EXPLORING THE CAUSES OF INDUSTRIAL LAND-USE REGULATIONS:
Theory and Evidence from China
Colophon
Exploring the Causes of Industrial Land-Use Regulations: Theory and Evidence from China

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Exploring the Causes of Industrial Land-Use Regulations: Theory and Evidence from China

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CHAPTER 1

Introduction
CHAPTER 1

Externalities exist everywhere in our society (Meade 1952, Heller and Starrett 1976). One agent’s activities can always, to a greater or lesser extent, improve or reduce other agents’ welfare or productivity. Foreseeing this, the agents being impacted are incentivized to take action to avoid or capture the potential externalities if they are able to do so, through either reaching private agreements or promoting formal policies (Dahlman 1979, Coase 1960, Cheung 1970). This phenomenon occurs especially when the activities bringing externalities are closely tied to land. It has long been recognized that the development of one plot of land will affect the welfare or productivity of surrounding locations, and that a variety of public policies or private agreements, later uniformly termed “land-use regulations” (LURs), are widely used to remedy these side effects (Cheshire 2013, Cheshire and Sheppard 1995).

LURs have been increasingly adopted in recent years and have played an important role in shaping the economy and the environment. However, although they are justified because they remedy externalities, LURs have been documented to be significantly related to many unwanted outcomes. For example, they can impact land prices (Severen and Plantinga 2018, Turner, Haughwout, and Van Der Klaauw 2014), induce land market segmentation (Levkovich, Rouwendal, and Brugman 2018), raise housing prices (Hilber and Vermeulen 2016, Huang and Tang 2012), induce urban sprawl (Brueckner and Sridhar 2012), harm a firm’s productivity (Cheshire, Hilber, and Kaplanis 2015), and aggregate economic growth (Hsieh and Moretti 2019).

These unexpected outcomes have motivated researchers to explore the origins of LURs more carefully. Many forms of LURs have been investigated, and different theories have been put forward. For example, in explaining the use of one type of density restriction in China, floor area ratio (FAR), Brueckner et al. (2017) argue that the local government in China uses FAR regulation to maximize its net revenues. The trade-off is that a higher FAR raises the land price but requires more supporting infrastructure. Moreover, in justifying industrial land supply in the US, Fischel (1974) and his followers argue that industrial land supply is used by communities to balance economic benefits and environmental losses induced by industrial activities (Erickson and Wollover 1987, Fox 1978). In addition, more and more research has started to dig into the political process present in the policymaking of LURs (Hilber and Robert-Nicoud 2013, Fischel 2015, Solé-Ollé and Viladecans-Marsal 2012). This thesis continues this strand of research by investigating the causes of LURs regarding industrial activities in China. Industrial land-use regulations (ILURs) are quite popular in China and have recently become more stringent. I ask: what are the motivations behind a variety of ILURs used by local governments, including restrictions on density, contractual duration, and amount of available land? For each type (or group) of ILURs, I establish the corresponding theoretical model or framework by combining knowledge from a broad literature, such as work on share tenancy, community site supply, and bidding for firms. I empirically document the impact of some key forces, including land scarcity, firm characteristics, political incentive schemes, and tax-sharing schemes.
This chapter is structured as follows. Section 1.1 introduces the various LURs being used. Section 1.2 reviews the literature investigating the rationale behind LURs. Section 1.3 highlights the research gaps. Section 1.4 introduces the ILURs adopted in China, and section 1.5 puts forward the research questions. Section 1.6 introduces the data and theoretical and empirical methods used. Section 1.7 presents an overview of the remaining chapters.

1.1 Forms of land-use regulation

LURs may have slightly different definitions among researchers. This thesis accepts the broader definition, in which LURs refer to all restrictions imposed on land use (Glaeser and Ward 2009, Gyourko, Saiz, and Summers 2008). It has been recognized that LURs vary remarkably in their forms and differ significantly across regions (Glaeser and Ward 2009, Gyourko, Saiz, and Summers 2008, Brueckner and Singh 2020). In this section, I try to better understand the nature of different LURs by creating a simple classification. LURs can be classified into three main types (Brueckner et al. 2017), depending on which aspect of land use is restricted. First is the traditional zoning law, which regulates the specific use of a specific location and separates incompatible land uses. The zoning law is the fundamental rule behind the other types of regulations and is currently used worldwide. For example, it is common practice that land zoned for residential use is separated from land zoned for industrial use within the developed area of a city. On the other hand, industrial land may be rezoned for residential or flexible mixed-use use with urban and economic development (Ferm and Jones 2017, Leigh and Hoelzel 2012).

The second type of LURs are volume restrictions, which regulate the amount of developable land or designate conservation areas. For example, Oregon State in the US uses urban growth boundaries to identify and separate urbanizable land from rural land in the long run (Grout, Jaeger, and Plantinga 2011). Similar instruments include population growth control and conservation protection. Also, less binding instruments may be used. For example, the national government in the Netherlands designates a relatively open area named “Green Heart” within the urbanized ring of the “Randstad” (Needham 2016). In addition, governments may restrict available land in the short run. For instance, the central government in China imposes annual caps on building land quotas allocated to local governments (Zhou et al. 2017). And many countries, such as the US and the Netherlands, use building permits (or development permits) to prevent undesirable developments parcel by parcel (D’Amato, Marin, and Rampa 2019, Needham 2016).

The third type of LURs consists of density restrictions, such as regulations deciding building height, lot size, and FAR (Glaeser and Ward 2009, Jackson 2016). Among them, lot size mainly refers to the area of an individual parcel for a single family (Zabel and Dalton 2011), while FAR refers to the ratio of the building’s total floor area to the size of the piece of land on which it is built. Density restrictions are often used to limit building and population density through imposing a maximum building height, minimum lot size, or maximum FAR (Bertaud and Brueckner 2005, Geshkov and DeSalvo 2012), while restrictions on minimum density are also found to be used to limit land consumption, such as maximum lot size and minimum FAR (Geshkov and DeSalvo 2012, Pasha 1992, Bertaud and Brueckner 2005).
Beyond the three types outlined above, many other forms of LURs that regulate more specific aspects of land use have received attention recently. For example, governments are increasingly adopting direct or indirect regulatory instruments to promote the supply of public goods, such as public facilities requirements (Quigley 2007) or provisions allowing developers to increase densities if they preserve more open space or build more affordable housing units (Glaeser and Ward 2009). Besides, more detailed restrictions on the design of the building are also applied, such as architectural reviews, appearance regulations, and development approval (Jackson 2016).

Another useful way to distinguish LURs is to look at who decides on certain LURs. Most LURs are imposed by local governments and regulate land users. Meanwhile, some LURs are enacted by the national government and constrain the policymaking of local governments, such as the national planning policy in the UK (Cheshire et al. 2012) and the land quota system in China (Ding 2003, Zhou et al. 2017). LURs can also be determined by a group of private landowners or communicates, such as deed restrictions and neighborhood covenants (Turnbull and Zahirovic-Herbert 2019). It should also be pointed out that LURs can be divided based on which type of land use the regulation addresses. Although this perspective is quite straightforward, it deserves attention, as LURs regarding different land uses can significantly diverge in terms of both form and stringency.

As mentioned at the beginning of this chapter, this thesis focuses mainly on two types of LURs regarding industrial use that are adopted by local governments in China: density regulations and volume restrictions. Specifically, the investigated density regulations refer to restrictions on a firm's inputs and outputs (FiOs) and to what I term capital-land ratio (CLR) regulations, in which the restrictions concern a firm's inputs. Volume restrictions, on the other hand, concern the annual amount of land supplied to industrial use. Both types of LURs are widely and increasingly used by local governments in China, evoking great interest of scholars and policymakers. I aim to investigate the motivations behind using them.

### 1.2 The rationale behind land-use regulations

The types and stringency of LURs differ greatly across countries and regions (Glaeser and Ward 2009, Gyourko, Saiz, and Summers 2008, Brueckner and Singh 2020). Growing research has been devoted to exploring the reasons for these differences. I first put forward a basic conceptual framework to help structure the literature on the rationale behind LURs, based on the argument of Fischel (2000) that zoning is a collective property right used by municipalities to maximize the net worth of those in control of the political apparatus. The benefits and costs caused by LURs can be quite complicated and involve many groups of agents. A simple example of zoning farmland for residential development can be used to illustrate this. First of all, owners of the farmland can benefit from the increase in land value. At the same time, owners of developed land may face a decline in housing prices. Simultaneously, renters may enjoy a lower rent. Besides, developers have a chance to profit from the development. Furthermore, the mobilization of residents caused by the change in housing prices may impact housing prices in neighboring cities.
Each group of agents is supposed to influence LURs to maximize its own benefits, and then LURs are the outcome of the political competition among these agents. It should be noted that the investigation of causes of LURs should be contingent on the types of LURs and the political system. On the one hand, the involved interest groups and related gains and losses may differ across the types of LURs. For example, compared with the above example, zoning farmland for industrial use may induce a more negative impact (environmental pollution) for adjacent residents but bring larger benefits (public service or employment opportunities) to relatively distant residents. On the other hand, the political system makes a large difference in terms of which group of agents can be supported by LURs. For example, in a centralized political system such as China, local officials may have stronger incentives to exploit LURs to meet the promotion criteria defined by the central government than to pursue citizens’ interests.

Guided by this framework, I next review the literature that models and tests the rationale behind LURs, most of which is about residential land. Last, I highlight existing research that investigates the causes of LURs regarding industrial activities.

1.2.1 Theories on the rationale behind land-use regulations

I first review existing research concerning volume restrictions. In very classic research, Brueckner (1995) models restrictions on the spatial size of a city as the outcome of political competition among residents (also renters) and landowners in a system of cities. In his model, one city's regulation reduces the economy-wide residents’ utility level, while it increases the total return to this city's absentee landowners. The city government trades off the utility of residents for the utility of landowners when deciding on the regulation. Later, several scholars have tried to characterize the political process more explicitly. For example, Ortalo-Magné and Prat (2014) consider three channels through which new housing construction impacts voters: reducing housing rent, lowering housing price, and improving local service. Their setting is dynamic: voters realize the impact on the current period and understand that the new construction can bring new voters and then change future voting outcomes. The political process follows the median voter theorem, which means that the candidate whose policy favors the interests of the median voter can win the election. In their model, the median voter is the cohort member with the median age, and the volume of new construction depends on how much housing median voters own. This in turn depends on the homeownership premium and voters’ expectations for future housing rents and voting outcomes.

The political rent obtained by the policymaker is also considered in some research. In the model put forward by Solé-Ollé and Viladecans-Marsal (2012), allowing more land to be developed enriches developers, as their profits increase if they are allowed to build on more land. Meanwhile, more development entails more costs for swing voters, who are indifferent to the incumbent or the challenger and are thus more sensitive to the utility loss induced by the policy. Developers influence policy through lobbying, while swing voters influence policy through elections. Therefore, by relaxing volume restrictions, the local incumbent gains political rent from the developers but faces a lower probability of
re-election. Solé-Ollé and Viladecans-Marsal further note that voters’ welfare is valued more under more intense political competition. D’Amato, Marin, and Rampa (2019) show how building permits are used to maximize the expected net rent from re-election. In their model, building permits reduce the utility of voters that experience environmental disasters, since building permits induce environmental impacts, and those voters are less keen to accept development by environmental disasters. In contrast, building permits can increase the utility of voters interested in sectors relying on building permits, while it does not impact those who vote for or against the politician for ideological reasons. Besides, building permits can improve social benefits by offering more or less socially valuable buildings and then improve incumbent politicians’ popularity, which reduces their difficulties in implementing other policies. The politician adjusts the number of building permits issued to maximize the expected benefits from re-election and popularity.

Volume restrictions are also investigated in centralized political systems. For example, Lichtenberg and Ding (2008) model how local officials in China use the amount of conversion of agricultural land into urban land to maximize their ongoing rewards from the central government. The urban land supply increases not only urban GDP, the value-added tax (VAT) revenue, and the land leasing revenue but also compensation for agricultural land. Local officials aim to maximize rewards from the central government, and in their model, these rewards include the increase in GDP and financial revenues. Local officials determine the developable urban land required to trade off urban GDP against net financial benefits. In a different way, extending the urban boundary in the model put forward by Wang, Zhang, and Zhou (2020) also requires lobbying efforts by local officials to seek extra land quotas, and local officials weigh three types of payoff, including GDP, residents’ welfare, and lobbying efforts, in deciding the optimal urban boundary.

Except for looking at volume restrictions, a few scholars also pay attention to the origins of some other types of LURs. For example, Brueckner et al. (2017) rationalize the maximum FAR regulation in China. A tighter maximum FAR regulation leads to lower land-leasing revenue as well as lower infrastructure costs. Local governments, also as landowners in their setting, use the FAR regulations to maximize the gap between land-leasing revenue and infrastructure costs. In addition, Hilber and Robert-Nicoud (2013) model the regulatory environment that increases the living cost of each household by a “regulatory tax” as the outcome of a political economy game between owners of developed and owners of undeveloped land. In their model, such a regulatory environment increases the price of developed land by restricting the development opportunity of undeveloped land, as well as causing a decline in the desirability of cities due to increasing living costs, which hurts all landowners. And the owners of undeveloped land (or land developers) and owners of developed land make up two competing lobbies that influence the planning board through lobbying contributions. Hilber and Robert-Nicoud’s model further simplifies the political process by assuming that the planning board gives equal weight to the cost and benefit to landowners of raising the local regulatory tax. At equilibrium, the planning board maximizes total land rents plus the regulatory tax revenue.
1.2.2 Empirical evidence of the rationale behind land-use regulations

The determinants of volume restrictions have been investigated intensively. By examining the amount of developable land in Spain it is found that left-wing parties’ being in power (representing voters who dislike growth) and political competition (indexed by vote margin) can lead to a decline in available urban land (Solé-Ollé and Viladecans-Marsal 2013, 2012). The impact of political competition is more profound in the suburbs, which are areas with more homeowners and commuters (Solé-Ollé and Viladecans-Marsal 2012). Moreover, D’Amato, Marin, and Rampa (2019) analyze building permits in Italy. In their research, building permits refer to permits for private and public buildings intended for economic activities, such as houses, commercial buildings, industrial plants, and hospitals, while infrastructure such as roads and railways is not included. They find that politicians tend to issue more building permits to earn the support of voters with a larger interest in construction sectors and issue fewer building permits in areas experiencing more past natural disasters. In addition, housing stock in England is examined by Coelho, Dellepiane-Avellaneda, and Ratnoo (2017). They first use data from the BSA (British Social Attitudes) survey and show that the probability of opposition to house-building increased greatly if the respondent was an owner-occupier; then, they document that a higher proportion of owner-occupiers among local households leads to the growth of local authorities’ dwelling stock. There is also evidence from China. Wang, Zhang, and Zhou (2020) aim to explore the impact of the career incentive of local leaders on urban expansion. They measure urban expansion by using the top percentiles in the distribution of the distance to the city center of all land parcels sold during each leader’s term of office, and measure the career incentive intensity based on an estimated promotion likelihood of local leaders. They offer solid evidence that the leader with higher career incentives is more likely to promote urban expansion.

Density regulations are also gaining attention. Been, Madar, and McDonnell (2014) investigate them based on a lot-level dataset from a period of unusually high rezoning activity in New York City, in which the lots can be either upzoned or downzoned. They find that both the neighborhood’s homeownership rate and voter turnout rate decrease the probability of upzoning but increase the probability of downzoning, suggesting that residents are part of the dominant voting block and their preference limits development in order to protect the value of their homes. Brueckner et al. (2017) examine density regulations using parcel-level FAR regulation in China. They use the estimated elasticity of land price to FAR to measure the stringency of FAR regulation in a city and find that regulation stringency is positively related to the number of historical sites for residential land and negatively related to tourist attractions for commercial land. In addition, when investigating lot size regulation in Massachusetts in the US, (Glaeser and Ward 2009) show that the historically higher housing densities can explain a large part of the smaller size of the current minimum lot than other towns, and that bigger and denser towns are much more likely to have cluster provisions (denser development under given provisions).

Some research examines the regulatory environment rather than looking at a specific regulatory tool. One prominent measure of the regulatory environment is the Wharton...
Residential Land Use Regulation Index (WRLURI), which covers more than 2,600 communities across the US based on a 2005 survey (Gyourko, Saiz, and Summers 2008). A WRLURI value of 1 implies that the measure is one standard deviation above the national mean. Using the WRLURI as a measure of regulation stringency, Hilber and Robert-Nicoud (2013) find that areas with a larger share of developed residential land located in Democrat-leaning states (where those voters are ideologically more sympathetic to regulation) or with less open land are more tightly regulated. In contrast, the homeownership rate and contemporaneous population density are not statistically significantly related to the WRLURI. Another relatively simple measure is used by Brueckner (1998). His measure is based on a survey of Californian cities and counties. The survey tabulation indicates a value of 1 if a city has adopted a given measure of nine, such as restrictions on housing permits, urban growth (via a boundary or greenbelt), square footage, rezoning, and density. The stringency index is the sum of these nine values. Brueckner documents that when neighboring cities impose more stringent regulations, a given city tends to respond positively. In addition, the regulatory tax approach is used by (Cheshire and Hilber 2008) to measure regulatory stringency when examining commercial LURs. This approach rests on economic theory and measures the total cost of regulatory constraints for the price of building space (Glaeser, Gyourko, and Saks 2005). Cheshire and Hilber (2008) find that the regulatory tax varies according to local prosperity, and its responsiveness to this depends on whether an area is controlled by business interests or by residents.

1.3 Research gaps

Most existing research is on residential land, while the literature regarding industrial land receives less attention. Restrictions on industrial land use might harm manufacturing and warehousing firms considerably, since the activities of these companies require vast areas of land (Dempwolf 2010, Nathan and Overman 2011) and the substitution of non-land capital for land might prove more difficult (Needham, Louw, and Metzemakers 2013). It is documented that in some US cities, the industrial land supply is so limited because of the pursuit of smart growth that local economic growth is negatively impacted (Leigh and Hoelzel 2012). In the Reading area in the UK, constraints on industrial land cause a high premium for industrial land adjoining residential zones (Cheshire and Sheppard 2005, Cheshire 2013). On the other hand, it is not rare to find that space for industrial activities is overly supplied by municipalities while desirable outcomes are not achieved. By examining the land supply in Central Scotland, Bramley and Kirk (2005) show that the take-up rate of industrial land is considerably lower than that of residential land. They suggest that the industrial land supply is far more than adequate. They also find that the take-up rate negatively correlates with the amount of available industrial land and interpret the result as the limited impact of land supply on industrial development. Similar evidence is also found in New York City in the US, where the Industrial Business Zone program—a type of industrial preservation policy meant to attract and retain industrial uses—is found effective in retaining industrial land but has no significant impact on promoting new industrial business registrations, employment, or building permits (Davis and Renski 2020). Municipalities in the Netherlands also tend to overly supply industrial land, motivated
by the ambition to ensure there is always sufficient land for industrial firms available, as suggested by a very large ratio of available to sold industrial land (Van Der Krabben and Buitelaar 2011). The less stringent regulation on industrial land in the Netherlands is also documented by Levkovich, Rouwendal, and Brugman (2018). They find that there is far less ready-to-be-developed land zoned for industrial use than such land for residential use. This gap can be partly explained by local land policies. In addition, local governments in China are also found to exceedingly supply parcels for industrial use to promote economic growth and engage in regional competition, which ultimately leads to inefficient land use (Huang and Du 2016, Yang, Zhuo, and Yang 2014, Yu, Zhou, and Yang 2019).

Fischel (1974) and his followers have proposed a community site theory to explain the use of ILURs (Erickson and Wollover 1987, Fox 1978). This theory argues that through screening unwanted firms, ILURs are used by communities to balance economic benefits and environmental losses induced by industrial activities. The underlying reason is quite straightforward. Generally, the tax revenue industrial activities generate for the local government is much higher than public services expenditures (Erickson and Wasylenko 1980, Erickson and Wollover 1987, Evenson et al. 2003, Fischel 1974). In addition, industrial activities are supposed to create employment benefits (Fischel 1974). This economic gain enables municipalities to offer more public services to residents or reduce their tax burdens. On the other hand, industrial activities can give rise to significant negative externalities for communities, such as congestion, crowding, loss of rural character, and environmental decay (Erickson and Wollover 1987, Fischel 1974). Therefore, local governments allow new industrial activities to the extent that the marginal increase in utility from the fiscal benefits generated by these activities equals the marginal decrease in utility from the accompanying environmental decay in order to maximize the welfare of citizens (Erickson and Wollover 1987).

Later, much empirical research has verified this theory, especially concerning the relationship between the tax system and industrial land supply. For example, Fraenkel and Krumholz (2019) examine state reforms that disproportionately redistribute property tax revenues in the US. They show that these state reforms cause a reduction in fiscal benefits from dirty industries for high equalization states and induce a decline in the number of large manufacturing establishments in affected counties. Burnes, Neumark, and White (2011), moreover, offer indirect evidence that local officials in jurisdictions with higher sales tax rates tend to make efforts to attract large stores and shopping centers rather than manufacturing. Moreover, research on China, where the related tax system is significantly different, documents the same industrial land supply effect. Xie, Zhu, and Li (2019) show that an increase in VAT revenue shared by local governments leads to an increase in industrial land supply, and Han and Kung (2015) find that local governments shift their efforts from fostering industrial growth to developing the real estate and construction sectors when their sharing in enterprise tax revenue was reduced.

I find the following research gaps regarding the causes of ILURs. First, an investigation into how the political economy impacts industrial land supply is only slightly conducted.
Evenson et al. (2003) document the impact of residents’ valuation of environmental amenities by showing that wealthier towns zone less of their open land for industrial use, a result shared by Erickson and Waselenko (1980). Shertzer, Twinam, and Walsh (2016) offer a relatively complicated story by documenting that the shares of Southern-born blacks or first-generation immigrants in neighborhoods can positively impact the area zoned for industrial uses, since these groups of residents are less wealthy and less represented by the zoning commission. Considering the various benefits and costs brought on by allowing industrial activities and the increasing evidence for the impact of the political economy on restrictions on other land uses, it is reasonable to expect that many unknown political forces behind ILURs remain to be explored.

Moreover, it should be noted that community site theory does not clarify how density restrictions are used by local governments to achieve their goals; neither does the related empirical analysis. On the other hand, CLR regulations have been extensively explored regarding residential land use. A possible reason that the restrictions on the CLR of industrial activities have received limited attention is that the forms of CLR regulation for industrial land are beyond building structure, which makes up the main inputs and outputs of residential use but not necessarily the main inputs and outputs of industrial use.

Finally, in countries such as the Netherlands, China, and Singapore, land for industrial development is mostly supplied by municipalities themselves, who also reap financial benefits from selling the land (Ming and Hin 2006, Ding 2003, Krabben, Ploegmakers, and Samsura 2011). In this situation, ILURs may be influenced by the additional incentive from the land supply. On the other hand, as municipalities rather than private landowners obtain land-sales revenues, specific ILURs that bring more fiscal or environmental benefits but induce lower land prices can be adopted without worrying about opposition of private landowners. Some indirect evidence is offered by showing that some municipalities reduce the industrial land price to attract industrial firms (Needham 1992, Kajitani and Fujii 2016).

China provides an excellent experimental field in which to explore the topic of ILURs. On the one hand, local governments benefit (or suffer) greatly from industrial activities within their jurisdictions due to the tax-sharing system and the centralized political system, which gives them a strong incentive to intervene in industrial development. On the other hand, the state-owned land system enables local governments to impose complicated and stringent LURs that may be difficult to implement in a privately owned land system. Indeed, as I will show below, these two types of forces lead to a variety of ILURs in China.

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1 Since 1994, the main tax revenues are shared among vertical governments; for example, in terms of the tax revenues paid by industrial firms, value-added tax and corporate income tax are both shared between the central government and sub-central governments, and they are the main fiscal revenues for local governments.
1.4 Industrial land development in China

I aim to examine ILURs adopted by China’s local governments. Given the highly centralized land-use regulation system in China, local ILURs are constrained by a set of regulatory policies from upper-level governments. In the following sections, I first introduce LURs mainly decided by the central or provincial governments, especially those concerning volume and density restrictions on industrial use. Next, I illustrate industrial land development (including the ILURs) implemented by county governments.

1.4.1 Land-use regulations

1.4.1.1 Land-use planning system

Starting in the 1980s, the central government in China has gradually established a top-down land-use planning system. There are five levels of land-use planning agencies: nation, province, municipality, county, and township. The plan made by the lower-level agency must conform to that of the upper level (Zhou et al. 2017). The heart of this planning system is the general land-use plan legalized by the Land Management Law of China (Liu and Zhou 2021), which includes a specific plan for each level of government for a period of 15 years. Besides, each level of planning agency or other government department can formulate special-purpose land-use planning and other types of LURs, such as density regulations.

The compiling of the first round of the general land-use plan began in 1993 and covered the period from 1986 to 2020. The compiling of the second round was started in 1999 and covered the period from 1996 to 2010. Both rounds have three levels of a specific plan: a national, provincial, and municipal (county) plan. The main difference is that the 1996–2010 plan regards farmland protection as the main target. It establishes the rule of farmland dynamic balance, which means that the conversion of farmland into building land by one government should be accompanied by an equal amount of new farmland through land consolidation within its jurisdiction. The 1996–2010 plan also regulates the quota for farmland and newly developable land for each level of government. Besides, the general land-use plan was added to the Land Management Law in 1998, which significantly enhanced its authority. The compiling of the third round began in 2008 and covered the period from 2006 to 2020. This round is based on data from the second national land-use survey in 2008, enabling the establishment of spatial zoning and a spatial planning database. In addition, this round includes the plan for five levels of government, including the nation, province, municipality, county, and township. I will introduce the land-use planning system based on this round of plans in detail.

