THE UNIVERSITY OF CHICAGO

LOCAL GOVERNMENT FINANCIAL CONSTRAINT AND SPENDING MULTIPLIER IN CHINA

A DISSERTATION SUBMITTED TO
THE FACULTY OF THE UNIVERSITY OF CHICAGO
BOOTH SCHOOL OF BUSINESS
IN CANDIDACY FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

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CHICAGO, ILLINOIS
JUNE 2023

TABLE OF CONTENTS

LIST OF FIGURES iv

LIST OF TABLES v

ACKNOWLEDGMENTS vi

ABSTRACT vii

1 INTRODUCTION 1

2 DATA 14

3 IDENTIFICATION STRATEGY 18
3.1 The "Land Finance" system 18
3.2 Measure raw land in the downtown area 22
3.3 The identification assumption 26
3.3.1 Relevance condition 26
3.3.2 Exclusion restriction 27

4 LOCAL GOVERNMENT SPENDING MULTIPLIER 44
4.1 Estimation framework 44
4.2 Empirical results 47
4.3 Heterogeneity of the multipliers 51
4.3.1 Local government debt capacity 51
4.3.2 Private input mobility 56
4.4 Characteristics of the fiscal experiment 58

5 MECHANISMS 60
5.1 Crowding-in of private inputs 60
5.2 The extent of input mobility 62

6 RESPONSES OF LOCAL FIRMS 66
6.1 Firm entry and firm size 66
6.2 Local firms' production and productivity 68

7 SPILLOVER EFFECT 73
7.1 Aggregate spillovers 73
7.1.1 Econometric framework 73
7.1.2 Empirical results 76
7.2 Technology diffusion and supply chain 79

8 CONCLUSION 83

REFERENCES 85

A DATA 90

B IDENTIFICATION STRATEGY 92
B.1 The Evolution of unoccupied land 92
B.2 Relevance condition 92
B.3 Exclusion restriction 94
B.4 Composition of new land supply 94

C LOCAL GOVERNMENT SPENDING MULTIPLIER 97
C.1 Definition of government spending 97
C.2 Regression results: 2SLS vs OLS 99
C.3 Multiplier in different sectors 99
C.4 The local government tax rate 103
C.5 The local governments' access to debt financing 103
C.6 Measurement of the debt ceiling-to-income ratio 105

D MECHANISMS 106

E RESPONSES OF LOCAL FIRMS 109
E.1 Population density and the effect of raw land proportion 109
E.2 Estimation of production function and TFPQ 110
E.3 More on the local firms' responses 113

F SPILLOVER EFFECT 116
F.1 Relation between sub-city- and city-level effect 116
F.2 Decomposition of direct and spillover effect 117
F.3 Measure downstream and upstream exposure 118

LIST OF FIGURES

1.1 Govt Infrastructure/Total Spending: China versus US 2

3.1 Local govt land sale revenue/budgetary expenditure 20
3.2 Geographical distribution of occupied land in Suqian, 2000 24
3.3 Estimating downtown boundary using occupied land for Shuyang 24
3.4 Parallel trend of cities and sub-cities with differential *raw* in various dimensions 33
3.5 The treatment effect of *raw* on land supply 38

4.1 Impulse Responses of Govt Spending and GDP 48
4.2 Marginal Effect of *raw* on City Government Spending 49
4.3 Estimated local govt spending multiplier 50

5.1 Marginal Effect of *raw* on Private Input 61
5.2 The direct effect from input increase 63
5.3 Implied share of immobile input 65

6.1 Marginal effect on firm entry and firm size 67

7.1 Decomposition of GDP Effect for 1% Increase of raw 78

B.1 Estimated downtown boundary: 2000 vs 2015 92
B.2 Patterns of City-level *raw* in 2000 93
B.3 Patterns of City-level *raw* in 2000 93
B.4 Illustration of urban and rural land requisition 95
B.5 *raw* and urban and rural land requisition 95

C.1 Definition of local government spending 97
C.2 State Fixed Capital Investment vs Urban Facility Fixed Investment 98
C.3 Local government spending multiplier in different sector 102
C.4 The annual change of city budgetary expenditures vs GDP, 2001-2019 103
C.5 Local govt access to debt financing in China 104
C.6 Debt ceiling-to-income ratio and govt spending growth 105

D.1 Marginal Effect of *raw* on Private Input 107
D.2 Marginal Effect of *raw* on Private Input 108

E.1 Population Density of central and satellite sub-cities 110
E.2 Marginal effect on accumulative govt spending of *raw* 111

LIST OF TABLES

2.1 Summary Statistics 16

3.1 City-level *raw* and land sale profitability 27
3.2 Correlation between *raw* and city characteristics in 2000 29
3.3 Urban Expansion and Urban Development: before versus after 2000 36
3.4 Treatment Effect of *raw* on the city's GDP 41
3.5 Sensitivity of estimates to the degree of selection on ubobservables 41

4.1 Government spending multiplier and debt capacity 54
4.2 Government spending multiplier and Private Capital Mobility 57

6.1 Government spending and local firms' output 70

7.1 Spillover effect on GDP within the city 77
7.2 Spillover effect of govt spending through supply chains 81

A.1 Variable definitions 90

B.1 Partial correlation between *raw* and city characteristics in 2000 94

C.1 The Two-Stage Least Square Estimation results 100
C.2 The OLS Estimation results 101

E.1 Pop. density and land demand 111
E.2 Government spending and firms' use of transportation services 114
E.3 Government spending and local incumbent firms' output 114
E.4 Local govt spending, population density and local firms' productivity 115

ACKNOWLEDGMENTS

I am grateful to my committee, consisting of Zhiguo He (chair), Raghuram Rajan, Eric Zwick, and Anthony Lee Zhang, for their invaluable guidance and unwavering support during the past two years of this project. Their insightful feedback and discussions have greatly benefited all aspects of the paper. The lessons learned from this experience extend beyond the scope of this project and will undoubtedly aid me in my future career pursuits.

I would like to express my deep gratitude to my family for their unwavering understanding and support throughout the past six years. Pursuing a doctoral degree abroad has presented its challenges, one of which is being separated from loved ones. I am immensely grateful to my family for allowing me to follow my dreams while they bore the pain of our separation.

ABSTRACT

I estimate the annual local government spending multiplier to range from 2.22 to 0.72 and the accumulated multiplier, which is the total increase of local output per 1 RMB increase of local government spending during 2001-2019, to be 11.8 at the prefecture city level in China, where government spending is known to have a significant impact on the supply side of the local economy. To achieve identification, I construct a novel instrument for local government spending: the fraction of unoccupied raw land in the downtown area in 2000. After 2000, as local governments increasingly rely on land sale revenues to finance expenditures, a higher fraction of unoccupied urban land is associated with less land requisition, which requires compensation to displaced occupants, and hence higher profits from land sales for local governments. Moreover, the fraction of raw land is orthogonal to a rich set of city fundamentals in 2000 thanks to the inefficient utilization of urban land before 2000. The multiplier is found to be significantly larger in cities where the local governments have smaller debt capacity and where the private capital is more mobile. Quantitatively, the crowding-in of private inputs following government spending - such as labor and capital - can explain over 70% of the output increase. At the firm level, government spending is found to improve local productivity and market access, and attract more firm entry. I also find significant and positive spillover effects of local government spending within each city. Overall, the paper highlights the macroeconomic importance of government spending targeting the supply side of the economy.

CHAPTER 1

INTRODUCTION

Government intervention in the form of fiscal spending in the private sector has been rising globally during the past decade. The primary interest lies in understanding the significant variation in the real effects of government spending. At the program level, Hendren and Sprung-Keyser [2020] reviews various government policies and finds that policies investing in children generate a higher return that others. On the aggregate level, the macroeconomic literature has shed light on factors that could affect the output effect of government purchase spending, which temporarily affects the demand side of the economy (Chodorow-Reich, 2019). However, relatively little is known about how government spending can affect the supply side on the aggregate level.

China provides an ideal setting to understand government policies that target the supply side of the economy. Although the central government has recently recognized the potential importance of policies targeting household consumption to promote economic growth, local government spending that focuses on the supply side - such as investment in public capital and other social infrastructure - has been vital for decades (Maskin et al., 2000). As Figure 1.1 illustrates, local governments in China constantly allocate a greater proportion of their spending to infrastructure than those in the US. Given China's persistent economic growth since the economic reforms in 1978, it is likely that local fiscal spending has played a significant and positive role. However, empirical evaluations of the efficiency of government spending in China have been scarce.

To estimate the causal effect of local government spending, it is crucial to identify exogenous variations in local government spending to address concerns about reverse causality and omitted variable bias.[1] In this study, I develop a novel instrument for local

1. Reverse causality can arise because economic growth can impact government spending through tax revenues, and examples of omitted variables are positive shocks that can favor economic growth and reduce central government financial support.

government spending in China after 2000 using the fraction of unoccupied raw land in the downtown area of each city in 2000. The relevance condition holds because with the rise of the land market since 2000, local governments can conduct land requisition, upgrade surrounding facilities and then sell the land, and local governments in cities with a higher fraction of unoccupied raw land incur lower compensation expense during land requisition and consequently enjoy higher profits from land sales. The exclusion restriction should also hold because in the data, the fraction of unoccupied raw land in the downtown area is orthogonal to both the level and the growth of various city characteristics in 2000, as well as major shocks after 2000, thanks to the inefficient utilization of urban land before 2000.

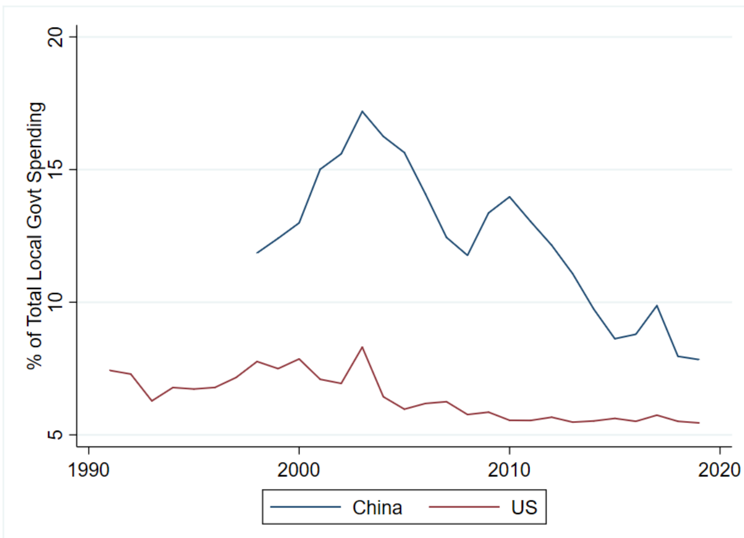


Figure 1.1: Govt Infrastructure/Total Spending: China versus US

Note: For China, the y-axis is the average percentage of government infrastructure investment spending across prefecture cities (see definitions in Section C.1); for the US, the y-axis is the average percentage of capital spending across states (data source: the State Expenditure Report of the National Association of Budget Officers).

With this instrument, I estimate that the accumulated government spending multiplier at the prefecture city level during 2001-2019, i.e., the increase of local output per 1 RMB increase of government spending, is 11.8 RMB, with the 95% confidence interval between 7 RMB and 16.6 RMB. The large multiplier can be attributed to the persistence of the effect of government spending. The annual multiplier, which represents the increase of real output in a single year when the total previous government spending increases by 1 RMB, ranges from 2.42 RMB and 0.72 RMB.

In the cross-section, the multiplier is significantly greater in areas with more limited government debt capacity and higher mobility of private capital. The mechanism is consistent with investment-based government spending models, where local government spending crowds in private inputs - such as labor, structural, and machinery capital - and this crowding-in of private inputs can quantitatively explain the aggregate output increase. At the firm level, local government spending is found to facilitate firm entry and enhance local productivity. Additionally, I observe considerable spillovers of local government spending across different regions within the same city.

I begin the empirical analysis by constructing a comprehensive panel dataset covering the city and sub-city level government budgetary expenditure, infrastructure investment and local economic activities. I utilize various statistical yearbooks compiled by multiple central ministries during 1996-2019. To examine the firm-level responses of government spending, I use the Firm Registry Information from the Industrial and Commercial Bureau, which includes the universe of firms registered before 2017, and the financial statements from the Annual Survey of Industrial Firms during 1998-2007.

The empirical strategy is based on the local governments' reliance on land sale revenues to finance their expenditures. Local governments in China can either acquire unoccupied land or requisition occupied land, sell it to the private sector, and use the profits from land sales to finance urban development. This practice is often referred to as "land finance" (Lin and Yi, 2011; Liu et al., 2014; He et al., 2022). The commercial land market in China was formalized around 2000, and since then, land finance has gradually become a significant source of income for local governments.

One important feature of land finance is that the profitability of land sales depends on the availability of unoccupied raw land in the downtown area. This is because urban land requisition requires a fair amount of compensation to displaced occupants and rural land requisition requires not only compensation but also creation of new agricultural land. In contrast, the unoccupied urban land requires no such expenses. Therefore, cities with a higher fraction of raw land in the downtown area in 2000 benefit more from the rise of the land market.

Building from the urban map developed by Liu et al. [2018], I calculate the fraction of unoccupied raw land in the estimated downtown area in 2000 ("*raw*" hereafter) for each city as well as the sub-city. The calculation of *raw* takes two steps. First, since most occupied and developed land locates in the downtown area, I estimate the downtown area as the large cluster of occupied and developed land. Second, I calculate the fraction of unoccupied raw land within the estimated downtown boundary.

The empirical strategy is to use *raw* as an instrument for local government spending after 2000. I start by examining the identification assumptions. First, the relevance condition holds. In the cross section of cities, higher *raw* is found to lead to significantly higher land sale profitability and less urban land requisition, consistent with the conjecture that *raw* captures the governments' compensation expense to occupants.

Second, regarding the exclusion restriction, I find that *raw* is orthogonal to a rich set of city characteristics in 2000. After controlling for provincial heterogeneity with the province fixed effect, *raw* is not significantly correlated with any measures of (1) local economic activities such as GDP, employment and the number of manufacturing firms; (2) government spending and initial infrastructure such as infrastructure investment and road area; (3) local firm characteristics such as productivity and various input use; and (4) land policies, such as land supply, land price and land zoning. As I will adopt the DID estimation strategy using *raw* as the treatment after 2000, I further show that cities with differential *raw* exhibit parallel trends before 2000 in all the outcome variables mentioned above. These results support the assumption that *raw* is orthogonal to the city fundamentals in 2000.

Why was the downtown land occupancy status uncorrelated with city fundamentals in 2000? Economic development typically increases land value and reduces the proportion of unoccupied land in the downtown area if the local government land allocation is efficient. In fact, the inefficiency of urban land use before 2000 was widely acknowledged by the central government in various official documents. Prior to 2000, urbanization was characterized by significant outward expansion into the agricultural land, with poor utilization of existing urban construction land. Outward urban expansion was more attractive due to poor enforcement of agriculture land protection laws before 2000. In the late 1990s, protection for agriculture land began to be strictly enforced and urban development shifted from outward expansion to better utilization of existing urban land. In the data, urbanization before 2000 was significantly and positively correlated with outward expansion but not urban land utilization, and such relationships were reversed after 2000.

In addition to its orthogonality, *raw* is also unlikely to be correlated with other local shocks to economic growth after 2000. One concerning factor that may be correlated with *raw* is land supply. A higher value of *raw* may imply more space for development, which can lead to faster economic growth through the land supply channel instead of the government spending channel. However, the DID estimation with the panel of cities revealed no significant and minimal treatment effect of *raw* on the net land supply to the private sector, i.e., the supply of land to the private sector using either unoccupied urban or agricultural land.[2] This finding indicates that the instrument fundamentally

2. Though higher *raw* does result in more land supply using the urban unoccupied land, it also leads to less rural land requisition and hence no effect on total land supply. Relatedly, the geographic composition of newly supplied land is affected. Nevertheless, since the median downtown area in 2000 is only 31 square kilometers, rural land adjacent to the peripheral downtown area is not significantly distant from

different from Saiz's instrument (Saiz, 2010) that employs geographic characteristics to instrument land supply.

To assess the omitted variable biases due to other potentially correlated shocks, I follow Oster [2019] to examine the sensitivity of treatment effects to the inclusion of observed controls. If a coefficient remains stable after inclusion of the observed controls, it indicates that omitted variable bias is limited. To implement Oster's approach, I estimate the treatment effect of *raw* on the city's GDP growth after 2000. I include the time-varying effect of starting point (i.e., GDP and government spending in 2000), the city's historical growth rate before 2000, its exposure to WTO shock and cyclicality. The quantitative analysis reveals that in order for the true effect to be 15% smaller than the treatment effect estimated with these controls, the degree of selection on other unobservables must be more than 5 times larger than that on all these observables. This suggests that the omitted variable bias, if any, is unlikely to have a significant quantitative impact.

Using *raw* as an exogenous shock to local government spending after 2000, I first document the impulse responses of local government spending and local GDP. Specifically, I estimate the treatment effect of *raw* on the present value of accumulated real local government spending and real GDP after 2000, using 2000 as the treatment year and controlling for province-by-year fixed effects.[3] The results show that the effect of *raw* is significantly positive and increasing for both the accumulated spending and GDP. When *raw* increases by 1%, the present value of accumulated government spending rises by approximately 38.7 RMB per capita, or 1.4 RMB per 100 RMB of accumulated land sale revenues, up until 2019. The present value of accumulated GDP increases by around

the average land within the downtown area, and such small difference in land geographic composition is unlikely to have any meaningful effect on output growth after 2000 across different cities.

3. The definition of local government spending includes spending financed by local tax revenues, central transfers and net debt issuance and excludes compensation expenses to removed occupants and the operation of social security funds. I adjust the nominal spending and GDP using the GDP deflator and the price in 2000.

474.6 RMB per capita during the same period.

Regarding the composition of government spending, the marginal propensity to spend on infrastructure investment has been high. During 2001-2004, about half of the increase in government spending is on infrastructure investment. The propensity decreases over time and is about 0.2 in 2019. The decreasing trend likely reflects fewer opportunities of infrastructure investment over time.

In line with the macroeconomic literature (Ramey, 2020), I define the multiplier as the ratio of the present value of the increase in output to that of government spending. The estimated multiplier is about 5 during 2001-2004, and it gradually increases over time, converging to around 11.8 in 2019, with the 95% confidence interval between 7 and 16.6. The increasing trend of the multiplier is consistent with predictions of models with government investment spending as government investment spending has a larger impact in the long run.

The annual multiplier, which indicates the increase in local output in a single year when the accumulated government spending since 2000 increases by 1 RMB, is estimated to be around 2.22 in the first few years after 2000. It then gradually decreases over time and reaches approximately 0.72 in 2019. Similar to the decreasing trend of the marginal propensity to invest, the decreasing trend of annual multiplier also indicates few investment opportunities over time.

As reviewed by Chodorow-Reich [2019], typical estimates of the local multiplier range from 1 to 2. These estimates usually examine the effect within 2 years, which makes them more comparable to the annual multipliers presented in this paper. In this regard, the multiplier in this paper is similar to existing findings. However, the significant difference lies in the persistence of the effect of government spending targeting the supply side, as compared to the effect of spending targeting the demand side.

Most relevant to government spending targeting the supply side, I investigate two aspects of heterogeneity of the multiplier. Firstly, the multiplier is found to be significantly smaller in cities where local governments have a larger debt capacity. Given the strong motivation of local officials to boost economic growth, a high multiplier can only exist in an equilibrium when local governments face financial constraints. Without any financial constraints, local governments would increase borrowing and spending and bring down the multiplier.

Secondly, for government spending that benefits the supply side to generate a substantial impact on local output, the supply side must respond. Theoretically, government spending that increases the local public capital or enhances intangible social infrastructure can increase the productivity of other inputs, leading to the crowding-in of private inputs and a larger effect on local output (Baxter and King, 1993). The responses of private capital depends on the mobility of capital. Using the measure of capital mobility proposed byLai et al. [2013], I find that the multiplier is significantly higher in cities with greater capital mobility. This result suggests that the impact of government spending on the supply side is more substantial when cities have a higher degree of capital mobility.

To provide direct evidence of the crowding-in of private inputs and their quantitative significance, I calculate the stock of structural and machinery capital for each city and year. Firstly, in line with models on government investment spending, I find that a higher *raw* leads to a significantly increase in employment and the stock of both structure and machinery capital. Secondly, to examine the quantitative importance of the crowding-in effect, I multiply the increase of private inputs with their marginal output, which is assumed to be wage for labor and is calculated as required return of private capital plus depreciation and minus price change for capital. With a reasonable assumption about the required return of private capital (Bai et al., 2006, Chen et al., 2019), the effect of increased inputs can explain over 70% of the increase of local output in every year after 2000.

In addition to examining the aggregate effect, I investigate how government spending affects the local economic structure by analyzing the responses of local firms. On the extensive margin, government spending can attract more firms, with no impact on the average firm size. On the intensive margin, local firms benefit in terms of both productivity and market access. Using data of industrial firms during 2001-2007, I estimate that a 1% increase of *raw* can increase the local firms' real output by 0.33%. Roughly half of this effect is due to the increase of material uses, 1/4 due to the increase of input utilization, and the other 1/4 due to the increase of productivity. Furthermore, the effect is larger for firms in industries that use more transportation services. These results suggest that government spending benefits local firms by increasing access to a more extensive market.

The spillover effect of local government spending on other places are of great interest both in the literature and to policy makers. I do not find evidence of spillovers across neighboring cities. Within each city, however, there could be spillover effects across different sub-cities as sub-cities within the same city are very integrated. Using *raw* on the sub-city level, I find significant and positive spillovers across different sub-cities. Evidence at the firm-level suggests that such spillovers occur through technology diffusion and supply chain linkages.

Literature Review. This paper fits into the literature on government spending multiplier. As discussed by Ramey [2020], both the mechanism and the magnitude of the government spending multiplier depend on the economic setting, such as whether government spending is consumption or investment. In the neoclassical approach, government consumption reduces the wealth of households, who respond by raising their labor supply. The rise in labor supply induced by the wealth effect is the key mechanism by which an increase in government spending raises output. In contrast, government investment increases the marginal output of capital and labor in the future, leading to higher labor demand and crowd-in of private capital. In the long run, the effect of government investment spending is higher than that of government consumption spending.

The recent revival of research, as reviewed by Chodorow-Reich [2019], mostly focuses on the general local government spending in the US, which is dominated by government consumption as shown in Figure 1.1. For example, Adelino et al. [2017] study changes of local government spending caused by bond rating adjustment, and find the effect is through government demand in the non-tradable sector and transfers and grants to the education sector. The American Recovery and Reinvestment Act (ARRA), enacted in early 2009 in the depths of the Great Recession, provides an opportunity to study the government investment multiplier because the ARRA grants to states were notionally intended for specific categories of spending, and some papers focus on the infrastructure portion. However, as pointed out by Dupor [2017] and Chodorow-Reich et al. [2012], states were capable of making the grants effectively fungible and the increase of local government spending was not limited to the targeted categories. The fungibility is one of the reasons why papers that study the infrastructure portion of the ARRA barely find any significant effect on employment (Leduc and Wilson, 2017, Dupor, 2017, Garin, 2019).[4] Another strand of papers focus on a specific type of government consumption spending, military purchases. Ramey and Shapiro [1998] studies the effect of US government military purchases using plausibly exogenous military shocks with the time series data, and Nakamura and Steinsson [2014] and Auerbach et al. [2020] study the cross sectional variation of government military purchases. Overall, Chodorow-Reich [2019] concludes the local government spending multiplier is about 1.8.

Some earlier papers focus on government investment in public capital. With annual US data during 1949-1985, Aschauer [1990] estimates that $1 increase of public infrastructure is associated with approximately $4 increase of annual output. Baxter and King

4. Other reasons include the delays between appropriations and actual outlays (Leeper et al., 2010), and the short horizon of these studies.

[1993] estimate that with the public capital productivity estimated by Aschauer [1989], the government investment multiplier is 13.02 when capital and labor responds to the permanent improvement of public capital. The early research, however, all suffers from the endogeneity issue of public capital investment and the anticipation effect of future government spending (Ramey, 2011a).

Little recent effort has been made towards better identification. Leduc and Wilson [2013] is an exception. They exploit the mechanisms by which the federal highway grants are apportioned to states to construct forecasts of current and future highway grants for each state and year during 1993-2010. They then use the change of expected future highway grants as measure of shocks to state highway spending and analyze the dynamic impulse response of economic activities to the highway spending shocks. They find considerably larger multipliers: the average annual output multiplier over a ten-year horizon is 1.3, roughly 2.7 on impact and 6.2 at peak. A more extensive literature has documented the causal effect of infrastructure on local economic activities, such as highways (Fernald, 1999, Duranton and Turner, 2012, Duranton et al., 2014) and telecommunications (Roller and Waverman, 2001), but they do not give direct estimates of multipliers.

As the literature is dominated by settings where government spending is consumption, my paper contributes by studying the long-run government spending multiplier in a setting where local government spending loads more on investment and mainly affects the supply side. Moreover, the local government spending may be more effective in a country like China where local officials' promotion is closely linked to the local economic performance (Maskin et al., 2000, Li and Zhou, 2005, Xiong, 2018). The career incentive may make local officials allocate resources in a more efficient way to help economic growth.

Very few studies have examined the government spending multiplier in China. Li and Zhou [2021] use changes of central-local connections as exogenous variation in earmarked transfers received by prefectural city-level governments and find the spending multiplier above one. Unfortunately, their sample size is very small and the changes of central-local connections may affect local economy through other confounding channels. Some other papers use the panel vector autoregression (VAR) method (Wang and Wen, 2019, Zhang, 2020). However, as pointed out by Ramey [2011a,b], most changes in government spending are anticipated, which can invalidate inferences from procedures that do not account for anticipations. Causal inference using VAR also relies on the underlying economic theory and can be biased if missing any relevant economic variables (Stock and Watson, 2001).

The international evidence based on settings involving government investment, especially using data from developing countries, has been sparse. Henry and Gardner [2019] survey evidence across numerous countries and conclude that in only a minority of countries do infrastructure projects, such as paved roads and electricity, clear the required hurdles. Izquierdo et al. [2019] use a variety of identification methods with data from Europe, US and Argentina and find that the multiplier on public investment is very high in places that start with low levels of public capital.

This paper is also related to the literature on corporate financial constraint. Governments who are financially constrained to make investment is analogous to firms. The local governments behave like firms as they manage the cities and finance the investment in infrastructure and other public goods with tax and land sale revenues as well as debt issuance (Tiebout, 1956; Boskin, 1973; Fisher, 2018), although their objective can be much more complex than maximizing profits. The firms' financial constraint, due to frictions in the financial markets (Jensen and Meckling, 1976; Myers and Majluf, 1984), distorts investment behaviors (Fazzari et al., 1987; Kaplan and Zingales, 1997; Zwick and Mahon, 2017; Whited, 1992). So does the government financial constraint. Despite the vast literature on corporate financial constraint, few papers study the effect of the government financial constraint, which is likely to have important macroeconomic consequences in a context where the local government plays an active role in promoting local economic growth.

