ESSAYS ON PUBLIC INFRASTRUCTURE INVESTMENT
AND ECONOMIC GROWTH

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Economics - Doctor of Philosophy

2013

ABSTRACT

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This dissertation is comprised of three essays on public infrastructure and economic growth. The first essay is a motivation from an empirical study on China's development story that finds puzzling negative effects of infrastructure on growth. The second essay goes in-depth into the historical and institutional details that have shaped the outcomes in China. The third essay addresses how the uncovered key factors provide incentives for overinvestment, which have implications beyond the Chinese border.

The dissertation is organized as follows. The first chapter is an introduction and overview of the roles of infrastructure capital in economic growth from the existing empirical and theoretical studies.

The second chapter presents the empirical study on the role of infrastructure capital in China's regional growth within a neoclassical economic growth model from the year 1990 to 2010. Four types of infrastructure capital are discussed: electricity, road, rail, and telecommunications. Using dynamic panel data estimation approaches, the results support a positive role of infrastructure in improving economic development in China. It shows that infrastructure has contributed to the convergence among China's provinces. However, declining growth momentum from rapid increase of road infrastructure, in particular in the lagging regions, suggests that road development has been too fast. Instead of the conventional wisdom of "road leads to prosperity" widely accepted among government officials in China, more roads lead to nowhere. The results resonate with the theoretical literature on the inverse U-shaped growth impact of infrastructure capital and the dominant "crowding-out effect" of private capital if there is too much infrastructure. They also address the puzzle in the current

literature debates as to the direction and magnitude of the growth impact of infrastructure.

Chapter 3 uncovers the historical and institutional features that contribute to the increasing infrastructure investment. It presents a historical account of China's infrastructure development during its economic reform and opening up period, in particular with the export oriented growth and urbanization. It also highlights the institutional characterisitics of infrastructure investment decision making and financing that in many ways determine the distinctive features of China's infrastructure development. A combination of fiscal decentralization and political centralization may be the driving forces that shape a development state as China.

Chapter 4 is a theoretical analysis interpreting the level and share of public investment in government expenditure composition observed in the China context. It addresses investment incentives behind the large scale and sometimes too much investment in infrastructure at the sub-national level. Fiscal competition among local governments encourages more investment in public infrastructure to attract mobile capital, such as the foreign direct investment. Local governments' quest for more output and revenue leads to favor toward productive public capital than other public services. Land financing further enhances the capacity of local governments to provide more public investment. Tax sharing may correct some of the inefficiencies but its effect is limited. Fiscal transfers that are pro-rich may reinforce incentives for more public investment. Equalization transfers that favor poor regions may equalize provision of public investment at the cost of residents' utilities. The analysis sheds light on the government's preference for public infrastructure investment observed in both developing and developed countries.

To my parents

ACKNOWLEDGEMENTS

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Chapter 1

INTRODUCTION

Public infrastructure and economic growth is a classic topic in economics. Ever since the second world war, economists have been intrigued with the roles of infrastructure in promoting economic growth. Despite the huge literature on this topic, empirical evidence shows that this topic is still relevant and important both for developed and developing countries. For example, many African countries realize that the immediate impediment to economic growth is the inadequacy of infrastructure (Foster and Briceno-Garmendia, 2010). There has also been hot debates whether the lack of infrastructure investment has lead to the economic decline in the United States (Economist, 2011a).

China has been investing heavily in infrastructure in the past three decades. Although the export led and investment driven development model has been identified as key to China's growth miracle, less known is the massive infrastructure investment along China's growth path. Its rich historical context of infrastructure investment has made China an ideal case to study the relationship between public infrastructure and economic growth.

This dissertation presents a set of studies on this topic with China as a background. The implications from this dissertation may be extended to other developing and developed countries. Infrastructure in this dissertation refers to the economic infrastructure that generates services from public utilities, public works and other transport sectors (e.g. World Development Report, 1994). It only covers the physical infrastructure and does not include the invisible infrastructure such as the governments policy framework and the market institutions that generate economic activities and influence investment decision making.

1.1 Roles of Infrastructure in Economic Growth

Infrastructure, according to empirical and theoretical studies such as Agenor and Moreno-Dodson (2006) and Anderson et al (2006), promotes growth through a number of channels. This section presents an overview on how infrastructure affect growth through these channels.

Firstly, infrastructure can enhance factor productivity. For example, infrastructure can increase the productivity of private capital. As a type of capital, infrastructure has its unique features that differentiate itself from other types of capital. Rosenstein-Rodan (1943), Nurkse (1952), and Hirschman (1957) identify infrastructure as social overhead capital that is necessary before all other types of investment are possible. The early definition of infrastructure is of a broader sense that includes social institutions. Nonetheless, the discussion highlights an important role of infrastructure in alleviating bottlenecks of economic growth. Implications of this role are closely related to the improvement of investment climate in developing countries. Weitzman (1970) presents a model with the combination of a Ramsey growth path with a path of optimal capacity expansion. For a certain amount of private capital to be functional, there has to be proportionate infrastructure in place.

Infrastructure not only expands production capacity expansion by creating a good environment for private production, but also reduces the cost of private production that uses infrastructure services intensively and enhances the durability of private capital. For example, World Bank (1999) shows that an improvement in road surface reduces the vehicle operating costs significantly in Vietnam. Development in cargo shipping greatly reduces the time and cost of international trade. Improvement in energy, transportation and telecommunications infrastructure directly reduces the cost of many firms that rely highly on the use of such infrastructure. In this sense, infrastructure benefits industries disproportionately. Fernald (1999) studied the linkage between transport and industries that uses transport infrastructure intensively and found positive effects of improving transport infrastructure on the productivity of infrastructure intensive industries.

Not only can infrastructure improve the productivity of private capital, it also encourages the formation of private capital. In this sense, infrastructure and private capital are complementary. Improving infrastructure can reduce the adjustment cost of private capital. Companies that previously refrain from production expansion may want to construct a new factory. By lowering the adjustment cost of investment, private firms are able to reallocate resources to places of higher return.

The complementarity between infrastructure and private capital cannot be taken for granted. Too much infrastructure can crowd out private investment. Either financing large infrastructure investment, for example through taxes, is distortionary; or the financing of large scale infrastructure reduces the pool of funds available to private sectors.

Infrastructure can also enhance the productivity of labor. For example, improvements in transport infrastructure can relieve stress for employees commuting. Electricity provision efficiency can reduce user cost and improve the livelihood of households.

Secondly, infrastructure induces economic growth through creating inter-sectoral linkages and facilitating resource allocation. As the private sector expands with better infrastructure, it creates forward and backward linkages across sectors and increases demand for backward stream and supply for forward streams. By allowing smooth mobility of labor and capital, infrastructure helps the resource allocation across sectors by reducing transportation cost, increasing the spread of information and technology.

Similarly, infrastructure also plays a role in regional growth, in particular inclusive growth. Across country, it contributes to the convergence of the developing countries with the developed world. Within a county, it can bridge the gap among different regions. By creating inter-regional linkages through mobility of factors, information and technology, lagging regions are able to catch up with the advanced regions. For example, transport infrastructure channels economic activities into the neighboring areas of the urban centers and helps the reallocation of investments. Transport infrastructure also helps the mobility of labor across regions. Energy constrained regions can benefit from the development of energy and

transport infrastructure, so that energy rich regions can provide for the constrained regions. As a result, it facilitates growth and structural transformation across regions.

Infrastructure, as a result, can help reduce poverty and affect income distribution. By creating inter-sectoral and inter-regional linkages, employees across regions and sectors can benefit from the expansion of private investment and enhancement of productivity. Calderon and Serven (2004) empirically tested the relationship between infrastructure investment and income distribution in a panel of 100 countries spanning over 40 years. They found significant effect of infrastructure on poverty reduction.

Note, however, the role of infrastructure may change with the existing amount of infrastructure. Aside from the crowding out effect discussed previously, infrastructure, in particular road infrastructure, has a network effect. Ten roads that create networks may help mobility of resources. The eleventh road, however, may actually divert current economic activities to other locations. At the initial stage of economic development, capital and labor can move to more advanced regions because of better investment climate and higher rate of return. Capital and labor in a more advanced economy can also move to less advanced regions because of new opportunities that grant higher return and lower living cost than congested metropolitan areas.

Thirdly, roles of infrastructure vary during development stages. Early discussion on infrastructure often emphasizes the role of infrastructure in stimulating economic takeoffs. Infrastructure investment is regarded as a "big push" to jumpstart a low-income country. Roles of infrastructure, however, are not restricted to an economy at its initial development. In fact, it has various roles to play along the development stages of an economy.

When the economy is at its initial stage with low economic activities and poor investment climate, large amount of investment in infrastructure is needed to create a good environment that attracts private capital. Much of the investment is "sunk cost", that once it is invested it cannot be recovered. After the necessary infrastructure has been created, such as adequate supply of electricity, transport, water and sewage, private investment begins to increase and

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private capital has gradually been formulated.

During the next stage, the economy begins to expand its production. Infrastructure has a larger role to play in terms of its complementarity to private capital. Productivity continues to improve in the sectors that use the particular type of infrastructure more intensively. There is increasing private capital accumulation. Infrastructure that links sectors and regions encourages intersectoral and interregional trade, thus creating more spillover effect across sectors as well as among regions. Demand for urban infrastructure begins to pick up as the urban centers start to grow with a concentration of economic activities, capitals, labors and innovative capital accumulation.

When the degree of urbanization increases, congestion becomes a problem. Infrastructure again becomes important to alleviate congestion and encourages the reallocation of private investment. It promotes the transformation of economic structure across regions.

Last but not the least, the discussions above on the roles of infrastructure have not taken into account the time it takes for the effects to happen. In fact, some of the roles can occur in the short run while others occur in the medium to long run. Infrastructure building can create jobs and contribute to current year GDP. The productivity effect of infrastructure through complementarity to private capital and inter-sectoral linkages may occur in the medium or long term. It may also take a long time for infrastructure investment to encourage regional convergence and ultimately reduce poverty.

The public nature of infrastructure also allows the government to use it often as a fiscal tool. Large allocation of infrastructure investment is often found in stimulus packages. The demand side intervention is widely used for countries to prevent foreseeable economic downturn (e.g. IMF, 2009). Understanding of the channels and timing will help policymakers to achieve specific policy objectives.

The exact roles of infrastructure and their impacts vary across countries. The outcome of infrastructure investment in economic development may be the result of various roles working together. Moreover, many cross country studies show that country specific factors such as

quality of infrastructure and institutional features affect the contribution of infrastructure to growth. Therefore, this dissertation uses China as a case to illustrate the role of infrastructure in China's rapid economic growth in the past two decades.

1.2   Research Questions

The main research questions asked in this dissertation are: 1) what roles have infrastructure played in China's recent economic development; 2) what historical and institutional factors have enabled such large amount of infrastructure building within a relatively short period of time; 3) how do the institutional features provide incentives for public investment over other types of spending for local governments in countries like China. The following three chapters address each of the three main questions.

Chapter 2

THE ROLE OF INFRASTRUCTURE IN CHINA'S REGIONAL ECONOMIC GROWTH

2.1 Introduction

Much is known and written about China's recent fast growth. The export-led and investment driven development model has been applauded by many scholars and policymakers as the key to China's economic growth (Prasad and Rajan, 2006, Riedel et al, 2007). Less is known, however, about the role of infrastructure investment in China's economic development. Along with its rapid growth and significant improvement in people's lives is a comparable infrastructure investment boom. According to the World Bank (1995), China's infrastructure investment was about 6.5% of its GDP in 1993, well above the average level of 4% GDP for developing countries. By the year 2009, investment in infrastructure sectors, energy, transport and telecommunication, water and sewage, etc, had reached to about 15% to 20% for the coastal provinces and municipalities. Meanwhile, investment in social sectors, such as education and health, is between 2-4% of the GDP.[1] China follows a distinct path of growth compared with its neighbor India. The massive infrastructure investment in the former has resulted in phenomenal changes in its landscape since the 1980s. In India, a comparable economic growth is associated with a sluggish public sector alongside with the prospering private sectors. Ever growing traffic jams and mismanaged public infrastructure are commonplace. This side of the story motivates this study on how infrastructure investment has contributed to China's success story and what its role will be for China to continue to grow.

This chapter builds on the theoretical literature and existing empirical studies on the linkage between infrastructure and economic growth. It addresses the following research

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[1]It is based on various issues of Provincial Statistical Yearbooks for China.

questions. First, has the persistent large amount of infrastructure investment played a positive role to China's regional economic growth? How much has different types of infrastructure contributed to the growth of the regions? Based on a neo-classical growth model, this chapter also asks whether infrastructure has contributed to the convergence of growth in China's provinces. Does the role of infrastructure vary with time and across different regions?

Four types of infrastructure - electricity, road, railway and telecommunications- are covered. It spans the years from 1990 to 2010 when major reforms and economic progressions come into full play. Using dynamic panel data estimation approaches, the empirical analysis takes each of China's 27 provinces and 4 municipalities as both independent and interconnected entities. This is more of the case when the Chinese government decides, from its central planning practices, to leave more decisions to the sub-national governments and to delineate enterprises from the government bodies so that they can react to the market conditions with more flexibility and efficiency.

The findings from this chapter show that indeed infrastructure has a positive role to play in China's fast growth. The effect varies greatly across different types of infrastructure. Contrary to the assumption that infrastructure always helps, which is perhaps behind the persistent large amount of infrastructure investment, some infrastructure, for example road infrastructure, has shown to be insignificant and even negatively related to economic growth in many parts of China during some time periods. Thus this chapter suggests overinvestment in the road infrastructure, which causes the dominant crowding out effect on the economy. The findings of this chapter, although contrary to the conventional wisdom held by many people and policymakers in China, resonate with theoretical and empirical literature that reveal an inverse U-shaped effect of infrastructure capital.

To proceed to the findings, the chapter is organized into the following parts. Part 2 provides a context of the literature debate and discusses how this chapter fits into the literature. Part 3 presents a simple neoclassical model with infrastructure capital, which will be the theoretical basis for the empirical analysis. Part 4 lets the data tell the story

about the role of infrastructure and interprets the findings from regressions. Alternative specification tests are performed with results reported. Part 5 is a conclusion.

2.2 Related Literature

One of the earliest discussions on the role of infrastructure starts from the classical development economics literature. Rosenstein-Rodan (1943), Nurkse (1952) and Hirschman (1957) argue for a positive role of infrastructure capital. Large amount of infrastructure investment is regarded as a necessity before all other types of investment are possible. The nature of infrastructure investment, which requires large sunk costs and whose benefits in general cover a large number of people, is considered best with public provision.

Theoretical consideration of infrastructure begins with Arrow and Kurz (1970) and Weitzman (1970) that formally incorporates public capital into their model. Recent academic discussion on the role of public capital can be found in Barro (1990). He builds an endogenous growth model with public investment financed by taxes. The result suggests there are conflicting forces of infrastructure investment that result in an inverse U-shape of its growth impact. An increase in public infrastructure initially raises growth rate, but then causes the growth rate to decline when infrastructure investment is beyond a certain level.

Whether infrastructure has a positive or negative role in economic development is thus an empirical question. As predicted in the theoretical discussion, empirical literature on this issue has found mixed results. Recent literature debate on the linkage between infrastructure and economic growth was sparkled by empirical studies on the role of infrastructure in the United States. These studies were closely linked to the question whether the productivity decline in the US after the 1970s has been due to a decline in its infrastructure investment. Aschauer (1989a) presents a study of US from 1953-1986 that shows a strong positive role for the nonmilitary public capital stock in determining the rate of return to private capital. Aschauer (1989b) further supports a positive role for infrastructure in the economic development of the 50 U.S. states. His results, however, were quickly challenged by Holtz-Eakin

(1994), who concluded with no significant relationship between public capital and private productivity for 48 states in the U.S. over 17 years. A number of studies that follow give a quite diverse and uncertain picture of the role of infrastructure as reviewed in Fisher (1997). Many of these studies support a positive but sometimes insignificant effect with different ways of measurement and empirical approaches.

This literature debate quickly goes beyond its national boundary. A number of studies look for evidence from cross country experiences. Devarajan, Swaroop and Zou (1996) explore the relationship between the composition of public expenditure and growth in 43 developing countries over 20 years. They show a surprising result that increasing the share of current spending has a large and significant impact on growth while increasing capital spending shares exerts negative influence on growth. Their study shows that developing countries have a different and interesting story to tell.

Cross country studies that capture both developed and developing countries are able to uncover quality, institutional and regional differences such as in Esfahni and Ramirez (2003) and Calderon and Serven (2004). They found that quality and institutional features are important factors influencing the effectiveness of infrastructure, thus giving another interpretation on the less positive or even negative relationship between infrastructure and growth.

Another advantage for cross country study is that it provides a good method to discover the role of infrastructure at different stages of development. Some countries are around steady state and some still lagging behind. Studies by Arslanalp et al(2010) on 48 OECD and non-OECD countries, Um et al (2009) on 20 MENA countries, Cavallo (2008) on 116 developing countries and Hulten (2005) on US, Spain and India show results that may not otherwise be captured in the study on US. They found infrastructure plays a role that's similar to what the theory predicted. Rather than finding a positive role of infrastructure, many of these cross country studies have shown non-linear effects from public infrastructure.

Interpretation of these results, however, does require some caution, as countries differ a

lot in their own characteristics. Some studies are often quick to give some general statement and quick remedies for the reasons of the non-linear effect, in particular the negative effect. These interpretations, however, oftentimes ignore the diversity and dynamics that are within each country. They rely on some general features of these countries and many country characteristics are left unexplored.

The limitations of cross country study calls for more country-specific studies. They usually tap the regional variations in infrastructure development and growth performances, such as Cadot et al (2006) on regions in France, Shioji (2001) on Japan and US regions and Roca-Sagales and Sala (2010) and Margquez and Ramajo (2010) on regions in Spain. Similar to the US study, they either study the effect on private production or sometimes production in the manufacturing sector, or the effect on regional growth.

Using the rich content of China's infrastructure development, this chapter contributes to the few studies that explore the relationship between infrastructure and economic growth in China. Among the few China studies, Bai and Qian (2010) presented an in-depth description of the infrastructure development in electricity, highways and railways at the national level with a review on the institutional features of these sectors, but no empirical testing has been performed. Fan et al (2004) explored the impact of infrastructure capital on economic development in rural China. Demurger (2001) reviewed the development of China's transport infrastructure and its relationship with regional economic growth in 24 provinces, excluding municipalities, from 1985 to 1998. Ding et al (2008) studied the role of telecommunications infrastructure to China's regional convergence. They found significant and positive role for telecommunications infrastructure. Banerjee et al (2012) examined the impact of access to transportation to county level growth in China.

There are other country studies that focus on a particular type of infrastructure. For example, Roller and Waverman (2001) on telecommunications infrastructure in 21 OECD countries, Duggal et al (2007) on US's IT infrastructure, Fernald (1999) on the road infrastructure to the productivity of the US's industrial sector and Gonzalez-Navarro and

Quintana-Domeque (2010) on the effect of a random experiment of urban road pavement in Mexico on private consumption. These papers have revealed interesting stories of the unique roles of different types of infrastructure.

This chapter builds on this line and discusses four types of infrastructure, electricity, road, railway and telephony. It recognizes that although many early studies use aggregated value, infrastructure capital is multidimensional. For example, the Shuioji (2001) study on US's and Japan's public infrastructure uses both aggregated value of public capital and disaggregated ones and shows that there are large differences between the two results. Disaggregated infrastructure capital gives a more rich understanding of their role in economic growth. Because of lack of an aggregated monetary level of infrastructure investment in China's statistical yearbooks, this chapter measures infrastructure investment levels by its physical measures (See Fisher (1997) for a discussion of physical measures and monetary measures of infrastructure).

2.3 The Model

The empirical analysis builds on the usual format of a Cobb-Douglas production function. An additional capital, infrastructure, enters into the production function as G, whereas Y is real GDP, K is the stock of private physical capital, H is the stock of human capital. As in the traditional Solow growth model, L is the labor, A is a labor-augmenting technology. The model assumes that infrastructure capital is a simple substitute to private capital and that the production function exhibits constant returns to scale (CRS) for all inputs and decreasing returns to scale for individual capital. Therefore, $\alpha + \beta + \gamma < 1$ and $0 < \alpha, \beta, \gamma < 1$.

$$Y_t = (A_t L_t)^{1-\alpha-\beta-\gamma} K_t^{\alpha} H_t^{\beta} G_t^{\gamma} \tag{2.3.1}$$

Assume the labor augmenting technology A_t follows the path, where t refers to time in years:

$$A_t = A_0 e^{gt} F_t \qquad \text{and together with} \qquad L_t = L_0 e^{nt} \tag{2.3.2}$$

n is the population growth rate, g is the exogenous rate of technological progress, F is a measurement for the openness of the economy. The openness variable is assumed to have a positive effect on technology improvement, either through introducing more competition or through better management and technology adoption.

Assuming that the accumulation of capital is of the form:

$$\frac{dK}{dt} = s_k Y_t - \delta K_t \tag{2.3.3}$$

The accumulation of human capital and infrastructure capital follow the same format with investment rate s_h and s_g respectively. Assume that the depreciation rate δ is constant over time and the same for all three types of capital. At the steady state:

$$y^* = [\frac{s_k^\alpha s_h^\beta s_g^\gamma}{(n+g+\delta)^{\alpha+\beta+\gamma}}]^{\frac{1}{(1-\alpha-\beta-\gamma)}}, \qquad \text{where} \qquad y^* = \frac{Y^*}{AL} \tag{2.3.4}$$

Take natural logs on both sides of (4), and then:

$$\ln \hat{y}_t = ln A_0 + gt + (\frac{\alpha}{1-\alpha-\beta-\gamma}) \ln \frac{s_k}{(n+g+\delta)} + (\frac{\beta}{1-\alpha-\beta-\gamma}) \ln \frac{s_h}{(n+g+\delta)}$$
$$+ (\frac{\gamma}{1-\alpha-\beta-\gamma}) \ln \frac{s_g}{(n+g+\delta)} + \theta \ln F_t \qquad \text{where} \qquad \hat{y}_t = \frac{Y}{L} \tag{2.3.5}$$

Equation (2.3.5) can be expressed in levels of capital instead of investment rates. For example, s_g for time period t can be rewritten as q_t, which is the measure of a particular type of physical infrastructure stock. The relationship between s_g and q_t is shown in equation (2.3.6). Similarly s_h can be rewritten as h_t, which is a measure of the stock of human capital.

$$\ln s_g = \ln \frac{G_t}{L_t} - \ln A_t = \ln \frac{G_t}{L_t} - (\ln A_0 + gt + \theta \ln F_t) = \ln q_t - (\ln A_0 + gt + \theta \ln F_t) \tag{2.3.6}$$

After some substitution and rearrangement, we get:

$$\ln \hat{y}_t = (\frac{\alpha}{1-\alpha-\beta-\gamma}) \ln s_k + (\frac{\beta}{1-\alpha-\beta-\gamma}) \ln h_t + (\frac{\gamma}{1-\alpha-\beta-\gamma}) \ln q_t$$
$$- (\frac{\alpha+\beta+\gamma}{1-\alpha-\beta-\gamma}) \ln (n+g+\theta) + (1 - \frac{\beta+\gamma}{1-\alpha-\beta-\gamma})(\ln A_0 + gt + \theta \ln F_t) \quad (*)$$

Equation (*) characterizes the long run relationship between real GDP per capita and the different types of capital.

Following Mankiw, Romer and Weil (1992), the economy approaches its steady state with a transition path from t_0 to t_{0+h} defined by the equation:

$$\ln y_{t_0+h} = (1 - e^{-h\eta}) \ln y^* + e^{-h\eta} \ln y_{t_0} \qquad \text{where} \qquad \eta = (1-\alpha-\beta-\gamma)(n+g+\delta) \quad (2.3.7)$$

Substitute $\ln y^*$ into equation (2.3.7) and also with $\ln y_t = \ln \frac{Y_t}{AL} = \ln \hat{y}_t - \ln A_0 - gt - \theta \ln F_t$, and get:

$$
\begin{aligned}
\ln y_{t_0+h} - \ln y_{t_0} = {} & (1 - e^{-h\eta})(\frac{\alpha}{1-\alpha-\beta-\gamma}) \ln \frac{s_k}{n+g+\delta} \\
& + (1 - e^{-h\eta})(\frac{\beta}{1-\alpha-\beta-\gamma}) \ln \frac{s_h}{n+g+\delta} \\
& + (1 - e^{-h\eta})(\frac{\gamma}{1-\alpha-\beta-\gamma}) \ln \frac{s_g}{n+g+\delta} \\
& + (1 - e^{-h\eta})\theta \ln F_{t_0+h} - (1 - e^{-h\eta}) \ln y_{t_0} \\
& + [(1 - e^{-h\eta})(t_0 + h)g + e^{-h\eta}hg] + (1 - e^{-h\eta}) \ln A_0
\end{aligned}
$$

Therefore an estimable equation can be expressed as:

$$
\ln\left(\frac{y_{i,t_0+h}}{y_{i,t_0}}\right) = b_k \ln \frac{s_{i,k}}{n_i+g+\delta} + b_h \ln \frac{s_{i,h}}{n_i+g+\delta} + b_g \ln\frac{s_{i,g}}{n_i+g+\delta} + b_f \ln F_{i,t_0+h}
$$
$$
+ b_c \ln y_{i,t_0} + c_i + a_{t_0+h} + u_{i,t_0+h} \quad (2.3.8)
$$

Equation (2.3.8) can also be expressed in investment levels:

$$
\ln \frac{y_{t_0+h}}{y_{t_0}} = b_k \ln s_{k,t_0+h} + b_h \ln h_{t_0+h} + b_g \ln q_{t_0+h} + b_n \ln(n+g+\delta) + \tilde{b}_f \theta \ln F_{t_0+h}
$$
$$
+ b_c \ln y_{t_0} + \tilde{c}_i + a'_{t_0+h} + u_{t_0+h} \quad (**)
$$

where $\alpha = \dfrac{b_k}{b_k+b_h+b_g-b_c}$; $\beta = \dfrac{b_h}{b_k+b_h+b_g-b_c}$; $\gamma = \dfrac{b_g}{b_k+b_h+b_g-b_c}$; $\theta = -\dfrac{b_f}{b_c}$ and $\tilde{b}_f = \delta(b_h + b_g)$. α, β, γ are elasticities of growth of real per capita GDP. This equation interprets the growth rate of real per capita GDP from time t_0 to t_0+h using private capital, human capital, public capital and FDI. In particular, the dependent variable is the growth of real GDP per capita. $\ln A_0$ is incorporated into the constant term in the regression. gt shows the time specific effect, which is embodied in a_t. It also shows how the initial condition y_{t_0} will affect the growth rate. Equation (**) will be the basis for the following empirical study.

2.4 Empirical Analysis

The primary purpose of this section is twofold. First is to study whether infrastructure has contributed to the conditional convergence of China's provinces. If the previous lagging regions grow at a faster rate than the previously advanced regions, there is evidence of conditional convergence among the regions. The second primary focus is to study to what extent infrastructure capital has contributed to regional economic growth. The parameters on the infrastructure capital are measures for the partial effects of different types of infrastructure and the original growth elasticities can be recovered from these parameters.

A panel dataset of 31 China's provinces and municipalities covering years 1990 to 2010[2] is constructed to test the relationship between infrastructure and regional growth. Four types of infrastructure capital are covered: electricity, road, railway and urban telephone usage. The data are collected from China statistical yearbooks, sector specific yearbooks and CEIC retrieved from the Chinese Academy of Social Sciences. Provincial data at the national level statistics yearbook are reported wherever possible, because they tend to be more accurate than provincial reports.

2.4.1 Description of Variables

Table 2.1 shows the list of variables used to estimate equation (**). The dependent variable is real GDP per capita growth for each province expressed as $\ln \frac{y_{i,t}}{y_{i,t-1}}$. Data computed by GDP income approach is used for the variable. Note that logarithmic transformations are performed on all variables according to equation (**).

