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# Land contributions to the supernormal development of infrastructure in China

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## Abstract

**Purpose** – Over the past 20 years, China's infrastructure has developed at an extraordinary speed. The current literature mainly focuses on the effects of political incentives on the infrastructure. However, this paper indicates that the structural change of China's land regime is an important clue and that the supernormal development of China's infrastructure is an explicable result for that.

**Design/methodology/approach** – This paper theoretically proves that in a politically centralized and economically decentralized economic entity with a public land-ownership regime, the self-financing mechanism formed by local officials through regulation of the land-grant price is the primary factor that influences the optimal supply volume of infrastructure in a region, in addition to political and economic incentives, and whether the self-financing mechanism can be formed or not depends on the structure of a country's land regime, which can help to explain the difference between the development of infrastructure in China and that in other developing countries from a theoretical angle.

**Findings** – The paper suggests that the mode is facing an important transformation toward land reform and new-type urbanization construction, and the replication and promotion of China's experience in infrastructure construction are of further significance under the Belt and Road Initiative as it provides a method for helping developing countries to eliminate infrastructure bottlenecks.

**Originality/value** – Through the test of multinational panel data, the paper indicates that the structural change of China's land regime around 1990 had an overall effect on the supernormal development of infrastructure in China. The paper indicates that the "land-based development mode" of China's infrastructure indeed contributed to the supernormal development of infrastructure in China, but there are still some shortcomings in this mode.

**Keywords** Infrastructure, Land, Regime, Political economy of growth

**Paper type** Research paper

## 1. Introduction: the mystery of China's infrastructure

Over recent decades, particularly after the mid-to-late 1980s, the positive effect of the infrastructure on economic growth has gained increasing attention in the academic circle.

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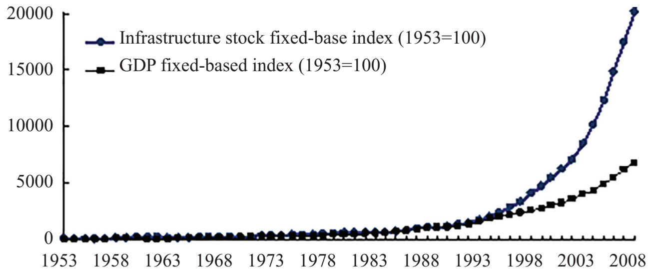
A lot of scholars, such as Rosenstein-Rodan (1943), Murphy *et al.* (1989), Barro (1990), Barro and Sala-i-Martin (1992), have revealed the importance of infrastructure to economic growth in the theoretical aspect; Aschauer (1989a, 1989b, 1989c, 1993), the World Bank (1994), Canning (1999), Straub (2008a, 2008b) and Fedderke and Bogetić (2009) have proven the importance of infrastructure to economic development empirically. To sum up, the importance of infrastructure to economic growth is embodied in two aspects: first, investment in infrastructure can fuel economic growth directly. Second, infrastructure stimulates economic growth by supporting the development of manufacturing and other industries. Since China's reform and opening-up, particularly the 1990s, infrastructure [1] has played an increasingly important role in China's economic growth. The studies of Chatterjee (2005), Straub *et al.* (2008) and Sahoo *et al.* (2010) disclose that the rapid development of China's physical infrastructure is the pillar for the high-speed and sustained growth of China's economy and increasingly enhanced manufacturing competence. China becomes world's factory as well as a big trading nation and achieves "growth miracles" precisely because good infrastructure conditions lower the costs of production and circulation in the manufacturing industry of China and enhance the market expanding ability and competitive competence of Chinese products. Therefore, in order to understand China's economic growth, the infrastructure mystery behind the economic growth must be unveiled first to deeply understand the significance of the government's initiative of pushing forward new-type urbanization construction and improving the quality and efficiency of economic growth.

A mystery of China's infrastructure is the supernormal development of infrastructure, reflected by the rapid growth of China's infrastructure stock over the past two decades. According to the estimation by Jin (2012) based on constant prices, China's infrastructure capital stock between 1990 and 2008 increased to 19,237.8*bn* yuan from 1,190.3*bn* yuan, which grew by more than 16 times at the average annual growth rate (AAGR) of 16.72%. Upon further analysis, it is found that the AAGR of China's infrastructure capital stock varied greatly in different stages from 1953 to 2008. The AAGRs in the periods of 1953–1978, 1979–1989, 1990–1998, 1999–2008 were 7.07%, 6.94%, 16.05% and 17.25%, respectively, and it should be noted that the AAGR from 1979 to 1989 was even lower than that of the period from 1953 to 1978. The turning point of growth emerged around 1990, and the AAGR after 1990 was twice as high as that before 1990. In addition, compared with the GDP growth, the growth of AAGR and that of GDP were roughly at the same rate before 1990, and the infrastructure AAGR tremendously exceeded the GDP growth after 1990, forming a prominent "scissors gap" (as shown in Figure 1 and Table 1). It is worth studying why the turning point of the infrastructure growth showed up around 1990 as well as the changes behind it. Even compared with that of other countries, the achievement of China's infrastructure construction was astonishing. According to the estimate by Zhao *et al.* (2013), the stock of China's infrastructure was ranked 15th in the world in 1990 and was seventh in 2000 and third in




**Source(s):** As cited by Jin (2012)

**Figure 1.**
Comparison between national infrastructure index and GDP index

2010, only after the United States and Japan. Actually, in terms of purchasing power parity (PPP), China was ranked first in the world. Over the past 20 years, China's infrastructure has achieved such supernormal development, which is rare in the world history of infrastructure construction and can be regarded as a miracle behind China's growth.

Another mystery of China's infrastructure is the "non-normal" nature, that is, the supernormal development of China's infrastructure cannot be adequately explained by the currently conventional theories and relevant literature. Scholars have given different answers to the causes of the growth of infrastructure in a country or region.

Randolph *et al.* (1996) establish a general equilibrium model and verified it with the panel data of 27 low- and middle-income countries. The results show that the economic development stages, urbanization level and labor force participation rate are the most significant factors that decide the infrastructure investment spending per capita of a country. This conclusion forms the "economic development hypothesis" of infrastructure. It reveals the importance of the economic development stage in which a country or region stays to infrastructure construction, that is, the importance of economic growth to infrastructure construction. According to this hypothesis, the faster the economy grows, the better the infrastructure will develop, and they should maintain roughly the same growth rate. However, although the ten-plus years after the beginning of China's reform and opening-up witnessed great achievement in the economic development, the annual growth of infrastructure during that period was not as good as that during the decades before the reform and opening-up, as shown in Table 1. What is the reason behind it? Why did China's infrastructure growth and economic growth form a prominent "scissors gap" instead of advancing at the roughly same pace? It is hard to explain based on the general equilibrium model.

As infrastructure construction is a public decision-making process, to explain the infrastructure investment decision with market mechanism only usually cannot work. As such, to explain the infrastructure investment decision from the perspective of the political economy other than the market factor becomes an important study angle, which thus forms the "political system hypothesis" of infrastructure. The studies of Williamson (1976), Spiller (1993), Levy and Spiller (1994) manifest that infrastructure investment has relatively prominent policy characteristics and therefore is especially sensitive to the system and political environment of a country. Crain and Oakley (1995), Henisz (2002), Esfahani and Ramírez (2003), Castells and Solé-Ollé (2005), Gasmi *et al.* (2009) study the decisive factor of infrastructure investment from the aspects of politics or political system. Among these scholars' studies, the one carried out by Henisz (2002) is the most representative. He believes that despite increasing empirical evidence for political system structure and economic performance over recent years, the data adopted in the analysis are acquired from only 30 years or so. Due to the relatively short time span of the samples, the interpretation of the results is limited, for it is especially hard to waive the influence of unobservable factors. For that purpose, he studied the relationship between institutional and policy environment and

| Reform of China's economic system | Before the reform and opening-up | | After the reform and opening-up | |
|---|---|---|---|---|
| Structural change of land regime | Before the formation of land reform | | After the formation of land reform | |
| Specific stages | 1953–1978 | 1979-1989 | 1990-1998 | 1999-2008 |
| AAGR of infrastructure stock (%) | 7.07 | 6.94 | 16.05 | 17.25 |
| AAGR of actual GDP (%) | 5.78 | 9.69 | 10.78 | 10.24 |

**Source(s)**: Database of National bureau of Statistics of China (http://data.stats.gov.cn/) and Jin (2012)

**Table 1.** Comparison of China's infrastructure and GDP growth rate in different stages

infrastructure investment through the panel data of more than 100 countries over the time span as long as two centuries. The result shows that the political system environment, especially with honest and credible policy and private property protection created by the government, is the most important factor that affects the infrastructure investment of a country, which can explain the key infrastructure investment differences between countries. Hence, Henisz's conclusion shows even more about the significance of unveiling the mystery of China's infrastructure. If we say that the reform and opening-up generated an impact on China's political and policy environment around 1980, China's political system structure and overall policy environment around 1990 did not change significantly. In such a political system environment, why did the turning point of China's infrastructure growth appear around 1990 instead of 1980? It is hard to explain it based on the political system hypothesis.

Infrastructure construction is locally distinctive because it is always closely related to the specific geographical location. Therefore, the disperse policy decision of local governments on infrastructure investment is more advantaged than the unified decision of the central government, which thus forms the "decentralization incentive hypothesis," and the representative literature about it was the World Bank's study. The study of Estache and Sinha (1995) shows that decentralization helps increase both the national and the local government's public infrastructure investment spending, and this trend is more evident in developing countries than in developed countries. Bardhan and Mookherjee (2006) also put forward a new theoretical framework to reveal that a centralized financing method may easily lead to excessive bureaucratic corruption; the decentralized financing method is easily favored by local officials; the user charge system for financing can improve the equity and efficiency of the decentralization model. China has implemented economic decentralization since the 1980s and financial decentralization since 1994, which seems to agree with the high-speed growth of infrastructure stock. However, India also implemented similar decentralization reforms since the 1990s. Why has not India's infrastructure well developed? How to explain it?