The rest of the paper is organized as follows. I describe the data in Chapter 2, introduce the identification strategy in Chapter 3, show the estimation of local government spending multipliers in Chapter 4, document the crowding-in of private inputs in Chapter 5 and the firm-level responses in Chapter 6. Finally in Chapter 7, I provide a framework to estimate the within-city spillovers and show two channels of the spillovers, i.e., technology diffusion and supply chain. I conclude in Chapter 8.

CHAPTER 2

DATA

I construct a comprehensive panel data about the local government fiscal statements and economic conditions from various sources. In 2019, China consists of 336 prefectural cities; each city consists of multiple sub-cities and there are 2215 sub-cities in total.[1] I first collect the city and sub-city level economic variables, such as GDP, GDP in the secondary and tertiary sector, population, budgetary expenditure and revenue, from the annual Urban Statistic Yearbooks during 1996-2019, which are compiled by the National Bureau of Statistics (NBS). The city level data also includes other economic variables such as real estate investment, total employment, and average wages. Although not frequently, the geographic composition of cities and sub-cities vary over time. As the base year of the analysis in this paper is 2000, I adjust the data of GDP, population, budgetary expenditure, and revenue based on the geographic composition defined in 2000.

The budgetary expenditures and revenues data are often missing in the Urban Statistic Yearbooks in the early years. To address this issue, I have supplemented the data with information sourced from the Fiscal Statistical Yearbooks of all sub-cities that are available prior to 2008. These yearbooks are compiled by the Treasury Department of the Ministry of Finance. The data is at the sub-city level and I aggregate them to the city-level using the geographic composition defined in 2000.

The urban infrastructure investment and land zoning data are from the Urban Construction Statistic Yearbook from 1991 to 2019, which are published by the Ministry of

1. There are three types of sub-cities according to the administrative classification: Xian, Xianjishi and Shixiaqu. The governments of Xian and Xianjishi enjoy a fair amount of independence in terms of local policies and finance, while the governments of each Shixiaqu are at the direct leadership of the city governments. Therefore, it is common practice to treat each Xian and Xianjishi as one sub-city and group all the Shixiaqu's within each city as one sub-city. For example, the statistic yearbooks only report statistics for all the Shixiaqu as a whole.

Housing and Urban-Rural Development. The data only covers the sub-city of Shixiaqu and Xianjishi but not Xian. There are 667 of the two covered types of sub-cities, and they account for about 80% of total GDP in 2019. I hand collect all the tables from the original files to ensure data accuracy. I do not find the yearbooks for the year of 1995-1997.

The land supply data is compiled from various sources. The city-level annual land supply data is from China's Land and Resources Statistical Yearbook from 1999 to 2016. For 2017-2019, I aggregate the transaction-level data from the Ministry of Natural Resources to the city-year level.[2] The annual land requisition data is taken from the Urban Construction Statistic Yearbook which is on the sub-city level, and I aggregate it to the city-year level.

The firm level data are taken from the Annual Survey of Industrial Firms during 1998-2007 conducted by the NBS. The data includes all firms in the manufacturing, mining, and utility sector with annual sales above a threshold. It contains detailed firm-level financial information and has been used widely in the literature.

Finally, to get the annual number and registered equity of active firms at the city level, I use the Firm Registry data from the Industrial and Commercial Bureau, which hosts basic information such as industry, establishment date, exit date, and location for all firms in China. I select firms in the manufacturing sector and calculate the number of firms that have established and not yet exited for each year and each city.

Table 2.1 describes all the data used in the paper, and Table A.1 in the appendix provides the definition of each variable.

2. To ensure the continuity and consistency of data from before and after 2016, I have aggregated transaction-level data for each city and year during the period of 2007-2016 and compare it to the data from the statistic yearbook. The result from the aggregation perfectly aligns with the yearbooks.

Table 2.1: Summary Statistics

Panel A: City level data

Obs		Mean	Median	St. Dev.	Obs
City	raw	0.55	0.58	0.24	337
	InfraInvt2Sale	0.38	0.21	0.55	310
	requi2supply	0.43	0.28	0.44	304
	CitySpillover	0.56	0.56	0.04	337
	Cyclicality	1.33	1.38	5.63	284
	WTOShock	0.04	0.01	0.10	284
	Historical Growth	0.20	0.21	0.15	282
	DTI	0.03	0.01	0.06	267
	DCTI	38.02	33.70	20.53	271
City-Year	log(GDP)	6.41	6.41	1.27	6748
	log(GDP_sec)	5.62	5.69	1.34	6735
	log(GDP_ter)	5.42	5.37	1.36	6717
	log(GDP_nr)	6.38	6.38	1.19	6525
	log(Stru)	4.23	4.40	2.09	6248
	log(Mach)	6.09	6.23	1.64	6238
	log(Emp)	3.40	3.35	0.78	5539
	log(Wage)	9.83	9.86	0.84	6248
	log(POP)	5.84	5.89	0.70	6770
	log(#Mfr)	8.02	7.97	1.36	6248
	NetLandSupply	1.29	0.79	2.20	6465
	log(BudExp)	4.31	4.40	1.44	6799
	log(BudRev)	3.53	3.49	1.50	6775

Panel B: Sub-city level data

Obs		Mean	Median	St. Dev.	Obs
Subcity	raw	0.53	0.58	0.27	2227
	popden	0.04	0.02	0.12	2342
Subcity-Year	log(GDP)	4.03	4.05	1.50	48611
	log(InfraInvest)	9.85	9.85	1.93	16329
	log(TranspInvest)	8.94	8.91	2.13	16182
	log(Road)	5.73	5.65	1.16	16437
	log(WaterPipe)	5.79	5.71	1.15	14910
	log(DrainPipe)	5.27	5.17	1.25	16425
	log(LandSupply)	3.78	3.97	1.63	29014
	log(LandPrice)	6.13	6.16	1.09	29014
	pubfac	0.11	0.11	0.05	15540
	munuti	0.04	0.03	0.03	15464

Panel C: Firm level data

Obs		Mean	Median	St. Dev.	Obs
Firm-Year	log(Capital)	8.31	8.26	1.74	1625648
	log(Labor)	4.58	4.51	1.13	1634431
	log(Material)	9.37	9.32	1.47	1619005
	log(Q)	9.19	9.25	1.56	744940
	log(Output)	9.70	9.63	1.42	1619438
	log(price)	0.18	0.10	0.39	726750
	ROA	0.07	0.03	0.14	1603150

CHAPTER 3

IDENTIFICATION STRATEGY

3.1 The "Land Finance" system

Local governments in China are financed by a combination of three income sources. In 2019, they receive 10 trillion RMB from local government budgetary revenues, 7.5 trillion RMB from the central government transfer payments, and 8 trillion RMB from local government-managed funds, of which 7.3 trillion RMB is from land sales.[1] The budgetary revenues consist of various taxes. The local government follows the uniform tax rates set by the central government and shares the tax revenues among different layers of the governments according to the scheme set by the central and provincial governments (He et al., 2022, Wu and Zhou, 2015). The central government transfer system is designed to balance the government fiscal capacity across regions. The last component is from sales of urban construction land. The sub-city government intermediates almost all transactions of urban construction land by taking either raw or occupied land, determining the land zoning, upgrading the surrounding facilities, and selling the land use rights to the private sector such as manufacturers or real estate developers. Land sale revenues are mostly retained by the sub-city level governments. The practice of financing local government spending through land sales is usually referred to as "land finance."

Land finance was first adopted in Shenzhen in 1980. When Shenzhen was designated as a "special zone" in 1979, it did not receive much financial support from the central government. The first challenge facing the local officials was how to finance the upgrade and construction of infrastructure. The director of the city's housing bureau, Mr. Jinxing Luo, came up with the idea of selling a land parcel to Mr. Tianjiu Liu, a businessman

1. See the Ministry of Finance's 2019 Report on the execution of the central and local budgets. Besides the aforementioned three sources, revenue of state capital operations is very small; revenue of social security funds is large but cannot be spent for other purposes except social security payments.

from Hong Kong, who then built the first commercial housing community in China's history, Donghuliyuan (Beautiful Garden around South Lake). The project turned out to be very successful as many people in Hong Kong had families in Shenzhen and they came to buy these houses for the family members. The profit from the land sale helped the city government build 240 apartments to accommodate government employees. One year later, Mr. Luo sold another five land parcels and raised 0.5B RMB, which was more than enough to finance all the infrastructure construction of the city's CBD at that time.

The wide adoption of land finance only began two decades later. The reform of Shenzhen was much ahead of other places in China. In 1980, houses were not yet private property and there was no commercial market for land either. Housing reform and the development of market-based houses in the 1980s and 1990s opened land leases for the residential land market. The industrial and commercial land market also developed with the reform of state-owned firms and the growth of private firms. In addition to the relatively small size of the land market during this period, many land parcels were allocated without any pecuniary transfers to the local governments. For example, the fraction of land supply without pecuniary payment to the local governments remained at 54% in 1999. This was due to the lack of formal regulations for the land market and substantial ambiguities in terms of how the land transactions should be organized.

In 1999, the Ministry of Land and Resources issued the Notice of Encouraging Bidding and Auctions as Means of Land Use Right Transfers. In 2001, the State Council issued the Notice on Improving the Management of Land Resources, in which it mandates that all land supply plans shall be made public, and all land transfers must be conducted with bidding or auction if there are more than one interested buyers. Such mandate was made law in 2002 and the land market finally formalized. The practice of land finance gradually became popular and has been widely used since then to finance local government spending, especially investment in local infrastructure. Figure

3.1 shows that the average land sale revenues as a fraction of local government budget expenditures were less than 5% before 2000, and increased dramatically since 2000 and stabilized at around 30%.

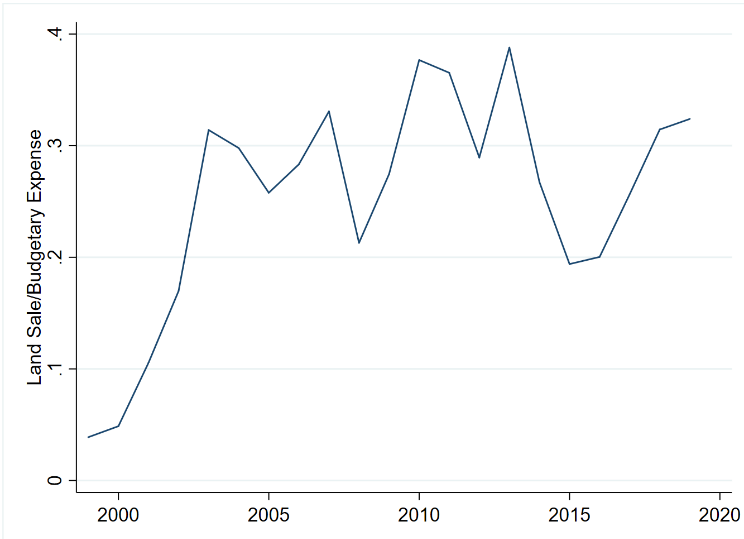


Figure 3.1: Local govt land sale revenue/budgetary expenditure

Note: This figure plots the average ratio between the land sale revenues and the budgetary expenditures across different cities.

Land in China is classified into two general categories: agricultural land and urban construction land. For those zoned as urban construction land, some can be left unoccupied, such as grassland and river banks. Unlike unoccupied land, to sell previously occupied urban construction land, the local governments need to first requisition the occupied land which requires compensation to the displaced occupants. In 2001, the State Council issued the Regulations on the Administration of Urban House Demolition and Relocation, of which the Article 24 mandates that the local governments must compensate the removed occupants with a fair rate. Overall, the compensation cost as a share of total land sale revenues has been significant. For example, in 2004, Guangzhou set a lower limit on the compensation rate to incumbent occupants, which ranges between 1600 - 3000 RMB/m^2 for the core downtown area and 950 - 1150 RMB/m^2 for the peripheral downtown area. As comparison, the house price in Guangzhou in 2004 ranges about 3000-4000 RMB/m^2. He et al. [2022] estimate for the residential land, compensation cost is about 1/3 of land sale revenues during 2007-2010. The Ministry of Finance reports about 80% of land sale revenues in 2014 were used to compensate incumbent occupants removed from the land in that year.

Local governments can also convert the agricultural land into urban construction land and sell it to the private sector. Despite some early master plans and regulations from the central government that limit such conversion, these regulations were poorly enforced.[2] As the central government became increasingly concerned about the security of agricultural land, in 1997 it issued the "Notice on Further Strengthening Land Management and Effectively Protecting Arable Land" to increase enforcement of land regulations. At the same time, the State Council conducted a national investigation on urban land use. The investigation revealed that during 1991-1996, total urban construction land supply reached 2.02 million hectares, 50.7% of which was converted from agricultural land. In 1998, the "Land Administration Law" was revised to better protect agricultural land. The new law regulates that whenever some agricultural land is requisitioned for urban construction use, besides compensation to displaced farmers, the same amount of arable land with the same quality must be created somewhere else.

To summarize, with land sale revenues becoming an important source of income for local governments after 2000, the cost to supply the land for the local governments depend on the status of the land. The unoccupied urban construction land comes without any incumbents to compensate, the occupied urban land requires incumbent compensation, and the agricultural land was available at low cost before 2000 but strictly protected after 2000 (i.e., requiring both compensation and new agricultural land creation).

To exploit variation of the local governments' benefit from land finance that is likely

2. Examples of these plans and regulations include the "Land Administration Law" first passed in 1986 and "National Master Plan for Land Use 1987-2000" approved in 1993.

uncorrelated with local economic conditions, I will look at the share of unoccupied urban construction land among the total urban construction land in 2000, which will affect the compensation expense and hence net profits from land sales for local governments after 2000. I estimate it using the average occupancy status of the land within the city's downtown area, where almost all the urban construction land locates. In the next sections, I will discuss how I measure it, whether and why it can help address the identification challenges in estimating the causal effect of local government spending.

3.2 Measure raw land in the downtown area

The land occupancy status is difficult to precisely measure. One closely related information which is relatively easy to obtain is land cover. Land in the downtown area can be classified into three types: unoccupied raw land, occupied land with construction, and occupied raw land without construction (e.g., grassland in a school or small farmlands on the peripheral downtown area).[3] For occupied raw land, the government shall also compensate the occupants but at a much lower rate. In practice, the compensation is often a function of the area with construction. Due to the relationship between occupancy status and land cover and the relatively low compensation rate for occupied raw land, I will ignore the difference between raw and unoccupied land and use the two terms interchangeably.

The estimation of Earth land cover using satellite remote-sensing data is a popular topic in geographic science (Liu et al., 2018, Sulla-Menashe et al., 2019, Zhang et al., 2020, Yang and Huang, 2021). In this paper, I will measure the fraction of raw land in the city's downtown area in 2000 based on map data developed by Liu et al. [2018]. Liu et al. [2018] use satellite images to classify every 30m$\times$30m polygon on Earth as

3. The protection of farmland only applies to those vast stretches of farmland defined as "basic farmland," not those segregated small pieces of farmland within the urban area.

covered by impervious surface or not, where the impervious surface refers to pavement, concrete, brick, stone, and other man-made impenetrable covers. Polygons identified as with impervious surface correspond to occupied land and those without impervious surface correspond to raw land in this paper. To estimate the downtown boundary, I rely on the fact that most of the developed lands are located in the downtown area while the suburban area mostly consists of farmland, forests and rivers. I then estimate the downtown boundary based on the cluster of occupied land. Finally, I calculate the fraction of raw land within the estimated downtown boundary.

To illustrate the calculation of the measurement, Figure 3.2 shows the geographic distribution of occupied land in the city of Suqian in 2000. The city consists of four sub-cities, including two Shixiaqu to the middle left and three other sub-cities. The dark area represents occupied land as identified with impervious surface. The occupied land forms four big clusters, which are perfectly in line with the downtown area of the four sub-cities. There are some extra small clusters that represent small developed towns not connected to the downtown area. Most of the city was not developed and consists of agriculture land, rivers, grassland, etc.

In Figure 3.3, I zoom in to take a close look at the center of Shuyang, which is the top-right sub-city in Figure 3.2. The first graph shows the distribution of occupied land. To estimate the downtown boundary, I aggregate all the polygons classified as with impervious surface by: (1) connecting any two neighboring polygons with distance less than one mile and (2) filling inside holes with area less than one square mile. The estimated downtown area is the colored area (green plus dark) shown in the second graph. The raw land within the downtown boundary is then the green area.[4]

Formally, I calculate the fraction of raw land within the city's downtown area as

4. I keep those small clusters not connected to the largest cluster in the calculation as land can also be supplied from these small towns. The empirical results using measures based on the single largest cluster for each sub-city barely change.

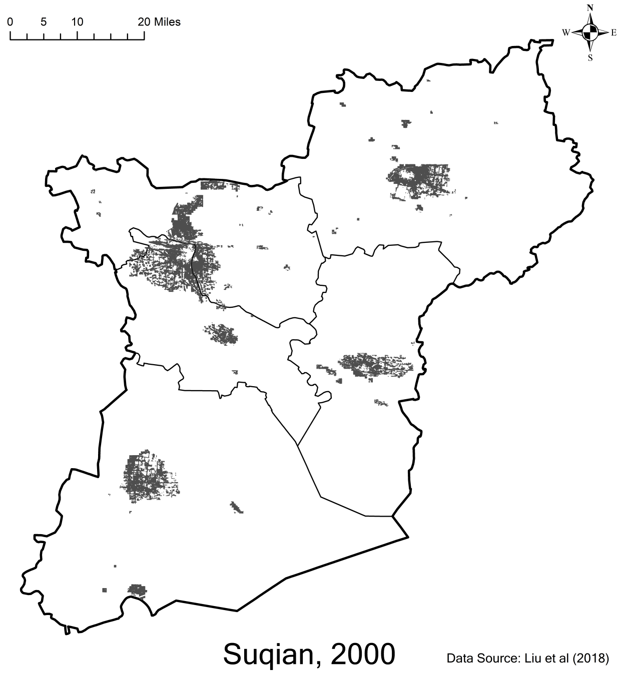
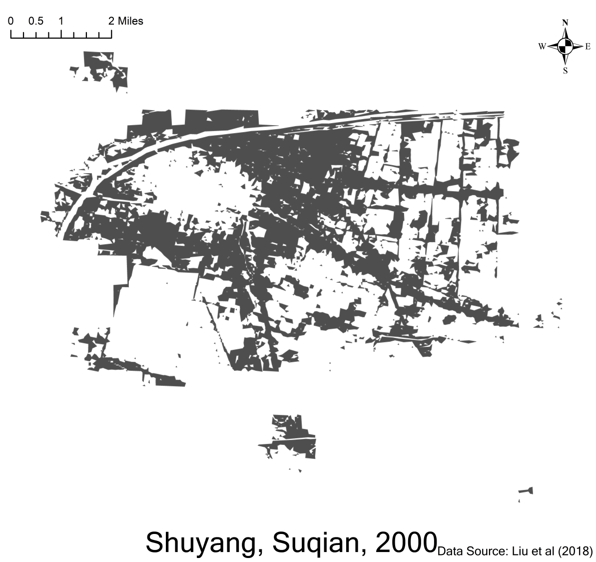
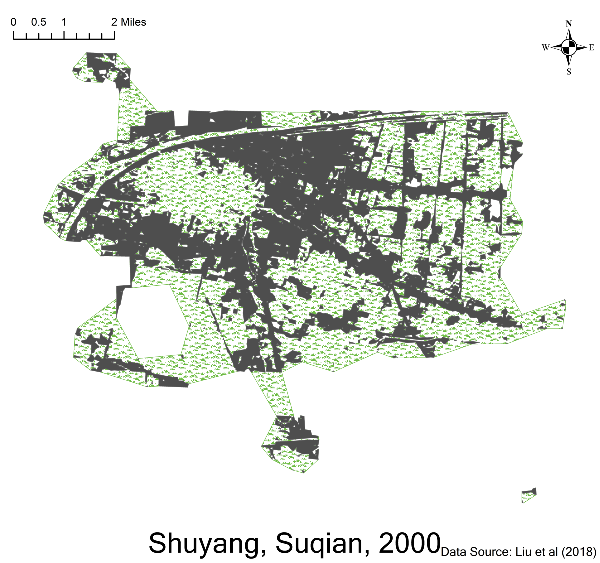


Figure 3.2: Geographical distribution of occupied land in Suqian, 2000



(a) Distribution of occupied land



(b) Estimate downtown boundary

Figure 3.3: Estimating downtown boundary using occupied land for Shuyang

Note: The first graph shows the geographic distribution of occupied land of Shuyang in 2000; the second graph illustrates the estimated downtown boundary in 2000.

follows:

$$raw_c = \frac{\sum_i Raw_{c,i}}{\sum_i DT_{c,i}}, \tag{3.1}$$

where $Raw_{c,i}$ is the size of raw land within the estimated downtown boundary of sub-city i in city c using the two procedures described above, and $DT_{c,i}$ is the size of the estimated downtown area of sub-city i in city c.

Similarly, I also calculate the fraction of raw land for each sub-city as follows:

$$raw_{c,i} = \frac{Raw_{c,i}}{DT_{c,i}} \tag{3.2}$$

Figure B.1 in the appendix compares the landscape of Shuyang between 2000 and 2015. First, the fraction of raw land has shrunk dramatically over time. In the first graph, the round green area on the top left used to be a piece of farmland and has been transformed into developed land, and the hexagon white area on the bottom left used to be the South Lake and has been filled and built into a residential community. Second, the downtown boundary in 2015 is almost the same as the downtown boundary in 2000. This aligns with the restriction on urban expansion into the agricultural land after 2000.

In the empirical analysis, I will use *raw* as an instrument variable for the local government spending after 2000 in a Difference-in-Difference estimation framework. In the following section, I will show the relevance condition and the exclusion restriction hold for *raw*.

3.3 The identification assumption

3.3.1 *Relevance condition*

I first check if as conjectured, *raw* affects the land sale profitability through the required compensation to removed occupants. The land sale revenues are mainly spent for two purposes: compensating removed occupants and financing infrastructure investment. Higher *raw* should imply less compensation to occupants and more to be spent on the infrastructure. In the data, I observe both the annual land sale revenues and the amount of land sale revenues spent on infrastructure investment. As the compensation expense usually occurs before land sales, I mitigate the issue of time mismatch by calculating the ratio between the accumulated land sale revenues spent on infrastructure and the accumulated land sale revenues during 2001-2005, and regress the ratio on *raw*, after controlling for provincial heterogeneity with province fixed effect.[5] Column (1) of Table 3.1 reports the results. As expected, for a given amount of land sale revenues, higher *raw* implies the city can spend more on infrastructure investment since less is spent as occupant compensation.

We can also check whether for a given amount of land supplied, higher *raw* is associated with a smaller fraction of land that is requisitioned with occupant compensation. I calculate the ratio between the size of urban land requisitioned with occupant compensation during 2001-2016 and the size of total land supplied during 2004-2019, assuming a three-year lag between requisition and supply, and regress it on *raw* after controlling for the province fixed effect. As shown in Column (2) of Table 3.1, given the total size of land supplied, higher *raw* is associated with a significantly smaller fraction of land that

5. I choose the period of 2001-2005 to better match the numerator with the denominator. In the data, I can only observe total infrastructure investment financed by contemporaneous land sale revenues and loans backed by future land sales; before 2005, the portion financed by loans is likely small and the portion financed by contemporaneous land sales dominates, which better matches the land sale revenues during 2001-2005.

Table 3.1: City-level *raw* and land sale profitability

	(1)	(2)
Dep Var	InfraInvt2Sale	Landexp2Supply
raw	0.589***	-0.282*
	(3.128)	(-1.811)
Province FE	Yes	Yes
Observations	307	301
R-squared	0.336	0.218

Note: This table shows the correlation between the city's *raw* with the fraction of accumulated land sale revenues spent on urban infrastructure investment (Column (1)) and the ratio between accumulated urban land requisition with compensation and urban land supply (Column (2)). Robust t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

is requisitioned.

3.3.2 Exclusion restriction

For *raw* to be a valid instrument for local govt spending after 2000, it has to satisfy two conditions. First, it is not correlated with local economic conditions in 2000 so that it does not simply capture differential growth path as a result of the initial conditions. Second, after 2000, it only affects local economic growth through government spending rather than any other channels. Below I will discuss the two conditions.

Orthogonality of Raw Land Proportion. I will show the orthogonality of *raw* against a rich set of local economic conditions in 2000 that may affect the future growth path, and the parallel trends of cities with differential *raw* before 2000 in various dimensions. The evidence lends strong support to the assumption that *raw* is exogenous to the city government in 2000 for the outcome that we want to study.

First, I examine the relationship between *raw* and various measures of economic activities and infrastructure in 2000. As some variables are at the city level and others are at the sub-city level for only part of the sub-cities, I run the following two regressions depending on what level the dependent variable is:

$$y_{c,2000} = \beta \times raw_c + \gamma_{p(c)} + \varepsilon_c \tag{3.3}$$

$$y_{c,i,2000} = \beta \times raw_{c,i} + \gamma_{p(c)} + \varepsilon_{c,i} \tag{3.4}$$

In Eq. (3.3) and (3.4), the LHS is the outcome variables in 2000 to be examined, $\gamma_{p(c)}$ controls for provincial heterogeneity, and ε_c and $\varepsilon_{c,i}$ are the random errors. In all the analysis in the paper, I control for provincial fixed effect for cross-sectional regressions and time-varying provincial fixed effect for panel regressions, due to the large heterogeneity across different provinces.

Table (3.2) reports the results. In Panel A, there is no significant correlation between *raw* with GDP, urban employment, the stock of structural and machinery capital, and the number of manufacturing firms in 2000, all scaled by the downtown size before taking log value. In other words, cities with more unoccupied land in the downtown area in 2000 did not exhibit lower level of economic development. The only variable that carries a significant correlation is population size. A smaller population likely leads to a smaller population in the downtown area and increases the fraction of unoccupied land size. If a smaller population reduces labor supply and negatively affects economic growth, then the estimated effect of local government spending on economic growth using *raw* as the instrument will be downward biased.