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2 See other types of spatial planning in (Liu and Zhou 2021), which includes main functional zone planning, urban-rural planning, and eco-environmental protection planning. In recent years, China has promoted national territory spatial planning to merge different types of spatial planning, aiming to delimit the regulatory boundaries of production, life, and ecological space development.
The formulation of the 2006–2020 plan follows a top-down process (Chen et al. 2016). The national level of the plan was first issued in 2008; subsequently, the province-level plan was issued based on the restrictions on the amount of land use in the national plan and, in turn, the municipality-, county-, and township-level plans were made. The national and provincial plans regulate the guidelines for spatial zoning, while municipal-county-town plans regulate specific spatial zoning. Spatial zoning mainly regulates to what extent the specific area is allowed to be developed. The jurisdiction area is divided into four zones: permitted-building zone, conditionally permitted-building zone, restrictively permitted-building zone, and prohibited-building zone. Besides, it regulates the zone of agriculture, settlement, and basic farmland. The land quota will be introduced in detail later.

To implement the general land-use plan, the central government further draws up the annual land-use plan, which mainly regulates the land quota (Zhou et al. 2017). This scheme was introduced in 1999. Ever since, its formulation and implementation have been adjusted several times, mainly in 2004, 2006, and 2016. I will introduce this type of plan by taking the annual land-use plan for 2006 as an example. The formulation of the annual plan takes place as follows. County-level governments draw up the suggested plan and submit it to municipal governments, and municipal governments draw up the suggested municipal plan and submit it to provincial governments. Next, provincial governments draw up the provincial plan and submit it to the Ministry of Natural Resources (called Ministry of Land and Resources before 2018) and copy it to the National Development and Reform Commission. Next, the Ministry of Natural Resources draws up the national plan based on the plan submitted by provincial governments, adds the national land plan to the national economic and social development plan, and then submits it to the state council. After National People’s Congress approves the national plan of economic and social development, the final annual land-use plan is established. The implementation of land quotas in the annual land-use plan is quite strict. Although province-level governments could apply to the Ministry of Natural Resources for an adjustment of the annual land-use plan if unpredictable key projects exist, the land quota for building land newly converted from agricultural land should not be exceeded. If the amount of actual new building land exceeds the quota in the plan, the corresponding quota in the next year will be reduced. In contrast, the unused quota can be used in the following year (and in the following two years after the policy reform in 2016) if it is approved.

Furthermore, and as regulated in the Land Management Law, the examination and approval of the conversion of agricultural into building land is also used to help implement the general land-use plan. The examination and approval is carried out in patches for a given year. The examination content mainly includes whether the land use of those parcels conforms to the general land-use plan and whether the necessary new farmland is added (or land reclaiming fee is paid) in order to comply with the rule of farmland dynamic balance. The examination and approval authority has varied slightly in recent years. Generally, before 2020, land-use conversion in most big cities, including all the province capitals, had to be examined and approved by the central government, while the rest was done by the provincial government. On the other hand, conversion of basic
farmland can be examined and approved by the central government only. From 2020, part of this authority has been delegated: conversion that does not affect basic farmland for all cities is examined and approved by provincial governments.

1.4.1.2 Volume restrictions by the planning system
The national general land-use plan regulates a set of land quotas for each province in the planning period (Zhou et al. 2017, Chen et al. 2016). Five quotas are obligatory: the minimum volume of farmland, the minimum volume of basic farmland, the maximum volume of urban and rural building land, the maximum volume of new building land converted from farmland, and the minimum volume of new farmland obtained through land consolidation. Other quotas are anticipatory, including the minimum volume of garden land, the minimum volume of woodland, the minimum volume of grassland, the maximum volume of building land, the maximum volume of urban and industrial land, the maximum volume of land for transportation, water conservancy and other infrastructure, the maximum volume of new building land, and the maximum volume of new building land converted from agricultural land. Each provincial plan further regulates the land quotas for municipalities within its jurisdiction, then the municipal plan regulates land quotas for counties, and counties regulate for townships. Therefore, all levels of the general land-use plan adopt the same set of land quotas.

I have described the formulation of the annual land-use plan in the above section. Here I would like to add that the bottom-up process mentioned before does not mean that the local government can decide its own land quotas. In fact, limited quotas allowed by the central government make it quite normal for upper-level governments to cut down quotas for governments under them. The obligatory quotas in the annual plan include the maximum volume of new building land converted from agricultural land (and farmland) and unused land, the maximum volume of new farmland through land consolidation and development, and the minimum volume of farmland. In 2016, the quota on the volume of urban building land “converted” from rural building land was also included in the plan. Here, “converted” does not mean the same parcel; instead, it means that one piece of building land was converted into farmland in a rural area, while another piece of farmland land was converted into building land in an urban area. The conversion here is a type of development rights exchange between rural and urban areas.

1.4.1.3 Density restrictions imposed by the planning system
Density is also regulated in the general land-use plan, which regulates the maximum volume of urban and industrial land per capita for each level of government at the end of the planning period. There are no density regulations in the annual land-use plan. Density regulations are mainly determined by local governments (Tan, Wang, and Zhang 2020). Although each level of government has similar land management and planning agencies, the county-level governments, which include about 2,800 jurisdictions,3 are most powerful, since they have the direct right to determine the allocation of urban land.
(Cheung 2014, Xu 2011). Generally, planning guidelines are first made by a land reserve and allocation committee consisting of local leaders and bureau directors from relevant agencies. Next, detailed density restrictions for each parcel of land are made by local planning agencies and can include FAR, building heights, and green space requirements.

For industrial land, the central government additionally imposes density restrictions through specific land policies in order to solve the industrial land-use inefficiency problem caused by regional competition for moving capital (Xu, Huang, and Jiang 2017, Huang and Du 2016). Since 2004, the central government has begun to stipulate the minimum or maximum CLR for different counties: 1) the minimum value of FAR, which varies by industry type; 2) the percentage of land occupied by administrative office and living service facilities, which must be less than 7%; 3) the percentage of land occupied by buildings, which must be more than 30%; 4) the percentage of land occupied by green space, which must be less than 20%; 5) the minimum fixed assets investment (FAI) per unit of land, which includes construction and structure and their auxiliary facilities, equipment, and land-leasing fees; it varies according to the grades of counties. Among these restrictions, FAI is the most important, because it includes building and equipment investments and varies based on the grades of counties. The central government raised the regulated value in 2008 and recently announced that this policy would be revised again. The exposure draft was posted in March 2021, and also regulates the index of minimum production value and tax revenue. Besides, provincial governments also issued the minimum-CLR policies for the counties within their jurisdictions. Before the first national policy in 2004, Shanghai and Zhejiang had established the minimum-CLR policies for their jurisdictions to improve industrial land allocation. Hereafter, more provinces began to adopt their own policies to improve the requirements for minimum CLR, and some provinces even adjusted their policies every few years.

County governments must add density restrictions to land-leasing contracts concluded with industrial firms when supplying parcels to them. The density restrictions may not be lower than the standard regulated by upper-level governments. The default clause is decided by county governments and varies between regions. Based on land-leasing contracts collected during my interviews in Xuchang city in Henan Province (Oct. 5, 2017), Wuxi city in Jiangsu Province (Oct. 18, 2017), and Yiwu city in Zhejiang Province (Aug. 10, 2017), the default clauses mainly include making corrections by firms within a fixed period, paying certain penalties by firms, or taking back land-use rights by governments, and they differ between regions in terms of strictness.

1.4.2 Industrial land development
Local governments, especially county-level governments, are highly involved in industrial land development due to state ownership of urban land (Lichtenberg and Ding 2008, Ding 2003). The practice of realizing this state ownership is that county governments first expropriate the land from farmers or rural collectives and then transfer specific years of land-use rights to land users after servicing the land. The maximum duration of land
leasing varies depending on land use. For industrial land, it is 50 years. This practice means that county governments have a monopoly on supplying newly developed urban land within their jurisdictions and act as the real owner of urban land by supplying it directly in the primary urban land market. Given that local governments are also the ones who decide on LURs, industrial land development in China is actually the integration of LURs and market transactions.

The industrial land development carried out by county governments must conform to the regulatory policies formulated by the central government, including the land-use planning system, density regulations, and the procedure to guarantee the transparency and competitiveness of land transactions. Generally, a typical local government follows three steps to develop industrial land. First, it announces the supply of available parcel(s) for industrial use on the land market website, stipulating the area, location, regulations regarding FAR and fixed assets investment intensity (FAII), and minimum land price. Second, firms bid on the land through either an English auction or two-stage bidding. Finally, the government releases the information on winners and parcels, again on the land market website.

Although it is allowed in the second step, competition among firms seldom occurs, and neither does the price premium caused by it. One of the reasons behind this is that, in most cases, county governments have already completed a preliminary selection of firms for the specific parcel before step one. An industrial development committee consisting of local leaders and bureau directors reviews the firm’s industrial type, investment scale, environmental impact, employment creation, etc., and reaches an investment agreement with the selected firm. Therefore, it is common that only the selected firm participates in bidding. To further ensure that the selected firm wins the bidding, some county governments may add an item to the investment agreement that stipulates that the government will compensate the firm for the land price premium above the negotiated land price. Other governments may use a more formal policy and explicitly regulate that only those firms approved by them can participate in the bidding. Compared with the formulation of density restrictions mentioned above, which mainly apply to residential and commercial land, density restrictions for industrial land are more likely to be determined directly by a committee who have a higher position in the hierarchy than planning agencies.

The amount of available industrial land is determined in this industrial land market. The land quota in the planning system only restricts the total newly developable land, allowing local governments to allocate the quota to different land uses according to local interests. Industrial land is thus supplied parcel by parcel by local governments in the industrial land market. The considerable autonomy partly explains why industrial land is overly supplied to attract moving capital (Huang and Du 2016, Yang, Zhuo, and Yang 2014), which induces lower land-use efficiency for some regions (Yu, Zhou, and Yang 2019, Zheng et al. 2016).

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4 Such as the mandatory use of English auction or two-stage bidding when supplying industrial land.
Various types of FIOs are regulated by local governments in the form of contractual arrangements. Usually, the land-leasing contract regulates only the aspects of FIOs required by the central government, such as FAR and minimum FAII. While the investment agreement regulates some additional aspects, such as the minimum total investment (including FAI), minimum production capacity, minimum tax payment, or minimum employment creation, the corresponding default clauses are also stated in detail. However, the items stipulated in an investment agreement vary between counties and can be very nontransparent. A potential reason is that detailed FIOs regulations are not publicly supported by the central government, not to mention that these regulations may be accompanied by subsidies to firms by local governments.

Not until recently have some regions begun to merge the investment agreement with the land-leasing contract. This practice is promoted by reform that sought to deepen the marketization of industrial land allocation, initiated by the central government in 2014. Rather than imposing mandatory policies like before, the central government aims to guide local governments on FIOs and contractual duration regulations by giving them discretion and encouraging local innovation. Specifically, the central government increases flexibility in terms of contractual duration, the transaction method, and the manner in which land-leasing fees are paid. Besides, tighter controls over FIOs, such as stipulations on the tax revenue to be generated by firms, are explicitly allowed and encouraged. Ever since, many local governments have implemented the corresponding reform policies. Some cities, such as Shanghai, have added all FIOs restrictions to the land-leasing contracts concluded with industrial firms and made them available to the public.

In short, although ILURs in China are quite centralized in terms of very stringent land quota and detailed capital-land regulations, local governments still have large room to use ILURs during industrial land development to fulfill their own objectives. They can not only adjust the amount of land allocated to industrial use but also impose density regulations when determining who is the winner in the land market.

1.5 Research questions

Based on the practice in China, this project examines the causes of ILURs within the context of public land supply. My first research question is related to the use of different forms of density regulations, or FIOs regulations in the research context, and contractual duration regulations by local governments in China. As I introduced in section 1.4, the central government orders local governments to implement specific types of density regulations, such as the minimum FAII and FAR. At the same time, local governments may impose regulations not required by the central government, such as minimum production capacity and minimum tax payment. Especially after having been influenced by the national reform that began in 2014, many local governments have explicitly begun to stipulate FIOs for many aspects of land use and offer shorter or longer land leasing terms for different firms. I ask why different forms of FIOs and different contractual duration are used by local governments when supplying industrial land.
Introduction

My second question is about the restriction on the amount of available industrial land. According to the community site supply theory put forward by Fischel (1974), industrial land supply is a policy tool used by local governments to trade off financial against environmental considerations. The extensive literature on this theory has empirically examined how industrial land supply is impacted by the tax scheme in place, while the role of political economy is rarely investigated. Industrial land supply in China is a good case study for this problem. On the one hand, local governments in China have great autonomy in allocating land quotas to industrial use. On the other hand, local leaders, who are also the policymakers regarding industrial land supply, have considerable career concerns and can be significantly affected by the political incentive scheme regulated by the central government. I thus ask whether and how the adjustment of industrial land supply is affected by changes in the political incentive scheme.

My third and fourth questions concern one type of density restriction, CLR regulations. CLR regulations here mainly refer to the minimum FAI per unit of land in China. Although many types of density restrictions (or FIOs restrictions) are adopted by local governments in China, only CLR regulations are used by all local governments, which allows me to quantitatively investigate the rationales behind higher or lower CLR regulations. I first focus on the relationship between CLR regulations and land price. On the one hand, local governments benefit from both industrial capital and land price and thus want a larger CLR and higher land price. On the other hand, CLR and land price can be two conflicting objectives, as more stringent CLR regulations may reduce the land price. I explore local governments’ trade-off between CLR and land price by asking whether and how the CLR regulations impact the land price. Furthermore, I pay attention to the dual role of CLR regulations, as they allocate industrial land and intervene in industrial development under regional competition by screening and attracting firms. Specifically, a higher minimum CLR may exclude unwanted firms, while a lower minimum CLR may help recruit wanted firms. It should be noted that this dual role of CLR regulations can probably be enhanced, given that CLR regulations can be imposed firm by firm in China’s case. I therefore ask whether and how CLR regulations are used as a firm-specific policy tool to intervene in industrial development. In sum, my four research questions are:

1. Why are different forms of FIOs regulations and different contractual durations used by local governments when supplying industrial land?
2. How is the adjustment of industrial land supply affected by changes in the political incentive scheme?
3. How do CLR regulations impact the land price?
4. How are CLR regulations used as a firm-specific policy tool to intervene in industrial development?
1.6 Data and methods

1.6.1 Data

In order to answer these questions, I have collected data from a variety of sources. To analyze detailed ILURs, I collected the related public law of three case regions—Shanghai city, Zhonglou district (in Changzhou city, Jiangsu Province), and Pingdu city (in Qingdao city, Shandong Province)—as well as industrial land-leasing contracts from Shanghai in 2017.

To measure the land supply area, land price, and CLR regulations, I collected parcel-level data on each transacted (2007–2018) and pre-announced (2011–2017) land parcel from the official land market website. The transaction dataset includes parcel-level information on transacted building land, such as land price, land area, land-leasing ways, land-leasing duration, the previous use of the parcel (farmland, building land, or both), its location, and its land class. The pre-announcement dataset includes parcel-level information on available building land, such as minimum FAI and FAR. By aggregating the parcel-level data, I obtained the amount of annual transacted building land for each use in each city. In addition, based on the industry-type information, I was able to obtain the amount of land supplied to each two-digit manufacturing industry, and then obtain the amount of land supplied to dirty industries according to the national survey of pollution sources in 2010 in China.

For the key independent variables used in the empirical analysis, the main data sources were the official yearbook and policy documents. I collected the emission (discharge) of industrial sulfur dioxide, industrial dust (and soot), and industrial wastewater from the China City Statistical Yearbook (2007–2017) to indicate the level of environmental quality in each municipality. In addition, I collected the national and province-level policy on restrictions on the CLR of industrial projects, which I based on the policy documents available on government websites. In total, there are 19 events of provincial policies after 2007, each of which regulated the minimum FAI and minimum value of FAR for each county under its jurisdiction. Moreover, the tax-sharing scheme data came from provincial policy documents and the official yearbook, including Financial Statistics of Cities and Counties (2006) and China Statistical Yearbook for Regional Economy (2011–2013).

The other key independent variables and control variables came from a variety of sources. The municipality and county socioeconomic datasets are from China City Statistical Yearbook and China Statistical Yearbook (County Level), covering population, urban employment, secondary industry GDP, primary industry GDP, land area, fiscal revenue, and fiscal expenditure. The land-use status data came from the China Land Survey and Planning Institute and land quota data from the general land-use plan. This dataset includes the area of the land with a slope below 15 degrees, area of developed land, and quota of developable land from 2006 to 2020. Local leaders’ personal information (including the party secretary’s and mayor’s age, education, and term of office) and air quality index (including the index and the class) came from public websites.6

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6 Local leaders’ names came mostly from http://www.hotelaah.com/, the corresponding personal information came mainly from https://ldzl.people.com.cn/dzlk/front/firstPage.htm, and the missing information was collected at https://baike.baidu.com/. The air quality index dataset came from https://www.mee.gov.cn/.
1.6.2 Methods

For each research question, I establish either an analytical framework or a theoretical model to rationalize the use of investigated regulations. Then, I present the corresponding qualitative or quantitative evidence.

To investigate the causes of restrictions on FIOs and contractual duration, I establish an analytical framework in which FIOs and contractual duration regulations are integrated into a land-leasing contract between the firm and the local government, based on the work of Cheung (2014). I theorize this contract as a share tenancy with an exogenous rental percentage and argue that FIOs and contractual duration regulations are used to minimize transaction costs. In this framework, the stringency of regulations is predicted by industrial land scarcity, redevelopment costs of stock industrial land within one region, and characteristics of the individual firm. These three factors affect the restrictions through changing transaction costs.

To characterize how the political incentive scheme impacts the industrial land supply, I build a simple one-city model based on the community site theory put forward by Fischel (1974). In my model, a municipality owns all industrial locations and has a monopoly on supplying them to external firms who possess heterogeneous technology. The city leader determines the amounts of industrial land supply to the degree that the utility from added financial benefits equals the disutility from added environmental decay in the marginal location.

To illustrate how CLR regulations impact the land price, I established a simple theory in which there exists one city and one representative firm. I show that if the government imposes a minimum CLR higher than the CLR would be in the setting without regulations, the industrial land price is supposed to be lower, but this price effect weakens as the optimal density determined by market participants grows in time.

Finally, to rationalize the use of firm-specific CLR regulations, I put forward a model to characterize how local governments use CLR regulations, the land price, and subsidies to allocate industrial land (and screen or attract firms) when faced with the tax scheme, frictions of subsidizing firms, and regional competition. My model is motivated by the survey of land supply practices of local governments in China and is closely related to the theory put forward by Cheung (2014) and Slattery (2020).

Empirically, to analyze the motivations behind restrictions on FIOs and contractual duration, I use three comparative cases to explore public law variation and 86 industrial land-leasing contracts, drawn up in Shanghai in 2017, to explore private law variation. For the latter three research questions, I implement the quantitative analysis. Specifically, I 1) identify the impact of the political incentive scheme by using the difference-in-differences (DID) design and the interaction between cadre evaluation system (CES) reform in 2013 and environmental quality level, 2) exploit province-level variation in the minimum CLR by using a DID event study design and examine land-price changes within a five-year
window around 19 province-level minimum-CLR events, and 3) test the impacts of the existing tax scheme on CLR regulations by exploring whether the sharing scheme of VAT in China affects FAII regulations.

1.7 Overview of the chapters

Chapter 2 explores the causes of using restrictions on FIOs and contractual duration. I propose an analytical framework that integrates ILURs into a land-leasing contract between the firm and the local government. This contract is theorized as a share tenancy with an exogenous rental percentage, and ILURs are used to minimize transaction costs. In this setting, the region with a higher scarcity of industrial land or higher redevelopment costs of stock industrial land is supposed to impose a shorter leasing term and tighter control of FIOs. At the same time, firms with a higher anticipated productivity will be offered a longer leasing term. These propositions are consistent with the patterns I reveal when analyzing recent regulatory policies of three cities in China and industrial land-leasing contracts in Shanghai.

Chapter 3 examines whether and how the political incentive scheme impacts industrial land supply. I establish a simple theoretical model with public landownership to guide the research. The city leader derives utility from both financial revenues and environmental amenities, and firms have to maximize the sum of fiscal revenues and land rent to compete for land. By allowing the city leader's valuation of environmental amenities to be influenced by both the political incentive for environmental protection and the level of the city's wealth and environmental amenities, I derive that an increase in the political incentive for environmental protection makes the cities that are confronted with a lower environmental quality experience a larger reduction in industrial land supply. I empirically investigate this research question by exploiting the recent CES reform in 2013 in China as a positive shock to local leaders' political incentive for environmental protection. Using the DID strategy, I document that a dirtier city experiences a significantly larger decline in industrial land supply after the reform. The results are robust to various measures of the city's pollution level and are not likely to be driven by time-varying unobservables, as shown by the falsification and placebo analysis. Besides, the heterogeneous analysis shows that the reform may have a larger impact on dirtier industries and wealthier cities, and the baseline results are mainly driven by local leaders with a stronger promotion incentive.

Chapter 4 investigates whether and to what extent a low industrial land price can be explained by tighter density regulations, based on evidence from China. I establish a simple theory to show that a binding minimum CLR leads to a lower industrial land price. I exploit province-level variation in the minimum CLR and use a DID event study design that uses the event dummy as the treatment. I examine land-price changes within a five-year window around 19 province-level minimum-CLR events and find that province-level minimum-CLR regulations do have a negative price effect in the first one and half years after the regulatory policy. The results are robust to the specifications adding controls for county-specific linear and quadratic time trends, using different event windows or continuous treatment indicators.
Chapter 5 explores how CLR regulations are used as a firm-specific policy tool to screen out or attract industrial firms. Based on institutional settings in China, I establish a theoretical model to characterize how local governments use CLR regulations, land prices, and subsidies to allocate industrial land (and screen or attract firms) when faced with the tax-sharing scheme, frictions of subsidizing firms, and regional competition. Like the existing literature, I model the bidding for firms as a private value open-outcry ascending scoring auction and provide an equilibrium in which the tax revenue incentivizes local governments to strengthen CLR regulations and the friction costs of subsidizing and the competition for mobile capital lead them to weaken CLR regulations. Using parcel-level CLR regulations from 2011 to 2018 in China, I empirically document that when county-level governments are allocated a larger share of VAT revenue, they tend to impose a larger minimum CLR on firms.
CHAPTER 2

Causes of Industrial Land-Use Regulations under the State-Owned Land System: A Share Tenancy Perspective
Abstract: Industrial land-use regulations (ILURs) are important policy instruments used by local governments in China to remedy the side effects of industrial production and protect scarce land. In recent years, this type of policy has become increasingly stringent. To explain the reasons for using them, we propose an analytical framework in which ILURs are integrated into a land-leasing contract between the firm and the local government. This contract is theorized as a share tenancy with an exogenous rental percentage, and ILURs are used to minimize transaction costs. In this setting, the region with a higher scarcity of industrial land or higher redevelopment costs of stock industrial land is supposed to impose a shorter leasing term and tighter control of firms’ inputs and outputs (FiOs); meanwhile, firms with higher anticipated productivity will be offered a longer leasing term. These propositions are consistent with the patterns we reveal by analyzing the regulatory policies of three Chinese cities around 2015 and the detailed regulations and default clauses stipulated industrial land-leasing contracts in 2017 in Shanghai.

Keywords: industrial land-use regulation; share tenancy; land scarcity; firm characteristics; state-owned land
2.1 Introduction

Land markets operate under various land-use regulations (LURs) imposed by governments (Cheshire and Hilber 2017). These regulations have become increasingly stringent over time and raised great interest in academia regarding their role in land markets. One common way to formulate the question concerning the relationship between land markets and LURs is to ask how LURs impact the land market. Researchers have found that LURs can restrict private landowners’ property rights, such as the right to adjust land use and land-use intensity, and impact the outcome of the land market (Geshkov and DeSalvo 2012, Cheshire and Hilber 2017, Hilber and Robert-Nicoud 2013). Under public landownership, however, the relationship between the land market and LURs can be more complicated: the government now becomes both a market participant and a policymaker. In this case, LURs are not necessarily imposed before the market transaction but can be part of it, and specific land-use rights that are difficult to restrict in zoning regulations for privately owned land can now be stipulated in private contracts with land users.7 This paper explores the complicated role of LURs in the land market under public landownership and particularly focuses on industrial land-use regulations (ILURs), as it seems more difficult to impose general zoning regulations in this segment.

We investigate this question based on evidence from China. The land tenure system in China regulates that urban land is state-owned, making local governments monopolistic suppliers in the primary urban land market within their jurisdictions (Ding 2003, He, Zhou, and Huang 2016). This land tenure system provides local governments with a convenient way to add detailed land-use controls to the market transaction process. As we will discuss in this paper further below, Chinese cities stipulate various firms’ inputs and outputs (FIOs) in the land-leasing contract or the attached investment agreement and adjust the contracts’ duration.8 Thus, our specific research questions investigate 1) whether and how FIOs and contractual duration regulations are used to allocate publicly owned land to industrial use; 2) to what extent these regulations vary across regions and even firms.

To explore these two questions, we propose an analytical framework in which FIOs and contractual duration regulations are integrated into a land-leasing contract between the firm and the local government, based on the work of Cheung (2014). We theorize this contract as a share tenancy with an exogenous rental percentage and argue that FIOs and contractual duration regulations are used to minimize transaction costs. In this framework, the stringency of regulations is predicted by industrial land scarcity, redevelopment costs of stock industrial land within one region, and characteristics of the individual firm. These three factors affect the FIOs and contractual duration regulations by changing transaction costs. This framework leads to three key propositions: first, controls on FIOs will be stipulated in industrial land-leasing contracts; second, a higher scarcity

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7 Private-law control can have some advantages, such as being better suited to controlling for future externality risks (Turnbull and Zahirovic-Herbert 2019).

