. Although the increases in the output level of the private sector and in the market wage rate improve the government budget condition by increasing the government's tax revenues from corporate profits and labor income, it is found that these positive effects are

dominated by the negative effect. The equilibrium size of the government budget deficit rises. The government has to rely more on money printing to finance its budget deficit. Since both the rates of output growth and money growth rise, the equilibrium effect on the inflation rate will be ambiguous.

In the case in which the internal finance constraints of the entrepreneurs are not binding, the increase in the supply of the public intermediate input to the private sector shifts the schedule of the marginal product of regular capital upward. This upward shift is reinforced by the increase in the labor input of each private firm resulting from the reallocation of labor in the economy. With the nominal interest rate on deposits remains unchanged, the increase in the marginal beneifit of captial investment induces the entrepreneurs to increases their captial investment and to reduce their holding of bank deposits. As a result, the propensity to invest of each entrepreneur increases. The increase in the regular capital investment will raise the level and growth rate of output further by the following two positive effects. First, because the private sector is relatively more efficient in production than the state sector ($\alpha^{\frac{1}{\sigma}}\delta < 1$), the reallocation of regular capital investment from the state sector to the private sector increases the aggregate output and the market wage rate of the economy. Second, because the private firms are more efficient in learning by doing than the state-owned firms, the increase in the regular capital investment of the private sector implies a faster rate of the improvement in the economy-wide technology and an increase in the level of output of each firm. Since these two positive effects on the growth rate of output reinforce the initial positive effects discussed above, the growth rate of output is higher on the new balanced growth path.

Although in the case in which the internal finance constraints of the entrepreneurs are nonbinding it is found that the policy change worsens the government budget condition and the equilibrium effect on the money supply growth rate is positive in this case, in the presence of the adjustment of the entrepreneurs' investment decisions, the equilibrium effect on the money supply growth rate is quite different. When the entreprenuers increase their regular capital investment, the induced additional positive effects on the output level of each firm and the market wage rate will improve the government budget condition. Because of this extra downward force on the money supply growth rate, it is found that all of the positive and negative effects on the government budget condition completely offset each other, and leave the equilibrium money supply growth rate unchanged. Given that the growth rate of output is higher, and the money supply growth rate is unchanged, the inflation rate is lower on the new balanced growth path.

Proposition 4: *Suppose that the government reduces the share of the public capital goods allocated to the state sector, λ_s, but increaes the share allocated to the private sector, λ_p, by the same amount, while maintaining the share of aggregate output used to construct the public capital goods constant (i.e., leaving β and $1-\lambda_s-\lambda_p$ unchanged). If the entrepreneurs face binding internal finance constraints, this policy change will increase the growth rate of money supply, but its effects on the growth rate of output and the inflation rate will be ambiguous. However, If the internal finance constraints of the entrepreneurs are non-binding, this policy change will increase the propensity to invest of the entrepreneurs, raise the growth rate of output, reduce the inflation rate, while leaving the money supply growth rate unchanged.*

$$sign\ \frac{dg}{d\lambda_{ps}} = sign\ [\lambda_s\theta - \lambda_p(1-\theta)],\ \ \frac{d\pi}{d\lambda_{ps}} = ?,\ \ and\ \ \frac{d\mu}{d\lambda_{ps}} > 0,\ \ for\ the\ case\ with\ \ \phi = 1;$$

$$\frac{d\phi}{d\lambda_{ps}} > 0,\ \ \frac{dg}{d\lambda_{ps}} > 0,\ \ \frac{d\pi}{d\lambda_{ps}} < 0,\ \ and\ \ \frac{d\mu}{d\lambda_{ps}} = 0,\ \ for\ the\ case\ with\ \ \phi \in (0,1);$$

$where\ \ d\lambda_{ps} = d\lambda_p = -d\lambda_s represents\ the\ simultaneous\ changes\ in\ \lambda_s\ and\ \lambda_p.$