Based on the political system hypothesis and the decentralization incentive hypothesis, Zhang *et al.* (2007) study the decisive issues of China's infrastructure investment according to the actual situation in China and put forward the "competition of attracting investment hypothesis," which is also known as "political incentive hypothesis." By far, the research of Zhang *et al.* provides the most influential theory that can explain why China has good infrastructure. According to the study, the outstanding achievement of China in infrastructure improvement is an explicable result of China-style financial decentralization model and the transition of government administration. The success of the decentralization model lies in the combination of the "responsibility upward" political system and financial decentralization. Under this system, the central government replaces political education to regional governments with "benchmark competition." Therefore, local officials carry out horizontal competition for better performance in office. The improvement of local infrastructure can promote investment attraction to achieve faster economic growth and better performance, and the prominently improved infrastructure is the most easily measured performance of officials. The authors found that the benchmark competition among local governments on investment attraction and the transition of government administration are the important factors to explain China's infrastructure investment decision. However, this study focuses on empirical research without corresponding theoretical models as supporting evidence. Probably in order to make up for the theoretical defects, Wang and Zhang (2008) build up a model about hierarchical political incentives to explain that political promotion incentives that the local government faces are the motivation for the local infrastructure development.

Bai and Qian (2010) carry out a study on the development issues of infrastructure sectors in China, including electric power, highway and railway industries, from the perspective of investment incentives. In their view, the investment incentive generated by the market-oriented pricing mechanism and decentralized competition is the main cause for the rapid development of electric power and highway industries in China to make these two industries maintain the same growth speed as that of GDP. Centralized railway operation with direct management of investment by the Ministry of Railways leads to a relatively low return on invested capital (ROIC) in the railway industry, which is an important reason for the lack of investment incentives and relatively slow development of the railway industry. Thereby, the "economic incentive hypothesis" of China's infrastructure development takes shape.

Both the political incentive hypothesis put forward by Zhang *et al.* and the economic incentive hypothesis by Bai *et al.* analyze the infrastructure supply from the aspect of incentive only, which are positive only on the premise that local governments' incentives for infrastructure investment are not constrained by the financing ability of local governments for infrastructure. However, a complete infrastructure supply behavior is not only affected by the incentive motivation but also constrained by the financing ability, and the latter factor prevails. A series of empirical evidence that McCawley (2010) listed out indicates that most developing countries in Asia have a strong and huge demand on infrastructure investment, and many of them have a lot of ambitious infrastructure investment plans but face challenges on the financing ability. The report of ESCAP (2006) also points out that the infrastructure capital demand of the Asian–Pacific region was about US$22.8*bn* per year between 2006 and 2010, among which the fund that could be provided by the government reached US$28*bn*, accounting for approximately 12.3%; the fund that could be provided by the private sectors was US$20*bn*, occupying 8.8% or so; the financing gap was about US$180*bn*, comprising 78.9%. Also, according to the report of ADB-ADBI (2009), between 2010 and 2020, the investment needs for infrastructure in Asia will reach as much as US$750*bn* with an even bigger financial gap. It can be seen from the following data that Asian countries have a strong desire to improve their infrastructure, but what do the governments have to develop the infrastructure?

To make up the shortcomings of the political incentive hypothesis, Tang and Chen (2012) study the reason for the rapid increase of China's infrastructure stock from the perspective of the actual supply capability. They believe that the current relative literature on the rapid growth of China's infrastructure investment mainly focuses on the needs, especially political needs, and neglects the supply capability. Many developing countries have recognized the significance of infrastructure to economic development. However, due to the limited capability of supply, the infrastructure in these countries has not been prominently improved. Therefore, it is necessary to reveal how the actual supply capability of China's infrastructure is improved in a supernormal way. For this purpose, based on the decentralization theory, they try to explain the rapid growth of China's infrastructure stock from the angle of land financial mode. According to their view, the establishment of financial decentralization system and the initiation of the market-oriented reform in land factors are the key conditions to facilitate the rapid development of China's infrastructure. However, land finance is a superficial cause. They did not go more in-depth for the underlying reasons and also left out the economic and political incentive motivation of the local governments. These limitations have substantially weakened the tenability of their analytical framework. Zuo and Yin (2013) establish a theoretical model based on China's actual conditions. They reach the conclusion that in equilibrium, the local governments will input more fiscal resources to the infrastructure construction that can add value to land and increase the future tax revenue. However, they were still limited to the analysis of land finance and lacked systemic review and in-depth research on realistic problems of China's infrastructure, which made their analysis limited.

In other words, there is one more fundamental question to be answered for explaining the supernormal development of China's infrastructure. In terms of the political and economic system, China remained the same political system and the administration model as well as continued pushing forward the reform and opening-up policy around 1990. Then why are the infrastructure development paths different in the same or similar political and economic environment? What kind of institutional adjustment did China make around 1990 that rendered the behavior of local governments so different? Furthermore, as no significant change has happened to China's political and economic environment since the mid-to-late 1990s, why does the "scissors gap" between the infrastructure growth and GDP growth get increasingly large? What kinds of adjustment in rights were made in the late 1990s that caused the local governments to act so differently? This paper tries to review the supernormal development of China's infrastructure from the perspective of the structural change in the land regime and gives answers to the aforementioned questions. In fact, analysis of the current literature from the angles of land finance and financing innovation can only explain the rapid growth of China's infrastructure stock superficially. The land regime structure with Chinese characteristics is the root cause.

In summary, this paper attempts to propose an analytical framework that takes into account the impact of changes in the structure of land regime on infrastructure growth, with the focus of local officials' optimal behavior on infrastructure supply under different structures of the land regime. We find that in addition to economic and political incentives, the local officials' self-financing mechanism by regulating the land-grant price, triggered by China's land reform around 1990, is the main factor that affects the optimal supply volume of infrastructure in a region. This mechanism has tremendously driven the supernormal development of China's infrastructure. The promulgation of the *Land Administration Law* revised and the reform of the housing system in 1998 promoted the development and improvement of the land market. It made the value of land more prominent, which strengthens the self-financing mechanism. Therefore, the supernormal development of China's infrastructure can be explained based on structural changes in the land regime.

## 2. The land-based development mode of China's infrastructure

The phenomenon of land supporting infrastructure development is not unique to China. As early as the 19th century, Western developed countries generally executed the right of regulating land development to finance urban infrastructure or relied on the sale and lease of limited public land to finance infrastructure. China enhances the supporting function of land by implementing public ownership of land. Actually, for developing countries, drawing private capital or foreign capital to infrastructure construction has certain limitations, and the financial support they can gain from international financial organizations is minimal (McCawley, 2010). Therefore, facilitating infrastructure development through land support has become the most common and important means adopted by developing countries.

### *2.1 Traditional theories of "land supporting infrastructure development"*

First, the "Beneficiary Pays" principle. The theory is based on the context of urbanization. According to the theory, a minority of citizens may gain benefits from the development of infrastructure and real estate by selling land or service and participating in the development and construction. However, the majority of citizens have to pay more taxes due to the arrival of new residents and new development programs, which will cause social inequity and a decline in overall welfare. Therefore, the local government requires real estate developers to provide certain physical or financial support for the construction of public infrastructure in this region, that is, imposing land-use exactions based on the land development regulation right as a condition for development. In fact, the exactions transfer the cost of new infrastructure to new residents through the real estate channel. The theoretical basis for land-use exactions is shown as follows: (1) as the existing infrastructure will contribute to the new developments, it should be regarded as a part of the development, and thus the cost of existing infrastructure shall be internalized. (2) Because most of the new infrastructures serve new residents, the cost of new infrastructure shall be paid by the new residents (Altshuler *et al.*, 1993). When the urban population increases continuously, and the citizens hope to maintain the previous public infrastructure service level, the quantity and investment of the infrastructure increase over time. The cost of the newly added investment should be paid by the users of the infrastructure, namely the new citizens. As the original citizens have paid for similar fees before, all the citizens will be fairly treated (Brueckner, 1997).

Second, the theory of "Land Value Capture (LVC)." As per the theory, once the infrastructure is completed or about to be complete, it will have significant spillover effects, and the value of surrounding land will increase rapidly, which will make the landowners or developers acquire gains from land value increments. However, land users or developers do not pay for the cost of such gains; instead, the taxpayers pay it. Therefore, the government can deal with the issues of social equity and internalization of infrastructure costs through LVC. The most common strategy for LVC is to sell the land that appreciates due to infrastructure investment or changes in zoning. If the government owns the land, the government can internalize the gains from infrastructure investment and capture most of the land value increments by selling land. Moreover, the potential profits of the land in the future can lead to various public–private joint ventures and provide private investors with opportunities to participate in infrastructure construction or finance through the land. As to countries with the land regime of private ownership, the governments have to gain the land. If the government gains more land than needed by infrastructure, it has the potential ability to capture land value gains. The more the surplus land, the stronger the ability to capture land value increment. Due to the differences in land requisition systems or regulations, it is easier for developing countries to requisition and sell lands for profits than Western developed countries (Peterson, 2009, pp. 64-66). The LVC theory agrees with George's theory (1879) of "sharing the unearned increment of the land" to some degree.

### *2.2 China's land-based development mode*

The land-based infrastructure development mode in China is similar to the two theories mentioned earlier. The difference among these three ideas lies in the structure of the land regime, which leads to a considerable gap in the competence to requisition, capture and financing. As shown in Figure 2, the land-based supernormal development mode of China's infrastructure consists of two aspects – explicit land support and implicit land support [2].

*2.2.1 Explicit support.* It refers to supporting infrastructure development by land through monetized exchanges in a public manner and public decision-making, including:

(1) The channel of tax revenue. This channel consists of direct tax revenue and indirect tax revenue on land. Direct taxes on land consist of land value increment tax, cultivated land conversion tax, urban land use tax, real estate tax and deed tax. Indirect taxes on land consist of business tax in the real estate sector and business tax in the construction sector. For example, tax revenue on land approximately constituted 29% of the total revenue for China's local governments in 2010, in which direct taxes on land accounted for 15.95% and indirect taxes on land 13% approximately (by estimate). To settle the cost of infrastructure via land taxation is a common method used by governments in various countries, and it plays an important role in China.