In Panel B, I examine the correlation between *raw* and local government spending and the level of infrastructure. The budgetary expenditure and infrastructure investment are the two main categories of local government spending. The budgetary revenues are the tax revenues and administrative fees shared by all layers of governments within each city, and budgetary expenditures are those financed by budgetary revenues plus central government transfers. For the infrastructure investment, part of it is financed with budgetary revenues and central transfers, and a big portion is financed by the land sale

Table 3.2: Correlation between *raw* and city characteristics in 2000

Panel A: City-level economic activities

Dep Var	(1) log(GDP)	(2) log(Pop)	(3) log(Emp)	(4) log(Struc)	(5) log(Mach)	(6) log(#Mfr)
raw	0.219	-0.592***	0.166	-0.173	0.336	-0.317
	(0.902)	(-2.599)	(0.392)	(-0.333)	(0.779)	(-0.983)
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	279	279	256	279	279	279
R-squared	0.375	0.314	0.301	0.262	0.289	0.500

Panel B: Government spending and infrastructures

Dep Var	(1) log(BugExp)	(2) log(BugRev)	(3) log(InfraInvest)	(4) log(RoadArea)	(5) log(WaterPipe)	(6) log(DrainPipe)
raw	0.0813	0.385	0.250	0.00734	0.118	0.214*
	(0.351)	(1.272)	(1.333)	(0.0889)	(0.938)	(1.895)
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	278	278	624	632	632	631
R-squared	0.254	0.417	0.303	0.360	0.222	0.303

Panel C: Firm productivity, utilization and output

Dep Var	(1) tfpq	(2) utili	(3) log(Labor)	(4) log(Capital)	(5) log(Material)	(6) P/E
raw	-0.00649	0.0304	0.0543	0.123	0.197	-25.83
	(-0.202)	(0.948)	(0.632)	(1.104)	(1.599)	(-0.35)
Prov-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	116,512	116,840	123,988	119,549	117,994	433
R-squared	0.246	0.255	0.249	0.183	0.211	0.307
#City	336	336	336	336	336	115

Panel D: Land supply and land zoning

Dep Var	(1) NetLandSupply	(2) logprice	(3) IndZone	(4) ResZone	(5) FacZone	(6) UtiZone
raw	0.432	-0.226	0.000956	-0.00628	0.00960	0.00802
	(1.238)	(-0.601)	(0.0562)	(-0.292)	(0.866)	(1.282)
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	287	306	630	630	630	629
R-squared	0.235	0.291	0.120	0.165	0.127	0.057
Obs	City	City	Subcity	Subcity	Subcity	Subcity

Note: The city and sub-city level variables are scaled by the actual or estimated downtown size. Standard errors are clustered by cities in Panel C. Robust t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

revenues. In 2000, there is no significant correlation between *raw* with all three measures of local government incomes and spending scaled by downtown size. In Column (4)-(6), I examine the correlation between *raw* with the level of infrastructure, including total road area (Column (4)), the total length of water supply pipelines (Column (5)) and drainage pipelines (Column (6)). No significant correlation was found for any of them, except slightly positive correlation for drainage pipelines. Cities with differential raw land in 2000 do not start with differential local government spending or level of infrastructure.

In Panel C, I look at the correlation between the sub-city's *raw* and local firm characteristics in 2000, including firms' productivity, input utilization, labor, capital, material, and the price-earnings ratio (P/E) of local public firms. There is no significant correlation between firm characteristics with *raw* either.[6]

In Panel D, I check the correlation between land supply and land zoning with *raw*. In Column (1), $NetLandSupply$ is total land supplied minus urban land requisitioned scaled by the estimated downtown size (the same scalar for *raw*), all measured in 2000. We can think of it as the land supply from the unoccupied urban land plus agricultural land outside the downtown area. Higher *raw* is not significantly associated with higher net land supply. In Column (2), there is no significant correlation between *raw* and average price of land sold in 2000. In Column (3)-(6), I look at the composition of land uses in 2000, including industrial, residential, urban facility and municipal utility land zoning. None of them were significantly correlated with *raw*. In Appendix B Table B.1 I report the partial correlation between *raw* and all of these characteristics. Except population size, none of them has a correlation larger than 0.1.

As I use the DID estimation strategy for most analysis in this paper, I examine whether cities with differential *raw* had experienced differential trends before 2000. If

6. Appendix E provides details on the calculation of these firm characteristics.

the fraction of unoccupied land is related to certain unknown city characteristics, such as local official capability or preference, which can lead to differential economic growth after 2000, then they shall also affect economic growth before 2000 as long as they are constant or slow-moving. The parallel trends prior to 2000 is evidence against this hypothesis and lend support to the identification assumption that without the rise of the land market, cities with differential *raw* would have evolved along the same trend, and hence the differential trend after 2000 must reflect the causal effect of *raw*.

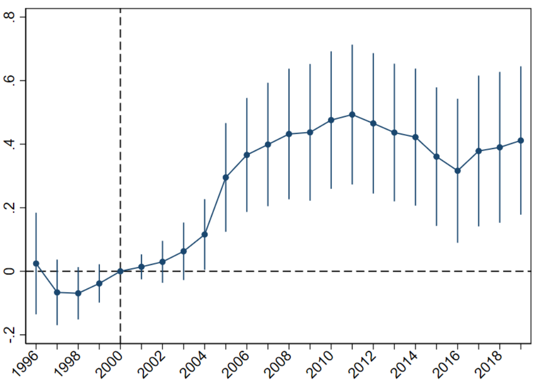
Depending on what level the outcome variable is on, I conduct the following DID estimation using 2000 as the base year to examine the parallel trend assumption for various economic measures:

$$y_{c,t} = \sum_{\tau \neq 2000} \mathbb{1}_{t=\tau} \cdot \beta_\tau \cdot raw_c + \xi_t \cdot y_{c,2000} + \alpha_c + \gamma_{p(c),t} + \varepsilon_{c,t} \tag{3.5}$$

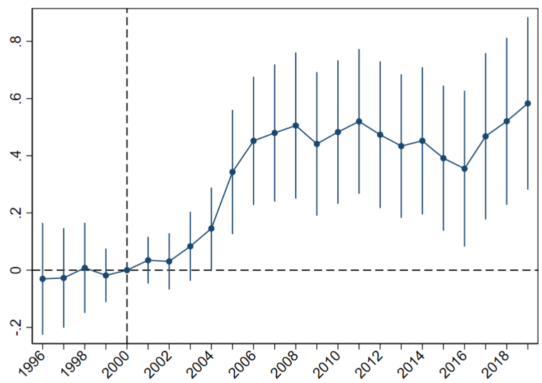
$$y_{c,i,t} = \sum_{\tau \neq 2000} \mathbb{1}_{t=\tau} \cdot \beta_\tau \cdot raw_{c,i} + \xi_t \cdot y_{c,i,2000} + \alpha_{c,i} + \gamma_{p(c),t} + \varepsilon_{c,i,t} \tag{3.6}$$

Figure 3.4 plots the 95% confidence interval of the β estimates for various y indicated under each graph. In Panel A, for GDP, GDP in the secondary and tertiary sector, number of manufacturing firms, budgetary revenues and budgetary expenditures, all of these variables exhibited parallel trends for cities with differential *raw* before 2000.[7] In Panel B, I investigate government infrastructure investment, infrastructure investment in transportation, road area, the length of water supply pipelines; all of them have exhibited parallel trends before 2000. Due to space limit I don't report the parallel trends for more variables, but the parallel trends hold for all the outcome variables that I examine in this paper, such as land zoning and local firms' productivity. The parallel trends along all these dimensions lend some support to the assumption that cities with differential *raw*

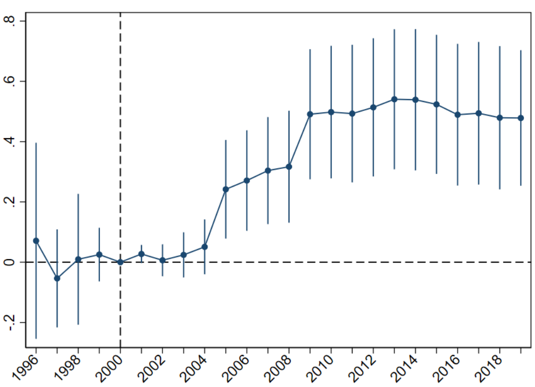
7. In Chapter 5 I will show the parallel trends before 2000 also hold for the employment, the stock of structural and machinery capital.



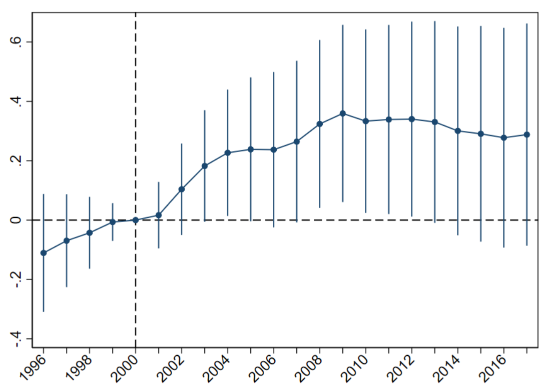
(a) $\log(GDP_{c,t})$



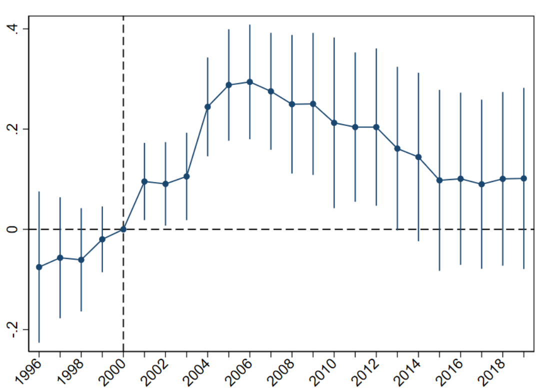
(b) $\log(GDP^{sec}_{c,t})$



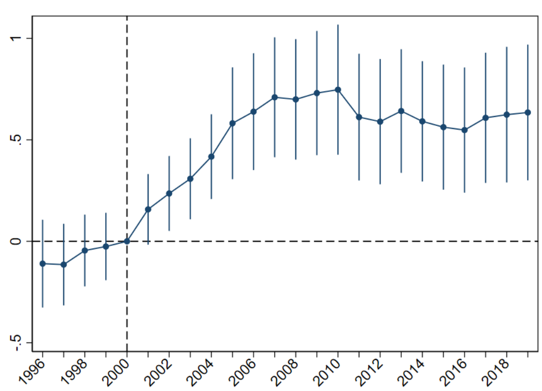
(c) $\log(GDP^{ter}_{c,t})$



(d) $\log(\#Mfr_{c,t})$

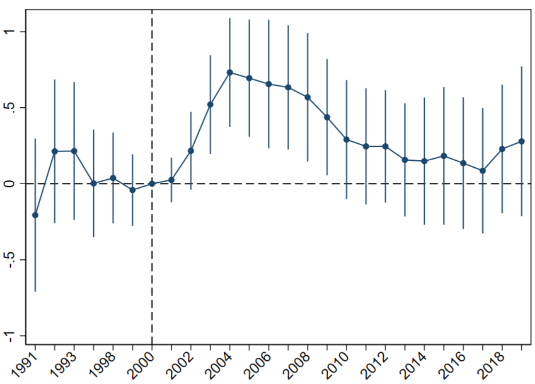


(e) $\log(BudExp_{c,t})$

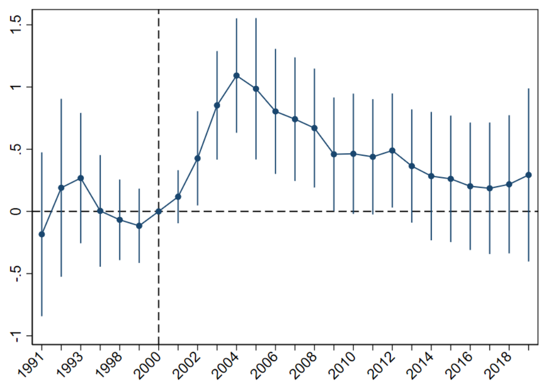


(f) $\log(BudRev_{c,t})$

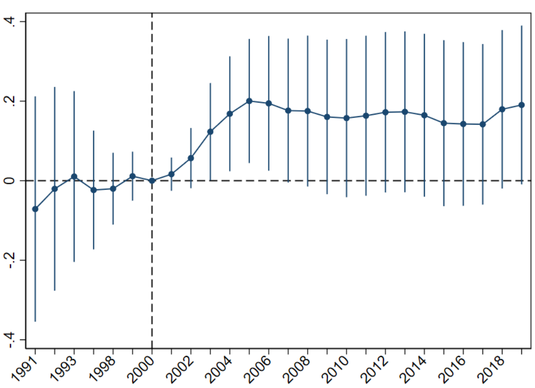
Panel A: City-level Economic Activities



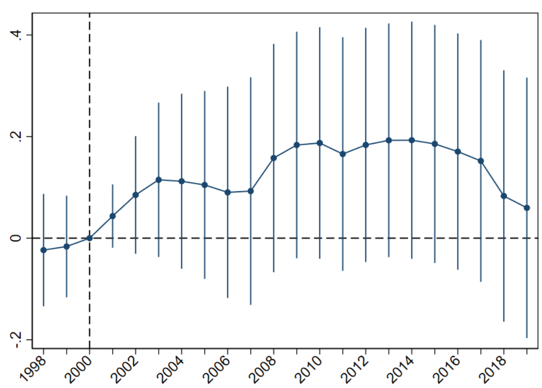
(g) $\log(GovtInvt_{c,i,t})$



(h) $\log(GovtInvt^{tra}_{c,i,t})$



(i) $\log(RoadArea_{c,i,t})$



(j) $\log(WaterPipe_{c,i,t})$

Panel B: Sub-city level Infrastructure

Figure 3.4: Parallel trend of cities and sub-cities with differential *raw* in various dimensions

Note: The figure plots the 95% confidence interval of the β estimates from Equation (3.5) and (3.6), where the dependent variable is indicated below each graph. All standard errors are clustered by the city.

would have experienced parallel growth path without the treatment.

The low correlation between the proportion of unoccupied land and various economic activity measures in 2000 raises doubts about the efficiency of urban land use. Improved economic development tends to increase land value and decrease the proportion of unoccupied land in the downtown area if the local government's land allocation responds to the private demand. In fact, the inefficiency of urban land use prior to 2000 has been well acknowledged by the central government in various official documents, and significant efforts have been made to increase urban land efficiency since 2000.

Urbanization prior to 2000 can be characterized as significant outward expansion into the agricultural land with poor utilization of existing urban construction land. Outward urban expansion was more attractive to local governments as there was large-scale flat farmland surrounding the downtown boundary that can be easily transformed to urban construction land and the compensation cost to displaced farmers was very low, while unoccupied raw land within the downtown was usually scattered and required significant coordination with occupants nearby. As I discuss above, despite some regulations in the early 1990s attempting to limit outward urban expansion and preserve agricultural land, such as the National Land Use Master Plan Outline for 1986-2000 issued in 1993, these regulations were poorly enforced. "I believe the main issue regarding land use now is excessive urban expansion," said Mr. Kexin Shu, the Deputy Director of the Land Use Management Division of the Ministry of Natural Resources, in a high-profile forum in 2005. "The main problems that we face in this regard are, firstly, the total amount of land used for urban construction is out of control and the utilization of existing urban land is pretty inefficient... as manifested by the loose and disorganized layout of the urban area with poor concentration."[8]

In April 1997, the State Council issued the "Notice on Further Strengthening Land

8. See the full context of the talk here.

Management and Effectively Protecting Cultivated Land"[9], followed by a national investigation on urban construction land use. According to the investigation report[10], from 1991-1996, total urban construction land supply reached 2.0 million hectares, only 75% of which was within the legally permitted quota and 5.8% of which was undeveloped. Local officials were also lectured to shift from outward urban expansion to more efficient land utilization during the investigation. In 1998, the "Land Administration Law" was revised and "Valuing and making better use of every inch of land, and effectively preserving farmland" was determined as a fundamental national policy. In April 1999, the National Land Use Master Plan Outline was updated to strictly enforce the revised law.

The shift of land use patterns is reflected in Table 3.3. Panel A presents the average size changes of occupied, raw and downtown land during three distinct time periods. From 1980 to 1990, outward urban expansion resulted in an average size increase of downtown land by 70.5 square kilometers, primarily due to the increase of occupied land. There was minimal change in the utilization of existing land, as seen in the size change of raw land. From 1990 to 2000, outward urban expansion slowed down, and utilization of existing land increased, consistent with the regulations issued in the 1990s. Lastly, from 2000 to 2015, outward urban expansion further decreased to 1.1 square kilometers per year, compared to 2.2 square kilometers per year during 1990-2000. During this time, the increased occupied land was about 6.0 square kilometers per year, 82% (=73.2/89.3) of which came from improved utilization of existing urban land.

Panel B presents the cross-sectional correlation between urban development and land use patterns. Due to the lack of GDP data before 1996, I use the growth of nighttime light intensity as a proxy for urban development (Henderson et al. [2012]). Consistent

9. See the document here.

10. See the report here.

Table 3.3: Urban Expansion and Urban Development: before versus after 2000

Panel A: Urban Expansion over time, Sq.Km.

	1980-1990	1990-2000	2000-2015
Occupied Land	69.053	56.127	89.321
Raw Land	1.470	-34.323	-73.221
Downtown Land	70.523	21.804	16.1

Panel B: Urban Expansion across cities

(a) 1990-2000

	$NtlGr_{2000}$	Raw_{2000}	$\log(DT_{2000})$
	(1)	(2)	(3)
$NtlGr_{2000}$		-0.0217	0.130***
		(-0.887)	(3.286)
Raw_{1990}	-0.0906	0.803***	
	(-0.964)	(22.03)	
$\log(DT_{1990})$			0.969***
			(80.44)
Observations	276	276	276
R-squared	0.363	0.851	0.980

(b) 2000-2015

	$NtlGr_{2015}$	Raw_{2015}	$\log(DT_{2015})$
	(1)	(2)	(3)
$NtlGr_{2015}$		-0.0679***	-0.0363
		(-2.637)	(-0.787)
Raw_{2000}	0.176*	0.791***	
	(1.731)	(19.00)	
$\log(DT_{2000})$			0.964***
			(62.64)
Observations	276	276	276
R-squared	0.457	0.841	0.967

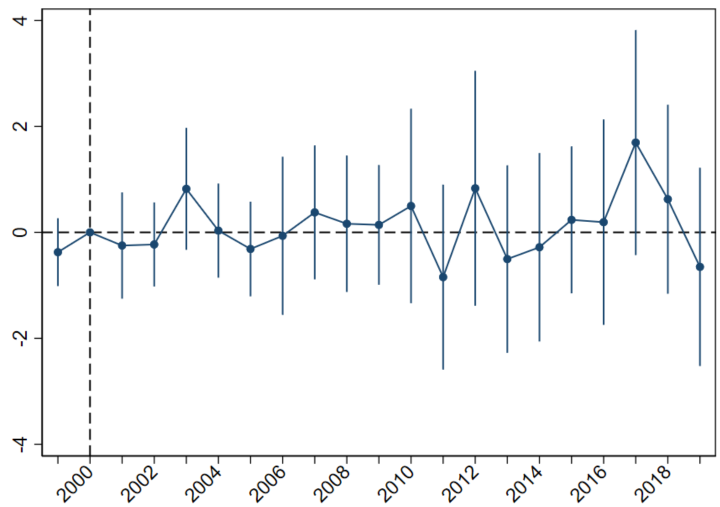
Note: The first panel reports the change of urban land during the three different periods, and the second panel shows the correlation between urban development (proxied by growth of nighttime light intensity) and change of *raw* from 1990 to 2000 and from 2000 to 2015. Robust t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

with the time trends in Panel A, urban development is associated with greater urban outward expansion during 1990-2000 but increased land utilization during 2000-2015. In Panel (a), the proportion of raw land in 1990 had no effect on urban development in the following decade (Column (1)). Urban development did not lead to better land utilization either (Column (2)), but it was positively correlated with a greater expansion of the downtown area. In Panel (b), a higher proportion of raw land in 2000 led to greater urban expansion in the next 15 years (Column (1)), which was associated with increased land utilization (Column (2)). However, the correlation with the expansion of downtown area during the same period became insignificant (Column (3)). These patterns are consistent with the consensus about the shift of urban development from from outward expansion to better utilization of existing urban land.

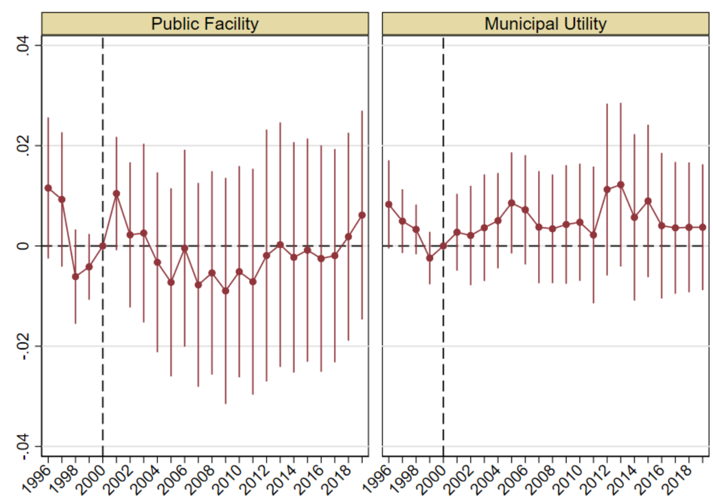
Nature of the Shock. After showing and explaining the orthogonality of raw land proportion in 2000, to use it as an instrument variable for local government spending, we need to show it affects future economic growth through government spending rather than pick up some other shocks after 2000.

One particular example of these shocks that might be correlated with *raw* is land supply as higher *raw* may imply more room for development. The argument is based on the conjecture that *raw* affects net land supply, i.e., the supply of previously unoccupied land. To check if this conjecture is true, I calculate $NetLandSupply$, the annual land supply minus urban land requisition and scaled by the estimated downtown size in 2000, and estimate the treatment effect of *raw* on $NetLandSupply$ using Equation (3.5). Figure 3.5 Panel (a) plots the 95% confidence interval of the β estimates. Not only are the coefficient estimates insignificant, but there is also no obvious trend as the coefficient fluctuates around zero. The result rejects the conjecture that *raw* affects future growth by increasing net land supply.

Why is more the downtown land occupancy status uncorrelated with more or less net



(a) Net land supply to private sector



(b) Infra and public facility land zoning

Figure 3.5: The treatment effect of *raw* on land supply

Note: The graph plots the 95% confidence interval of the β estimates from Equation (3.5), where the dependent variable is annual net land supply to the private sector (i.e., total land supply minus land requisitioned scaled by the estimated downtown size in 2000) for Panel (a) and the fraction of land zoning for infrastructure and public facilities for Panel (b).

land supply? The answer is that after 2000 as protection for agricultural land strengthens, local governments prioritize land supply using unoccupied urban construction land and only turn to agricultural land when the *raw* is low. Higher *raw* is associated with more net land supply from the downtown area but less from the rural area. In total, the net land supply from unoccupied urban land and agricultural land is not affected by *raw*. Appendix B provides some empirical evidence on the composition of net land supply.

In addition to land supply to the private sector, higher *raw* might affect land supply for public uses, which could have direct effect on economic growth independent of government spending. Figure 3.5 Panel (b) plots the effect of *raw* on land zoning for public facility and municipal utility using Equation (3.6). Again, there is no evidence that downtown land occupancy affects land zoning for public uses.

Beside land supply, there might be other confounding factors that correlate with *raw*, directly affect future growth path but are unobservable to us. As these are unobserved, we cannot control for them directly. A popular approach to evaluate the potential bias from omitted control variables is to explore the sensitivity of the estimated coefficients to the inclusion of observed controls. Such sensitivity depends on the correlation between the included control and *raw* and how much it explains the dependent variable. Coefficients that remain stable after the inclusion of observed controls can be interpreted as exhibiting limited bias due to the unobserved controls (Altonji et al., 2005). Oster [2019] suggests a quantitative approach to evaluate the sensitivity after taking into account the explanatory power of the control variables as measured by the R^2 value.

To follow Oster's approach, I conduct the following reduced-form regression to estimate the treatment effect of *raw* on GDP growth and gradually add various candidates for confounding factors in X_c.

$$\log(GDP_{c,t}) = \beta \cdot \mathbb{1}_{t>2000} \cdot raw_c + \alpha_c + \gamma_{p(c),t} + X_c \cdot \Gamma_t + \varepsilon_{c,t}, \tag{3.7}$$

I consider the following covariates, which are all measured based on information available in 2000. The first is $(\log(GDP_{c,2000}), \log(AG_c^{2000}))$, which can lead to differential economic growth path. The second is historical growth before 2000 that can reflect some slow-moving city characteristics which affect economic growth both before and after 2000. The third is a measure of exposure to the WTO shock in 2001, which is calculated as the city's export to GDP ratio in 2000 multiplied by the average export growth of each product from 2000 to 2011 weighted by the city's export of that product in 2000. This measure is found to have a significantly positive effect on the city's GDP growth after 2000. The forth is the city-level cyclicality. The economic reforms and entry to WTO led to high GDP growth for China, and cities that were more pro-cyclical would experience higher economic growth. I construct the city-level cyclicality measure by regressing the city's annual real GDP growth on the country's annual real GDP growth using data during 1996-2000.[11] Fourth, although Figure 3.5 shows that raw does not affect the net land supply, for robustness check I also calculate the accumulated $NetLandSupply$ and include it as one regressor in X_c. Lastly, in case of spillovers across cities, η_t may capture the spillover effect from neighboring cities. If raw_c between neighboring cities is correlated, then η_t would be correlated with raw_c. Following the spatial economics literature, I construct the inverse-distance weighted average raw_c of other cities for each city c, $CitySpillover_c$. [12]

Table 3.4 reports the estimation results. Compared to the result reported in Column (1) without any controls (except for the city and province-by-year fixed effect), the in-

11. Thanks Ralph S. J Koijen for this suggestion.

12. I try four different measures of across-city spillovers. The first is the inverse-distance weighted average raw_c of all other cities in China. The second is based on only those with population density above the median. In Chapter 7, I will show how the spillover effects within the city depends on the population density. So, one reasonable conjecture is that the across-city spillover may also depend on the population density. The third measure is based on cities within the distance of 500 km. Cities more than 500 km away are likely to exert zero effect. The last is based on cities with both population density above median and distance within 500 km. There is no evidence of across-city spillovers regardless of the measure of spillovers. Due to space limit, I only report results with the first measure.

clusion of controls gradually increases the models' within R-squared but has a minimal effect on the size of the estimated coefficient.

Table 3.4: Treatment Effect of *raw* on the city's GDP

Dep Var: log(GDP)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\mathbf{1}_{t>2000} \cdot raw$	0.353***	0.375***	0.319***	0.291***	0.297***	0.293***	0.279***
	(3.734)	(4.242)	(4.145)	(3.831)	(3.910)	(3.753)	(3.130)
$\mathbf{1}_{t>2000} \cdot CitySpillover$							0.387
							(0.600)
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prov-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Base Year Effect	No	Yes	Yes	Yes	Yes	Yes	Yes
Historical Growth	No	No	Yes	Yes	Yes	Yes	Yes
WTO Shock	No	No	No	Yes	Yes	Yes	Yes
Cyclicality	No	No	No	No	Yes	Yes	Yes
Accu. NetLandSupply	No	No	No	No	No	Yes	Yes
Observations	6,630	6,630	6,582	6,582	6,582	5,730	5,730
R-squared	0.988	0.990	0.992	0.992	0.992	0.992	0.992
Within R-squared	0.0233	0.155	0.258	0.298	0.306	0.218	0.218
#City	279	279	277	277	277	276	276

Note: This table shows the treatment effect of *raw* on the city's GDP growth after 2000. I add time-varying effect of $(\log(GDP_{c,2000}, \log(AG_c^{2000})$ from Column (2), historical growth from Column (3), the WTO shock from Column (4), a cyclicality measure from Column (5), and the accumulated $NetLandSupply$ from Column (6), and $cityspillover$ in Column (7). Note all other variables cover 1996-2019 except that $NetLandSupply$ covers 1999-2019. Standard errors are clustered by cities. T-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3.5: Sensitivity of estimates to the degree of selection on ubobservables

	beta					
R_max	0.25	0.2	0.15	0.1	0.05	0
1.000	0.416	0.844	1.255	1.648	2.023	2.379
0.9934360	5.441	10.755	15.347	19.082	21.932	23.950

Note: The table reports the value of δ, the degree of selection on unobservables relative to that on observables used as controls in Table 3.4 Column (5), so that the true effect of *raw* equals β under R_{max} specified in the first column. The methodology follows Oster [2019].