The first set of right-hand-side variables are the variables of interest. Private sector investment rate s_{it} is measured by real private investment in fixed assets to real GDP. Note it does not account for private investment in the form of share-holding companies and limited liability companies, which include investment by state and collective units that are

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[2]The data are updated to latest available, which is the year 2011. Not all provinces have data till then, so it is an unbalanced panel.

Table 2.1: Description of variables

Variables	Definition
$ln(RGDPPC_t/RGDPPC_{t-1})$	Growth rate of real per capita GDP
POP	Permanent population, 10 thousand people
GRADS	Percentage share of grads from higher education to permanent population
RDEP	Real dependence ratio
RSPINV	Share of real private investment in fixed assets to total GDP in 1990 prices
RFDICY	Real FDI actually utilized, yuan
$ln(ngd)$	Adjustment by population growth, technology change and capital depreciation
ELECPDMP	Electricity production (100 kwh per person)
HWMP	Length of road km per million people
Road classification variables	Length of classified roads, expressway, Class I road, Class II road, Class III road, Class IV road, and unclassified road, in km per million people.
RWLENMP	Length of railway km per million people
URTELESUBHP	Urban telephone subscribers per 100 people
CELLHP	Cell phone units per 100 people
ZONE	Eastern: 10 provinces and municipalities Central: 6 provinces Western: 12 provinces and municipality Northeastern: 3 provinces

not accounted separately, for example, public private partnerships in the transport sector. Although it is a conservative measure of the exact amount of private investment, it clearly separates from the measures for infrastructure capital.

Only data on human capital stock and physical infrastructure capital stock are available. In particular, the infrastructure variable q_t is the level of each type of infrastructure scaled by permanent population. The assumption is that it is positive and significant. q_t can be the length of road or railway per million people, electricity production per million people[3],

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[3]Electricity production per million people is used as a proxy for the electricity generating capacity to avoid missing data problem. In general the more electricity generating power, the more production there will be. Regression results show that a comparison using each measure yields similar results.

and telephone subscribers per 100 people. The human capital stock h_{it} is measured by the share of the number of graduates from higher education to total permanent population for province i at time t. The flexibility of the estimable model in equation (**) can solve the problem of finding data on investment values of human capital and infrastructure capital.

Because all the capital stock variables are scaled by population as indicated in the theoretical model, a population measure is needed. Here permanent population is used. It is the registered population[4] minus the registered population that reside out of state and plus the migration population residing over six months. By allowing migration, it can better measure the contribution such a population base creates and the services that it receives in a province.

The openness variable F is measured by FDI flow. FDI is assumed to be affecting the technology improvement. Only utilized FDI data are used for this variable. A time average population growth rate n_i is calculated for each province from 1990 to 2011. Following Mankiw, Romer and Weil (1992) and Knight et al (1993), $g + \delta$ is assumed to be 0.05. The assumption is that the results are robust to changes in $g + \delta$. Hence the variable ngd is the adjustment by population growth, technology improvement and capital depreciation. Coefficient on this variable is expected to be negative.

The second set of variables includes time period and regional dummies to capture national policy change that affects infrastructure development. The dummy variables for economic region correspond to the Eastern, Central, Western and Northeastern regions respectively. This regional grouping uses the classification adopted by the China Statistical Yearbooks[5]. It reflects the geographic locations, natural endowments and economic performances of the

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[4]The registered population is based on the Hukou system in China. Each Hukou shows a household registration record that identifies a person as a resident of an area.

[5]The Eastern region includes municipalities, Beijing, Tianjin and Shanghai, and provinces Hebei, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan. The provinces in the Central region are Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan. The Western region covers Inner Mongolia, Guangxi, Sichuan, Guizhou, Yunnan, Tibet, Shannxi, Gansu, Qinghai, Ningxia, Xinjiang and municipality Chongqing. The Northeastern region consists of Liaoning, Jilin and Heilongjiang.

provinces.

Another feature of this model is that it includes not only the province specific factor, but also a time specific effect. This chapter clarifies two types of time effect. One is a common time effect that is felt by all provinces, such as macroeconomic policies that affect all regions. It is one source of cross sectional dependence among provinces and will be taken out by subtracting year averages of all related variables during empirical estimation. Another is an individual specific time effect which varies by province. This time specific effect will be tested by estimating the equation (**) before and after the structural breaks.

The structural breaks are identified to reflect changes observed in the development history of four types of infrastructure. The first one is around the year 1995, where there is significant increase in the railway stock and when that of the growth of electricity production decreases. The second one is around the year 2000, when increases in all four types of infrastructure were witnessed. The third one is around the year 2005, when again the level of electricity production and road network dramatically increases and when that of the telephone users decrease and the number of cell phone users climbs up.

These structural breaks in infrastructure development broadly reflect macroeconomic policies that possibly affect the investment decisions. First is the 1994 tax sharing reform (details are described in Chapter 3). The reform clarifies the types of taxes that are being shared and their respective ratios between the central and local governments. The reform has resulted in an unbalanced assignment of revenue and expenditure responsibilities, where the subnational governments' tax revenues decline but expenditure responsibilities remain. This has encouraged sub-national governments to invest in productive public infrastructure investments in order to attract mobile capital.

Second is the fiscal stimulus program around the year 1998. In response to the East Asian financial crisis, the former premier Zhu Rongji initiated the first fiscal stimulus in China's history to counter the negative spillover effects. This period of time is also associated with the most drastic reform in the state owned enterprises (SOEs), many of which are

large enterprises in the infrastructure sector. Not only is there increasing infrastructure investment, but also a diversification of the investment entities and financing sources.

Third, in the year of 2000, the long contemplated Western Development Plan was approved. Infrastructure was considered to be the necessary big push for lagging Central and Western regions. The result of this Plan is large infrastructure investment tiered toward the lagging inland areas.

Fourth, the investment system reform in 2004[6]. This reform further placed market based principles to diversify ownership for investment provision, improve accountability and streamline the investment approval process. Infrastructure investment underwent a drastic boom around the year 2005, where the growth of infrastructure capital even outpaces that during the fiscal stimulus program in 1998. The model will incorporate these structural breaks at years 1995, 2000 and 2005, to see whether the effect of infrastructure on economic development changes before and after these time periods.

An additional control is $rdep_{it}$: the dependence ratio, measured as the sum of number of population aged from 0-14 and from 65 and above to the number of population aged from 15 to 64 years old. This is to control for population structure. The assumption is that the higher the rate, the more burdensome working age population will feel.

2.4.2 Time Series Properties of the Data

Unit root tests are performed on all variables. The basic structure is the augmented Dicky-Fuller unit root tests with time trend. Given the panel data nature, three types of unit root tests are performed. One is Levi-Lin-Chu test. This test assumes that individual provinces share the same coefficient on the lagged values of dependent variable, while allowing their intercept to vary by province. The other two are the Im, Pesaran and Sin and the Fisher type augmented Dicky-Fuller tests that allow the slope of the lagged dependent variables to vary by province. All tests allow for individual intercept and time trend. The step-down

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[6]See a discussion on China's investment reforms in Chapter 3.

approach is used for lag length selection. The maximum lag length is selected according to
Schwert (1989). The results are presented in Table 2.2.

Table 2.2: Panel unit root test

| Variable | Levi-Lin-Chu | | Im, Pesaran and Shin | | Fisher-type | |
	Level	1st diff	Level	1st diff	Level	1st diff
Ln(RGDPPC)*	I(1)	I(1)	I(1)	I(0)	I(1)	I(0)
Ln(RSPINV)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)
Ln(RFDICY)*	I(1)	I(0)	I(0)	I(0)	I(0)	I(0)
Ln(GRADS)*	I(0)	I(0)	I(1)	I(0)	I(0)	I(0)
Ln(RDEP)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Ln(ELECPDMP)*	I(1)	I(1)	I(1)	I(0)	I(1)	I(0)
Ln(HWMP)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)
Ln(CLRDMP)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Ln(RDEXPMP)*	I(0)	I(0)	I(0)	I(0)	I(1)	I(0)
Ln(RDCLIMP)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Ln(RDCLIIMP)*	I(0)	I(0)	I(1)	I(0)	I(1)	I(0)
Ln(RDCLIIIMP)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Ln(RDCLIVMP)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)
Ln(RDUCMP)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)
Ln(RWLENMP)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Ln(URTELESUBHP)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)
Ln(CELLSUBHP)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)

*show that the results differ among the three types of panel unit root tests

A first look at the results show that a number of the variables are $I(1)$ and most variables
are $I(0)$ in first differences. This shows that these variables have unit roots, but their first
differences or growth rates do not. However there are a few differences in the reported results
from Levi-Lin-Chu test and the Fisher type test. The results show that in estimating the
models, the nonstationary nature of the variables has to be considered.

Another question arising from the unit root test is that whether the nonstationary real
GDP per capita and the right hand side variables are cointegrated. If so, it shows real GDP
per capita and the different types of capital have a long run relationship. In theory it is the
case, as is derived in the theoretical model.

The relationship in the real data confirms the prediction of the theoretical model. Vari-

Table 2.3: Panel cointegration test

Kao Residual Cointegration Test
Series: LRGDPPC LRSPINV LRFDICY LGRADS LELECPDMP LHWMP
LURTELESUBHP
Sample: 1990 2011
Included observations: 682
Null Hypothesis: No cointegration
Trend assumption: No deterministic trend
Automatic lag length selection based on asymptotic t-statistic (p=0.1)
with a max lag of 4.
Newey-West fixed bandwidth and Bartlett kernel

	t-Statistic	Prob.
ADF	-3.297821	0.0005
Residual variance	0.001549	
HAC variance	0.002210	

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESID)
Method: Least Squares
Sample (adjusted): 1993 2010
Included observations: 523 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID(-1)	-0.172725	0.020396	-8.468686	0.0000
D(RESID(-1))	0.322547	0.039168	8.234975	0.0000
D(RESID(-2))	0.164837	0.037215	4.42933	0.0000
R-squared	0.203748	Mean dependent var	-0.001432	
Adjusted R-squared	0.200686	S.D. dependent var	0.037261	
S.E. of regression	0.033313	Akaike info criterion	-3.960017	
Sum squared resid	0.577074	Schwarz criterion	-3.935583	
Log likelihood	1038.544	Hannan-Quinn criter.	-3.950448	
Durbin-Watson stat	2.121986			

ables such as real GDP per capita, real private investment in fixed assets, foreign capital, share of graduates and infrastructure capital, which potentially have unit roots, are tested together for cointegration. All these variables are transformed so that common time effects are extracted to control for the pairwise cointegration among different provinces. Because of limited sample size, the Pedroni residual cointegration test and Kao test are chosen. The Pedroni test rejects the null of no cointegration relationship if allowing for individual heterogeneity in the coefficients. Kao test also rejects the null of no cointegration relationship

(Table 2.3). Therefore, there is evidence of a cointegrating relationship among the variables.

2.4.3 Regression Analysis

2.4.3.1 Empirical Challenges

Several empirical challenges arise given the nature of the model and the data. First is the presence of dynamics in the model. The model includes a lagged dependent variable. Elimination of fixed effects using demeaning cannot solve the problem of endogeneity between the transformed regressors and the unobserved terms. It is because the lagged dependent variable will be correlated with the demeaned error term that contains information in $t - 1$, quoted as Nickell bias (Nickell, 1981). Therefore, traditional fixed effect approach might yield inconsistent results in the presence of dynamics. An alternative solution proposed by Anderson and Hsiao (1982) is to use first difference to eliminate the unobserved fixed effect. But correlation still exists, because Δlny_{t-1} is correlated with Δu_{it}.

The second issue is unit root and cointegration among in the sample data. Nonstationarity in the dependent and explanatory variables can cause spurious regression. The third problem is reverse causality. Infrastructure can be a source of growth, but fast growth demands more infrastructure. Therefore, infrastructure investment and economic growth tend to reinforce each other. The fourth is the problem of endogeneity of different forms of capital. There may be other factors in the unobserved components aside from the province specific factor and exogenous variables identified. Last but not least, China's provinces tend to move together because of economic conditions that affect all provinces. The cross-sectional dependence violates the assumption of usual panel data estimation. This issue has been partly dealt with by subtracting common time effect from all variables.

Using the vector error correction model can deal with part of the problems and offers several advantages[7]. First, given that the unit root variables are cointegrated, the model

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[7]A number of approaches can be used for the cointegrated dynamic panel data structure of the sample. Their results are compared and contrasted, for example, the traditional

can clarify both the long run and short run relationship between infrastructure capital and economic growth. In particular, the long run effect is of particular importance to scholars and policy markers. Second, if weak exogeneity can be assumed, the estimated long run parameters are super-consistent, regardless of the variance structure used. Third, the flexibility of the vector error correction model allows control for possible endogeneity from the lagged short-run dynamics to the unobserved factors by incorporating more lagged differenced terms.

Moreover, the dynamic nature of the model in the form of a lagged dependent variable can be accounted for in the specification of an error correction form. If we take the different forms of capital as X_{it}, the model in equation (**) can be rewritten into the following error correction form if only one lagged short run dynamics are included. To show this, equation (**) can be written as follows:

$$\ln \frac{y_{it}}{y_{i,t-1}} = b_c \ln y_{i,t-1} + \delta_{10,i} X_{it} + \delta_{11,i} X_{i,t-1} + \tilde{c}_i + \tilde{a}_t + u_{it}$$

After some transformation:

$$\Delta \ln y_{it} = \phi_i (\ln y_{i,t-1} - \theta_{0i} - \theta_{1i} X_{it-1}) + \delta_{10i} \Delta X_{it} + \tilde{a}_t + u_{it} \qquad (***)$$

The parameters θ_s in the bracket represent the long run cointegrating relationship. $\theta_{0i} = \dfrac{\tilde{c}_i}{b_c}$ and $\theta_{1i} = \dfrac{(\delta_{10i} + \delta_{11i})}{b_c}$. ϕ_i represents the speed of error correction adjustment, where $\phi_i = b_c$. Therefore, the conditional convergence coefficient equals to the speed of adjustment parameter. Note the long run relationship is characterized between the level of real GDP per capita and other forms of capital, rather than the growth rate. With the parameters of long run cointegration relationship, we can recover the original growth elasticities in the neoclassical growth model.

The estimation uses the dynamic fixed effects estimator on the error correction model (Blackburne III and Frank, 2007). It assumes that that the cointegrating vector to be equal

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OLS, pooled OLS, fixed effects and random effects, first difference IV, etc. The results are available upon request.

across all panel units. Moreover, it assumes that the speed of adjustment coefficient and the short run coefficients to be the same across panel units. These assumptions will later be relaxed to allow for regional variation in the coefficients. Note that equation (***) has a time fixed effect. To take off the common time effect, the variables used in the regression analysis are all demeaned by its year averages. The estimation uses robust standard errors accounting for serial correlation and heteroskedasticity.

In addition, the vector error correction model assumes weak exogeneity in the explanatory variables. While adding more lagged differenced terms in the error correction form in equation (***) accounts for some endogeneity, there are other types of endogeneity for example feedback effects from infrastructure investment this year to the real GDP per capita next year. To check the robustness of the result, this chapter uses the difference GMM, proposed by Holtz-Eakin, Newey and Rosen (1988) and popularized by Arellano and Bond (1991), and system GMM proposed by Arellano and Bover (1995) and Blundell and Bond (2000).

Note that the long run relations estimated by the sample cannot be interpreted as the actual steady state relations because China can hardly be regarded as approaching its steady state. Even though the coastal areas are comparable to advanced economies, its large inland area is still at its initial level of development.[8] Therefore, the "long run" relationship between infrastructure capital and growth can only be interpreted as the path followed by China's provinces during the past two decades.

2.4.3.2 Average Effect of Infrastructure Capital

Assuming no structural changes in the long run cointegrating relationship across region, the average effect of infrastructure capital is estimated in Table 2.4. The results show that infrastructure can play a positive role in China's regional economic growth. The negative and significant short run speed of adjustment parameter supports the hypothesis of conditional

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[8]A comparison of China's provinces with countries can be found in the Economist (2011b).

convergence among provinces in China. Additional infrastructure investment, however, can either increase or decrease the real per capita GDP growth as shown by the signs of marginal contributions of infrastructure. In fact, there is evidence of negative marginal effect in the long run for road infrastructure. The results also support a time varying effect of infrastructure capital when structural breaks are included. Infrastructure development has contributed to the economic development during some period of time, but more infrastructure isn't always better.

The magnitude of marginal contribution of infrastructure varies by types and over time[9]. Marginal contribution of electricity infrastructure to real GDP per capita is on average positive but not significant. One percent increase in electricity production per million people will increase the real GDP per capita by 0.3 percent. The marginal contribution of electricity differs across time. The role of electricity production becomes more important during the 2000s, with positive and significant marginal effect exceeding all other types of infrastructure capital. Given rapid electricity generating capacity expansion staring from the 2000s, the results suggest that China's provinces have benefited from economies of scale in electricity production and alleviation of energy bottlenecks for the fast growing economy.

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[9]Equations 2.4.2 to 2.4.8 in Table 2.4 test the effect of infrastructure capital over time. Time periods are selected according to the structural breaks identified. Hausman tests are performed among equations to see whether there are structural differences between the parameters.

Table 2.4: Average effect of infrastructure capital (1990-2010)

(Dependent variable: $\ln(RGDPPC)_t$*; dynamic fixed effects with robust standard errors)*

	1990-2010 (2.4.1)	2006-2010 (2.4.2)	1990-2005 (2.4.3)	2001-2010 (2.4.4)	1990-2000 (2.4.5)	1996-2010 (2.4.6)	1990-1995 (2.4.7)	1998-2002 (2.4.8)
Short run error correction coefficient								
	−0.113****	−0.300****	−0.183****	−0.149****	−0.263****	−0.126***	−0.352***	−0.250***
	(−3.76)	(−5.47)	(−5.15)	(−4.79)	(−4.94)	(−2.60)	(−3.24)	(−2.82)
Long run cointegrating relationship								
Ln(RSPINV)	0.0731	0.276***	−0.0122	0.113	−0.0671	0.111*	−0.107	0.0457
	(0.90)	(2.91)	(−0.19)	(1.31)	(−0.95)	(1.74)	(−1.31)	(0.86)
Ln(RFDICY)	0.118*	0.0016	0.0862**	−0.0168	0.0546*	0.00385	0.0452*	0.00328
	(1.94)	(0.04)	(2.24)	(−0.35)	(1.74)	(0.08)	(1.78)	(0.11)
Ln(GRADS)	0.153	−0.0338	0.0147	0.144	−0.126	0.149	0.0889	0.0169
	(0.96)	(−0.22)	(0.11)	(1.13)	(−0.82)	(1.07)	(0.46)	(0.11)
Ln(RDEP)	0.178	−0.0434	0.172	0.223	0.388	0.0497	0.261	0.286
	(0.37)	(−0.12)	(0.45)	(0.76)	(1.29)	(0.13)	(0.51)	(0.81)
Ln(ELECPDMP)	0.28	0.391***	−0.103	0.680****	−0.0789	0.829****	0.334	−0.128
	(1.24)	(2.92)	(−0.64)	(6.01)	(−0.64)	(4.47)	(1.23)	(−0.68)
Ln(HWMP)	−0.0765	0.315*	−0.189**	0.0757	−0.185	0.00888	0.65	−0.131
	(−0.61)	(1.79)	(−2.06)	(0.82)	(−1.12)	(0.12)	(1.57)	(−1.39)
Ln(RWLENMP)	0.162	0.0883	0.0981	0.151	−0.0137	0.207	0.266	0.213**
	(1.12)	(0.69)	(1.30)	(0.79)	(−0.21)	(1.60)	(1.07)	(2.03)
Ln(URTELESUBHP)	0.171	−0.328	0.185	−0.157	0.133	−0.276*	0.518***	0.203
	(0.91)	(−1.56)	(1.51)	(−0.86)	(1.35)	(−1.81)	(2.68)	(1.17)

t statistics in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$, ****$p < 0.001$

The marginal effect of railway is on average positive but insignificant. One percent increase in railway length per million people will increase real GDP per capita by 0.16 percent. Over time, its role becomes stronger during rail expansion around the turn of the century.

Telephone usage also contributes to the improvement of real GDP per capita. One percent increase in urban telephone users will increase the real GDP per capita by 0.17 percent, but the effect is not significant. Its role has been significant during the early 1990s and gradually becomes less significant and even negative during late 2000s.

Contrary to our expectation, road infrastructure has a negative effect on the level of economic development, although the effect is insignificant on average. One more percent of road length per million people will reduce real GDP per capita by about 0.08 percent. Over time, the marginal contribution of road expansion changes from positive and insignificant during the early 1990s, to negative and significant during the late 1990s and positive during the latest expansion around the year 2005. The mixed results for road expansion suggests that road investment may be inefficient.

The marginal effect of private capital is positive but insignificant on average. Its marginal contribution has become stronger during late 2000s. It suggests that the enterprise reform during late 1990s to early 2000s may improve the productivity of private capital. Foreign capital has contributed to China's export oriented economy by bringing in resources, technology and good management. Its marginal contribution is particularly strong in the 1990s, while its role seems to decline in late 2000s when the productivity of private capital improves.

The contribution of human capital is on average positive but not significant. Proxied by the share of number of graduates, one more percent of human capital can bring in 0.15 percent of real GDP per capita. The dependence ratio seems to contribute to the economy during most time except after the year 2005. It suggests as the number of elderly people grows and the number of newborns decreases, it brings a lot of burden to the young and working aged people.

Additional tests are performed by including more lagged differenced terms to account for possible endogeneity between these lagged differenced terms with the unobserved factors. The marginal effect of electricity becomes even larger, but this comes at the cost of greatly reducing the time period covered in the beginning of 1990s. The negative effect of road infrastructure becomes larger as well, yet still insignificant. Effect of railway becomes the largest when one lagged differenced term $\Delta X_{i,t-1}$ is included and tends to decline when more lagged differences are included. Marginal effect of telephone stays positive but insignificant on average. Its magnitude decreases with more lagged difference terms included. In general the differences among them are minimal and Hausman tests reject that they are different.

2.4.3.3   Regional Effect of Infrastructure Capital

Given the vast difference across China's regions and changing policy focus over time, this section performs an analysis on subsamples of each economic region to capture the regional and time variations of the impact from infrastructure capital. The purpose is to see whether the growth impact of infrastructure is similar across regions. In particular, it seeks to identify the sources of negative marginal effects from road expansion by uncovering regional characteristics. Regional analysis also relaxed the assumptions posed by the dynamic fixed effect. It allows the coefficients of the cointegrating vector to be different across China's sub-national regions.

The historical development of the four types of infrastructure capital in the four sub-national regions resonates the pattern of development at the national level. The growth of electricity production is particularly strong for the Eastern and Central regions. Road network expansion around the year 2000 mainly come from investment in the Central and Western regions and that around the year 2005 coming from all regions. Rail expansion is mainly a result of investment in the Eastern and Central regions in the 2000s. Telephone usage expansion persists until after the year 2006, when the role of cell phone has gradually replaced that of telephone.

Table 2.5 presents the regional effects of infrastructure capital[10]. All regions have shown evidence of conditional convergence, except for the Western region, where the speed of adjustment parameter is not significant. The speed of adjustment is fastest in the Central region among the others and slowest in the Western region.

Table 2.5: Regional effect of infrastructure capital (1990-2010)

(Dependent variable: $\ln(RGDPPC)_t$; *dynamic fixed effects with robust standard errors)*

	National (2.4.1)	Eastern (2.5.1)	Central (2.5.2)	Western (2.5.3)	Northeastern (2.5.4)
Short run error correction coefficient					
	−0.113****	−0.149****	−0.230****	−0.121	−0.170*
	(−3.76)	(−3.64)	(−3.93)	(−1.59)	(−1.73)
Long run cointegrating relationship					
Ln(RSPINV)	0.0731	0.146**	−0.0727	−0.524**	0.385****
	(0.90)	(1.98)	(−0.61)	(−2.14)	(3.71)
Ln(RFDICY)	0.118*	0.141*	0.0377	0.0541	−0.115
	(1.94)	(1.82)	(0.81)	(1.24)	(−0.84)
Ln(GRADS)	0.153	0.439	−0.0755	0.203	−0.156
	(0.96)	(1.62)	(−0.65)	(1.01)	(−0.33)
Ln(RDEP)	0.178	0.266	0.395	0.268	−1.64****
	(0.37)	(0.56)	(0.71)	(0.40)	(−3.78)
Ln(ELECPDMP)	0.28	−0.309	0.923**	0.563**	1.026****
	(1.24)	(−1.39)	(2.56)	(2.01)	(3.49)
Ln(HWMP)	−0.0765	−0.0215	−0.176	−0.368	0.50
	(−0.61)	(−0.18)	(−1.42)	(−1.20)	(1.25)
Ln(RWLENMP)	0.162	0.173	0.223	0.464*	0.0874
	(1.12)	(1.30)	(1.11)	(1.86)	(0.12)
Ln(URTELESUBHP)	0.171	0.386****	0.276**	−0.452***	−0.237
	(0.91)	(3.40)	(2.04)	(−2.70)	(−1.26)

t statistics in parentheses
*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$, ****$p < 0.001$

Electricity production has positive and significant effects on real per capita GDP for the Central, Western and Northeastern regions. In particular the coefficients for the Northeastern regions are greater than one. Its effect in the Eastern region, which consists of the fastest

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[10]Regressions with more lagged differenced variables are also run. Results are reported if different from the basic regression in Table 2.5.

growing provinces, has an average negative effect, although insignificant. The discussion on time varying effect across the region will shed light on the reasons for this result.

Road infrastructure shows negative effects on almost all regions expect the Northeastern region. Considering the fast growth of road expansion in the Central and Western regions, road investment seems to be inefficient. In particular, the marginal effect of roads in the Western region is negative and large in magnitude, albeit insignificant.

Railway infrastructure contributes positively to all major regions on average. In particular, the marginal effect in the Western region is strongest, reflecting the important role of railway in linking the inland region to the coastal region.

Telecommunications infrastructure is in general positively related to real GDP per capita, except in the Western and Northeastern regions. Its marginal contribution is the largest for the advancing Eastern region. Given the data limitation, the role of cell phone usage is discussed within a shorter sample period in the robustness check.

In summary, regional analysis shows that different types of infrastructure play different roles across regions. Moreover, their roles may change over time due to changing economic environment. The following analysis therefore focuses on the regional impact of infrastructure over time using the structural breaks identified. It aims to identify souces for the mixed results found in some type of infrastructure in some regions. The regression results are in Table A.1 to Table A.4 in Appendix A.

For the Easern region, the negative average marginal effect of electricity capacity expansion seems to come from the 1990s. Its marginal contribution becomes positive and significant during the latter half of the 2000s. Given that the speed of electricity capacity expansion increases after the year 1998, the initial negative effect may reflect the large sunk cost associate with rapid capacity expansion, before any meaningful gains can be registered.

Road expansion in the Eastern region during the fiscal stimulus program period seems to yield an average negative effect. Its marginal effect during the latest road expansion in 2006, however, becomes positive, but not significant. The results show that not all road expansion

is good at all times.

Railway infrastructure has been increasingly conducive to economic development in the Eastern provinces. Its marginal effect is strongest during the early 2000s with coefficients around 0.3. The marginal effect declines after the year 2005.

Telephone usage growth has been phenomenon before the year 2005. Results show that the marginal effect of telephone usage is positive and significant, with coefficient as high as 0.9 during the early 1990s. However, its marginal effect turns to negative and significant after the year 2005 with increasing role of the cell phone.

For the Central region, electricity production plays an increasingly stronger role in the 2000s for the Central region. The role of road network shows a mixed story. From the mid-1990s to the early 2000s, the marginal effect is negative and significant, suggesting that road expansion during the period may be inefficient. Yet marginal contribution of road expansion after 2005 becomes positive and significant. Railway development in the Central region seems to be important throughout the 1990s. Its marginal contribution is very strong during the early 1990s. Its role declines after the year 2005. Telephone usage continues to play a positive role throughout the period with marginal contribution significant in before the year 2005.