(2) The channel of nontax revenue. This channel consists of land examination and approval, land lease, land grant, capital contributions (or equity investment) with valued land-use rights and authorized operation. Land examination and approval

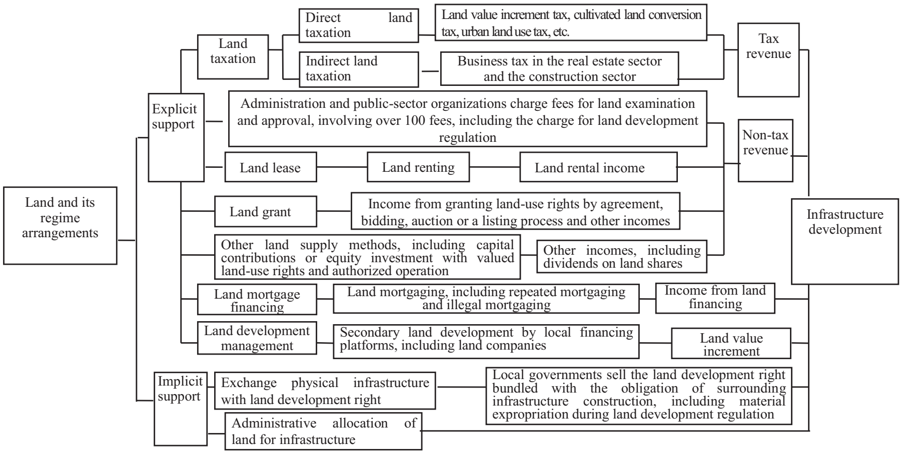



**Figure 2.**
Land mode of the supernormal development of China's infrastructure

cause land examination and approval charges, while land grant, land lease and capital contributions or equity investment with valued land bring in land-grant income, land rental income and other incomes for the government, respectively. In 2010, the land-grant income constituted 67.62% of the total revenue for China's local governments of that year while the land rental income accounted for 0.12% and other income less than 0.01%. It can be seen that the nontax revenue channel takes land grant as the principal method. The fees for land examination and approval are also a significant income for China's government, whose magnitude ratio is not under consideration due to lack of data.

(3) The channel of land mortgage financing. It means that the local government and financing platforms support infrastructure development by getting a loan from banks with the land as collateral. This channel is powerfully supportive. In 2007, the total loan amount of land mortgage financing reached 2507.777*bn* yuan, comprising 106.39% of the total revenue for China's local governments of that year.

(4) The channel of land value increments. It means that after the first-grade land development and payment of land grant fees to the government of the city/county, the local financing platform redevelops the land and transfers it to real estate developers at a market price to capture the majority of land value increments, which will be directly used for infrastructure investment and to satisfy local governments' needs for infrastructure construction. After the global financial crisis in 2008, this method plays an increasingly strong role in regional infrastructure construction.

*2.2.2 Implicit support.* Implicit support, which refers to channels supporting infrastructure development through the land in an implicit way such as nonmonetized contract, includes:

(1) Exchanging land development rights with physical infrastructure. It means that the local government "sells" the real estate developers the land development rights bundled with obligations to construct infrastructure in the designated surrounding region. The developers are granted with the land development rights and should be responsible for constructing the infrastructure agreed. This method is well received in the development of new development zones or real estates in China. It makes a great contribution to the infrastructure construction; however, its magnitude ratio is not under consideration due to lack of data.

(2) Allocating land for infrastructure by administration organizations. It is a unique method under the land regime of public ownership and provides strong support. For example, China's allocated land for infrastructure in 2010 was 138,267.34 ha, accounting for 20% of the overall supply of state-owned construction land. If the local governments need to purchase the land at a price equivalent to the average land-grant price of that year (i.e. 9.35*m* yuan per hectare) under private ownership of land, the governments will spend a total of 1,292.8*bn* yuan, equal to 31.83% of the total revenue for China's local governments of that year. This expenditure is not a small number for most developing countries and even some developed countries, but China's local governments can save it.

In summary, due to the unique land regime structure of China, the methods of land to make contributions in infrastructure development has more supporting means and greater levels of support in China, compared with that in other countries and regions, and has a more special supporting role in China. Hence, the super competence to support China's infrastructure development through the land is formed.

### *2.3 Structural changes in China's land regime and the formation and enhancement of land-based development mode*

Since the reform and opening-up, the structural changes in China's land regime can be divided into two stages. The first stage was around 1990, featuring the reform of urban land ownership, the land requisition system and the compensated transfer system of land-use rights. According to Article 10 of the *Constitution of the People's Republic of China (1982*), all urban land is state-owned, which puts an end to the private ownership of urban residential land in China. The *Regulations on the Requisition of Land by the State for Construction* enacted in 1982 provided a legal framework for local governments to requisition collective-owned land. However, this Law was accused of having an obvious bias toward the state ownership of urban land and the local governments, which planted the seeds for compulsory acquisition of land by the government later. Both the *Land Administration Law* approved in 1986 and the subsequent amendments did not amend any relevant provisions on land requisition. The reform of China's compensated transfer system of land-use rights began with the first open land auction in Shenzhen in 1987, which was also the first open land auction in China. It was formed in the *Interim Regulations of the People's Republic of China Concerning the Assignment and Transfer of the Right to the Use of the State-owned Land in the Urban Areas* and the *Interim Procedures for the Administration of Foreign Investment in the Development and Management of Whole Areas of Land* promulgated by the State Council in 1990. Particularly, the revision on Article 10 of the *Constitution* and the revision of *Land Administration Law* made in 1988 during the National People's Congress (NPC) are the keys in the reform of land transfer system, which stipulates that state-owned land can be paid for use and transferred in accordance with law. Since then, the compensated transfer system of land has taken root in China, and the functions of the land market and land value gradually come into play. However, the land expropriation system and the arrangement that only the state-owned land can be transferred and the collective land is not permitted to be transferred brought about local governments' compulsory acquisition of land later.

Hence, China's local governments have built strong capability of allocating, expropriating and granting land as well as financing through the state ownership of urban land, requisition system of collective-owned land and compensated transfer system of state-owned-land use rights, providing an engine for the supernormal development of China's infrastructure since 1990. Among the aforementioned means, the compensated transfer system of rights of using urban state-owned land ensures that the local governments can grant the state-owned-land use rights without difficulty to gain income from land, which is the crucial institutional arrangement that makes local governments gain the capability of granting land and enables land to be collateral for financing by manifesting the value of the land. The state ownership of urban land enables the local governments to have enough land for allocation and grant of land-use rights. In contrast, the local governments under private ownership of land have minimal urban public land. The collective ownership of land in suburban and rural areas and the requisition system of collective-owned land become potent means for local governments to supplement or increase the urban state-owned land, ensuring the sustainability of allocation and grant of land-use rights within a certain period. By then, the ability of land contribution in the supernormal development of China's infrastructure has been basically formed.

The second phase took place in the mid-to-late 1990s, featuring the amendment of the *Land Administration Law* and the reform of the housing system. According to the *Land Administration Law* (1998 revision), any unit or individual that needs to use the land for construction must apply for the use of state-owned land according to law. If the state engages in economic construction, it may expropriate collectively owned land in accordance with the law. If one's land is expropriated, it shall be compensated according to the original use of the land. These stipulations strengthen the local governments' land requisition and expropriation ability. The reform of China's housing system started with *Notice on Further Deepening the Reform of Urban Housing System and Speeding up Housing Construction* issued by the State Council in 1998, which requires that the country should stop the physical distribution of housing and gradually implement the monetization of housing distribution from the second half of 1998. The reform has pushed forward the great development of China's land market and the real estate industry. The increasing demand for commercial and residential land and the continuous manifestation of the function of land value provide more space for local governments to finance through lands. Therefore, these two institutional reforms have enhanced both the demand for infrastructure and the supply capability of infrastructure under the background of China's fight against the Asian financial crisis of 1997, expanding domestic demand and starting a new round of industrialization and urbanization, thus strengthening the ability of land contribution to the supernormal development of infrastructure and further widening the "scissors gap" between China's infrastructure growth and economic growth.

To sum up, it is because of the structural changes in the land regime that the land-based mode of supernormal development of China's infrastructure is formed. A question arises: "What are the infrastructure supply behaviors of local officials behind this mode?" To answer this question, we have made the following analysis.

## 3. Theoretical models

This section mainly focuses on local officials' infrastructure supply behaviors.

### *3.1 Model environment and basic hypothesis*

This model examines the infrastructure supply behaviors of local officials in a politically centralized and economically decentralized economic entity, with reference to the theoretical framework about infrastructure and economic growth by Acemoglu (2005) and the theoretical framework about the local officials' behaviors of granting land by Zhang *et al.* (2011). Specifically speaking, the conditions for this model are an economy containing lands that consists of $N$ regions, and each region has a local government, while there is only a central planner in the whole economy, that is, the central government. The local government is the producer of local infrastructure, and investment in infrastructure mainly relies on the input of the local government. As the representative of the local government, local officials have two kinds of preferences: local government consumption and local output. The local officials take consumers' reactions toward policies into consideration [3].

The infrastructure supply behavior of local officials depends on two major factors: one is the local officials' capability of financing for infrastructure, which is usually highly related to the structure of an economic entity's land regime when the local government is constrained by the issued bonds and credit guarantees; the other is the local officials' incentive motivation, and its strength is usually related to economic and political incentives offered to local officials [4]. Hence, when other conditions remain unchanged, the structure of the land regime and political system of an economic entity will exert an important influence on the infrastructure supply behavior of local officials.

*3.1.1 Production function.* Hypothetically, each region may be different in the following two aspects: one is the conditions of endowment ($B$); the other is endogenous policies. Assuming that there is a representative enterprise in the region $i$, whose production function takes the following form:

$$Y_t^i = B_t^i \left(K_t^i\right)^{\omega} \left(A_t^i\right)^{\alpha} \left(L_t^i\right)^{\psi} \tag{1}$$

Equation (1) is the Cobb–Douglas (C-D) production function with $K$ for the enterprise's capital input, $A$ for infrastructure input and $L$ for land input. $B$ represents endowment, which means all endowments except land, including labor, technology, management, labor capital and so forth. $t$ represents time, and "$i$" stands for the region ($i = 1, 2, \ldots, N$). $\omega$, $\alpha$ and $\psi$ refer to the output elasticity of capital, infrastructure and land, respectively, all of which are greater than zero. $\omega + \alpha + \psi < 1$ [5].