In Table 3.5, following Oster [2019], I report the degree of selection on unobservables relative to that on observables used as controls in Table 3.4 Column (5), δ, such that the estimated coefficient is 0.297 under the true value of (β, R_{max}) specified in the second row and the first column. The R_{max} is the hypothetical R-squared from the regression if we included the unobservables as controls in X_c. For example, when $R_{max} = 1.00$ and $\beta = 0.2$, the degree of selection on unobservables would be 0.844 time that on a combination of all the five controls that I have included in Column (5). If one believe the degree of selection on unobservables is as large as that on observables, i.e., $\delta = 1$, then the corresponding β would be 0.181, roughly half that in Column (1).

The assumption of $R_{max} = 1.00$ is unrealistically high. For any post-2000 shock to the local economic growth to be correlated with *raw*, it is either a direct effect of government spending (and hence part of the mechanisms and not a concern for identification) or loads differentially on cities depending on some unobserved city characteristics in 2000 which is correlated with *raw*. Therefore, we only need to be concerned about unobservable covariates in 2000. Such city-level covariates in 2000 are not likely to explain all the within-province variation of GDP growth across different cities assumed by $R_{max} = 1.00$. Following Oster [2019], I assume the within R_{max} to be 1.3 times the within R-squared in Column (5),[13] which corresponds to the R_{max} reported in the last row of Table 3.5. Under this more reasonable value of R_{max}, the selection on unobservables would be much larger under any assumptions about the true δ. If the degree of selection on unobservables is as large as that on observables, i.e., $\delta = 1$, then the corresponding β would be 0.289, which barely differs from that in Column (5). I conclude that the omitted variable bias due to some unobserved covariates, if any, must be minimal.

To summarize, the proportion of unoccupied land within the city's downtown area in 2000 appears to be orthogonal to city economic activities in 2000, probably due to the poor utilization of existing urban area by local governments before 2000. After 2000, as the land market quickly rose and rural land requisition was strictly limited, unoccupied land within the downtown area led to significant variation of the local governments' profitability from land sales and hence government spending. The effect of unoccupied

13. The value of 1.3 is the cutoff value that would allow 90% of randomized results from top journals to survive

land on economic growth mainly by affecting local government spending and the omitted variable bias, if any, should be minimal. In short, the proportion of unoccupied land within the downtown area in 2000 can be a valid instrument for local government spending after 2000 to study the causal effect of local government spending on economic growth.

CHAPTER 4

LOCAL GOVERNMENT SPENDING MULTIPLIER

In this chapter I report the estimation of the local government spending multiplier. I first lay down the estimation framework, show the estimation of the multiplier, discuss the heterogeneity of the multiplier, and note some particular characteristics of the fiscal experiment studied in this paper.

4.1 Estimation framework

For the fiscal experiment in this paper, local government spending shall respond in all the years after 2000 due to *raw*, either directly through higher land sale profitability or indirectly through higher tax revenues resulting from larger tax base. There are two time dimensions for the multiplier, one for the government spending and the other for the output. For example, how would government spending in 2005 affect local output in 2010? When the economy is at the steady state, the multiplier may not depend on the time of the government spending but only on the lapse between spending and outcome. The economy of China during my sample period is unlikely to be at the steady state. Spending in the earlier years when the stock of public capital was low shall generate larger effect on local output than additional spending in later years. As *raw* is a constant for each city, I will not be able estimate the dynamic effect of government spending occurred in different years.

Conceptually, the estimate to be considered in this chapter is, for certain time period, with a windfall of 1 RMB and if we allow the local governments to optimally allocate the spending of 1 RMB across different years within this period, how much total output in this period would increase. This definition closely follows the macro literature on government spending multiplier (Ramey, 2020). To this end, I define the present value of output and government spending as follow:

$$GDP_c^t = \sum_{\tau=1998}^{t} GDP_{c,\tau} * (\frac{1}{1+R})^{\tau-2000} \tag{4.1}$$

$$G_c^t = \sum_{\tau=1998}^{t} G_{c,\tau} * (\frac{1}{1+R})^{\tau-2000} \tag{4.2}$$

In Equation (4.1) and (4.2), $GDP_{c,\tau}$ is the real GDP and $G_{c,\tau}$ is the real government spending of city c in year τ, both using the price in 2000. The two variables GDP_c^t and G_c^t are the present value of the accumulated GDP and government spending evaluated in the year of 2000, using R as the discount rate. [1]

To get the impulse responses of government spending and GDP after 2000 following an increase of *raw*, I estimate the following two equations to get the dynamic treatment effect β_t:

$$\log(G_c^t) = \beta_t^1 \cdot raw_c + X_c \cdot \Gamma_t^1 + \alpha_c^1 + \gamma_{p(c),t}^1 + \varepsilon_{c,t}^1$$
$$\log(GDP_c^t) = \beta_t^2 \cdot raw_c + X_c \cdot \Gamma_t^2 + \alpha_c^2 + \gamma_{p(c),t}^2 + \varepsilon_{c,t}^2$$

I include the time-varying effect of the starting point $X_c = (\log(G_c^{2000}), \log(GDP_c^{2000}))$ to control for differential growth path. The impulse response of GDP_c^t and G_c^t for a 1% increase of raw_c is then calculated as:

$$\Delta G^t = 1\% \cdot \hat{\beta}_t^1 \times \frac{1}{C} \sum_c G_c^t, \tag{4.3}$$

$$\Delta GDP^t = 1\% \cdot \hat{\beta}_t^2 \times \frac{1}{C} \sum_c GDP_c^t, \tag{4.4}$$

where C is the number of cities.

1. Section C.1 in Appendix C provides details on the calculation of the local government spending G. It includes spending financed by local budgetary revenues, central government transfers, land sale revenues and net debt issuance and excludes compensation expense to displaced occupants. I choose the starting year to be 1998 because it is the first year for which I observe both budgetary expenditure and infrastructure investment so that I can calculate $G_{c,t}$.

To get the multiplier for the period until year t, consider the following relationship between GDP and government spending:

$$\log(GDP_c^t) = \beta_t \cdot \log(G_c^t) + \alpha_c + \gamma'_{p(c),t} + X_c \cdot \Gamma'_t + \epsilon'_{c,t},$$

where β_t captures the elasticity of the accumulated GDP to the accumulated government spending, α_c is the time-invariant city fixed effect, $\gamma'_{p(c),t}$ is the province-by-year fixed effect that captures the province-level heterogeneous shocks, $X_c = (\log(G_c^{2000}), \log(GDP_c^{2000}))$ controls for differential growth path, and $\epsilon'_{c,t}$ is the error term.

To get rid of α_c, consider $\log(GDP_c^t) - \log(GDP_c^{2000})$ for $t > 2000$:

$$\log(GDP_c^t) = \beta_t \cdot \log(G_c^t) + \gamma_{p(c),t} + X_c \cdot \Gamma_t + \epsilon_{c,t}, \tag{4.5}$$

where $\gamma_{p(c),t} = \gamma'_{p(c),t} - \gamma'_{p(c),2000}$, $\Gamma_t = \Gamma'_t - \Gamma'_{2000} + [-\beta_{2000}, 1]^T$ and $\epsilon_{c,t} = \epsilon'_{c,t} - \epsilon'_{c,2000}$.

With the elasticity estimate of $\hat{\beta}_t$, I can then calculate the spending multiplier M_t as follows (Leduc and Wilson, 2013):

$$M_t = \hat{\beta}_t \cdot \mathbf{E}_t[\frac{GDP_c^t}{G_c^t}] \tag{4.6}$$

The estimate of M_t tells when the local government spending increases by 1 RMB and allocates the spending across different periods during 2001-t (with return rate on savings to be R), how much the local output during the same period would increase. To estimate β_t in Equation (4.5), I will use raw_c as an instrument for $\log(G_c^t)$ for $t > 2000$. The two identification assumptions are:

$$\begin{cases} \text{Relevance Condition:} & Cov(\log(G_c^t), raw_c | \gamma_{p(c),t}, X_c) \neq 0 \\ \text{Exclusion Restriction:} & \mathbf{E}\left[raw_c \cdot \epsilon_{c,t}\right] = 0, t > 2000 \end{cases}$$

The relevance condition holds as I have shown in Section 3.3.1. To ease the discussion on the exclusion restriction, assume the following process for $\epsilon'_{c,t}$:

$$\epsilon'_{c,t} = f(\epsilon'_{c,t-1}) + \eta_{c,t},$$

where $\eta_{c,t}$ is i.i.d. over time.

The violation of the exclusion restriction can be caused by either $\mathbf{E}[raw_c \cdot \epsilon'_{c,2000}] \neq 0$ or $\mathbf{E}[raw_c \cdot \eta_{c,t}] \neq 0$ for $t > 2000$. As discussed in Section 3.3.2, raw_c is not significantly correlated with any city fundamentals in 2000 and hence $\mathbf{E}[raw_c \cdot \epsilon'_{c,2000}] \neq 0$ is unlikely to hold. Moreover, the discussion in Table 3.4 lends some support to the assumption that $\mathbf{E}[raw_c \cdot \eta_{c,t}] = 0$. Therefore, raw_c is a valid instrument for $\log(G_c^t)$.

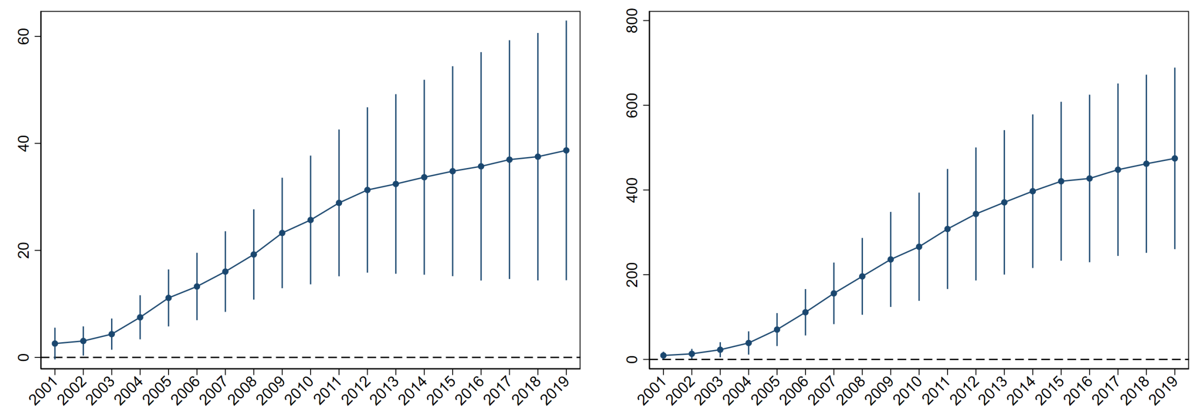
To conduct the estimation, we still need one parameters: R. Conceptually, the correct rate to discount the government spending should be their marginal cost of capital, which when proxied by their bond yields ranges between 3.5% and 7.5% (He et al., 2022). Since the government bond issuance concentrates in later years and the cost of capital might be higher in earlier years, I will use a more conservative value of $R = 10\%$ in this paper. To be consistent, I will also use $R = 10\%$ to discount the real GDP.[2]

4.2 Empirical results

Figure 4.1 shows the impulse responses of G_c^t and GDP_c^t given by Equation (4.3) and (4.4), scaled by the city's population in 2000. There is a persistent and increasing treatment effect of *raw* on government spending and GDP. When *raw* increases by 1%, the accumulated government spending will increase by about 38.7 RMB per capita and the accumulated GDP will increase by about 474.6 RMB per capita until 2019.

To check the dynamic composition of government spending, I divide total government spending into two components: government investment in infrastructure and other

2. The estimated multiplier turns out not sensitive to the choice of R. Setting $R = 5\%$ barely changes the estimates of M_t.



(a) Government Spending per capita

(b) GDP per capita

Figure 4.1: Impulse Responses of Govt Spending and GDP

Note: The figure plots the estimated increase of government spending and GDP per capita for a 1% increase of *raw*, along with the 95% confidence interval. The confidence interval is calculated using bootstrap by re-sampling cities independently within each province 500 times.

categories of spending. Using the same estimation procedures as for total government spending, Figure 4.2 shows the impulse responses of the two types of spending. When *raw* increases by 1%, both types of spending experience an increase over time. After 2012, there is no further incremental effect on government infrastructure spending while the the effect on other types of spending continues to grow.

The dash line, which shows the marginal propensity to spend on infrastructure investment, reveals two messages. First, the marginal propensity to invest in infrastructure has been high in China. In the first four years, when government spending increases by 1 RMB, roughly half is spent on infrastructure investment. The propensity decreases to about 0.2 in 2019, which is still likely higher than that in other countries. This high propensity to spend on infrastructure is consistent with the conjecture that local governments in China have a strong incentive to promote economic growth with infrastructure investment. Second, the propensity to invest has been decreasing over time, likely due to decreasing opportunities of infrastructure investment. It may be very profitable to increase the highway from 0 to 1. But with an existing highway, the marginal return from building another one might be low.

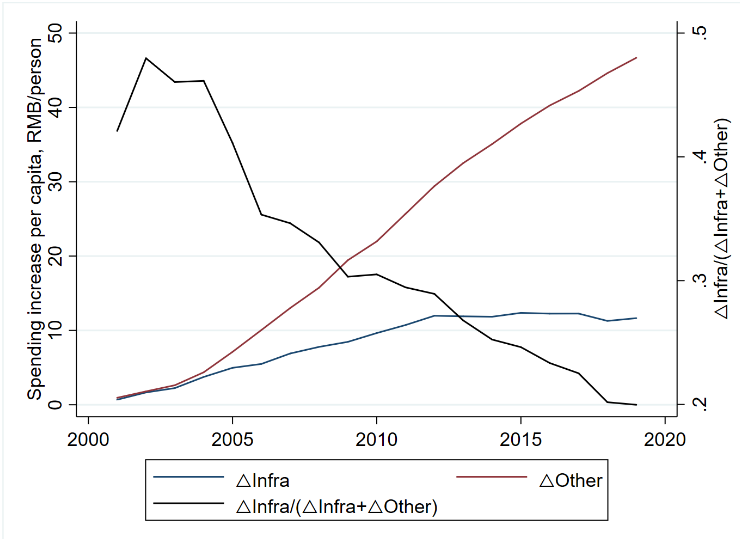


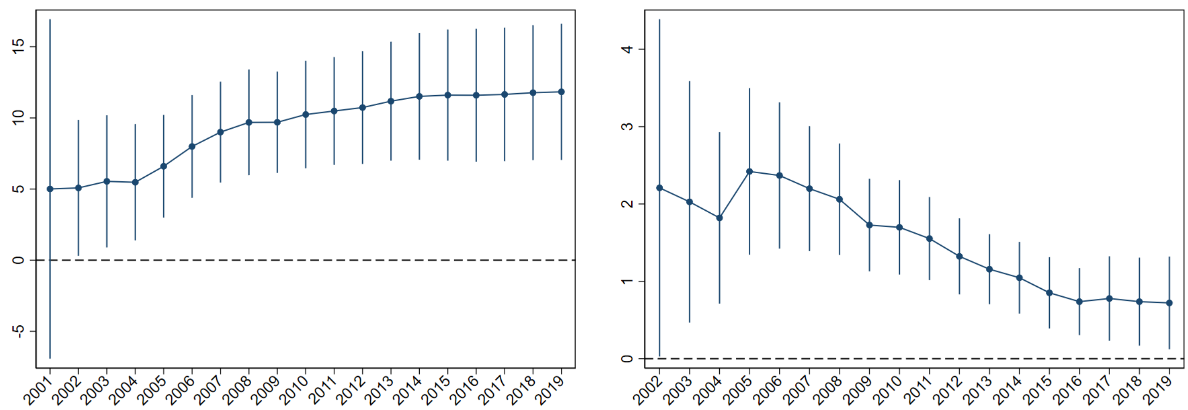
Figure 4.2: Marginal Effect of *raw* on City Government Spending

Note: This figure shows the average marginal effect of accumulated government investment spending and other spending as well the ratio between the two effect, when *raw* increases by 1%.

Figure 4.3 Panel (a) shows the estimated government spending multiplier using Equation (4.6). The impact multiplier, i.e., the multiplier immediately after 2000, is about 5. It then increases steadily over time and converges to about 11. In 2019, the multiplier is estimated to be 11.8 with the 95% confidence interval between 7 and 16.6. The increasing trend of the multiplier is consistent with predictions of models with government investment spending as the effect of government investment is larger in the long run when it leads to positive adjustment of the private inputs. In Chapter 5, I will show that it is the endogenous responses of the private inputs, including private investment and employment, that lead to the large and persistent multiplier.

The slowdown of the increasing trend, however, suggests that the effect of government spending on annual GDP becomes smaller over time. This is confirmed in Panel (b), which shows the annual multiplier, which is the effect of accumulated government spending on the annual GDP by replacing GDP_c^t with $GDP_{c,t}$ in Equation (4.5) and

(4.6). The annual multiplier tells how much local output in year t can increase when the present value (evaluated in year t) of government spending prior to t increases by 1 RMB. The annual multiplier dramatically decreases over time. The annual multiplier is between 2 and 3 in the first few years and then decrease smoothly over time. In 2019, the annual multiplier is only about 0.6, i.e., the local real GDP will increase by about 0.6 RMB in 2019 when the present value of government spending during 2001-2019 increases by 1 RMB.



(a) Estimated local govt spending multiplier (b) Annual local govt spending multiplier

Figure 4.3: Estimated local govt spending multiplier

Note: Panel (a) plots the estimated local government spending multiplier using Equation (4.6) along with the 95% confidence interval. The confidence interval is calculate using bootstrap by re-sampling cities independently within each province 500 times. Panel (b) plots the annual multiplier using similar specification except replacing GDP_c^t with $GDP_{c,t}$.

In Appendix C, I decompose GDP into different sectors. In 2019, the multiplier is roughly 2 due to the effect on the real estate sector, 5.7 with the 95% confidence interval between 0.5 and 10.9 due to the effect on the manufacturing sector, and 3.2 with the 95% confidence interval between 0.5 and 5.9 due to the effect on the tertiary sector.

How should we compare the estimates to those in the literature? The typical estimates as reviewed by Chodorow-Reich [2019] range between 1 and 2. Importantly, these estimates usually look at the effect on local output in very short horizon, such as 1-2 years. Therefore, the annual multiplier in this paper is theoretically more comparable to the estimates in most literature. In this sense, the multiplier in this paper is close to what researchers find in other settings. The dramatic difference, however, is on the persistence of the effect of government spending. Different from government spending that temporarily increase the consumption demand, government spending in public capital and other intangible social infrastructure can affect the supply side by improving local business conditions, leading to crowd-in of private inputs and generating persistent effect into the future. It is the persistence that leads to a large accumulated multiplier of 11.8 over the 19-year horizon.

4.3 Heterogeneity of the multipliers

There are more interests in the heterogeneity of the multiplier rather than the value of the multiplier itself. The heterogeneity of the multiplier is informative about the underlying mechanisms and can also guide fiscal policies to achieve more efficient outcomes. In this section, I exploit cross-sectional heterogeneity along two dimensions that are particularly important in the context of government spending as investment.

4.3.1 Local government debt capacity

One convenient way to evaluate the local government's benefit from its spending is to look at the tax benefits as a result of the larger tax base. In Appendix C I estimate that during 2001-2019, the marginal tax rate for local governments is about 17.1%. Multiply the multiplier with the marginal tax rate, we get the tax return to be 2 RMB, with the 95% confidence interval between 1.2 RMB and 2.8 RMB. As the number is significantly above 1, it means on average, the local governments can make more profits in the form of long-run tax revenues if they can spend more. The total benefit is even higher if we ever consider other aspects of benefit, such as the officials' higher chance of getting promoted.

The large benefit from the perspective of local governments can only hold in equilibrium with myopic local officials or local government financial constrained. The city governors typically stay in office for 4-5 years and a myopic official will downplay the long-run benefits. Without government financial constraint, given the local governments' strong incentive to promote economic growth and the high tax return of government spending, the government should have spent more and brought the multiplier down. Measuring the extent of local official myopia is challenging. In this section, I will investigate whether the multiplier is smaller if the city has better access to outside financing.

If compared to the counterpart in the US, the local governments in China appear to have less access to debt financing during the sample period. Panel (a) of Figure C.5 in Appendix C shows that in 2019, the distribution of local government debt-to-income ratio is almost the same between China and US. But note that local governments in China have a much higher income growth rate. Before 2019, the annual growth rate of local government total income is well above 10% for China, while it is well below 10% for the US. Therefore, if local governments in China had similar access to outside debt financing as those in the US in 2019, they should have higher rather than similar debt-to-income ratio.

Before 2019, the local government debt access must be even worse. Under the 1995 budget law, China's local governments are banned from issuing bonds or borrowing from banks directly. To circumvent these restrictions, the local government financing vehicles (LGFVs) are set up as non-government entities that can borrow from banks and undertake the duty of urban construction. According to the estimates from Wu [2015], the local government debt-to-GDP ratio increased from 8% in 2000 to 18% in 2008. On November 9, 2008, in response to the Global Financial Crisis, China initiated a four-trillion RMB stimulus to be conducted during 2009-2010 (Acharya et al., 2022). Over 60% of the stimulus is infrastructure investment made by the local governments, who could only finance the investment with more debt. As a result, local government debt experienced a fast increase since 2009. Wu [2015] estimates the local government debt-to-GDP ratio jumped to more than 25% in 2009. However, such relaxation of local government debt use was soon restricted from further growing as the central government became concerned about the rising local government debt level. In 2015, the central government introduced the debt ceiling management on local government debt balance. Panel (b) of Figure C.5 shows how much debt the local governments use relative to the debt ceiling imposed by the central government. In 2019, the debt balance-to-ceiling ratio is above 80% for most all the local governments, indicating that they would borrow more if allowed to.

To test whether better debt access allows the local governments to take more profitable investment opportunities and leads to a smaller marginal effect of government spending in equilibrium, I interact local government spending with a measure of the government debt access in the baseline regressions:

$$\log(GDP_c^t) = \beta_t \cdot \log(G_c^t) + \kappa_t \cdot DTI_c \cdot \log(G_c^t) + \theta_t \cdot DTI_c + X_c \cdot (\Theta_t \cdot DTI_c + \Gamma_t) + \gamma_{p(c),t} + \varepsilon_{c,t} \tag{4.7}$$

In Equation (4.7), κ_t captures how the effect of government spending depends on the local governments' debt access. The discussion above predicts $\kappa < 0$. I consider the most flexible specification by also allowing the base effect to vary with the governments' debt access. To estimate this equation, I will use $(raw_c, DTI_c \cdot raw_c)$ as instruments for $(\log(G_c^t), DTI_c \cdot \log(G_c^t))$.

The first candidate for the measure of local governments' debt access is their ex-ante debt-to-income ratio, which is the amount of urban infrastructure investment financed by loans divided by the government budgetary expenditure, both measured in 1999. Table 4.1 Panel A reports the results. For both $t = 2004$ and $t = 2008$, I find the effect of government spending on local output to be significantly smaller for cities with higher debt capacity, consistent with my prediction. In terms of magnitude, a one standard deviation increase of DTI will decrease the elasticity of output to government spending by 0.21 for 2004 and 0.29 for 2008, which is considerable compared to the average elasticity of 0.48 for 2004 and 1.01 for 2008. For the year after 2008, the estimated coefficient of the interaction term remains negative although insignificant, probably because DTI before 2000 has lower predicting ability for debt access more than 10 years away.

Table 4.1: Government spending multiplier and debt capacity

Panel A: Ex-ante debt-to-income (DTI)

Dep Var: log(GDP)	(1)	(2)	(3)	(4)
Year	2004	2008	2014	2019
log(G)	0.664***	1.264***	1.752***	2.094***
	(2.988)	(4.236)	(3.823)	(3.245)
DTI*log(G)	-3.690**	-5.101**	-6.230	-6.777
	(-2.217)	(-2.091)	(-1.463)	(-1.287)
DTI Effect	Yes	Yes	Yes	Yes
Base Year Effect	Yes	Yes	Yes	Yes
Prov FE	Yes	Yes	Yes	Yes
Observations	263	263	263	263
R-squared	0.993	0.967	0.907	0.855
F statistic	4.380	7.358	6.499	4.760

Panel B: Ex-post debt ceiling-to-income (DCTI)

Dep Var: log(GDP)	(1)	(2)	(3)
Year	2008	2014	2019
log(G)	1.125***	1.919***	2.448***
	(5.099)	(4.105)	(3.192)
DTI*log(G)	-0.562	-1.084**	-1.495**
	(-1.412)	(-2.239)	(-2.218)
DTI Effect	Yes	Yes	Yes
Base Year Effect	Yes	Yes	Yes
Prov FE	Yes	Yes	Yes
Observations	270	270	270
R-squared	0.972	0.906	0.832
F statistic	6.724	6.919	4.229

Note: This table shows the relationship between the multiplier and the government debt capacity. The debt capacity is measured using the domestic loan borrowing scaled by total income in 1999 for Panel A and the government debt ceiling in 2019 scaled by its total income in 2000 for Panel B. Robust t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The second candidate for the measure of local governments' debt access is their ex-post debt ceiling-to-income ratio, which is the city governments' debt ceiling in 2019 scaled by their income in 2000. In Appendix C I show there is a strong positive correlation between debt ceiling and government spending growth from 2000 to 2019. The pattern suggests higher debt ceiling is more likely to be driven by better access to debt financing rather than higher demand for debt due to lower incomes from other sources.

Table 4.1 Panel B reports the results. Higher debt ceiling is associated with a significantly smaller elasticity of output to government spending, especially in later years when debt ceiling in 2019 is more relevant for measuring their debt capacity.

The heterogeneity of the government spending multiplier with respect to the debt use confirms my conjecture that financial constraint is a necessary condition for the high multipliers. Moreover, it also links to the discussion on China's local government debt risks by highlighting the large heterogeneity across different cities. In cities with lower level of debt, more debt issuance should be allowed as the marginal gain is high. But in cities that have used more debt, strict restriction should be imposed as the marginal government spending generates smaller effect on local output.

The role of local government debt capacity in shaping the multiplier naturally leads to another question. If the local output effect of government spending is so large, why did not the central government relax the local governments' borrowing constraint and allow them to spend more? One explanation can be the externality of local government spending through the capital market and the negative spillovers that are internalized by the central but not the local governments. From the central government's perspective, given the amount of national savings, government borrowing and spending would crowd out the private investment. However, the local governments take the interest rate in the national capital market as given, and would not consider how their individual borrowing could drive up the interest rate and crowd out the private investment. Moreover, there would be local crowding-in since the increase of local public capital raises the productivity of private capital and attracts more private investment from other places. Such crowding-in effect can lead to large local multiplier but at the cost of investment in other places, and the cost is not internalized by the local government but very likely by the central governments. The misalignment of interests between the central and local governments may explain why the central government finds it optimal to limit local government debt capacity, even if the local multiplier is high.