In the Western region, the role of electricity production gradually becomes more important, as the coefficients become positive and significant in the 2000s. Marginal contribution of road expansion is on average negative, but not significant. The expansion during the fiscal stimulus program may be particularly inefficient as shown by the negative and significant coefficient. On the other hand, rail investment plays a stronger role throughout the sample period. The marginal effect of railway infrastructure seems to be stronger during the early 1990s and the late 2000s. The marginal effect of telephone is on average negative and significant, in paricular before the year 2005. Further conclusions can only be made after the role of cell phone is considered in the next section.

For the Northeastern region, estimation of the long run relationship in the Northeastern

region also encounters the small sample problem. Because there are only three provinces in the region, the period between 2006 and 2010 and the period 1998 to 2002 couldn't be tested.

Electricity production seems to be very strongly related to real GDP per capita, in particular during the early 2000s, suggesting a large role of electricity in its regional development. Marginal contribution of Road development after the year 2000 is negative and significant. In particular, road investment during the fiscal stimulus period does not seem to contribute to economic development while that after the year 2005 may become positive. Railway development on average has a minimal effect on real GDP per capita. It seems to exert a negative marginal effect throughout the 1990s and early 2000s. Its marginal contribution improves after the year 2005. Telephone usage has contributed to economic development during the late 1990s, while its role declines during the 2000s, echoing the experience of other regions in China.

In conclusion, the effects of large infrastructure investment programs differ across China's sub-national regions[11]. Moreover, the marginal effect changes over time. Provinces in almost all parts of China overcome the initial sunk costs in electricity capacity expansion and enjoyed the benefits from alleviation of energy bottlenecks in the 2000s. Road expansion during the fiscal stimulus period seems to be negatively associated with economic development in all regions, whereas the expansion after the year 2005 seems to work better to promote growth. A possible explanation is that during the late 2000s private sector development increases in the lagging Central and Western regions as a result of structural change in the coastal regions. Infrastructure investment, therefore, has encouraged more industrial development in those regions than in the fiscal stimulus period, when infrastructure investment did not necessarily come with more private investment. Investment in railway development seems to contribute significantly in most regions until after the year 2005, except in the Northeastern provinces. The role of railway network seems to be stronger for the Northeastern region after the year

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[11]More lagged differenced terms are included in the regression. The results are similar.

2005. The role of the telephone as a communication tool has been strong throughout until after the year 2005 for the Eastern, Central and Northeastern regions. On the other hand, marginal contribution of the telephone in the Western region has been negative throughout the sample period.

Indeed China is one of the top performers in terms of its economic growth. It is also one of the top performers in building and expanding infrastructure. However, massive infrastructure spending has not always been transformed into faster growth. The marginal effects of massive infrastructure spending seem to suggest overinvestment some types of infrastructure during some historical episodes in some regions.

2.4.4 Alternative Specifications and Results

2.4.4.1 Road Classifications and Cell Phone Usage

The objective of modern transportation development gradually shifts from road connectivity to the speed and quality of travel. High speed train, subway and higher quality expressway are all examples of the current transportation development in China. It is therefore interesting to explore whether the quality and speed of transportation contributes to the provincial growth. Meanwhile, the role of telephone has been gradually replaced by cell phones for greater mobility. Given data limitation, a regression with a smaller sample from 1998 to 2010 is performed with roads of detailed classifications and cell phone users (Table 2.6).

Road classification shows that the significant increase in road stock in 2001 and 2006 comes mostly from unclassified roads and Class IV roads. Almost all regions have experienced high growth of road networks in these categories. Compared with the other region, the Central and Western regions have received the largest amount of road investment. In particular, the unclassified road investment in the Western region is faster than other areas after the year 2006.

Cell phone usage has increased even faster than that of the telephone. There is continuous

Table 2.6: Regional effect of infrastructure capital (1998-2010)

(Dependent variable: $\ln(RGDPPC)_t$; dynamic fixed effects with robust standard errors)

	National (2.6.1)	Eastern (2.6.2)	Central (2.6.3)	Western (2.6.4)	Northeastern (2.6.5)
Short run error correction coefficient					
	−0.185****	−0.178****	−0.552****	−0.195****	−0.658*
	(−5.21)	(−4.75)	(−4.49)	(−4.00)	(−1.76)
Long run cointegrating relationship					
Ln(RDEXPMP)	0.0512	0.179***	0.0558	0.0239	−0.0275
	(1.55)	(2.82)	(0.95)	(0.78)	(−0.26)
Ln(RDCLIMP)	0.0228	0.132	0.0463***	0.0418	−0.0818
	(0.58)	(0.99)	(3.20)	(0.74)	(−0.58)
Ln(RDCLIIMP)	−0.0214	−0.0906	−0.212***	−0.15	0.203
	(−0.22)	(−0.47)	(−3.15)	(−1.52)	(0.62)
Ln(RDCLIIIMP)	−0.115**	0.234	−0.379****	−0.0747	−0.158
	(−2.19)	(0.99)	(−4.62)	(−1.26)	(−0.44)
Ln(RDCLIVMP)	0.0525	0.000321	0.012	0.106	−0.282*
	(0.77)	(0.00)	(0.19)	(0.95)	(−1.69)
Ln(RDUCMP)	0.013	−0.0033	−0.0155	0.00804	0.0373
	(0.51)	(−0.21)	(−0.69)	(0.17)	(0.54)
Ln(URTELESUBHP)	−0.167	−0.382*	−0.218*	−0.119	0.00325
	(−1.28)	(−1.77)	(−1.65)	(−0.69)	(0.03)
Ln(CELLSUBHP)	0.198**	0.0446	0.473****	−0.0263	0.304
	(2.15)	(0.23)	(5.08)	(−0.17)	(1.06)

t statistics in parentheses
$^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$, $^{****}p < 0.001$

increase in the use of cell phone during the whole sub-sample period. The need for mobility and cost reduction have made the cell phone gradually more attractive than the telephone. When both the cell phone and the telephone are considered, the role of the telephone becomes insignificant. In particular, the cell phone has become increasingly important for the Central region. Its effects to real GDP per capita seem to be smaller in the Western region, where marginal effect is negative but insignificant. The results suggest that the telecommunication technology has made cell phone more appealing from a regional development perspective, in particular for the fast transforming Central regions.

Estimation of road investment at disaggregated level reveals new findings. Expressway

construction seems to benefit the Eastern region the most, whereas Class I road network seems to contribute to the Central region the most. This suggests that as regions move ahead in economic development, demand for road services has moved from simple mobility to the quality and speed of services.

The average negative marginal effect of road seems to come from Class II and Class III road investment. When regional variations are considered, the marginal contribution of Class II and Class III roads is negative and significant for the Central region. Class IV roads have exerted a negative marginal effect for the Northeastern region. The marginal effects of unclassified roads are in general in significant. They are negative in the Eastern and Central regions.

2.4.4.2 Endogenous Investment Decisions

Previous discussion on the effect of infrastructure capital rests on the assumption that there is weak exogneity in the infrastructure capital. This section relaxes this assumption and treats all types of capital as endogenous and uses the difference GMM and system GMM approaches for estimation. The basic idea is to find instrumental variables within the system. One difference of the Arellano-Bond GMM and system GMM from the error correction model is that they only estimate the short run relationship. The estimates are comparable to the short run portion of the error correction model results, which previous analysis has not discussed much.

Following the advice from Roodman (2006), both one step and two step estimations with robust standard errors are performed. To limit the number of instruments, only one instrument for each variable and lag distance, rather than one for each variable, each time and lag distance. Difference GMM and system GMM regressions with more lags are performed[12].

The results show that conditional convergence coefficient is of the expected sign and significant when more lags are used as instruments. The marginal effects of infrastructure

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[12]These results are available upon request.

capital in the difference and system GMM are in general insignificant. The negative effect of road infrastructure stays in the system GMM one step and two step estimations. The results show that the estimation suffers from the weak instrument problem. Coefficients are very sensitive to the number of lags used, when more lagged instruments are used to consider possible effects from lagged infrastructure investment to future economic growth.

2.4.4.3   Growth Elasticities

One advantage of the long run relationship estimation is that the original elasticities can be recovered from the regression. This section recovers the growth elasticities from the long run cointegrating relationship estimated from the error correction model using zero to one lagged difference. Note that the long run relationship corresponds to that in equation (*).

Table 2.7: Growth elasticities in China

Variables	Long run coefficients
$\ln(s_k)$	0.102
$\ln(h_t)$	0.203
$\ln(q_t)$	
Electricity	0.293
Road	-0.141
Railway	0.286
Telephone	0.197
$\ln(F_t)$	0.12
ϕ	-0.093
α	0.05
β	0.1
γ	0.33
θ	0.74
η	0.03

Results show that under the assumptions of the neoclassical growth model, the elasticities of private capital, human capital and the aggregated infrastructure capital are 0.1, 0.2 and 0.64. It assumes that different types of infrastructure enter the production function as simple substitute. That is $Y_t = (A_t L_t)^{1-\alpha-\beta-\gamma} K_t^{\alpha} H_t^{\beta} G_{1t}^{\gamma 1} G_{2t}^{\gamma 2} G_{3t}^{\gamma 3} G_{4t}^{\gamma 4}$, where $\gamma = \gamma 1 + \gamma 2 + \gamma 3 +$

$\gamma 4$. While this is a strong assumption, the recovered coefficients show that elasticity of infrastructure capital is very large (Table 2.7).

In the classical study by Mankiw, Romer and Weil (1992) on 98 countries over the period of 1960 to 1985, they found that the elasticities of private capital is 0.31 for non-oil countries, 0.29 for intermediate countries and 0.14 for OECD countries. Elasticities for human capital are 0.28 for non-oil countries, 0.3 for intermediate countries and 0.37 for OECD countries. Knight, Loyaza and Villanueva (1993) used panel data approach to test the same dataset. Their coefficient on private capital is 0.20 for all countries and 0.21 for developing countries. The coefficient for human capital is 0.095 for all countries and 0.32 for developing countries. A recent study by Barossi-Filho, Silva and Diniz (2005) used dynamic panel data approach to estimate the simple Solow growth model from 1960-1995 on 53 countries. Their estimate for the elasticity of capital in the restricted model is 0.34.

Elasticities recovered from the neoclassical model with infrastructure capital shows that elasticity of private capital is lower than the previous studies, partly because the definition used for gross capital formation is different. In previous studies, gross capital formation not only accounts for pure private capital formation, but also the other types of capital that belong to state owned enterprises or quasi-public service units. The private capital used here, however, is a conservative measure that excludes capital from share holders and joint ventures with state elements. The purpose is to differentiate with the public infrastructure capital, proxied by the physical measures. Considering this, the relatively small elasticity of the private capital can be understood.

The elasticity of human capital seems to be consistent with some results and is significantly lower than the studies in Mankiw, Romer and Weil (1992). One explanation for this is that the measure of human capital in this study is the number of graduates from higher education, a much narrower definition than the other studies.

The results suggest the large role played by the infrastructure capital in sustaining economic growth in China. It also shows the relatively large negative effect of road expansion

on economic growth, as its long run coefficients is negative and even larger than that of the private investment in magnitude.

2.5   Conclusion

This chapter studies the relationship between infrastructure capital and economic growth in China's provinces and municipalities. The results show that infrastructure has a positive role to play in China's regional economic growth. This is particularly evident in the case of the electricity and railway infrastructure for the lagging regions.

The findings of the chapter also yield what, at first glance, seem very surprising results. Although there is infrastructure construction boom, the marginal contribution of some types of infrastructure is insignificant and even become negative in some regions. The results are robust to different specifications and approaches. It indicates that more infrastructure capital is not always better. Too much infrastructure can be detrimental economic growth. This result contrasts many studies that conclude with a policy recommendation for more roads in the Western and Central regions (e.g. Luo, 2004).

These empirical findings should not be so surprising from a theoretical perspective. There is a limit to the growth effect of infrastructure capital in general. There are a number of possible interpretations for these findings. More public infrastructure may actually crowd out private capital. This "crowding-out effect" comes from a number of ways. First, preferential lending for government supported infrastructure projects results in inefficiency in resource allocation. Second, fast development of infrastructure drives up the cost of inputs and induces inflation. In fact, the price index for fixed asset investment sharply rises during years of heavy infrastructure construction. Third, beautiful roads with no traffic or accompanying private sector development wont yield productive outcomes. Certain types of infrastructure, such as road network, may also have a network effect (e.g. in Fernald, 1999). Building one road may be productive, but building more may divert existing traffic. Meanwhile, lagging regions may lack the absorptive capacity given large amount of infrastructure investment (Berg

et al, 2011). As a result, the seemingly productive infrastructure investment may become unproductive if there is an excessive amount of them. The results question the conventional wisdom that road development leads to prosperity. A large resource waste from building roads can lead to nowhere.

This conclusion, however, cannot be over-interpreted as there should be a specific level of infrastructure investment. Instead it shows that there is a level of infrastructure investment that's comparable to the level of development. More infrastructure investment can drag the economy during some time for some regions.

The empirical findings have important policy implications. The recommendation for more road infrastructure in lagging regions may be misleading. Spending too much on building roads may not be a better option than developing the energy or railway sector. Within the road sector, building Class II or III roads in the Central region may not be better than Class I roads.

The results in this chapter also contribute to the recent effort to empirically test the neoclassical economic growth model. The elasticities of different types of capital recovered from the estimation shows that public capital or quasi-public capital formation plays a big role in China's economic growth.

These findings open up new questions for further research. For example, why do sub-national governments invest excessive amount of public infrastructure? How these governments, in particular those in the poor regions, are able to build large amount of infrastructure? These two questions are addressed in the following two chapters. Answers to these questions can provide lessons on how to induce a positive impact from public infrastructure investment.

Chapter 3

CHINA'S PUBLIC INFRASTRUCTURE INVESTMENT

3.1 Introduction

China has been mobilizing large amounts of resources for infrastructure investment ever since the reform and opening up in late 1970s. The last thirty years have witnessed drastic changes in its physical landscape as China gradually grows from an agrarian economy to an urbanized manufacturing state. The export driven economy has ignited production expansion and the creation of forward and backward linkages that call for more investment in sectors such as energy, transport, and telecommunication technology. Moreover, the rapid urbanization process that comes with the structural transformation in China has created large demand for infrastructure. Infrastructure investments are targeted to alleviate bottlenecks in many urbanizing coastal areas with a growing number of migration workers. Meanwhile, the roles of infrastructure change as the economic conditions in China continue to evolve. Infrastructure investment has shifted from accommodating to the growth of an export oriented economy to a fiscal stimulus tool in the lagging area. China has indeed been leading other developing countries in infrastructure building. Infrastructure investment has become one of the most important pillars of China's growing export-oriented and investment led economy.

One the other hand, the effectiveness of infrastructure investment is seldom questioned in China. Chapter 2 has revealed that although infrastructure has contributed to China's growing economy in general, there is evidence of too much infrastructure in some sectors during some time periods. This chapter addresses two questions arising from the empirical evidence. Firstly, why China has been able to invest in such large amount of infrastructure in a relatively short period of time. Secondly, what factors have provided incentives to overinvest in the public sector. This chapter addresses these two questions by unveiling the decision making process and financing patterns for infrastructure investment and the issues

arised from the current institutional arrangements in China.

Decentralization is thought to be a key reason behind China's success in infrastructure development. Ever since the reform and opening up, China has undergone a decentralization of public investment decision making from the central government to lower levels of government and a gradual delineation of enterprise from the government. However, literature shows that fiscal decentralization itself does not guarantee more public goods provision. Another side of the successful infrastructure building story rests with China's centralized political system. Each level of the government is responsible for the higher level of government. The performance rating of the government officials is aligned with the economic performance of the jurisdiction. Under these institutional features, China does witness the rapid increase of infrastructure stock during a relatively short period of time.

Meanwhile, the booming investment in infrastructure sectors is not without problems. Frequent reports of inefficient investment projects come to the surface. The various cases and anecdotes reflect underlying systematic issues with infrastructure investment. China's political system places high demand on the personal influence of government officials. The unbalanced fiscal revenue and expenditure assignments between the central and lower levels of the government poses enormous pressure on the sub-national governments to fulfill their expenditure obligations. It creates incentives at the lower levels of the government to invest more in productive public infrastructure than other types of spending, both to attract mobile capital and to rein in more tax revenue. The extra-budget accounts proliferate and land financing has become a rule rather than an exception. The lower levels of the government are able to borrow through various means by leveraging on its public assets and explicit or implicit guarantees from the central government. The indirect borrowing and untransparent extra-budgetary accounts exacerbate the issue of soft budget constraint. As a result, inefficient and risky projects arise that may not yield long run benefits and may not be plausible given the current and projected local economic conditions. Often these projects are hard to prevent and already costly when they are revealed to the public.

This chapter elaborates on these issues in the following parts. Part II gives a historical account of the infrastructure development in China over the last twenty years. Both cross country and within country comparison will be discussed. Part III highlights the institutional features that are behind such persistent large scale infrastructure investment. Part IV describes the financing side of infrastructure development. Part V concludes.

3.2 Infrastructure Development in China

3.2.1 A Historical Context

Infrastructure development in China involves both the hands of the market and the government. While the structural transformation and urbanization process call for more infrastructure, the state has played a proactive role during various stages of China's economic development.

Infrastructure development is an integral part of the Special Economic Zone (SEZ) development across China. At the beginning, barren land in remote villages designated as SEZs require large infrastructure investment to shape them into production centers. The years from 1980 to 1989 marked the beginning of the historic establishment of four SEZs. Since the year 1990, China has witnessed mushrooming SEZs spreading from the coastal area to more inland and lagging provinces. Infrastructure is accommodating to the growth of an export oriented economy at this stage. Since many special zones are far away from the major economic centers, they need roads, railways and energy to support the export industries. In the early 1990s, transport sector, in particular the railway sector, was given special attention in the national development plan because of its critical role in transporting essential goods such as coal, oil products and grain. When the economy grows to a more advanced level, congestion costs and rising factor prices have become the bottlenecks of the economy. Such bottlenecks typically rest with the energy and transport infrastructure that are the backbone of the economy. China's accession into the WTO in 2001 further motivated a well-integrated

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infrastructure network, where energy, transport and telecommunications are supporting each other to fuel the economic growth.

Infrastructure development has also been part of the fiscal stimulus programs in China. In the year 1998, the former Premier Zhu adopted a counter-cyclical fiscal policy to address possible economic downturn after the Asian financial crisis. Infrastructure spending, for the first time in China's history, became an instrument for fiscal stimulus to spur nationwide growth. In the year 2008, facing the negative effect of the global economic recession, infrastructure investment again became an important part of the massive fiscal stimulus program.

The productive nature of infrastructure investments has also been used to bridging the economic gaps between the lagging region and the advanced regions. In the year 2000, the national government launched the long-contemplated Western Development Plan to promote growth and catch-up in China's inland provinces. Since then large amounts of infrastructure have been mobilized toward the lagging regions.

The result of the interaction of market and the state is a rapid transformation of landscape across China. The following section presents an overview of China's development in major infrastructure sectors.

3.2.2 Stylized Facts of China's Infrastructure Investment

3.2.2.1 Overview

China started with relatively low levels of infrastructure investment in energy, transport and telecommunications before its reform and opening up. With China gradually opening up to trade and investment, China's infrastructure investment reached about 6.5% of GDP, well above the average level of 4% of GDP for developing countries by the year 1993 (World Bank 1995). Its size of investment continued to grow in the past two decades. Figure 3.1 shows the size of China's fixed assets investment in the infrastructure subsectors[1]. In particular,

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[1]Fixed assets investment in infrastructure related sectors may be broader than investment in infrastructure alone. Therefore the actual investment in infrastructure may be smaller.

Figure 3.1: China's fixed assets investment in infrastructure sectors
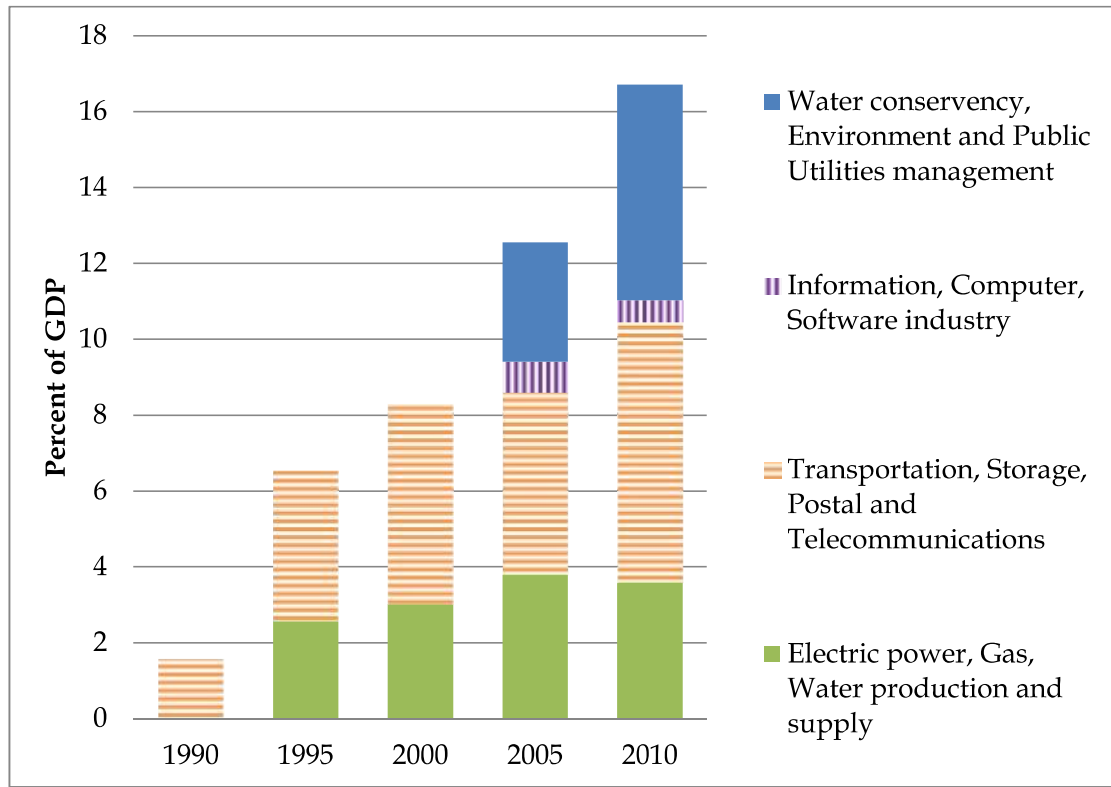
For interpretation of the references to color in this and all other figures, the reader is referred to the electronic version of this dissertation.
Source: China Statistical Yearbook, various issues.

the accounted infrastructure subsectors have grown to account for more than 15% of GDP by the year 2010. Among them, investment in transportation subsectors have grown from less than 2% of GDP in 1990 to about 7% of GDP by 2010[2].

As a result of the large scale investment activities, China has witnessed strong growth in its infrastructure stock (Table 3.1). Electricity capacity has seen one of the most remarkable growth performance over the last twenty years. The annual growth rate of its production capacity stays at about 9%. By 2010, it has ranked the second largest amount of electricity

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The accounting categories change several times over the last two decades. Figure 3.1 here presents the available sector-specific investment from the China Statistical Yearbooks.

[2]The definition of transportation subsector changes over time. It did not include "Storage" for the year 1990. While after the year 2004, the telecommunications subsector was accounted as a separate account into the "Information, Computer and Software industry".

in the world only behind the United States. In per capita terms, which measures the services covered for the residents, its level is leading the lower middle income countries, and comparable to the upper middle income countries(See Figure B.1 to Figure B.4 in Appendix B).

Table 3.1: Infrastructure development in China

Type	1990	2011	Annual growth rate
Electricity			
Electricity generating capacity (1000kw)	13789	105576	8.7%
Electricity production (100 million kwh)	6212	47217	10.2%
Transport			
Road(km)	1028348	4106400	7.7%
Railway operating length (km)	57899	95234	2.4%
Road cargo turnover (million ton-km)	335810	5137470	17.4%
Rail cargo turnover (million ton-km)	1062238	2946579	5%
Road passenger turnover (million passenger-km)	262032	1676020	9.3%
Rail passenger turnover (million passenger-km)	261263	961229	6.5%
Telecommunications			
Fixed line telephone subscribers (10000 units)	685	28512	20.9%
Cell phone subscribers (10000 units)	1.8	98625	80.7%

Source: China Statistical Yearbooks, various issues

Similarly the road network has been expanding rapidly with an annual growth rate of 8% over the last twenty years. The road network scaled by population and geographical size has far exceeded the lower middle income country group and is comparable to the medium level of the upper-middle-income countries. On the other hand, the railway network has seen relatively slow growth compared with the other infrastructure subsectors. The annual growth rate is about 2% over the last two decades. Its network scaled by population and geographical size is also relatively low compared with lower middle income countries. However, the actual state of development in the rail sector may be higher because much of the development in the rail sector has been in the form of in electrification and double tracking, which is not reflected in the rail operating length.

Meanwhile, road transport has become more important for freight and passenger traffic

over the last two decades. The average growth rate of passenger turnover is 17%, and that of the cargo turnover 9%. Although the rail traffic has also undergone rapid growth, by the year 2010, road traffic turnover from both freight and passenger exceed that of the railway.

China has been taking advantage of the recent advance in the telecommunication technology. The fixed line telephone users increased at an annual rate of 21% and the number of cell phone users skyrocketed at an annual rate of 81% over the last two decades. In per hundred people terms, both the numbers of telephone and cell phone users are leading the lower middle income countries and are comparable to other upper middle income countries, albeit relatively low compared with high income countries. Meanwhile, Internet users per hundred people are much higher than the lower middle income countries and comparable to the upper middle income countries, despite the relatively lower position than the high income countries.

The sectoral comparison shows that China has become one of the most remarkable performers in the infrastructure development among other countries. In general, China has been upgrading infrastructure stock to a level comparable to the level of income, as shown in the cross country comparison.

3.2.2.2   Regional infrastructure development

The overall boom in infrastructure investment has hidden the vast differences in regional investment given large variations in endowment, geographical nature and economic conditions across China's regions. As the roles of infrastructure change throughout different stages of economic development, the pattern and speed of infrastructure development vary across regions.

Figure 3.2 presents an incomplete picture of the development scenario in China's four major regions. It is incomplete because disaggregated data by sector are not available for the 1990s. Therefore, Figure 3.2 is best read by looking at individual sectors for years before 2000. For the transport sector, there has been a continued growth of its size relative to

Figure 3.2: Regional fixed asset investment in infrastructure sectors
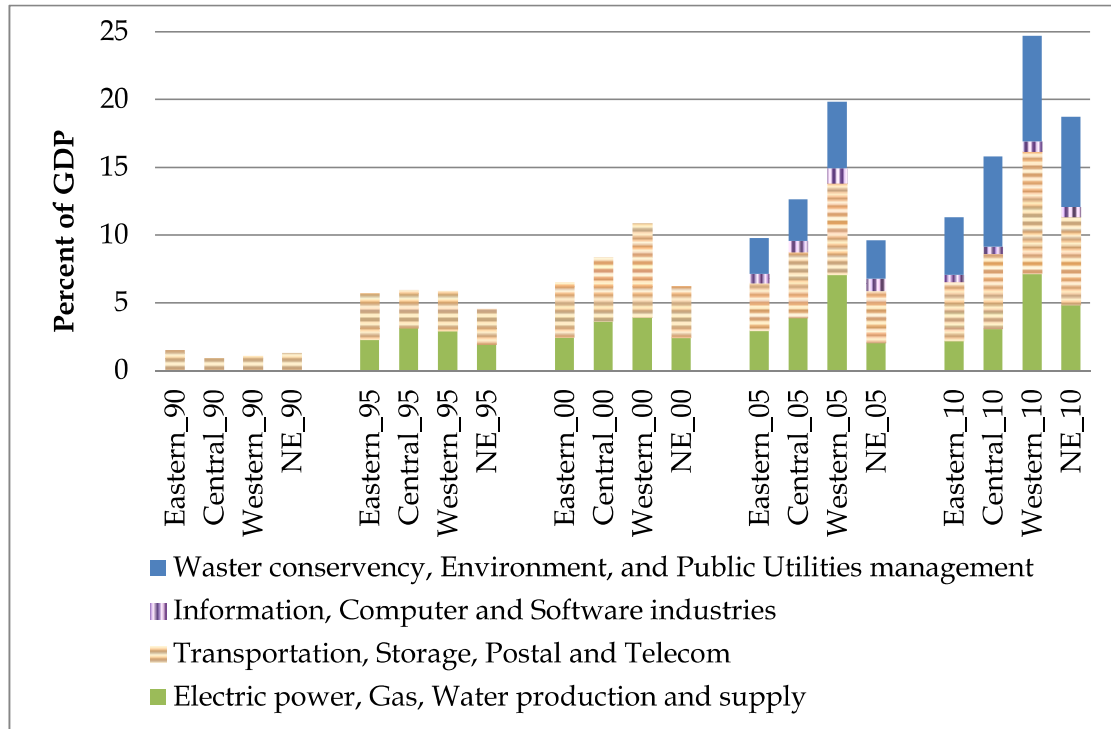
Source: China Statistical Yearbooks, various issues.

the provincial GDP. In the early 1990s, the transport infrastructure investment to GDP is larger in the Eastern region than the others, but the sizes to GDP do not differ much. Starting from the year 2000, the pattern has reversed. Transport investment to GDP in the Western region dramatically increases from about 1% in 1990 to 7% in 2000, followed by the Central (4.7%) and Eastern regions (4.1%). By the year 2010, the transport investment to GDP in the Western region has become even higher (9%), with Northeastern region 6.6%, the Central region 5.5% and the Eastern region 4.4%. This reversed pattern of transport sector investment has echoed the periods of the proactive national policy to bridge regional development gap by investing heavily in transport infrastructure.