8 Similar LURs are used in other countries. In Singapore, where urban land is mainly state-owned, firms’ R&D inputs are also stipulated to optimize industrial land allocation (Ming and Hin 2006); in Switzerland, long-term ground leases granted on municipal land are used to implement an active land policy that leads to a better allocation of land to specific projects and to a more precise control of building activity (Gerber, Nahrath, and Hartmann 2017).
CHAPTER 2

of industrial land or higher redevelopment costs of stock industrial land will lead to the imposition of shorter leasing durations and tighter controls on FIOs; third, the higher the anticipated firm productivity, the longer the land leasing duration that will be offered.

In the case studies, we distinguish between two types of ILURs: public law and private law (Ellickson 1973). Public law refers to the local government’s policies that restrict industrial land use generally, while private law refers to contractual arrangements between local governments and firms that regulate the specific land use of each parcel. We use three comparative cases to explore the variation in public law and analyze 86 industrial land-leasing contracts drawn up in Shanghai in 2017 to explore the variation in private law. We find that FIOs and contractual duration regulations are used in all case regions, but to a different extent. A region with a higher scarcity of industrial land or higher redevelopment costs of stock industrial land tends to impose more stringent FIOs and contractual duration regulations. Stringency here refers to the types of FIOs, the length of the contract, and the enforcement of these stipulations. Moreover, we show that firms with a higher anticipated productivity tend to be offered a longer leasing term, both in the local policy and the land-leasing contract analysis. We also explore how less stringent FIOs and contractual duration regulations can be caused by a larger proportion of building investment to total input or a higher elasticity of substitution between land and other production factors.

Our paper is related to two strands of literature. The first is research on the role of LURs in the land market, especially density regulations. On the one hand, this topic has been extensively explored by estimating how different density regulations impact land market outcomes. For example, the imposition of a maximum building height (or floor area ratio, hereafter FAR) can reduce the land price (Geshkov and DeSalvo 2012), limit housing supply (Barr 2016), and induce the spatial expansion of cities (Brueckner and Sridhar 2012, Geshkov and DeSalvo 2012). On the other hand, growing research has been devoted to investigating the rationale behind density regulations. For example, justifications of height limits include that they protect the urban landscape, limit interior light reduction from building-induced shadows in earlier times (Barr 2016), and reduce infrastructure costs (Brueckner and Sridhar 2012). Since it focuses on private landownership, the existing literature implies that density regulations are imposed before the land transaction. We contribute by analyzing the use of density regulations as part of the transaction process under a state-owned land system and focus on industrial land. Brueckner et al. (2017) have documented the rationale of the upper limit of building height for residential land in China as maximizing the net revenue from land development. We extend this idea to various types of FIOs regulations and contractual duration regulations in industrial land transactions and rationalize the choice for regulatory stringency that refers to the stipulation and enforcement of these regulations. We show that regulatory stringency is chosen to minimize transaction costs in a share tenancy contract.
Our study also adds to the knowledge on the accountability of business incentives in industrial recruitment to local governments. It has been found that incentive-backed industrial recruitment (including tax credits, subsidies, and free land) is sustainably popular in the US (Weber 2007). To make the granting of incentives more accountable, performance management has increasingly been used (LeRoy 2005, Weber 2002, Lindblad 2006, Zheng and Warner 2010). Specifically, local governments use contractual mechanisms to specify and enforce subsidized firms’ obligations, such as employment creation and higher tax payments (Weber 2002). For example, some local governments require subsidized firms that fail to achieve agreed-upon employment targets to pay back part of the money they received (Warner and Zheng 2011). The extent to which the granting of business incentives is subject to accountability is found to be affected by financial pressure and the organizational capacity of local governments, structural characteristics of communities, and local political processes (Lindblad 2006, Sullivan 2002). Our research contributes to this literature by offering evidence on how FIOs regulations and contractual durations are used as performance management for incentives offered to firms when the land is publicly owned. We document the specific types of FIOs stipulated in performance management under the state-owned land system and show how a financial penalty and the expropriation of land-use rights are used to make business incentives more accountable. We also explain variations in accountability stringency from a transaction costs perspective and show how stringency differs among regional and firm characteristics.

This paper is organized as follows. Section 2.2 reviews the evolution of ILURs in China. Section 2.3 provides a theoretical explanation of the use of ILURs. In section 2.4, we present the results of our case analysis. Section 2.5 briefly discusses the use of regulations under private landownership and explains the policymakers’ incentive problem. Section 2.6 concludes.

2.2 Institutional background

Local governments in China have had a monopoly on supplying newly developable land since 1982, when the Constitution regulated that urban land must be state-owned. Before the reform of urban land marketization, local governments granted land-use rights to industrial firms for free. Since 1987, the marketization of urban land supply has been gradually implemented (Zhu 1994). A set of schemes, such as the market-oriented supply method, were introduced to guarantee the transparency and competitiveness of land transactions.

For a long time, the use of contractual duration regulations in the industrial land market was not obvious. The Land Management Law decrees that the maximum leasing duration for industrial land is 50 years, and local governments rarely use a shorter term. In contrast,
the use of FIOs regulations is widely existent but quite cloudy. Restrictions on the capital-land ratio (CLR), including FAR, fixed assets investment (FAI), and a green space ratio, are used for all industrial land. However, their adoption may result from the enforcement of national policy. Local governments may spontaneously stipulate firms’ outputs, such as tax revenues. Nevertheless, neither the process of reaching an agreement on these restrictions nor the specific stipulations are transparent.12

In 2014, the central government tried to promote the industrial land market by reforming FIOs and contractual duration regulations.13 Rather than imposing mandatory policies like before, the central government aims to guide local governments on FIOs and contractual duration regulations by giving them discretion and encouraging local innovation. Specifically, the central government has increased flexibility in terms of the contractual duration, the transaction method, and the way in which land-leasing fees are paid. Besides, tighter controls on FIOs, such as stipulations of the tax revenue generated by firms, are explicitly allowed and encouraged. Ever since, many local governments have implemented the corresponding reform policies, and some cities, such as Shanghai, have added all FIOs restrictions to the land-leasing contracts signed with industrial firms and made them available to the public (Dai, Gu, and Xie 2020). Our empirical research is based on the practice of local governments after this reform.

2.3 Theoretical framework

2.3.1 Share tenancy as the essence of industrial land supply

We characterize the role of ILURs in the land market under public landownership by regarding the industrial land-leasing contract between local governments and firms as a share tenancy contract. As is well documented in the literature, firms’ decisions to relocate to a region’s jurisdiction will benefit the local government in terms of additional tax revenue (Han and Kung 2015), employment (Adams, Regibeau, and Rockett 2014), and agglomeration economy (Greenstone, Hornbeck, and Moretti 2010). Since a local government generally obtains higher benefits when a firm produces more in a fixed location, we argue that an industrial land-leasing contract can be theorized as a share tenancy contract.14 Therefore, from the local government’s perspective, the actual land rent consists of a certain percentage of output generated by firms, although the nominal rent refers to the land-leasing price only.

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12 We obtained information about restrictions on firms’ outputs by interviewing officials from the departments of natural resources in three cities: Xuchang city in Henan Province (Oct. 5, 2017), Wuxi city in Jiangsu Province (Oct. 18, 2017), and Yiwu city in Zhejiang province (Aug. 10, 2017).

13 There are two relevant policies: the Guidance Opinion of the Ministry of Land and Resources on Promoting the Economical and Intensive Utilization of Land (2014) and the Announcement on Experimental Reform of Deepening Marketization of Industrial Land Allocation (2014). This reform consists of a trial project in four prefecture cities: Fuxin city in Liaoning Province, Jiaxing city in Zhejiang Province, Wuhu city in Anhui Province, and Wuzhou city in Guangxi Province.

14 Share tenancy is defined as a land lease under which the rent is a contracted percentage of the output yielded from the tenant per time period (Cheung 1968).
We assume that the rental percentage used in industrial land tenancy is exogenous for local governments. The rental percentage of non-tax benefits, such as employment growth, is not explicitly specified by any laws or policies and is determined before the industrial land supply. For the rental percentage of tax revenues, on the other hand, fiscal decentralization in some countries may lead to an endogenous rental percentage, since local governments can adjust the tax rate related to industrial production. Therefore, our assumption applies to an institutional setting in which the industry-related tax system is highly centralized and the tax rate can usually not be freely decided by local governments and firms. In terms of China, Cheung (2014) proposes that the rental percentage between local governments and firms in China is 4.25% when regarding the industrial added value as the whole output of firms. He derives this number from multiplying the VAT rate for firms (17%) by the share of VAT obtained by local governments (25%) (Zhou 2006).

Under an exogenous rental percentage, contractual parties are supposed to adjust the ratio of the government’s inputs to FIOs in order to achieve economic efficiency (Cheung 2014). The major inputs of local governments include infrastructure investments and subsidies. For firms, the primary inputs are land-leasing fees and investments in building and equipment, and the main outputs are industrial added value, employment growth, and other externalities. All these inputs and outputs thus should be stipulated in the land-leasing contract. Consequently, the industrial land-leasing contract under an exogenous rental percentage should be characterized as 1) stipulations of government inputs, including infrastructure investments and subsidies; 2) stipulations of FIOs; and 3) land-leasing duration. In accordance with this paper’s topic, the following section in this paper will focus on the second and third types of stipulations.

### 2.3.2 Characteristics of regions and firms, transaction costs, and industrial land-use regulations

#### 2.3.2.1 Determining mechanisms of industrial land-use regulations

New institutional economics argues that contractual arrangements are chosen to minimize transaction costs (Furubotn and Richter 2010). We propose that the same economic criteria determine industrial land-leasing contracts. Industrial land-leasing contracts usually involve four types of transaction costs: rent dissipation, costs of negotiation and enforcement, costs of transferring firms’ specific assets, and costs of renegotiation. Contractual parties are supposed to determine the land-leasing duration and FIOs stipulations based on the trade-off among these transaction costs.

The problem with this logic of new institutional economics is that directly measuring and comparing these transaction costs is difficult, making it hard to explain the variation in

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15 Differently, the rental percentage in the farmland-based sharecropping tenancy is generally decided by the negotiation between landlords and tenants (Cheung 1968, Sengupta 1997).

16 It is important for the contractual parties to freely negotiate the sharing rate and stipulations on non-land inputs so as to avoid loss of economic efficiency (Cheung 1968, 2015).

17 There is an increasing literature emphasizing the role of transaction costs in land use planning (Alexander 2001, Lai, Davies, and Lorne 2016, Webster et al. 2005). Also see Hu, Lu, and Wu (2019) for the investigation into the impact of transaction costs on industrial land renewal in China.
CHAPTER 2

contractual arrangements. Considering that observable economic constraints may affect these transaction costs and determine the contractual arrangements (Furubotn and Richter 2010, Cheung 2015), the choice of contractual arrangements can be predicted and explained by measuring these observable influencing factors instead. Using this train of thought, this paper focuses on three main factors that affect transaction costs: the scarcity of available industrial land relative to firms’ demand for industrial space (measuring relative land scarcity), the redevelopment costs of stock industrial land, and firm characteristics.

We propose the following conceptual framework to illustrate ILURs’ determining mechanism under the state-owned land system (Figure 2.1). First, FIOs and contractual duration are stipulated in the share tenancy reached by local governments and firms. Second, local governments’ choice of FIOs and contractual duration is subject to land scarcity and redevelopment costs of the stock industrial land, and the corresponding regulations accepted by firms are subject to their characteristics. Finally, FIOs and contractual duration regulations are consistent with the economic principle of minimizing transaction costs.

It should be noted that local governments tend to play a leading role in determining ILURs, since they dominate the industrial land market within their jurisdictions. Local governments, however, have to accept firms’ demand for ILURs under fierce regional competition for moving capital, making it still meaningful to consider the impacts of firm characteristics.

Figure 2.1: Determining mechanism of industrial land use.

There are other factors, such as policy pressure from higher-level governments, rivals’ choice of ILURs, and the career incentive of local officers.
2.3.2.2 Transaction costs and industrial land-use regulations

This section will explain how ILURs are affected by the four types of transaction costs. To do so, we separately analyze the cost difference between more stringent and less stringent controls on FIOs and the cost difference between long-term and short-term land-lease durations.

First, more stringent control on FIOs reduces the costs of rent dissipation. From the perspective of asset ownership, failing to stipulate FIOs in share tenancy causes ambiguity when defining rights of land use (Hart 2017), and the resulting “waste” is called rent dissipation (Cheung 1970). If FIOs are stipulated less stringently, firms have an incentive to demand more land than is implied by economic efficiency at the stage of signing the contract. They tend to use the land in a less efficient manner within the contractual duration. Both these phenomena indicate more rent dissipation. More stringent controls on FIOs, which function as a more transparent definition of land-use rights, is thus used to reduce rent dissipation.

However, the negotiation and enforcement of these controls can prove prohibitively costly because of either information asymmetries or contractual incompleteness (Hart and Moore 2004). Specifically, some contingent controls are infeasible because the local government and the firm do not share the same information; even if they have symmetrical information, the costs of processing and using the information such that appropriate arrangements can be included and implemented may be so high that corresponding controls will not be stipulated in the contract. Moreover, compared with short-term controls on FIOs, long-term controls on FIOs are more costly to specify in a manner that can be enforced. Therefore, negotiation and enforcement costs induce contractual parties to stipulate fewer controls on FIOs, especially for long-term FIOs.

Second, a relatively long leasing duration is chosen to reduce the cost of transferring firms’ assets attached to land (Cheung 1969) because of the assets specificity of firms’ investments (Williamson 1979). When transferring firms’ property rights in the event of tenancy dismissal, this assets specificity may cause a dispute between local governments and firms over the value of related assets, leading to higher anticipated costs. An appropriately long leasing duration can be used to reduce these costs.

However, a longer leasing duration can only be chosen at the expense of some cost advantages that a shorter leasing duration would provide, for instance lower costs of renegotiating contractual terms (Cheung 1969). Contractual renegotiation can benefit one or all parties, because market uncertainty makes it difficult for contractual parties to agree on all eventualities when signing the contract. Nevertheless, the differential knowledge of the market and requirements to revise income distribution will make renegotiation prohibitively costly (Cheung 1969). Specifically, local governments and firms may enter into disputes concerning FIOs when market conditions change; thus, a renegotiation process aiming to improve efficiency may cause considerable transaction costs. Hence, an appropriately short leasing duration is a convenient arrangement to reduce these costs. In addition, another obvious cost advantage of using a short leasing duration is that negotiating and enforcing long-run FIOs will be unnecessary.
2.3.2.3 Regional characteristics, firm characteristics, and industrial land-use regulations

We next explain how the region and firm characteristics in the framework affect ILURs. First, land scarcity impacts both controls on FIOs and contractual duration by changing rent dissipation costs. Land scarcity here refers to the scarcity of available industrial land relative to firms’ demand for industrial space, and it indicates the level of land productivity in one region. Since land-use rights cannot be defined completely in a contract (Hart and Moore 2004), rent dissipation always exists, and its magnitude depends on the stipulation of FIOs and land productivity. Therefore, a higher land scarcity will lead to more rent dissipation with given stipulations of FIOs and contractual duration, making rent dissipation costs higher relative to costs of negotiation and enforcement and costs of transferring the firm’s specific assets. As a response to this, local governments are on the one hand supposed to impose more stringent controls on FIOs, which aim to rebalance the costs of rent dissipation and the costs of negotiation and enforcement. When it is still prohibitively costly to stipulate long-term FIOs, local governments may on the other hand choose a shorter leasing duration, resulting in a balance between the costs of rent dissipation and those of transferring the firm’s specific assets.

Second, redevelopment costs of stock industrial land can affect both controls on FIOs and contractual duration by making the potential renegotiation costs and rent dissipation more explicit for local governments. Redeveloping stock industrial land refers to a process in which local governments renegotiate FIOs with firms before the contract expires. If an agreement cannot be reached, they can terminate the existing contract and sign a new one with another firm. This redevelopment does not necessarily need to happen if the stock land is already allocated to more efficient use through the property market. Nevertheless, the market mechanism of industrial land transfer tends to not function well, thus inducing high redevelopment costs. If a new agreement on FIOs is reached and the contract is continued, these costs refer to the renegotiation costs. And if the government terminates the contract, these costs refer to the firm’s compensation, which can be regarded as another form of renegotiation costs involved in a new contract. In either case, to avoid these costs, local governments could choose a shorter leasing duration, or—if the cost of transferring firms’ assets attached to the land is significantly high and a relatively long contract has to be chosen—enforce tighter controls on long-term FIOs. Nevertheless, these costs are likely to be underestimated or even ignored. As higher redevelopment costs make these costs explicit, we expect that local governments are incentivized to choose a shorter leasing duration and impose more stringent controls on long-term FIOs.

Third, we argue that the anticipated firm productivity is supposed to affect renegotiation costs. Certain firms, such as high-tech, well-known, or large enterprises, generally do not fear losing their competitive advantage in the long run. Thus, contracting with them involves less rent dissipation in the long term and requires less effort in renegotiating FIOs. Consequently, a longer leasing duration will be chosen for firms with a higher anticipated productivity.
Causes of Industrial Land-Use Regulations under the State-Owned Land System

To summarize, our analytical framework puts forward three propositions: 1) with a state-owned land system and an exogenous rental percentage, FIOs are supposed to be regulated by local governments in the industrial land-leasing contract; 2) when land scarcity increases or redevelopment costs of stock industrial land are higher, local governments tend to increase the stringency of land-use regulations by choosing a relatively short leasing duration and tighter controls on FIOs; 3) higher anticipated firm productivity will contribute to a longer land-leasing duration.

2.4 Case studies

2.4.1 Research method

We use two types of ILURs adopted by local governments in China to test the propositions. One is public law, which stipulates general controls on ILURs via the recent reform policies, and the other is private law, which stipulates specific controls in the industrial land-leasing contract. These two analyses are literal replications but with different emphases.

The public law analysis compares three regions and is designed as a gradient control of industrial land use. The selected regions include Shanghai city, Zhonglou district (in Changzhou city, Jiangsu Province), and Pingdu city (in Qingdao city, Shandong Province), all of which issued reform policies regarding ILURs on their own initiative in around 2015. We first compare regional characteristics by using land price and industrial development stage to measure industrial land scarcity and using the ratio of stock industrial land area to built-up area to measure stock industrial land redevelopment costs. Then we explore the FIOs and contractual duration regulated in each region’s policy to test the propositions. Specifically, we test proposition 1 by comparing FIOs regulations across regions, proposition 2 by characterizing the gradient of stringency of ILURs in three regions’ policies, and finally proposition 3 by contrasting land-leasing durations across firm characteristics, indicating anticipated productivity.

Our private law analysis is based on Shanghai’s industrial land-leasing contracts and aims to examine propositions 1 and 3 particularly. Since 2014, Shanghai city has published all land-leasing contracts, including detailed contractual arrangements, and our analysis is based on the 86 industrial land-leasing contracts signed in 2017. By analyzing the common feature of FIOs regulations in 86 contracts and the detailed FIOs regulations and default clause of one typical contract, we can test proposition 1 and explore some other implications, such as the difference between controls on building and non-building investments. Moreover, by comparing these contracts’ FIOs and contractual duration regulations, we test proposition 3 and aim to uncover other implications, such as the variation in FIOs regulations across firm characteristics.


20 These contracts can be found here: http://www.shgtj.gov.cn/tdyssc/.
2.4.2 Regional comparison

2.4.2.1 Case selection

Until the end of 2017, as far as we know, 19 prefecture city governments and nine county-level governments issued independent reform policies on ILURs, besides four trial cities. Another five prefecture city governments issued policies on reducing the costs of the real economy, which are partly related to ILURs. The difference between the two types of policies is that the former focuses on ILURs while the latter emphasizes the reduction of firms’ costs only. Hence, the former policy is probably more stringent in terms of ILURs. The spatial distribution of these regions is shown in Figure 2.2. It is evident that reform areas, which adopt independent reform policies on ILURs, are mainly located in the eastern developed region.

Shanghai city, Zhonglou district, and Pingdu city are our selected cases. They launched the reform in 2014, 2015, and 2016, respectively. They were chosen because 1) they all adopted the reform policy without direct intervention from the central government; 2) Zhonglou and Pingdu are county-level regions and have actual allocation rights on industrial land, while Shanghai has accumulated experience on ILURs after revising its policy in 2016, although it is a higher-level region; 3) they are all in the eastern developed region but possess different levels of economic development. The first two reasons guarantee that the stringency of ILURs is more likely to be affected by local factors, while the third reason ensures that the level of influencing factors differs across the three cases.
2.4.2.2 Differences in industrial land scarcity and redevelopment costs across the three regions

This section evaluates the industrial land scarcity and redevelopment costs of stock industrial land in the three regions. We use the average industrial (and residential) land price and industrial development stage in each region as indicators of industrial land scarcity. Generally, a reduction in industrial land availability or an increase in firms’ demand for production space will lead to a higher degree of land scarcity and a higher industrial land price. However, it is possible that the plot-level industrial land price in China does not fully indicate land scarcity, because a higher degree of land scarcity may result in higher land-use intensity while the land price is kept constant to attract some firms. We moderate this influence by using the average land price of all industrial plots in one region to measure industrial land scarcity. We further use average residential land price as a robustness test.

Moreover, we use one region’s industrial development stage to indicate firms’ demand for industrial space. Locating in a region at a more advanced stage of industrial development is generally more advantageous for firms. We use the proportion of secondary and tertiary industry and the ratio of secondary industry to tertiary industry to evaluate a region’s industrial development stage (Thabet 2015). The region with a higher proportion of secondary and tertiary industry and a lower ratio of secondary industry to tertiary industry is in a more advanced industrial development stage.

As the three regions enacted their reform policies mostly in 2016, we use data from 2015. Table 2.1 shows that the average industrial land price and average residential land price are the lowest in Pingdu and the highest in Shanghai. Moreover, the proportion of secondary and tertiary industry is the smallest in Pingdu and the largest in Shanghai, while conversely, the ratio of secondary industry to tertiary industry is the highest in Pingdu and the lowest in Shanghai. Obviously, the ranking of industrial land price is consistent with that of the residential land price and the industrial development stage, implying that the ranking of the degree of land scarcity is reliable.

We use the ratio of stock industrial land area to built-up area to measure the costs of stock industrial land redevelopment. It has been documented that many local governments are currently forced to bear considerably large costs when trying to redevelop inefficiently used industrial land (Hu and Lu 2016). As we are limited by data availability, we cannot measure the total costs that local governments incur to redevelop all inefficiently used industrial land within their jurisdictions. Nevertheless, the area of stock industrial land could be used as an alternative indicator. This is because before this reform, the contractual duration of most industrial land leases is 50 years, and there are probably no FIOs regulations on long-run land use. Therefore, each parcel of stock industrial land can lead to local governments bearing certain costs in the end.

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21 Shanghai revised its reform policy in 2016, and our comparison will be based on the revised version.
22 The data is from the Chinese land market website: http://www.landChina.com/. We excluded low-rent housing land and public rental housing land, the land-leasing fees of which are quite low.
Due to differences in the urban areas’ sizes among the three regions, we use the ratio of stock industrial land area relative to built-up area instead. Table 2.1 shows that the ratio of stock industrial land area relative to built-up area is the lowest in Zhonglou and the highest in Shanghai.

As shown in Table 2.1, ILURs in Pingdu is subject to the lowest degree of industrial land scarcity, while that in Shanghai is subject to the highest degree of industrial land scarcity. Meanwhile, redevelopment costs of stock industrial are highest in Shanghai, while these costs are lower in Pingdu and Zhonglou. Therefore, according to proposition 2, Shanghai is supposed to adopt the most stringent ILURs, while Pingdu is supposed to adopt the least stringent ones. We will examine this in the next section.

Table 2.1: Constraints on ILURs in the three cases.

<table>
<thead>
<tr>
<th>Regions</th>
<th>The scarcity of industrial land relative to firms’ investments</th>
<th>Redevelopment costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Industrial land price (Yuan/m²)</td>
<td>Residential land price (Yuan/m²)</td>
</tr>
<tr>
<td>Pingdu</td>
<td>220</td>
<td>1292</td>
</tr>
<tr>
<td>Zhonglou</td>
<td>571</td>
<td>9319</td>
</tr>
<tr>
<td>Shanghai</td>
<td>1063</td>
<td>16009</td>
</tr>
</tbody>
</table>

Note: 1. Land price data was taken from the Chinese land market website, http://www.landChina.com/, and we excluded low-rent housing; 2. the data on redevelopment costs and industrial development stage was collected from the China Urban Construction Statistics Yearbook and China Statistical Yearbook (County Level), while the data on Zhonglou was replaced by data of the municipal districts of Changzhou; 3. the exchange rate of the US dollar to the Yuan was 6.49 on March 5, 2021.

2.4.2.3 Comparison of industrial land-use regulations in three cases

We first compare contractual duration regulations. As Table 2.2 shows, land-leasing contracts in Pingdu expire after 20, 30, 40, or 50 years, while in Zhonglou and Shanghai, contracts expire in less than 30 years (20 years in Shanghai) or less than 50 years. Looking at contract duration, it is apparent that contractual duration regulations are least stringent in Zhonglou. Additionally, the conditions that determine the contract length vary: For Pingdu, it is stated that “[c]ontractual duration should be chosen according to the industry life cycle, which is determined by the local National Development and Reform Commission, Bureau of Industry and Information Technology and Bureau of science and Technology.” In Zhonglou, the narrative is that “[c]ontractual duration of key industries, which include important investment-attracting industries, strategic emerging industries, and advanced manufacturing industries ... could be 50 years ... while that of other industries could be 30 years.” For Shanghai, the regulations are specified as: “Contractual duration of newly developed industrial projects should not be more than 20 years ... while that of state-level and prefecture-level key industrial projects and strategic emerging industry should not be more than 50 years ... and that of standard plant and research and development headquarters should not be more than 50 years.”
A comparison of the three cases shows that regulations regarding land-leasing contract length are most unambiguous and most stringent in Shanghai, while regulations in Pingdu are the least unambiguous and least stringent.