4.3.2 Private input mobility

The government financial constraint is a necessary but not sufficient condition for the large multiplier. As pointed out by Ramey [2020], government investment in public capital can generate large effect on local output if it leads to crowding-in of private input. Essentially, government spending that increases the local public capital or improve the intangible social infrastructure can increase the productivity of other inputs, and hence private firms respond by increasing private inputs, leading to larger effect on local output. In the next chapter I will show quantitatively that the crowding-in of private inputs can largely explain the output effect. In this section, I will check whether the multiplier is higher in cities where the private capital is more mobile.

When the private capital is more mobile, government spending can attract more private investment from other places. In cities with immobile capital, private investment can only increase at the cost of consumption. While more public capital can increase the productivity of private capital, it can also increase current consumption due to the wealth effect, and hence the short-run effect on private investment is ambiguous. Regardless of the sign of the effect, the increase of private investment would be smaller than in the case with more mobile private capital.

I borrow the estimates of province-wide capital mobility from Lai et al. [2013]. Following Shibata and Shintani [1998], Lai et al. [2013] measure local capital mobility based on the correlation between growth of local consumption and net output with permanent income consumers. Under financial autarky, provincial savings equal provincial investments and hence the two are perfectly correlated. With financial integration, growth of consumption depends on the expected change of permanent income and loads less on the current net output.

To check how local private capital mobility affects the multiplier, I estimate Equation (4.7) by replacing DTI_c with IM_c from Lai et al. [2013], a higher value of which corresponds to less mobility. Table 4.2 reports the results. For years before 2008, we find the elasticity of output to government spending to be significantly smaller if local capital is less mobile. The interaction term becomes insignificant in later years, probably because the IM_c is estimated using data before 2008 and becomes less relevant for later years.

Table 4.2: Government spending multiplier and Private Capital Mobility

Dep Var: log(GDP)	(1)	(2)	(3)	(4)
Year	2004	2008	2010	2019
$\log(G)$	0.643**	1.187***	1.299***	2.185***
	(2.553)	(4.555)	(4.757)	(3.068)
$IM \times \log(G)$	-0.521*	-0.724**	-0.613	-0.947
	(-1.670)	(-2.082)	(-1.548)	(-1.032)
Group-Base Effect	Yes	Yes	Yes	Yes
Group FE	Yes	Yes	Yes	Yes
Prov FE	Yes	Yes	Yes	Yes
Observations	215	215	215	215
R-squared	0.994	0.979	0.972	0.898
F statistic	4.304	7.705	8.719	3.539

Note: This table shows the relationship between the multiplier and the government debt capacity. The debt capacity is measured using the domestic loan borrowing scaled by total income in 1999 for Panel A and the government debt ceiling in 2019 scaled by its total income in 2000 for Panel B. Robust t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The discussion in this section sheds light on two important factors that impact the effect of government spending that directly benefits the supply side. A combination of government financial constraint and greater private capital mobility can lead to a larger marginal effect of government spending.

4.4 Characteristics of the fiscal experiment

As highlighted by Ramey [2011a], the magnitude of the multiplier depends on the characteristics of fiscal experiments. I discuss several important features of the fiscal experiment in this paper.

The first is related to the finance of the fiscal spending. Unlike other experiments where the local government spending is financed by grants or federal spending without direct wealth effect on local households, the marginal change of local government spending in this paper is financed by less transfers to occupants removed from the land. Conceptually, this works like a non-distortive lump-sum tax on local households. In later years when the economy grows, the local government's tax revenues increase. But in other papers, the multiplier is usually too small to generate sizable impact on the local government tax revenues, which is probably why no paper has ever examined the reinforcement effect of economic growth on government spending through more tax revenues.

Second, I have examined a persistent rather than temporary shock to local government spending. A persistent change of government spending especially investment spending usually leads to higher multipliers than a temporary change (Ramey, 2020).

Third, one may be concerned that the estimates in this paper may suffer from anticipation bias. As argued by Ramey [2011b], when the market participants anticipate the future increase of government spending, they may respond before the spending actually happens. In my context, firms may take into account of future government spending when deciding which city to enter. If *raw* is positively correlated with future government spending, then the estimated effect of realized government spending on current GDP will be biased upwards. This is likely a concern before 2012. But as I show in

Figure 3.4, *raw* is not significantly correlated with the flow of government spending after 2012 thanks to central government transfers and local government debt issuance, the estimated M_t after 2012 is likely less immune to this bias.

Lastly, note that this is a local multiplier. Although in the last column of Table 3.4, I show there is no evidence of stronger spillovers to neighboring cities, it does not mean that we can equate the local multiplier to the national multiplier. Imagine the spillover across cities is such that it does not depend on the distance between the pair of cities, then the measure of $CitySpillover$ will not be able to capture it. In the next chapter, I show local government spending leads to large crowd-in of private capital in forms of firm entry. It is likely that the across-city spillover effect on firm entry does not depend on the distance between city pairs but on whether the two cities have similar industry structure. For example, an auto manufacturing firm is more likely to choose the location of a new factory between two cities with similar availability of inputs, rather than between two neighboring cities. Therefore, the insignificant coefficient estimates of $CitySpillover$ do not necessarily imply the national multiplier is the same as the city-level multiplier.

CHAPTER 5

MECHANISMS

In this chapter, I provide evidence showing that the mechanism is consistent with a model where the government spending affects the supply side and the large long-run multiplier is due to the endogenous response from the private sector. I will first show that local government spending can increase local private input, including labor, machinery and structure capital, and the magnitude of the increase of private inputs can largely explain the multiplier.

5.1 Crowding-in of private inputs

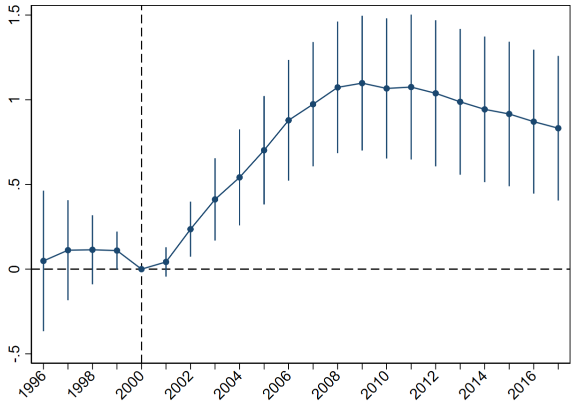
To study the crowding-in of private investment, I estimate the stock of two types of private capital, structure and machinery. For each type of capital in each year t, I calculate the stock as the cost to invest using the output goods in year t. Denote $I_{c,t}$ as the nominal private investment in city c and year t, δ as the annual depreciation rate, P_t^I as the price of the capital in year t and P_t as the price of all the other goods in year t, both normalized to be 1 in 2000. The stock of capital $K_{c,t}$ is then given by:

$$K_{c,t} = \frac{P_t^I}{P_t} \sum_{\tau} \frac{I_{c,\tau}}{P_\tau^I} (1-\delta)^{t-\tau}$$

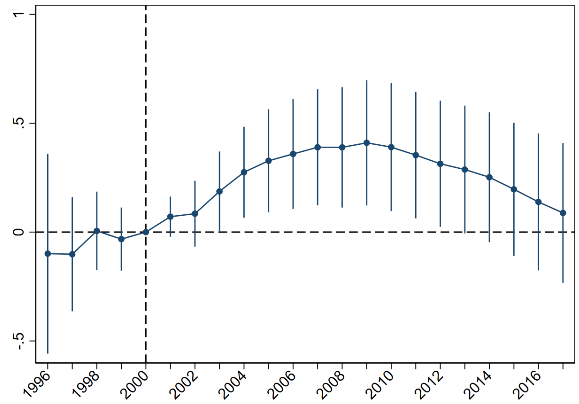
Following Munnell [1990] and Bai et al. [2006], I will use $\delta = 8\%$ for structure capital and $\delta = 15\%$ for machinery capital.

Figure 5.1 plots the dynamic treatment effect of raw_c on the city's stock of structure capital, machinery capital and non-agriculture employment using Equation (3.5). Cities, regardless of their raw_c, experienced parallel trends with respect to all the three types of private input before 2000, but quickly diverged since 2000. The effect on capital was more immediate than on labor, but the magnitude of the effect starts to decrease since

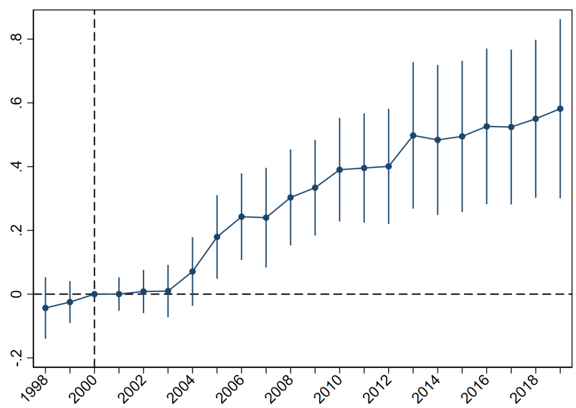
2008, while the effect on employment keeps increasing.



(a) $\log(Struc_{c,t})$



(b) $\log(Mach_{c,t})$



(c) $\log(Emp_{c,t})$

Figure 5.1: Marginal Effect of *raw* on Private Input

Note: The figure plots the 95% confidence interval of the β estimates from Equation (3.5), where the dependent variable is indicated below each graph. For employment, the data is only available for 13 cities before 1998 and so I start from 1998. All standard errors are clustered by the city.

Are the increases of private inputs enough to explain the multiplier? To answer this question, we need to know the marginal output of each input. If the labor market is competitive, the marginal output of employment is wage. For private capital, assume the required rate of return on private investment is R, the following equation holds:

$$1 + R = \frac{dY}{dK} + 1 - \delta + \frac{P^I_{t+1}/P^I_t}{P_{t+1}/P_t} \rightarrow \frac{dY}{dK} = R + \delta - \frac{P^I_{t+1}/P^I_t}{P_{t+1}/P_t}$$

Bai et al. [2006] estimates the return on private capital in China is about 20% since 1998, and Chen et al. [2019] finds the return has decreased to about 10% since 2010. I try both 20% and 10% for R and assume both structure and machinery capital earn the same return R.

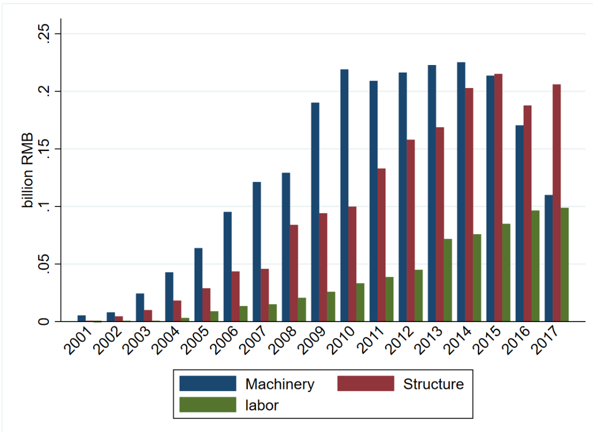
In Figure 5.2 Panel A, the left graph shows the increase of private input multiplied by its marginal output when *raw* increases by 1%, under the assumption that $R = 20\%$. The machinery equipment plays the most important role in the earlier years, but becomes small in the last three years. The effect from structural capital and labor increases gradually over time. In the right graph, the total effect from the increase of the three inputs aligns well with the increase of local GDP. In other words, under the assumption that the return of private investment is $R = 20\%$, almost all the GDP effect can be explained by the increase of the private input.

The assumption of $R = 20\%$ maybe unrealistically high as it is the average not marginal return estimated by Bai et al. [2006]. In Panel B, I consider a more conservative value for $R = 10\%$. In this case, the increase of the private input can still explain roughly 70% of the total GDP effect, as shown in the right graph. The difference between the total effect and the input effect represents the direct effect of local government spending.

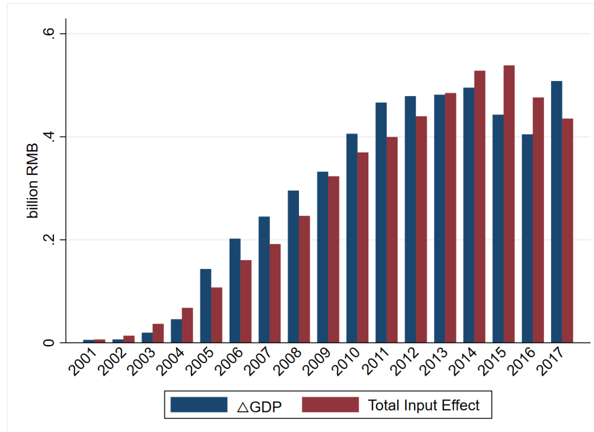
5.2 The extent of input mobility

How should we interpret the size of the crowding-in of private inputs? In particular, how should we think about the role of private input mobility to justify the crowding-in of private inputs? To map the crowding-in effect to input mobility, consider the following city-wide production function:

$$Y = A \cdot G^{\gamma} M^{\alpha} N^{1-\alpha},$$

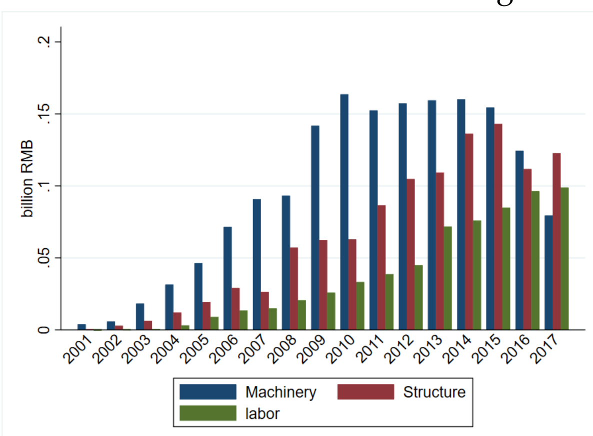


(a) Contribution of inputs

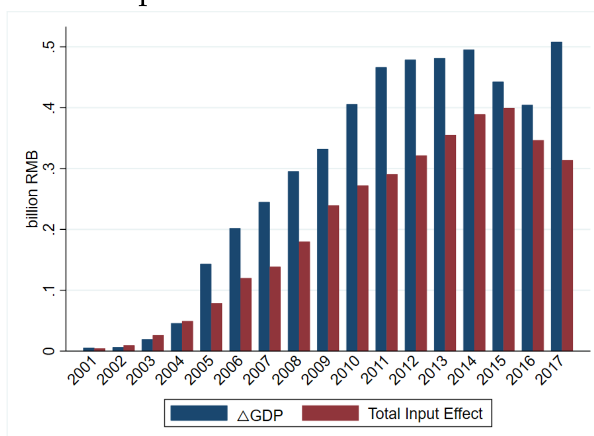


(b) Total Effect vs Input Effect

Panel A: Marginal return of capital = 20%



(c) Contribution of inputs



(d) Total Effect vs Input Effect

Panel B: Marginal return of capital = 10%

Figure 5.2: The direct effect from input increase

Note: This figure plots the effect on local output through the increase of private inputs, i.e., machinery, structure and labor. I assume a marginal return on private capital to be 20% in Panel A and 10% in Panel B.

where G is public capital resulting from local government spending, M is mobile input, and N is immobile input. As N is immobile, it is fixed. For M to be mobile, the private sector will determine its demand for M taking G and the P_M, which is the price for input M in the national market, as given. Solve for the optimal use of M, we get

$$M^{\star} = \frac{\alpha Y}{P_M}$$

Substitute the optimal $M^{\star}$ into the production function, we get the equilibrium output elasticity to G:

$$\frac{d\log(Y)}{d\log(G)} = \frac{\gamma}{1-\alpha} \tag{5.1}$$

According to Equation (5.1), the output elasticity to government spending increases monotonically with α, which is the share of mobile inputs among all the inputs. Based on the elasticity estimated from Equation (4.5) and $\gamma = 0.25$ which is estimated by Baxter and King [1993], we can then back out what α should be so that the elasticity equals what I have estimated.

Figure 5.3 shows the implied share of mobile capital along with the output elasticity. Overall, the implied input mobility increases over time. In the early years, the share of mobile inputs is only about 40%, and by 2019 it has increased to about 80%. The increasing trend is consistent with various reforms in the banking sector and the stock market that lead to an integrated national capital market (Lai et al., 2013), as well as labor market reforms that reduces the cost of moving (Meng, 2012). According to the firm registry data, among all the firms registered by 2017 that are subsidiaries of other firms, for 55% of them the parent firms are from different cities.

To summarize, the large long-run multiplier can be quantitatively explained by the crowding-in of private inputs, and the magnitude of the crowding-in effect can be justi-

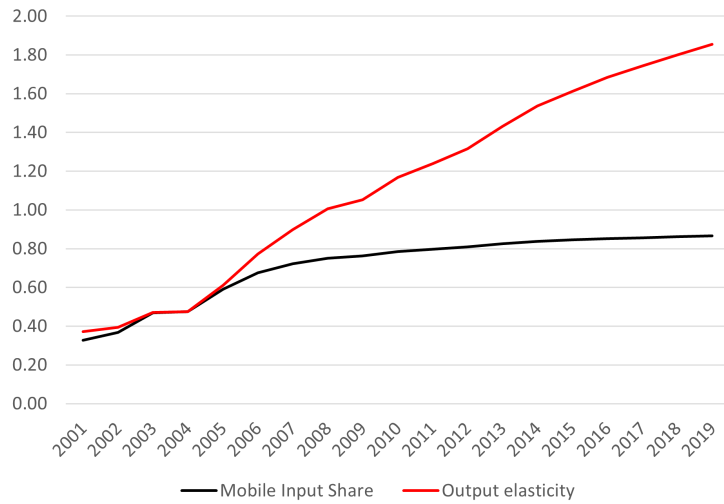


Figure 5.3: Implied share of immobile input

Note: The figure plots the implied share of mobile inputs, α, based on Equation (5.1) as well as the output elasticity to local government spending which is the IV estimates of β in Equation (4.5).

fied with a reasonable parameter of input mobility.

CHAPTER 6

RESPONSES OF LOCAL FIRMS

In this chapter, I move from the aggregate effect to firm-level responses to local government spending. The change of local economy can occur through either the extensive or the intensive margin. On the extensive margin, new firms enter and some exiting firms exit. On the intensive margin, any single firm experiences improvement of productivity, faces different demand and horizontal competition. This analysis will shed light on how government spending affects the local firms, leading to the aggregate output multiplier that we have studied so far.

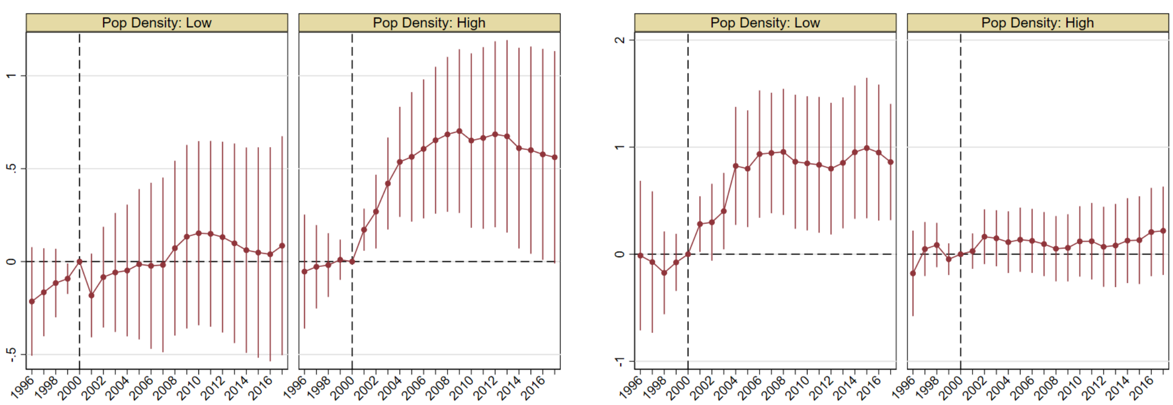
How much the local governments can benefit from *raw* depends on the local population density. In Appendix E, I show that higher population density leads to higher land demand, drives up the land price and hence the compensation rate, which would make occupied land more valuable as it can save the local governments more compensation expense. To the extent that the scale of government spending may lead to differential responses of local firms, I shall differentiate the local firm responses for cities with high and low population density. In other words, I will study how *raw* affects local production for cities with high and low population density separately.

6.1 Firm entry and firm size

I shall start by analyzing whether government spending affects the extensive margin by looking at the equilibrium number of active manufacturers, i.e., the number of firms that have entered the local market and not yet exited. To this end, I use the Firm Registry data and calculate $\#Mfr_{c,t}$, the number of manufacturers registered in city c and surviving at the end of year t. To measure the size of these manufacturers, I also calculate $AveE_{c,t}$, which is the average registered equity of all the surviving manufacturers. Using

Equation (3.5), I then analyze how raw affects $\log(\#Mfr)$ and $\log(AveE)$.

Figure 6.1 shows the dynamic treatment effect by the city's population density in 2000. Interestingly, for cities with low population density, local government spending does not appear to facilitate entry of more firms, but attracts larger firms, while in cities with high population density, local government spending attracts more firms but does not affect the average firm size. One explanation for the different patterns may be that, with a small windfall of resources, the local government prioritizes spending to helping larger firms, which tends to attract larger firms. With a larger windfall of resources, however, the local governments are able to serve all firms, attracting more firms regardless of their size.



(a) Number of Mfrs (b) Average Registered Equity

Figure 6.1: Marginal effect on firm entry and firm size

Note: The figures plot the average marginal effect of the number of active manufacturers and average registered equity for a 1% increase in raw, for cities with high and low population density separately.

6.2 Local firms' production and productivity

In this section, I study how any given firm is affected by the local government spending. Consider the following firm-level production function:

$$Q_{k,j,t} = A_{k,j,t} \cdot (Z_{k,j,t}K_{k,j,t})^{\alpha_k^j} \cdot (C_{k,j,t}L_{k,j,t})^{\alpha_l^j} \cdot M_{k,j,t}^{\alpha_m^j} \tag{6.1}$$

In Equation (6.1), $Q_{k,j,t}$ is the output of firm k from industry j in year t, measured by the price in 1990; $A_{k,j,t}$ is productivity, $Z_{k,j,t}K_{k,j,t}$ is effective utilization of capital $K_{k,j,t}$, $C_{k,j,t}L_{i,t}$ is effective utilization of labor $L_{k,j,t}$, and $M_{k,j,t}$ is material. Unlike a technology shock that directly affects firms' productivity, local government spending may work by increasing access to larger markets, which will lead to a direct impact on the firms' input utilization. Mixing utilization in the productivity measure may affect the interpretation about the effect on productivity.

By taking logarithm, we can decompose the real output into five components:

$$\log(Q_{k,j,t}) = tfpq_{k,j,t} + utili_{k,j,t} + \alpha_m^j \cdot \log(M_{k,j,t}) + \alpha_k^j \cdot \log(K_{k,j,t}) + \alpha_l^j \cdot \log(L_{k,j,t}), \tag{6.2}$$

where $tfpq_{k,j,t} = \log(A_{k,j,t})$ and $utili_{k,j,t} = \alpha_k^j \log(Z_{k,j,t}) + \alpha_l^j \log(C_{k,j,t})$.

There are many ways to obtain the factor share $(\alpha_k^j, \alpha_l^j, \alpha_m^j)$ and the TFPQ measure, a subject of ongoing debt in the literature. I will estimate the production function with the simple "factor share" method (Criscuolo et al., 2019). Appendix E provides details on the construction of factor shares.

To measure utilization, Basu [1996] assumes that material use is proportional to the effective utilization of inputs that are not easy to adjust in the short run, and hence the deviation of material use from these inputs can be seen as a measure for input utilization.

Following Basu [1996], I estimate utilization as follows:

$$util i_{k,j,t} = \alpha_k^j \cdot (\log(M_{k,j,t}) - \log(K_{k,j,t})) + \alpha_l^j \cdot (\log(M_{k,j,t}) - \log(L_{k,j,t}))$$

The $tfpq_{k,j,t}$ is then defined as the residual by subtracting the other four components in Equation (6.2) from $log(Q_{k,j,t})$.

With the measure of the five components, I then examine the effect of *raw* with the following specification:

$$y_{k,j,t} = \beta \cdot raw_{c(k)} + \gamma_{p(k),j,t} + \varepsilon_{k,j,t}, \tag{6.3}$$

where $y_{k,j,k}$ is one of the six variables in Equation (6.2), $raw_{c(k)}$ is the *raw* of the city where the firm k is registered, $\gamma_{p(k),j,t}$ controls for province-industry-year fixed effect, and $\varepsilon_{k,j,t}$ is the residual term.[1]

Table 6.1 reports the estimation results with the sample period of 2001-2007 for cities with high and low population density separately. In Panel A, for cities with high population density, government spending leads to a significant increase to real output. The magnitude of the effect is economically important. A 1% increase of *raw* leads to the growth of firms' output by 0.34%. In Column (2)-(6), I decompose the effect into five different components. Roughly half of the effect is driven by an increase of material uses, 1/4 by an increase of productivity, and 1/4 by more efficient resource utilization. The large effect through material uses and input utilization suggests that local government spending improves local firms' access to larger markets. The productivity improvement can arise through multiple channels. For example, government spending in public cap-

1. The industry classification is taken from China Input-Output Table of 2002. In the Annual Survey of Industrial Firms, firms are classified based on China's Industrial Classification for National Economic Activities 1994 and 2002. I match the classification with the classification used in China Input-Output Table of 2002.

Table 6.1: Government spending and local firms' output

Panel A: Population density: high

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep Var	log(Q)	tfpq	utili	$s^m \cdot \log(M)$	$s^k \cdot \log(K)$	$s^l \cdot \log(L)$	logprice	roa
raw	0.336**	0.0801**	0.0878**	0.183**	-0.0120	-0.00438	-0.0630**	-0.0266
	(2.598)	(2.576)	(2.529)	(2.033)	(-0.378)	(-0.915)	(-2.533)	(-1.505)
Prov-Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	905,302	898,076	902,527	908,006	910,524	916,216	248,904	898,298
R-squared	0.182	0.364	0.194	0.267	0.600	0.763	0.517	0.153
#City	160	160	160	160	160	160	160	160

Panel B: Population density: low

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep Var	log(Q)	tfpq	utili	$s^m \cdot \log(M)$	$s^k \cdot \log(K)$	$s^l \cdot \log(L)$	logprice	roa
raw	-0.0947	-0.0959*	0.0276	0.00208	-0.0150	-0.00749	0.0377	-0.0264
	(-0.556)	(-1.941)	(0.640)	(0.0184)	(-0.615)	(-1.196)	(0.982)	(-1.276)
Prov-Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	287,073	284,738	287,222	289,168	289,489	291,454	83,580	285,636
R-squared	0.337	0.415	0.326	0.468	0.713	0.825	0.594	0.210
#City	176	176	177	177	177	177	176	177

Note: This table shows the effect of local government spending on local firm's output for cities with high and low population density separately. Column (2)-(6) decompose the effect on output into productivity, utilization, and input uses. The sample includes all firms during 2001-2007. All standard errors are clustered by city. T-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

ital and other intangible social infrastructure can have a direct effect on firms' productivity as such public inputs are captured by the productivity measure. Other channels include more R&D investment induced by better market access that can improve productivity, more entry of more productive firms which increases the average productivity of the pool of local firms, or simply more fierce competition due to more firm entry that pushes firms with low productivity out of the market.