For the electricity sector, the rapid increase has mostly been felt by the Western and Central regions. By the year 2010, the electricity investment to GDP shares are 7% in the

Western region and 3% in the Central region. This investment effort partly reflects the relatively rich mineral endowments in the inland regions. The electricity generated in the inland regions is supporting the growing demand from the coastal region through projects such as the natural gas transmission from the West to the Eastern regions.

In the meantime, as the telecommunication and internet and software industries grow, they are separated from the transport sector account in the early 2000s. Although the size of investment is less than 1% of GDP, there has clearly been a preference for the Western region. There are strategic policies to develop the Western area through investment in advanced technologies in the telecommunications and related industries that are not so reliant on natural resources.

Investment in the water conservancy and public utilities management subsector has also seen rapid increase in the late 2000s[3]. By the year 2010, investment in this sector accounts for about 8% of GDP in the Western region, followed by 6.7% in the Central and Northeastern regions and 4% in the Eastern region. Part of the increase reflects the rapid urbanization process that demands more public utilities.

Overall, the four infrastructure related sectors account for about 25% of GDP in the Western region and 11% of GDP in the Eastern region in the year 2010. Compared with the overall infrastructure investment level of 6.5% of GDP in 1993, the infrastructure investment growth in the Western region hsa become very high, again reflecting the regional development policy for lagging regions.

The regional distribution of infrastructure also reflects the strategic roles infrastructure plays in China's regional development. There is considerable capacity expansion in electricity production in the Central and Western regions. By the end of 2010, the electricity capacity scaled by population in the Western region is higher than the more advanced Eastern and Northeastern regions. The growth of electricity production is comparable to its capacity expansion. By the year 2010, the production scaled by population in the Western region

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[3]There is no disaggregated data for this sector before the year 2000.

is the same as the Eastern region and much higher than the Northeastern region. Again, a considerable amount of electricity from the inland provinces is transmitted to the coastal areas.

Road network expansion has gained speed in the Central and Western regions. Given the densely populated Eastern region, road length shared by the same number of people is less than other regions, particularly lower than the Western region. The spatial density of road is higher in the Eastern and Central regions and much lower in the Western region, given its vast geographical area. Comparing to road expansion, railway expansion seems to be much slower in all regions. Among them, the rail network in the Western region grows slightly faster at a 3% annual rate. This again does not reflect the technological and capacity improvement in the sector in terms of electrification and double-tracking.

In terms of traffic on the transportation networks, railway has traditionally played a major role in freight traffic and is instrumental in passenger traffic especially during national holidays. The cargo turnover by railway is much higher than road cargo turnover in the beginning of the 1990s. The road network, in the meantime, has gradually replaced the role of rail in short-length transport. The role of road in supporting the manufacturing sector, especially the light industry, was greatly enhanced in the 1990s when the manufacturing sector soared with the export-oriented economy. With the unique feature of a more flexible and door-to-door service, the growth of cargo turnover in the road sector has been faster than the railway sector. By the end of 2000s, road has become more important for freight transportation. In particular, the Eastern and Central regions have been relying more on roads for their freight transport than railways. For passenger traffic, road has played an increasing role also. It carries more passenger traffic than railway in all regions, except the Northeastern region.

The growing traffic on the transportation networks also reflects the changing roles of regions. In the year 1990, the Northeastern region has the highest cargo and passenger turnovers compared with others. However, the Central region has gradually become a major

corridor linking the coastal regions with the inland provinces. By the year 2010, the Central region has replaced the Northeastern region to have the highest cargo turnover and the passenger turnover among the others. Despite efforts in building transport networks in the Western region, it has yet to see the feight and passenger traffic growing to be comparable to other regions.

Perhaps one of the most dramatic changes occurs in the telecommunication sector. The telephone has popularized in both the urban and rural areas. Growth of urban telephone subscribers is on average much higher than other types of infrastructure and much higher in the lagging inland regions. Compared with the telephone, the spread of the cell phone is even faster. The growth rate of cell phone subscribers has reached to about 40% in the inland regions. Cell phone usage has gradually replaced the role of the telephone because of its mobility and low cost.

In conclusion, indeed the persistent large scale infrastructure expansion over the last thirty years is unprecedented in the history of most developing countries. Together with the modernizing infrastructure is the changing role of different types of infrastructure and of different regions. The inland Central and Western regions have received the fastest growth of infrastructure investment and thus fastest expansion of all types of infrastructure discussed. In particular, the relatively rich endowment in national resources has enabled the inland regions to support the increasing energy demand in the coastal region. The Central region has also played an increasing role in connecting the inland and coastal regions. Meanwhile, the rapid urbanization process has enhanced the role of road network in short-length transport and the role of cell phone for an increasingly mobile population. Indeed, the rapid expansion of infrastructure networks has been shaping China's economy, whereas the changing economic conditions in turn influence the way we use different types of infrastructure.

How China has managed to build such large amount of infrastructure within a relatively short period of time remains an interesting issue. As China introduces more market based principles into its economy, so do the infrastructure sectors. To make infrastructure pro-

vision more responsive and efficient, there has been a gradual decentralization of decision making power to the lower levels of government and a delineation of enterprises from the government. The ownership structure of investment has been greatly diversified over the last two decades. Instead of the central government, the sub-national governments are taking an increasing role in infrastructure provision. In particular, the sub-national governments have large incentives for heavy investment in infrastructure over expenditure on other social sectors. Together with the massive infrastructure investment are concerns about the speed and efficiency of investments. For example, there are the so-called "white elephant" projects, "fishing projects" and "beard projects"[4].

Behind these infrastructure investment patterns is the changing institutional environment that goes with the reform and opening up of China's economy. The next two sections interpret the phenomenon in infrastructure development by explaining the key institutional factors that shape the patterns of infrastructure investment in China. It discusses important features in the political, fiscal and investment system relevant to infrastructure development. It seeks to answer the following questions. First, who are the key players in the decision making of infrastructure investment? Second, how infrastructure projects are selected? Third, how has funding been allocated to these projects?

Due to the scope of this study, the discussion does not elaborate on the project implementation and monitoring side of the story to explain some of the low efficiency. However, the trend of delineation of enterprises from the government has greatly improved specialization of firms involved in infrastructure building. Overall, the enterprise sector has accumulated a lot of experiences in designing, building and assessing the impact of the projects and hence the construction quality.

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[4] "White elephant" projects refer to those investments that help the image building of the officials, but not useful in nature. "Fishing projects" refer to those that are described as low cost high efficiency, but eventually witness frequent cost-overruns. "Beard projects" refer to those projects that take forever to be completed because of shortage of fundings.

3.3 Institutional Features of China's Infrastructure Investment

A number of fundamental reforms in the investment system, fiscal system and the enterprise sector have enabled the large scale infrastructure investment in China. This section first discusses the important elements of infrastructure decision making process throughout the various reforms. It then describes how these elements are put together at the central and subnational levels in the planning, preparation and approval process of infrastructure investment. It suggests that political centralization and fiscal decentralization may have shaped what is now China with modern infrastructure. The strong incentives of the government, in particular in the lower levels of governments, for infrastructure investment, are a result of a number of factors in the existing institutional arrangement.

3.3.1 Elements of Investment Decision Making

The purpose of this section is to introduce the major players in the decision making process and their respective roles. It reviews a number of key elements that constitute the decision making process for investment, including the political structure behind the investment decision making, and two important aspects, namely the Five Year Plan(s) and the budget, that facilitate the infrastructure investment.

3.3.1.1 The double-track political system

Before delving into the major players in infrastructure decision making, there is one unique feature of China's decision making process, which is the "party/administration double-track system" throughout the organizational structure at different levels of government. At each level of government, there is one party position and one administrative position. These two positions can be held by two different people or the same official. In the case where the two positions are given to two people, the party secretary has the final say on major policy and personnel issues, although he or she does not necessarily engage in day-to-day administrative

responsibilities. Party officials at each level of government are responsible for the higher level of party authority. The party, therefore, is virtually in control of all major issues in China.

The institutional arrangement of China's government can be best represented by Figure 3.3 (Economist, 2012; Liu, undated). Among them, the following institutions are the major players in investment decision making. At the top of the structure is the Central Party Committee (CPC), which handles policy agenda and guides the law making process. Under the leadership of the CPC, there are the National People's Congress (NPC), the highest legislative authority, the State Council, the highest executive authority and the Chinese Peoples Political Consultative Conference (CPPCC), performing the role of policy consultation at the highest level. The CPC will appoint leaders to take charge of the NPC, CPPCC and the State Council, as indicated by the blue arrows.

At the sub-national and local levels, there are sub-national party organizations, the lower levels of governments and the line ministries. The red box highlights the dual track system in China's political structure. The black box highlights the major players in the sub-national government. The solid line refers to direct leadership to the one level above.

3.3.1.2 The Plans

The government formulates comprehensive plans of different nature that cover policies, targets and detailed projects. The major units involved in the preparation and approval of the plans are the National Peoples Congress, the State Council, and sectoral ministries, including the Ministry of Finance and People's Bank of China (these units are highlighted in the green boxes in Figure 3.3). There are long term plans, for example, the blueprint for certain sectors by sectoral ministries; the Five Year Development Plans (FYPs) and the more detailed annual investment plans (AIPs). Their roles and coverages are discussed as follows.

First is the Five Year Development Plan (FYP). Starting from the year 1953, China has been formulating five year plans to guide the direction of the economy. The aim of the

Figure 3.3: Structure of the government
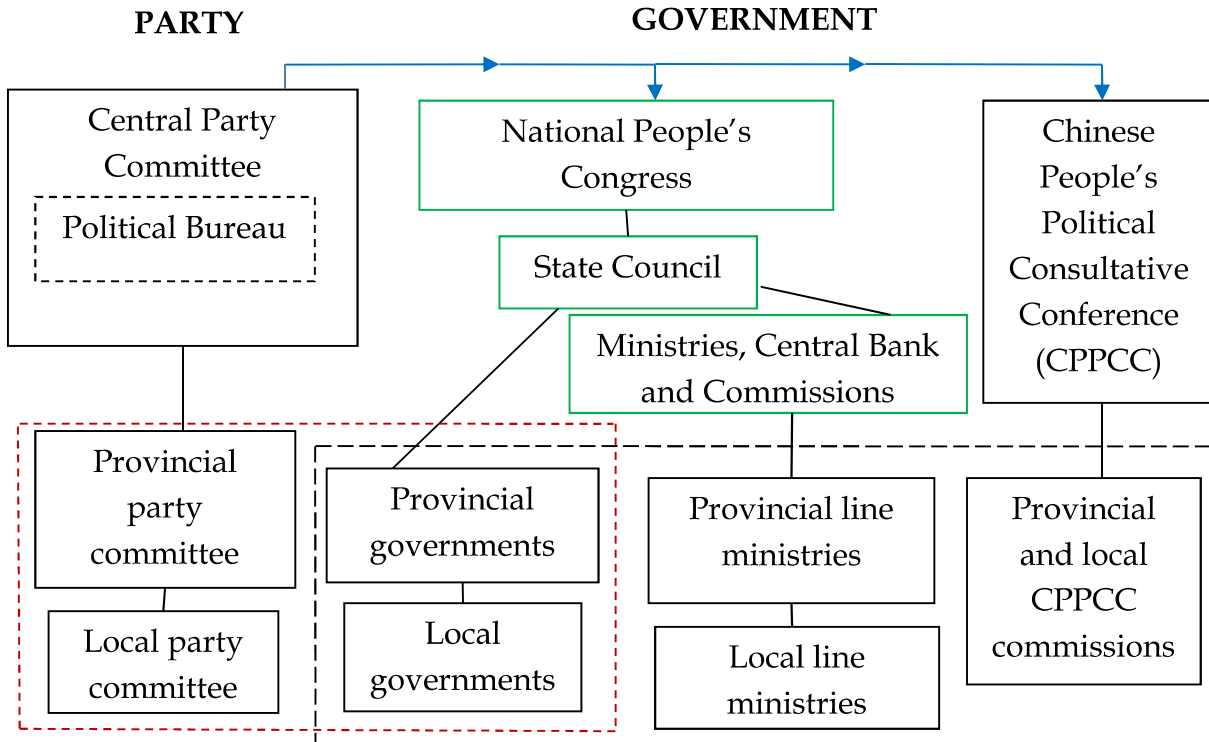
FYP is to align the medium term investment activities with the priorities of the economy to achieve the blueprint described in the Plan. The FYPs have been undergoing remarkable changes ever since the economic reform and opening up in the late 1970s. Rather than setting out mandatory targets that are unrealistic to achieve (World Bank, 1992), the Plan has gradually become more focused on setting the national strategic directions and policy goals. To reflect the nature of a development concept, starting from the 11th FYP, it has been referred to as the "program" rather than the "plan".

The FYPs usually include: 1) Macroeconomic framework. It aims to set out the general framework of national policies and directions that the economy is heading for. This includes development strategies and sectoral priorities. In particular, it sets industrial policies to achieve sectoral and national economic goals. 2) The instruments of the plan. These are a set of explicit targets to achieve the development goals. 3) The role of the state. The

FYP recognizes the market based incentives and focuses on correcting market failures and alleviating key bottlenecks in the public sector. This includes provision of public infrastructure to improve investment climate in the coastal area and to stimulate economic growth in the lagging inland regions. The FYP also reflects the governments intention to address inefficiency in the state-owned enterprises by introducing structural reforms.

A typical process of the formulation of the FYP usually takes more than two years, including research, drafting, review and approval before it is finally put to implementation. In the past, the government agency responsible for formulating the Plan was the Strategic Planning Department of National Development and Reform Commission (NDRC) in the State Council. The research phase of the process starts in general more than a year back. For example, if the 12th Five Year Plan is to be approved for the period from 2011 to 2015, the research process starts as early as late 2008. After the research process takes place for about a year, the NDRC announces the drafting will start in the fall of 2009. Then in the early 2010, the draft plan is to be approved first by the State Council, and then by the 11th National People's Congress in March of 2010. Afterwards more detailed drafting will proceed and by mid autumn in 2010, a mature draft will be presented to the Central Party Committee for review and approval. This reviewed draft approved by the central party leadership will be submitted for final approval at the NPC in March of 2011.

To reflect the perspectives of a larger range of shareholders instead of that of the few top policymakers, the planning process has incorporated more open conversation and monitoring in recent years. This includes consulting from experts, holding public consultation, inviting multilateral organizations (e.g. the World Bank) for a mid-cycle review process and performance evaluations of officials responsible for implementing the Plan.

There are five year plans prepared at the sub-national and local levels of government. The process is similar, albeit at a lower level of the government. Usually the five year plans wont be approved until after the national FYP is approved at the center.

Second is the annual investment plan (AIP). The annual national investment plan is

designed to reflect the objectives and priorities set in the FYP. The NDRC takes the responsibility of preparing the annual plan, and it closely works with the Ministry of Finance and the People's Bank of China and other relevant organizations. The plan covers a consolidated list of separate investment plans of the central government and the provinces. At the sub-national level, the provincial investment plans include the plans of the municipalities, which in turn include investment by the counties. There are certain thresholds on the size of the projects at each level of the NDRC (see a discussion on the investment reforms). The annual investment plan also includes expenditure and financing details of each project. All the projects are approved by the NDRC at different levels according to their category, size and importance. Within the projects, some are considered top priority and given "key project" status.

Aside from the FYPs, different national ministries and regional groups prepare plans that cover even longer time horizons. Examples are a master plan for urban development in the municipalities, the National Medium to Long Term Plan for Science and Technology Development (2006-2020), and the Plan for the Reform and Development of the Pearl River Delta (2008-2020).

3.3.1.3   The Budget

The budget reflects the financing priorities of the government. The Ministry of Finance (MOF) prepares the budget under the general guidance of the State Council. The budget proposals are prepared by each national ministry and also each level of the government. The MOF consolidates the proposals and submits to the State Council. The State Council then submits the budget proposal to the National People's Congress for final approval. The provincial and local governments prepare their own budgets. Usually the lower level government cannot approve their budget until the central government budget has been approved.

Ever since the reform and opening up, China's budget has been undergoing a number of changes. First is the decentralization of budget responsibilities toward lower levels of

government consistent with the fiscal decentralization process. The national budget has refrained from being an all-encompassing instrument for investment allocation. Instead, the devolution of fiscal responsibilities has created investment incentives at lower levels of government that are thought to be more responsive to the local need. Second, the scope of the budget has been significantly reduced reflecting the changing role of the state. The share of budgetary support for investment in fixed assets has declined from 9% in 1990 to only 5% in 2010 (Table 3.2). Nevertheless, the budget remains important as a macroeconomic policy tool, a resource mobilizer to achieve social objectives and a tool for accountability for the each level of the government (World Bank, 1993). Different from the FYPs, China does not have a medium term fiscal plan. The budget in China typically covers one year, which is shown in later discussions as problematic for managing resources.

3.3.2 Related reforms

3.3.2.1 Investment reforms

The investment system reform has been taking place as part of the economic reform and opening up of the Chinese economy. A number of key reforms in the investment system have supported the process of the gradual devolution of decision making and a delineation of enterprises from government functions. The main objectives of these reforms are described as follows.

First is to improve accountability. Before the reform and opening up, the government, in particular, the central government is directly involved in the identification, financing, implementation of investment projects. During the late 1970s and the early 1980s, in order to tackle inefficiency in the investment system, the government introduced a number of measures to improve accountability in the investment preparation, implementation and management. First, by the end of 1984, all state investment projects were to be financed on a repayable basis, thus ending the practice of financing all investment by grants that

bear no interest. Second is introducing enterprise reforms in the project preparation and implementation stages. This included establishing the China International Engineering Consulting Corporation in the year 1985 to specialize in feasibility studies and evaluations of medium to large projects, introducing contractual responsibility agreements between construction firms and the government and establishing six investment corporations to handle investment funds in the year 1988. By the year 1994, these investment corporations were replaced by the establishment of the State Development and Investment Corporation that specialized in industrial investment, financial services and state-owned assets operation. In the meantime, a number of national financial institutions were established to perform the role of extending policy loans to the government projects. These institutions are the China Development Bank, Agricultural Development Bank of China and the Import and Export Bank of China as national financial institutions responsible for policy loans.

Second is to streamline investment approval and improve management. The government gradually takes measures to reduce its role in investment decision making and in streamlining the approval process. In the year 1988, the government created the National Economic and Planning Commission combining the State Planning Commission and the State Economic and Trade Commission to manage capital construction and technical transformation projects. This Commission was renamed as National Development and Reform Commission in the 2003. Aside from delineating the provision of public investment from public ownership, the central government relaxed the investment threshold below which the sub-national governments are responsible for. Until recently, all projects under RMB 50 million can be approved by the provincial government. The threshold at the local level has also been relaxed accordingly. Moreover, the investment approval was streamlined in 1984. Until the early 1990s, only initial project proposal, the feasibility study and blueprint estimates are needed for approval.

To better manage public investment, investment has been classified into social, "basic industry and infrastructure", and competitive projects. Each type of project is linked with

respective government responsibilities, source of funding and approval process. For example, the competitive projects are mainly constructed by enterprises instead of the government units and do not need government approval. However, these projects do need to be recorded or verified by the government to get investment information for better macroeconomic management.

The third objective is to mobilize resources to finance investment. As part of the effort to delineate the public ownership from provision and financing of public services, the investment reforms introduced alternative financing sources. First, the government allowed foreign direct investment and started issuing national debt in the early 1980s. In the year 1983, the government created special investment funds to ensure funding for prioritized sectors such as the energy sector. In 1984, the government created the People's Bank of China as the central bank and identified a number of commercial banks to handle policy lending guided by the central bank. This practice was later abandoned as it created inefficiency in the financing system. In the year 1994, a number of policy institutions were established and policy lending was separated from commercial lending in the institutional arrangement. In the meantime, the government started to collect fixed assets investment adjustment taxes in 1991 to guide investment to prioritized areas and to create new sources of revenue.

These efforts have reflected the government's intention to introduce more market based principles to improve accountability and to reduce the role of the government in overall decision making, planning and approval process. At the same time, these efforts are balanced by maintaining macroeconomic management and providing guidance in industrial policies through policy lending, while allowing the market to play a bigger role in other areas.

The 2004 investment reform has marked another major change in investment system. Despite the long contemplation of investment reforms in the area of decision making, a comprehensive investment reform didn't come out until in the year 2004, when the State Council announced the Decision on Reform of the Investment System. Based on the efforts made by previous reforms, this Decision has made a few steps further in the same line of

principles. In the area of accountability, the Decision clarifies that the enterprises rather than the government play a major role in investment decision making. It further reduces the scope of approval from the government. For projects funded by private sources, no government approval is needed. Instead, the projects will either be recorded or verified for macroeconomic management purposes. Aside from this, macroeconomic management will utilize the role of the plans, financing mechanisms and public information instead of direct intervention. For important projects funded by the government, there are measures to introduce more transparency in the evaluation and approval process. These include expert consultation, public hearing and evaluation by professional firms. To further mobilize resources, private financing is allowed for projects that are have a more competitive nature and thus more profitable. It also emphasizes more comprehensive monitoring system and legal system at every stage of the investment planning, approval, and assessment after completion.

The results of these investment reforms do create more incentives at lower levels of the government and has introduced private and quasi-public entities into infrastructure investment. Together with the enterprise reform, the investment level in the infrastructure sector greatly has increased and the quality of work improved.

3.3.2.2   Fiscal decentralization

Along with the investment reforms aiming to decentralize decision making power and improve accountability is the decentralization in the fiscal system. The major purpose of the fiscal reform is to improve the incentive and efficiency of public services provision at the sub-national and local levels, and to balance between improving accountability at the lower levels of governments and maintaining macroeconomic control at the center.

Before the fiscal reform in the 1980s, the sub-national and local governments collected and submitted all taxes and profits to the center, which then allocated the revenues to provinces according to expenditure needs approved by the center. Because of the heavy-handedness of the central government in collecting and allocating revenues, the system lacks incentives

at the lower levels of governments and cannot accurately reflect local public service needs given information asymmetry between the center and the sub-national regions.

In the 1980s, the government carried out a number of fiscal reforms to improve the intergovernmental relations between the center and the lower levels of governments. The sub-national governments were allowed to retain part of the collected tax revenue. The result did encourage the tax collection efforts at lower levels of governments, but it also significantly reduced the total amount of revenues the central government receives. Not only the total central revenue shinked, the share of central revenue in total revenue declined from 44% in 1978 to 23% in 1993, whereas that of the sub-national government increased to 77% in 1993. Facing the dwindling revenue, the central government was not able to cover its expenditure responsibilities and imposed inflationary pressure to the economy throughout the 1980s. Moreover, the efforts by the central government to renegotiate the contract terms with the sub-national governments encouraged them to move the budget revenue to the extra-budgetary accounts, which were not subject to revenue sharing. By the year 1993, four types of revenue sharing were carried out and six different contract types were used between the central and sub-national governments (Jin and Zou, 2003).

In response to the problems in the fiscal contract system in the 1980s, the 1994 tax sharing reform aimed to redefine the intergovernmental fiscal relations between the center and the sub-national governments. The detailed objectives were: 1) improving tax structure; 2) raising total revenue by increasing the revenue to GDP ratio; 3) raising the centrallocal revenue ratio; 4) designing a more transparent revenue sharing system with the lower levels of governments. The Reform specified the sharing terms between central and local government according to specific types of taxes. For example, the central government retained all tariff duties and 75% of the value added taxes, and the local government retained sales taxes and 25% of the value added tax.

The reform has significantly increased the revenue base of the central government, but has not improve the expenditure assignment between the central and sub-national governments.

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On one hand, the increasing revenues at the center allows the central government to enhance its capacity for fiscal transfer to bridge regional disparity, and to enhance the capacity for macroeconomic management. On the other, the lower levels of governments face enormous pressure to meet their expenditure obligations. The issue of proliferation of extra-budgetary accounts exacerbated. This unbalanced revenue and expenditure assignment has become one of the root causes to explain the sub-national government's behavior for more productive public investment, for leveraging the public owned land and for increasing reliance on the extra-budgetary revenues and expenditures.

In a nutshell, the political structure, investment system and fiscal regime have created a system of "unified leadership and decentralized management" or more explicitly called "fiscal decentralization with political centralization" (Blanchard and Shleifer, 2001). Despite the advantage in aligning the investment activities with the national strategic plans and policies, the centralized political system has given the government officials at various levels of the government strong influence in decision-making. The decentralized investment and fiscal system have encouraged public service provision to be more responsive and efficient, but also created undesirable reactions at lower levels of governments.

3.3.3 Infrastructure Planning, Preparation and Approval

Given the important elements of decision making, this section describes how the major players interact with each other for the planning, preparation and approval of infrastructure investments. With emphasis on the decision making process, the chapter acknowledges that the fundamental reasons for the existence of "white elephant" projects, "fishing projects" and the kind rest with the decision making process. Therefore, this section aims to uncover issues in this process that have shaped the patterns of infrastructure investment in China: 1) why public investment dominates; 2) why governments favor infrastructure investment over social sectors; and 3) what are the issues in the decision making process that result in inefficiency in infrastructure projects, such as the "fishing projects".

3.3.3.1 National level

The government units that closely work together for the infrastructure decision making process are the National Development and Reform Commission (NDRC), the Ministry of Finance (MOF), the People's Bank of China (PBC) and respective sectoral ministries. The NDRC plays a leading role in the formulation of the national economic development strategies, the national economic plans including the Five Year Plans and the annual investment plans, and also coordinates the implementation of investment projects. The MOF and PBC, on the other hand, are responsible for the budgeting and financing side of the investments.

In principle, the planning process involves both a top-down and a bottom-up process. As described in the preparation of Five Year Plans, comprehensive background research work is performed by the national agencies involved in planning. The planning capacity of the system has been improving while China is accumulating knowledge and experience throughout the reform period. Nevertheless, the de facto planning process remains a bargaining game. Not only are there debates and compromises among the NDRC, MOF and PBC, there are also frequent interactions among the planning agencies and the sectoral ministries and provincial level governments.

There are a number of issues associated with the current planning process. First, the targets of the Five Year Development Plan are becoming less responsive due to rapid changes in the economic conditions. Despite the development priorities set in the national strategic plan, the actual projects funded by the budget reflect what projects are given the de facto priorities. As a result, the budgeting process has becoming less related with the actual planning process. Second, the role of the budget in managing and prioritizing infrastructure investment has been declining. The budgeting is prepared based on last years expenditures. Since the reform and opening up, budgetary support for infrastructure projects have significantly reduced. Those that hold large funding resources become the de facto decision maker. What projects are funded is a bargaining game among various government units and between the central and lower levels of governments.