This policy change can be considered as a combination of the two individual policy changes discussed respectively in Proposition 2 and 3. From Proposition 2, the equilibrium effects of a reduction in the share of the public capital goods allocated to the state sector, while other policy variables remaining constant, can be summarized as follows. If the entrepreneurs face binding internal finance constraints, the policy change will reduce the growth rate of output and raise the growth rate of money supply and the inflation rate. In addition, if the internal finance constraints of the entrepreneurs are non-binding, the policy change will increase the propensity to invest of the entrepreneurs, raise the growth rate of output, reduce the inflation rate, while leaving the money supply growth rate unchanged. From Proposition 3, we can also summarize the equilibrium effects of an increase in the share of the public capital goods allocated to the private sector, while other policy variables remaining constant. If the entrepreneurs face binding internal finance constraints, the policy change will increase the growth rate of output and reduce the growth rate of money supply and the inflation rate. In addition, if the internal finance constraints of the entrepreneurs are non-binding, the policy change will increase the propensity to invest of the entrepreneurs, raise the growth rate of output, reduce the inflation rate, while leaving the money supply growth rate unchanged.

In the case in which the internal finance constraints of the entrepreneurs are non-binding, the directions of the equilibrium effects of these two individual policy changes on each of the key macroeconomic variables are identical. Hence, it is obvious that if the government raises the share of the public capital investment allocated to the private sector and reduces the share allocated to the state sector simultaneously by the same magnitude, on the new balanced growth path, the growth rate of output will be higher, and the the inflation rate will be lower, while the money supply growth rate unchanged remaining.

In the case in which the entrepreneurs face binding internal finance constraints, the equilibrium effects of the two individual policy changes on the money supply growth rate are in the same the direction, but those on the growth rate of output are in opposing directions. Hence, the equilibrium effect of a combination of these two policy changes on the money supply growth rate is positive, but that on the growth rate of output will be ambiguous. It follows that the equilibrium effect on the inflation rate is also ambiguous. However, it can be shown that the direction of the equilibrium effect on the growth rate of output depends positively on the sign of the expression $[\,\lambda_s\theta-\lambda_p(1-\theta)\,]$.

5. Conclusion

Utilizing a dynamic general equilibrium model, we study the implications of public investment in infrastructure in the transforming Chinese economy. We show that an increase in debt-financed public investment in infrastructure is not necessarily growth enhancing in the long run. As the public investment is financed by government bonds, the amount of investment funds avaliable to both state and non-state sectors is reduced. This crowding out effect reduces the capital invetsment in both state and non-state sector and then the output growth rate of the economy may not be increased by this debt-financed public investment although more availability of infrastructure has a positive effect on the economy wide productivity.

Other than the effect of an increase in public investment on the economy, we derive how the allocation of public investment in infrastructure among state and non-state sectors affects the macroeconomic performance of the economy. Given the dual structure in production in China, the type or location of public investment may be sector specific, e.g. public investment in heavy inductry or in the Western/Northeastern part of the country may benefit state sector more while public investment in light industry or in the Southern/Coastal region of the country may benefit private sector more. Accordingly, we assume that public capital goods are classified into three groups. The first type of public capital supplies public intermediate inputs to both state and

private sectors while the other two types supply public intermediate inputs to state and private sectors repsectively. Under this assumption, we derive the effects of reallocation of public investment between the two sectors. As the financial markets in China are only partially reformed, most of the financial resources are chanelled to state setor. We show that this institutional feature significantly affects how the reallocation of public investment may affect the economy. Although it is suggested that government should give less support to the less efficient state sector, we show that a reduction in the allocation of public investment in infrastructure to state sector sector may be growth enhancing when entrepreneurs in non-state sector are not facing binding internal financial constraints. It is the case because entrepreneurs can invest more as the wage rate is reduced by this policy change. However, the same policy may reduce the output growth rate of the economy when the entrepreneurs cannot increase their capital investment because of binding internal financial constraints. We also derive the effects of an increase in the allocation of public investment in infrastructure to non-state sector. We show that this policy change necessarily increases the output growth rate and reduces the inflation rate when the entreprenuers in the sector are not facing binding internal financial constraints. However, it may not be the case if the entrepreneurs in non-state sector cannot invest more because of those binding internal financial constraints.

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