How does government spending affect local competition and firms' profitability? In Column (7)-(8), I examine the effect on the product price and firms' ROA. Government spending leads to lower product price, which can result from both more firm entry on the extensive margin, which echoes the results in Figure 6.1, and higher productivity and output on the intensive margin. The positive effect on productivity and negative effect on product prices counteract each and in equilibrium, local firms do not end up with higher profitability. In scenarios where the shock is firm-specific, firms with positive shock can achieve and sustain higher profitability. But in scenarios where the shock is city wide, differences in profitability cannot be sustained in equilibrium as firms can enter and exit to eliminate the differences.

In Panel B, for cities with low population density where the windfall of revenues is small, we do not observe any significant effect on local firms' production, input use or product price. If local governments in these cities mainly spend the resources to target larger firms, it is possible that we do not see sizable effect on the average firms.

Appendix E shows more patterns on how local firms are affected by government spending. First, as a significant portion of local government resources is spent to improve local infrastructure, firms that use more transportation services shall benefit more. I construct the industry-level use of transportation services as the share of railway, highway, waterway, and urban public transportation services in the industry's total intermediary input, using China's Input-Output table. Table E.2 in Appendix E shows that firms that use more transportation services indeed benefit roughly 50% more from local government spending, and the additional effect on output is mainly driven by more material uses as well as higher productivity.

Second, to understand the source of the productivity improvement, I also estimate Equation (6.2) using only firms that were established before 2000. Table E.3 in Appendix E shows that there is a similar effect of *raw* on firms' output and productivity. The evidence suggests that the improvement of productivity is not simply driven by entry of more productive firms.

To sum, the firm-level evidence sheds light on how government spending affects local production, leading to the output multiplier that we observe on the aggregate. Government spending improves local firms' market access and productivity, leading to more firm entry, which drives down the product price and eliminates the difference in profitability in equilibrium.

CHAPTER 7

SPILLOVER EFFECT

A central topic in the estimation of local government spending multiplier is the geographic spillovers. In Table 3.4, I do not find any evidence supporting spillovers across neighboring cities. Within each city, different sub-cities are more integrated and there could be spillover effects across different sub-cities. Such spillovers are not likely to be driven by the reallocation of funds among these sub-city governments because they are independent in finance. The existence of the spillovers can only be caused by the interaction between market participants. In this chapter, I will first quantify the aggregate spillovers within each city, and then using firm-level evidence to document spillovers through technology diffusion and supply chains.

7.1 Aggregate spillovers

I will start with an econometric model to decompose the effect of *raw* into the direct effect of the sub-city's spending on itself and the spillover effect on other sub-cities within the city. I will then estimate the model and evaluate the relative magnitude of the direct and spillover effect.

7.1.1 Econometric framework

Recall the reduced form regression model describing the effect of raw_c on $\log(GDP_{c,t})$:

$$\log(GDP_{c,t}) = \mathcal{B}_t \cdot raw_c + \alpha_c + \gamma_{p(c),t} + \varepsilon_{c,t} \tag{7.1}$$

In Eq. (7.1), c denotes city, t denotes year, and $p(c)$ is the province of city c. I model $\log(GDP_{c,t})$ as consists of a dynamic treatment effect of raw_c, $\mathcal{B}_t \cdot raw_c$, the city fixed effect α_c, the province-by-year fixed effect $\gamma_{p(c),t}$, and a random shock term $\varepsilon_{c,t}$. The parameter $\mathcal{B}_t$ captures the city-wide general equilibrium effect, i.e., when the city-wide raw land proportion increases by one percent, how much the total GDP would increase. Under the assumption that the treatment effect is homogeneous across different sub-cities, $\mathcal{B}_t$ also reports the GDP growth of each sub-city when the city-wide raw land proportion increases.

Now, consider a similar specification on the sub-city level:

$$\log(GDP_{c,i,t}) = \hat{\beta}_t \cdot raw_{c,i} + \alpha_{c,i} + \gamma_{p(c),t} + \varepsilon_{c,i,t} \tag{7.2}$$

In Eq. (7.2), i denotes the sub-city in city c, and $\hat{\beta}_t$ describes when the sub-city's own raw land proportion, $raw_{c,i}$, increases by one percent, how much its own GDP would increase. For sub-cities in the same city, $raw_{c,i}$ and $raw_{c,i'}$ are likely to be positively correlated due to similar geographic characteristics or history reasons. If $raw_c = raw_{c,i}$, then $\hat{\beta}_t = \mathcal{B}_t$; if $raw_c \neq raw_{c,i}$, then increase of $raw_{c,i}$ is not accompanied with the same increase of $raw_{c,i'}$ of other sub-cities in the same city, and hence $\hat{\beta}_t \neq \mathcal{B}_t$ in case of either negative or positive spillover effect across different sub-cities.

To capture such spillover effect, I augment Eq. (7.2) by adding the term, $spillover_{c,i} \equiv raw_c - raw_{c,i}$:

$$\log(GDP_{c,i,t}) = \beta_t \cdot raw_{c,i} + \rho_t \cdot spillover_{c,i} + \alpha_{c,i} + \gamma_{p(c),t} + \varepsilon_{c,i,t} \tag{7.3}$$

In Equation (7.3), holding $spillover_{c,i}$ fixed, β_t describes when both sub-city i and all other sub-cities in the same city increase their raw land proportion by one percent, how much the sub-city i's GDP would increase; conceptually, β_t and $\mathcal{B}_t$ describe the same effect. In Appendix F, I show that under some regular assumptions, $\beta_t \approx \mathcal{B}_t$. Holding $raw_{c,i}$ constant, ρ_t captures the marginal spillover effect of raw_c due to the change of raw land proportion in other sub-cities in the same city.

Compared to estimating Eq. (7.1) to get $\mathcal{B}_t$, the advantage of estimating Eq. (7.3) is that we can get both the city-wide general equilibrium effect and the spillover effect. Instead of regressing on $(raw_{c,i}, spillover_{c,i})$, one may also regress on $(raw_{c,i}, raw_c)$, but the coefficients will not be straightforward to interpret. That is, the coefficient loading on $raw_{c,i}$ would be the effect when the proportion of raw land increases in the sub-city i but decreases in other sub-cities such that the city-wide raw land proportion remains unchanged.

What if β_t is heterogeneous? Denote the effect for sub-city i as $\beta_{i,t}$. The estimation of Eq. (7.3) will deliver the average effect, $\mathbf{E}[\beta_{i,t}]$. The estimation of Eq. (7.1) will deliver the weighted average effect,

$$\mathcal{B}_t = \mathbf{E}\left[\sum_i \frac{DT_{c,i}}{DT_c} \cdot \beta_{i,t}\right].$$

As long as $\beta_{i,t}$ is not correlated with the relative size of the sub-city, we will still have $\beta_t = \mathcal{B}_t$. As we will see below, indeed the two estimates, $\hat{\beta}_t$ and $\hat{\mathcal{B}}_t$, are very close in terms of magnitude.

We can now decompose the total effect into the direct effect and spillover effect using Equation (7.3). Consider a marginal increase of $raw_{c,i}$ by μ while keeping $raw_{c,i'}$ unchanged. As a result, raw_c will increase by $\frac{DT_{c,i}}{DT_c}\mu$. Based on Equation (7.3), we can then calculate the effect on sub-city i's own $GDP_{c,i,t}$ (i.e., direct effect) and on all the other sub-cities' $GDP_{c,i',t}$ (i.e., indirect effect). Now, repeat the same procedures for all the sub-cities and sum all the direct effect and the spillover effect, which gives the total direct and spillover effect for a 1% increase of raw_c.

The total direct effect sums up to

$$\sum_i \Delta GDP_{c,i,t} = \Big(\beta_t \cdot GDP_{c,t} - \rho_t \cdot \sum_i GDP_{c,i,t}(1 - \frac{DT_{c,i}}{DT_c})\Big)\mu.$$

The total spillover effect sums up to

$$\sum_i \sum_{i' \neq i} \Delta GDP_{c,i',t} = \rho_t \cdot \sum_i GDP_{c,i,t}(1 - \frac{DT_{c,i}}{DT_c})\mu.$$

The total effect is hence

$$\sum_i \Delta GDP_{c,i,t} + \sum_i \sum_{i' \neq i} \Delta GDP_{c,i',t} = \beta_t \cdot GDP_{c,t}\mu.$$

7.1.2 Empirical results

The existence and the magnitude of the geographic spillovers are likely to depend on the scale of local government spending. Therefore, it makes sense to estimate the spillover effect for cities with high and low population density separately, similar to what I have done in Chapter 6. I then estimate Equation (7.2) and (7.3) using cities with high and low population density separately.

I first show how the addition of *spillover* into Equation (7.3) makes difference from Equation (7.2). To simplify the presentation, I pool 2001-2019 together by replacing (β_t, ρ_t) with $(\mathbb{1}_{t.2000} \cdot \beta, \mathbb{1}_{t>2000} \cdot \rho)$. Table 7.1 reports the results.

Column (1)-(2) report the estimation results based on cities with high population density. Compared to Column (1), the addition of *spillover* in Column (2) leads to a much larger estimate of *raw*, which goes up from 0.215 to 0.480 and the spillover effect turns out to be positive. The difference between Column (2) and (1) makes sense. Without *spillover* included as the regressor, *raw* describes how much $\log(GDP_{c,i,t})$ increases when $raw_{c,i}$ increases, while $raw_{c,i'}$ of other sub-cities may increase by less. With *spillover* included, $raw_{c,i}$ describes how much $\log(GDP_{c,i,t})$ increases when the raw land proportion of all sub-cities increase by the same magnitude. Given the positive sign of the spillover effect, we should expect the coefficient of $raw_{c,i}$ to be larger in Column (2). Moreover, with *spillover* included, $\hat{\beta} = 0.480$, very close to the estimate of $\hat{\mathcal{B}} = 0.493$, confirming the prediction above that $\beta_t \approx \mathcal{B}_t$.

Column (3)-(4) report the estimation results based on cities with low population density. Compared to Column (3), the addition of *spillover* in Column (4) leads to a very small change to the coefficient estimate of *raw*, and the coefficient estimate of *spillover* is also small and insignificant. The evidence suggests that in cities with a small windfall of resources and hence small increase of local government spending, there is no significant spillovers across different cities.

Table 7.1: Spillover effect on GDP within the city

Dep Var: log(GDP)	(1)	(2)	(3)	(4)
Pop. Density	High	High	Low	Low
$\mathbf{1}_{t>2000} \cdot raw$	0.215***	0.480***	0.129**	0.167
	(3.478)	(4.848)	(2.033)	(1.343)
$\mathbf{1}_{t>2000} \cdot spillover$		0.457***		0.0581
		(3.691)		(0.431)
Sub-city FE	Yes	Yes	Yes	Yes
Prov-Year FE	Yes	Yes	Yes	Yes
Base Year Effect	Yes	Yes	Yes	Yes
Observations	24,456	24,456	24,080	24,080
R-squared	0.982	0.982	0.982	0.982
Within R-sq.	0.0303	0.0391	0.0378	0.0379
#City	157	157	157	157

Note: The table reports the estimated direct and within-city spillover effect of govt spending on GDP using Eq. (7.2) and (7.3). I divide the sub-cities into two groups based on the central sub-city's population density in 2000. Standard errors are clustered by cities. T-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

I now decompose the total effect into direct and spillover effect using the framework from Section 7.1.1. Since there is no evidence of significant spillovers in cities with low population density, I will focus on cities with high population density. Figure 7.1 shows the direct and spillover effect for $\mu = 1\%$ for each year. The magnitudes of the direct and spillover effect are on the same scale. On average, 45% of the total effect is direct effect and 55% is the spillover effect. This result not only points out the large positive spillovers, but also implies that the sub-city benefits more from its spending than other neighboring sub-cities. To see why, consider the case where the effect of the sub-city *i*'s spending is evenly distributed among all sub-cities within the city. In this case, the share of direct effect should be the inverse of the number of sub-cities within each city, which is between 1/6 and 1/7.

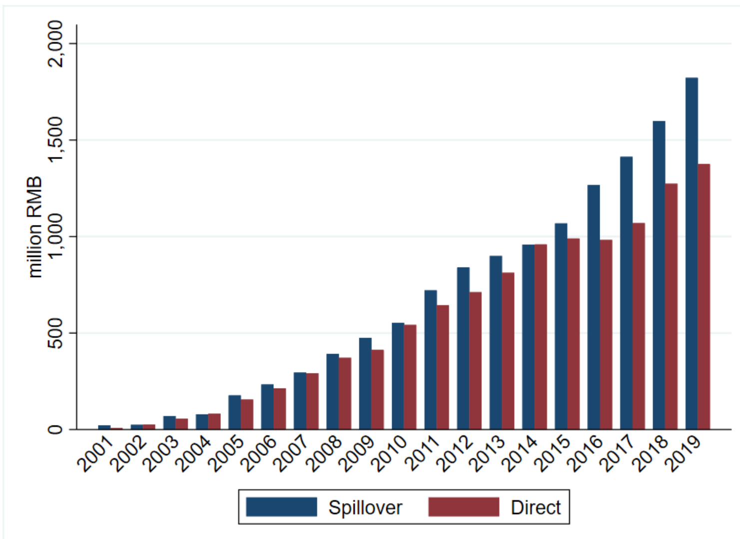


Figure 7.1: Decomposition of GDP Effect for 1% Increase of raw

Note: The graph shows the direct and spillover effect on GDP when $raw_{c,i}$ increases by 1%.

The large positive spillover effect has policy implications on coordination between neighboring sub-cities. In the context of China, local officials are evaluated and promoted based on the local economic performance. If such evaluation is based on the performance relative to peers in the neighboring sub-cities, it will discourage local officials' incentive to spend and to promote economic growth because the officials are negatively impacted by the positive spillovers of their spending on their competing peers. Such coordination problem is mitigated if they are evaluated based on the absolute growth from previous years or based on comparison with peers from other cities. Follow-up research can look into the details of the evaluation system and examine whether it can affect the coordination across neighboring administrative regions.

7.2 Technology diffusion and supply chain

Conceptually, the spillover across regions can only occur through firm interactions in the form of either technology diffusion or supply chain linkages. In this section, I will provide empirical evidence supporting the existence of both forms of interaction. The evidence is based on the heterogeneity of spillovers across different firms based on their position in the supply chain relative to firms in other sub-cities.

First, the technology diffusion should be stronger between two firms when they are in the same industry and share similar technology. To test this prediction, I construct a horizontal exposure measure based on the similarity between the firm's own industry and the industry of firms in other sub-cities of the same city. Specifically,

$$Horizontal_{c,i,j} = \frac{\sum_{k:c(k)=c,i(k)\neq i} Sale_{k,j,2000}}{\sum_{k:p(k)=p(c)} Sale_{k,j,2000}} \tag{7.4}$$

In Equation (7.4), k represents the firm, c represents the city, i represent the sub-city, and j represents the industry. In words, $Horizontal_{c,i,j}$ is for any given industry j in year 2000, the share of sales from firms in city c but not in sub-city i in the total sales of firms in the same province as city c. I use the city's industry composition in 2000 to avoid endogenous changes of industries after 2000. The denominator is to control for different size of industries. Intuitively, a higher value of *Horizontal* implies more firms from the same industry are located in the other sub-cities within the same city. For each sub-city i, I then divide the industries j into two equal groups based on $Horizontal_{c,i,j}$. The within-sub-city classification ensures that *raw* and *spillover* are comparable for the two groups of firms.

Table 7.2 Panel A shows how the spillover effect depends on the extent of horizontal exposure. As there is no evidence of significant spillovers within cities with low population density, I focus on cities with high population density. In Column (1) and (2), the effect on firms' output is similar for the two groups. In Column (3) and (4), as predicted, the spillover effect on $tfpq$ is only significant and positive for firms with high horizontal exposure. In Column (5) and (6), after controlling for $tfpq$, the effect on firms' output is smaller for firms with high horizontal exposure, as high horizontal exposure implies more competition. To summarize, higher horizontal exposure leads to greater technology diffusion since firms would share more similar technology, but smaller effect on output after controlling for productivity due to more competition.

Second, the spillover through output-input linkage should be stronger if firms are more vertically connected to firms from other sub-cities. To test this prediction, I construct two measures of vertical exposure. The upstream exposure measure is the probability that a firm in sub-city i buys inputs from firms in other sub-cities in the same city c. The downstream exposure measure is the probability that a firm in sub-city i sells output to firms in other sub-cities in the same city c. Appendix F provides details on the calculation of the two measures. For each sub-city i, I then divide the industries j into two equal groups based on *Downstream* exposure and *upstream* exposure separately.

Table 7.2 Panel B shows how the effect on firms' output depends on the firms' supply chain position. As predicted, the spillover effect is highest for firms with both high downstream and high upstream exposure; the effect decreases to about 70% for the group of firms with high downstream and low upstream or high upstream and low downstream exposure; the effect is smallest for the group of firms with both low downstream and low upstream exposure.

To summarize, the spillover effect depends on the firms' supply chain position. The technology diffusion is stronger if firms share similar technology to firms in other sub-

Table 7.2: Spillover effect of govt spending through supply chains

Panel A: Horizontal Exposure

	(1)	(2)	(3)	(4)	(5)	(6)
Horizontal Exposure	High	Low	High	Low	High	Low
Dep Var	log(Q)	log(Q)	tfpq	tfpq	log(Q)	log(Q)
raw	0.316***	0.385***	0.110***	0.0433	0.266**	0.372***
	(2.908)	(3.015)	(2.942)	(1.342)	(2.538)	(2.958)
spillover	0.317**	0.424***	0.174***	0.0609	0.254*	0.408***
	(2.336)	(2.712)	(3.708)	(1.647)	(1.865)	(2.640)
tfpq					0.386***	0.377***
					(8.100)	(9.569)
Prov-Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	136,076	111,437	134,604	110,184	134,604	110,184
R-squared	0.184	0.218	0.292	0.292	0.194	0.226
#City	156	160	156	160	156	160

Panel B: Vertical Exposure

Dep Var: log(Q)	(1)	(2)	(3)	(4)
Downstream Exposure	High	High	Low	Low
Upstream Exposure	High	Low	High	Low
raw	0.622***	0.389***	0.328*	0.247*
	(3.758)	(3.296)	(1.916)	(1.708)
spillover	0.502**	0.359**	0.352*	0.283
	(2.162)	(2.062)	(1.960)	(1.558)
Prov-Ind-Year FE	Yes	Yes	Yes	Yes
Observations	40,411	66,516	67,216	72,314
R-squared	0.296	0.189	0.191	0.160
#City	160	155	156	155

Note: These tables show how the effect of government spending on local firms depend on the firms' relative supply chain position. Panel A groups local firms based on the horizontal exposure, i.e., the presence of competing firms in the same industry in other sub-cities within the same city; Panel B groups local firms based on the vertical exposure, i.e., the probability of selling and buying from firms in other sub-cities within the same city. The sample includes all firms during 2001-2003. All standard errors are clustered by city. Robust t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

cities. The spillover effect through output-input linkages is stronger if firms are more vertically connected with firms, either upstream or downstream, in other sub-cities.

CHAPTER 8

CONCLUSION

Government intervention in the form of fiscal spending in the private sector has been rising globally during the past decade. The interests are mainly in understanding the great variation of the real effect of government spending. On the program-level, Hendren and Sprung-Keyser [2020] reviews various government policies and find that policies investing in children generate higher return that others. On the aggregate level, much has been learned about what could affect the output effect of government purchase spending, which temporarily affects the demand side of the economy, in the macroeconomic literature (Chodorow-Reich, 2019). But relatively little is known on how government spending can affect the supply side on the aggregate.

China is a perfect case for understanding government policies targeting the supply side. Although recently the potential of policies that target household consumption in promoting economic growth has been recognized by the central government, government spending that affects the supply side has been important for several decades. The compensation of local officials have been designed to induce their efforts to promote economic growth, and local fiscal policies have been the most powerful tool. However, empirical evaluation of the efficiency of local government spending has been surprisingly sparse. On one hand, China has experienced persistent high economic growth since entry to WTO, which suggests a positive role of local fiscal policies; on the other hand, there has been widespread suspicion on the government deep intervention with the supply side of the market economy. The debate cannot be answered without a good estimate of the return of the government spending.

The paper makes several contributions towards the understanding of the effect of local government spending. First, I develop an innovative identification strategy by exploring the local government's endowment of unoccupied raw land before the rise of the commercial land market. This approach has the potential to be used in other countries where land requisition is a big deal for local governments, such as India. As I only evaluate the overall effect on local economic growth in this paper, more studies can be done on specific channels and policies with this identification strategy. Second, government spending that targets the supply side can have much more significant and prolonged effect than those targeting the demand side, at least for developing countries where the stock of public capital and intangible social infrastructure is under provision. Going forward with sufficient public capital, further spending in public capital may not continue to generate good return. However, the important lesson should be that whenever there is under-provision of certain inputs by the private sector, there will be a role for the government spending. Third, a high multiplier can exist in equilibrium when the governments are financially constrained. In fact, a lot of cities in China may be overusing debt as the marginal government spending barely increases local output. But in cities where the local governments have not used much debt, there may be gains from relaxing debt capacity. Lastly, there are positive spillover effects of government spending within an integrated market. Although there is no evidence of spillovers across neighboring cities, more work should be done on potential spillovers in other dimensions so that we can go from the local to the national multiplier.

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APPENDIX A

DATA

Table A.1: Variable definitions

Panel A: City level data

Obs	Variables	Definition
City	raw	Raw Land Proportion at the end of 2000.
	InfraInvt2Sale	Urban facility investment financed by land sales/total land sales during 2001-2005.
	requi2supply	Urban land expropriated during 2001-2013 / urban land supplied during 2003-2015.
	CitySpillover	Inverse distance-weighted average raw of other cities, where distance is between the centroid of central sub-cities.
	Cyclicality	OLS coefficient by regressing the city's real annual GDP growth rate on the country's real annual GDP growth rate during 1996-2000.
	WTOShock	Export over GDP ratio in 2000 multiplied by the export-weighted average growth of product-level export from 2000 to 2011.
	Historical Growth	The growth of GDP from 1997 to 2000.
	DTI	Urban Infra investment financed by loans over govt income in 1999.
	DCTI	Ctiy govt debt ceiling in 2019 scaled by its income in 2000.
City-Year	GDP	GDP in 100 million RMB.
	GDP_sec	GDP in the secondary sector in 100 million RMB.
	GDP_ter	GDP in the tertiary sector in 100 million RMB.
	GDP_nr	GDP minus real estate invest in 100 million RMB.
	Stru	Stock of structural capital, price normalized to be 1 in 2000.
	Mach	Stock of machinery capital, price normalized to be 1 in 2000.
	Emp	Number of employees in the non-aggriculture sector, 10,000 person.
	Wage	Average annual wage of employees in the non-agriculture sector, RMB.
	POP	Population in 10,000 people.
	#Mfr	Number of manufacturers at the beginning of the year, 1996-2017.
	NetLandSupply	(LandSupply - LandExp) / estimated downtown area.
	BudExp	City government budgetary expenditures, 100m RMB.
	BudRev	City government budgetary revenues, 100m RMB.

Panel B: Sub-city level data

Obs	Variables	Definition
Subcity	RawProp	Raw Land Proportion at the end of 2000.
	popden	Total population / urban land size in 2000, person/100 Sq.Me.
Subcity-Year	GDP	GDP in 100 million RMB.
	InfraInvest	Total facility invest in 10,000 RMB.
	TranspInvest	Transporation (road plus railways) invest in 10,000 RMB.
	Road	Road area in 10,000 Sq.Me.
	WaterPipe	Length of water pipelines in 1km.
	DrainPipe	Length of drainage pipelines in 1km.
	LandSupply	Total land supply via agreement and auctions. Data is from land.china.
	LandPrice	Average land price per square meter. Data is from land.china.
	pubfac	Fraction of urban construction land zoned for public facilities (e.g. schools, hospitals, etc).
	munuti	Fraction of urban construction land zoned for municipal utilities (e.g. urban roads, water supply utilities, etc).

Panel C: Firm level data

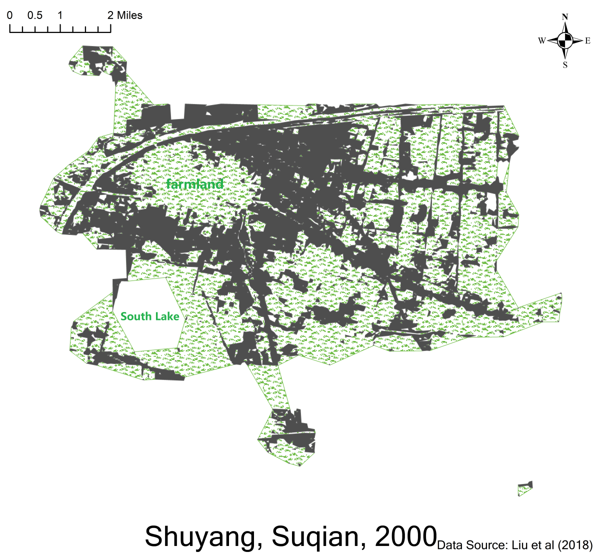
Obs	Variables	Definition
Firm-Year	Capital	Capital in 1000 RMB.
	Labor	Labor.
	Material	Material use in 1000 RMB.
	Q	Output measured in 1990 price in 1000 RMB.
	Output	Output measured in current price in 1000 RMB.
	price	Price relative to 1990.
	ROA	Return on asset.

APPENDIX B

IDENTIFICATION STRATEGY

B.1 The Evolution of unoccupied land

Figure B.1 compares the landscape of Shuyang between 2000 and 2015.



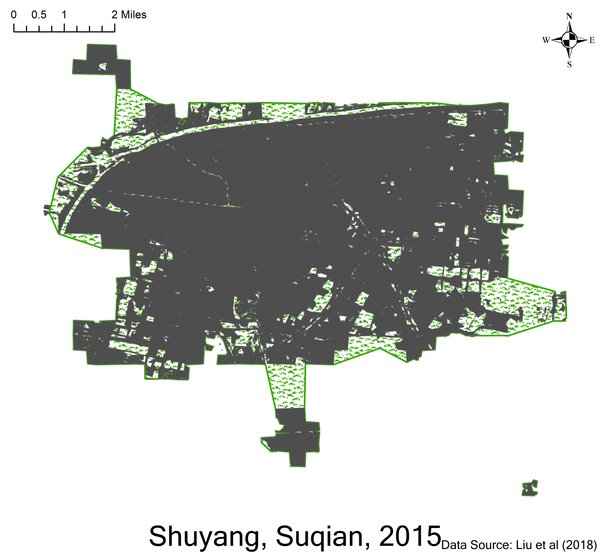


Figure B.1: Estimated downtown boundary: 2000 vs 2015

Note: The first graph shows the geographic distribution of occupied land and the estimated downtown boundary of Shuyang in 2000 and the second in 2015.

Figure B.2 shows the time series of *raw* and the cross sectional relationship between *raw* in 2000 and in 2015.

B.2 Relevance condition

Figure B.3 shows the binned scatterplots for Table 3.1.