Second, we look at the stringency of controls on FIOs. Additional to FIOs regulations required by the central government, other types of FIOs are controlled to different degrees in the three cases. In Pingdu, a firm has to reach an investment agreement with the local government, which regulates the minimum tax revenue generated by firms. In Zhonglou, the policy suggests that the minimum tax revenue and employment generated by firms is best regulated in the investment agreement. Finally, in Shanghai, the land-leasing contract must stipulate FIOs, energy conservation, environmental protection, and the indigenization of employment. It is clear that Shanghai is the most stringent in terms of what types of FIOs are regulated. Zhonglou and Pingdu both apply fewer controls.

To measure the stringency of controls more accurately on FIOs in the three cases, we have analyzed contractual arrangements regarding the enforcement of FIOs stipulations. In Pingdu, a two-period lease term is adopted: “The first period is 10 years ... if the FIOs targets are not reached, land-use rights in the second period will not be granted ... land will be taken back without compensation.”

In Zhonglou, there are three ways to enforce the stipulations: “1) a two-period lease term should be adopted ... the first period should not be more than five years ... if the FIOs targets are not reached, land-use rights in the second period will not be granted ... land will be taken back without compensation ... 2) performance bonds should be charged, and they equal 5% of land-leasing fees and should not be more than 1.5 million Yuan ... 80% of performance bonds are used for the assessment of the start date, and 20% of that is used for the assessment of the completion date ... 3) if industrial land is inefficiently used ... local governments have the right to take back land through negotiation.”

Shanghai regulations are more or less similar to those of Zhonglou: “1) a two-period lease should be adopted gradually ... if the FIOs targets are not reached, land-use rights in the second period will not be granted ... 2) performance bonds can be charged and equal a certain percentage of land-leasing fees in order to limit the start date, completion date, and commissioning date ... 3) Land-use performance should be evaluated separately every 3–5 years after the commissioning date, and the previous year before contract expiration date ... if the actual FIOs are not up to the agreed target, or if the firm causes serious environmental pollution, the land will be taken back without compensation ... the indigenizing of employment can be required by county-level governments, and in case of the violation of the agreement, the land will be taken back without compensation.”

As we can see, in all three cases, two-period lease terms are used to motivate the firm to enforce the stipulated investment and tax in the first period, but the Zhonglou and Shanghai regulations are not as compulsory as those in Pingdu. Alternatively, in Zhonglou and Shanghai, performance bonds and land-use performance evaluation are adopted to
motivate the firm to enforce the stipulated FIOs. Performance bonds in both cases are used to meet the agreed project dates, which in Shanghai include the commissioning date while in Zhonglou not. Land-use performance evaluation in both regions is used to motivate the firm to enforce the stipulated FIOs in the long run. In Shanghai, it elaborately regulates the evaluation time and default clause and is thus more stringent than in Zhonglou.

Table 2.2: Land-use regulations in three case regions.

<table>
<thead>
<tr>
<th>Case region</th>
<th>Land-leasing duration</th>
<th>Stipulations of FIOs</th>
<th>Enforcement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Duration</td>
<td>Criteria</td>
<td>Types</td>
</tr>
<tr>
<td>Pingdu</td>
<td>20, 30, 40, 50 years.</td>
<td>Industry life cycle.</td>
<td>Investment;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tax.</td>
</tr>
<tr>
<td>Zhonglou</td>
<td>&lt; 30 years;</td>
<td>Important investment-attracting industries, Strategic emerging industries; Advanced manufacturing industries.</td>
<td>Investment; Tax; Employment.</td>
</tr>
<tr>
<td></td>
<td>&lt; 50 years.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shanghai</td>
<td>&lt; 20 years;</td>
<td>Key industrial project; Strategic emerging industries; Standard plant; R&amp;D headquarters.</td>
<td>Inputs; Outputs; Energy conservation; Environmental protection; Indigenizing employment.</td>
</tr>
<tr>
<td></td>
<td>&lt; 50 years.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Three conclusions can be derived from the above comparison. First, the minimum value of fixed assets investment (FAI), tax revenue, or employment is stipulated in the three cases, which supports proposition 1. Second, the industries with a higher anticipated productivity, such as important investment-attracting industries strategic emerging industries and advanced manufacturing industries, are granted longer leasing duration in Zhonglou and Shanghai, which is implied by proposition 3. Third, the three cases’ comparison shows that both FIOs and contractual duration regulations are the most stringent in Shanghai, while they are slightly more stringent in Zhonglou than in Pingdu. Therefore, the ranking of the stringency of ILURs among the three cases is the same as the ranking of industrial land scarcity and the redevelopment costs of three regions, which is consistent with our proposition 2.
2.4.3 Comparison across industrial firms in Shanghai

2.4.3.1 Typical industrial land-use regulations in Shanghai

Since 2014, Shanghai has gradually implemented the reform of ILURs. For example, the ratio of a 20-year lease to a 50-year lease has increased annually from 0.03 in 2014 to, subsequently, 0.12 (2015), 0.24 (2016), and 0.58 (2017). Instead of regulating part of FIOs in the investment agreement, which is common in most cities, Shanghai requires all FIOs regulations to be stipulated in the land-leasing contract and all land-leasing contracts to be published. Therefore, based on these released contracts, we can access every plot's detailed ILURs. Table 2.3 shows the principal ILURs specified in private law (land-leasing contracts) in 2017 in Shanghai. Two kinds of default clauses are distinguished: the financial penalty and the expropriation of land-use rights.

Table 2.3: Industrial land-use regulations in Shanghai.

<table>
<thead>
<tr>
<th>Types of land-use control</th>
<th>Penalty</th>
<th>Expropriation of land-use rights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land-leasing duration</td>
<td>Does not meet the standard after a comprehensive assessment.</td>
<td></td>
</tr>
<tr>
<td>Land-use intensity</td>
<td>Beyond the upper limit or below the lower limit.</td>
<td></td>
</tr>
<tr>
<td>Floor area ratio.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building occupation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion of green space.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed assets investment.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Office &amp; living facilities.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project schedule</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start date.</td>
<td>Delay less than a certain number of months.</td>
<td></td>
</tr>
<tr>
<td>Completion date.</td>
<td>Delay more than a certain number of months.</td>
<td></td>
</tr>
<tr>
<td>Commissioning date.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output: sales revenue, tax revenue</td>
<td>Goal not reached but still above a certain percentage of target output.</td>
<td></td>
</tr>
<tr>
<td>Comprehensive assessment</td>
<td>If not up to standard in the assessment (every certain number of years).</td>
<td></td>
</tr>
</tbody>
</table>

Note: we compiled the regulations based on 86 industrial land-leasing contracts in Shanghai in 2017.

In this section, we will examine how these controls are consistent with our theory’s implications by examining, as an example, one typical industrial land-leasing contract. This contract is between the plan and natural resources bureau of Jiading district and an automobile parts company (contract No. 19, Jiading district, 2017). This example shows the specific FIOs regulations and the corresponding default clause in detail.

We need to clarify default clauses, which can contain either a penalty or the expropriation of land-use rights. The severity of a penalty is determined in three different ways: via 1) a certain percentage of performance bonds; 2) a certain percentage of land-leasing fees, where the percentage is the same as the ratio of the gap between actual and target FIOs.

The reform in Shanghai is also called Life Cycle Management of Industrial Land, which especially emphasizes the enforcement of various regulations, see Dai, Gu, and Xie (2020) for a detailed illustration.
to target FIOs; 3) a certain percentage of the gap between actual and target FIOs. We term the above three types of penalties Penalty1, Penalty2, Penalty3 in turn. The expropriation of land-use rights is done through one method in this contract: return the land-leasing fee of the remaining contract duration and compensate the firm according to the residual value of construction, structure, and their auxiliary facilities. We term it Expropriation.

The following outlines detailed stipulations on ILURs. First, the land-leasing duration of this contract is 20 years. The firm has the right to apply for a contract extension only if a comprehensive assessment is completed. If the criterion is not fulfilled, Expropriation is adopted.

Moreover, both building and non-building investments are stipulated in the contract. The FAR is 1.92, and the upper limit of building density and lower limit of the proportion of green space must meet the technical criterion; in case of violation of this agreement, Penalty2 is adopted. The proportion of land occupied by the administrative office and living service facilities must be less than 7%, and the corresponding building area must be less than 1557.57 m². If this agreement is violated, Penalty2 is adopted (fixed percentage: 1%), and building facilities must be removed as well. If the minimum amount of FAI is not completed within one month after the completion date, Penalty2 is adopted.

Besides, the project schedule is controlled, and the firm needs to pay performance bonds, which are assigned to start date (60%), completion date (20%), and commissioning date (20%). If the start date or completion date is delayed by less than six months, Penalty1 is adopted, and the percentage is 50%; if the date is delayed by more than six months but less than one year, Penalty1 is still adopted, but the percentage is 100%; if the date is delayed by more than one year, Expropriation is adopted, the down payment is deducted, and the remaining performance bond is returned. If the commissioning date is delayed by less than six months, Penalty1 is adopted, and the percentage is 100%; if it is delayed by more than six months, Expropriation is adopted.

This contract also stipulates the output of the firm, which includes sales volume and tax revenue. The firm needs to reach the target tax revenue within the given time. If the actual tax revenue is below the criterion but above 80% of it, Penalty3 is adopted, and the percentage is 20%; if the actual tax revenue is below the criterion’s 80%, Expropriation is adopted. A comprehensive assessment, which starts from the third year after reaching the target output and takes place every three years, is also stipulated. If the actual output is not up to the criterion, Expropriation is adopted.

The detailed ILURs above help understand the nature of industrial land contracts in China as share tenancy. On the one hand, we should note that the explicit controls on FIOs—regarding building and non-building investments, project schedule,24 sales volume, and tax revenue—are implied in proposition 1. Also, it needs to be pointed out that investments in building and non-building are subject to “opposite” controls. The

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24 A project schedule is used to make sure that the firm starts production on time.
Causes of Industrial Land-Use Regulations under the State-Owned Land System

stipulations on building investments, which include a specific FAR, maximum building density, and minimum proportion of green space, aim to reduce land-use intensity, while the minimum value of FAI and tax revenue aims to increase land-use intensity. It is argued that more building investments do not always contribute to higher potential benefits generated from industrial land, while more non-building investments or tax revenue do. The other argument is that firms have the incentive to build more and then rent these properties out, which probably increases infrastructure costs but generates less tax revenue for local governments.

On the other hand, the rule of default penalties supports the idea that the ratio of the government’s inputs to FIOs is adjusted to achieve economic efficiency, which is mentioned in our analytical framework. If firms’ actual building or non-building investments cannot meet the contractual criterion, Penalty2 is adopted. If the project schedule (tax revenue) cannot meet the contractual criterion and is within certain limits, Penalty1 (Penalty3) is adopted. And then, as the contract says, the corresponding stipulation can be regarded as having been performed, and the firm can continue to possess land-use rights. These penalties—no matter whether they equal a certain percentage of performance bonds, a certain percentage of land-leasing fees, or a certain percentage of the gap between actual and target FIOs—could be regarded as adjusting the land-leasing fees and, in an indirect way, help adjust the ratio of the government’s inputs to FIOs.

2.4.3.2 Variation in land-use regulations according to firm characteristics

Next, based on our contracts database, we would like to explore how ILURs’ stringency differs with firm characteristics. First, we find that ILURs vary between four industry types. Industrial land is divided into four types in Shanghai: industrial land–industrial project (I-I) (70 contracts); industrial land–standard plant (I-S) (two contracts); R&D headquarters–industrial project (R-I) (eight contracts); R&D headquarters–generic use (R-G) (six contracts). Correspondingly, industrial firms are classified as one of the four types when applying for industrial land. After comparing their ILURs, we find the following differences, as shown in Table 2.4: 1) the leasing duration of I-S, R-I, and R-G is 50 years, while that of I-I includes both 20 and 50 years; 2) target output is not stipulated in I-S and R-G; 3) a commissioning date is not stipulated in R-G; 4) a comprehensive assessment is not stipulated in all I-S contracts and is stipulated in one of the R-I and two of the R-G contracts. It shows that the I-S and R-G contracts are subject to the least stringent controls, and the I-I contract is most tightly controlled.

The reasons for the above variations are rooted in the heterogeneous firm characteristics of the four industry types. Contrary to those of other firms, the revenues of I-S firms come from renting out the plant. Therefore, they have the incentive to contract with “standard plant” users (mostly small firms) who can afford the highest rent, and this arrangement is probably most efficient for land zoned for standard plants. Therefore, the outputs of I-S firms are relatively stable. In addition, they mainly invest in buildings, so their main

25 The restriction on the proportion of land occupied by administrative office and living service facilities and the corresponding building area may be used to prevent firms from building more for residential or commercial use.
CHAPTER 2

inputs have been stipulated in the building density. Considering these two reasons, local governments do not need to impose very tight controls on I-S firms.

As with I-S firms, building investment also accounts for a large part of inputs for R-I and R-G firms. The difference is first that R-I and R-G firms usually concern “R&D,” “high-tech,” and “headquarters,” indicating relatively high productivity in the long run. Besides, there is a relatively high elasticity of substitution between land and all other production factors, especially for R-G firms. This high elasticity leads to considerably higher land-leasing fees, which make up a large part of total inputs. Actually, the recent price regulation policy in Shanghai says,26 “the starting price of R-I land should not be lower than 150% of the benchmark price of industrial land, and that of R-G land should not be lower than 70% of the benchmark price of land for commercial use.” These three characteristics can lead to less stringent controls on long-term land use for the R-I and R-G firms.

In sum, the longer leasing terms for I-S, R-I, and R-G firms are consistent with proposition 3. Controls on FIOs tend to be less stringent when contracting with firms with a higher anticipated productivity, when building investment is considered the primary input, or when there is a high elasticity of substitution between land and other production factors.

Table 2.4: Variation of land-use regulations across industry types in Shanghai.

<table>
<thead>
<tr>
<th>Types of land-use control</th>
<th>Industrial Land–Industrial Project</th>
<th>Industrial Land–Standard Plant</th>
<th>R&amp;D Headquarters–Industrial Project</th>
<th>R&amp;D Headquarters–Generic Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 contracts</td>
<td>2 contracts</td>
<td>8 contracts</td>
<td>6 contracts</td>
<td></td>
</tr>
<tr>
<td>Land leasing duration (Years)</td>
<td>20 or 50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Project schedule: commissioning date</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Output: sales revenue, tax revenue</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Comprehensive assessment</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes (4)</td>
</tr>
</tbody>
</table>

Second, we want to offer more evidence of the variation in land-leasing contract terms within the I-I type that is due to anticipated firm productivity. We use the target tax revenue, the target tax intensity, and foreign direct investment (FDI) to indicate the anticipated firm productivity. A comparison of 70 contracts of I-I firms in all of Shanghai city shows that the average target tax revenue (3,668 million Yuan) and average target tax intensity (2,036 Yuan/m²) of 20-year contracts is far lower than those of 50-year contracts (respectively 13,301 million Yuan and 2,720 Yuan/m²). In addition, we find that all FDI contracts concern 50-year leasing terms, although they have a relatively low target tax revenue and tax intensity (6,083 million Yuan and 2,097 Yuan/m²). These results are consistent with our proposition 3.

26 In 2016, the average commercial land price of Shanghai city is 40,320 Yuan/m², while the average industrial land price is 1,436 Yuan/m². Data can be obtained online: http://www.landChina.com/.
2.5 Discussion

This section briefly discusses the use of FIOs and contractual duration regulations in two institutional arrangements that we ignored in the main analysis. The first is the private landownship system. Since tighter FIOs regulations decrease the land price, private landowners are incentivized to prevent tighter FIOs regulations from being adopted. The second is that there exists a political incentive problem for policymakers. Local officers may be motivated to place more weight on short-term benefits, which leads to less stringent regulations, especially for long-term FIOs.

These two “unfavorable” institutional arrangements induce additional transaction costs for the use of FIOs and contractual duration regulations, such as the costs of political competition between landowners and other residents and the costs of supervising and incentivizing local officers. We argue that governments may use various policy instruments to overcome these obstacles and minimize transaction costs. In countries with private ownership of land, local governments might expropriate the land from private owners in advance and supply it directly to firms (Hu, Lu, and Wu 2019), as is the practice in the Netherlands (Ploegmakers, Van Der Krabben, and Buitelaar 2013). While in countries faced with severe problems of incentives for local officers, the central government may seek to emphasize economic development equality in the official performance evaluation, as is China’s current practice. Alternatively, the direct intervention of higher-level government regarding ILURs is also a way to deal with local officers’ incentive problems; The Index of Land-Use Regulations for Industrial Projects implemented by the central government in China is an example of the latter.

Additional costs may be induced by the direct intervention of higher-level governments, since they may lack sufficient information on sub-regions’ heterogeneity. To improve economic efficiency, higher-level governments are supposed to determine the degree of direct intervention after balancing the intervention’s benefits and costs. We want to introduce the practice of Shanghai as a good example. First, although the city-level government elaborately and rigorously stipulates the types of firms that can receive only a 20-year leasing term, each district (county) is still granted specific quotas of 50-year leasing term contracts for these firms. Second, district departments (counties) have the discretion to impose restrictions on most aspects of FIOs. However, they have to accept liability for corresponding stipulations, while the city-level government—quoted from one officer—“just builds a platform for county-level governments to impose land-use regulations conveniently.”

27 Notifications on Improving the Performance Assessment of Local Party and Government Leading Groups and Leading Officers was published in 2013, to encourage local officers to pay more attention to the quality of local economic development. Since 2013, more and more regions cancel or weaken the assessment of GDP.

28 Based on an interview with officers from the Shanghai plan and land resources bureau on August 30, 2017.
2.6 Conclusions

This research contributes to the understanding of the use of ILURs. By integrating FIOs and contractual duration regulations into a share tenancy with an exogenous rental percentage, we have explored the use of ILURs under the state-owned land system. Consistent with the propositions, our case study has revealed that various types of FIOs, which mainly refer to FAI and tax revenue, are stipulated in the land-leasing contract. We have also shown the positive influence of industrial land scarcity, redevelopment costs of stock industrial land, and the anticipated productivity of firms on the stipulation and enforcement of FIOs and contractual duration regulations.

Our research in China may have some implications for developing countries. First, for other counties in the rapid economic development stage, the practice of ILURs adopted by local governments in China can provide a reference for implementing more active land-use policies. Second, the national government could increase land-use efficiency and promote local economic development by empowering local governments to determine ILURs and restrict industrial land availability. Third, direct national regulatory policies regarding ILURs should be imposed cautiously because of regional heterogeneity.
CHAPTER 3

Impacts of the Political Incentive for Environmental Protection on Industrial Land Supply: Evidence from the Cadre Evaluation System Reform in China
Abstract: This paper investigates the implications of the political incentive system reform for industrial land supply. We establish a simple theoretical model with public landownership to motivate the research, in which the city leader derives utility from both financial revenues and environmental amenities and firms have to maximize the sum of fiscal revenues and land rent to compete for land. By allowing the city leader’s valuation of environmental amenities to be influenced by both the political incentive for environmental protection and the level of the city’s wealth and environmental amenities, we derive that an increase in the political incentive for environmental protection causes the cities confronted with worse environmental quality to experience a larger reduction in industrial land supply. We empirically examine the stronger political incentive for environmental protection in China that resulted from the cadre evaluation system (CES) reform in 2013. Using the interaction of municipalities’ pre-CES environmental quality with the introduction of CES reform, we document that dirty cities experience a significantly larger decline in industrial land supply following the reform. Our results are robust to various measures of the city’s pollution level and are not likely to be driven by time-varying unobservables, as shown by the falsification and placebo analysis. Besides, the reform may have a larger impact on dirtier industries and wealthier cities, and our baseline results are mainly driven by local leaders, who are more likely to be promoted.

Keywords: industrial land-use regulation; political incentive; environmental protection; cadre evaluation system; China
3.1 Introduction

Local governments adopt land-use regulations (LURs) as one critical instrument to intervene in industrial development. Motivated by reducing the side effects of land use or promoting local economic growth, they may restrict land availability or land-use intensity through zoning or control building permits by reviewing the induced environmental impacts and economic benefits. Nevertheless, these supply-side forces of industrial land supply may go against market forces and cause an efficiency loss for the local or national economy. For example, in some US cities, the industrial land supply is so limited that local economic growth is negatively impacted (Leigh and Hoelzel 2012), while many municipalities in the Netherlands exceedingly supply parcels for industrial use, leading to inefficient land use (Van Der Krabben and Buitelaar 2011). Besides, industrial land is found to be overly supplied under regional competition for economic growth in China (Huang and Du 2016, Yang, Zhuo, and Yang 2014), leading to lower land-use efficiency in some regions (Yu, Zhou, and Yang 2019, Zheng et al. 2016).

Better evaluating the consequences of industrial land supply policies requires a deeper understanding of the underlying determinants, particularly the non-market forces. Environmental impacts on local residents are the main side effects of allowing industrial activities and can be a critical consideration in decision-making on industrial land supply. However, up until now, limited empirical research is devoted to exploring this question, and the lack of knowledge is especially pronounced in institutional settings with a state-owned land tenure system and a centralized political system, such as China. In this paper, we investigate how the adjustment of industrial land supply is affected by changes in the political incentive system. Specifically, we study the increase in local leaders’ political incentives for environmental protection, which resulted from the cadre evaluation system (CES) reform that began in 2013 in China. We analyze its differential impact on the amount of industrial land supply in more or less polluting regions.

Facilitated by the stipulation in China’s Constitution that the state must own urban land, local governments act as the real owner of urban land and supply it directly in the primary urban land market. Under this public ownership, urban land supply is an integration of LURs and market transactions. For example, the local government’s industrial land supply involves decisions on the availability of specific parcels, the intensity of land use, and the screening of unwanted firms. In this paper, we focus on the amount of industrial land supply.

In China, CES plays a vital role in the central government’s selection of local leaders under its centralized political system. It regulates the weight assigned to various objectives and thus incentivizes local leaders to achieve them. As a goal that conflicts with economic growth, environmental protection did not gain much weight in CES until

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29 Existing research mainly focuses on separating land for industrial use (especially polluting industries) from residential districts. For example, it is found that industrial properties are more likely to be located near municipal boundaries than in the interior of a suburb (Jacob and McMillen 2015).

30 This term was written into the Constitution of China in 1982.
recently. Although environmental targets in the five-year plan for economic and social development were changed from low-priority soft targets to hard and veto-level targets in 2006, the strong emphasis on the economic growth target suppressed local leaders’ incentives for environmental protection to a great degree. Since 2013, the central government has placed considerable emphasis on environmental protection in CES; in contrast, the weight assigned to the GDP growth goal has been significantly reduced. This reform began with a speech by new President Xi Jinping on June 28 and was followed by a series of related policies at the end of 2013 and in the following years. We regard this CES reform in 2013 as a positive shock to local leaders’ political incentive for environmental protection (relative to economic growth).

We build a simple one-city model to characterize the short-run industrial land supply. The model is based on the community site theory put forward by Fischel (1974), which argues that zoning land for industrial use is aimed at making a trade-off between the benefits and costs that result from allowing industrial activities and at maximizing local communities’ utilities. In our model, a municipality owns all industrial locations and has a monopoly on supplying them to external firms that possess heterogeneous technology. The city leader determines the amount of industrial land supply to the degree that in the marginal location, the utility from added financial benefits equals the disutility from added environmental decay. By allowing the city leader’s valuation of environmental amenities to be influenced by both political incentives for environmental protection and the level of the city’s wealth and environmental amenities, we derive the testable proposition that an identically positive shock to the political incentive for environmental protection makes dirty cities experience a larger reduction in industrial land supply than clean cities.

Motivated by the theoretical model, we identify the impact of the CES reform in 2013 by using the difference-in-differences (DID) design and the interaction of municipalities’ pre-CES environmental quality with the introduction of the CES reform, in which the city with worse environmental quality experiences a higher treatment intensity. Our estimation is based on a municipality-level panel dataset on land supply (2011–2017). The results indicate that after the 2013 reform, dirtier cities have experienced a significantly larger decline in the amount of industrial land supply. Specifically, cities with a double level of environmental pollution have experienced a 12.2% reduction in the amount of industrial land supply. We validate the parallel assumption by showing that there was no significant difference in industrial land supply between dirty and clean cities before the reform. We show that the baseline results are robust to various measures of pollution levels in

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31 On the one hand, industrial activities generally bring employment, fiscal gain, economic growth, and agglomeration economies (Fischel 1974, Greenstone, Hornbeck, and Moretti 2010, Bartik et al. 2019). Nevertheless, industrial activities can also induce significant negative externalities for communities (Luechinger 2014, Currie et al. 2015, Persico and Venator 2019). In China, local governments have obtained 25% of industrial value-added tax and 40% of corporate income tax since 1994. Both these shares contribute to the main local fiscal revenue. In addition, the law assigns most land-leasing revenue to local governments.

32 The argument that local governments in China do make a trade-off between economic and environmental considerations is documented by many studies, which we review in detail later. Recent evidence is an official survey on the implementation of environmental protection policies, which reports that local governments faced with higher economic downward pressure make less effort to improve environmental quality (Zhou 2020).
Impacts of the Political Incentive for Environmental Protection on Industrial Land Supply

a city. We also show that the results are not likely to be driven by the anti-corruption campaign or the entire country’s downward economy through falsification and placebo analysis. Last, the heterogeneous analysis shows that the CES reform may be having a larger impact on dirtier industries and wealthier cities, and our results are mainly driven by local leaders with stronger promotion incentives.