*3.3.2 The decision of infrastructure.* From Equation (1), the infrastructure investment is indispensable for final products of the society. Infrastructure investment and enterprise investment are complementary (Barro, 1990; Acemoglu, 2005). As the infrastructure construction has a hysteresis effect, the local government's infrastructure investment spending $G_t^i$ during the period of $t$ actually decides the infrastructure level ($A_{t+1}^i$), that is,

$$A_{t+1}^i = \left(\phi G_t^i\right)^{1/\phi} \tag{2}$$

where $\phi > 1$ indicates that investment technology conforms to the law of diminishing marginal returns, and the addition of $\phi^{1/\phi}$ is for standardization. Equation (2) refers to the full depreciation of $A_t^i$. Acemoglu (2005) adopted the same handling method. The following result can be acquired from Equation (2):

$$G_t^i = \left(A_{t+1}^i\right)^{\phi} / \phi \tag{3}$$

*3.3.3 Social constraints.* Hypothetically, there is one representative consumer in the region $i$, and its target function is as follows:

$$\sum_{t=0}^{\infty} \tilde{\beta}^t u\left(C_t^{Ci}\right) \tag{4}$$

where $\tilde{\beta}^t$ refers to the consumer discount factor, and $C_t^{Ci}$ is for consumer's consumption in the region $i$ during $t$. The budget constraint condition that the consumer faces is displayed as follows:

$$K_{t+1}^i = (1 - \pi) Y_t^i \left(K_t^i, A_t^i, L_t^i\right) - C_t^{Ci} \tag{5}$$

where $\pi$ refers to the government tax rate. Equation (5) means that the enterprise is fully depreciated, and the consumer owns the enterprise. Hypothetically, for consumers, $L$ is a constant [6]. As a result, the maximization of the utility problem of consumers is transferred to Equation (4) in the condition when the constraint Equation (5) is satisfied.

Hypothetically, the specific form of the consumer utility function in the region $i$ is as follows:

$$u\left(C_t^{Ci}\right) = \ln C_t^{Ci} \tag{6}$$

Referring to the existing conclusion of the Ramsey model and Equation (1), the solution of the optimal consumption function in the region $i$ is inferred as:

$$C_t^{Ci} = (1 - \tilde{\beta}^t \omega)(1 - \pi) B_t^i \left(K_t^i\right)^{\omega} \left(A_t^i\right)^{\alpha} \left(L_t^i\right)^{\psi} = (1 - \tilde{\beta}^t \omega)(1 - \pi) Y_t^i \left(K_t^i, A_t^i, L_t^i\right) \tag{7}$$

Putting Equation (7) into Equation (5), the social constraint on local officials can be drawn as:

$$K_{t+1}^i = \omega(1 - \pi) \tilde{\beta}^t Y_t^i \left(K_t^i, A_t^i, L_t^i\right) \tag{8}$$

*3.2 Benchmark model: infrastructure supply under private ownership of land*

*3.2.1 Budget constraint on the local governments.* Under completely private ownership of land, assuming that lands are directly provided by peasants, the land market is exogenously given to the local governments. Hypothetically, a local government $i$ has only two sources of income during $t$. One is local financial income $\pi Y_t^i$ based on taxation with a unified tax rate $\pi$ regulated by the central government, and finance sharing is not under consideration. The other is the initial financial income $S_0^i \geq 0$. The local government $i$ has two kinds of expenditure during $t$: government consumption spending ($C_t^{Ri}$) and infrastructure investment expenditure ($G_t^i$). Then the budget constraint on the local government $i$ during $t$ is as follows:

$$G_0^i + C_0^{Ri} = S_0^i + \pi \bar{P}_0^i Y_0^i,\; G_t^i + C_t^{Ri} = \pi \bar{P}_t^i Y_t^i \tag{9}$$

where $\bar{P}_t^i$ is normalized as 1. Equation (9) indicates that the infrastructure investment cost of the local government can be recovered by taxation, and the initial financial income can be acquired when $t = 0$ [7].

*3.2.2 Local officials' utility.* In a politically centralized economic entity, as the leaders of the local government, local officials must consider government consumption ($C_t^{Ri}$) and the local output ($Y_t^i$) during the term of office, which indicates that local officials face economic incentives as well as political incentives with a bias toward output. If the two kinds of utility can be added, the local officials' utility function can be displayed as follows:

$$U^i = \sum_{t=1}^{T} \beta^t \left[\lambda C_t^{Ri} + (1 - \lambda) Y_t^i\right] \tag{10}$$

where $T \geq 2$ with boundedness suggests that the local officials' term of office is more than a year, displayed as $t = 1, 2, \ldots, T$. $\beta$ refers to the discount factor for local officials. $0 < \lambda \leq 1$ refers to the degree to which local officials attach importance to government consumption and local output. The greater $\lambda$ is, the local officials are more in favor of government consumption. When $\lambda = 1$, it suggests that the local officials show a complete preference for government consumption regardless of local output. The smaller $\lambda$ is, the local officials more prefer local output, assuming $\lambda > 0$ [8].

*3.2.3 Local officials' infrastructure supply behavior.* Assuming $\phi > (1-\beta\omega)\alpha/[1-(2-\omega)\beta\omega]$ to ensure that the system has a stable saddle path. Given the initial infrastructure level ($A_0^i$), the local officials maximize the utility function (10) when the constraints (8) and (9) are both satisfied [9]. When Equations (3) and (9) are put into Equation (10), the optimal problem of local officials can be shown as follows:

$$\underset{\{A_{t+1}^i\}}{Max} \sum_{t=0}^{T} \beta^t \left[ (1-\lambda+\lambda\pi) Y_t^i \left( K_t^i, A_t^i, L_t^i \right) + \lambda S_0^i - \frac{\lambda}{\phi} \left( A_{t+1}^i \right)^{\phi} \right]$$
$$s.t. \quad K_{t+1}^i = m\tilde{\beta}^t Y_t^i \left( K_t^i, A_t^i, L_t^i \right) \tag{11}$$

where $m = \omega(1-\pi)$, and the terminal condition is $G_T = 0$, that is, $A_{T+1} = 0$. Then the Lagrangian function that the local officials face is as follows:

$$Q^i = \sum_{t=0}^{T} \beta^t \left[ (1-\lambda+\lambda\pi) Y_t^i + \lambda S_0^i - \frac{\lambda}{\phi} \left( A_{t+1}^i \right)^{\phi} \right] + \sum_{t=0}^{T} \beta^t \mu_t \left[ m\tilde{\beta}^t Y_t^i - K_{t+1}^i \right] \tag{12}$$

Under the circumstance where $L$ is exogenously given, the optimal condition is deduced as follows:

$$\frac{\partial Q^i}{\partial A_{t+1}^i} = -\lambda \left( A_{t+1}^i \right)^{\phi-1} + \beta(1-\lambda+\lambda\pi) \frac{\partial Y_{t+1}^i}{\partial A_{t+1}^i} + \beta m \tilde{\beta}^{t+1} \mu_{t+1} \frac{\partial Y_{t+1}^i}{\partial A_{t+1}^i} = 0 \tag{13}$$

$$\frac{\partial Q^i}{\partial K_{t+1}^i} = \beta(1-\lambda+\lambda\pi) \frac{\partial Y_{t+1}^i}{\partial K_{t+1}^i} - \mu_t + \beta m \tilde{\beta}^{t+1} \mu_{t+1} \frac{\partial Y_{t+1}^i}{\partial K_{t+1}^i} = 0 \tag{14}$$

$$\frac{\partial Q^i}{\partial \mu_t} = m\tilde{\beta}^t Y_t^i - K_{t+1}^i = 0 \tag{15}$$

According to Equations (13)–(15) and the specific format of the production function of Equation (1), the following result can be further deduced:

$$-\frac{\lambda}{\alpha\beta m} \frac{\left( A_t^i \right)^{\phi}}{Y_t^i} + \frac{1}{m}(1-\lambda+\lambda\pi) + \frac{\omega\lambda\tilde{\beta}^t}{\alpha} \frac{\left( A_{t+1}^i \right)^{\phi}}{K_{t+1}^i} = 0 \tag{16}$$

$$m\tilde{\beta}^t Y_t^i - K_{t+1}^i = 0 \tag{17}$$

Equations (16) and (17) constitute the dynamic system of the utility maximization issue of local officials under this condition. When the system is stable, $A_{t+1}^i = A_t^i$, $K_{t+1}^i = K_t^i$, and $Y_{t+1}^i = Y_t^i$. Based on Equations (16) and (17), the following result can be inferred:

$$A^{i\phi} = \frac{\alpha\beta(1-\lambda+\lambda\pi)}{\lambda(1-\beta\omega)} Y^i \tag{18}$$

Taking the logarithm of both sides of Equation (18), we can gain the following result:

$$\ln A^i = \frac{1}{\phi-\alpha} \left\{ \ln \left[ \frac{\alpha\beta(1-\lambda+\lambda\pi)}{\lambda(1-\beta\omega)} \right] + \ln B^i + \omega \ln K^i + \psi \ln L^i \right\} \tag{19}$$

The economic meaning of Equation (19) is straightforward, which reveals the local officials' infrastructure supply behavior. To be more specific, the optimal infrastructure supply by local officials depends on the initial endowment in this region, enterprise investment and the amount of land used by enterprises. The aforementioned analysis shows that even under private ownership of land, local officials still have economic or output incentives to encourage them to supply infrastructure, which is the fundamental reason why local governments of different countries are all dedicated to improving infrastructure. It is also consistent with the hypothesis of economic incentives for infrastructure raised by Bai and Qian (2010).

Moreover, the stability of the dynamic system needs to be studied. First, for the convenience of calculation, $\lambda$ is set as 1, which does not affect the result of stability analysis. Then, log-linearization is carried out in Equations (16) and (17), and the results show that the corresponding characteristic matrix has the following features: First, the determinant of the characteristic matrix is equal to $1/\beta$, which is greater than 1; second, the trace of the characteristic matrix is shown as $(\omega\phi\beta\omega + \phi + \alpha\beta\omega - \alpha)/\phi\beta\omega$. According to the hypothesis that $\phi > (1-\beta\omega)\alpha/[1-(2-\omega)\beta\omega]$, the trace of the matrix is greater than 2. Based on the conclusion of Azariadis (1993, p. 75), it can be deduced that the dynamic system entails a stable saddle path, so the system is proven stable [10].