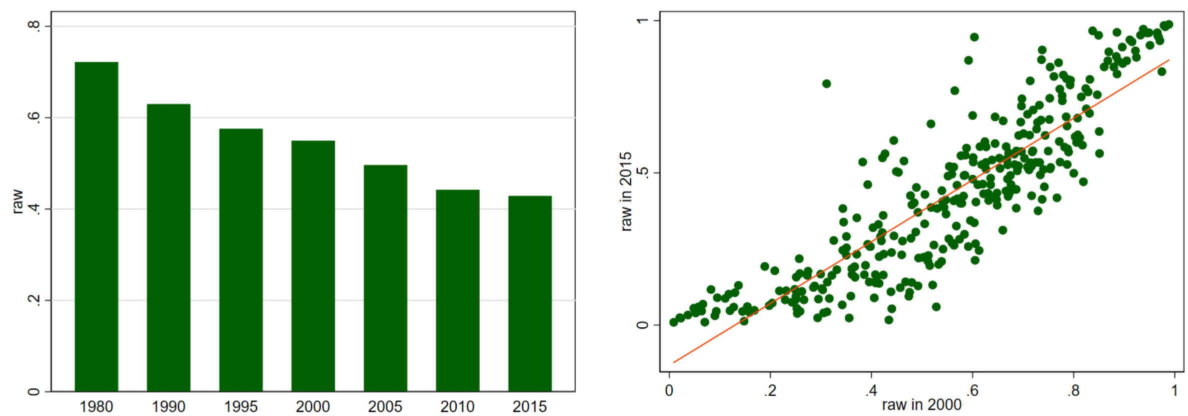
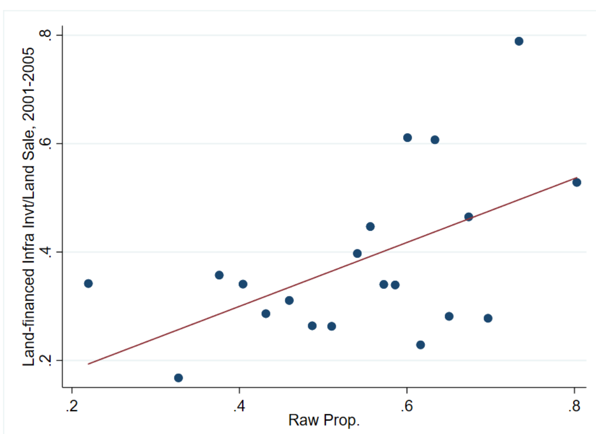
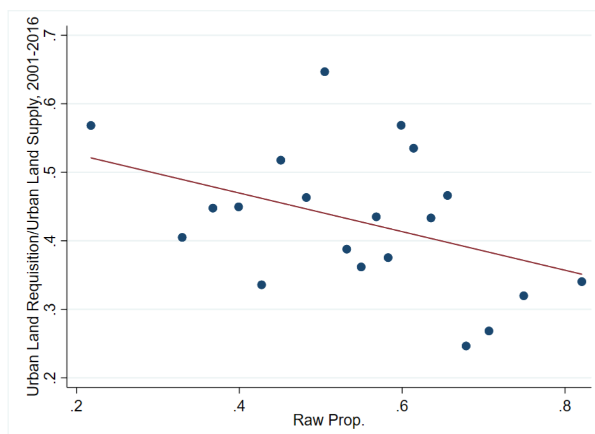


Figure B.2: Patterns of City-level *raw* in 2000

Note: The first graph shows the average city-level raw land proportion over time, and the second shows the binned scatterplot of raw land proportion in 2015 against in 2000 across different cities.



(a) $InfraInvt2Sale$



(b) $Requi2Supply$

Figure B.3: Patterns of City-level *raw* in 2000

Note: This figure shows the binned scatterplots between the city's *raw* and the fraction of accumulated land sale revenues spent on urban infrastructure investment (Panel (a)) and the ratio between accumulated urban land requisition with compensation and urban land supply (Panel (b))

B.3 Exclusion restriction

Table B.1 shows the partial correlation between *raw* and city characteristics in 2000 after absorbing the province fixed effect.

Table B.1: Partial correlation between *raw* and city characteristics in 2000

1. Economic Activities					
log(GDP)	log(Pop)	log(Emp)	log(Struc)	log(Mach)	log(#Mfr)
0.0689	-0.1605	0.0257	-0.0119	0.0908	-0.0617
2. Govt Spending and Infra					
log(BugExp)	log(BugRev)	log(InfraInvt)	log(Road)	log(WaterPipe)	log(DrainPipe)
0.0221	0.0799	0.059	0.0058	0.0358	0.077
3. Firm characteristics					
tfpq	utilization	log(Labor)	log(Capital)	log(Material)	P/E
-0.0019	0.0128	0.0018	0.0098	0.0192	-0.0185
4. Land Supply and Zoning					
NetLandSupply	log(price)	IndZone	ResZone	FacZone	UtiZone
0.0763	-0.0354	0.0023	-0.0119	0.0333	0.0522

Note: The table reports the partial correlation between *raw* and the characteristics of city and sub-city in 2000 after absorbing the province fixed effect. In Row 1, 2 and 4, all the variables are scaled by the estimated downtown size.

B.4 Composition of new land supply

In this section, I explain why the downtown land occupancy status is not associated with more or less net land supply. The answer is that after 2000 as protection for agricultural land strengthens, local governments prioritize land supply using unoccupied urban construction land and only turn to agricultural land when the *raw* is low. In total, the net land supply from unoccupied urban land and agricultural land is not affected by *raw*.

Figure B.4 provides an illustration. Consider two cities, one with $raw = \frac{1}{4}$ and the other with $raw = \frac{1}{2}$. Both redevelop the inner core of the downtown area. For City 1, the net land supply from urban area is 1/4 and it adds additional 1/4 land supply from the peripheral agricultural land. For City 2, it was able to supply 1/2 of unoccupied land from the downtown area. As a result, both cities' net land supply is 1/2.

Figure B.5 provides empirical evidence for the patterns mentioned above. In the data,

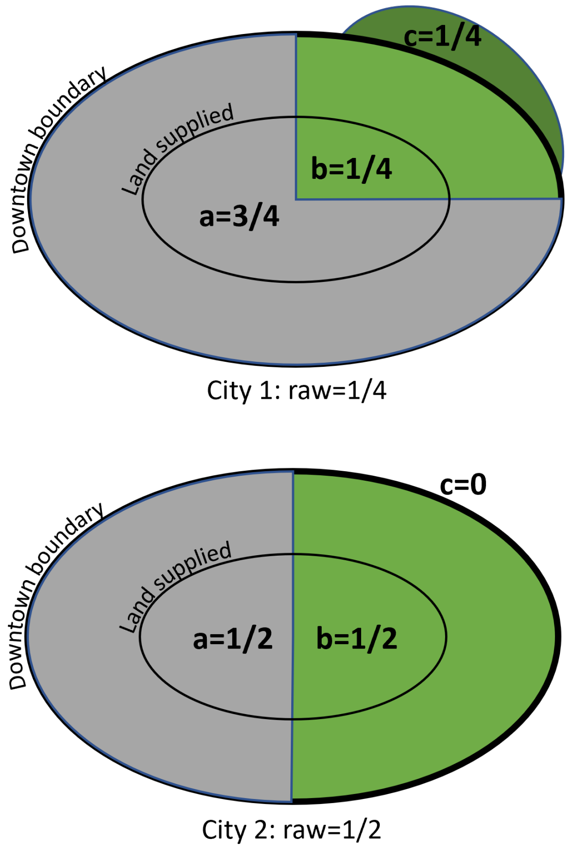
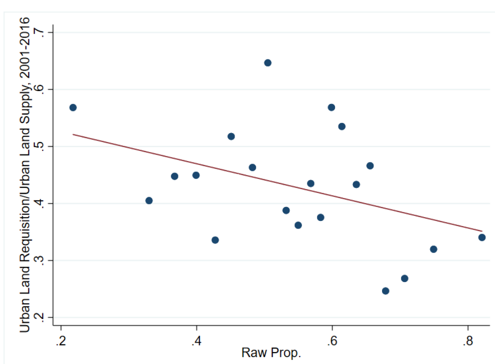
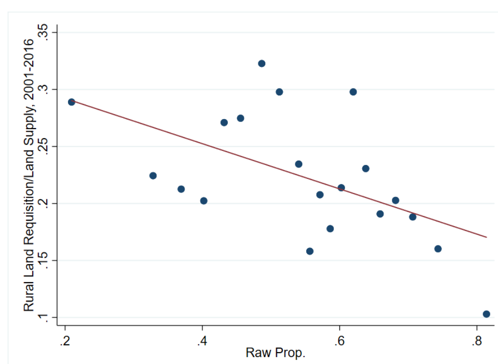


Figure B.4: Illustration of urban and rural land requisition



(a) Urban Land Requisition



(b) Rural Land Requisition

Figure B.5: *raw* and urban and rural land requisition

Note: This figure plots the ratio between accumulated urban land requisition with compensation and urban land supply (Panel (a)) and the ratio between accumulated rural land requisition and total land supply (Panel (b)).

I observe both accumulated urban land requisition (a) and rural land requisition (c), and I can calculate supply from occupied urban land as accumulated total land supply minus (a+c). Panel (a) shows the negative correlation between $\frac{a}{a+b}$ and *raw*, suggesting higher *raw* is associated with more net land supply from the downtown area. Panel (b) shows the negative correlation between $\frac{c}{a+b+c}$ and *raw*, suggesting higher *raw* is associated with less land supply from the agricultural land. Both are consistent with my discussions above.

APPENDIX C

LOCAL GOVERNMENT SPENDING MULTIPLIER

C.1 Definition of government spending

Figure 6 illustrates the relationship between different concepts. As I describe in Section 3.1, the local governments are financed by three income sources: budgetary revenues, central government transfer payments, and land sale revenues. I also list the net debt issuance as one income source. The budgetary revenues and central transfers are used for budgetary expenditures, which include part of the infrastructure investment. The land sale revenues are spent for compensation to removed occupants and infrastructure investment. I define total local government spending as the sum of the budgetary expenditure and infrastructure investment minus the overlap and divide it into two components: infrastructure and other spending.

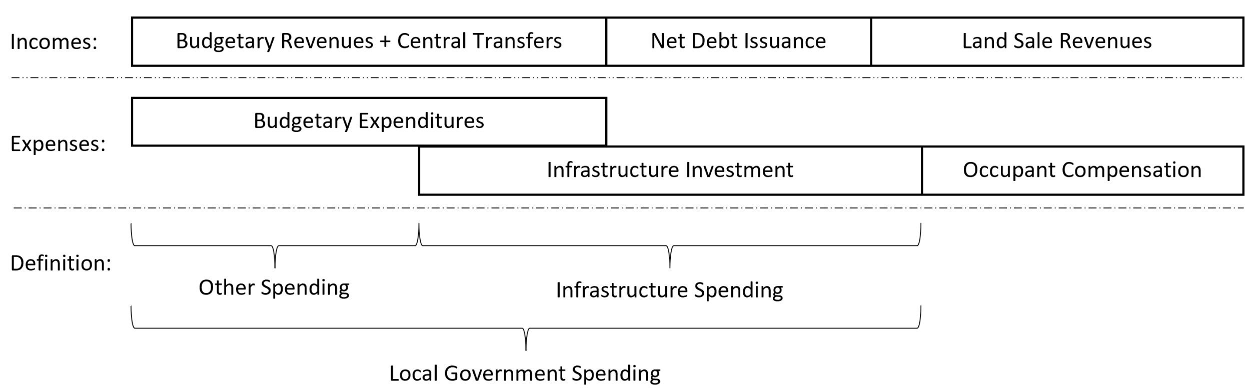


Figure C.1: Definition of local government spending

Besides the Urban Construction Statistic Yearbook, another commonly used measure for government investment is the fixed capital investment financed with state budgetary revenues and transfers. This alternative measure is not widely available at the city level. For example, the data is not available at the city level before 2000; the number of cities with available data is 90 in 2005 and ranges between 133 and 152 since 2005. I therefore

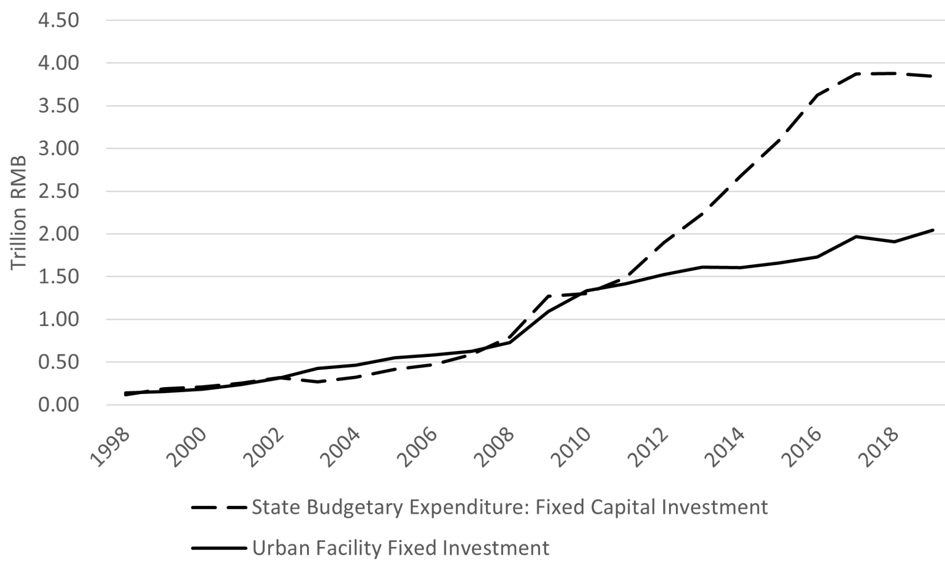


Figure C.2: State Fixed Capital Investment vs Urban Facility Fixed Investment

Note: This figure compares the two measures of government investment: the fixed capital investment financed with state budgetary revenues and transfers, and the urban facility fixed investment from the Urban Construction Statistic Yearbook.

use the data from the Urban Construction Statistic Yearbook which provides much better coverage at the city level.

Figure C.2 compares the aggregate fixed capital investment financed with state budgetary revenues and transfers versus the urban facility fixed investment used in this paper. Before 2008, this alternative measure is slightly smaller than the Urban Facility Fixed Investment. After 2012, it grew much faster than the Urban Facility Fixed Investment. In 2019, it is about double the Urban Facility Fixed Investment. There are ambiguities in terms of whether this alternative measure includes investment financed with debt which is not part of the budgetary expenditures. The dramatic change after 2012 likely reflect the change of definition. However, it is also possible that the Urban Statistic Yearbook systematically under-report the local government investment. If it only reports half of the actual government investment, then the estimate average multiplier over the 19-year horizon will decreases to about 7-9.

C.2 Regression results: 2SLS vs OLS

Table C.1 reports the Two-Stage Least Square estimation results of Equation (4.5). Table C.2 reports the OLS estimation results of Equation (4.5). The OLS estimates are smaller than the 2SLS estimates, indicating negative correlation between $\log(AG_c^t)$ and $\varepsilon_{c,t}$ in Equation (4.5). The negative correlation may be caused by the fiscal balance through central transfers. As I show in Figure 3.4, cities with higher *raw* have significantly higher budgetary revenues but their amount of budgetary expenditures is not significantly higher. The difference is driven by the central government transfers. Central government grants more transfers to places with smaller *raw*. Places with positive growth shocks may received less central government transfers, leading to a negative correlation between the growth of government spending and growth shocks.

C.3 Multiplier in different sectors

To estimate the multiplier in the non-real estate sector, I deduct the amount of real estate investment, adjusted by the GDP deflator, from the real GDP and estimate how much the accumulated present value increases when local government spending increases by 1 RMB. The change of real estate investment captures the effect on upstream materials of increasing demand from the real estate construction. It would over-estimate the effect of the increasing demand from the real estate sector if part of the materials are produced by firms in other cities, and it does not capture the value-added in the real estate sector. So, the deduction of real estate investment is only a rough adjustment to exclude effect through the real estate sector. Figure C.3 Panel A shows that after excluding effect from the real estate sector, the multiplier decreases slightly to 9.8 in 2019, with the 95% confidence interval between 5.5 and 14.1.

In Figure C.3 Panel B, I look at the multiplier in the secondary and tertiary sector.

Table C.1: The Two-Stage Least Square Estimation results

	(1)	(2)	(3)	(4)	(5)	(6)
Year	2001	2002	2003	2004	2005	2006
$\log(AG)$	0.372	0.395*	0.471*	0.476**	0.611***	0.773***
	(1.556)	(1.738)	(1.927)	(2.223)	(3.032)	(3.551)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	279	279	279	279	279	279
R-squared	0.999	0.997	0.994	0.990	0.984	0.978
F statistic	4.152	6.845	9.181	13.16	17.67	19.03

	(7)	(8)	(9)	(10)	(11)	(12)
Year	2007	2008	2009	2010	2011	2012
$\log(AG)$	0.899***	1.005***	1.052***	1.168***	1.238***	1.315***
	(3.895)	(4.038)	(4.165)	(4.000)	(4.090)	(4.066)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	279	279	279	279	279	279
R-squared	0.972	0.963	0.956	0.941	0.934	0.924
F statistic	19.66	19.95	21.44	17.27	17.23	16.48

	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Year	2013	2014	2015	2016	2017	2018	2019
$\log(AG)$	1.432***	1.536***	1.611***	1.685***	1.743***	1.800***	1.855***
	(3.904)	(3.729)	(3.574)	(3.451)	(3.392)	(3.302)	(3.228)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	279	279	279	279	279	279	279
R-squared	0.911	0.897	0.885	0.874	0.866	0.855	0.845
F statistic	14.51	12.92	11.71	10.72	10.25	9.709	9.186

Note: This table reports for each year, the causal effect of accumulated real government spending on real GDP using Equation (4.5), where the accumulated government spending is instrumented with *raw*. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table C.2: The OLS Estimation results

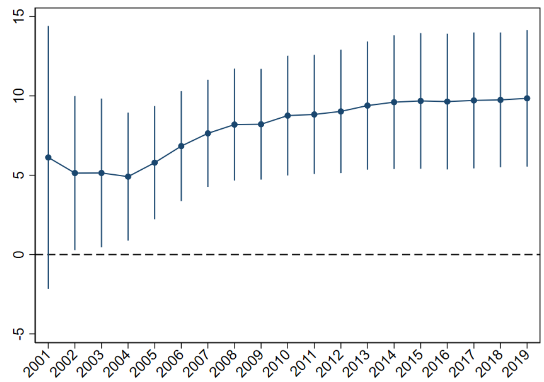
	(1)	(2)	(3)	(4)	(5)	(6)
Year	2001	2002	2003	2004	2005	2006
logspend	0.0948***	0.0937***	0.178***	0.233***	0.346***	0.427***
	(3.798)	(2.950)	(4.243)	(5.158)	(7.086)	(7.978)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	279	279	279	279	279	279
R-squared	1.000	0.999	0.997	0.995	0.992	0.989

	(7)	(8)	(9)	(10)	(11)	(12)
Year	2007	2008	2009	2010	2011	2012
$\log(AG)$	0.489***	0.517***	0.532***	0.509***	0.540***	0.557***
	(8.650)	(8.605)	(8.468)	(8.297)	(8.598)	(8.634)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	279	279	279	279	279	279
R-squared	0.987	0.984	0.980	0.977	0.975	0.972

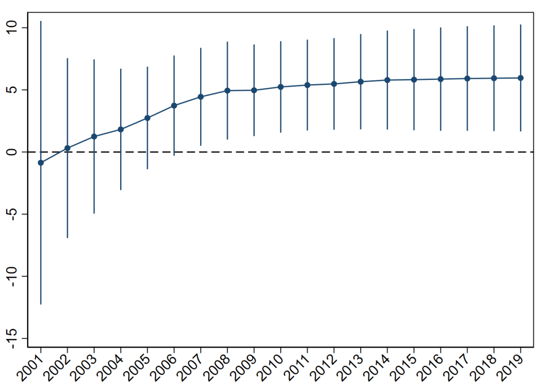
Dep Var: log(GDP)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Year	2013	2014	2015	2016	2017	2018	2019
$\log(AG)$	0.562***	0.558***	0.549***	0.550***	0.556***	0.549***	0.544***
	(8.534)	(8.314)	(8.124)	(8.084)	(8.071)	(7.901)	(7.841)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	279	279	279	279	279	279	279
R-squared	0.970	0.968	0.966	0.965	0.964	0.963	0.963

Note: This table reports for each year, the OLS estimation results of Equation (4.5). Robust t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

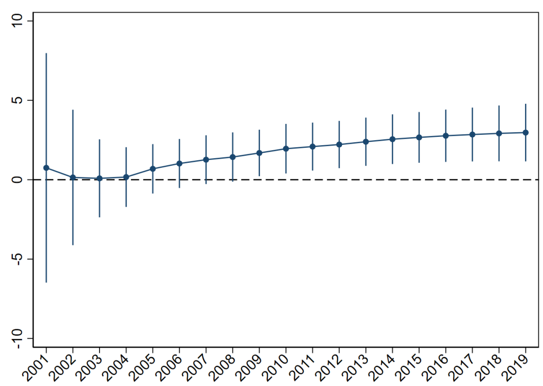
In 2019, the average multiplier from the secondary sector is estimated to be 5.7 with the 95% confidence interval between 0.5 and 10.9, and the average multiplier from the tertiary sector is estimated to be 3.2 with the 95% confidence interval between 0.5 and 5.9.



Panel A: $\log(GDP - \text{Real Estate Investment})$



(a) $\log(GDP^{sec})$



(b) $\log(GDP^{ter})$

Panel B: GDP in the secondary and tertiary sector

Figure C.3: Local government spending multiplier in different sector

Note: The figure plots the estimated local government spending multiplier for GDP minus real estate investment (Panel A) and in the secondary and tertiary sector (Panel B), using Equation (4.6) along with the 95% confidence interval. The confidence interval is calculate using bootstrap by re-sampling cities independently within each province 500 times.

C.4 The local government tax rate

Figure C.4 shows that a linear relationship between the annual change of city government budgetary expenditures (budgetary revenue plus central transfers) and the local GDP fits the data well. During 2001-2019, the marginal tax rate for local governments is estimated to be about 17.1%, with a tight 95% confidence interval between 16.8% and 17.4%.

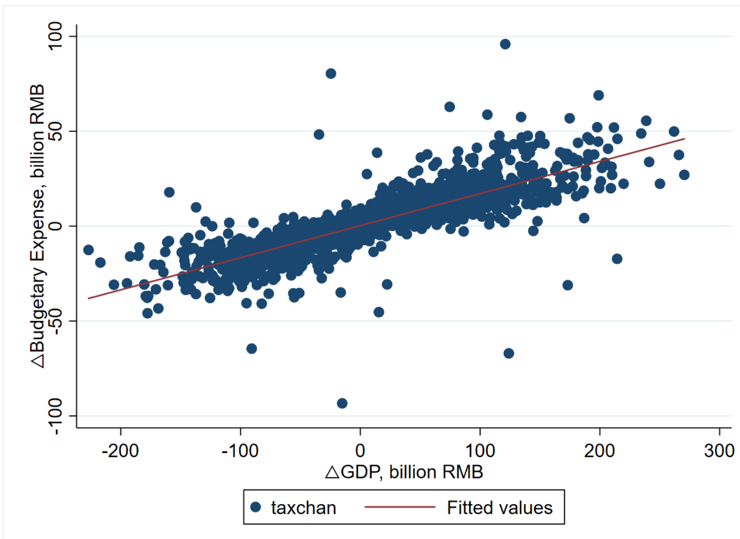


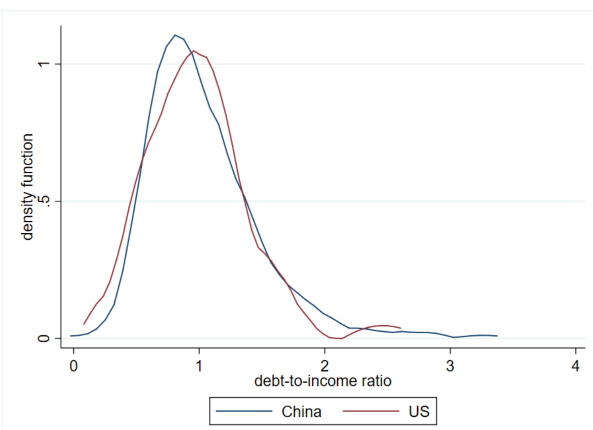
Figure C.4: The annual change of city budgetary expenditures vs GDP, 2001-2019

Note: This figure plots the annual change of the city government budgetary expenditures vs GDP for the sample cities during 2001-2019.

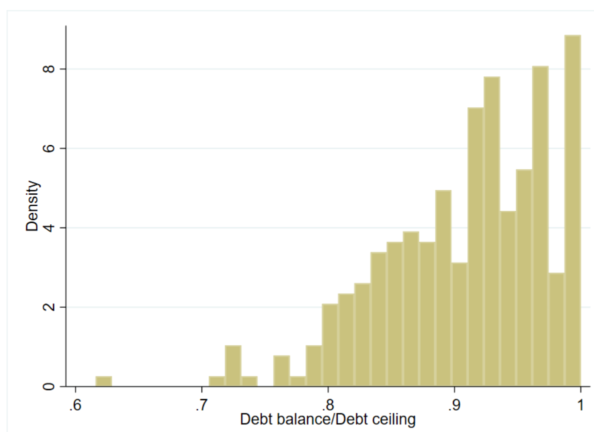
C.5 The local governments' access to debt financing

Figure C.5 provides some suggestive evidence that the city governments in China have less access to debt financing as compared to those in the US. Panel (a) shows that in 2019, the distribution of local government debt-to-income ratio is almost the same between China and US. But note that local governments in China have a much higher income growth rate. Before 2019, the annual growth rate of local government total income (budgetary revenue + central transfers + land sale profits measured with infrastructure investment) is well above 10% and is likely to continue after 2019 for China, while it is well below 10% for the US. Moreover, local governments in China have better investment opportunities. Therefore, if local governments in China had similar access to outside debt financing as those in the US in 2019, they should have higher rather than similar debt-to-income ratio.

Before 2019, the local government debt access must be even worse. Before 2008, local governments can only borrow from banks and cannot issue bonds. The limit on bond issuance was relaxed quite a bit since 2009 to support the fiscal stimulus in response to the Global Financial Crisis. However, such relaxation was soon reversed as the central government became concerned about the rising local government debt level. In 2015, the central government introduced the debt ceiling management on local government debt balance. Panel (b) of Figure C.5 shows that in 2019, the debt balance/ceiling ratio is almost all above 0.8. This suggests that the debt ceiling has been binding for most governments.



(a) Dist. of local govt DTI in 2019



(b) Dist. of local debt/ceiling in 2019

Figure C.5: Local govt access to debt financing in China

Note: The first graph shows the distribution of local government (prefecture city for China and all government units under the state for US) debt-to-income ratio in 2019; the second graph shows the distribution of local government debt balance/regulatory ceiling in 2019.

C.6 Measurement of the debt ceiling-to-income ratio

One may be concerned whether higher debt ceiling implies better financing access or more demand for debt financing due to lack to other incomes. Figure C.6 shows a strong positive relationship between the city government's debt ceiling-to-income (DCTI) ratio and the government spending growth from 2000 to 2019. In other words, higher debt ceiling-to-income ratio is not due to a lack of incomes but consistent with the interpretation of better debt financing.