Our research is closely related to the literature on the causes of industrial land-use regulations (ILURs). This research has attracted growing attention recently. In a very classic study, Fischel (1974) proposed a community site theory to explain the use of the industrial land supply by arguing that through screening out unwanted firms, communities use the industrial land supply to balance economic benefits and environmental losses induced by industrial activities (Erickson and Wollover 1987, Fox 1978). Later, much empirical research has verified this theory, especially concerning the relationship between the tax system and industrial land supply. For example, Fraenkel and Krumholz (2019) find that state reforms in the US that redistribute property tax revenues disproportionately—which decreases fiscal benefits from dirty industries for some counties—significantly reduce the number of large manufacturing establishments in affected counties. Moreover, Burnes, Neumark, and White (2014) offer indirect evidence that local officials in jurisdictions with higher sales tax rates tend to make an effort to attract large stores and shopping centers rather than manufacturing. Moreover, research on China, where the related tax system is significantly different, documents the same industrial land supply effect. Xie, Zhu, and Li (2019) show that an increase in value-added tax (VAT) revenue shared by local governments leads to an increase in industrial land supply, and Han and Kung (2015) find that local governments shift their efforts from fostering industrial growth to developing the real estate and construction sectors when their share in enterprise tax revenue was reduced.

Nevertheless, the investigation into how the valuation of environmental amenities by communities influences industrial land supply is still limited. As far as we know, only Shertzer, Twinam, and Walsh (2016) explore this, looking at how the shares of Southern-born blacks or first-generation immigrants in neighborhoods positively impact the area zoned for industrial uses. We contribute to this literature by theoretically and empirically investigating how the political incentive for environmental protection, which leads to environmental amenities being valued more, impacts industrial land supply. We extend Fischel’s theory to a different institutional setting, where the land is state-owned, and highlight the impact of the political incentive for environmental protection. We offer solid evidence by documenting that in a centralized political system, the CES’s higher valuation of environmental amenities leads to a decline in industrial land supply.

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33 Recently, a growing literature also tries to explain the causes of residential land-use regulations, such as rent-seeking of the landowner (Hilber and Robert-Nicoud 2013) or institutional fragmentation (Cappelli, Guastella, and Pareglio 2020).

34 The impact of political incentives or residents’ preference for other land uses has gained a lot of attention. For example, Cheshire and Hilber (2008) find that the regulatory tax on commercial land use varies according to local prosperity, and the responsiveness of the regulatory tax to local prosperity depends on whether an area is controlled by business interests or residents. Ahfeldt et al. (2017) document that residents’ preference for heritage impacts the zoning of conservation areas, and Solé-Ollé and Viladecans-Marsal (2013) show that citizen-voters’ preference for growth affects the amount of newly developed land through impacting the party in office.
Our research also adds to the knowledge on how local leaders’ political incentives affect environmental quality in China. On the one hand, this literature finds that local leaders’ career concerns motivate them to promote economic growth at the cost of increasing pollution. For instance, the pollution discharge increases significantly in the period before the Provincial Communist Party Congress, which is a result of local leaders’ strong political incentives to pursue short-term economic performance before congresses (Tian and Tian 2020). The pollution discharge can also increase if the newly appointed official is locally promoted, normally transferred, or transferred at a higher frequency (Deng, Wu, and Xu 2019). Besides, gaining political connections with key officials in the central government also increases pollution, since connections affect promotion incentives by increasing the marginal returns of pollution (Jia 2017). On the other hand, researchers have documented that the increased weight of environmental protection in the CES motivates local leaders to improve the local environment by sacrificing economic growth. For example, after the central government adds sulfur dioxide (SO₂) and chemical oxygen demand (COD) emissions reduction into the main performance evaluation criterion in 2006, it is documented that SO₂ emissions and the GDP growth rate experience a pronounced reduction (Chen, Li, and Lu 2018), and COD at the province boundaries also decreases significantly (Kahn, Li, and Zhao 2015).35

Our research adds the evidence that the political incentive can motivate local leaders to trade economic growth for environmental quality by using the recent CES reform in China and documents that the restriction on industrial land supply is a vital channel through which the political incentive promotes environmental improvement.36 The use of land supply tools is also implied by Kahn, Li, and Zhao (2015), who find that the decrease in COD at the province boundaries is possibly caused by locating COD-intensive industries far away from rivers. Unlike Kahn, Li, and Zhao (2015), our results suggest that incentivized local leaders use land supply to intervene in the number of newly established firms and screen out unwanted dirty industries.

This paper is structured as follows. Section 3.2 introduces industrial land supply and CES in China. In section 3.3, we establish a theoretical framework on industrial land supply. Then we present the data and empirical strategy in section 3.4. The empirical results are shown in section 3.5. Section 3.6 concludes.

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35 It is also found in the paper of Kahn, Li, and Zhao (2015) that water pollutants such as petroleum, mercury, and phenol do not significantly reduce at boundaries. None of these pollutants are in the objective performance criteria, although they are more harmful to public health.

36 The use of the other policy tool is also documented in recent research, for example, when facing higher pollutant emission reduction pressure, a local leader lowers their economic growth target (Zhang 2020) and suppresses production by the regulated firms while promoting production by unregulated firms (Bo 2020).
3.2 Industrial land supply and the cadre evaluation system in China

3.2.1 Land-use planning system and the primary industrial land market

China’s industrial land supply is constrained by a top-down land-use planning system established by the central government. Specifically, the planning system determines the long-run and annual newly developable land in each sub-national region via a strict land quota system, which restricts the amount of rural-urban land conversion through the general and annual land-use plan in order to assure China’s national food security. Nevertheless, local governments still enjoy substantial autonomy in allocating quota to different land uses. Therefore, restrictions on how much land is available for industrial use are greatly affected by local interests.

The land tenure system in China regulates that the state must own urban land. The practice of realizing this state ownership is that local governments first expropriate the land from farmers or the rural collective and then transfer specific years of land-use rights to land users after servicing the land. This practice means that the local government has a monopoly on supplying newly developed urban land within its jurisdiction and acts as the real owner of urban land by supplying it directly in the primary urban land market. Given that local governments are also decision-makers regarding land-use policies, the process of urban land supply in China is actually the integration of LURs and market transactions. Under the regulatory policies on the urban land market imposed by the central government—such as the procedures to guarantee the transparency and competitiveness of land transactions (including the mandatory use of English auction or two-stage bidding when supplying industrial land)—a typical local government follows three steps to supply industrial land. First, it announces the supply of available parcel(s) for industrial use on the land market website, stipulating the area, location, minimum land price, and regulations on floor area ratio (FAR) and fixed assets investment (FAI). The next step, also the most important and complicated one, is that the local government selects those with a demand for land according to type of industry, investment density, environmental impact, land price, and other benefits and costs brought by firms. Finally, the government releases the information on winners and parcels, again on the land market website.

We can understand how the industrial land market in China works by clarifying what local governments do in the second step. Specifically, they first select some candidates after evaluating the firm’s characteristics (not including the land price offered by the firm). This evaluation involves not only the crucial departments—such as the development and reform commission, ecology and environment bureau, and the planning and natural...
resources bureau—but also an economic (industrial) development office led by local leaders. Next, local governments determine the winner according to the land price bidding organized by the land department (also the planning and natural resources bureau). The complexity of this selection process derives from the fact that competition among firms in the land price bidding procedure rarely exists, no matter whether the English auction or two-stage bidding is used by the local government. This fact implies that the local government has probably determined the winner by evaluating the firm, which involves many departments before the land price bidding procedure. This conjecture shows a distinctively different land market and helps us develop a simple but reliable theory to characterize industrial land supply in China.

3.2.2 Cadre evaluation system

China’s political system is distinguished by highly centralized personnel controls at the national level (Xu 2011). As a vital instrument of implementing this personnel management, CES plays a significant role in determining whether local officers are eligible for promotion and thus influences local officers’ incentives when they are making policies. For example, the enormous weight assigned to GDP growth in cadre evaluation has been documented to contribute significantly to explaining regional competition in economic development (Li and Zhou 2005).

Besides promoting economic growth, CES has also been used in recent years to tackle the pollution problem (Wang 2013, Zheng and Kahn 2017). For example, the environmental targets in the five-year plan for economic and social development were changed from low-priority soft targets to hard and veto-level targets in 2006, which meant a dramatic elevation of environmental considerations in cadre evaluation. However, it should be noted that the central government still considerably emphasized economic growth, and thus meeting the economic growth target remained the most crucial determinant of promoting local leaders. This priority of economic growth suppressed the environmental incentive of local leaders to some degree.

Since 2013, a significantly greater emphasis has been placed on environmental protection in cadre evaluation by the central government. The start of this reform was signaled during the National Organization Work Conference on June 28, when new president Xi Jinping required that the CES be improved to take people’s livelihood, social progress, and ecological protection as important criteria instead of using the single GDP growth

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43 This is supported by all the interviews with local officials. Besides, research on China documenting the use of land price as a type of subsidy (Xu, Huang, and Jiang 2017, Zhang et al. 2017) also supports this conjecture, since now the land price is difficult to be used as the market criterion.

44 This is different from cases in most Western countries, where the promotion of local leaders is determined by the electorate.

45 In 2004, a “green GDP” system was established to incorporate environmental costs into GDP calculations and thus motivate local leaders to consider environmental decay when making local economic policy. This system was ultimately not implemented and has currently ended because of “technical uncertainties,” according to the authorities.
indicator. Later, on December 6, a formal policy was issued in which the promotion criteria of local leaders were adjusted to place more weight on local environmental protection and less weight on economic growth. In the following years, a series of policies was announced to implement this reform. In August 2015, a trial policy on local cadres’ responsibility for environmental protection was issued, making it clear that local cadres must be responsible for local environmental pollution induced by their decision-making. Moreover, at the end of 2015, a national environmental protection supervision committee was established to enforce the environmental priority reform, leading many local officials to be held accountable for local environmental decay. In the empirical section, we use this reform of cadre performance evaluation in 2013 as the exogenous shock to the political incentive for environmental protection.

3.3 Motivating theory

We build a simple one-city model to characterize short-run industrial land supply and motivate our empirical research. The basic idea is that, since allowing industrial firms to locate in the city brings both financial revenues and environmental decay, the city leader acts as a social planner and aims to maximize the city’s utility from these benefits and losses using the industrial land supply as a policy instrument. Nevertheless, how the city leader values environmental amenities is influenced by the political incentive scheme, such as promotion criteria of city leaders in a centralized political system. Therefore, if the political incentive for environmental protection is larger, the city leader tends to supply less industrial land. Besides, if cities differ in environmental quality, the same political incentive scheme reform will induce a differential impact on industrial land supply. The formal model is as follows.

Consider a linear city including a continuum of locations whose urban boundary is in location $x = 0$. Beyond location $0$ is the land used for agriculture before allowing industrial firms to locate there, with a fixed agricultural land rent $c$. Industrial production requires capital and land. The production function at location $x$ is $A(x)f(K(x), H(x))$, where $A(x)$ denotes technology, $K(x)$ the amount of industrial capital employed, and $H(x)$ the amount of land. We assume the return to scale is constant and $f(\cdot)$ is strictly increasing and strictly concave in land and industrial capital. We also assume that in each location, the land area is one, so $H(x) = 1$ for all locations, then the production function at location $x$ is $A(x)f(K(x), 1)$.

Firms own the industrial capital and invest as much as they want under the constraint of a constant capital cost $i$, which is determined outside the city. We assume firms are

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47 Notice on Improving the Performance Assessment of Local Party and Government Leading Groups and Leading Cadres.
48 Measures for the Accountability of Party and Government Leading Cadres for Environmental Damage (Trial Implementation), issued on August 9, 2015.
49 For example, up until July 2017, the environmental protection supervision had covered 23 provinces; 11,390 local officials or owners of enterprises were held accountable for environmental pollution. See http://www.nbd.com.cn/articles/2017-07-17/1128791.html.
50 Or the voter’s preference if the city is an elected government.
endowed with heterogeneous technologies, and for the sake of simplicity, we assume that a more advanced technology indicates not only a higher output but also a smaller extent of environmental decay. Thus, the environmental impact function at location \( x \) can be written as \(- B(A(x)) p(K(x), 1)\), with \( \frac{\partial B(A(x))}{\partial A(x)} < 0 \).

We assume a tax scheme that taxes land rent using a fixed percentage; therefore, the tax scheme does not impact the industrial capital input.\(^{51}\) If the city land is privately owned, the government gains only the tax revenue, which equals a certain percentage of land rent generated by firms' locating. In the state-owned land system, on the other hand, the government gains both tax revenue and the rest of the land rent, which equals the total land rent.\(^{52}\) In the following analysis, we consider the situation that the city government is the landowner, but our conclusion applies to a situation in which land is privately owned.

As the landowner, the city government supplies the land from location \( x = 0 \) to the farther location in the city in turn. In each supplied location, the city government gains financial revenues \( g(x) = A(x) f(K(x)) - iK(x) - c \) and bears a decrease in environmental amenity \( e(x) = -B(A(x)) p(K(x)) \). And we assume that the city government, also the land supplier in our setting, values both financial revenues and environmental amenities. That is, the city government's utility increases with tax revenue and land price, while it decreases with environmental decay.

Under the above assumptions, the functioning of the industrial land market in our model is quite complicated. In a typical land market, the government first imposes various LURs, and then the firms bidding the highest land price are the winner and can be granted land-use rights. While in our industrial land market, the city government aims to allocate the land to the firm that brings the highest increase in the government's welfare in terms of both financial revenues and environmental amenities. Regulatory policies may be decided before the land transaction, just as in the typical land market, and may also be determined or adjusted during the land transaction in the form of parcel-level policies, such as performance management (Weber 2002, Zheng and Warner 2010), industry type review, and environmental review or LURs. To put it another way, the land price is not the only competition criterion in our industrial land market; firms' performances also play a significant role and are possibly even more critical. These competition criteria enable firms with more advanced technology to obtain a location preferentially during firms' competition for land, since they can bring more financial revenues and cause less environmental decay. As a result, technology, financial revenues, and environmental decay in specific locations decrease with the distance of this location to the urban boundary, which is \( \frac{\partial A(x)}{\partial x} < 0 \), \( \frac{\partial g(x)}{\partial x} < 0 \), and \( \frac{\partial e(x)}{\partial x} < 0 \).

\(^{51}\) Taxing pure land rent is rationalized in Henry George theorem as the efficient level of public expenditures the optimal population should be financed entirely with a 100% tax on land rents (George 2006). In China, taxing industrial added value could be theorized as collecting land rent from the perspective of landowners (local governments) (Cheung 2014). In some other countries, the property tax system is taxing land and building together (Lee 2019) and is thus close to the arrangement of taxing land rent.

\(^{52}\) The latter case is same as the situation that there exists no tax scheme while the land is state-owned.
Moreover, we need to model how environmental amenities are valued. We focus on two types of factors. The first is the political incentive scheme that impacts how local officials value environmental amenities. The other is the extent of the city’s wealth and environmental amenities. Research based on many Western countries argues that the city’s demand for environmental amenities increases with wealth. Similarly, recent studies on China find that environmental regulations become more stringent in relatively developed cities (Zheng and Kahn 2017, Zheng et al. 2014), implying that environmental amenity is increasingly valued. Therefore, we use the following objective function of the local leaders:

\[
U = \left[ G + \int_0^D g(x) \right]^\mu \left[ E + \int_0^D e(x) \right]^\nu
\]  

(3-1)

Here \( G \) and \( E \) refer to the financial revenues and environmental amenities before supplying industrial land in this city, which is consistent with the setting that we focus on short-run industrial land supply. The parameters \( \mu \) and \( \nu \) indicate the elasticity of the city leader’s utility to financial revenues and environmental amenities in turn. We use them to measure the relative importance of financial revenues and environmental amenities in the political incentive scheme. As discussed above, they affect the city’s valuation of environmental amenities and are exogenous to the city’s existing environmental amenities and financial revenues. We let \( 1 > \mu > 0 \) and \( 1 > \nu > 0 \), which means that the utility increases with financial revenues and environmental amenities at a decreasing rate.

The city government needs to determine how much industrial land is supplied from the boundary to location \( D \) to achieve the desired balance between financial and environmental objectives. We can solve the equilibrium level of industrial land supply \( D^* \) by setting the marginal utility from supplying \( D^* \) to zero. The equilibrium level of industrial land supply is:

\[
\frac{g(D^*)}{e(D^*)} = \frac{\nu}{\mu} \frac{G + \int_0^{D^*} g(x)}{E + \int_0^{D^*} e(x)}
\]  

(3-2)

We can derive that \( \frac{\partial D^*}{\partial (\nu/\mu)} < 0 \) and \( \frac{\partial^2 D^*}{\partial (\nu/\mu) \partial E} > 0 \) (see A1 in Appendix for the process). The implication is that when the political incentive scheme increases the weight assigned to environmental protection (relative to financial revenues), the newly supplied industrial land will be less in the short run. Moreover, the negative land supply effect caused by the stronger political incentive for environmental protection can be larger if the city is more polluting. The intuition behind this relationship is that an identically positive shock to the political incentive for environmental protection can induce a larger increase in the valuation of environmental amenities if this city is dirtier, as is shown in the equation:

\[
\frac{\partial U}{\partial (\mu + \int_0^D e(x))} = \frac{\nu \times (G + \int_0^D e(x))}{\mu \times (G + \int_0^D g(x))}
\]

\[
\frac{\partial^2 U}{\partial (\mu + \int_0^D g(x)) \partial (\nu + \int_0^D e(x))} = \frac{\mu \times (G + \int_0^D g(x))}{\nu \times (G + \int_0^D e(x))}
\]

See (Li et al. 2019), using a parameter in the central government’s utility function to indicate the importance of economic growth in its preference.
The testable implication is:

**Hypothesis:** The switch to a political incentive scheme that assigns relatively more weight to environmental protection motivates city leaders to reduce industrial land supply, and this effect is stronger for the city with worse environmental quality.

### 3.4 Data and empirical strategy

#### 3.4.1 Data

We compiled five sources of datasets for the analysis. First is the land supply dataset from China’s land market website, https://www.landchina.com/. This is the official website for building land transactions in China. Since 2007, it has started to cover all transacted building land parcels in the primary land market. This dataset includes rich parcel-level information, such as land use, area, price, land user, and industry type, and is increasingly used in the literature (Chen and Kung 2019, Wang and Yang 2021). By aggregating the parcel-level data, we obtained the amount of annual transacted building land for each use in each city. In addition, based on the industry-type information, we were able to obtain the amount of land supplied to each two-digit manufacturing industry and then obtain the amount of land supplied to dirty industries according to the national survey of pollution sources in China in 2010. Specifically, the SO$_2$-intensive industries refer to six two-digit industries and account for 88.5% of industrial SO$_2$ emissions. The dust(soot)-intensive industries refer to eight two-digit industries and account for 69.6% of industrial dust emission and 83.4% of industrial soot emission. The water-intensive industries refer to 16 two-digit industries and account for 81.1% of COD discharge, 85.9% of ammonia nitrogen discharge, 78.8% of petroleum discharge, and 96.5% of volatile phenol discharge. See detailed industry types in Table 3.1.

The second dataset source is the municipality’s statistical dataset from the China City Statistical Yearbook. It covers the city’s socioeconomic data and emission (discharge) of industrial sulfur dioxide, industrial dust (and soot), and industrial wastewater. Third, we collected the land-use status data from the China Land Survey and Planning Institute and land quota data from the general land-use plan. This dataset includes the area of the land with a slope below 15 degrees, area of developed land, and quota of developable land from 2006 to 2020. The fourth and fifth datasets are local leaders’ personal information (including the party secretary’s and mayor’s age, education, and term of office) and the air quality index (including the index and the class), which we collected from the public website.

We finally obtained a balanced panel of 272 municipalities, in which the area of the land with a slope below 15 degrees and the quota for developable land from 2006 to 2020 are constant across the periods. The summary statistics of each variable are shown in Table 3.2.

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54 We define the dirty industries according to the Regulation on the National General Survey of Pollution Sources (2010).

55 The local leaders’ names are mainly from http://www.hotelaah.com/, the corresponding personal information is mainly from https://ldzl.people.com.cn/dzlk/front/firstPage.htm, and the missing information is collected from https://baike.baidu.com/. The air quality index dataset is from https://www.mee.gov.cn/.
### Table 3.1: Pollution discharge by selected dirty industries.

<table>
<thead>
<tr>
<th>Two-digit industry</th>
<th>SO\textsubscript{2}</th>
<th>Soot (dust)</th>
<th>Wastewater</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mining and washing of coal (06)</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Processing of food from agricultural products (13)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Manufacture of foods (14)</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Manufacture of alcohol, beverages, and refined tea (15)</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Manufacture of textiles (17)</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Manufacture of leather, fur, feather, and related products; footwear industry (19)</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Processing of timber, manufacture of wood, bamboo, rattan, palm, and straw products (20)</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Manufacture of paper and paper products (22)</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Processing of petroleum, coking, processing of nuclear fuel (25)</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Manufacture of chemical raw materials and chemical products (26)</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Manufacture of medicines (27)</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Manufacture of non-metallic mineral products (30)</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Smelting and processing of ferrous metals (31)</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Smelting and processing of non-ferrous metals (32)</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Manufacture of metal products (33)</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Manufacture of general-purpose machinery (34)</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Manufacture of railway, ships, aerospace, and other transportation equipment (37)</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Production and supply of electric power and heat (44)</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

**Percentage of total discharge explained by selected industries (%)**

|                          | 88.50 | 83.40 | 69.60 | 81.10 | 85.90 | 78.80 | 96.50 |

**Notes:** We compiled the table according to the *Regulation on the National General Survey of Pollution Sources* (2010). The two-digit industry classification is based on the *Industrial Classification for National Economic Activities* (GB/T 4754—2011), and the code is shown in parentheses.
Table 3.2: Summary statistics.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Municipality characteristics (2010–2017)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population (10^4)</td>
<td>4352</td>
<td>448.46</td>
<td>316.21</td>
<td>19.5</td>
<td>3392</td>
</tr>
<tr>
<td>Land area (100 sq. km)</td>
<td>4352</td>
<td>167.75</td>
<td>222.03</td>
<td>11.13</td>
<td>2533.56</td>
</tr>
<tr>
<td>GDP (10^9 Yuan)</td>
<td>4352</td>
<td>221.24</td>
<td>293.65</td>
<td>10.4</td>
<td>2817.86</td>
</tr>
<tr>
<td>Percentage of primary GDP</td>
<td>4352</td>
<td>12.73</td>
<td>7.8</td>
<td>0.03</td>
<td>49.89</td>
</tr>
<tr>
<td>Percentage of secondary GDP</td>
<td>4352</td>
<td>49.19</td>
<td>9.93</td>
<td>14.95</td>
<td>82.24</td>
</tr>
<tr>
<td>General budget revenue (10^9 Yuan)</td>
<td>4352</td>
<td>20.6</td>
<td>45.57</td>
<td>0.53</td>
<td>664.23</td>
</tr>
<tr>
<td>General budget expenditure (10^9 Yuan)</td>
<td>4352</td>
<td>573.74</td>
<td>869.05</td>
<td>50.1</td>
<td>9868.7</td>
</tr>
<tr>
<td>Employment in urban unit (10^3)</td>
<td>4352</td>
<td>108.51</td>
<td>126.78</td>
<td>0.83</td>
<td>1737.12</td>
</tr>
<tr>
<td>Average fixed assets of enterprises above designated size (10^9 Yuan)</td>
<td>4352</td>
<td>9.92</td>
<td>13.37</td>
<td>0.02</td>
<td>160.7</td>
</tr>
<tr>
<td>Output value of enterprises above designated size (10^9 Yuan)</td>
<td>4352</td>
<td>342.79</td>
<td>445.65</td>
<td>1.53</td>
<td>3244.51</td>
</tr>
<tr>
<td>Value-added tax payable by enterprises above designated size (10^9 Yuan)</td>
<td>4352</td>
<td>47.08</td>
<td>14.38</td>
<td>13.82</td>
<td>134.99</td>
</tr>
<tr>
<td>Percentage of land with a slope below 15 degrees</td>
<td>4352</td>
<td>0.71</td>
<td>0.21</td>
<td>0.18</td>
<td>1</td>
</tr>
<tr>
<td>Building land of city and town (sq. km)</td>
<td>4352</td>
<td>283.91</td>
<td>253.89</td>
<td>39.1</td>
<td>2082.97</td>
</tr>
<tr>
<td>Newly developed land since 2007 (sq. km)</td>
<td>4352</td>
<td>93.96</td>
<td>89.84</td>
<td>1.12</td>
<td>1125.24</td>
</tr>
<tr>
<td>Newly developed land since 2011 (sq. km)</td>
<td>4352</td>
<td>57.71</td>
<td>63.18</td>
<td>0</td>
<td>825.23</td>
</tr>
<tr>
<td>Quota for developable land from 2006 to 2020 (sq. km)</td>
<td>4352</td>
<td>104.47</td>
<td>125.37</td>
<td>31.43</td>
<td>1353.28</td>
</tr>
<tr>
<td>Municipal-average air quality index</td>
<td>4352</td>
<td>41.49</td>
<td>46.92</td>
<td>0.01</td>
<td>256.37</td>
</tr>
<tr>
<td>Ratio of days with lower air quality (Class &lt;= 5)</td>
<td>4352</td>
<td>0.02</td>
<td>0.05</td>
<td>0</td>
<td>0.51</td>
</tr>
<tr>
<td>Discharged industrial wastewater (10^6 metric tons)</td>
<td>4352</td>
<td>67.45</td>
<td>79.02</td>
<td>0.52</td>
<td>868.04</td>
</tr>
<tr>
<td>Emission of industrial SO_2 (10^3 metric tons)</td>
<td>4352</td>
<td>49.57</td>
<td>64</td>
<td>0.29</td>
<td>1869.25</td>
</tr>
<tr>
<td>Emission of industrial dust (soot) (10^3 metric tons)</td>
<td>4352</td>
<td>36.2</td>
<td>145.75</td>
<td>0.45</td>
<td>5168.81</td>
</tr>
<tr>
<td><strong>Municipal leaders (2010–2017)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secretary's age</td>
<td>4352</td>
<td>53.12</td>
<td>3.47</td>
<td>42</td>
<td>66</td>
</tr>
<tr>
<td>Secretary's education (1 = doctoral degree)</td>
<td>4352</td>
<td>0.28</td>
<td>0.45</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Secretary's term of office</td>
<td>4352</td>
<td>2.62</td>
<td>1.58</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Mayor's age</td>
<td>4352</td>
<td>50.88</td>
<td>3.71</td>
<td>37</td>
<td>62</td>
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<tr>
<td>Mayor's education (1 = doctoral degree)</td>
<td>4352</td>
<td>0.26</td>
<td>0.44</td>
<td>0</td>
<td>1</td>
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<tr>
<td>Mayor's term of office</td>
<td>4352</td>
<td>2.41</td>
<td>1.41</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td><strong>Land supply (2011–2017) (hectare)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of industrial land supply</td>
<td>3808</td>
<td>239.51</td>
<td>243.29</td>
<td>0</td>
<td>3319.72</td>
</tr>
<tr>
<td>Amount of residential land supply</td>
<td>3808</td>
<td>176.41</td>
<td>197.13</td>
<td>0</td>
<td>2812.68</td>
</tr>
<tr>
<td>Amount of commercial land supply</td>
<td>3808</td>
<td>85.21</td>
<td>77.74</td>
<td>0</td>
<td>823.56</td>
</tr>
<tr>
<td>Amount of land supplied to manufacturing firms</td>
<td>3808</td>
<td>155.39</td>
<td>174.01</td>
<td>0</td>
<td>2825.1</td>
</tr>
<tr>
<td>Amount of land supplied to dirty firms</td>
<td>3808</td>
<td>102.86</td>
<td>122.66</td>
<td>0</td>
<td>2242.63</td>
</tr>
<tr>
<td>Amount of land supplied to dirty firms (water)</td>
<td>3808</td>
<td>87.45</td>
<td>114.74</td>
<td>0</td>
<td>2128.74</td>
</tr>
<tr>
<td>Amount of land supplied to dirty firms (SO_2)</td>
<td>3808</td>
<td>29.9</td>
<td>56.95</td>
<td>0</td>
<td>1460.43</td>
</tr>
<tr>
<td>Amount of land supplied to dirty firms (dust)</td>
<td>3808</td>
<td>42.7</td>
<td>63.26</td>
<td>0</td>
<td>1589</td>
</tr>
</tbody>
</table>
3.4.2 Empirical strategy
We use the CES reform starting in June 2013 as a treatment for industrial land supply. This reform was implemented after a new administration took office, making it reasonable to accept that the CES reform caused an exogenous shock to local governments’ political incentives for environmental protection. Although this reform was uniformly applied to all cities in China, we can measure the differential treatment intensity according to our theoretical model; that is, cities with worse environmental quality are impacted more heavily by the reform. Therefore, we can use the following DID design as the baseline model to identify the impact of the June 2013 CES reform on industrial land supply:
\[
\ln Y_{it} = \theta \ln P_t \times 1(\tau \geq 2014h1) + \beta_1 \ln X_{i(t-1)} + \beta_2 \ln X_{i(t-1)} \times \alpha_t + \delta_{pro} \times u_t + u_t + \alpha_t + \epsilon_{it}
\]
(3-3),

where subscripts \( i, t \) index municipality-level cities and time (six months), respectively. The dependent variable, \( \ln Y_{it} \), is the (log) amount of industrial land supply from 2011 to 2017 in a city, derived from the aggregation of parcel volume in the land transaction dataset. We also used the amounts of land supply for other uses to exercise robustness tests.