*3.2.4 Discussion.* In the case where other conditions remain unchanged, the more the local government prefers local output, the smaller $\lambda$ is, then the larger the value of the right side of Equation (19) is, and the larger $\ln A^i$ is. It reveals that under private ownership of land, even if the input, including endowment, capital and land, remains unchanged, the local governments with a bias toward production will supply more infrastructures. That is, the production-oriented government has a positive effect on infrastructure development.

### *3.3 Extended model: infrastructure supply under public ownership of land*

The infrastructure supply behavior of local officials is studied in the case where all the conditions remain the same as those of the benchmark model except the land regime. It should be noted that public ownership of land herein contains the institutional regulations favorable to land grant, land lease and financing, which means that enterprises purchase lands from local governments. Assuming that revenues generated from explicit and implicit land support in Figure 2 are included in the model at a fixed percentage of land-grant income, which is indicated by $\vartheta$.

*3.3.1 The budget constraint on local governments.* In the case of completely public ownership of land, the local government has capabilities such as granting land, and the local officials have the pricing power on the land requisition and land grant, but they need to requisition or expropriate the land from peasants before granting enterprises use rights of this land, on the hypothesis that there is no land reserved. As such, the budget constraint on the local government is changed. Compared with the benchmark model, the local government's income in the extension model has one more item, that is, the land-related incomes, including the land-grant income $(P_t^i L_t^{si})$ and other land incomes $(\vartheta P_t^i L_t^{si})$ [11]. $P_t^i$ stands for land-grant price, $L_t^i$ for the area of land granted or requisitioned and $\vartheta$ for the fixed ratio of other land incomes to the land-grant income $(\vartheta > 0)$. The local government's expenditure here has one more item, compared with the benchmark model, which is the land requisition cost $(P_t^{ei} L_t^i)$ with $P_t^{ei}$ for the unit cost of the land requisitioned by the government. Therefore, the budget constraint on the local government $(i)$ during $t$ is changed from Equation (9) to the following equation:

$$G_t^i + P_t^{ei} L_t^i + C_t^{Ri} = \pi Y_t^i + (1+\vartheta) P_t^i L_t^i \tag{20}$$

Equation (20) indicates that the local government's infrastructure investment cost can be recovered by taxation and land grants.

*3.3.2 Local officials' utility.* In a politically centralized environment, hypothetically, the local government is required by the central planner to pay attention to the welfare of local peasants whose land is requisitioned, that is, land-lost peasant consumption ($C_t^i$), for maintaining social stability. Therefore, the utility function of local officials is changed to the following formula from Equation (10).

$$U^i = \sum_{t=1}^{T} \beta^t \left[\lambda C_t^{Ri} + (1-\lambda) Y_t^i + \zeta C_t^i\right] \quad (21)$$

Regarding the aforementioned formula, $\zeta > 0$ measures the degree to which the local officials attach importance to local land-lost peasants' consumption.

*3.3.3 The budget constraint [12] on peasants.* Due to the consideration of $C_t^i$, the budget constraint on the land-lost peasants needs to be analyzed. Hypothetically, the peasants only manage land, and their income fully depends on land. At the beginning of $t$, the area of the land they own is $L_t^{0i}$; during $t$, the area of the land requisitioned is $L_t^i$ with the compensation for the unit area of the land being $P_t^{ei}$ and the unit income for managing land being $R_t^i$. In the case of $P_t^{ei} < R_t^i$, the land compensation fees cannot ensure their original income. Due to the ambiguous land property right, peasants have no negotiating power in the process of land requisition, so they can only accept the land compensation standard issued by the local government (Zhang *et al.*, 2011). Therefore, the budget constraint on land-lost peasants in the region ($i$) goes as:

$$C_t^i = R_t^i\left(L_t^{0i} - L_t^i\right) + P_t^{ei} L_t^i \quad (22)$$

*3.3.4 The infrastructure supply behavior of local officials.* Now the optimal behavior of the local officials is the maximized Equation (21) in the case where constraint Equations (8), (20) and (22) are satisfied, that is,

$$\begin{aligned} \underset{\{A_{t+1}^i\}}{Max} \sum_{t=0}^{T} \beta^t \Big[ & (1-\lambda+\lambda\pi) Y_t^i + \lambda S_0^i - \frac{\lambda}{\phi}\left(A_{t+1}^i\right)^{\phi} + \lambda(1+\vartheta) P_t^i L_t^i \\ & + (\zeta-\lambda) P_t^{ei} L_t^i + \zeta R_t^i \left(L_t^{0i} - L_t^i\right)\Big] s.t. \quad K_{t+1}^i = m\tilde{\beta}^t Y_t^i\left(K_t^i, A_t^i, L_t^i\right) \end{aligned} \quad (23)$$

where the terminal condition is: $L_T^i = 0$, $G_T = 0$, aka, $A_{T+1} = 0$. The Lagrangian function that the local officials face is as follows:

$$\begin{aligned} Q^i = \sum_{t=0}^{T} \beta^t \Big[ & (1-\lambda+\lambda\pi) Y_t^i + \lambda S_0^i - \frac{\lambda}{\phi}\left(A_{t+1}^i\right)^{\phi} + \lambda(1+\vartheta) P_t^i L_t^i + (\zeta-\lambda) P_t^{ei} L_t^i \\ & + \zeta R_t^i \left(L_t^{0i} - L_t^i\right)\Big] + \sum_{t=0}^{T} \beta^t \mu_t \left[m\tilde{\beta}^t Y_t^i\left(K_t^i, A_t^i, L_t^i\right) - K_{t+1}^i\right] \end{aligned} \quad (24)$$

Compared with Equation (12), the term of $\lambda(1+\vartheta)P_t^i L_t^i + (\zeta-\lambda)P_t^{ei} L_t^i + \zeta R_t^i (L_t^{0i} - L_t^i)$ is added to the right side of Equation (24), but the addition is not directly related to variables such as $A$ and $K$. Hence, the optimal condition should be constituted by Equations (13)–(15) of the benchmark model and the following Equation (25).

$$\frac{\partial Q^i}{\partial L_t^i} = (1-\lambda+\lambda\pi)\frac{\partial Y_t^i}{\partial L_t^i} + \lambda(1+\vartheta)P_t^i + (\zeta-\lambda)P_t^{ei} - \zeta R_t^i + m\tilde{\beta}^t \mu_t \frac{\partial Y_t^i}{\partial L_t^i} = 0 \quad (25)$$

First, according to Equation (25), the following result can be deduced:

$$\frac{\partial Y_t^i}{\partial L_t^i} = Z\left(P_t^i\right) \quad (26)$$

where $Z(P_t^i) = \{\zeta(R_t^i - P_t^{ei}) + \lambda[P_t^{ei} - (1+\vartheta)P_t^i]\}/(1-\lambda+\lambda\pi+m\tilde{\beta}^t\mu_t)$ is the marginal cost of the local officials' granting land; $\mu_t$ is the Lagrange multiplier or shadow price, which is positive, and its solution is a measure of the influence of change in constraints caused by $m\tilde{\beta}^t Y_t^i$ on the maximum utility of local officials. Equation (26) indicates that when the local officials' utility is maximized, the marginal output of land grant equals its marginal cost. The marginal cost depends on some factors, including the price difference between the land grant and the land requisition and the difference between total incomes from land and compensation fee for land requisition. In the case where $\partial Z(P_t^i)/\partial P_t^i < 0$, the higher the land-grant price is, the lower the marginal cost of the land grant is. The local officials' decision is to make a trade-off between the GDP growth brought about by land grants and the opportunity cost of the land grant. Based on Equations (1) and (25), the following equation can be gained:

$$L_t^i = \psi^{1/(1-\psi)}\left(B_t^i\right)^{1/(1-\psi)}\left(A_t^i\right)^{\alpha/(1-\psi)}\left(K_t^i\right)^{\omega/(1-\psi)}\left[Z\left(P_t^i\right)\right]^{-1/(1-\psi)} \tag{27}$$

The hidden economic meaning of Equation (27) manifests local officers' behaviors of granting land and measures the positive correlation between land supply ($L$) and land-grant price ($P$).

Furthermore, it can be known from the optimal condition, except for Equation (25), the other conditions are the same as in the benchmark model, while the condition of land supply ($L$) and land price ($P$) contained in Equation (25) is exogenously given in terms of the dynamic system. Therefore, it can be inferred that just like the benchmark model, the dynamic system under this condition has a stable saddle path and stationary equilibrium.

According to Equation (1), (18) and (27), the following equation can be deduced:

$$\begin{aligned}\ln A^i = \frac{1}{\phi-\phi\psi-\alpha}\bigg\{&\psi\ln\psi + (1-\psi)\ln\frac{\alpha\beta(1-\lambda+\lambda\pi)}{\lambda(1-\beta\omega)} + \ln B^i \\ &+ \omega\ln K^i - \psi\ln Z\left(P^i\right)\bigg\}\end{aligned} \tag{28}$$

The economic meaning of Equation (28) is obvious, which reveals the infrastructure supply behavior of local officials with the capabilities of granting land, financing and so on. Compared with Equation (19), the first term before the brace on the right side of Equation (28) is greater, which means that public ownership of land strengthens the marginal utility of infrastructure of factor input. In addition, the first term inside the brace on the right side is a newly added term, which is greater than zero, while the second term inside the brace on the right side gets smaller than that in Equation (19). Therefore, the positive and negative effects are not prominent. Furthermore, due to the negative correlation between $P^i$ and $Z(P^i)$, Equation (28) indicates the positive correlation between $P_t^i$ and $A_t^i$.

What's more important is that under public ownership of land, the local officials can control the amount of land supply ($L$) and the land price ($P$) at the same time, and Equation (28) discloses the positive correlation between land-grant price and infrastructure, thus forming the financing mechanism for local officials to supply infrastructure by regulating the land-grant price. The local officials can meet the needs of infrastructure investment by increasing the land-grant price to achieve the effective supply of infrastructure. Compared with private ownership of land, this is the most prominent advantage of local officials' infrastructure supply under public ownership of land.

*3.3.5 Discussion.* In the case where other conditions remain unchanged, if the local governments show more preference for local output, the value of $\lambda$ will be smaller, and the second term inside the brace on the right side of Equation (28) will get greater. It indicates that under public ownership of land, even if the input of endowment, capital, land and other factors remains unchanged, the local government with a bias toward output provides more infrastructure than the government with no preference for production, that is, the production-oriented government has positive effects on infrastructure. Furthermore, the existence of $\vartheta$ in $Z(P^i)$ means that other explicit revenues and implicit revenues from land also have a positive impact on infrastructure. The greater the $\vartheta$ is, the greater the impact will be.