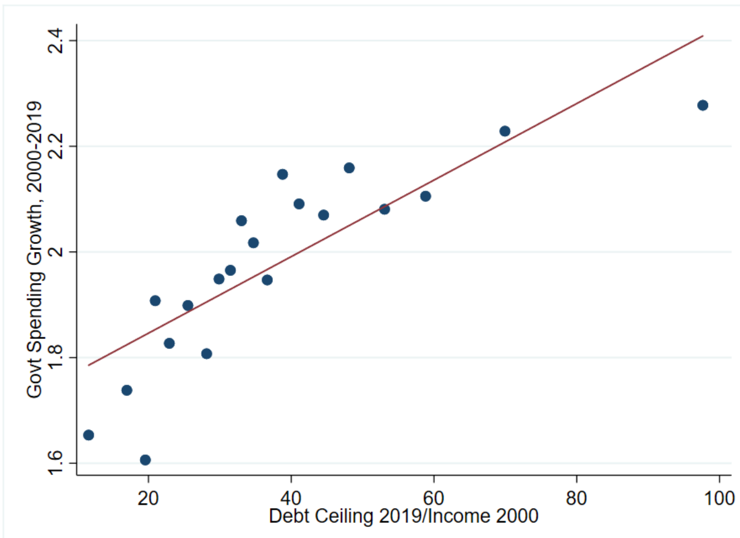


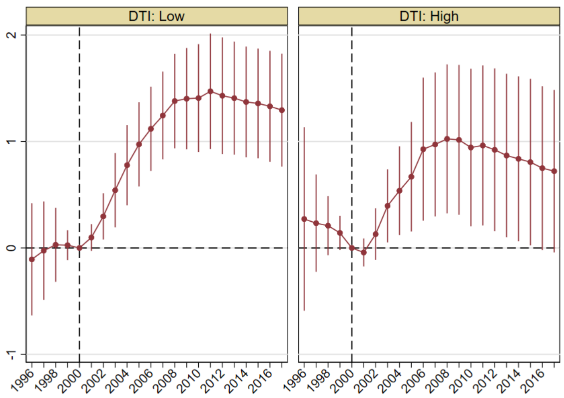
Figure C.6: Debt ceiling-to-income ratio and govt spending growth

Note: The graph shows the binned scatter plot between the city's debt ceiling-to-income (DCTI) ratio and the spending growth from 2000 to 2019. The DCTI ratio is the debt ceiling in 2019 scaled by the govt spending in 1999.

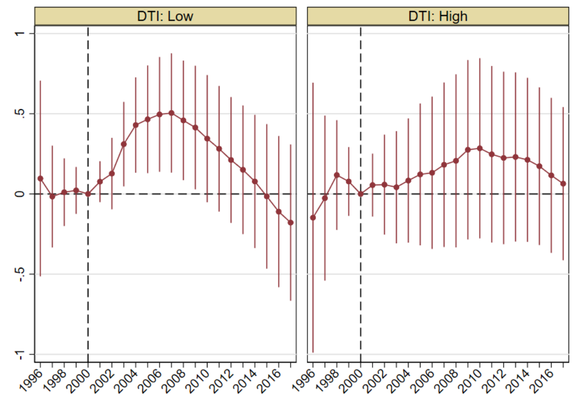
APPENDIX D

MECHANISMS

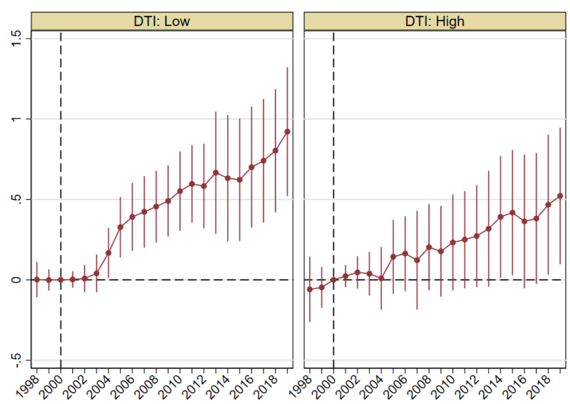
Figure D.1 and D.2 show how the crowding-in of private inputs varies with the local governments' debt capacity and provincial capital mobility. In cities with low debt ceiling to income ratio, the crowding-in effect appears stronger for all the three private inputs especially structural capital and employment. In cities with better capital mobility, the crowding-in effect is much larger for structural capital, and also slightly larger for employment in earlier years. These patterns echo the heterogeneity analysis of local output in Section 4.3.



(a) $\log(Struc_{c,t})$



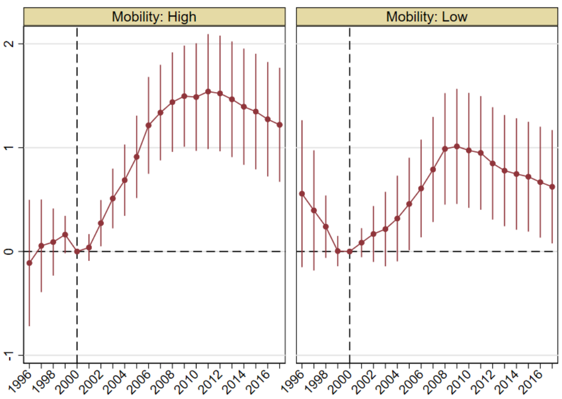
(b) $\log(Mach_{c,t})$



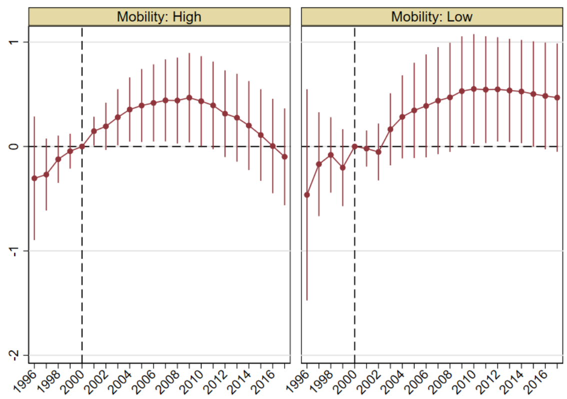
(c) $\log(Emp_{c,t})$

Figure D.1: Marginal Effect of *raw* on Private Input

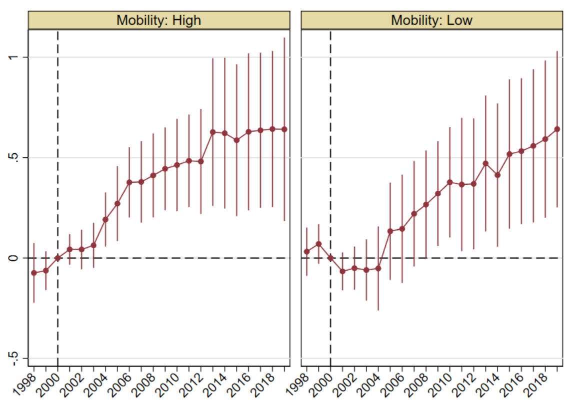
Note: The figure plots the 95% confidence interval of the β estimates from Equation (3.5), where the dependent variable is indicated below each graph. I conduct the estimation for cities with high and low debt ceiling-to-income (DCTI) group separately. For employment, the data is only available for 13 cities before 1998 and so I start from 1998. All standard errors are clustered by the city.



(a) $\log(Struc_{c,t})$



(b) $\log(Mach_{c,t})$



(c) $\log(Emp_{c,t})$

Figure D.2: Marginal Effect of *raw* on Private Input

Note: The figure plots the 95% confidence interval of the β estimates from Equation (3.5), where the dependent variable is indicated below each graph. I conduct the estimation for cities with high and low capital mobility separately. All standard errors are clustered by the city.

APPENDIX E

RESPONSES OF LOCAL FIRMS

E.1 Population density and the effect of raw land proportion

In this section, I present evidence on how the benefit from more occupied land depends on the local population density. Essentially, higher population density leads to higher land demand, drives up land price and hence compensation rate, which would make occupied land more valuable as it can save the local governments more compensation expense.

As one city typically consists of multiple sub-cities and hence multiple downtown regions that are disconnected to each other, I define the central sub-city as the one with the largest average GDP in 2000-2004, and all the others as the satellite sub-cities. Figure E.1 plots the population density (person per 100 sq.me) of all these satellite sub-cities against that of the central sub-city in 2000. There is not much variation in population density across all the satellite sub-cities. For only 2.4% of the satellite cities, their population density exceeded 0.1 in 2000. In contrast, there is much greater variation of population density across the central sub-cities.

For the analysis in this paper, I will use the population density of the central sub-city to to group the cities into high and low group. Compared to classification based on the city-wide population density, this approach has the advantage of avoiding miss-classification due to some satellite sub-cities with massive land but small population. After all, most population and economic activities concentrate in the central sub-city and it is the population density of the sub-city that is most relevant for our analysis. I choose the threshold (as indicated by the red vertical line) to separate all the sub-cities into two equal-sized group.

In Figure E.2, I repeat the construction of Figure 4.1 Panel A for cities with high and

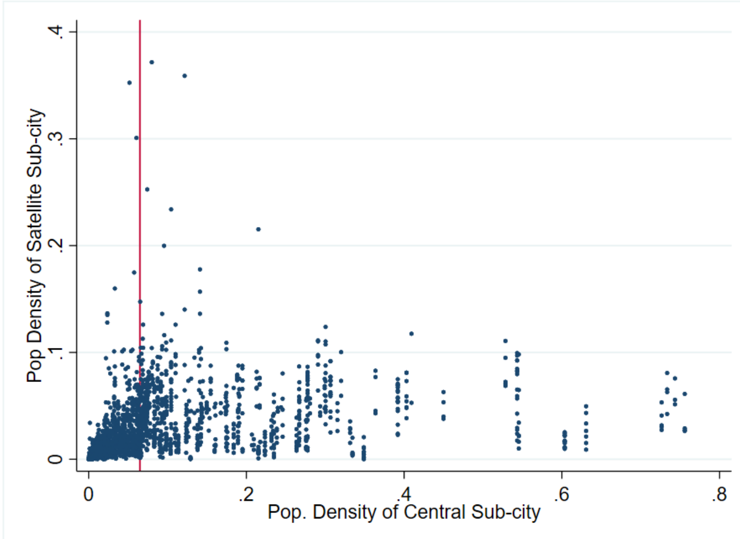


Figure E.1: Population Density of central and satellite sub-cities

Note: The graph plots the population density of the satellite sub-cities against that of the central sub-city, both measured in 2000.

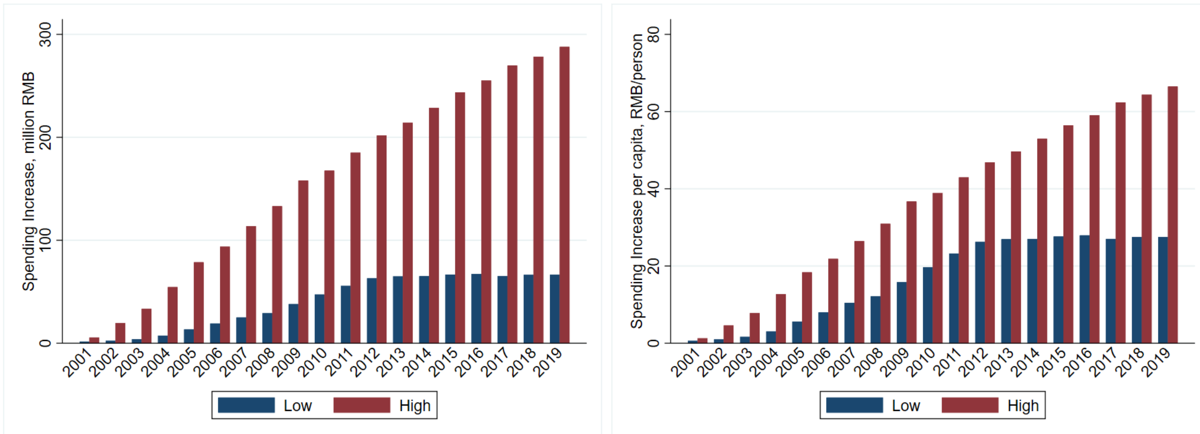
low population density separately. As conjectured, cities with high population density exhibited a much higher increase of government spending for a 1% increase of *raw*, no matter in terms of total amount or amount per person.

Table E.1 provides evidence consistent with the land demand channel. Higher population density leads to more land supply and higher land price, regardless of controlling for downtown size and GDP per capita.

E.2 Estimation of production function and TFPQ

For simplicity, I will ignore $Z_{k,j,t}$ and $C_{k,j,t}$ from Equation (6.1) and write the $\log(TFPQ)$ as follows:

$$tfpq'_{k,j,t} = \log(Q_{k,j,t}) - \alpha_m^j \cdot \log(M_{k,j,t}) - \alpha_l^j \cdot \log(L_{k,j,t}) - \alpha_k^j \cdot \log(K_{k,j,t}) \tag{E.1}$$



(a) Accumulated Spending (b) Accumulated Spending per capita

Figure E.2: Marginal effect on accumulative govt spending of *raw*

Note: The figures plot the average marginal increase of the accumulated govt spending, both total and per capita, for a 1% increase in *raw* for cities with high and low population density separately.

Table E.1: Pop. density and land demand

	(1)	(2)	(3)	(4)
Dep Var	log(LandSupply)	log(LandPrice)	log(LandSupply)	log(LandPrice)
popden	9.863***	5.722***	2.482***	3.840***
	(13.90)	(16.63)	(5.054)	(11.76)
log(DT)			0.456***	0.142***
			(14.46)	(9.986)
log(GDP/POP)			0.399***	0.0373
			(9.169)	(0.918)
Prov-Year FE	Yes	Yes	Yes	Yes
Observations	28,943	28,943	28,943	28,943
R-squared	0.359	0.488	0.531	0.516
#City	328	328	328	328

Note: This table shows the correlation between *raw* and the log of total land supply and average land price for each sub-city during 2007-2019. Standard errors are clustered by city. Robust t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In Equation (E.1), $Q_{k,j,t}$ is the firm k's sale in year t measured in fixed price in 1990, $M_{k,j,t}$ is material, $L_{k,j,t}$ is employment, and $K_{k,j,t}$ is capital stock. Assume constant return to scale technology, I can then proxy the input elasticity using the cost share of the input:

$$\alpha_m^j = \bar{S}_{j,t}^m,\ \alpha_l^j = \bar{S}_{j,t}^l,\ \alpha_k^j = 1 - \bar{S}_{j,t}^m - \bar{S}_{j,t}^l,$$

where $\bar{S}_{j,t}^m$ is the share of materials in revenues and $\bar{S}_{j,t}^l$ is the share of labor wages in revenues, for the industry j in year t.

In the Annual Survey of Industrial Firms data, sales measured in the fixed price in 1990 are only available for the period 1998-2003, but sales measured in the current price is always available during the whole period 1998-2007. To get an estimate of the fixed-price sales for 2004-2007, I calculate the output weighted average log price for each industry in each city during 2001-2003, and then combine the average price with the current-price sales to estimate the fixed-price sales for 2004-2007.

Specifically, denote sales measured in current prices as R_{it}, I then adjust the price as follows.

$$p_{c,j} = \sum_{k,t:c(k)=c} \log\left(\frac{R_{k,j,t}}{Q_{k,j,t}}\right) \cdot \frac{Q_{k,j,t}}{\sum_{k,t} Q_{k,j,t}}\ , t \in \{2001, 2002, 2003\}$$

$$\log(Q_{k,j,t}) = \log(R_{k,j,t}) - p_{c(k),j}\ , t \in \{2004, 2005, 2006, 2007\}$$

I then subtract the measure of resource utilization from $tfpq'_{k,j,t}$ to get $tfpq_{k,j,t}$:

$$tfpq_{k,j,t} = tfpq'_{k,j,t} - utili_{k,j,t}$$

E.3 More on the local firms' responses

In this section, I show more empirical patterns on how local firms are affected by government spending. First, as a significant portion of local government resources is spent to improve local infrastructure, firms that use more transportation services shall benefit more. Fernald [1999] shows that when growth in roads changes, productivity growth changes disproportionately in US industries with more vehicles, an proxy for the use of transportation services. I do not have data on the firm's vehicles. Instead, I construct the industry-level use of transportation services as the share of railway, highway, waterway, and urban public transportation services in the industry's total intermediary input, using China's Input-Output table in 2002. I then generate a binary indicator of *low*, which equals 1 if the firm is in an industry with transportation cost share below the median and 0 otherwise. I then define $high = 1 - low$, and interact *raw* with $(low, high)$ in Equation (6.3).

Table E.2 shows that firms that use more transportation services indeed benefit roughly 50% more from local government spending, and the additional effect on output is mainly driven by more material uses as well as higher productivity.

Second, to understand the source of the productivity improvement, I also estimate Equation (6.2) using only firms that were established before 2000. Table E.3 shows that there is a similar effect of *raw* on firms' output and productivity. The evidence suggests that the improvement of productivity is not simply driven by entry of more productive firms. The productivity improvement of existing firms can result from better public capital, more R&D investment in response to better market access, or more exit of firms with low productivity as a result of more fierce competition.

Third, to examine whether the timing of the productivity improvement matches the timing of the treatment effect of *raw*, I estimate the effect of *raw* on local firms' productivity year-by-year, after controlling for province-year-industry fixed effect. Table E.4

shows that the effect in productivity became significant right since 2001. Before 2000, local firms in cities with higher *raw* did not exhibit higher or lower productivity.

Table E.2: Government spending and firms' use of transportation services

	(1)	(2)	(3)	(4)	(5)	(6)
Dep Var	log(Q)	tfpq	utili	$s^m \cdot \log(M)$	$s^k \cdot \log(K)$	$s^l \cdot \log(L)$
Low*raw	0.275**	0.0655**	0.102***	0.149*	-0.0360	-0.00953
	(2.390)	(2.161)	(2.849)	(1.841)	(-1.004)	(-1.448)
high*raw	0.404**	0.0965**	0.0717*	0.221*	0.0143	0.00146
	(2.446)	(2.565)	(1.956)	(1.919)	(0.475)	(0.306)
Prov-Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	897,485	890,347	894,764	900,174	902,702	908,335
R-squared	0.181	0.364	0.194	0.265	0.600	0.763
#City	160	160	160	160	160	160

Note: This table shows in cities with high population density, how the effect of local government spending on local firm's output varies with the firms' use of transportation services, i.e., the share of transportation service expenses in total intermediate input expenses. The sample includes all firms during 2001-2007. All standard errors are clustered by city. T-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table E.3: Government spending and local incumbent firms' output

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep Var	log(Q)	tfpq	utili	$s^m \cdot \log(M)$	$s^k \cdot \log(K)$	$s^l \cdot \log(L)$	logprice	roa
raw	0.316***	0.0794**	0.0794**	0.165**	-0.00964	-0.00265	-0.0610**	-0.0228
	(2.728)	(2.502)	(2.251)	(2.113)	(-0.339)	(-0.591)	(-2.483)	(-1.280)
Prov-Ind-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	567,594	562,668	565,579	569,184	572,665	576,292	222,175	566,067
R-squared	0.212	0.377	0.215	0.291	0.625	0.770	0.526	0.162
#City	160	160	160	160	160	160	160	160

Note: This table shows the effect of local government spending on the output of local firm established before 2000 for cities with high population density. Column (2)-(6) decompose the effect on output into productivity, utilization, and input uses. The sample includes all firms during 2001-2007. All standard errors are clustered by city. T-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table E.4: Local govt spending, population density and local firms' productivity

Dep Var: tfpq	(1)	(2)
Pop Density	High	Low
1(year=1998)*raw	0.0117	0.0600
	(0.266)	(1.138)
1(year=1999)*raw	0.00690	-0.0544
	(0.206)	(-0.920)
1(year=2000)*raw	0.0355	-0.0428
	(0.955)	(-0.714)
1(year=2001)*raw	0.0578*	-0.0439
	(1.744)	(-0.928)
1(year=2002)*raw	0.0717**	0.0266
	(2.255)	(0.421)
1(year=2003)*raw	0.0751*	-0.158**
	(1.921)	(-2.481)
1(year=2004)*raw	0.0866***	-0.126**
	(2.654)	(-2.223)
1(year=2005)*raw	0.0894**	-0.126**
	(2.511)	(-2.134)
1(year=2006)*raw	0.0933**	-0.118*
	(2.567)	(-1.894)
1(year=2007)*raw	0.0729**	-0.0691
	(2.007)	(-1.053)
Prov-Ind-Year FE	Yes	Yes
Observations	1,142,519	376,393
R-squared	0.332	0.381
#City	160	176

Note: This table shows the correlation between the local firms' TFPQ and the city's *raw* during 1998-2007 for cities with high and low population density separately. All standard errors are clustered by city. T-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

APPENDIX F

SPILLOVER EFFECT

F.1 Relation between sub-city- and city-level effect

Proposition 1. *Assume Eq. (7.3) is the underlying data generating process for* $\log(GDP_{c,i,t})$*. If* $\varepsilon_{c,i,t} \perp raw_{c,i'}$ *and* $GDP_{c,i,2000} \propto DT_{c,i}$*, then the city-wide causal effect of* raw_c *on* $\log(GDP_{c,t})$ *is approximately* β_t*, i.e.,* $\mathcal{B}_t \approx \beta_t$*.*

Proof. For simplicity, I normalize the year 2000 to be $t = 0$. Without loss of generality, assume $\beta_0 = \rho_0 = 0$. Denote $\Delta\gamma_{p(c),t} = \gamma_{p(c),t} - \gamma_{p(c),0}$, $\Delta\varepsilon_{c,i,t} = \varepsilon_{c,i,t} - \varepsilon_{c,i,0}$, and $y_{c,i,t} = \frac{GDP_{c,i,t}}{GDP_{c,i,0}}$. We can then rewrite Eq. (7.3) as follows:

$$\log(y_{c,i,t}) = \beta_t \cdot raw_{c,i} + \rho_t \cdot spillover_{c,i} + \Delta\gamma_{p(c),t} + \Delta\varepsilon_{c,i,t} \tag{F.1}$$

Apply Taylor expansion of $\log(y_{c,i,t})$ at $\bar{y}_{p(c),t}$, we get

$$\log(y_{c,i,t}) \approx \frac{y_{c,i,t}}{\bar{y}_{p(c),t}} - 1 + \log \bar{y}_{p(c),t}$$

Conduct a weighted sum of Eq. (F.1) using $\frac{GDP_{c,i,0}}{GDP_{c,0}} = \frac{DT_{c,i}}{DT_c}$ as the weight and replacing the LHS with the Taylor expansion, we get

$$\begin{aligned}
&\frac{GDP_{c,t}/GDP_{c,0}}{\bar{y}_{p(c),t}} - 1 + \log \bar{y}_{p(c),t} \\
=&(\beta_t - \rho_t) \cdot \sum_{i:c(i)=c} \frac{DT_{c,i}}{DT_c} raw_{c,i} + \rho_t \cdot raw_c + \Delta\gamma_{p(c),t} + \Delta\varepsilon_{c,t} \\
=&\beta_t \cdot raw_c + \Delta\gamma_{p(c),t} + \Delta\varepsilon_{c,t},
\end{aligned}$$

where $\varepsilon_{c,t} = \sum_{i:c(i)=c} \frac{DT_{c,i}}{DT_c} \varepsilon_{c,i,t}$.

Reverse the Taylor expansion approximation on the LHS, we get

$$\log(GDP_{c,t}) - \log(GDP_{c,0}) \approx \beta_t \cdot raw_c + \Delta\gamma_{p(c),t} + \Delta\varepsilon_{c,t}$$

Denote $\log Y_{c,0} = \alpha_c$. We get the expression as Eq. (7.1).

Finally, since $\varepsilon_{c,i,t} \perp (raw_{c,i'}, spillover_{c,i'})$, we have $\varepsilon_{c,t} \perp raw_c$. Therefore, β_t captures the causal effect of raw_c on the city-wide GDP growth.

□

F.2 Decomposition of direct and spillover effect

Consider a marginal increase of $raw_{c,i}$ by μ while keeping $raw_{c,i'}$ unchanged. As a result, raw_c will increase by $\frac{DT_{c,i}}{DT_c}\mu$. By Eq. (F.1), $GDP_{c,i,t}$ will increase by

$$\Delta GDP_{c,i,t} = GDP_{c,i,t} \cdot (\beta_t - \rho_t(1 - \frac{DT_{c,i}}{DT_c}))\mu,$$

and $GDP_{c,i',t}$ ($i' \neq i$) will increase by

$$\Delta GDP_{c,i',t} = GDP_{c,i',t} \cdot \rho_t \frac{DT_{c,i}}{DT_c}\mu.$$

The total spillover effect to all other sub-cities sums up to

$$\sum_{i' \neq i} \Delta GDP_{c,i',t} = (GDP_{c,t} - GDP_{c,i,t}) \cdot \rho_t \frac{DT_{c,i}}{DT_c}\mu.$$

Now, let all sub-cities in city c increase their raw land proportion by μ. The total direct effect sums up to

$$\sum_i \Delta GDP_{c,i,t} = \Big(\beta_t \cdot GDP_{c,t} - \rho_t \cdot \sum_i GDP_{c,i,t}(1 - \frac{DT_{c,i}}{DT_c})\Big)\mu.$$

The total spillover effect sums up to

$$\sum_i \sum_{i' \neq i} \Delta GDP_{c,i',t} = \rho_t \cdot \sum_i GDP_{c,i,t}(1 - \frac{DT_{c,i}}{DT_c})\mu.$$

The total effect is hence

$$\sum_i \Delta GDP_{c,i,t} + \sum_i \sum_{i' \neq i} \Delta GDP_{c,i',t} = \beta_t \cdot GDP_{c,t}\mu.$$

F.3 Measure downstream and upstream exposure

Denote $Q_{c,i,j}$ as the output of all firms in industry j registered in city c sub-city i in 2000, and $W_{c,i,j}$ as the total intermediate inputs used by firms in industry j registered in city c subcity i in 2000.

Downstream Exposure. For a given firm in industry j_1, the exposure to downstream industries in other sub-cities is the probability that it sells products to firms in other sub-cities. I estimate this probability as the total demand for product j_1 from firms in other sub-cities divided by the total supply of product j_1 from firms in this city.

Formally, denote s_{j_1,j_2} as the use of input j_1 for every 1 RMB of total input used by firms in industry j_2 calculated using China Input-Output Table of 2002. I define the downstream exposure as follows:

$$Downstream_{c,i,j} = \frac{\sum_{i' \neq i} \sum_{j' \neq j} W_{c,i',j'} \cdot s_{j,j'}}{\sum_i Q_{c,i,j}} \quad \text{(F.2)}$$

Upstream Exposure For a given firm in industry j_2, the exposure to upstream industries in other sub-cities is the probability that it buys inputs from firms in other sub-cities. I estimate this probability as the total supply of each input from firms in other sub-cities divided by the total demand for this input. As firms use multiple inputs, I calculate the average probability weighted by the share of this input in the firms' total input uses.

Formally,

$$Upstream_{c,i,j} = \sum_{j' \neq j} s_{j',j} \cdot \frac{\sum_{i' \neq i} Q_{c,i',j'}}{\sum_{i_1,j_1} W_{c,i_1,j_1} \cdot s_{j',j_1}} \quad \text{(F.3)}$$