\( P_t \) refers to the level of environmental pollution in city \( i \). The key and difficult question is how to measure \( P_t \) empirically, given that environmental pollution is related to a variety of pollutants and changes with time. In this baseline model, we calculate the two-year average pollution level for each pollutant based on the emission (or discharge) volume per resident of three types of pollutants in 2013 and 2012, which are industrial sulfur dioxide, industrial dust (and soot), and industrial wastewater. Since the unit of three measures is different, we first obtain a comparable value for each measure by dividing the mean value of all cities in each year, and then we calculate the mean of the comparable value of each measure to get a pollution level for each city. We also try several alternative ways to calculate the pollution level in the robustness section (3.5.2).

\( 1(\tau \geq 2014h1) \) is a dummy that equals 1 if time \( t \) is in and after the first half of 2014. The treatment period lags six months behind the first informal speech of President Xi in June 2013, consistent with the fact that the land transaction process may last several months. The interaction term and also treatment measure \( \ln P_t \times 1(\tau \geq 2014h1) \) indicates the differential treatment intensity for cities with different environmental amenity levels. We expect the sign of \( \theta \) to be negative, which implies that cities facing more serious environmental pollution tend to supply less industrial land.

---

56 Yao et al. (2020) also find that after 2013, the difference in GDP growth between municipalities with promoted and unpromoted leaders has decreased significantly, suggesting that GDP growth has been assigned significantly less weight after 2013. Therefore, the relative weight of environmental quality significantly increased.

57 The calculation process could be expressed as \( P_t = (P_{tSO_2} + P_{tDUST} + P_{tWATER}) / \beta, \) where \( P_{tSO_2}, P_{tDUST}, \) and \( P_{tWATER} \) indicate the actual emission of sulfur dioxide, industrial dust, and industrial wastewater, and \( P_{tSO_2}, P_{tDUST}, \) and \( P_{tWATER} \) indicate the average emission of sulfur dioxide, industrial dust, and industrial wastewater for all sample cities.

58 Although it takes only about a month and a half from announcing that land is available for bidding to announcing the winner on the land market website, we have learned that before this public transaction, there is an uncertain period during which the local government selects firms and negotiates about inputs and outputs, according to my interviews in Xuchang city in Henan Province (Oct. 5, 2017), Wuxi city in Jiangsu Province (Oct. 18, 2017). The interviews include Yiwu city in Zhejiang Province (Aug. 10, 2017).
\( X_{i(t-1)} \) is a group of control variables. They contain population, jurisdiction area, GDP, percentage of secondary- and primary-industry GDP, general budget revenue and expenditure, average wage, urban employment, index of enterprises above designated size (including the output value, average fixed assets, and VAT payable), percentage of the land area below 15 degrees, building land of city and town, area of newly developed land since 2007 and 2011, quotas of developable land from 2006 to 2020, party secretary's and mayor's age, education and term of office, municipal-average air quality index, and the percentage of days with an air quality class in and above 5 (class 6 is the worst air quality).

Since we are using the time change as the treatment, our estimation can be biased if the CES reform or other events impact industrial land supply through the channels correlated with environmental pollution. Therefore, we try our best to control for the time-varying unobservables. First, we allow the impact of all control variables to vary with the period dummy, \( u_t \), to control for other possible channels through which the CES reform may impact industrial land supply, such as the economic development stage, fiscal condition, and land availability. Furthermore, we use the province-period fixed effect, indicated by \( \delta_{pro} \times u_t \), to control for all time-varying unobservables that occurred at the province-level, such as the national environmental policy—which stipulates different emission reduction targets for different provinces—and the anti-corruption campaign that began at the end of 2012 but is being implemented province by province. Besides, we carry out a falsification and placebo analysis in the robustness section to further rule out the possibility that our results are driven by other time-varying confounding unobservables.

### 3.5 Results

#### 3.5.1 Baseline results

We estimate the equation (3-3) in section 3.4 by adding the control of period fixed effects, city characteristics, province fixed effects, municipality fixed effects, province-period fixed effects, and the interaction between city characteristics and period fixed effects in turn, the results of which are shown in Table 3.3. Note that the coefficient of the interaction term, \( \theta \), identifies the differential effect of CES reform. We find that \( \theta \) is significantly negative after adding the period fixed effect, which is consistent with the theory. When introducing city characteristics and fixed effects gradually, we notice that \( R^2 \) becomes larger, implying that there exist unobservable variables fixed by period or region. Besides, the magnitude of \( \theta \) grows significantly (-0.139 to -0.188) after controlling for province-period fixed effects in Column (5). This growth suggests that the province-specific, time-varying unobservables also impact industrial land supply through the environmental pollution channel or the other channels correlated with environmental pollution, but in the opposite direction compared with the CES reform. As we mentioned in the empirical strategy section, these province-specific, time-varying unobservables may include various national environmental regulations that impose differential pollution reduction targets on provinces and the anti-corruption campaign implemented at different times for different provinces. It should also be noted that the magnitude of \( \theta \) decreases significantly (-0.188 to -0.122) after controlling for the interaction term between the county characteristics.
Impacts of the Political Incentive for Environmental Protection on Industrial Land Supply

with period fixed effects in Column (6). This decline indicates that the CES reform or time-varying unobservables impact the industrial land supply through channels correlated with environmental pollution. We have mentioned these channels in section 3.4, including the cities’ different economic development stages, fiscal conditions, land availability, etc. For example, when the city’s industrial structure, which is highly correlated with environmental pollution, evolves with time and transforms from secondary industry to service industry, less industrial land will be demanded; therefore, our results may be overestimated if the dynamic impact of industrial structure is not controlled.

We explain the implications of the results by using Column (6) as an example, which shows a point estimate of -0.122 for $\theta$. Since both our dependent variable and the pollution level use their logarithm, this result implies that after the central government assigned more weight to environmental amenities in 2013, cities with a double level of environmental pollution experienced a 12.2% reduction in the amount of industrial land supplied. We should emphasize that this reduction may partly be caused by the demand side of industrial land, since incentivized local leaders in dirty cities may raise environmental standards during the selection of industrial firms. Nevertheless, the more stringent environmental review is motivated by the CES reform and can be regarded as a policy tool to assist the industrial land supply. This is consistent with the practice in China we mentioned in section 3.2 and the theory in section 3.3.

Table 3.3: Impacts of the CES reform on industrial land supply (Baseline).

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log amounts of industrial land supply</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\ln P_t \times 1(\tau \geq 2014h1)_t$</td>
<td>-0.203***</td>
<td>-0.137**</td>
<td>-0.151***</td>
<td>-0.139**</td>
<td>-0.188***</td>
<td>-0.122***</td>
</tr>
<tr>
<td></td>
<td>(0.057)</td>
<td>(0.059)</td>
<td>(0.056)</td>
<td>(0.056)</td>
<td>(0.055)</td>
<td>(0.059)</td>
</tr>
<tr>
<td>$\ln P_t$</td>
<td>0.164***</td>
<td>0.190***</td>
<td>0.193***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.062)</td>
<td>(0.062)</td>
<td>(0.060)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Period FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Controls</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Province FE</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Municipality FE</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Province-Period FE</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Controls-Period FE</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>R2</td>
<td>0.095</td>
<td>0.548</td>
<td>0.593</td>
<td>0.677</td>
<td>0.720</td>
<td>0.757</td>
</tr>
<tr>
<td>Observations</td>
<td>3808</td>
<td>3808</td>
<td>3808</td>
<td>3808</td>
<td>3752</td>
<td>3752</td>
</tr>
</tbody>
</table>

Notes: The table reports result from estimating equation (3-3) by adding period fixed effects, city characteristics, province fixed effects, municipality fixed effects, the interaction between province fixed effects and period fixed effects, the interaction between city characteristics, and period fixed effects. In total, 56 singleton observations were dropped from Column (5). The mean volume of industrial land supply is 240 ha. The mean pollution level index is 1. Standard errors in parentheses are clustered on municipality fixed effects. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. 
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Since we are using the DID model, the validity of our results rests on the assumption that more and less polluting cities move in parallel in terms of industrial land supply if there is no CES reform. Like the existing literature, we use the difference in industrial land supply between more and less polluting cities in leading terms to assess the parallel trend. Specifically, we examine the link between the pollution level and industrial land supply period by period. The specification of the model is as follows:

\[
\ln Y_{it} = \sum_{h=2011h1}^{2017h2} \theta_h \ln P_i \times 1(t = h) + \beta_1 \ln X_{i(t-1)} + \beta_2 \ln X_{i(t-1)} \times u_t + \delta_{pro} \times u_t + u_t + \alpha_i + \varepsilon_{it}
\]

(3-4)

1\((t = h)\) equals 1 if one period equals a time indicator \(h\), ranging from the first half of 2011 to the second half of 2017. Other specifications are the same as the baseline model. Therefore, \(\theta_h\) can capture the difference between more and less polluting cities each year. Figure 3.1 plots the estimated \(\theta_h\), and the value in the second half of 2013 is normalized to zero. As shown in the figure, the industrial land supply of more and less polluting cities before the CES reform is pretty close, supporting the parallel assumption. Moreover, we find that there is a fluctuation in \(\theta_h\) after the CES reform. Specifically, \(\theta_h\) in the first half of 2015 is even larger than the value before the CES reform, while the value in the second half of 2016 is especially smaller than in other periods. We understand this fluctuation by comparing it with the timeline of the specific policies aiming to implement
the CES reform. Before the trial policy on local cadres’ responsibility for environmental protection in August 2015, there was only a relatively general policy on the reform of the promotion criteria of local leaders, which was issued in December 2013. Local officials may be uncertain whether this reform will be enforced in the future, as it declared, and some officials may ignore the CES reform, which leads to a rebound increase in industrial land supply in more polluting cities. Only in August 2015, when the specific policy to clearly define the responsibility of local cadres for environmental pollution was issued, did local officials start to be incentivized again. Similarly, the larger decline in industrial land supply in more polluting cities in the second half of 2016 is possibly related to the national environmental protection supervision, which began at the end of 2015.

3.5.2 Robustness test

One concern is whether our baseline results are robust when using other measures of the pollution level. First, we calculate each city’s pollution level by using the pollution level in 2013. The results are shown in Column (1) of Table 3.4. As we can see, compared with the baseline results, using the pollution level in 2013 leads to slightly larger impacts. This difference is possibly caused by the differential reduction in the pollution emission (or discharge) of three pollutants across cities. We also use the pollution level lagged by a year rather than a constant value for all periods (Column 2), and now the empirical strategy is just the two-way fixed effects model rather than DID. The result is less statistically significant. This is not surprising, since environmental pollution may be correlated with the industrial land supply. When we instrument the pollution level lagged one year with the value lagged two, three, and four years (Column 3), the results become significant, and the magnitude is quite close to that of the baseline results. Moreover, rather than using the average value of three pollutants’ emissions, we use the maximum value of three pollutants’ emissions and replicate the baseline and last three specifications. As shown in Column (4) to Column (7), these results are all significant, and the pattern of the magnitude is quite similar to that of the previous results.

Table 3.4: Impacts of the CES reform on industrial land supply (alternative measures of pollution level).

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollution Level in 2013</td>
<td>ln P_i × 1(τ ≥ 2014h1)_t</td>
<td>-0.149** (0.060)</td>
<td>-0.092+ (0.062)</td>
<td>-0.134** (0.063)</td>
<td>-0.125*** (0.047)</td>
<td>-0.139*** (0.049)</td>
<td>-0.086+ (0.056)</td>
</tr>
<tr>
<td>Pollution Level in Lagged Year</td>
<td>R2</td>
<td>0.757</td>
<td>0.757</td>
<td>-</td>
<td>0.757</td>
<td>0.757</td>
<td>0.757</td>
</tr>
<tr>
<td>Pollution Level in Lagged Year (IV, 2SLS)</td>
<td>Observations</td>
<td>3752</td>
<td>3752</td>
<td>3752</td>
<td>3752</td>
<td>3752</td>
<td>3752</td>
</tr>
</tbody>
</table>

Notes: Column (1) reports the estimation using the pollution level of 2013, and Column (2) uses the pollution level in the lagged one year. Column (3) instruments the pollution level lagged one year with the value in the lagged two, three, and four years. Column (4)-(7) use the maximum level of three pollutants’ emissions and replicate the baseline and last three measures. Standard errors in parentheses are clustered on municipality fixed effects. + p < 0.1, * p < 0.10, ** p < 0.05, *** p < 0.01.
Another concern is that our results may be driven by other time-varying confounding factors. We first mediate the concern about the non-linear effect of the economic development or the other county characteristics by adding the interaction term between the square of county characteristics and period fixed effects in Column (1) of Table 3.5, and we find that the result remains significant and the magnitude is close to that of the baseline results.

One prominent time-varying confounding event is the recent anti-corruption campaign in China, which began at the end of 2012 and might have affected industrial land supply through a channel related to the city’s pollution level, such as land-induced corruption. As we discussed in the empirical strategy and baseline results, we can control its impact to a great extent by adding provincial-period fixed effects, given that the central government’s inspection in the anti-corruption campaign takes place province by province. This section further mitigates this concern by implementing a falsification analysis that estimates the impact of the CES reform on the amount of residential land supply and commercial land supply. The idea is that if the baseline results are driven by the anti-corruption campaign, these two types of land supply should also be impacted, as they are documented to be closely related to local officials’ corruption (Zhao et al. 2020, Cai, Henderson, and Zhang 2013). The results are shown in Columns (2) to (5) in Table 3.5. As we can see, both estimations from the baseline model and the specification instrumenting using lagged values show positive impacts, and none of the results are significant. Therefore, our baseline results are not likely to be driven by the anti-corruption campaign.

The other possible time-varying force is the change in the external economic environment of China’s cities, which experienced a significant decline in 2012, when using the national GDP growth rate as an index. Thus, a negative shock to national economic growth may exert a larger impact on less productive cities, and the productivity may be related to the pollution level in a city. We alleviate this concern in two ways. First, as shown in Figure 3.1, there is neither an evident decline regarding the land supply effect of the pollution level in 2012 nor a declining trend of the GDP growth pattern after 2013. Second, we carry out a placebo analysis by estimating the impact of the CES reform on cities with different level of productivities, as indicated by wages or GDP per capita. We use the same method as the baseline specification to calculate the wage index and GDP per capita index, and we do not expect the same significant impact, because the CES reform does not necessarily exert a differential impact on less productive cities. The results are shown in Columns (6) and (7) in Table 3.5. As we can see, neither of them is significant, which does not support the argument that our estimation is driven by the change in the external economic environment.

59 From 2011 to 2017, the GDP growth rate in China was 9.6%, 7.9%, 7.8%, 7.3%, 6.9%, 6.7%, and 6.8% annually, according to the World Bank.
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Table 3.5: Impacts of the CES reform on industrial land supply (time-varying confounders).

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
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<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Industrial Land Supply</td>
<td>Residential Land Supply (Baseline)</td>
<td>Residential Land Supply (IV, 2SLS)</td>
<td>Commercial Land Supply (Baseline)</td>
<td>Commercial Land Supply (IV, 2SLS)</td>
<td>Impact of Wage on Industrial Land Supply</td>
<td>Impact of GDP on Industrial Land Supply</td>
</tr>
<tr>
<td>ln P_t × 1</td>
<td>-0.118**</td>
<td>0.008</td>
<td>0.039</td>
<td>0.004</td>
<td>0.045</td>
<td>0.263</td>
<td>-0.346</td>
</tr>
<tr>
<td>(τ ≥ 2014h1)_t</td>
<td>(0.054)</td>
<td>(0.058)</td>
<td>(0.064)</td>
<td>(0.087)</td>
<td>(0.094)</td>
<td>(0.536)</td>
<td>(0.550)</td>
</tr>
<tr>
<td>Controls×2-Period</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>R2</td>
<td>0.804</td>
<td>0.730</td>
<td>-</td>
<td>0.635</td>
<td>-</td>
<td>0.757</td>
<td>0.757</td>
</tr>
<tr>
<td>Observations</td>
<td>3752</td>
<td>3752</td>
<td>3752</td>
<td>3752</td>
<td>3752</td>
<td>3752</td>
<td>3752</td>
</tr>
</tbody>
</table>

Notes: Column (1) controls the interaction term between the square of county characteristics and the period fixed effects. Column (2) and (3) estimate using the residential land supply as the dependent variable, and Column (4) and (5) use the commercial land supply. Columns (2) and (4) use the baseline specification, while Columns (3) and (5) instrument the lagged one year with the lagged two, three, and four years. Column (6) and (7) replace the pollution level with the wage index and GDP per capita index. Standard errors in parentheses are clustered on municipality fixed effects. + p < 0.2, * p < 0.10, ** p < 0.05, *** p < 0.01.

### 3.5.3 Heterogeneous effects

This section analyzes the heterogeneous effects of the CES reform in order to explore the underlying mechanism. First, we estimate heterogeneity among different industry types. Based on the transaction dataset and the Regulation on the National General Survey of Pollution Sources (2010), we can derive the amounts of land supplied to manufacturing firms and dirty firms in terms of three pollutants. It should be noted that our classification is based on two-digit industry types due to the available data, and may thus incorrectly include, to some degree, several clean firms in the dirty type. We expect that this classification works, since these industry types can account for most pollution emissions (discharge) in China, as illustrated in section 3.4. We estimate the impacts on these different types of land supply separately, the results of which are shown in Table 3.6. As we can see, Column (1) in Panel A shows a larger impact on the land supplied to manufacturing firms than the baseline model (-0.182 vs. -0.122). This larger impact can be explained by the fact that non-manufacturing uses, most of which are warehouses, are generally less polluting than manufacturing uses. Column (2) in Panel A shows a slightly larger impact on the land supplied to dirty firms (-0.136 vs. -0.122), but it is statistically insignificant, possibly caused by our inaccurate classification. Columns (3) to (5) in Panel A show that the CES reform had an insignificantly positive impact on dirty firms in terms of industrial SO₂ emission (0.026 vs. -0.122), while it had a considerably larger and statistically significant impact on dirty firms in term of industrial dust (soot) emission (-0.398 vs. -0.122) and industrial wastewater discharge (-0.335 vs. -0.122). These differences imply that our baseline results are mainly driven by a reduction of the land supplied to the latter two industry types. In sum, our heterogeneity analysis shows that the impact of the CES reform is larger on the land supplied to dirtier industries.\(^60\)

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\(^{60}\) This result is consistent with the finding of Chen, Li, and Lu (2018) which shows a negative effect of SO₂ reductions targets imposed by the central government on the entrance of dirty firms.
CHAPTER 3

This larger impact implies a more stringent environmental review by city governments in the land supply process, which is consistent with local governments’ practice in China and the analysis in our theoretical model.

Second, we analyze the heterogeneous impact across cities with different economic statuses by adding an interaction term between the treatment measure in the baseline specification with GDP per capita or fiscal revenue per capita, the results of which are shown in Columns (1) and (2) in Panel B of Table 3.6. We find that the signs of the two coefficients are both insignificantly negative. Nevertheless, the negative sign possibly suggests that wealthier cities may reduce land supply more, which is not surprising according to our theory.

Finally, we explore heterogeneity across local leaders faced with different intensities of promotion incentives. Here, the intensity of promotion incentives refers to the differential promotion probability when local leaders fulfill the same targets set by upper-level governments. It is reasonable to argue that the local leader with a stronger promotion incentive tends to respond more to the CES reform. Consistent with the existing literature (He, Wang, and Zhang 2020, Yao et al. 2020), we use the party secretary’s age to indicate the intensity of the promotion incentive. Specifically, since the party secretary aged 57 or over has a significantly smaller promotion incentive—due to the implicit rule that a municipal-level leader cannot be promoted if their age is 57 or over (He, Wang, and Zhang 2020, Wang and Wang 2020)—we define the age dummy as one where the party secretary’s age is below 57. We add the interaction term between the treatment measure in the baseline model with the age dummy, the result of which is shown in Column (3) in Panel B. We find that the treatment coefficient becomes insignificantly positive, while the coefficient of the term interactieng with the age dummy is negative, with a larger magnitude than that of the baseline results (-0.132 vs. -0.122). When we use age 58 as the threshold—as suggested by Yao et al. (2020)—in Column (5) of Panel B, the corresponding coefficient becomes larger and statistically more significant (-0.222 vs. -0.122). These results mean that the party secretary with a stronger promotion incentive (age below 57 or 58) supplies significantly less industrial land than the party secretary with a weaker promotion incentive in response to the CES reform, suggesting that our baseline results are driven mainly by the local leader with a higher promotion incentive.
Table 3.6: Impacts of the CES reform on industrial land supply (heterogeneous effect).

<table>
<thead>
<tr>
<th>Panel A</th>
<th></th>
<th>(1)</th>
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<th>(5)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Manu.</td>
<td>Dirty Firms (Three</td>
<td>Dirty Firms (SO₂)</td>
<td>Dirty Firms (Dust, Soot)</td>
<td>Dirty Firms (Water)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manufacturing Firms</td>
<td>Pollutants)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ln Pt &gt; 1(τ ≥ 2014h1)τ</td>
<td>-0.182*</td>
<td>-0.136 (0.129)</td>
<td>0.026 (0.287)</td>
<td>-0.398** (0.192)</td>
<td>-0.335* (0.181)</td>
<td></td>
</tr>
<tr>
<td>R2</td>
<td>0.680</td>
<td>0.661</td>
<td>0.531</td>
<td>0.542</td>
<td>0.618</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>3752</td>
<td>3752</td>
<td>3752</td>
<td>3752</td>
<td>3752</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B</th>
<th>Economic Status (GDP)</th>
<th>Economic Status (Fiscal Revenue)</th>
<th>Promotion Incentive (Age &lt; 57)</th>
<th>Promotion Incentive (Age &lt; 58)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln Pt &gt; 1(τ ≥ 2014h1)τ</td>
<td>-0.149** (0.061)</td>
<td>-0.134** (0.065)</td>
<td>-0.007 (0.107)</td>
<td>0.090 (0.116)</td>
</tr>
<tr>
<td>ln Pt &gt; 1(τ ≥ 2014h1)τ xHetero</td>
<td>-0.048 (0.069)</td>
<td>-0.023 (0.051)</td>
<td>-0.132+ (0.098)</td>
<td>-0.222** (0.108)</td>
</tr>
<tr>
<td>R2</td>
<td>0.758</td>
<td>0.757</td>
<td>0.757</td>
<td>0.757</td>
</tr>
<tr>
<td>Observations</td>
<td>3752</td>
<td>3752</td>
<td>3752</td>
<td>3752</td>
</tr>
</tbody>
</table>

Notes: Columns (1) to (5) of Panel A report the result of impacts on the amount of land supplied to manufacturing firms, dirty firms, and dirty firms in terms of industrial SO₂ emissions, industrial dust (soot) emissions, and industrial wastewater discharge, respectively. Columns (1) and (2) of Panel B add the interaction term between the treatment and the economic status (GDP per capita and fiscal revenue per capita). Columns (3) and (4) of Panel B add the interaction term between the treatment and local leaders’ promotion incentive (dummy of age below 57 and age below 58). Standard errors in parentheses are clustered on municipality fixed effects. +p < 0.2, *p < 0.10, **p < 0.05, ***p < 0.01.