*3.4 Conclusive analysis and comparison*

Based on the aforementioned analysis of the benchmark model and the extended model and the comparison, it is found that when the factor input is constant, the main factor determining local officials' optimal infrastructure supply is the self-financing mechanism formed by local officials by regulating the land-grant price, which is highly related to the structure of a country's land regime. Under public ownership of land, local officials can achieve self-financing of infrastructure by regulating the land-grant price, which means that as long as the land price can rise, any infrastructure investment needs of local officials can be met, thus achieving a powerful capability of infrastructure self-supply. It can be seen that the local government under public ownership of land has stronger financing ability than the government under private ownership of land, and thus it can supply more infrastructures. Apart from that, it is concluded from the discussion section of aforementioned models that in the case of other conditions remaining unchanged, if the local government shows more preference for output in this region, it will provide more infrastructures. In other words, that a production-oriented government has a preference for infrastructure and economic incentives are the most basic incentives will stimulate a local government to provide infrastructure.

Given the situation of China, the authors find that China belongs to the condition of the extended model. China adopts socialist public ownership, that is, the ownership by the whole people and collectives, of land, and the current land regime structure grants the local government strong capabilities of granting land and financing. In addition, China's local government is production-oriented, and the local officials prefer local output. That is, the value of $\lambda$ is relatively small, which also causes the local government to supply more infrastructure. Yao (2011) believes that China's government is a production-oriented government. Zhang *et al.* (2007) assert that as to the local governments, the investment decision of infrastructure seems to be related to fulfilling the objective of economic growth instead of reallocation issues. Thus, the local officials' optimal supply of infrastructure in China is the greatest one among all the cases. The matching of public ownership of land and production-oriented government facilitates the supernormal development of China's infrastructure. The bias of local officials toward output can exist under both private ownership and public ownership of land and is a universal means for all countries, only varying in degree of effect. However, public ownership of land with its unique system structure is the special means of China, and other countries under private ownership of land can hardly imitate them completely. This is the fundamental reason why China can achieve the supernormal development of infrastructure within such a short period, while other countries cannot make the same achievement.

The authors analyzed the situation of India as a reference. India adopts a private land regime, and local governments in India do not have the function of economic development (Bardhan, 2006), so local officials in India do not have direct incentives for boosting the economic output. Therefore, India belongs to the situation of the benchmark model with no bias for output, which is the worst condition in infrastructure supply under the economically decentralized regime. This is also a reason why India's infrastructure falls behind and forms a prominent contrast with China [13]. According to the estimate by the Ministry of Finance of India, if the infrastructure can keep pace with economic development, India's GDP growth will increase by 2% (Heymann *et al.*, 2007). In fact, a lot of developing countries under private ownership of land such as Laos and Cambodia also face the same problem.

## 4. Empirical test

The aforementioned analysis includes two significant aspects [14]. First, China's explicit and implicit land support has an essential influence on the supernormal development of China's infrastructure. The most representative channel is local officials' self-financing mechanism for infrastructure by regulating the land-grant price. Second, structural changes in China's land regime around 1990 can be regarded as a policy reform of China in a particular stage. The overall effect of the policy on China's infrastructure growth can be verified by comparing multinational samples. Therefore, this section adopts the traditional regression analysis method to testify the hypothesis about China's land support and uses the synthetic control method in the comparative case study to investigate the overall policy effect resulting from the reform of China's land regime [15].

### *4.1 Traditional regression analysis method*

4.1.1 Metric model specification. In order to verify the tenability of the land support hypothesis, combined with the aforementioned theoretical analysis, it is assumed that the endowments of different regions indicated by $B^i$ are different. To be specific, the endowment is set as $\ln B^i = a + u_i$, where $a$ is a constant and $u_i$ is a disturbing term, subject to the standard lognormal distribution. Hence, based on Equation (28), the metric model of the infrastructure supply behavior of China's local officials takes the following form:

$$\ln A_{it} = a_0 + a_1 \ln P_{it} + a_2 \ln K_{it} + a_3 \ln X_{it} + u_{it} \tag{29}$$

where the constant term $\alpha_0$ includes $a$ and other constants of Equation (28); $A$ is for infrastructure capital stock in a province/municipality; $P$ is for the average land-grant price on the provincial or municipal level [16]; $K$ is for enterprise investment, of which variate is substituted by the actual yearly foreign direct investment (FDI) of each province/municipality; $X$ is for a set of control variables. $a_1$ is the regression coefficient. When the land support hypothesis is proven true, $a_1 > 0$. There may be some endogeneity problems in Equation (29).

*4.1.2 Empirical analysis.*

(1) Data illustration and descriptive statistics. Due to the limitation of data, the paper can only select the panel data of 30 provinces/municipalities between 1999 and 2008 for analysis (Chongqing is incorporated into Sichuan province for calculation). We chose provinces as the unit of analysis because the provincial governments play a significant role in promoting financing through granting land according to the *Land Administration Law* enacted in 1998. We selected the sample data between 1999 and 2008 because the new *Land Administration Law* enacted in 1998 started to take effect on January 1, 1999, and the latest estimates of infrastructure capital stock of every province were up to 2008 (Jin, 2012), and no data updated was found when the authors wrote this paper. The descriptive statistics of correlated variables are shown in Table 2 in detail.

(2) Model estimate. In order to gain a reliable result, after conducting the Hausman test to choose between fixed effects (FEs) and random effects, we selected the fixed effect (FE) estimate. We acquired a significant result of the land support hypothesis. To solve the problem between autocorrelation and heteroskedasticity, we carried out a revised estimate with the robust Driscoll–Kraay standard errors. The result shows that the land support hypothesis has significant explanatory power. The initial regression results are listed in Table 3 in detail.

*4.1.3 Endogenous problems.* We conducted the *C*-statistic endogeneity test first, and then we tried to overcome the endogeneity problem via instrumental variable (IV) approach and further testified the solidity of the result through the generalized method of moments (GMM) in a FE panel data model. The regression situation is shown in Table 4, which suggests that the estimate is valid and reliable. Given the land factor, the land support hypothesis is proven positive. We examined different instrumental variables' impact on the result, and all instrumental variables have passed the validity check (the detailed analysis is not reported in this paper).

### 4.2 Synthetic control method

In order to explore the overall impact that public ownership of land and a series of institutional arrangements in favor of land grants have on the supernormal development of China's infrastructure, we chose China as the treatment group and 22 OECD countries as the potential comparative reference group [17], and the data used are the balanced panel data collected from the aforementioned 23 countries from 1970 to 2002. The reason why we only chose 22 OECD countries for the comparison is because of our lack of data about the infrastructure capital stock of other countries. The samples start in 1970 because we consider that there is a certain number of years away from the policy reform period as well as the availability of data and end in 2002 mainly because Kamps (2006) only estimated the infrastructure capital stock of OECD countries by 2002, and no new data have been found so far. Although the structural change in China's land regime that is favorable for the land income of China's local governments began with the 1982 version of Constitution and then the *Land Administration Law* (1986) and was formed in the land transfer system in 1990, the symbolic milestone of the land regime structural change is the first national land auction in Shenzhen in 1987. Hence, we selected the period between 1970 and 1987 to fit the predictive variables. Our objective is to construct the "counterfactual" variables. We simulate the potential infrastructure capital stock of China under the condition of no structural change in the land regime with the weighted average of the OCED countries. Then we compare it with the actual infrastructure capital stock of China to estimate the influence that the structural change in the land regime exerts on China's infrastructure development. The explained variables and predictive variables are shown in Table 6.

*4.2.1 The influence of structural changes in the land regime on the supernormal development of China's infrastructure.* Based on the analysis through the synthetic control method, Table 5 shows the weighted combination of synthesized China. In order to explore

| Variables | Mean | Standard deviation | Minimum value | Maximum value | Observed value |
|---|---|---|---|---|---|
| Log Koc of infrastructure capital stock per capita (lnA) | 8.890812 | 0.668481 | 7.242494 | 10.88083 | 300 |
| Log Koc of average land-grant price (lnP) | 5.108906 | 0.907519 | 1.792246 | 7.533015 | 300 |
| Log Koc of FDI per capita (lnFDI) | 5.358969 | 1.569653 | 1.14668 | 8.341105 | 300 |
| Labor participation rate (LPR) | 0.538085 | 0.068619 | 0.36958 | 0.776283 | 300 |
| Log Koc of GDP per capita (lnGDP) | 9.150196 | 0.594623 | 7.76811 | 10.91492 | 300 |
| Urbanization rate (URR) | 0.427181 | 0.141030 | 0.219879 | 0.874569 | 300 |
| Log Koc of infrastructure initial value per capita (lnA0) | 8.570417 | 0.674107 | 6.846299 | 10.52000 | 300 |
| Financial correlation ratio (FIR) | 2.346917 | 0.741488 | 1.296529 | 5.899243 | 300 |
| Industrialization rate (INR) | 0.382162 | 0.101485 | 0.081674 | 0.562423 | 300 |

**Note(s)**: Unless otherwise specified, the data were extracted from *China Compendium of Statistics 1949–2008*, database of National Bureau of Statistics of China (http://data.stats.gov.cn/), and *China Land & Resources Almanac* of the corresponding year