The preparation of projects belongs to the government agencies that sponsor the projects. As the government gradually introduces more market forces into the investment system, the preparation of many projects in sectors such as power, water and sanitation are performed by the sponsoring firms. A complete preparation process usually includes project concept proposal, pre-feasibility study, feasibility study, detailed engineering design, appraisal and final approval. Each step requires some form of reviews and approval. The level of approval depends on the size of the project. In the past, the NDRC approves all projects that are funded by the budgets and projects that are funded by non-state sources. Afterwards various investment reforms have gradually relaxed the threshold of the size of projects to be approved by the lower levels of the planning commissions. Now projects that are not funded by governmental sources do not subject to government approval, but will in different cases be recorded. Given the complaints about lengthy approval process, the investment system reforms have streamlined the process and reduced the steps only to include the approval of the initial project proposal, the feasibility study and the blueprint and budget estimate.

3.3.3.2 Provincial and municipal levels

The planning, preparation and approval process of infrastructure in principle is similar to the process at the national level, except that they are performed by respective provincial and municipal government agencies.

However, a number of issues have made the de facto decision making process more complicated. First, the fragmented budgeting power has made the actual decision making process a bargaining game again. Despite the instrumental role of the Development and Reform Department (DRD, NDRC at the sub-national level), the government units that have more financing resources have more influence over which projects will be selected. In particular, during the late 1990s, more resources are consolidated to the Department of Finance (DOF, MOF at the sub-national level), in particular for provinces with better fiscal capacity. The DOF sometimes decides to fund a project even before it is approved by the DRD. Or there

is the other way round. The DRD approves a project while the DOF refuses to fund the project. Often times those that are more interested to implement the projects are the line ministries.

Second, the political structure has made the leadership in the provincial and municipal governments influential in deciding which projects to investment. If leaders of these sectoral ministries contact the provincial governor or party leader or majors and if they approve, the DRD usually will select the project and DOF will provide funding. If they refuse, then the project usually cannot be selected. As a result, there is a tendency to misalign short run political gain away from the long run economic development objectives.

Third, the fragmented authorities have made investment management difficult. Each government units that have certain amount of funding and can have some influence over which projects to fund. There is no government entity that consolidates investment projects together and evaluates their aggregated pros and cons. Although the DRD may have the capacity to perform this role, the dwindling budgetary resource has made its role of project approval declining over time, in particular in some provinces (Wu, 2011).

Fourth, the fiscal decentralization reforms have created a mismatch between expenditure and revenue assignment as discussed in the fiscal decentralization reform section. The sub-national and local governments have to find "innovative" way of financing the expenditure responsibilities because they cannot borrow directly. The examples of "innovative" ways are: 1) creation of urban investment corporations as arms for the sub-national and local government for commercial loans; 2) creation of urban commercial banks that give preferential loans to urban development projects; 3) moving to extra-budgetary accounts that need not be shared with the center, in particular for many municipal governments; 4) utilizing land acquisition revenues as an important source of extra-budgetary revenue. Land in China is publicly owned and managed by the municipal government. Rural lands are owned by the collective units. Although transaction of ownership is not allowed by the Land Management Law, land use rights can be transacted. The municipal governments are able to retain large

amount of extra-budgetary revenues from the large gap between acquisition prices and sales prices. In other cases, land can also be used as collateral for large amount of commercial loans.

The innovations in financing expenditure responsibilities have indeed expanded the revenue sources at sub-national and local governments, but have also created a number of unintended consequences. First is the soft-budget constraint problem at sub-national and local governments. Although soft-budget constraints exist in many countries, the indirect borrowing and the proliferation of extra-budgetary accounts that are hard to monitor have made it difficult to measure the implicit debts carried by the lower levels of government. Second, land acquisition is unsustainable both as a source of financing and as a natural resource. Many cities have faced shortage of urban land and the fertile land for farming is under the threat of illegal utilization. Although there are laws concerning the usage of land, the laws are often ad hoc after large sunk costs have already occurred.

3.4 Financing Infrastructure

3.4.1 Patterns of Infrastructure Financing

This section discusses the financing patterns of infrastructure against the institutional background in the previous section. As data for the financing structure of infrastructure investment is not available, this section uses the data for investment in fixed assets instead[5]. The exact financing patterns may be different as infrastructure investment is only a portion of the total fixed assets investment[6].

Table 3.2 presents the historical change in the share of different sources of financing for

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[5]For the definition of investment in fixed assets, please refer to National Bureau of Statistics of China (2012).

[6]In the section on stylized facts of infratructure investment, it shows that infrastructure subsectors accounted for about 15% of GDP by the year 2010. Compared with the total fixed assets investment financing of 77% of GDP in 2010, infrastructure investment may be around one fifth of the fixed assets investment.

investment in fixed assets. Overall, the scale of investment dramatically increases over the past twenty years, reflecting the investment oriented growth pattern in China. The total amount of financing for fixed assets investment grows from 24% of GDP in 1990 to 77% of GDP in 2010. There are five major ways of financing such large scale of investment. Among them, self-raised funds refer to extra-budgetary funds for investment in fixed assets from central government ministries, sub-national governments, enterprises and self-raised funds from public service units. "Others" refer to funds for investment in fixed assets from sources such as capital raised through bond issuance by enterprises and financial institutions, from individuals and through donations, as well as funds transferred from other units.

Table 3.2: Sources of financing for fixed assets investment

	1990		1995		2000		2005		2010
State	393	(9)	621	(3)	2110	(7)	4154	(5)	14678 (5)
Domestic loans	886	(20)	4199	(21)	6727	(20)	16319	(17)	47258 (15)
Foreign investment	285	(6)	2296	(11)	1696	(5)	3979	(4)	4987 (2)
Self-retained funds	2954	(65)	10648	(52)	16317	(49)	55106	(58)	197099(63)
Others			2761	(13)	6260	(19)	15033	(16)	46943 (15)
Total	4518		20525		33110		94591		310964

Unit: 100 million RMB. Percentage shares are in brackets.
Source: China Statistical Yearbooks, various issues.

Since the 1980s, the role of the state has been declining as the government in China gradually withdrew from controlling every aspect of the economy. By the end of 2000s, the share of state funded investment only accounted for less than 5%, from about 9% in 1990. Together with this trend is the increasing reliance on self-retained funds. By the year 2010, it accounted for 63% of total financing. It reflects the increasing importance of extra-budgetary funds from various levels of government and public service units in financing investments such as infrastructure. Bank lending ranks as the second largest source of financing, although its relative share has been gradually declining. Meanwhile, the role of "Other" source of financing gradually catches up with the traditional bank lending channel. It suggests that there are increasing cases of financing from capital raised through bond issuance by corporate

and financial institutions as China's capital markets become more diversified.

Regional allocation of financing fixed assets investment can be found in Table 3.3. The role of state funding as a regional policy tool can also be found in the regional distribution of state funding. The Eastern region receives the highest share of state budget financing throughout most of the past decade until the end of the 2000s. By the year 2010, the lagging Central and Western regions received more state budget funding than the more advanced regions. The role of self-retained funds has been increasingly more important in the Eastern region, as the region strives to fund increasing demand for fixed assets investment. In the meantime, the "Other" source of financing is explored and new forms of financing plays a major role in the Eastern region. The other regions gradually pick up in terms of financing through self-retained funds and other forms of financing, as seen from the dramatic increase in these two types of financing channels from the year 2005 to 2010. Meanwhile, bank lending has been gradually concentrated to the Eastern region until the late 2000s. Similar pattern can be found for foreign investment in fixed asset investment.

Comparing the financing structure of each region yields new findings (Table 3.4). Despite large amount of state budget going to the Eastern region, the share of budget is a relatively low in its financing structure, reflecting the availability of alternative financing channels for the Eastern region. On the other hand, the relatively scant alternative financing sources in the lagging regions suggest that the budget plays a larger role in their fixed asset investment activities. Self retained funds are still the dominant source of financing across regions, with the shares in Central and Western regions slightly lower than the more advanced regions. Domestic loans accounts for the second largest share among all five major sources of financing for all regions.

Over time, the role of state capital has been declining in all four regions, with its role relatively larger in the Central and Western regions by the year 2010. The share of bank lending reduces in all regions, with the Central and Western regions declining from a relatively higher share of over 25%. The foreign investment share also drops significantly. The

Table 3.3: Regional allocation of financing fixed asset investment by source

	Total	Budget	Domestic loans	Foreign investment	Self-retained funds	Others
1995						
Eastern	39	30	31	44	41	40
Central	23	32	28	20	22	20
Western	12	17	15	7	11	13
NE	26	20	26	29	25	28
2000						
Eastern	52	38	50	68	55	38
Central	18	26	20	10	16	24
Western	11	17	12	5	10	14
NE	19	19	18	16	20	24
2005						
Eastern	78	41	72	84	81	84
Central	8	24	11	5	7	6
Western	5	16	7	3	4	4
NE	9	18	10	8	8	6
2010						
Eastern	32	17	38	52	30	42
Central	27	32	23	16	28	23
Western	14	28	17	5	12	16
NE	27	23	22	27	30	18

Numbers are in percentage. Vertical aggregation by region in each year adds up to 100%.
Source: Complied by author from China Statistical Yearbooks, various issues.

main reason comes from the rapid increase of the share of self-retained funds and the other source of financing, in particular for the Central and Northeastern regions.

Despite these facts, the infrastructure investment only accounts for a portion of the fixed assets investment. The limitation of data availability prevents further break down of financing sources for infrastructure sectors. To fill the gap, individual sources of financing data are explored, by the funding breakdown of the budget and extra-budgetary fund; bank lending and bond issuance to get a rough idea of the amount of financing to infrastructure investment.

First, the allocation of budgetary financing are presented in Table 3.5[7]. There is a

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[7]Before the year 2007, China's public finance and expenditure account does not have cat-

Table 3.4: Regional financing structure for fixed assets investment

Region	Year	Budget	Domestic loans	Foreign investment	Self-retained funds	Others
Eastern	1995	3.6	18.3	15.6	53.2	9.3
	2000	5.9	23.3	8.6	55.5	6.8
	2005	2	17.3	6	56.8	17.9
	2010	2.2	15.8	2.5	61.7	17.8
Central	1995	6.4	27.2	11.7	47	7.7
	2000	11.3	26.7	3.7	46	12.3
	2005	5	16.3	2.7	63.4	12.6
	2010	5.2	11.7	0.9	70.3	11.9
Western	1995	6.8	29.2	7.9	46.5	9.6
	2000	12.1	27	3.2	45.5	12.2
	2005	7.6	19.3	1.5	56.2	15.5
	2010	8.8	16.3	0.6	58.9	15.4
Northeastern	1995	3.7	22.7	15.1	48.8	9.6
	2000	7.9	22.2	5.5	53	11.4
	2005	4.7	11.8	2.3	67.4	13.7
	2010	3.8	11.2	1.6	74.2	9.2

Unit: percentage shares

considerable amount of budget financing for infrastructure projects. Before the year 2007, the share of capital construction to GDP is on average about 2% from 1990 to 2006, with the share in the 2000s around 2.3% on average. On the other hand, the total expenditure for education, science and health is about 2.9% of GDP, with the average share in the 2000s 3.2%.

Capital construction has a relatively higher budgetary share in the Western region, with its size to GDP about 2% compared with 1% in all other regions. Aggregated budgetary spending on infrastructure sectors, such as transportation, mining, power and information, urban and rural community affairs, is about 2.7% of GDP in the Eastern and the Central

egorical spending based on sector, rather it has a "Capital construction" account that encompasses all large scale investment in different sectors. From the year 2007, the accounting approach has changed and the expenditure has been expressed by sectors instead of functions. Part of the power and telecommunications infrastructure investment is listed under the "Mining, power and information". The urban infrastructure investment is listed under the "Urban and rural community affairs" (simplified as "Community affairs" in Table 3.5).

regions, 3.8% of GDP in the Western and 3.5% of GDP in the Northeastern region. Even though the education and health sectors have been receiving increasing budgetary support over the last few years, the increase in infrastructure sectors has been surpassing the social sectors, except for the Western region. This pattern of financing reflects the geographic preference toward the Western region and a sectoral preference for the infrastructure sectors.

Table 3.5: Local budgetary financing across region (% of GDP)

Region	Year	Capital constr.	Transport-ation	Mining, power & info.	Commu. affairs	Edu.	Health
Eastern	1995	0.7				1.9	
	2000	1				1.5	0.5
	2005	1.1				1.6	0.4
	2007		0.2		1.2	2.2	0.6
	2010		0.7	0.6	1.4	2	0.8
Central	1995	0.4				2.2	
	2000	1				1.7	0.4
	2005	1				2	0.5
	2007		0.4		0.9	2.6	0.8
	2010		0.9	0.7	1.1	2.8	1.3
Western	1995	0.9				3	
	2000	2				2.2	0.7
	2005	2.4				2.6	0.8
	2007		1		1.3	3.4	1.1
	2010		1.4	0.8	1.6	4	1.7
NE	1995	0.7				2.2	
	2000	1				1.5	0.4
	2005	1.4				1.7	0.4
	2007		0.4		1.2	2.5	0.7
	2010		1	0.9	1.6	2.5	1.1

Source: Complied by author from China Statistical Yearbooks, various issues.

Second, the patterns of extra-budgetary fund financing are presented in Table 3.6. As noted before, the extra-budgetary financing is the main component of the self-retained fund, which presents the majority of financing for fixed assets investment. Table 3.6 presents the categorical structure of the extra-budgetary expenditure[8]. The total size of this account

[8]The accounting approach has undergone a number of changes. The 1996 number cannot be

is about 2%-3% GDP on average. Aside from the "Capital construction" expenditure that is mostly infrastructure spending, there are funds coming from the "Township government self-raised and coordinated expenditure" and large infrastructure projects that are financed by the "Special expenditure", such as the earmarked fund (see a discussion in Ma and Zhou, 2008). Under the new categories adopted in the year 2007, the amount of extra-budgetary fund that goes to transportation can now be directly measured. It is the second largest expenditure after education[9].

Third, transfer from the central government constitutes another important portion to fill the state budget gaps in financing infrastructure investment. The fiscal transfer system was created after the 1994 tax sharing reform that aims to recentralize the revenue capacity of the central government. The resources collected through tax sharing allow the central government to correct for some of the unbalances in the local expenditure responsibility and revenue capacity from the tax sharing arrangement and to achieve growth and equality objectives.

There are in general three types of transfers in China, namely, the general purpose transfer, such as an unconditional grant; the specific purpose transfer, which specifies the particular use of the grant, sometimes with matching grants required, and a tax rebate system, which returns a portion of the collected taxes (value-added taxes and consumption taxes and corporate and individual income taxes after the year 2002) from the tax sharing arrangement to the original provinces. The effects of these three types of transfers differ. Tax rebates are allocated based on a predetermined rule (see Lin, 2011 for the details of the rule). More advanced regions tend to receive more tax rebates than the poor regions. While tax rebates reward faster growth, the other two types of transfers are aimed to reduce

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compared with the previous numbers because of the coverage of extra-budgetary account changes. From 1997, extra-budgetary account expenditure does not include government funds that are included in the budget. From 2004, extra-budgetary expenditure is recorded as extra-budgetary special account expenditure. From the year 2007, new expenditure categories are introduced to replace the previous ones.

[9]After fiscal decentralization reforms in China, most of the expenditure responsibilities for education rest with lower levels of the government, such as local or township governments.

Table 3.6: Extra-budgetary expenditure by category (% of GDP)

Year	Total	Capital constr.	Special exp.	Township level gov. self-raised and coordi. exp.	Operating and admin. exp.	Urban mainte. exp.	Other
1996	5.4	2.1	0.4	0.2	1.8		0.9
1997	3.4	0.6	0.4	0.4	1.6		0.4
1998	3.5	0.5	0.5	0.4	1.9		0.2
1999	3.5	0.6		0.4	2	0.1	0.3
2000	3.6	0.4		0.4	2.2	0.1	0.3
2001	3.5	0.3		0.4	2.3	0.1	0.4
2002	3.2	0.2		0.2	2.2	0.1	0.4
2003	3.1	0.2		0.2	2.1	0.1	0.4
2004	2.7	0.2		0.1	2	0.1	0.3
2005	2.8	0.2		0.1	2.1		0.5
2006	2.7	0.2		0.1	1.9		0.5

Year	Total	Transp-ortation	Edu.	Social security and employment	General public services	Commu. affairs	Other
2007	2.3	0.4	0.8	0.1	0.2	0.3	0.5
2008	2	0.3	0.7	0.1	0.2	0.3	0.4
2009	1.8	0.3	0.7	0.1	0.2	0.2	0.4

Source: Complied by author from China Statistical Yearbooks, various issues.

regional gaps by equalizing levels of public services (e.g. Zhang and Zheng, 2011)

The structure of transfers changes significantly over the last twenty years, reflecting the changing objectives of the central government. Tax rebates account for over 50% before the year 2000, second by general purpose transfers and specific purpose transfers (Tian, 2010; Zhan, 2011). This transfer structure, as many scholars argue, has exacerbated the regional gaps and has rendered the effects of total transfer pro-rich (Zhang and Zhen, 2011). After the year 2000 that marked the start of the Western Development Plan, the central government gradually shifted toward more transfers for equalization purposes, in particular for the lagging regions, either through general purpose transfer or through specific transfers in transport, education and health services. As a result, the share of tax rebates declines rapidly. By the year 2011, it only accounted for 12% (MOF, 2013), while the specific purpose

transfer accounts for 42% and general purpose transfers 46%. The transfer structures across regions also differ significantly, with more tax rebates to the advanced Eastern provinces and more specific and general purpose transfers to the Central and Western provinces (Zhang, 2012).

Fiscal transfer has become increasingly important as part of the local government fiscal revenue. According to Lin (2011), about 40% of the government expenditures are financed by central government transfers in recent years. The total fiscal transfer totals about USD 618 billion in 2011, with about half general purpose transfers. As the central transfer gradually shifted toward equalization, the support for the lagging regions has increased. By the year 2011, Sichuan province in the Western region and Henan, Hunan and Hubei in the Central region have received the highest total transfers from the central government averaging USD 35.6 billion each province (CEIC data). As most local governments spend according to how much they collect, these transfers become essential in supporting infrastructure investment. For example, the central government has provided transfers with productive nature to support the development of the transport, energy and automobile sectors (Zhang, 2012).

Fourth, bank credit presents another major portion of fixed assets financing. As described in the investment reforms, a number of financial institutions have been established to perform the policy lending role, which give priorities to key infrastructure projects. For commercial lending, beside the four major commercial banks in China, there are also urban commercial banks that are partly owned by the lower levels of governments. Although in China, lower levels of governments cannot borrow, they have created borrowing arms such as the urban investment corporations(UICs). Although the exact amount of bank lending to the infrastructure sectors is not available, the lending pattern from the China Development Bank (CDB)[10] can give a good picture of the financing pattern for major infrastructure projects.

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[10]The China Development Bank was created in 1994 by the Policy Bank Law as one of the policy banks responsible for raising funding for large infrastructure projects. It was reorganized as a share-holding company with the Ministry of Finance and the Central Huijing Investment Company as share holders in 2008.

Figure 3.4: Average sectoral share of total outstanding loans by the China Development Bank (2001-2011)
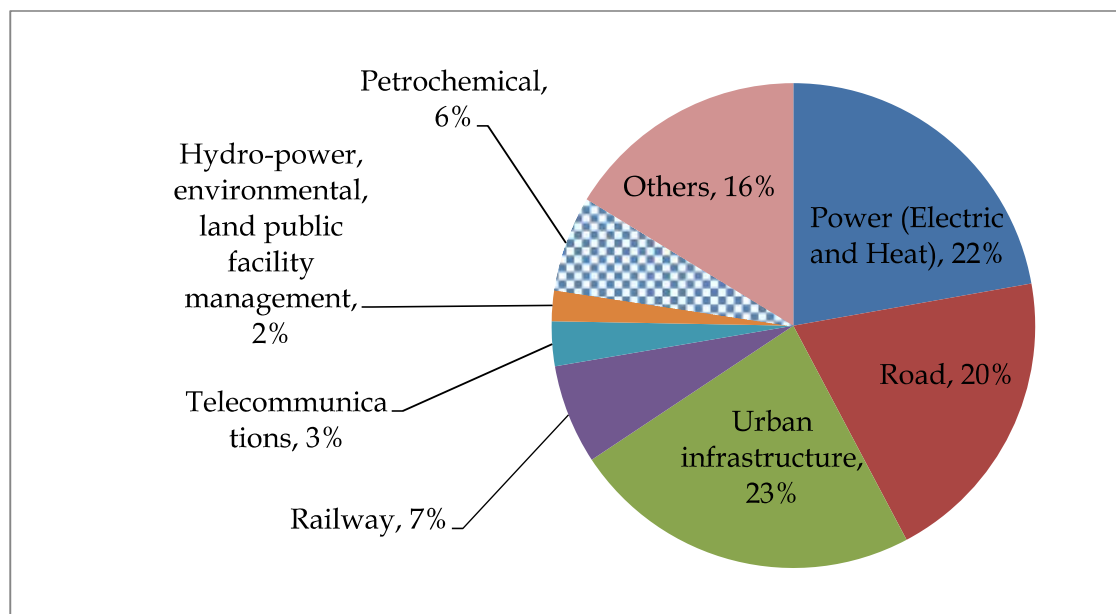
Source: China Development Bank Annual Report, various issues.

Figure 3.4 shows the infrastructure financing from China Development Bank by industrial structure. The CDB undertakes major infrastructure projects financing in China. By the end of 2011, the outstanding loans from China Development bank was USD 885.3 billion (16% of GDP), in which USD 98 billion was in the power sector, USD 149.4 billion in the road sector, USD 54 billion in the railway sector, USD 12.4 billion in the telecommunications sector and USD 200.3 billion in urban infrastructure.

3.4.2 Issues

The financing from budgetary, extra-budgetary and fiscal transfer resources shows that there are a number of channels that are used for infrastructure financing from the state. There are budgetary allocation to capital constructions, allocation from special expenditure, funds from township governments and transfers from the central government. The fragmented nature of

budgetary and extra-budgetary allocation has caused difficulty in monitoring and managing financing sources for infrastructure investment. Different channel of sources are subject to different management and approval process. Often the relevant unit where the funding comes from has a larger say in what kind of projects to be implemented. Ma and Zhou (2008) give a detailed description on the particular budgetary account and managerial approaches. As the amount of central transfer increases, it also causes lots of concerns. Aside from the structure of transfers that may increase regional gaps in public service provision, including infrastructure provision, the allocation process may also induce inefficient provision. Except for the tax rebates that are rule-based, other types of transfers have been allocated mostly by "discretion". Lower levels of governments tend to compete and lobby for the specific and general purpose transfers that amount to several trillions in RMB (Guo, 2012, China Comment, 2013). Specific purpose transfers with matching grants may reduce the "demand" for such transfers. However, matching puts even greater pressure for the lagging regions with already tightening budget under the tax sharing arrangement. In reality, it causes more problems than cures (Zhang, 2012). For example, some provinces may take out the matching fund after the transfer funds are allocated . Despite of these issues, the overall declining role of the budgetary financing has limited the possible inefficiencies in the process.

Although bank loans account for a relatively smaller share of total financing in fixed asset investment, bank lending is important especially for large infrastructure projects. The establishment of urban investment corporations and urban commercial banks also extend the amount of available sources for infrastructure investment. In many cases, the UICs can get easier access to bank loans because of the implicit guarantees from the relevant levels of government or because of the state owned public land as collateral. Urban commercial banks also give priority to finance public infrastructure projects as the de facto owners of these banks are lower levels of governments.

The extended borrowing arms have caused concerns about the implicit debt of the lower levels of governments, for example in the form of contingent liabilities. By the year 2010, the

estimated debt from the central government was USD 997.8 billion and that from the lower levels of governments was USD 1583.1 billion. Meanwhile, the central government budget and extra-budgetary revenue was USD 633.5 billion and that of the lower levels of governments were USD 599.9 billion and including the transfers from the central government and tax returns the total revenue of the lower levels of government was USD 1077.6 billion. Figure 3.5 shows the allocation of sub-national and local government debt by sector. Municipal construction and transportation account for over 60% of the total amount of debt. The financing structure of the large amount of local government debt is shown in Figure 3.6. About 80% of the local government debt is financed by bank loans, with fiscal and bond financing account for only about 10%. The expected debt repayment by the local government is estimated to be USD 11834.9 billion by 2015. The risks carried by these local governments may become clearer if there is additional information on the type and structure of the loans.

In a nutshell, analysis on the financing side of infrastructure investment shows that although the role of the state in providing budgetary support to investment has been declining, the government, in particular the lower levels of governments are actively engaged in the provision of infrastructure, either through extra-budgetary funds or extended borrowing arms. Such large scale investment initiatives have caused real concerns about the indebtedness of the local governments and the macroeconomic effects of financing large scale infrastructure (for example the "reversed transmission of the pressure for easing monetary policy"). Such pressure may be part of the reason for the frequent change of reserve ratios in the banking sector to curb the overheated economy after the year 2008.

3.5 Summary

The chapter documents recent patterns of infrastructure development in China and its sub-national regions. China's scale and speed of infrastructure investment have been comparable to its growth performance over the last two decades. Institutional analysis suggests a number of reasons that enables large infrastructure investment.

Figure 3.5: Sectoral allocation of local government debt (2010)
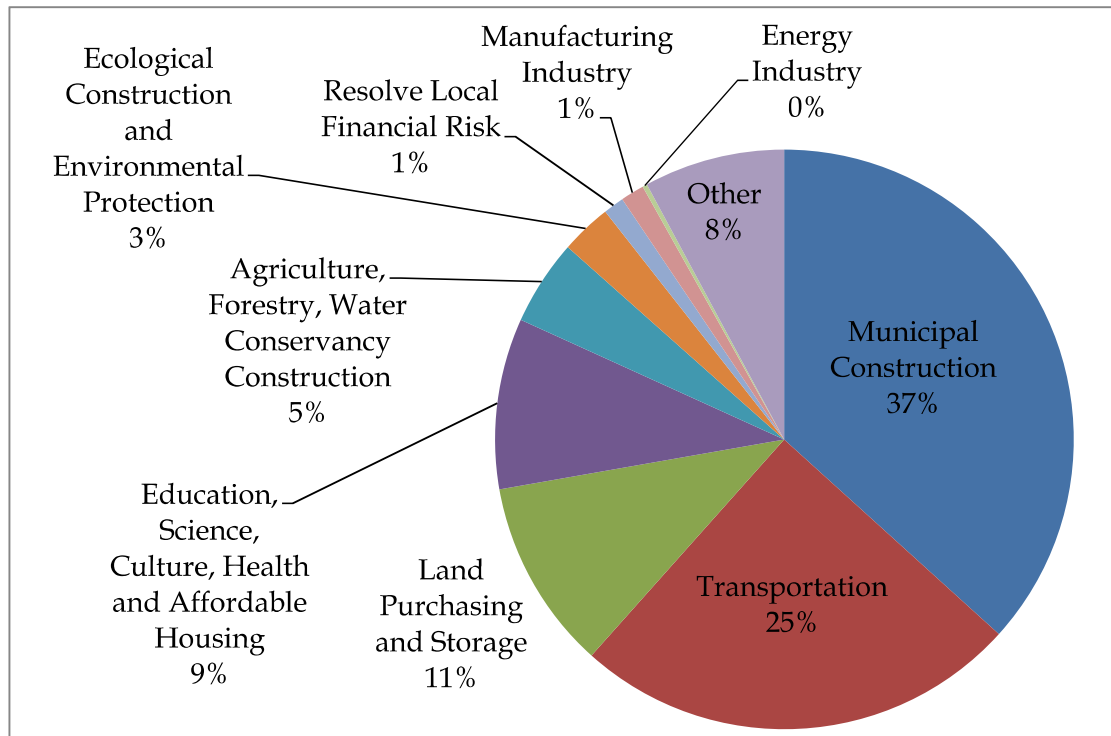
Source: CEIC

First, it argues that the "unified leadership with decentralized management" has placed high demand on the personal influence of the government leaders. The political centralization has ensured that economic development policy goals are clear and stable. The upward accountability and performance ratings connected with GDP growth have put in place strong incentive in particular at the lower levels of government to develop their economy. China in the past thirty years has benefitted from the discretion and wisdom at the central leadership, who have placed paramount emphasis on economic development. Yet risks remain. If the leadership at various stages makes unwise decisions, the consequence will be large and hard to prevent in the first place. There are already a number of such cases in the local infrastructure development (Cai Jing Magazine, 2011). Particularly in the sub-national regions, personal influence sometimes replaces the institutionalized decision making process, making

Figure 3.6: Financing structure of local government debt (2010)
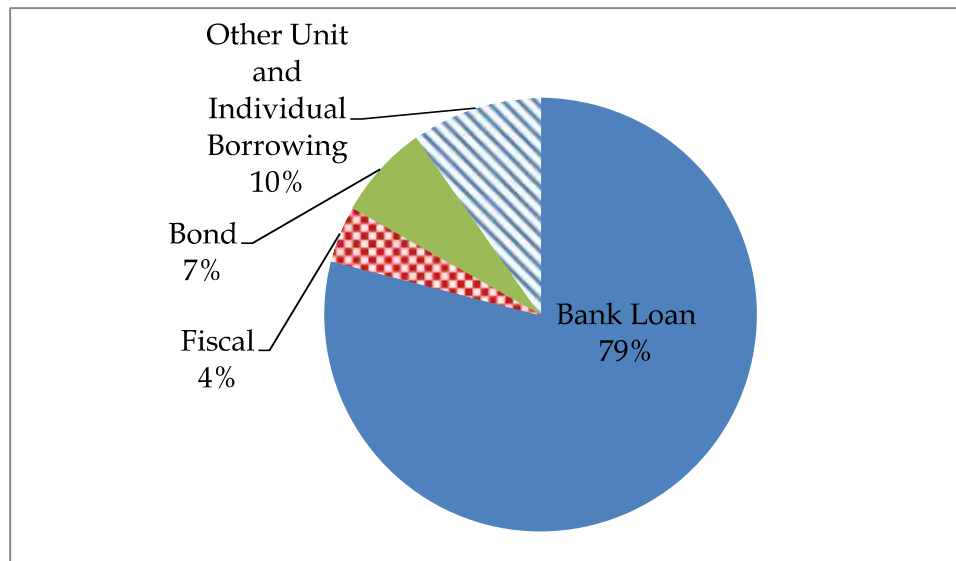
the investment prioritization a bargaining game among different government entities.