3.6 Conclusions

Industrial land supply is widely used by local governments to intervene in industrial development in order to achieve economic, social, and environmental objectives. Therefore, exploring determinants of industrial land supply has been an increasingly important topic for both academia and governments. This research has focused on whether and how the adjustment of industrial land supply is used to respond to a change in the political incentive for environmental protection. We have established a simple theoretical model by extending the community site supply theory put forward by Fischel (1974) to inform our research. In the model, we highlight the influence of political incentives for environmental protection on local leaders’ valuation of environmental amenities and derive that an increase in the political incentive for environmental protection motivates local leaders to supply less industrial land. This negative impact is especially large if the city is dirtier. We have empirically investigated this research question by using the recent CES reform in 2013 in China as a positive shock to local leaders’ political incentives for environmental protection, where CES is documented to be used as the primary tool to select local officials in China’s centralized political system. Moreover, the fact that local governments have a monopoly on supplying newly developed urban land enables them to extensively intervene in industrial development through industrial land supply. Using
the DID strategy, we have found that dirtier cities experience a significantly larger decline in industrial land supply. Our results are robust to various measures of the city’s pollution level. We have also moderated concerns about time-varying unobservables by carrying out a falsification analysis, which estimates the impact on the residential and commercial land supply, and a placebo analysis, which replaces the pollution level with wage and GDP per capita. Last, the heterogeneous analysis has shown that the reform may have a larger impact on dirtier industries and wealthier cities, and our baseline results are mainly driven by local leaders with stronger promotion incentives.

Our research implies that through emphasizing environmental protection in cadre evaluation criteria, the central government in China effectively incentivizes local officials to reduce the industrial land supply, which probably promotes the quality of economic development. Nevertheless, it should be noted that the CES must be designed elaborately and carefully, since it may induce some cities to assign excessive weight to environmental pollution relative to economic growth. Our research does not offer direct evidence on this question, but our results suggest that the adverse effect of the CES reform may especially exist in the less developed regions, as rejecting new firms’ locating can harm the development of the agglomeration economy. Further studies on the CES reform’s heterogeneous impact are needed in order to design better cadre evaluation criteria and related environmental protection targets.

3A Derivative process of the key steps in the theory

We use two steps to derive \( \frac{\partial D^*}{\partial (v/\mu)} < 0 \) and \( \frac{\partial^2 D^*}{\partial (v/\mu) \partial E} < 0 \) from equilibrium equation (3-2) in section 3.3.

In the first step, we derive \( \frac{\partial (v/\mu)}{\partial D^*} < 0 \) and \( \frac{\partial^2 (v/\mu)}{\partial D^* \partial E} < 0 \).

Equation (3-2) can also be written as

\[
\frac{v}{\mu} = \frac{G(D^*)}{-E(D^*)} \times \frac{E + \int_E^{D^*} E(x)}{G + \int_E^{D^*} G(x)}
\] (3A-1)

Based on equation (A1-1), we can derive that,

\[
\frac{\partial (v/\mu)}{\partial D^*} = \frac{\partial G(D^*)}{\partial D^*} \times \frac{E + \int_E^{D^*} E(x)}{G + \int_E^{D^*} G(x)} + \frac{E + \int_E^{D^*} E(x)}{G + \int_E^{D^*} G(x)} \times \frac{G(D^*)}{-E(D^*)}
\] (3A-2)
And we can derive,
\[
\frac{\partial}{\partial D^*} \left( E + \int_0^{D^*} E(x) \right) = \frac{\partial}{\partial D^*} \left( E + \int_0^{D^*} E(x) \right) \times \frac{1}{G + \int_0^{D^*} G(x)} - \left( E + \int_0^{D^*} E(x) \right) \frac{\partial}{\partial D^*} \left( G + \int_0^{D^*} G(x) \right)
\]

(3A-3)

We know that \( \frac{\partial}{\partial D^*} (E + \int_0^{D^*} E(x)) < 0 \) and \( \frac{\partial}{\partial D^*} (G + \int_0^{D^*} G(x)) > 0 \), so we get that \( \frac{\partial}{\partial D^*} (\frac{E + \int_0^{D^*} E(x)}{G + \int_0^{D^*} G(x)}) < 0 \).

Together with \( \frac{\partial}{\partial D^*} G(D^*) < 0 \), we get that \( \frac{\partial}{\partial D^*} (\frac{G(D^*)}{E(D^*)}) < 0 \).

By including equation (A1-3) in (A1-2), we can get the derivative of \( \frac{\partial}{\partial D^*} (\frac{G(D^*)}{E(D^*)}) \) with respect to \( E \),
\[
\frac{\partial^2}{\partial D^* \partial E} (\frac{G(D^*)}{E(D^*)}) = \frac{\partial}{\partial D^*} (\frac{G(D^*)}{E(D^*)}) + \frac{G(D^*)}{E(D^*)} \frac{\partial}{\partial D^*} (\frac{G(D^*)}{E(D^*)}) \times \frac{1}{G + \int_0^{D^*} G(x)} - \left( E + \int_0^{D^*} E(x) \right) \frac{\partial}{\partial D^*} \left( G + \int_0^{D^*} G(x) \right)
\]

(3A-4)

Since \( \frac{\partial}{\partial D^*} (\frac{G(D^*)}{E(D^*)}) < 0 \) and \( \frac{\partial}{\partial D^*} (G + \int_0^{D^*} G(x)) > 0 \), we get \( \frac{\partial^2}{\partial D^* \partial E} (\frac{G(D^*)}{E(D^*)}) < 0 \).

In the second step, we derive \( \frac{\partial}{\partial D^*} (\frac{G(D^*)}{E(D^*)}) < 0 \) and \( \frac{\partial^2}{\partial D^* \partial E} (\frac{G(D^*)}{E(D^*)}) < 0 \). By assuming \( D^* \) is monotonic in \( \frac{\partial}{\partial D^*} (\frac{G(D^*)}{E(D^*)}) \) with respect to \( E \), we know \( \frac{\partial}{\partial D^*} (\frac{G(D^*)}{E(D^*)}) < 0 \).

By assuming \( D^* \) is monotonic in \( \frac{\partial}{\partial D^*} (\frac{G(D^*)}{E(D^*)}) \) with respect to \( E \), we know \( \frac{\partial}{\partial D^*} (\frac{G(D^*)}{E(D^*)}) < 0 \). Based on \( \frac{\partial}{\partial D^*} (\frac{G(D^*)}{E(D^*)}) < 0 \), we get
\[
\frac{\partial^2}{\partial D^* \partial E} (\frac{G(D^*)}{E(D^*)}) = \frac{\partial}{\partial D^*} (\frac{1}{\frac{\partial}{\partial D^*} (\frac{G(D^*)}{E(D^*)})}) = \frac{-1}{\left( \frac{\partial}{\partial D^*} (\frac{G(D^*)}{E(D^*)}) \right)^2} \times \frac{\partial^2}{\partial D^* \partial E} (\frac{G(D^*)}{E(D^*)})
\]

(3A-5)

We then learn \( \frac{\partial^2}{\partial D^* \partial E} (\frac{G(D^*)}{E(D^*)}) > 0 \) based on \( \frac{\partial^2}{\partial D^* \partial E} (\frac{G(D^*)}{E(D^*)}) < 0 \).
CHAPTER 4

Exchanging Land Price for Density: Evidence from China
CHAPTER 4

Abstract: The land market operates under various types of regulatory policies. Evaluating the efficiency of the land market requires a better understanding of the relationship between regulatory policies and the land market. This paper focuses on industrial land and investigates whether and to what extent a low industrial land price can be explained by tighter density regulations, based on evidence from China. We established a simple theory to show that a binding minimum capital-land ratio (CLR) leads to a lower industrial land price. We exploit the province-level variation in the minimum CLR and use a difference-in-differences (DID) event study design that uses the event dummy as the treatment. We examine land-price changes within a five-year window around 19 province-level minimum-CLR events and find that province-level minimum-CLR regulations do have a negative price effect in the first one and half years after the regulatory policy is implemented. Our results are robust to specifications that add controls for county-specific linear and quadratic time trends, use different event windows, or use continuous treatment indicators. Our research documents the negative price effect of minimum-density regulations for industrial land and offers direct evidence that the government in China exchanges the land price for a higher density of industrial investment.

Keywords: capital-land ratio; land-use regulation; industrial land; land price; China
4.1 Introduction

The land market operates under various types of regulatory policies. One of the very fundamental but controversial questions regarding the land market is how to understand the relationship between those regulatory policies and the land market (Cheshire and Hilber 2017). A growing literature has been devoted to how regulatory policies, which may have various reasons, affect the land market. On the one hand, these regulatory policies could influence land prices, directly impacting the winner in the land market (Severen and Plantinga 2018, Turner, Haughwout, and Van Der Klaauw 2014, Kok, Monkkonen, and Quigley 2014). On the other hand, if land prices are impacted differently across land uses, these policies could cause market segmentation and lead to inefficient land allocation (Levkovich, Rouwendal, and Brugman 2018). We continue this strand of research by focusing on the relationship between the industrial land market and density regulations, both of which have received growing but still limited attention. We ask how density regulations affect industrial land allocation by investigating how the land price is impacted. If a negative price effect of density regulations is documented, we may offer evidence that the price mechanism is weakened if density regulations are used when allocating industrial land.

The industrial land price has been documented to be considerably lower than it should be, for example lower than the residential land price or lower than the land rent calculated based on production output. Especially in China, the industrial land price is documented to be significantly lower than the residential land price and even lower than the cost of acquiring and servicing land. The low price of industrial land is argued to have various causes, such as overly supplied industrial land or subsidies for firms, and is thus argued to be responsible for urban sprawl and inefficient land use. Unlike the existing research, we would like to ask whether and to what extent the low industrial land price can be explained by more stringent density regulations. Specifically, we investigate whether and to what extent minimum capital-land ratio (CLR) regulations, one widely adopted regulatory policy regarding industrial land use in China, affects the industrial land price.

The effect of minimum-density regulations is conceptually different from that of maximum-density regulations, such as height restrictions or floor area ratio (FAR) limits. Minimum limits will become less binding over time, because the optimal density determined by market participants grows in time. In contrast, the price effect of maximum limits is expected to grow over time, as the market tends to demand higher density.

Empirically, we exploit the province-level variation in the minimum CLR and use a difference-in-differences (DID) event study design, which uses the event dummy as the treatment. We examine land-price changes within a five-year window in 19 province-
level minimum-CLR events and find that province-level minimum-CLR regulations have a negative price effect in the first one and half years after the regulatory policy is implemented. Specifically, the land price is reduced by 15.8% if the minimum CLR is doubled. Our results are robust to specifications that add controls for county-specific linear and quadratic time trends, use different event windows, or use continuous treatment indicators. In addition, by using several sub-groups to estimate the baseline model, we find that province CLR regulations have a slightly larger impact on the price of large parcels, a slightly larger impact on parcels located farther away from the county center, and a significantly larger impact on counties with higher fiscal revenue per capita and secondary GDP per capita.

Our research is mainly related to two strands of literature. First is the literature on the impact of land-use regulations (LURs) on the land price. This price effect has been documented to vary with the types of LURs. One of the types that has received more attention recently is density regulations, such as restrictions on building height, FAR, or lot size. By extending the monocentric urban model, Geshkov and DeSalvo (2012) suggest that binding density regulations for a location, regardless of whether they set a minimum or a maximum density, reduce the price of that location. Existing empirical research is mainly about maximum-density regulations and is often implemented indirectly. For example, by showing that a larger density increases the land price, some research implies that density is restricted to a lower level, which decreases the land value (Glaeser and Ward 2009, Brueckner et al. 2017). This paper contributes by empirically documenting the negative price effect of minimum-density regulations for industrial land. Our research could also help explain the large gap between residential and industrial land prices.

Moreover, our research contributes to the literature on the determinants of the industrial land price in China. The land price of industrial use is documented to be considerably lower than that of residential use (Wu et al. 2014). This is mainly attributed to regional competition for moving industrial capital, in which the lower land price is used as a subsidy for firms (Kajitani and Fujii 2016, Wu et al. 2014, Xu, Huang, and Jiang 2017). We reformulate this exchanging-of-land-for-capital story from the perspective of the price effect of LURs and offer direct evidence that local governments exchange the land price for a higher density of industrial investment.

63 Moreover, the price effect of restrictions on land availability has also been investigated. For example, it is found that more stringent regulation of residential use and less stringent regulation of industrial land use leads to a higher residential land price and a lower industrial land price (Levkovich, Rouwendal, and Brugman 2018). Meanwhile, an urban growth boundary has a positive effect on the land price, but the significance of this varies according to location (Grout, Jaeger, and Plantinga 2011). Some research also explores the price effect of the comprehensive regulatory environment, which uses different measures and gets different results. For example, by using Wharton Land Use Regulation data (WRLURI), it is found that a 1 standard deviation increase in land-use regulation decreases land value by about one-third (Turner, Haughwout, and Van Der Klaauw 2014). By using data on more than 100 Florida cities and a number of restrictive land-use management techniques to measure land-use regulations, one author finds that greater regulation restrictiveness decreases the land price (Ihlanfeldt 2007). However, by using the number of independent reviews and approvals required by a locality before the issuance of a building permit and the number of separate reviews by local authorities required to approve a zoning change, other researchers find that cities that require a more stringent regulation have higher land prices (Kok, Monkkonen, and Quigley 2014).
This paper is structured as follows. Section 4.2 introduces the industrial land supply and CLR regulations in China. In section 4.3, we establish a simple theory on minimum-CLR regulations. Next, we present the data and empirical strategy in section 4.4 and section 4.5. The results are shown in section 4.6. Finally, section 4.7 concludes.

### 4.2 Institutional background

Because of the regulation that urban land must be owned by the state, the primary industrial land market in China consists mainly of county governments and firms. Specifically, the county government expropriates the land from rural collectives and supplies it to firms after servicing it. Since the county government can benefit and suffer from many aspects when supplying industrial land, the allocation mechanism in the industrial land market may need to balance these benefits and losses and maximize a variety of goals, which makes the allocation process quite complicated. For example, a big firm is offered a lower land price, and the minimum fixed assets investment (FAI) or output per unit of land is negotiated and written into the land-leasing contract in some regions after the tax-sharing reform in 1994. This complicity in allocating industrial land gives county governments more discretionary power and, driven by political economy, local officials may supply industrial land inefficiently due to the regional competition for moving capital.

After witnessing an excessive supply of industrial land in November 2004, the central government issued the first national policy on minimum CLR, the *Index of Land-Use Controls for Industrial Projects*, aimed at constraining county governments’ inefficient industrial land supply. This policy regulated the minimum CLR for different counties regarding the following aspects: 1) the minimum value of FAR, which varies with industry type; 2) the proportion of land occupied by the administrative office and living service facilities, which must be less than 7%; 3) the coefficient of building occupation, which must be more than 30%; 4) the percentage of green space, which must be less than 20%; 5) the minimum FAI per unit of land, which includes construction, structure and their auxiliary facilities, and equipment investment and land-leasing fees, and varies with the grades of counties. Later, in January 2008, the value for the index was raised. Recently, the central government announced that the national policy would be revised again. The exposure draft was posted in March 2021, and the index of minimum production value and tax revenue was added to the policy.

Additionally, provincial governments also issued minimum-CLR policies for the counties within their jurisdictions. Before the first national policy in 2004, Shanghai and Zhejiang had established minimum-CLR policies for their jurisdictions to improve industrial land allocation. Hereafter, more provinces began to adopt their own policies to improve the requirements for minimum CLR, and a few provinces even adjusted their policies every few years. In total, we observe 26 events of provincial minimum-CLR policy adoption, as is shown in Table 4.1.

---

64 This term was written into the Constitution of China in 1982.
65 The village collectives are also eligible for supplying industrial land through leasing, but the amount is quite small.
Both national and provincial minimum-CLR regulations are binding for the industrial land market, since the regulations are designed to improve land-use intensity through imposing a higher CLR than the optimal CLR for the industrial market; that is, the CLR determined by county governments and firms. There are many possible reasons why the CLR determined by county governments and firms is lower than the CLR desired by the upper-level governments. Besides the impact of the political economy we mentioned earlier, the tax-sharing system may also have a considerable influence. The county government can increase the minimum CLR only to the degree that it maximizes the benefits, including the tax revenue assigned to it, but the minimum CLR should be improved more to maximize the total tax revenue.

Moreover, we should emphasize that minimum-CLR regulations may be binding for limited periods only, as the equilibrium CLR in the market may grow with time. This possibility can be verified by a series of facts. For example, the national government improved the CLR standard in 2008 and again in 2021, and some provincial governments imposed a higher CLR standard after the national policy. Besides, a few provinces increase their CLR standard every three to seven years. These revisions suggest that the national and provincial government may recognize the increase in the equilibrium CLR in the market, and then the minimum-CLR standard is revised to assure a binding regulation and achieve a higher industrial land-use intensity than the market does.

Table 4.1: Provinces issuing minimum-CLR regulations.

<table>
<thead>
<tr>
<th>Province</th>
<th>Time of issuing the policy (quarter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shanghai</td>
<td>2004q3, 2009q1, 2012q4, 2016q1</td>
</tr>
<tr>
<td>Tianjin</td>
<td>2008q4, 2015q4</td>
</tr>
<tr>
<td>Shandong</td>
<td>2005q2</td>
</tr>
<tr>
<td>Guangdong</td>
<td>2005q3</td>
</tr>
<tr>
<td>Guangxi</td>
<td>2010q2, 2015q4</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>2007q1, 2011q2, 2015q1</td>
</tr>
<tr>
<td>Hebei</td>
<td>2012q1, 2015q2</td>
</tr>
<tr>
<td>Henan</td>
<td>2004q4, 2008q1</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>2003q4, 2007q1, 2014q1</td>
</tr>
<tr>
<td>Fujian</td>
<td>2005q1, 2008q3, 2013q3</td>
</tr>
<tr>
<td>Guizhou</td>
<td>2011q2</td>
</tr>
<tr>
<td>Liaoning</td>
<td>2006q3</td>
</tr>
<tr>
<td>Chongqing</td>
<td>2007q4</td>
</tr>
</tbody>
</table>

### 4.3 Motivating theory

As we have illustrated in the institutional background section, the primary industrial land market in urban areas in China that we are interested in is characterized as a transaction between county governments and industrial firms. Meanwhile, upper-level governments,
such as provincial governments, have an incentive to impose restrictions in the form of a minimum CLR to improve land allocation efficiency. These binding CLR regulations are supposed to lead to losses for firms relative to the situation without regulations, and when the firm's loss is subsidized by county governments through lowering the land price, we can then observe a negative price effect of minimum-CLR regulations. Moreover, as the market forces, either from county governments or firms, lead to a higher CLR with time, the province's policy can be less binding and cause a smaller reduction in the land price. The following is the formal model.

In the model, we consider the setting that there exists one representative landowner, one representative firm, and the government. In the context of China, the landowner can be the county government, while the government refers to the provincial government. Nevertheless, our theory also applies to cases in which land is privately owned.

The production function of the firm in this region is $Y = Af(K, H)$. $A$ denotes technology, $K$ is the amount of industrial capital employed, and $H$ is the amount of land. We assume the return to scale (land plus industrial capital) is constant and $f(\cdot)$ is strictly increasing and strictly concave in land and industrial capital. We also assume that the land supplied to this firm is fixed and equals 1, that is, $H = 1$. Next, $K$ represents the CLR that we are interested in, and returns to the scale of industrial capital are decreasing. We could write this production function as follows:

$$Y = Af(K) \quad (4-1)$$

We first consider a situation in which no CLR regulations exist. We assume that the firm gets zero profits other than the capital cost and maximizes the rent for the landowner in order to acquire land tenure rights. The firm is supposed to maximize the rent by increasing its capital investment to a degree that makes the marginal product of the capital equal to the capital cost, that is, $\frac{\partial Y}{\partial K} = i$.

Since we know that $\frac{\partial^2 f(K)}{\partial K} < 0$, by using $g(x)$ to represent $\frac{\partial f(x)}{\partial x}$ and $g^{-1}(x)$ to represent the inverse function of $g(x)$, we get the CLR determined by the firm,

$$K^* = g^{-1}(i/A) \quad (4-2)$$

And through equations (4-1) and (4-2), we get $Y^*$,

$$Y^* = f(g^{-1}(i/A)) \quad (4-3)$$

---

66 See (Desmet and Rossi-Hansberg 2014) argues that when the amount of land in a location is fixed, returns to scale are decreasing as a result of congestion costs.
Furthermore, we derive the land rent for the landowner. Since we assume that the firm obtains zero profits, the landowner should obtain all surplus production. Thus, the land rent for the landowner $R^*$ is $R^* = Y^* - iK^*$. According to (2) and (3), the $R^*$ is,

$$R^* = f \left( g^{-1}(i/A) \right) - ig^{-1}(i/A) \quad (4-4)$$

Now we consider the situation that the government imposes minimum-CLR regulations indexed by $K$. We assume that this $K$ is larger than $K^*$, $g^{-1}(i/A)$, and thus binding for the firm. These binding CLR regulations make the marginal product of the firm lower than the capital cost, which is $\frac{\partial f(K)}{\partial K} < i/A$, causing an amount of loss for the firm, denoted as $S$. The firm’s loss, $S$, must be compensated, since the firm can choose not to buy the land. If we extend the model to multiple landowners or regions, this choice means that the firm can always find another location that either compensates the firm for the loss or does not impose minimum-CLR regulations. We assume that this subsidy is fully borne by the landowner. This is consistent with the situation in China, because the provincial government will not compensate the county government for improving the minimum CLR. Besides, we assume that the subsidy is funded through lowering the land price; this assumption is a little stronger for China’s practice, since the county government may use other policy tools, such as a tax holiday. However, as long as the land price tool is partly used, allowing for other subsidy channels would not alter the qualitative predictions of the model but would result in smaller predicted decreases in land price in regions experiencing minimum-CLR regulations. Based on these assumptions, the land rent under CLR regulations is still the total surplus production function, that is,

$$S = iK + R^* - Af(K) \quad (4-5)$$

Furthermore, we can get the first derivative of $S$ with respect to $K$,

$$\frac{\partial S}{\partial K} = i - A \times \frac{\partial f(K)}{\partial K} \quad (4-6)$$

Since $K$ is larger than $g^{-1}(i/A)$, which means that $g(K) = \frac{\partial f(K)}{\partial K} < i/A$, we get $\frac{\partial S}{\partial K} > 0$; that is, the necessary subsidy increases with the minimum CLR. Under the assumption that the firm is wholly subsidized by lowering the land price, the land price is supposed to decrease with the minimum CLR.

Next, we characterize how the negative price effect evolves with a change in market forces. It should be noted that the magnitude of the negative price effect increases with the gap between the minimum CLR set by the regional government and the optimum CLR for the market. The minimum CLR does not change before the regional government revises it, while the optimum CLR for the market may change with market forces. We assume that productivity grows with time because of market forces, such as advances in technology or productive amenities. We denote this relationship as $\frac{\partial A(T)}{\partial T} > 0$; here, $T$ is the time. Now, the necessary subsidy is:

---

67 "Market forces" here refers to firms and landowners, and in our context, the latter is the county government.
\[
S(T) = iK + A(T)f(K^*) - i \times K^*(T) - A(T)f(K) 
\] (4-7)

The derivative of \(S(T)\) with respect to \(T\) is,
\[
\frac{\partial S(T)}{\partial T} = \frac{\partial A(T)}{\partial T} f(K^*) + A(T) \frac{\partial f(K^*)}{\partial K^*} \frac{\partial K^*(T)}{\partial T} - i \times \frac{\partial K^*(T)}{\partial T} - \frac{\partial A(T)}{\partial T} f(K) \] (4-8)

Since \(A(T) \frac{\partial f(K^*)}{\partial K^*} = i\), we can further get,
\[
\frac{\partial S(T)}{\partial T} = \frac{\partial A(T)}{\partial T} \left( f(K^*) - f(K) \right) \] (4-9)

The implication of equation (4-9) is straightforward: if the productivity does not increase to the degree that makes \(K^* \geq K\), the necessary subsidy decreases with time (or productivity). In other words, the negative price effect of one specific set of minimum-CLR regulations also decreases with time.

**Proposition:** A binding restriction on minimum CLR lowers the industrial land price, and—given that this minimum-CLR regulation policy does not change—the magnitude of its negative effect decreases with the increase in productivity (and thus time).

### 4.4 Data

We used mainly three sources of datasets for the empirical analysis. These include 1) a land transaction dataset (jiegou Gonggao), containing information on transacted parcels for industrial use taken from China's official land market website, www.landchina.com; 2) regulations on the CLR of industrial projects from the policy document available on the government website; and 3) a county-level socioeconomic dataset from China City Statistical Yearbook and China Statistical Yearbook (County Level).

The land transaction dataset covers the period from 2007 to 2018 and includes each parcel's land price, land area, land-leasing duration, and detailed location. Some errors in land prices may exist in the raw land-supply dataset; for example, some parcels' price is zero or missing, or one parcel's price can be 10 times higher than the price of other parcels within the same county. These errors may be mistakes made by civil servants when filling in forms. We dealt with these possible errors through the following two steps. First, we dropped the observations that miss one of the above four attributes (or have zero for land price). Second, we compared the parcels with extremely high prices (higher than 5,000 Yuan/m²) with the majority of the other parcels within the same county and obtained the corrected land price by dividing the original price by 10 (or 100, 1000, or 10000, depending on the price of the majority of parcels). Third, we discarded those parcels of which the price is 10 times higher or 10 times smaller than the median price within the same county and the same year.
In addition, we discarded those parcels of which the land-leasing duration is shorter than 10 years, since these are more likely to be rented temporarily to industrial firms who are unlikely to invest in them in the long run. We also manually collected the location of each county’s Central Business District (CBD), which is identified by the seat of the local government, enabling us to measure the distance of the parcel to the county’s CBD. We first obtained the coordinates of the parcels and the CBD according to the detailed address on the record and then calculated great-circle distances using the haversine formula. The observations with abnormally large distances were dropped according to the criterion that the distance is larger than the double value of the square root of county size. See the summary statistics of parcel characteristics in Table 4.2.