**Table 2.** Descriptive statistics of correlated variables

**Table 3.** Preliminary regression results: fixed effect model [explained variables: Log Koc of infrastructure capital stock per capita (lnA)]

| Explanatory variable | Equation (1) FE | Equation (2) FE | Equation (3) FE | Equation (4) Driscoll–Kraay | Equation (5) Driscoll–Kraay | Equation (6) Driscoll–Kraay |
|---|---|---|---|---|---|---|
| lnP | $0.020^{**}$ (0.010) | | 0.016 (0.010) | $0.020^{**}$ (0.009) | | $0.016^{*}$ (0.009) |
| lnFDI | | $0.030^{**}$ (0.012) | $0.026^{**}$ (0.012) | | $0.030^{***}$ (0.005) | $0.026^{***}$ (0.005) |
| LPR | $0.851^{***}$ (0.242) | $0.920^{***}$ (0.241) | $0.896^{***}$ (0.241) | $0.851^{***}$ (0.302) | $0.920^{***}$ (0.317) | $0.896^{***}$ (0.315) |
| lnGDP | $0.291^{***}$ (0.076) | $0.301^{***}$ (0.075) | $0.281^{***}$ (0.076) | $0.291^{***}$ (0.079) | $0.301^{***}$ (0.093) | $0.281^{***}$ (0.082) |
| URR | $0.740^{***}$ (0.266) | $0.754^{***}$ (0.263) | $0.726^{***}$ (0.263) | $0.740^{***}$ (0.157) | $0.754^{***}$ (0.163) | $0.726^{***}$ (0.148) |
| lnA0 | $0.670^{***}$ (0.041) | $0.698^{***}$ (0.041) | $0.694^{***}$ (0.041) | $0.670^{***}$ (0.068) | $0.698^{***}$ (0.078) | $0.694^{***}$ (0.072) |
| FIR | $0.047^{**}$ (0.022) | $0.045^{**}$ (0.022) | $0.045^{**}$ (0.022) | $0.047^{*}$ (0.026) | 0.045 (0.031) | 0.045 (0.028) |
| INR | $0.580^{*}$ (0.314) | 0.437 (0.309) | $0.524^{*}$ (0.313) | $0.580^{**}$ (0.211) | $0.437^{*}$ (0.224) | $0.524^{**}$ (0.250) |
| cons | $-0.98^{***}$ (0.340) | $-1.09^{***}$ (0.333) | $-0.94^{***}$ (0.347) | $-0.98^{***}$ (0.201) | $-1.09^{***}$ (0.273) | $-0.94^{***}$ (0.203) |
| *R*-sq | 0.884 | 0.872 | 0.872 | 0.989 | 0.979 | 0.979 |
| Observed value | 300 | 300 | 300 | 300 | 300 | 300 |

**Note(s)**: The number in the bracket is the standard error, and standard errors in Equations (4)–(6) are Driscoll–Kraay robust standard errors. FE represents the fixed-effects regression. Driscoll–Kraay means estimating fixed-effects regression with Driscoll–Kraay standard errors, with lag = 1. "***", "**" and "*" indicate that results of the two-tailed test are significant at the significance level of less than 1, 5 and 10%, respectively (similarly hereinafter)

**Table 4.** Regression results: considering endogeneity [explained variables: Log Koc of infrastructure capital stock per capita (lnA)]

| Explanatory variables | Equation (7) IVFE | Equation (8) IVFE | Equation (9) IVFE | Equation (10) FEGMM | Equation (11) FEGMM | Equation (12) FEGMM |
|---|---|---|---|---|---|---|
| lnP | 0.035*** (0.011) | | 0.035*** (0.011) | 0.034*** (0.010) | | 0.034*** (0.011) |
| lnFDI | | −0.004 (0.019) | −0.002 (0.019) | | −0.004 (0.019) | −0.003 (0.019) |
| LPR | 0.788*** (0.272) | 0.859*** (0.264) | 0.785*** (0.273) | 0.750*** (0.269) | 0.845*** (0.252) | 0.746*** (0.270) |
| lnGDP | 0.394*** (0.099) | 0.428*** (0.092) | 0.396*** (0.098) | 0.386*** (0.099) | 0.427*** (0.092) | 0.387*** (0.098) |
| URR | 1.005*** (0.329) | 1.147*** (0.328) | 1.009*** (0.335) | 1.029*** (0.326) | 1.130*** (0.324) | 1.034*** (0.331) |
| lnA0 | 0.573*** (0.053) | 0.591*** (0.049) | 0.574*** (0.053) | 0.580*** (0.052) | 0.592*** (0.049) | 0.581*** (0.053) |
| FIR | 0.082*** (0.025) | 0.080*** (0.024) | 0.082*** (0.025) | 0.082*** (0.025) | 0.082*** (0.024) | 0.083*** (0.025) |
| INR | 0.979*** (0.369) | 0.790** (0.378) | 0.980*** (0.372) | 0.982*** (0.365) | 0.826** (0.373) | 0.990*** (0.369) |
| Instrumental variables | L.lnGDP, L.FIR L.lnA0, L.LPR | IVs of Equation (7) and l.lnFDI | The same as Equation (8) | The same as Equation (7) | The same as Equation (8) | The same as Equation (8) |
| Underidentification | 44.44 ($p$ = 0.00) | 35.64 ($p$ = 0.00) | 36.51 ($p$ = 0.00) | 44.44 ($p$ = 0.00) | 35.64 ($p$ = 0.00) | 36.51 ($p$ = 0.00) |
| Weak IV | 77.17 | 15.44 | 15.25 | 77.17 | 15.44 | 15.25 |
| Overidentification | 1.85 ($p$ = 0.40) | 0.52 ($p$ = 0.77) | 1.82 ($p$ = 0.40) | 1.85 ($p$ = 0.40) | 0.52 ($p$ = 0.77) | 1.82 ($p$ = 0.40) |
| Endogeneity | 19.89 ($p$ = 0.00) | 21.59 ($p$ = 0.00) | 21.73 ($p$ = 0.00) | 19.89 ($p$ = 0.00) | 21.59 ($p$ = 0.00) | 21.73 ($p$ = 0.00) |
| $R$-sq | 0.977 | 0.976 | 0.977 | 0.977 | 0.976 | 0.977 |
| Observed value | 270 | 270 | 270 | 270 | 270 | 270 |

**Note(s)**: Table 4 is the results of estimates under the order of xtivreg2 by the Sata software. The figures within the bracket in the table (testified terms excluded) are the robust standard errors of heteroskedasticity and autocorrelation. The constant term is not reported. IVFE refers to the fix-effect instrumental variable method, and FEGMM refers to the fixed-effect GMM estimate, implemented in a two-step manner. Underidentification refers to the underidentification test with Kleibergen–Paap rk LM statistic. Weak IV means weak instrumental variable Test tith Kleibergen–Paap rk Wald $F$ statistic. Overidentification refers to the overidentification test with Hansen's $J$ statistic. Endogeneity means the endogeneity test of the difference of two Sargan–Hansen statistics. $p$ refers to probability value whether the weights of the four countries are linear interpolation–oriented, we change the targeted countries for simulation, respectively. The results show that the country names and weight coefficients for each simulated synthesis are all different, which indicates there is no linear interpolation. It can be known from Table 6 and Figure 3 that the year 1987 is a turning point. The synthetic control method fits well the features of China's infrastructure growth before 1987, so this method is suitable for estimating the effect of China's land regime reform on the supernormal development of infrastructure. From 1987, the infrastructure capital stock of real China is continuously higher than that of synthesized China, with enlarging difference forming a prominent "scissors gap." This difference means that compared with the condition of no land regime reform, the land regime reform greatly increases China's infrastructure capital stock [18], and the enlarging difference was further strengthened after the land requisition system and housing system reform in 1998. Assuming that there were no structural changes in the land regime around 1990, the potential infrastructure capital stock of China in 2002 would be US$117.417*bn* (in constant 1995 prices, similarly hereinafter), which is $485.573*bn* less than the actual amount, and the actual volume increases by 4.1355 times compared with the potential amount [19].

*4.2.2 Robust permutation test.* We followed Abadie *et al.*'s method (2010) improved by Liu and Fan (2013) to measure the volatility of infrastructure capital stock by calculating the difference between the real number and the synthesized number of each country's infrastructure capital stock, dividing it by the current composition amount and multiplying it by 100%. If the variation distribution is significantly different, it is suggested that our findings about China's infrastructure growth are significant.

From Figure 4, there is little difference between the volatility of China and that of other countries before 1987, but after 1987, the difference is gradually greater and forms a

**Table 5.**
Weighting coefficients of different countries in synthesized China

| Country | Denmark | Greece | Portugal | Spain |
|---|---|---|---|---|
| Weighting coefficient | 0.056 | 0.295 | 0.516 | 0.133 |

**Table 6.**
Fitting and comparison of predictive variables

| | China | Synthesized China | 23 countries |
|---|---|---|---|
| Infrastructure capital stock (US$100*m*, in constant 1995 prices, similarly hereinafter) | 479.4444 | 503.2101 | 4120.957 |
| Initial value of the infrastructure capital stock (US$100*m*) | 427.2588 | 475.4194 | 3982.344 |
| Enterprise capital stock (US$100*m*) | 1176.276 | 3201.923 | 14,465.53 |
| Economic development level (GDP, US$100*m*) | 1630.446 | 1435.388 | 6806.656 |
| Urbanization level (urbanization rate) | 0.1916518 | 0.5550522 | 0.7031252 |
| Financial development level (domestic credits as % of GDP) | 0.5562777 | 0.7072565 | 0.7216378 |
| Economic exploitation level (merchandise trade as % of GDP) | 0.1429303 | 0.3258198 | 0.4335437 |
| Infrastructure capital stock in 1970 (US$100*m*) | 246.8 | 348.3228 | 2890.317 |
| Infrastructure capital stock in 1972 (US$100*m*) | 297.5 | 385.9155 | 3180.991 |
| Infrastructure capital stock in 1978 (US$100*m*) | 469.4 | 498.22 | 4071.526 |
| Infrastructure capital stock in 1984 (US$100*m*) | 593.9 | 597.0445 | 4887.93 |
| Infrastructure capital stock in 1985 (US$100*m*) | 664.5 | 616.7829 | 5005.339 |
| Infrastructure capital stock in 1986 (US$100*m*) | 748.5 | 641.4064 | 5123.461 |

**Note(s)**: The data about China's infrastructure capital stock come from Jin (2012). The data about infrastructure capital of 22 OECD countries come from Kamps (2006). The original data about China's physical capital stock come from China Center for Economic Studies of Fudan University. The rest of the data all come from the World Development Index and OECD database of the World Bank

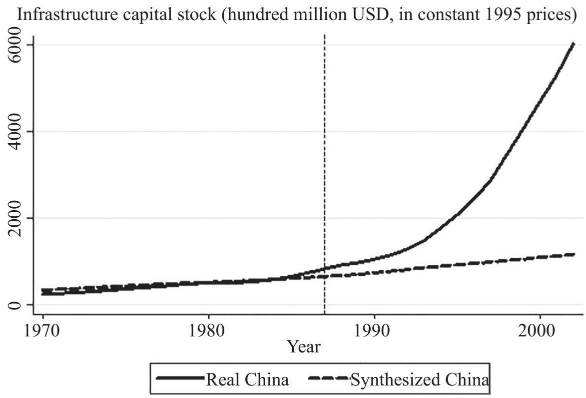



**Figure 3.**
China's real and synthesized infrastructure capital stock

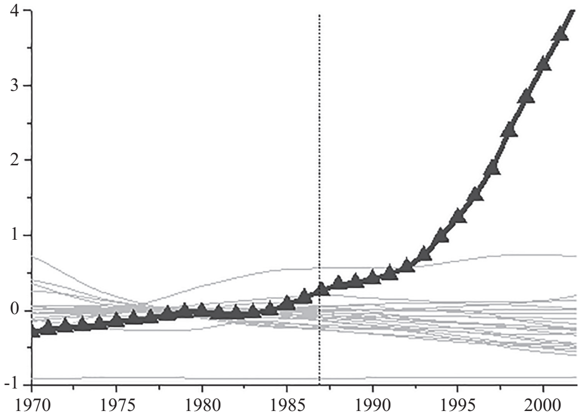



**Figure 4.**
Estimated volatility distribution of China and other

prominent "scissors gap." Furthermore, we also calculated the ratio of the average volatility after 1987 to that before 1987. The results of the study on the ratio show that the country with the highest ratio is China, and the ratio is as high as more than 12. It indicates that the land regime reform has a significant influence on infrastructure growth, which is not a coincidence.