Second, the unbalanced fiscal revenue and expenditure assignments at the sub-national level have encouraged lower levels of governments to seek alternative resources. They invest heavily in infrastructure to compete for FDI. They move local fiscal revenue to extra-budget accounts that are not subject to tax sharing. They resort to land financing as part of the extra-budgetary revenue. The interests of disadvantaged land users are often not protected. The land resource limit also poses risks to the sustainability such financing. Despite recent controls aimed at curbing illegal land transaction, the incentives remain because of the fiscal arrangement. The monitoring process renders to ad hoc measures when it already involves large sunk costs.

Third, the soft budget constraint problem poses significant risks to the sovereign in financing large scale infrastructure investment. The government sector has been leveraging extensively through indirect borrowing from the quasi-state investment corporations. The banking sector implicitly favors projects from these quasi-state corporations because of the

explicit or implicit government guarantee. This financing mechanism in many cases imposes risks for implicit debt on the national government. Although common in other developed and developing countries, when combined with sub-national government's strong investment incentives (oftentimes for short-term political gain), the soft-budget constraint may produce inefficient projects.

Detecting such projects is usually ad hoc. The fragmented authorities associated with the fragmented budgeting power have made decision making process lack of transparency and efficiency. The lack of multi-year fiscal framework has made the Five Year Plans disconnected from the Budget. In many provinces, the de facto inclination of budgetary power to the department of finance has made the coordination with the provincial development and reform commission as well as line ministries more difficult. Although budgetary support has become less important over the years, infrastructure investment has become increasingly reliant on extra-budgetary funds and borrowing from the financial and non-financial sectors.

The result of a combination of these factors has indeed changed the much of China's physical landscape. It fulfills the high demand for infrastructure in the rapid urbanization process. It also improves the productive efficiency of infrastructure dependent industries. There are, however, concerns about the heavy-handedness of the government in economic development. Although through various reforms in the investment, fiscal and enterprise system, the role of government is still strong. Government investment or quasi-state investment still accounts for a large share of the total investment in the society. The lower levels of governments are actively engaged in the productive investment in the infrastructure sector, although recently the central government calls for more emphasis on the traditional public service sectors such as health care. The responsibilities of lower levels of governments extend from public goods provision to every aspect of economic growth in the jurisdiction. Such development state has resulted in the unique patterns in China's infrastructure investment. In many cases, the lack of transparency has made the process of project selection and funding decisions a hotbed for investment inefficiencies.

Chapter 4

FISCAL DECENTRALIZATION AND THE COMPOSITION OF LOCAL GOVERNMENT EXPENDITURE

4.1 Introduction

This chapter aims to interpret the reasons behind China's large amount of or sometimes too much infrastructure investment. While there are many possible interpretations for the phenomenon, this section focuses on the local government's investment behavior with fiscal decentralization. It provides a theoretical analysis on the level and composition of local government[1] expenditure toward public investment in a decentralized economy. Empirical evidence of cross country studies often find conflicting results about the effect of decentralization on the provision of public investment. While developing countries such as China and more advanced European Union countries such as Spain have seen rapid increase in the local provision of, for example, the transport and energy infrastructure (Esteller and Sole, 2005; Kappeler and Valila, 2008; and Chapter 3), other countries such as Russia and Brazil have seen less regional provision of public investment (Blanchard and Shleifer, 2001). What's more, studies by Clarida (1993) and Clarida and Findlay (1994) in their papers on European integration argue that regional integration can result in a higher level of public infrastructure investment than two identical nation-states. The empirical literature, on one hand, focuses on decentralization alone and may hide economic and institutional details that together shape the outcomes of the level and composition of public expenditure. On the other hand, the literature seems to agree that when more than one level of government is introduced, the institutional incentives will be different.

Alternative reasons have been proposed to explain the increase of government expenditure. Perhaps one of the earliest studies is the wellknown Wagner's law that observes

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[1]Throughout this chapter, local government is referred as opposed to the central government.

government expenditure rising with the growth of an industralized economy. More recent studies such as Rodrik (1998), Epifani and Gancia (2009) and Spence (2006) argue that openness is a reason for increasing government size, either through aversion to risk exposure, increasing international trade, or international capital mobility. Meanwhile, Garrett (2001) found that openness tends to have opposite effect on government sizes from empirical observations. These studies on the size of governments often focus on the aggregated government expenditure without differentiating the compositions.

A number of papers have established the theoretical framework on the composition of government expenditure. Barro (1990) and Barro and Sala-i-Martin (1992) included government spending in a growth framework. Devarajan et al (1996), Chen (2005) and Ghosh and Gregoriou (2008) extended the growth framework to consider different functions of public expenditure entering either into the production function or individual utility or both. These studies, however, only focus on a national unity government.

Studies on the composition of government expenditure in a decentralized economy can perhaps be traced back to the fiscal competition literature. Early studies of fiscal competition focused on the effect of tax competition on the composition of local government expenditure (e.g. Zofrow and Mieszkowski, 1986; Wilson, 1991 and Hwang and Choe, 1995). It was not until recently theoretical papers elaborated on how public investment can also be a device for fiscal competition. Cai and Treisman (2005) show that fiscal competition in the form of public investment tends to increase the level of public investment in both the lagging and advanced regions. A considerable number of studies build models of public investment as devices for fiscal competition in the China context (e.g. Fu, 2008, Wang and Xu, 2009 and Huang, 2011). Results do confirm the observation that local governments spend more on public infrastructure than other public goods. Other studies present the political economy interpretations of the inefficient provision of public goods such as Besley and Coate (2003) and Robinson and Torvik (2005).

This chapter builds upon the literature on decentralization, fiscal competition and the

composition of government expenditure. Applying to China's development context, the main features of the model are as follows. The first is the regional competition for capital which is referenced in the existing literature. Instead of the tax policies in the tax competition literature, this chapter focuses on expenditure policies. Second, it includes a partially selfish local government objective that is likely within a decentralized structure. Third, it uncovers how land financing can effect the level and composition of public investment. Including land financing can alter the regional polarization of public capital caused by technology gaps suggested by in Cai and Treisman (2005). Fourth, it shows how partial decentralization with tax sharing and fiscal transfers affect the incentives for public investment at the local level.

This chapter contributes to the existing literature by focusing on the key elements that shaped the level and composition of government expenditure in countries like China. It describes the reasons behind local governments' favor of public investment over other public goods in an open economy and shows how land financing can exacerbate the distortions. It also shows how fiscal transfers can reinforce the incentives for more public investment and how equalization objectives may come at a welfare cost. The analysis of this chapter sheds light on the size and composition of government expenditure in many developing and advanced countries. It also contributes to the understanding of optimal government expenditure and of reasons for inefficiencies in the expenditure composition.

4.2 The China Context

For the past three decades, China has seen remarkable growth performances, partly fueled by its unprecedented large scale infrastructure investment. Infrastructure has become one of the major instruments for the national government to stimulate growth and to reduce regional inequality. Such large scale infrastructure investment does not necessarily yield desirable effects. The empirical study in Chapter 2 has shown that on average marginal growth effect of road infrastructure is low and insignificant and becomes even negative and significant in the lagging regions in China during some time periods. The results suggest inefficiency

in the government expenditure, in particular, government expenditure composition favoring infrastructure investment.

The demand side reasons for such spending drive for public investment not only comes from faster growth and urbanization process, but also from the fact that local officials seek to maintain high output growth. For officials in rich regions with more revenue sources, more public investment means more GDP and better chances of promotion. For lagging regions with less amount of infrastructure to begin with, alleviation of infrastructure bottlenecks can attract more private investment and growth potential. GDP growth has become the most important performance criteria for government officials' personal promotion. Moreover, in an institution where local leadership can exert huge influence in decision making, local officials try to retain as much resources in their own control to influence the economic growth process.

Increasing revenue capacity also expands the possibility of a larger supply of public infrastructure. Although theory already predicts that accumulation of public capital may not always translate into higher growth (Barro, 1990), alternative financing resources available for local government officials have encouraged decisions based less on sound economic reasoning. Public investment is expensive for both rich and poor regions. With the central government tightening the revenue pool through tax sharing, local governments feel enormous pressure to seek alternative ways to finance public infrastructure. Land financing is an ideal because it is easy to get access to and promises huge amount of revenue without raising taxes. Land revenue has played an increasingly more important role in fiscal revenue than revenues from fast output growth. This alternative financing resource has proved to be effective in building large infrastructure in a short period of time, even for lagging regions, but may also be the exact reason why more infrastructure leads to lower growth.

The central government has some power to correct the tendency to overspend in local governments by tax sharing and redistribution. Yet central fiscal transfers in China sometimes are reinforcing the favor for public investment. The role of tax rebate dominated compared with general purpose and specific purpose transfers before the year 2000. The effect of fiscal

transfers, therefore, have been on average pro-rich, meaning more fiscal transfers to the advanced regions that have more capacity to provide infrastructure. The general and specific transfers are based less on rules but "discretion" and oftentimes subject to lobbying by the local governments (see Chapter 3).

The rest of the chapter is developed into the following sections. Section 3 presents the structure of the basic model and derives the optimal conditions for public investment given centralized provision. It is presented as a comparison to the various extensions under decentralized provision of public goods. Section 4 shows how fiscal competition and partially selfish government objectives can alter the equilibrium conditions for public investment. Section 5 adds the supply side factor from land financing. Section 6 discusses the effects of fiscal transfers on the equilibrium conditions of local public expenditure. Section 7 concludes.

4.3   Basic Model with Optimal Government Expenditure

There is one central government and N regions. Residents are assumed to be immobile across regions. Each region is endowed with the same number of residents, and assume the population growth is zero. There are two types of public expenditure in the model: one public investment good that enters into the production function; another a public consumption good that enters into the resident's utility. Examples of these two types of public capital are transport infrastructure and health services. The representative agent's utility is characterized by:

$$U(c, g^c) = c^\eta (g^c)^{1-\eta} \tag{4.3.1}$$

η is the share of private consumption in individual's utility. $0 < \eta < 1$.

Each representative agent owns a firm. The production function is a usual Cobb-Douglas technology. It exhibits decreasing returns to scale with respect to each of the private and public productive capital, so that $0 < \alpha$, $\beta < 1$ and $0 < \alpha + \beta < 1$ if considering the other inputs such as labor. It is assumed that the productive public capital G^I is a pure public good, so that it is the total stock of G^I that enters into the production function of each firm.

$\dfrac{\partial^2 y_i}{\partial g_i^{I\,2}} < 0$ and $\dfrac{\partial^2 y_i}{\partial k_i \partial g_i^{I}} > 0$. The production function is:

$$y = Ak^{\alpha}(G^{I})^{\beta}$$

Aggregating the above equation to get the economy wide output:

$$Y = AK^{\alpha}(G^{I})^{\beta} \tag{4.3.2}$$

The total population and and the total number of firms are normalized to 1. At the end of the period, the representative agent consumes his net income. His budget constraint is:

$$c = (1 - \tau)y \tag{4.3.3}$$

For the public sector, its expenditure is financed by a flat rate income tax on output, τ. Both levels of government run a balanced budget. The share of public investment good in its total revenue is θ and public consumption good is $1 - \theta$.

$$G^{I} + G^{c} = \tau Y \tag{4.3.4}$$

Assuming for now that the decision making power rests with the central government. The social planner is assumed to have complete information about private utility and production function and acts benevolently to maximize the representative agent's utility. The economy wide resource constraint is:

$$Y = C + G^{c} + G^{I} \tag{4.3.5}$$

The social planner's problem is to choose C, G^{I}, G^{c} to maximize the representative agent's utility as in equation (4.3.1), with the production function and economy wide resource constraint. First order conditions with respect to C, G^{I}, G^{c} yields the following equations:

$$F_{G^{I}} = 1 \tag{4.3.6}$$

$$U_{G_{c}} = U_{c} \tag{4.3.7}$$

The marginal contribution of public productive capital to output is equal to the marginal cost of public good provision. One unit of consumption goods can be turned into one unit of public good. The private and public conumption goods are allocated until the marginal contributions of these two types consumption goods equal. These two conditions ensure a social optimum for the level and composition of public infrastructure.

Consider equation (4.3.6), optimal G^I can be solved as:

$$G^{I*} = (\beta A K^\alpha)^{\frac{1}{1-\beta}}$$

and

$$Y^* = (\beta^\beta A K^\alpha)^{\frac{1}{1-\beta}}$$

Therefore $G^{I*} = \beta Y^*$.

From equation (4.3.7) and the specific utility function in equation (4.3.1), we get:

$$\frac{\eta G^c}{(1-\eta)C} = 1$$

Together with the economy wide resource constraint, we can solve G^{c*} and C^* as:

$$C^* = \eta(1-\beta)Y^* = \eta(1-\beta)(\beta^\beta A K^\alpha)^{\frac{1}{1-\beta}}$$

$$G^{c*} = (1-\eta)(1-\beta)Y^* = (1-\eta)(1-\beta)(\beta^\beta A K^\alpha)^{\frac{1}{1-\beta}}$$

with $\dfrac{G^I}{G^c} = \dfrac{\theta}{1-\theta}$, the optimal allocation of public expenditure is:

$$\theta^* = \frac{\beta}{1-\eta+\eta\beta} \equiv \theta^{o*} \tag{4.3.8}$$

The optimal level of taxation is:

$$\tau^* = \frac{G^I + G^c}{Y} = 1 - \eta + \beta\eta$$

τ can also be interpreted as the ratio between the public sector G and the total economy Y. The optimal utility is obtained by plugging in the private and public consumption. Comparative statics show that increasing policy variables θ and τ will decrease utility.

Dynamic solutions to the same model yields a saddle-point equilibrium. To obtain implications for the level and composition of public infrastructure without loss of generality, the following section focuses on the static cases of the model.

Note that although the fiscal decentralization literature (e.g. Oates, 1999) argues that decentralization can yield more efficient allocation of public resources than centralized provision, this is based on assumptions such as asymmetric information on the part of the central government, and that the local governments will be more responsive to local needs. Given the assumptions set in this section, the results of centralized provision are socially optimal. To see why, consider a simple case when the consumption decision is devolved to the individual. Instead of the social planner making consumption choices based on economy wide resource constraint, individuals have to make consumption choices based on after-tax income. The result of consumption level or consumption path in a dynamic setting is lower (e.g. Barro, 1990). The results derived in this section is a benchmark for the following analysis within a decentralized arrangement.

4.4   Decentralized Provision

Now instead of central provision, the central government fully devolves its decision making to the N local governments. Here public productive capital is assumed to be pure public goods within each region, but excludable across regions. It is also assumed that the public productive capital does not spillover to other regions, nor does congestion take place. The local governments take income tax rate τ as exogenously set by the central government throughout the fiscal decentralization arrangement. This assumption is suitable for the case of China as the central government has the legislative power to set most tax rates, such as value added taxes, business taxes, consumption tax and corporate taxes (Fan and Zhang, 2010).

4.4.1 Competition Effect

According to the tax competition literature, local governments tend to "race to the bottom" using tax policy in order to attract and retain mobile capital such as the FDI. Local governments, instead of tax policies, can also use public investment to attract mobile capital (Cai and Treisman, 2005; Zhang, 2007). Reasons for this have already been discussed in the literature, such as Agenor and Moreno-Dodson (2006). Better public investment lowers the adjustment costs of private capital and often times is the precondition for private investment. In the China context, huge infrastructure investment drives are usually accompanied with the development of Special Economic Zones (SEZs). Local officials not only use tax breaks, but also provide the fully equipped area with transport connections, electricity and water systems.

With decentralized decision making, the results depend very much on the mobility of factors across regions (e.g. Zodrow and Mieszkowski, 1986; Wilson, 1991; Hwang and Choe, 1995; and Richter and Wellisch, 1996). Throughout this chapter, labor is assumed to be immobile across regions. Although for the China context, there is much labor mobility across provinces, on the whole, labor mobility across major geographical regions, such as the Eastern and Western regions, is relatively small compared with the size of the population in each region. For the effect of capitla mobility, the section compares the equilibrium conditions between immobile and mobile capital cases.

Suppose each region is faced with the same number of residents and the same production function, but may have different private capital endowment. Local governments are still assumed to be benevolent. Each local government chooses g^I and g^c in its own jurisdiction to maximize the representative agent's utility. Consider first the case of immobile capital. Suppose each region is endowed with $\bar{k}_i$ units of private capital. For the local government's optimization problem, the first order conditions with respect to g_i^I and g_i^c yield the following

equation:

$$\frac{\partial y_i}{\partial g_i^I} = \frac{\dfrac{\partial U_i}{\partial g_i^c}}{\dfrac{\partial U_i}{\partial c_i}(1-\tau) + \dfrac{\partial U_i}{\partial g_i^c}\tau} = \frac{1}{\dfrac{U_c^i}{U_{g^c}^i}(1-\tau) + \tau}$$

With the specification of individual utility,

$$\frac{U_c^i}{U_{g^c}^i} = \frac{\eta g_i^c}{(1-\eta)c_i} = \frac{\eta(1-\theta_i)\tau}{(1-\eta)(1-\tau)} \tag{4.4.1}$$

Therefore:

$$\frac{\partial y_i}{\partial g_i^I} = \frac{1}{\dfrac{U_c^i}{U_{g^c}^i}(1-\tau) + \tau} = \frac{1}{\dfrac{\eta(1-\theta_i)\tau}{(1-\eta)} + \tau} = \frac{1-\eta}{\tau(1-\theta_i\eta)} \equiv M^o \tag{4.4.2}$$

The optimal level of g_i^I can be solved to be a function of the policy parameters τ and θ_i.

$$g_i^I = [\frac{A\beta \bar{k}_i^{\alpha}\tau(1-\theta_i\eta)}{1-\eta}]^{\frac{1}{1-\beta}} = g_i^{Io}$$

The levels of public investment are the same across regions if the initial private capital endowment is the same. Given that g_i^I is immobile, equlibrium conditions satisfy:

$$g_i^I \frac{\partial y_i}{\partial g_i^I} = \beta y_i \tag{4.4.3}$$

Also $\dfrac{g_i^I}{y_i} = \theta_i\tau$. The optimal share of public investment θ_i^* can be solved as a solution to the following equation:

$$\theta_i = \frac{\beta}{\dfrac{\partial y_i}{\partial g_i^I}\tau} = \frac{\beta(1-\theta_i\eta)}{1-\eta}$$

Therefore:

$$\theta_i^* = \frac{\beta}{1-\eta+\beta\eta} = \theta^{o*} \tag{4.4.4}$$

The result shows that there is a symmetric equilibrium with regard to the composition of public investment taking τ as exogenously set by the central government. When each region is endowed with the same amount of private capital, where $\bar{k}_i = \bar{k} = \dfrac{K}{N}$ and the total

population across all regions, N, is normalized to one, there is symmetric equilibrium in the level of public investment also. The decentralized provision is equivalent to centralized provision.

Now consider the case if capital is perfectly mobile. Assume that each region is small enough so as not to affect the nationwide interest rate r. Therefore, private capital will be allocated until the after tax marginal return of private capital equals the marginal cost of capital r.

$$(1 - \tau)\frac{\partial y_i}{\partial k_i} = r \tag{4.4.5}$$

The optimization problem yields the first order condition for g_i^I.

$$\frac{\partial y_i}{\partial k_i}\frac{\partial k_i}{\partial g_i^I} + \frac{\partial y_i}{\partial g_i^I} = \frac{1}{\dfrac{U_c^i}{U_{g^c}^i}(1 - \tau) + \tau} = \frac{1 - \eta}{\tau(1 - \theta_i\eta)} \equiv M^o \tag{4.4.6}$$

Public productive capital not only contributes to aggregate output, but also has positive output effect through attracting more mobile capital into the region. The first term in equation (4.4.6) is the well known "competition effect" (Cai and Treisman, 2005). The equilibrium level of public investment is greater than the capital immobile case and the optimal level of public investment is:

$$g_i^I = [\frac{A\beta k_i^\alpha \tau(1 - \theta_i\eta)}{(1 - \eta)(1 - \alpha)}]^{\frac{1}{1-\beta}} = (\frac{1}{1 - \alpha})^{\frac{1}{1-\beta}}[\frac{A\beta k_i^\alpha \tau(1 - \theta_i\eta)}{(1 - \eta)(1 - \alpha)}]^{\frac{1}{1-\beta}} \tag{4.4.7}$$

If $k_i = \bar{k}_i$, optimal level of public investment is higher than the case without mobile capital. Similarly, the equilibrium composition of public expenditure is

$$\theta_i^* = \frac{\beta}{(1 - \alpha)(1 - \eta) + \eta\beta} = \theta^* \tag{4.4.8}$$

This can be plugged into equation (4.4.5) and with equation (4.4.7) to solve for the equilibrium k_i, g_i^I, g_i^c and c_i. In the mobile capital case, there are symmetric equilibria in the level and composition of government expenditure. Competition for private capital has not only induced more public investment compared with the capital immobile case but also increased the equilibrium share of public investment over that of public consumption services. Fiscal

competition for mobile private capital proves to be a key reason for more public infrastructure.

4.4.2 Partially Selfish Government

The devolution of decision making power often comes with a risk. Although the social planner may be benevolent, he may lack the precise information at the local level. The local officials who obtain better information, however, may be selfish. This section describes how partially selfish local government will affect the level and composition of local government expenditure.

Governments across countries often take economic growth or a combination of growth and welfare as part of their objectives (Tobin, 1964; Qian and Roland, 1998). With higher growth, there may be more income for residents and higher consumption possibilities. An alternative objective may be maximizing the net revenues or own consumption for government officials, such as described in Epple and Zelenitz (1981) and Cai and Treisman (2005). With more fiscal revenue, the power residing with the officials is higher, in particular with political institutions where government officials have more decision making influence. The incentives may also arise from investment hunger as described in Zou (1991). More capital accumulation is aligned with the interest of the officials as they take pride in what they have accomplished during their term. Robinson and Torvik (2005) suggest that officials may even feel attractive to "white elephant" projects because the ability to undertake such projects acts as a strategic advantage. Government officials may also favor one particular interest group than another, for example, to attract mobile residents as described in Richter and Wellisch (1996).

Both the strive for GDP growth and hunger for more capital accumulation exist in the China context. Local governments are similar to an enterprenuer, making investments to increase GDP and the chance of promotion. Based on the literature and empirical evidence, the partially selfish local government is modeled as:

$$W_i = U(c_i, g_i^c) + \lambda R_i \qquad (4.4.9)$$

This setup has the advantage of combining both factors of growth and fiscal revenue objectives. Local governments are assumed not only to value the utility of its residents but also its revenue income. With more revenue sources, they are able to do more to show that they are competent. Given the exogenously set τ, concerns of own revenue is equivalent to the concern about local GDP output. There is a continuum of possibility about the degree of deviation from the benevolent social planner. λ, the weight given to regional GDP or local revenue resouces, is a measure of deviation from the benevolent objective. Assume λ is exogenously given. $\lambda \geq 0$ and can be greater than 1. In the extreme case, when λ is very large, the local governments only care about its own revenue or GDP.

Under factor immobility, the first order conditions of the local government yields:

$$\frac{\partial y_i}{\partial g_i^I} = \frac{1}{\frac{U_c^i}{U_{g^c}^i}(1-\tau) + \tau + \frac{\lambda\tau}{U_{g^c}^i}} \equiv M^\lambda \tag{4.4.10}$$

M^λ is a function of structural parameters and policy parameters τ and θ_i. When $\lambda = 0$, $M^\lambda = M^o$. The result is the same with equation (4.4.2). When $\lambda > 0$, $M^\lambda < M^o$. Given that $\frac{\partial^2 y_i}{\partial g_i^{I2}} < 0$, the equilibrium level of public investment is larger, with increasing weight on local revenue resources. Note that because λ can be greater than 1, the marginal contribution of public capital can be infinitely small.

The equilibrium composition of public investment $\theta_i^{\lambda*}$ is also symmetric across regions, because:

$$\theta_i^\lambda = \frac{g_i^I}{\tau y_i} = \frac{\beta}{\frac{\partial y_i}{\partial g_i^I}\tau} = \frac{\beta}{M^\lambda \tau} = \theta^{\lambda*} \tag{4.4.11}$$

Therefore, $\theta^\lambda M^\lambda = \theta^o M^o = \frac{\beta}{\tau}$. With $M^\lambda < M^o$, $\theta^\lambda > \theta^o$. The equilibrium share of public investment is higher than complete decentralization with benevolent government.

The whole system can be pinned down if the central government's choice τ is determined, because both $\frac{\partial y_i}{\partial g_i^I}$ and θ^λ are functions of structural parameters β and η and policy parameter τ.

Suppose the central government is benevolent and sets the uniform tax rate τ until $\frac{\partial U_i}{\partial c_i} = \frac{\partial U_i}{\partial g_i^c}$, which is one of the first order conditions in the social optimum case. The marginal contribution of private and public consumption in each region is equal to 1. Then equilibrium M^λ will be less than 1. The equilibrium level of public investment is higher than the social optimal case.

The second possibility is that the central government set τ until $\frac{\partial y_i}{\partial g_i^I} = 1$, another first order condition in the social optimum case (equation (4.3.6)). Then with equation (4.4.10), $\frac{\partial U_i}{\partial c_i} = \frac{\partial U_i}{\partial g_i^c}$ with $\lambda = 0$. The result is the same as the complete decentralization case. If $\lambda > 0$, $\frac{\partial U_i}{\partial c_i} < \frac{\partial U_i}{\partial g_i^c}$, equilibrium level of public consumption is lower.

Now suppose the central government is accomodating local government's behavior and set τ as if it is equal to the tax rate if local governments have tax autonomy, which is symmetric in equilibrium. This accomodative behavior will result in the following equation:

$$\frac{\partial U_i}{\partial c_i} = \frac{\partial U_i}{\partial g_i^c} + \lambda$$

Plugging in equation (4.4.10) and arranging terms will yield:

$$\frac{\partial y_i}{\partial g_i^I} = \frac{\dfrac{\partial U_i}{\partial g_i^c}}{\dfrac{\partial U_i}{\partial c_i}} = \frac{\dfrac{\partial U_i}{\partial c_i} - \lambda}{\dfrac{\partial U_i}{\partial c_i}}$$

Because λ can be greater than 1, the marginal contribution of public capital to the output can even become negative.

Under the same reasoning, the level and share of public investment will be even higher givern the competition effect for mobile capital.

4.4.3 Decentralization with Tax Sharing

A more practical fiscal decentralization arrangement is partial decentralization with local jurisdictions sharing their tax revenues with the central government. China introduced tax sharing reform in the year 1994 to increase central revenue capacity in the face of dwindling

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central revenues under the contract system. Complete characterization of partial decentralization involves both a tax sharing and a redistributive policy at the center. This section focuses on the effect of tax sharing alone while leaving the complete set-up to the section on fiscal transfer. It is assumed now that the collected taxes are all consumed by the central government.

The local government now needs to share their fiscal revenues with the central government at rate κ. κ is assumed to be exogenous and set by the central government. In China, for example, the value added taxes are set by the central government to be shared at a flat rate (Wu, 2011). Now the local government revenue is $(1 - \kappa)\tau y_i$. Still assume that the local government is partially selfish as in the last section. The first order conditions yield the following equation:

$$\frac{\partial y_i}{\partial g_i^I} = \frac{1}{\frac{U_c^i}{U_{g^c}^i}(1 - \tau) + \tau(1 - \kappa) + \frac{\lambda\tau(1 - \kappa)}{U_{g^c}^i}}$$

Different from the equation (4.4.1), now

$$\frac{U_c^i}{U_{g^c}^i} = \frac{\eta g_i^c}{(1 - \eta)c_i} = \frac{\eta(1 - \theta_i)\tau}{(1 - \eta)(1 - \tau)}\left(\frac{1}{1 - \kappa}\right)$$

Thus:

$$\frac{\partial y_i}{\partial g_i^I} = \frac{1}{\frac{\eta(1 - \theta_i)(1 - \kappa)\tau}{1 - \eta} + \tau(1 - \kappa) + \frac{\lambda\tau(1 - \kappa)}{U_{g^c}^i}} \tag{4.4.12}$$

where

$$U_{g^c}^i = (1 - \eta)c_i^\eta(g_i^c)^{-\eta} = (1 - \eta)\left(\frac{1}{1 - \kappa}\right)^\eta\left[\frac{1 - \tau}{(1 - \theta_i)\tau}\right]^\eta$$

First consider benevolent local governments. When $\lambda = 0$ and capital is immobile, $\frac{\partial y_i}{\partial g_i^I} = \left(\frac{1}{1 - \kappa}\right)\frac{1 - \eta}{(1 - \theta_i\eta)\tau} = \left(\frac{1}{1 - \kappa}\right)M^o > M^o$. Thus the equilibrium level of public investment under tax sharing is lower than without tax sharing. Tax sharing has reduced the fiscal capacity of local governments.

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The equilibrium share of public investment can be written as:

$$\theta_i^{s,\lambda=0*} = \frac{g_i^I}{(1-\kappa)\tau y_i} = \frac{\beta}{(1-\kappa)\tau \dfrac{\partial y_i}{\partial g_i^I}} = \frac{\beta}{(1-\kappa)\tau M^o \dfrac{1}{1-\kappa}} = \theta^{o*} \tag{4.4.13}$$

When capital is mobile across regions,

$$\frac{\partial y_i}{\partial k_i}\frac{\partial k_i}{\partial g_i^I} + \frac{\partial y_i}{\partial g_i^I} = \frac{1}{\dfrac{U_c^i}{U_{g^c}^i}(1-\tau) + \tau(1-\kappa)} = \frac{1-\eta}{\tau(1-\theta_i\eta)(1-\kappa)} \equiv M^o(\frac{1}{1-\kappa}) \tag{4.4.14}$$

Can solve for g_i^I:

$$g_i^I = (\frac{1-\kappa}{1-\alpha})^{\frac{1}{1-\beta}}[\frac{A\beta k_i^\alpha \tau(1-\theta_i\eta)}{(1-\eta)(1-\alpha)}]^{\frac{1}{1-\beta}} = (\frac{1-\kappa}{1-\alpha})^{\frac{1}{1-\beta}}g_i^{Io}$$

The last equal sign holds if $k_i = \bar{k}_i$. With tax sharing, the competition effect on equilibrium level of public investment is uncertain. When $\kappa = \alpha$, tax sharing can reverse the competition effect introduced by mobile private capital.

Because $g_i^c = (1-\kappa)\tau y_i - g_i^I = \dfrac{1-\theta_i}{\theta_i}g_i^I$. Plugging in the equation (4.4.14), the equilibrium share of public investment is:

$$\theta_i^* = \frac{\beta}{(1-\alpha)(1-\eta) + \eta\beta} = \theta^* \tag{4.4.15}$$

Tax sharing only has a level effect but does not change the relative shares of public production and consumption capital.

Now consider the case when $\lambda > 0$. Equation (4.4.12) can be written as:

$$\frac{\partial y_i}{\partial g_i^I} = \frac{1}{\dfrac{\eta(1-\theta_i)(1-\kappa)\tau}{1-\eta} + \tau(1-\kappa) + \dfrac{\lambda\tau(1-\kappa)}{U_{g^c}^i}} = \frac{1}{\dfrac{\eta(1-\theta_i)\tau}{1-\eta} + \tau + \dfrac{\lambda\tau}{U_{g^c}^i}}(\frac{1}{1-\kappa})$$

$$M^\lambda < M^\lambda(\frac{1}{1-\kappa}) = \frac{\partial y_i}{\partial g_i^I} < M^o(\frac{1}{1-\kappa}) \tag{4.4.16}$$

Therefore, tax sharing reduces the equilibrium level of public investment preferred by the partially selfish local governments.

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Now

$$\theta^o = \theta_i^{s,\lambda=0} \frac{\beta}{(1-\kappa)\tau M^o(\frac{1}{1-\kappa})} < \theta_i^{s,\lambda} \equiv \frac{g_i^I}{(1-\kappa)\tau y_i}$$

$$= \frac{\beta}{(1-\kappa)\tau \frac{\partial y_i}{\partial g_i^I}} < \frac{\beta}{(1-\kappa)\tau M^\lambda(\frac{1}{1-\kappa})} = \theta^\lambda \quad (4.4.17)$$

Tax sharing does not change the composition of expenditure for local governments. By similar reasoning, tax sharing under the mobile capital case reduces the level of public investment for selfish governments but the expenditure remains the same.

4.5   Land Financing

The above analysis is based on the assumption that regions are homogeneous except for private capital endowment. With mobile private capital, it results in a symmetric equilibrium of the allocation of private capital, public investment and private and public consumption. A more realistic question is whether the allocations will be different with heterogenous regions. Recent literature on fiscal decentralization with heterogenous regions suggests that technological capacity gaps have "polarized" the levels of public investment between the lagging and advancing regions. In particular, in Cai and Treisman (2005), they argue that lagging regions tend to experience a vicious cycle of less technological capacity, less public infrastructure, attracting less private capital and eventually resort to more public consumption instead. Spence (2006) also argues that initial "attractiveness" will determine the variations in business-friendly policies. This argument, however, does not quite fit into China's regional growth story. In Chapter 2, although on average marginal contribution of road infrastructure tends to be small and insignificant, it is in the lagging regions that marginal contribution of road infrastructure becomes negative and significant. This seems to be puzzling. To understand how lagging regions have the capacity to invest heavily in infrastructure, land financing needs to be introduced into the model.

Land based financing has become an appealing tool for the local government officials in China. A number of reasons have contributed to its wide practice. First, the government is the owner of the land in China. The rights to land use are assigned to private parties with certain length of time. Second, the public ownership has given local governments opportunities to make huge gains in land businesses by taking advantage of large price differences between purchases from previous land users, such as farmers, and sales to the developers and other private parties. These land revenues are now the major item in the extra-budgetary account of the local governments in China. For some provinces, net revenue from land financing accounts for more than 60% of the total extra-budgetary revenues (Zhou, 2008). Third, land revenues are not subject to sharing with the center. Land financing, therefore, becomes a rule not an exception. This enhanced financing capacity further fuels the local spending drive for more public investment. Even lagging regions in the vast Western area can take advantage of their land endowment. Although it seems to eliminate the financing gap for large infrastructure projects, land financing has become frequently short-sighted and posed threats to the sustainability of large infrastucture investment (Cai Jin, 2011).

This section discusses the effect of land financing on the level and share of public investment in heterogenous regions. Each region still has the same number of residents, but they differ in technolgoy A_i, and land area L_i, $i = m, n$. Now the local government has an additional source of revenue besides income taxes: the revenues from land value capture. We can think of the previous cases where the government does not charge for land use. The government can either be a capturer of land value or a land developer that intends to add more values through public investment on land. Studies particularly on China have found that the public ownership of land has enabled local government officials to manage land business or operate as land developers (Lichtenberg and Ding, 2009; Chau and Zhang, 2011; Tang and Chen, 2012). Separating the two cases enbables us to know how land financing may not only have an income effect, but also a substitutional effect on public investment.

4.5.1   Government as Land Value Capturer

Now the production function of the private sector also includes land rents.

$$y_i = A_i k_i^{\alpha} (g_i^I)^{\beta} L_i^{\gamma} \qquad (4.5.1)$$

Because land is immobile across regions, the land value is set to equal $L_i \dfrac{\partial y_i}{\partial L_i}$ (e.g. in Chau and Zhang, 2011). With the production function, total land revenues are:

$$L_i \frac{\partial y_i}{\partial L_i} = \gamma y_i \qquad (4.5.2)$$

The public sector is the owner of land and residents are the users of land. To capture land value, the local governments have to compensate these residents. The land revenue is shared between the government and the local residents at rate μ, the share of which is obtained by the local government. Because of the public ownership, residents have little negotiation power over how much they would be compensated. Therefore, μ is assumed to be exogenous and determined by the local government.

The local government revenue comes from two sources, tax revenue on the output, and net revenues from land development, $\mu \gamma y_i$. First consider a case with heterogenous regions and additional land value capture within a complete fiscal decentralization. Now the income of the representative agent not only comes from after-tax income but also compensation paid by the government of the amount $(1 - \mu)\gamma y_i$. Suppose capital is immobile, first order conditions for local government's optimization problem yields:

$$\frac{\partial y_i}{\partial g_i^I} = \frac{1}{\dfrac{\partial U_c^i}{\partial U_{g^c}^i}[(1 - \tau) + (1 - \mu)\gamma] + (\tau + \mu\gamma)} = \frac{1}{\dfrac{\eta(1 - \theta_i)(\tau + \mu\gamma)}{1 - \eta} + (\tau + \mu\gamma)} = \frac{M^o \tau}{\tau + \mu\gamma}$$

$$(4.5.3)$$

with

$$\frac{U_c^i}{U_{g^c}^i} = \frac{\eta g_i^c}{(1 - \eta)c_i} = \frac{\eta(1 - \theta_i)(\tau + \mu\gamma)}{(1 - \eta)[(1 - \tau) + (1 - \mu)\gamma]}$$

Therefore, the equilibrium level of public investment is higher than the case with complete decentralization. Specifically, g_i^I can be solved as:

$$g_i^I = [\frac{A_i \beta \bar{k_i}^\alpha L_i^\gamma (1 - \theta_i \eta)}{1 - \eta}]^{\frac{1}{1-\beta}} (\tau + \mu\gamma)^{\frac{1}{1-\beta}}$$

The larger the developed land area, the higher public investment there can be.

Given $g_i^I \frac{\partial y_i}{\partial g_i^I} = \beta y_i$,

$$\theta_i^{L*} = \frac{g_i^I}{y_i(\tau + \mu\gamma)} = \frac{\beta}{\frac{\partial y_i}{\partial g_i^I}(\tau + \mu\gamma)} = \frac{\beta}{M^o(\frac{\tau}{\tau + \mu\gamma})(\tau + \mu\gamma)} = \frac{\beta}{M^o \tau} = \theta^{o*} = \frac{\beta}{1 - \eta + \beta\eta}$$

(4.5.4)

Equilibrium share of public investment coincides with the socially optimal case and the case with complete decentralization. The additional land financing resouces have only a level effect, but not a price effect.

Under capital mobility, competition for capital will result, as in the previous cases, a higher share of public investment, with

$$\theta_i^* = \theta^* = \frac{\beta}{(1 - \alpha)(1 - \eta) + \beta\eta}$$

(4.5.5)

The level of public investment with a combination of the competition effect and land value capture both working toward higher tendency for public investment. Specifically, g_i^I can be solved as:

$$g_i^I = [\frac{A_i \beta \bar{k_i}^\alpha L_i^\gamma (1 - \theta_i \eta)}{1 - \eta}]^{\frac{1}{1-\beta}} (\frac{\tau + \mu\gamma}{1 - \alpha})^{\frac{1}{1-\beta}}$$

Plug in equation (4.4.5) for k_i to get equilibrium g_i^I as a function of structural and policy parameters and A_i and L_i, the endowment in technology and land. When heterogenous regions differ in technology paramater A_i, the polarization effect still exists, yet different with land use. Compared with Cai and Treisman's paper that conlcudes $\frac{g_m^I}{g_n^I} = (\frac{A_m}{A_n})^{\frac{1}{1-\alpha-\beta}}$, the equilibrium ratio of public expenditure between the advanced and lagging regions is:

$$\frac{g_m^I}{g_n^I} = (\frac{A_m L_m^\gamma}{A_n L_n^\gamma})^{\frac{1}{1-\alpha-\beta}}$$

(4.5.6)

Despite the fact that gaps in technology tend to polarize public investment in two regions, regions with larger land area are able to invest in large infrastructure projects. Lagging regions may also have the capacity to invest heavily in public infrastructure even though they may not possess better technology and management skills. As is often the case in China, the lagging regions in the Western and Central area have relatively more land endowment than the advancing coastal area. Including land value capture here only has an income effect (change in levels) but no price effect (change in composition) in both cases of capital mobility.

4.5.2 Government as Land Developer

Land used for local expenditure financing usually requires substantial investment, for example, to change raw land into developed land that the private sector is able to build upon. In practice, local governments acquire land from the urban fringe, usually abandoned land or farm land. Then the local governments build infrastruture such as road, water system and electricity networks. Much of the special economic zones (SEZs) in China are developed this way. The local government, after developing the land, can charge the private sector for land rentals or land use right. Perhaps this is a reason why the Henry George Theorem says that there is a relationship between aggregated government spending and aggregated land rents. The local governments benefit from price differences between raw land and developed land. With their negotiation power over the rate of compensation μ, local officials can maximize the amount of land value they can get.

A simple model capturing this feature can be characterized by the following equations:

$$y_i = Ak_i^\alpha (g_i^I)^\beta [L(g_i^I)]^\gamma \tag{4.5.7}$$

Because land is immobile, equation (4.5.2) still holds. The compensation to previous land users is still a fraction of the total land value, $1 - \mu$, and local governments obtain the rest

of land value. Now first order conditions yield:

$$\frac{\partial y_i}{\partial g_i^I} + \frac{\partial y_i}{\partial L_i}\frac{\partial L_i}{\partial g_i^I} = \frac{1}{\frac{\partial U_c^i}{\partial U_{g^c}^i}[(1-\tau)+(1-\mu)\gamma]+(\tau+\mu\gamma)}$$

$$= \frac{1}{\frac{\eta(1-\theta_i)(\tau+\mu\gamma)}{1-\eta}+(\tau+\mu\gamma)} = M^o(\frac{\tau}{\tau+\mu\gamma}) \quad (4.5.8)$$

Therefore, equilibrium level of public investment is higher.

Solving the equilbrium share of public investment θ^{ld}, the left hand side is $\frac{y_i}{g_i^I}(\beta +$
$\gamma\frac{g_i^I\partial L_i}{L_i\partial g_i^I}) = \frac{y_i}{g_i^I}(\beta+\gamma\phi)$, where ϕ is the elasticity of land supply to public investment. The equilibrium share of public investment is:

$$\theta_i^{ld*} = \frac{g_i^I}{(\tau+\mu\gamma)y_i} = \frac{(\beta+\gamma\phi)}{M^o\frac{\tau}{\tau+\mu\gamma}}(\frac{1}{\tau+\mu\gamma}) = \frac{\beta}{M^o\tau}+\frac{\gamma\phi}{M^o\tau} > \theta^{o*} \quad (4.5.9)$$

Compared with the government as a land capturer, now public investment input also has an effect on land area supply. When the elasticity of land supply to infrastructure investment increases, the share of public investment is higher. Therefore, the equilibrium share of public investment is higher with land development compared with land capture only. This shows that when public investment can increase land supply, the level and composition of public expenditure will be geared toward more public investment.

4.6   Fiscal Transfer

This section will complete another side of the partial fiscal decentralization by including redistributive policy from the center using transfers. The objective is to see whether fiscal transfers from the central government can correct or exacerbate the local incentive for more public investment. Empirical studies on cross country experiences show that redistributive policies are adopted by the central government for various objectives. Early literature suggests that redistributive policies are to correct for the regional disparities in the provision of

public services or per capital fiscal expenditure resulting from different regional revenue capacities (e.g. Buchanan, 1950). The aim is to ensure that basic public services are provided equally for the rich regions and the poor. A relavent policy objective is to fill the fiscal gaps between revenue capacity and basic expenditure demand, so that regions with less revenue capacity are able to provide similar levels of public services. Countries like Germany seem to follow this objective (von Hagen and Hepp, 2000). Others show that reducing income disparity is an important goal for redistributive policies. For example, Sala-i-Martin and Sachs (1991) shows that transfers from the federal government have compensated about 28% to 40% of the observed regional income differences. Studies on Canada (Delors, 1989) also show that federal transfers have reduced income differences between provinces. Moreover, Park and Philippopoulos (2003) and Sanguinetti and Tommasi (2004) show that fiscal transfers not only reduce long term regional disparity, but also reduce the adversary effect from temporay shocks to regional income or fiscal revenues. Redistributive policies can also help to enhance the efficiency of public good provision under "race to the bottom" tax competition (Buettner, 2006).

In China, fiscal transfers are often used to reduce the fiscal gaps between revenue and expenditure. Reducing income disparity has become a clearer goal after the "Western development plan" during the late 1990s and the early 2000s (Fan and Zhang, 2010). Similar to other countries, there are three major types of fiscal transfers that can have different effect toward these policy goals. The first type is block grants, which have few restrictions on the use of the grants. Second is specific or earmarked grants that are used for specific projects. These grants may or may not require local governments to match each grant with a certain amount of money. A third type is a revenue sharing grant or tax rebate that returns the shared revenue based on formulas that are proportional to either the tax bases, the shared taxes or to the size of the regional economy.

This section discusses two types of fiscal transfers, the revenue sharing grant or tax rebate and the equalization transfer. In reality, central transfers are a combination of revenue

sharing, specific purpose and block transfers with different weights for each type of transfer[2].
Therefore the equilibrium level and composition of public investment is a combination of the
effects from each type of transfer.

In this section, it is assumed that transfers will not change the regional tax effort. This
is more realistic to China's case, because after the 1994 tax sharing reform, the central
government centralized its tax collection effort and established special tax collection agencies,
instead of local governments collecting taxes on behalf of the central government. It is also
assumed that there is no fiscal externalities across regions. Transfers are assumed to be
allocated to the local governments instead of the residents.

Note that because of the model settings here, conclusions in this section do not interpret
the "flypaper effect", the fact that a grant is reinforcing more public investment than a
reduced rate of tax sharing. Many studies (e.g. Fan and Zhang, 2010) suggest a number of
reasons that can explain the "flypaper effect", such as the disincentives to tax collection, fiscal
illusion, interest groups and decision making based on median-voters and local government
objectives, to name a few.

4.6.1   Revenue Sharing Grant

Now suppose the central government uses a fraction, s, ($0 \leq s \leq 1$), of its collected revenue
as a revenue sharing grant. In China, s was over 50% of the total fiscal transfer before the
year 2000. Assuming regional allocation of this grant is based on weights proportional to the
tax collected from each region. There are studies that base allocation weights on population,
on tax base, or on per capita income. With the assumptions of exogenously set tax rate
and same population across regions, the weights in this section are based on the size of the
economy. In China, tax rebates are rule based, which tend to award rich regions much more
than the poor regions. Therefore, suppose each region receives a weight $w_i = \dfrac{\kappa \tau y_i}{\kappa \tau \sum y_i} = \dfrac{y_i}{Y}$.
With κ and τ set uniformly at the center, the weight is proportional to the relative size of

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[2]For the structure of fiscal transfer in China, see a discussion in Chapter 3.

the regional economy to the whole country. Richer regions receive more tax rebates. As before, suppose the central government consumes the rest of the collected taxes. Therefore, each region receives:

$$T_i = w_i s \kappa \tau Y = \frac{y_i}{Y} s \kappa \tau Y = s \kappa \tau y_i \tag{4.6.1}$$

The local government's budget constraint now becomes:

$$g_i^c + g_i^I = (1 - \kappa) \tau y_i + s \kappa \tau y_i = (1 - \kappa + s \kappa) y_i \tag{4.6.2}$$

Consider only the capital immobile case here as the capital mobile case will be similar with the reasoning above. The first order condition of the local government's maximization problem have become:

$$\frac{\partial y_i}{\partial g_i^I} = \frac{1}{\dfrac{\partial U_c^i}{\partial U_{g^c}^i}(1 - \tau) + (1 - \kappa + s \kappa) \tau} = \frac{1}{\dfrac{\eta(1 - \theta_i)\tau}{1 - \eta} + \tau} \left(\frac{1}{1 - \kappa + s \kappa} \right)$$

$$= M^o \left(\frac{1}{1 - \kappa + s \kappa} \right) < M^o \left(\frac{1}{1 - \kappa} \right) \tag{4.6.3}$$

The marginal contribution of public investment capital is lower than the case without a revenue sharing grant, $s = 0$. There is more public investment with the revenue sharing grant. By similar reasiong as in previous sections, equilibrium $\theta_i = \theta^{o*}$. Revenue sharing grant acts as a reduced rate of tax sharing. Instead of the sharing rate κ, the rate is now $(1 - s)\kappa$. Therefore, the effect of a revenue sharing grant is partially reversing the effect of tax sharing alone on the level and composition of public investment. Tax rebates that are pro-rich tend to reinforce the local expenditure toward public investment for the advanced regions.

With heterogenous regions differing in technology, the revenue sharing grant won't affect ratios between public investment in the lagging and advanced regions, either with or without land financing.

4.6.2 Equalization Transfer

An important factor of redistribution is an equity concern on the part of the central government. Knowing that public investment can be productive and attractive for private capital and eventually economic growth, the central government often uses the retained revenue for equalization purposes. This section looks at the effect of equalization transfers on the local governments' behavior.

Cross country studies have shown that countries adopt different kinds of equalization transfer rules, ranging from more subjective to more formula based rules (e.g. Bahl, 2000; Ahmad et al, 2002 and Shah, 2006). Weights for equalization transfers can be based on wealth measure (such as private capital endowment in Park and Philippopoulos, 2003), on expenditure levels (such as Qiao et al, 2008) and on difference to growth objectives (Cakir and Neyapti, 2007). In China, equalization transfers are not rule based, but in general the allocation of transfers is geared toward the lagging regions. This section, therefore, uses weights based on relative regional output to total output to reflect the pinciple that equalization transfers compensate lagging regions more.

Similar to the case with heterogenous regions, assume technological capacity $A_m > A_n$. Suppose the weight of equalization transfer to the lagging region is w. Suppose $w = (1 - \frac{y_n}{Y}) = \frac{y_m}{Y}$. If $y_m = y_n$, then it becomes a block transfer that returns all collected taxes to the original regions. With technology gaps increasing, the lagging region in this case gets all collected taxes from the advanced region. $\frac{w}{1-w} = \frac{y_m}{y_n} > 1$. The local government's budget constraint is:

$$g_i^c + g_i^I = (1 - \kappa)\tau y_i + T_i = (1 - \kappa)\tau y_i + \kappa \tau y_j \qquad (4.6.4)$$

Now the optimization of local government i not only faces its own budget constraint, but also takes the neighboring jurisdiction's budget constraint as given. Consider the capital immobile case and the capital mobile case can be extended through similar reasoning. Let

the Lagrangian be:

$$L = U[(1-\tau)y_i, g_i^c] + \lambda_1^i[(1-\kappa)\tau y_i + \kappa\tau y_j - g_i^c - g_i^I)] + \lambda_1^j[(1-\kappa)\tau y_j + \kappa\tau y_i - g_j^c - g_j^I]$$

The first order condition with respect to g_i^I becomes:

$$\frac{\partial y_i}{\partial g_i^I} = \frac{\dfrac{\partial U_i}{\partial g_i^c}}{\dfrac{\partial U_i}{\partial c_i}(1-\tau) + \dfrac{\partial U_i}{\partial g_i^c}(1-\kappa)\tau + \lambda_1^j \kappa\tau}$$

Additional public investment also benefits the neighboring region through the equalization transfer. To understand the shadow price λ_1^j, consider that the central government chooses τ to maximize the total utilities of residents in both regions and set τ to accomodate regional choices on public consumption and investment. The first order conditions show that λ_1^j is the shadow price of marginal utility from public consumption in the neighboring region, $U_{g^c}^j$. Therefore the above equation becomes:

$$\frac{\partial y_i}{\partial g_i^I} = \frac{1}{\dfrac{U_c^i}{U_{g^c}^i}(1-\tau) + (1-\kappa)\tau + \dfrac{U_{g^c}^j}{U_{g^c}^i}\kappa\tau} \tag{4.6.5}$$

and equilibrium shares of public investment for the rich and poor regions are:

$$\theta_m = \frac{g_m^I}{R_m} = \frac{g_m^I}{(1-\kappa)\tau y_m + \kappa\tau y_n} = \frac{1}{\dfrac{\partial y_m}{\partial g_m^I}\dfrac{}{\beta}[(1-\kappa)\tau + \kappa\tau\dfrac{1-w}{w}]} \tag{4.6.6}$$

and

$$\theta_n = \frac{g_n^I}{R_n} = \frac{g_n^I}{(1-\kappa)\tau y_n + \kappa\tau y_m} = \frac{1}{\dfrac{\partial y_n}{\partial g_n^I}\dfrac{}{\beta}[(1-\kappa)\tau + \kappa\tau\dfrac{w}{1-w}]} \tag{4.6.7}$$

Because $g_i^I \dfrac{\partial y_i}{\partial g_i^I} = \beta y_i$ and $\dfrac{w}{1-w} = \dfrac{y_m}{y_n}$.

Three equilibrium outcomes will be discussed here. First is when there is symmetric equilbrium in public investment shares across region. Second is when the levels of public

investment are equalized. The third outcome is that public investment is higher in the lagging regions than the advanced regions.

Suppose we look for symmetric equlibrium in public investment shares, so that $\theta_i = \theta$. Given equation (4.6.6) and equation (4.6.7), the equilibrium $\dfrac{\partial y_m}{\partial g_m^I} > \dfrac{\partial y_n}{\partial g_n^I}$. Because:

$$\frac{U_c^i}{U_{g^c}^i} = \frac{\eta g_i^c}{(1-\eta)c_i} = \frac{\eta(1-\theta)[(1-\kappa)\tau y_i + \kappa \tau y_j]}{(1-\eta)(1-\tau)y_i} \tag{4.6.8}$$

With $y_m > y_n$, we have:
$$\frac{U_c^m}{U_{g^c}^m} < \frac{U_c^n}{U_{g^c}^n}$$

Therefore, the relative levels of private to public consumption will be higher in the advanced regions. If $g_m^c \geq g_n^c$, the equilibrium level of public investment $g_m^I \geq g_n^I$ and equilibrium private consumption is higher in the advanced regions also. With equality in public consumption services holds, the equilibrium level of public investment also equals across region. The equilibrium private consumption $c_m > c_n$. Consumer welfare is higher in the advanced regions. If $g_m^c < g_n^c$, equilibrium level of public investment in the lagging region will also be higher. For this to happen, the technology and private capital endowments in the advanced regions need to be much higher than the lagging regions. The ratio of equilibrium level of private consumption across region may be uncertain. Thus equalization transfers that equalize the shares of public investment may also equalize the levels of public productive capital and consumption services. The consumer welfare, however, may still be lower in the lagging regions.