Furthermore, we adopted the placebo test to study two extreme countries under the condition of changing treatment groups (refer to Figures 5 and 6. The results show that the two countries' condition shows no identical or similar features with China's condition. Therefore, the synthetic control method offers strong evidence to show that the structural change in the land regime in the 1990s influences the supernormal development of China's infrastructure.

## 5. Conclusion

Now many countries have public land. Land-support financing of infrastructure is also a manner commonly used by countries to develop their infrastructure. However, few countries implement completely public ownership of land like China. It is the public ownership of land and the special institutional structure, which was formed in the special period, that generate

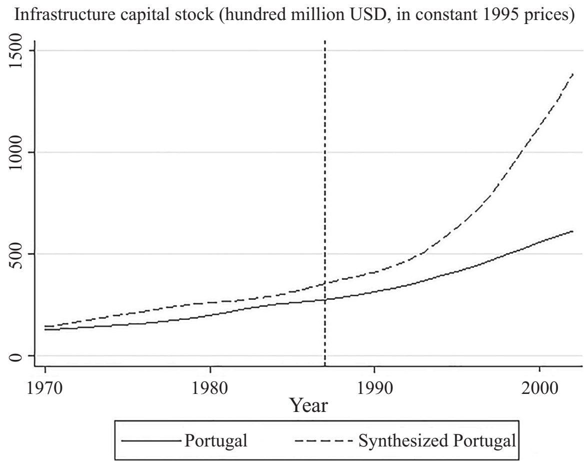



**Figure 5.**
Portugal's real and synthesized infrastructure capital stock

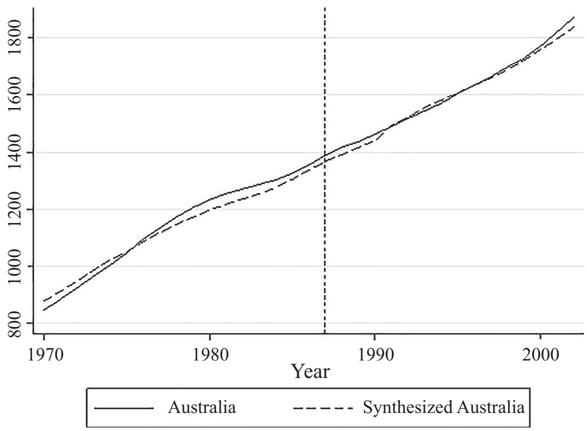



**Figure 6.**
Australia's real and synthesized infrastructure capital stock

the land-support development mode of China's infrastructure. This mode not only makes the land support the development of China's infrastructure from the aspect of material but also enables the value of lands to play a bigger role. In the case where local governments are generally constrained by "payroll finance" (i.e. a large proportion of the budget has been earmarked for paying salaries of government functionaries), and the local economic takeoff has an urgent and huge need for funds for infrastructure construction, the land plays a role in accumulating and concentrating funds for local infrastructure construction through its value channel, which is indispensable for creating China's growth miracle. The big push model and its extended theories (Rosenstein-Rodan, 1943; Murphy *et al.*, 1989) also confirm it. Many developing countries make it difficult for their economies to take off because they fail to solve the financing problem for infrastructure construction. Therefore, from this perspective only, we cannot attach too much importance of land to China's economic growth as well as infrastructure development. In this respect, China has created the most successful example in swapping land assets for infrastructure assets.

Although this kind of land regime structure arrangement is greatly supportive for local governments, it is at the expense of interests of land-lost peasants and the efficiency of the land market, resulting in a series of distorting problems, which makes it difficult for China's government to implement function transformation and the market-oriented reform of land. In this respect, the "Land-support Development" mode of China's infrastructure is the main root of various significant problems in the current economic society, which has huge social risks and financial debt risks and is not sustainable. Therefore, we suggest that the central government should advance the reform of land requisition system and protect the interest of land-lost peasants to alter the situation where the land expropriation is biased toward local governments. Here are some key measures: first, requisition land at a market-oriented price (including the increment generated upon the completion of planned infrastructure programs) to break the mechanism formed by the local governments to realize the infrastructure self-financing by regulating the land-grant price. Second, carry out a market-oriented land reform based on property rights to change the supply method of lands for construction and further promote fairness and justice in land transactions. Third, promote the new-type urbanization, fundamentally change the phenomenon of local government's dependence on land-based finance, establish a fair and sharing allocation system of the land increment and so on. In conclusion, the solution lies in the land regime reform and new-type urbanization. Also, under the strategy of Belt and Road Initiative, it is of great practical significance to replicate and promote China's experience in infrastructure construction and use it to help developing countries to eliminate the bottleneck of infrastructure.

## Notes

1. The object of study in this article is economic infrastructure. According to the definition provided by the World Bank, infrastructure consists of economic infrastructure and social infrastructure. Economic infrastructure refers to engineering constructions, equipment, facilities under long-term usage and services for economic production and household needs, including public utilities, public works and other transport sectors (World Bank, 1994).
2. Unless otherwise specified, the original data in this section were extracted from the *China Land & Resources Almanac* and *Finance Yearbook of China* of 2008 and 2011.
3. It means considering the impact of social constraints on the infrastructure supply behavior of local officials. Many thanks go to the anonymous reviewer for the advice.
4. The economic incentive is manifested by local officials' pursuit of maximizing the economic benefits of local government, which is the most basic incentive mechanism for local officials. Political incentives are reflected in the local officials' bias toward output, which is highly related to the economic entity's political system structure.
5. $\omega + \alpha + \psi < 1$ means that the production of the representative companies is hypothesized as decreasing returns to scale.
6. It is assumed that the land supplier is different from the representative consumer, implying that the land $L$ is either provided directly by the peasants (the peasants are the land suppliers under private ownership of land) or provided by the local government (the peasants' land will not be provided to the enterprise until it is expropriated or requisitioned by the local government under public ownership of land).
7. Many thanks go to the reviewer's suggestions on the budget constraint on local governments.
8. If $\lambda = 0$, the local government's consumption is likely to be negative, so this hypothesis is excluded. Thanks to the reviewer for the advice.
9. It must be noted that in the centralized politics, as the representatives of local governments, the constraints on local officials' infrastructure supply are the budget constraints on local governments rather than on local officials themselves.
10. For further details on the derivation process of log-linearization, please contact the author.

11. Other revenues from land refer to all revenues, including explicit revenues and implicit revenues, except land-grant income.
12. It needs to be noted that hypothetically, the peasants discussed herein only manage land with the land as their sole income source, and the government has pricing right over the land expropriated and requisitioned. As such, peasants are utterly passive in terms of consumption decisions, which is fundamentally distinctive with the free decision-making behavior of representative consumers. As the representative consumer owns the enterprise and the enterprise purchases land (or land-use rights) from the government, then the government expropriates or requisitions land from peasants, peasants discussed herein are a special group completely different from representative consumers. Thanks to the reviewer for the advice on strengthening the explanation.
13. In the *India Infrastructure Report 2009*, IDFC gives an extensive report on taking land as the critical resource of India's infrastructure and points out that land is the heart for infrastructure construction in India. It illustrates the intense need of infrastructure for land in India and difficulties as well as problems existing in India's solving issues of market construction, land expropriation and compensation, according to Nirmal *et al.* (2009).
14. Thanks to the anonymous reviewer's advice to have an empirical test to testify the idea, "the structure change of land regime affects the land-grant price" and the suggestion of using multinational samples to conduct an empirical test. However, the empirical test cannot be realized as the actual time when the land regime reform took place is inconsistent with the statistical time range of official data. Therefore, this paper takes the statement that land regime structure affects the land-grant price as a given condition, which is embodied in the aforementioned realistic and theoretical analysis.
15. Due to the word limit, this part simplifies the actual data processing procedure and the illustration of the empirical process for regression and only reports regression results. For further details, please contact the author.
16. In regard to the issue of adopting the average land-grant price instead of land-grant income to serve as substitution variable of land support, land-grant income had been taken into consideration during the deducing process of Equation (28), but the transferred land area was unitized in the deducing process. Hence, the land-grant income was transformed into the average land-grant price. The authors also conducted a regression analysis with the land-grant income as the primary explanatory variable, and the conclusion is also tenable. Thanks to the reviewer for pointing out the question of whether the land-grant price can be the substitution variable for explicit and implicit revenues from land.
17. 22 OECD countries refer to Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and United States.
18. The two curves began to diverge from 1985, which may be due to the effects of the land regime reform at the early stage and the enactment of the *Land Administration Law*.
19. It's important to note that although endogeneity problem may arise between infrastructure capital stock and the initial value of infrastructure capital stock, as well as between the enterprise capital stock and output, we believe that the conclusion's directivity will not be affected, regardless of the neglect of endogeneity analysis, because the synthetic control method has the feature of avoiding endogeneity and considering the current technical difficulties in technology and the great differences in economic characteristics between China and OECD countries.

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