If the central government sets τ and κ so that there is symmetric equilibrum in the level of public investment $g_m^I = g_n^I$, then results depend on the tax sharing rate κ. When $\kappa \geq \dfrac{1}{2}$, $\theta_m \geq \theta_n$. The equilibrium share of public investment is higher in the advanced region. The relative size of marginal contribution of public investment to output is uncertain across regions, dpending on the technology and private capital endowment. With equation (4.6.8), $\dfrac{U_c^m}{U_{g^c}^m} < \dfrac{U_c^n}{U_{g^c}^n}$. If the equilibrium level $g_m^c = g_n^c$, then share of public investment equals across region also. The equilibrium consumption level $c_m > c_n$. The provision of public investment

and consumption services is equalized across regions, but consumer welfare in the lagging regions is lower. If $g_m^c < g_n^c$, the ratio of equilibrium level of private consumption across region is uncertain. The equilibrium share of publc investment in the advanced region is higher. Therefore, when tax sharing rate is high, there is a possiblity for the provision of public goods, both productive capital and consumption services, to be equal across regions, but it does not equalize consumer welfare.

If $\kappa < \frac{1}{2}$, $\frac{\partial y_m}{\partial g_m^I} > \frac{\partial y_n}{\partial g_n^I}$ and $\theta_m < \theta_n$. In this case, it is uncertain whether $\frac{U_c^m}{U_{g^c}^m} < \frac{U_c^n}{U_{g^c}^n}$, depending on parameter values and endowment gaps. With $g_m^I = g_n^I$ and $\theta_m < \theta_n$, the equilibrium level of public consumption services is lower in the lagging regions, $g_m^c > g_n^c$.

Therefore, an equalization transfer that equalizes the levels of public investment across regions may equalize the provision of public consumption services if the tax sharing rate is high. In the case when public consumption services equal, the equilibrium consumer welfare is lower in the lagging region. If the tax sharing rate is low, equalization transfers that equalize the levels of public investment across regions may not be able to equalize public consumption services such as health care.

Consider the last case when the equilibrium $g_m^I < g_n^I$, when public investment in the lagging regions turns out to be higher than the advanced regions. When $\kappa \geq \frac{1}{2}$, $R_m \leq R_n$. The ratio of equilibrium share of public investment across region is uncertain. Whether marginal contribution of public investment in the advanced region is higher or not is uncertain either, depending on technology and private capital endowment. When $\frac{\partial y_m}{\partial g_m^I} > \frac{\partial y_n}{\partial g_n^I}$, which implies that the technology and private capital endowments are much larger in the advanced regions, $\theta_m < \theta_n$. It is uncertain whether $\frac{U_c^m}{U_{g^c}^m} < \frac{U_c^n}{U_{g^c}^n}$ or not. If $\frac{\partial y_m}{\partial g_m^I} \leq \frac{\partial y_n}{\partial g_n^I}$, then $\theta_m > \theta_n$ and $\frac{U_c^m}{U_{g^c}^m} < \frac{U_c^n}{U_{g^c}^n}$. Because $g_m^I < g_n^I$ and $\theta_m > \theta_n$, the equilibrium level of public consumption services is much lower in the advanced regions. When tax sharing is high and that the lagging regions strive to have a higher public investment, the advanced region may hurt.

If $\kappa < \frac{1}{2}$, $\theta_m < \theta_n$. Therefore, given eq 4.6.6 and eq 4.6.7, $\frac{\partial y_m}{\partial g_m^I} \leq \frac{\partial y_n}{\partial g_n^I}$. Whether

$\frac{U_c^m}{U_{g^c}^m} < \frac{U_c^n}{U_{g^c}^n}$ is uncertain. But with $g_n^I > g_m^I$, $g_m^c \geq g_n^c$. Public consumption services is higher in the advanced region. When tax sharing is low, lagging regions may have a higher level of public investment capital, but its public consumption service is lower than the advanced region.

These three outcomes show that equalization transfer may achieve equalization in the provision of public investment and public consumption services. However, consumer welfare in the lagging regions may still be lower than the advanced regions. When the level of public investment in lagging regions exceed that of the advanced regions, they have to give up more public consumptions when tax sharing rate is low. Equalization transfers with the objective to equalize the share or level of public investment may not be able to equalize consumer welfare across regions.

4.7 Conclusion

This chapter addresses the reasons behind the increasing public investment within a theoretical model based on the China context. It shows that consistent with other literature, competition for mobile capital has been an important factor. The government's GDP orientation proves to be a key demand side element to understand the incentives for more public investment. It also finds that alternative financing resources from land value capture and land development enable even the lagging regions to increase the level and composition of public investment. This conclusion resonates the case of China. It contradicts the results from Cai and Treisman (2005) that predicts lagging regions with large technology gaps tend to experience a vicious cycle from limited public investment. This may be good news for the lagging regions, but may also be bad news if they lack the capacity to manage large amount of resouces. Fiscal transfers have a role to play to affect the level and composition of public investment. While revenue sharing grant is likely to reinforce regional gaps, equalization transfers can increase the level and composition of public investment in the lagging regions, but consumer welfare may still be lower.

APPENDICES

APPENDIX A

TIME VARYING EFFECTS OF INFRASTRUCTURE CAPITAL

BY REGION (1990-2010)

The role of infrastructure, as discussed in Chapter 1, varies during different development stages. As China undergoes rapid economic growth with continuing reforms, the effects of infrastructure may be different over time. This appendix provides the regression results for the effects of infrastructure capital across the sample period by China's main regions. The structural breaks are selected according to infrastructure development over time. A summary of the findings are in Chapter 2 and Section 4.3.3.

Table A.1: Time varying effects of infrastructure capital - the Eastern region

(Dependent variable: $\ln(RGDPPC)_t$; *Method: dynamic fixed effects with robust standard errors)*

	1990-2010 (2.5.1)	2006-2010 (A.1.1)	1990-2005 (A.1.2)	2001-2010 (A.1.3)	1990-2000 (A.1.4)	1996-2010 (A.1.5)	1990-1995 (A.1.6)	1998-2002 (A.1.7)
Short run error correction coefficient								
	−0.149****	−0.458**	−0.146***	−0.232****	−0.145	−0.151***	−0.564	−0.177
	(−3.64)	(−2.40)	(−3.22)	(−4.70)	(−1.59)	(−2.64)	(−1.62)	(−0.46)
Long run cointegrating relationship								
Ln(RSPINV)	0.146**	0.00146	0.0452	0.121*	0.0298	0.121***	−0.074	−0.012
	(1.98)	(0.02)	(0.49)	(1.85)	(0.37)	(3.04)	(−0.61)	(−0.07)
Ln(RFDICY)	0.141*	0.195*	0.169	0.144**	0.196*	0.0895	0.0764	0.051
	(1.82)	(1.81)	(1.46)	(2.49)	(1.8)	(1.35)	(0.88)	(0.32)
Ln(GRADS)	0.439	0.208*	0.287	0.225****	−0.0478	0.384*	−0.0654	0.458
	(1.62)	(1.87)	(0.89)	(3.3)	(−0.13)	(1.7)	(−0.29)	(0.65)
Ln(RDEP)	0.266	0.658**	0.0165	−0.00422	0.0264	0.335	1.221	0.503
	(0.56)	(2.39)	(0.02)	(−0.02)	(0.02)	(0.86)	(1.3)	(0.24)
Ln(ELECPDMP)	−0.309	0.106	−0.649***	0.26	−0.729	0.272	0.0721	−1.022
	(−1.39)	(0.7)	(−2.87)	(1.48)	(−1.11)	(1.42)	(0.13)	(−0.64)
Ln(HWMP)	−0.0215	0.679***	0.000112	0.0544	0.397	0.0339	1.038*	−0.127
	(−0.18)	(2.88)	(0.00)	(0.65)	(0.8)	(0.33)	(1.7)	(−0.23)
Ln(RWLENMP)	0.173	0.0349	0.0584	0.303	−0.122	0.363	0.0619	0.21
	(1.3)	(0.2)	(0.65)	(1.54)	(−0.50)	(1.58)	(0.33)	(0.32)
Ln(URTELESUBHP)	0.386****	−0.246	0.386**	−0.152	0.25	−0.177	0.896**	0.53
	(3.4)	(−0.83)	(2.46)	(−0.77)	(0.84)	(−1.15)	(2.56)	(0.36)

t statistics in parentheses
*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$, ****$p < 0.001$

Table A.2: Time varying effects of infrastructure capital - the Central region

(Dependent variable: $\ln(RGDPPC)_t$*; Method: dynamic fixed effects with robust standard errors)*

	1990-2010 (2.5.2)	2006-2010 (A.2.1)	1990-2005 (A.2.2)	2001-2010 (A.2.3)	1990-2000 (A.2.4)	1996-2010 (A.2.5)	1990-1995 (A.2.6)	1998-2002 (A.2.7)
Short run error correction coefficient								
	−0.230****	−0.469	−0.355****	−0.221	−0.486****	−0.126*	−0.555****	−0.138
	(−3.93)	(−1.06)	(−3.86)	(−1.61)	(−3.89)	(−1.67)	(−3.67)	(−0.18)
Long run cointegrating relationship								
Ln(RSPINV)	−0.0727	0.241	−0.0709	−0.011	−0.0394	−0.115	−0.0395	0.807
	(−0.61)	(0.64)	(−0.86)	(−0.03)	(−0.25)	(−0.37)	(−0.46)	(0.16)
Ln(RFDICY)	0.0377	0.0157	0.0279	0.0187	0.0393	−0.0242	0.116**	−0.613
	(0.81)	(0.11)	(0.96)	(0.12)	(0.64)	(−0.11)	(2.43)	(−0.13)
Ln(GRADS)	−0.0755	−0.384	−0.266***	−0.152	−0.127	−0.32	0.431	−0.195
	(−0.65)	(−1.62)	(−2.66)	(−0.64)	(−0.74)	(−0.67)	(0.93)	(−0.07)
Ln(RDEP)	0.395	−0.895	0.798	0.572	0.761	1.325	−0.671	2.931
	(0.71)	(−0.84)	(1.11)	(1.2)	(1.05)	(0.66)	(−0.95)	(0.21)
Ln(ELECPDMP)	0.923**	0.701	0.959****	1.049***	0.62	2.271	−1.19	−0.208
	(2.56)	(1.4)	(4.06)	(2.77)	(1.23)	(1.41)	(−1.56)	(−0.02)
Ln(HWMP)	−0.176	0.880**	−0.466**	0.0362	−0.316	−0.216	3.313**	0.482
	(−1.42)	(2.27)	(−2.26)	(0.13)	(−0.94)	(−0.72)	(2.4)	(0.06)
Ln(RWLENMP)	0.223	−0.649	0.239****	0.114	0.135	0.0114	0.731****	−2.675
	(1.11)	(−0.80)	(3.59)	(0.1)	(0.68)	(0.02)	(4.07)	(−0.16)
Ln(URTELESUBHP)	0.276**	0.103	0.203***	0.031	0.155*	0.165	0.190**	−0.265
	(2.04)	(0.27)	(3.10)	(0.09)	(1.87)	(0.38)	(2.00)	(−0.16)

t statistics in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$, ****$p < 0.001$

Table A.3: Time varying effects of infrastructure capital - the Western region

(Dependent variable: $\ln(RGDPPC)_t$*; Method: dynamic fixed effects with robust standard errors)*

	1990-2010 (2.5.3)	2006-2010 (A.3.1)	1990-2005 (A.3.2)	2001-2010 (A.3.3)	1990-2000 (A.3.4)	1996-2010 (A.3.5)	1990-1995 (A.3.6)	1998-2002 (A.3.7)
Short run error correction coefficient								
	−0.121	−0.403***	−0.259	−0.191****	−0.415**	−0.186	−0.208	−0.346***
	(−1.59)	(−2.75)	(−1.83)	(−4.70)	(−2.01)	(−1.76)	(−0.76)	(−2.68)
Long run cointegrating relationship								
Ln(RSPINV)	−0.524**	0.14	−0.378**	−0.174	−0.353****	−0.156	−0.587	0.0148
	(−2.14)	(0.8)	(−2.48)	(−1.33)	(−4.21)	(−1.25)	(−1.57)	(0.09)
Ln(RFDICY)	0.0541	−0.0745	0.0514	−0.103**	0.0406	−0.00464	0.09	0.0133
	(1.24)	(−1.70)	(1.50)	(−2.13)	(1.58)	(−0.14)	(0.93)	(0.51)
Ln(GRADS)	0.203	0.212	−0.0865	0.503****	0.00449	0.332	−0.0397	−0.0436
	(1.01)	(0.82)	(−0.55)	(3.63)	(0.03)	(1.75)	(−0.05)	(−0.34)
Ln(RDEP)	0.268	−0.0644	0.0724	−0.0742	0.195	−0.39	−0.985	0.322
	(0.4)	(−0.12)	(0.27)	(−0.23)	(0.67)	(−1.08)	(−0.43)	(0.77)
Ln(ELECPDMP)	0.563**	0.353**	0.166	0.735****	−0.00465	0.716****	0.231	−0.00695
	(2.01)	(2.09)	(0.76)	(6.19)	(−0.05)	(3.39)	(0.35)	(−0.04)
Ln(HWMP)	−0.368	0.246	−0.233	0.0494	0.0595	−0.0126	−0.299	−0.294***
	(−1.20)	(1.55)	(−1.83)	(0.75)	(0.25)	(−0.11)	(−0.12)	(−3.23)
Ln(RWLENMP)	0.464	0.23	0.159	0.102	0.0264	0.183	0.878	0.244
	(1.86)	(1.02)	(1.25)	(0.59)	(0.32)	(1.33)	(0.82)	(1.82)
Ln(URTELESUBHP)	−0.452***	−0.222	−0.252**	0.124	−0.115	−0.23	0.653	−0.137
	(−2.70)	(−0.52)	(−2.15)	(1.63)	(−1.29)	(−1.67)	(0.63)	(−1.18)

t statistics in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$, ****$p < 0.001$

Table A.4: Time varying effects of infrastructure capital - the Northeastern region

(Dependent variable: $\ln(RGDPPC)_t$; *Method: dynamic fixed effects with robust standard errors)*

|	1990-2010 (2.5.4)	1990-2005 (A.4.1)	2001-2010 (A.4.2)	1990-2000 (A.4.3)	1996-2010 (A.4.4)	1990-1995 (A.4.5)
Short run error correction coefficient						
	−0.170*	−0.282****	−0.516****	0.0562	−0.117****	0.0651
	(−1.73)	(−4.00)	(−3.62)	(0.24)	(−5.51)	(0.13)
Long run cointegrating relationship						
Ln(RSPINV)	0.385****	0.188	0.0359	−0.154	0.219	−0.0707
	(3.71)	(1.38)	(0.18)	(−0.17)	(1.57)	(−0.02)
Ln(RFDICY)	−0.115	−0.117	−0.0192	0.822	−0.290****	−0.0475
	(−0.84)	(−1.05)	(−0.33)	(0.26)	(−3.85)	(−0.05)
Ln(GRADS)	−0.156	0.26	0.291	−10.02	−0.381	−11.94
	(−0.33)	(0.55)	(0.87)	(−0.24)	(−0.63)	(−0.14)
Ln(RDEP)	−1.640****	−1.462**	1.554	12.11	−0.135	13.92
	(−3.78)	(−2.00)	(1.47)	(0.26)	(−0.09)	(0.13)
Ln(ELECPDMP)	1.026****	1.020**	0.271	−10.47	0.794**	−11.75
	(3.49)	(2.12)	(0.8)	(−0.26)	(2.47)	(−0.13)
Ln(HWMP)	0.501	0.173	−1.192****	6.073	0.0971	−4.293
	(1.25)	(0.4)	(−7.73)	(0.25)	(0.21)	(−0.22)
Ln(RWLENMP)	0.0874	−0.0746	−0.178	−4.488	−0.599*	−0.239
	(0.12)	(−0.37)	(−0.32)	(−0.24)	(−1.84)	(−0.07)
Ln(URTELESUBHP)	−0.237	−0.177	−0.555*	0.479	0.469	−4.933
	(−1.26)	(−0.53)	(−1.80)	(0.12)	(1.42)	(−0.27)

t statistics in parentheses

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$, ****$p < 0.001$

APPENDIX B

INFRASTRUCTURE STOCK

CHINA VS. OTHER MIDDLE-INCOME COUNTRIES

This appendix provides a cross country comparison between China and the upper and lower-middle-income countries in terms of their stock of four types of infrastructure: electricity, road, railway and telephone line. The income grouping is based on the World Development Indicators from the World Bank. In July 2011, China was reclassified from the lower-middle-income country to the upper-middle-income country by the World Bank.

Each graph presents the level of a particular type of infrastructure against the level of GDP per capita in 2005 prices for the latest year that data are available. Upper-middle-income countries are presented by the diamond sign, while the lower-middle-income countries the circle.

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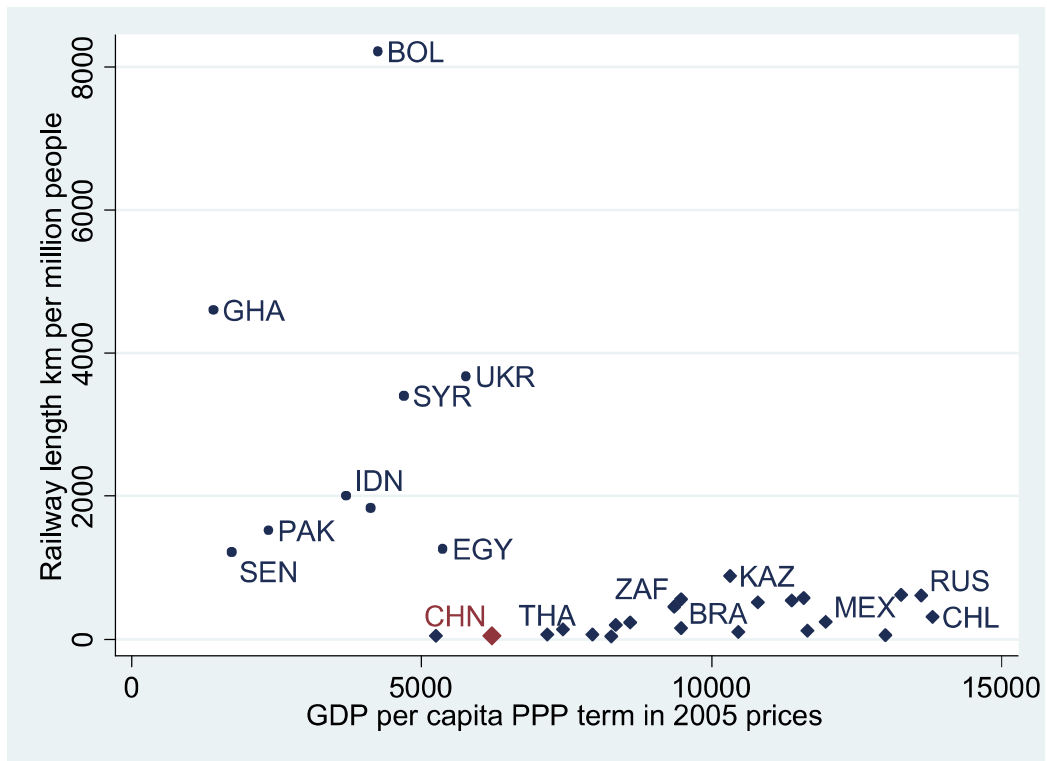
Figure B.1: Electricity production (2010)
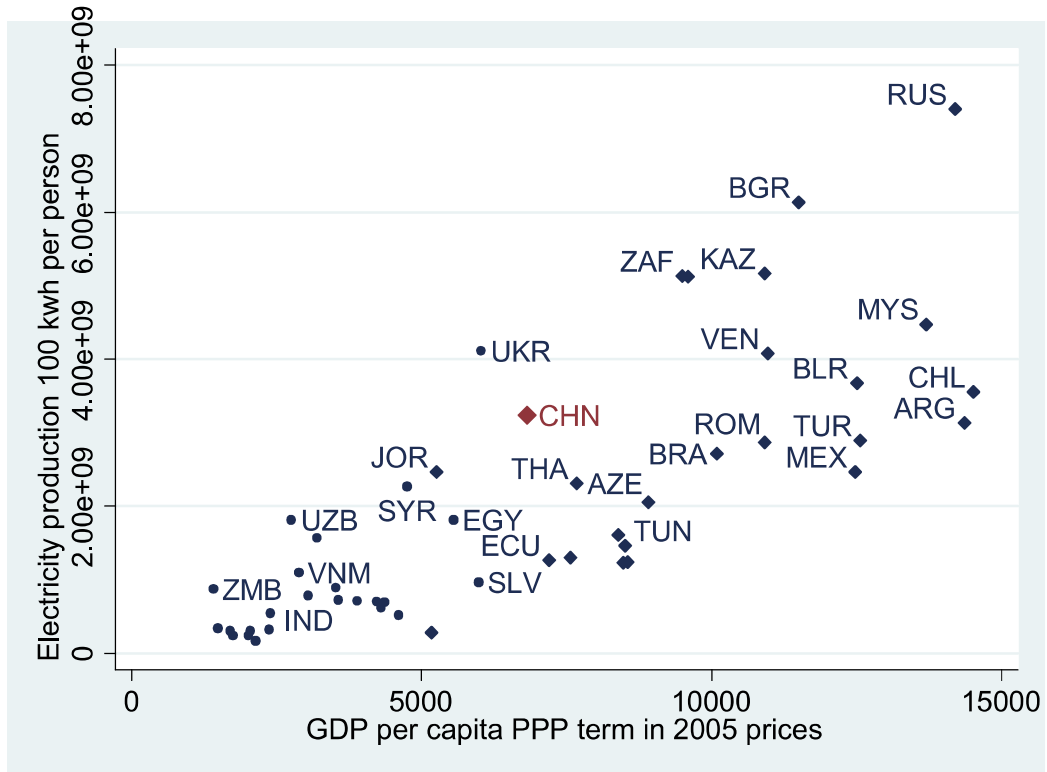
Source: *World Development Indicators, The World Bank*
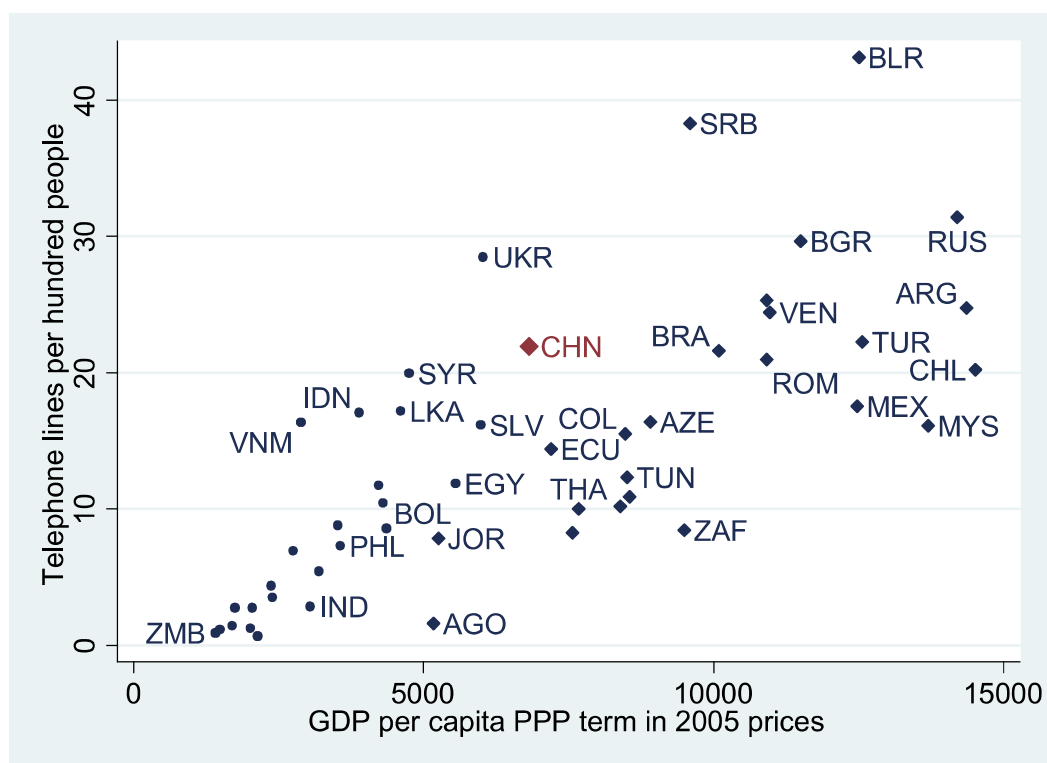
Figure B.2: Road length (2009)
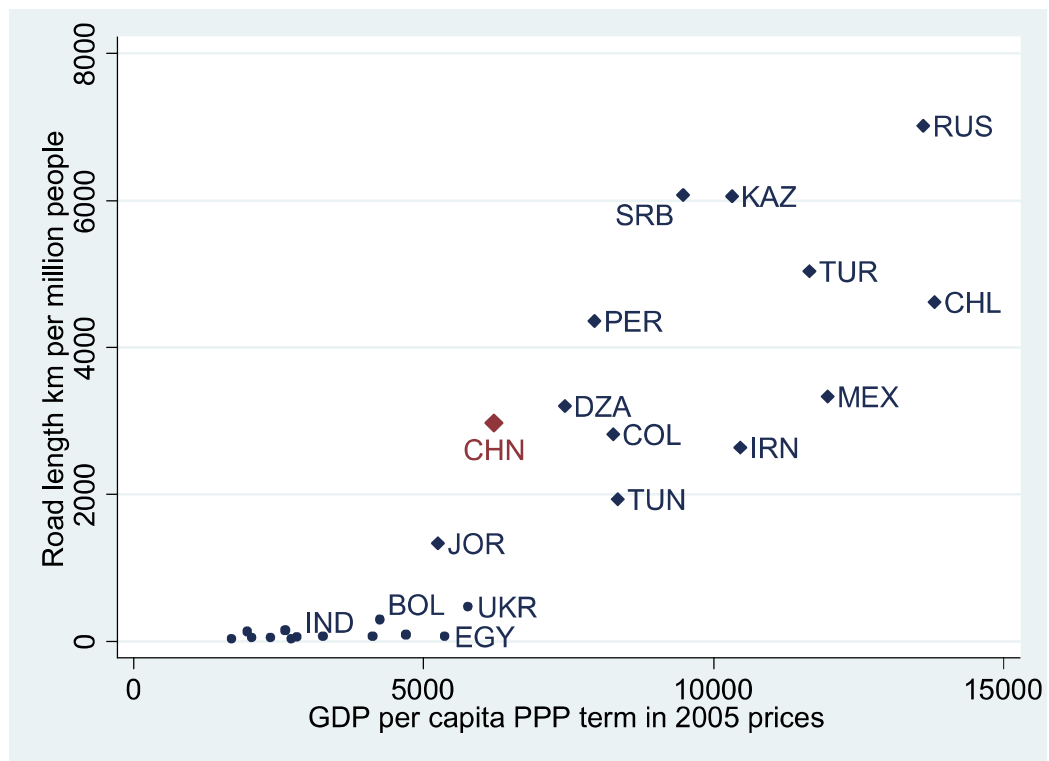
Source: *World Development Indicators, The World Bank*

Figure B.3: Railway length (2009)

Source: *World Development Indicators, The World Bank*

Figure B.4: Telephone line (2010)

Source: *World Development Indicators, The World Bank*

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