In terms of regulations on the CLR of industrial projects, we found 24 events of provincial policies in total, each of which stipulates the minimum fixed assets investment intensity (FAII) and other types of regulations for all counties under the provinces’ jurisdiction. Among these, there are 19 events of provincial policies after 2007. We used these to identify the impact of CLR regulations on the land price. To consider the impact of relevant national policies, we also collected the national policies that regulate CLR (issued 2004 and 2008) and the minimum industrial land price (issued in 2007) for each county. See summary statistics of provincial CLR regulations in Table 4.2.

The socioeconomic dataset covers the period from 2007 to 2018 and contains the population, urban employment, secondary industry GDP, primary industry GDP, jurisdiction’s area, fiscal revenue, and fiscal expenditure. The data for the counties was obtained mainly from the China Statistical Yearbook (County Level). As the data for most districts under municipality is not available in this yearbook, we obtained the data for districts under municipality as a whole from the China City Statistical Yearbook. We dropped the observations of some newly established counties that are missing during most periods. Besides, some variables in several counties are missing for several years, and we replaced them with the value before or after that year. See summary statistics of county characteristics in Table 4.2.
The result indicates that since we define the treatment as three quarters, and half year, we find that the estimated time trends implies that the dummy \( \theta \) equals 1 if the minimum CLR was raised \( (\theta > 0) \).

\( \theta \times \) equals 1 if the minimum CLR was raised \( (\theta > 0) \).

\( \theta \times \) could be calculated as \( \text{counterfactual land price using a DID event study design. Our event-based approach uses a framework similar to that of Cengiz et al. (2019) and examines land-price changes within a five-year window around 19 province-level minimum-CLR events. By focusing on land-price changes around the event window, we incompletely capture the long-run effects of the minimum CLR. Nevertheles, as we show below, we find no evidence of a change in CLR up to three years after the minimum-CLR regulations.}

\( \text{Our basic regression specification is the following:} \)

\[
\ln R_{ijt} = \sum_{\tau = -4}^{5} \theta^\tau I_{ik}^\tau + \beta_1 \text{Parcel}_{ij} + \beta_2 \ln X_{jt} + \beta_3 \ln X_{jt} \times Trend_t + \beta_4 \Delta \ln NatPol_{jt} + Trend_t + \alpha_j + u_t + \epsilon_{ijt}
\]  

(4-10)
CHAPTER 4

Where subscripts $i$, $j$, $t$ index parcels, counties, and quarters, respectively. The dependent variable, $\ln R_{ijt}$, is the (log) industrial land price. The dummy $I_{jt}^T$ equals 1 if the minimum CLR was raised $\tau$ years from date $t$. This definition implies that $\tau = 0$ represents the first year following the minimum-CLR increase (i.e., the quarter of treatment and the subsequent three quarters), and $\tau = -1$ is the year (four quarters) before treatment. In the baseline model, we define the treatment as $I_{jt}^T$, thus the treatment switches from 0 to 1 at event date $\tau = 0$, $Parcel_{ij}$ controls for a group of parcel characteristics, which contain land-leasing ways, land-leasing duration, the previous use of the parcel (farmland, building land, or both), and location. $X_{it}$ controls for a group of county characteristics, including population, urban employment, secondary industry GDP, primary industry GDP, land area, fiscal revenue, and fiscal expenditure. We also control for the time trends $Trend_i$, and allow them to differ by county characteristics. $\Delta Nat Pol_{it}$ controls for the minimum-CLR change caused by the national policy in 2008, and we allow its effects to exist in the next five years. $\alpha_j$ and $u_t$ control for the county fixed effect and period fixed effect.

We use the estimated $\theta_t$ from equation (1) to calculate the change in land price in response to the policy. The change in land price between event date $-1$ and $\tau$ could be calculated as $\Delta \ln R_t = \theta_t - \theta_{-1}$. Our approach identifies the causal effect of the minimum CLR under the assumption that the land price in the treated and untreated provinces moves in parallel in the absence of the policy change. We use the leading terms to assess pre-existing trends. It should be noted that strategic interaction among regions may lead to an increase in minimum CLR in the untreated regions, which makes our identification strategy underestimate the impact, especially for the long-run price effect.

4.6 Results

4.6.1 Baseline results

We estimate the baseline model (5-1), and the results are shown in Table 4.3. We gradually add the national policy in 2008, period fixed effects, county characteristics, parcel characteristics, county fixed effect, and the interaction between county characteristics and trend. We find that $\Delta \ln R_{0}$, $\Delta \ln R_{1}$, and $\Delta \ln R_{2}$, which represent the treatment effect in the first three half years separately, become quite stable after introducing county fixed effects. These coefficients are all significantly negative from Column (6) to (7), indicating that province-level minimum-CLR regulations do have a negative price effect. The treatment effect in the fourth and fifth half year, $\Delta \ln R_{3}$ and $\Delta \ln R_{4}$, is not significant in general, although it is negative. Furthermore, the treatment effect in the sixth half year, $\Delta \ln R_{5}$, is insignificantly positive with a small magnitude after adding county fixed effect. This dynamic pattern of the price effect is consistent with the theoretical prediction; that is, the optimum CLR determined by the market is growing, and the province-level policy becomes less binding, thus leading to a decreasing impact on the land price. Several possible reasons can be found for this declining price effect. First, this could be driven by the advancing production technology and increasing scarcity of land. Especially in the sixth half year, we observe a positive price effect (although insignificant). Moreover, as
we put it in the empirical strategy, this decline may be caused by strategic interaction between county governments. The untreated counties may improve their minimum CLR because their neighboring counties are treated. Last, county governments in untreated regions may relax the implementation of the province policy after they experience the negative impact on attracting firms.

Table 4.3: Impacts of CLR regulations on industrial land price (baseline).

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
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</thead>
<tbody>
<tr>
<td>( \Delta \ln R_0 )</td>
<td>-0.245***</td>
<td>-0.102*</td>
<td>-0.112**</td>
<td>-0.130**</td>
<td>-0.067+</td>
<td>-0.071**</td>
<td>-0.069**</td>
</tr>
<tr>
<td></td>
<td>(0.078)</td>
<td>(0.056)</td>
<td>(0.056)</td>
<td>(0.060)</td>
<td>(0.045)</td>
<td>(0.034)</td>
<td>(0.033)</td>
</tr>
<tr>
<td>( \Delta \ln R_1 )</td>
<td>-0.157**</td>
<td>-0.092</td>
<td>-0.133*</td>
<td>-0.134*</td>
<td>-0.084</td>
<td>-0.087*</td>
<td>-0.087*</td>
</tr>
<tr>
<td></td>
<td>(0.080)</td>
<td>(0.073)</td>
<td>(0.076)</td>
<td>(0.072)</td>
<td>(0.064)</td>
<td>(0.053)</td>
<td>(0.052)</td>
</tr>
<tr>
<td>( \Delta \ln R_2 )</td>
<td>-0.123*</td>
<td>-0.078</td>
<td>-0.111**</td>
<td>-0.069+</td>
<td>-0.049</td>
<td>-0.048*</td>
<td>-0.051**</td>
</tr>
<tr>
<td></td>
<td>(0.064)</td>
<td>(0.057)</td>
<td>(0.055)</td>
<td>(0.044)</td>
<td>(0.037)</td>
<td>(0.025)</td>
<td>(0.026)</td>
</tr>
<tr>
<td>( \Delta \ln R_3 )</td>
<td>-0.081*</td>
<td>-0.040</td>
<td>-0.126**</td>
<td>-0.077*</td>
<td>-0.069+</td>
<td>-0.037</td>
<td>-0.044</td>
</tr>
<tr>
<td></td>
<td>(0.056)</td>
<td>(0.053)</td>
<td>(0.054)</td>
<td>(0.044)</td>
<td>(0.044)</td>
<td>(0.033)</td>
<td>(0.034)</td>
</tr>
<tr>
<td>( \Delta \ln R_4 )</td>
<td>-0.131***</td>
<td>-0.052</td>
<td>-0.168***</td>
<td>-0.064*</td>
<td>-0.051</td>
<td>-0.008</td>
<td>-0.025</td>
</tr>
<tr>
<td></td>
<td>(0.044)</td>
<td>(0.046)</td>
<td>(0.048)</td>
<td>(0.038)</td>
<td>(0.040)</td>
<td>(0.030)</td>
<td>(0.031)</td>
</tr>
<tr>
<td>( \Delta \ln R_5 )</td>
<td>-0.061</td>
<td>-0.045</td>
<td>-0.170***</td>
<td>-0.062*</td>
<td>-0.025</td>
<td>0.016</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.073)</td>
<td>(0.064)</td>
<td>(0.061)</td>
<td>(0.032)</td>
<td>(0.034)</td>
<td>(0.023)</td>
<td>(0.024)</td>
</tr>
<tr>
<td>( \Delta \ln R_{0/3} )</td>
<td>-0.152***</td>
<td>-0.078*</td>
<td>-0.121***</td>
<td>-0.103**</td>
<td>-0.067*</td>
<td>-0.061**</td>
<td>-0.063**</td>
</tr>
<tr>
<td></td>
<td>(0.050)</td>
<td>(0.044)</td>
<td>(0.045)</td>
<td>(0.040)</td>
<td>(0.035)</td>
<td>(0.027)</td>
<td>(0.027)</td>
</tr>
</tbody>
</table>

National policy: No Yes Yes Yes Yes Yes Yes
Quarter FE: No No Yes Yes Yes Yes Yes
County char.: No No No Yes Yes Yes Yes
Parcel char.: No No No No Yes Yes Yes
County FE: No No No No No Yes Yes
County char. trend: No No No No No Yes Yes

R2: 0.015 0.085 0.109 0.350 0.408 0.651 0.653
Observations: 290659 290659 290659 290659 290658 290641 290641

Notes: This table reports results from estimating equation (5-1) by adding the national policy, period fixed effects, county characteristics, parcel characteristics, county fixed effect, the interaction between county characteristics, and linear trend, respectively. \( \Delta \ln R_0 \) to \( \Delta \ln R_5 \) represent the treatment effect from the first half year to the sixth half year, separately. And \( \Delta \ln R_{0/3} \) is the average treatment effect from the first half year to the fourth half year. Standard errors in parentheses are clustered on county fixed effects. + p < 0.15, * p < 0.10, ** p < 0.05, *** p < 0.01.

\( \Delta \ln R_{0/3} \) is the average treatment effect from the first half year to the fourth half year. Taking Column (7) as an example, the estimated coefficient means the land price decreases by 6.3% after the province regulation. By using the average increase in minimum FAR, 40%, the coefficient of 6.3% indicates a 15.8% decrease in the land price.
when the minimum CLR is doubled. We can compare this magnitude with Guizhou Province’s policy on industrial land price in October 2011. It determines that if the FAII is raised by more than 40%, the land price could be reduced by 25%. The estimated price effect, 15.8%, is about one-fourth of the price effect of the regulation in Guizhou’s policy, 62.5%. This gap suggests that the price effect may be underestimated. Possible reasons include the regional competition we mentioned above; either the increase in minimum CLR in untreated counties or the loss of implementation of provincial policy in treated counties can lead to a smaller price effect. Moreover, as we discussed in the theoretical section, the county government may subsidize the firm by using other policy tools rather than lowering the land price, making us observe a smaller price effect.

In Figure 4.1, we show the estimated $\Delta \ln R_1$ in the specification of Column (7) of Table 4.3. The result indicates that $\Delta \ln R_{-3}$, $\Delta \ln R_{-2}$, and $\Delta \ln R_{-1}$ are pretty close, which means that the treatment and non-treatment provinces do not show a significant difference in industrial land price in the leading one and half years and thus support the parallel assumptions.

4.6.2 Robustness checks

We assess the robustness of the main results to a variety of specifications. First, we add county linear and quadratic trends to control for the additional time-varying unobservables. In the presence of two pre-treatment and three post-treatment dummies, the trends are estimated using variation outside of the five-year window around the treatment. They are thereby unlikely to be affected by either lagged or anticipation effects. The results are shown in Table 4.4. Column (1) is the baseline specification, while Column (2) and
Column (3) control for the county linear and quadratic trends. As is shown, the price effect remains significant, although the magnitude is slightly larger in Column 2.

Moreover, we estimate the specifications with a six-year or seven-year event window. Column (4) is two years before and four years after, Column (5) is three years before and three years after, and Column (6) is two years before and five years after. As we are using a window longer than that of the baseline specification, we control for both the county linear and quadratic trends. The results remain significant.

Additionally, we estimate the following specification, in which $I^T_{jt} \times \Delta \ln CLR_{j,t-\tau}$, rather than $I^T_{jt}$, is used as the treatment variable.

$$\ln R_{ijt} = \sum_{\tau=-2}^{2} \theta_\tau [I^T_{jt} \times \Delta \ln CLR_{j,t-\tau}] + \beta_1 Parcel_{ij} + \beta_2 \ln X_{jt} + \beta_3 \ln X_{jt} \times Trend_t + \beta_4 \Delta \ln NatPol_{jt} + Trend_t + \alpha_j + u_t + \varepsilon_{ijt}$$  

(4-11)

$\Delta \ln CLR_{j,t-\tau}$ indicates the average change of (log) minimum CLR within the province (averaged over industry types). In this specification, we consider the differential change across events, and now the treatment switches from 0 to $\Delta \ln CLR_{j,t-\tau}$ at event date $\tau = 0$. As is regulated in the policy, changes in FAII and FAR can be used to measure the change in CLR. Nonetheless, we prefer to rely on the results using the FAII, since it includes both the structure and equipment investment, while FAR refers to the structure only. In the same specification, we also use the change of (log) minimum CLR of the county, instead of the province, to measure $\Delta \ln CLR_{j,t-\tau}$. The results are shown in Columns (7) and (8).

Column (7) uses the change in the average value of minimum FAI in a province, and Column (8) uses the change in a county. The results indicate that when the province government raises the minimum FAI by 100%, the land price decreases by about 23%, which is a little larger than our baseline result, 15.8%.
**CHAPTER 4**

Table 4.4: Impacts of CLR regulations on industrial land price (robustness).

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
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<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta \ln R_{0/3}$</td>
<td>-0.063**</td>
<td>-0.077***</td>
<td>-0.064**</td>
<td>-0.053**</td>
<td>-0.069**</td>
<td>-0.047**</td>
<td>-0.231***</td>
<td>-0.230**</td>
</tr>
<tr>
<td></td>
<td>(0.027)</td>
<td>(0.030)</td>
<td>(0.027)</td>
<td>(0.022)</td>
<td>(0.031)</td>
<td>(0.022)</td>
<td>(0.088)</td>
<td>(0.094)</td>
</tr>
<tr>
<td>County linear trends</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>County quadratic trends</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Window: Ante4-Post7</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Window: Ante6-Post5</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Window: Ante4-Post9</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Province average value</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>County average value</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>R²</td>
<td>0.653</td>
<td>0.716</td>
<td>0.777</td>
<td>0.777</td>
<td>0.777</td>
<td>0.777</td>
<td>0.653</td>
<td>0.655</td>
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<td>290637</td>
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</tbody>
</table>

Notes: This table reports the results of the robustness test. $\Delta \ln R_{0/3}$ is the average treatment effect from the first half year to the fourth half year. Column (1) is the baseline specification, Column (2) and Column (3) control for the county linear and quadratic trends, Column (4) and Column (6) use different event windows, Columns (7) and (8) use continuous measures (the average minimum FAII in the province or county) of the treatment instead of the policy dummy. Standard errors in parentheses are clustered on county fixed effects. + p < 0.15, * p < 0.10, ** p < 0.05, *** p < 0.01.

Last, we estimate the following two-way fixed effects model:

$$\ln R_{jt} = \sum_{\tau = -2}^{2} \theta_{\tau} \ln CLR_{j,t-\tau} + \beta_1 Parcel_{ij} + \beta_2 \ln X_{jt} + \beta_3 \ln X_{jt} \times Trend_t + \beta_4 \Delta \ln NatPol_{jt} + Trend_t + \alpha_j + u_t + \epsilon_{ijt}$$

(4-12)

The results are shown in Table 4.5. Column (1) shows the baseline result. Column (2) uses the average FAII value of the province, while Column (3) uses the average FAII value of the county. Different from the baseline results, Columns (2) and (3) show an insignificant price effect, and all signs are positive. The specification of the model could account for this result. In this two-way fixed effect setting, we estimate by comparing the land price within the entire period; however, as implied in the baseline results, the province policy is no longer binding in the farther periods. Therefore, the increase in minimum CLR driven by market forces in the long run can be accompanied by an increase in the land price, resulting in a seemingly positive price effect.
Table 4.5: Impacts of CLR regulations on industrial land price (two-way FEs).

<table>
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<tr>
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<th>Baseline</th>
<th>Province</th>
<th>County</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>$\Delta \ln R_{0/3}$</td>
<td>-0.051*</td>
<td>0.024</td>
<td>0.040</td>
</tr>
<tr>
<td></td>
<td>(0.031)</td>
<td>(0.038)</td>
<td>(0.030)</td>
</tr>
<tr>
<td>Province average value</td>
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<td></td>
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</tr>
<tr>
<td>County average value</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>R2</td>
<td>0.653</td>
<td>0.651</td>
<td>0.653</td>
</tr>
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<td>Observations</td>
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<td>243211</td>
<td>242996</td>
</tr>
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</table>

Notes: This table reports results from two-way fixed effect specifications. $\Delta \ln R_{0/3}$ is the average treatment effect from the first half year to the fourth half year. Column (1) is baseline specification, Column (2) uses the average value of minimum FAII in the province. Column (3) uses the average value of minimum FAII in the province. Standard errors in parentheses are clustered on county fixed effects. + p < 0.15, * p < 0.10, ** p < 0.05, *** p < 0.01.

4.6.3 Heterogeneous effects

By estimating the baseline specification using sub-groups, we analyze the heterogeneous effect across parcel size, economic development, and parcel’s distance to the city center to explore the underlying mechanism. We divide the parcels within one county and one quarter into two groups according to the size of the parcel and the distance to the county center separately. Columns (1) and (2) in Table 4.6 show that the regulation has a slightly larger impact on a large parcel, which indicates a larger price impact for big firms. One reason behind this result is that a large firm tends to take the stipulated capital investment more seriously due to the higher probability they are supervised by the government or greater caution about the default clause, which we found in the survey. Another possible reason is that large firms generally have more location choices and are more mobile, inducing fiercer competition among regions.

Columns (3) and (4) show that the regulation has a larger impact on parcels located farther away from the county center. A possible underlying reason is that farther parcels could have a smaller CLR without regulations; therefore, the regulation that is uniform in a county is supposed to be more stringent for them.

Moreover, we divide the parcels within one province and one quarter into two groups according to the county’s fiscal revenue per capita and secondary GDP per capita separately. Columns (5) and (6) show that the regulation has a significantly larger impact on counties with higher fiscal revenue per capita. Similarly, Columns (7) and (8) show a significantly larger impact on counties with higher secondary GDP per capita. These results imply that the provincial government tends to impose a more stringent regulation on developed counties when designing the CLR policies.
Table 4.6: Impacts of CLR regulations on industrial land price (heterogeneous effects).

<table>
<thead>
<tr>
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<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Large parcel</td>
<td>Small parcel</td>
<td>Far away from CBD</td>
<td>Close to CBD</td>
<td>High fiscal revenue</td>
<td>Low fiscal revenue</td>
<td>High secondary GDP</td>
<td>Low secondary GDP</td>
</tr>
<tr>
<td>ΔlnR_{0/3}</td>
<td>-0.065**</td>
<td>-0.049*</td>
<td>-0.059+</td>
<td>-0.036*</td>
<td>-0.138*</td>
<td>-0.014</td>
<td>-0.105*</td>
<td>-0.021</td>
</tr>
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<td>(0.028)</td>
<td>(0.028)</td>
<td>(0.038)</td>
<td>(0.021)</td>
<td>(0.079)</td>
<td>(0.019)</td>
<td>(0.063)</td>
<td>(0.020)</td>
</tr>
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<td>0.624</td>
<td>0.703</td>
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</tbody>
</table>

Notes: This table reports the results of sub-group specifications. ΔlnR_{0/3} is the average treatment effect from the first half year to the fourth half year. Columns (1) and (2) estimate the price effect for parcels with large and small sizes within one county and one quarter, Columns (3) and (4) for parcels located far from or close to the county center within one county and one quarter, Columns (5) and (6) for counties with high and low fiscal revenue per capita, and Columns (7) and (8) for counties with high and low secondary GDP per capita. Standard errors in parentheses are clustered on county fixed effects. * p < 0.10, ** p < 0.05, *** p < 0.01.

4.7 Conclusions

By establishing a motivating theory, we show that binding CLR regulations can induce a loss for firms relative to the situation without regulations. When the firm’s loss is compensated by county governments through lowering the land price, we can observe a negative price effect of minimum-CLR regulations. Using a DID event study design, we have documented a significantly negative price effect of province minimum-CLR regulations. Specifically, the land price decreases by 15.8% if the minimum CLR is doubled. Besides, we have documented that the negative price effect disappears in the long run, which may be caused by the increase in the equilibrium density level determined by market forces. Our results are robust to adding controls for county-specific linear and quadratic time trends, different event windows, and continuous treatment indicators. We have also found that province CLR regulations have a slightly larger impact on the price of large parcels, a significantly larger impact for counties with higher fiscal revenue per capita and secondary GDP per capita, and possibly a larger impact on parcels located farther away from the county center.

By showing that more stringent regulatory tools can weaken the price tools or price mechanism, our research suggests that the regulatory tools and price tools can substitute each other in land allocation. However, we have not offered evidence of whether regulatory tools are efficient in allocating land. From interviews with local officials, we know that implementing regulatory tools is costly for governments. Besides, regulatory tools may induce the firm to invest more (in specific aspects), thus impacting productivity.

Although our evidence comes from province regulations, our research may also imply county governments’ possible use of minimum CLR in allocating industrial land. The

declining price effect indicates that county governments, as the market participants in our theoretical model, raise the minimum CLR within their jurisdictions with time. On the other hand, the minimum CLR determined by county governments seems to be lower than the CLR desired by the upper-level government. A question that then arises is how to motivate county governments to impose a higher minimum CLR other than through direct regulation by upper-level governments? The possible answer includes improving county governments’ tax incentives by raising the sharing rate of value-added tax (VAT) revenue, enhancing political incentives by assigning more weight to the CLR when evaluating local official performance, or reducing the quota of available land.

Moreover, our research helps understand how policy tools aiming to intervene in industrial development impact the industrial land market. Like density regulations, the environmental standards for industrial firms or restrictions on industry types may also impact the price of land zoned as industrial use. In China’s case, the losses caused by the lower land price are borne by local governments, as they are landowners, while in other cases, private landowners may have to suffer these losses. If this is true, a corresponding subsidy policy is needed when regional governments use regulatory tools to intervene in industrial development.
CHAPTER 5

The Use of Capital-Land Ratio Regulations in Allocating Industrial Land: Theory and Evidence from China
Abstract: Local governments worldwide are highly engaged in using various public policies to intervene in local industrial development. This paper explores how capital-land ratio (CLR) regulations are used as a discretionary policy tool to screen out or attract industrial firms. Based on institutional settings in China, we establish a theoretical model to characterize how local governments use CLR regulations, land price, and subsidies to allocate industrial land (and screen out or attract firms) when faced with the tax-sharing scheme, frictions connected to the need to subsidize firms, and regional competition. Like the existing literature, we model the bidding for firms as a private value open-outcry ascending scoring auction and provide an equilibrium in which the tax revenue incentivizes local governments to strengthen CLR regulations, and the friction costs of subsidizing and the competition for mobile capital lead them to weaken CLR regulations. Using parcel-level CLR regulations from 2011 to 2018 in China, we empirically document that when county-level governments are allocated a larger share of value-added tax (VAT) revenue, they tend to impose a larger minimum CLR on the firm. Our findings add to knowledge on how land-use regulations (LURs) and subsidies are simultaneously used in regional competition and help understand the relationship between the tax scheme and LURs.

Keywords: Capital-land ratio; industrial land; tax scheme; subsidy; regional competition
5.1 Introduction

Local governments use various public policies to intervene in local industrial development. These policies, whether they are economic incentive policies or regulatory policies, can impact the location of industrial firms as well as the spatial distribution of industrial activities. The motivation for these local policies and their welfare consequences have raised great interest in academia and have been investigated intensively. Recently, firm-specific policy tools, such as subsidies offered to firms, have been given increasing attention, fueled by the availability of comprehensive data. A typical firm-specific policy can vary among individual firms according to local governments' objectives and firms' heterogeneity in terms of productivities and externalities. This feature can make the local policy better at adapting to the economic environment and internalizing the externalities brought by firms, which is supposed to lead to an efficient allocation of industrial capital.

In this paper, we focus on how capital-land ratio (CLR) regulations are used as a firm-specific policy tool to screen out or attract industrial firms. Here, CLR regulations refer to the minimum industrial capital per unit of land required by local governments. These regulations must be specified when supplying parcels to industrial projects in China. The central government (and some provincial or municipal governments) requires a county-specific minimum standard, and the county government can decide whether to impose a higher value parcel by parcel. Since urban land is state-owned and all newly available parcels are supplied by local governments, our research question is also about how CLR regulations are used to allocate industrial land in the land market in China's context.

We establish a theoretical model to rationalize the use of discretionary CLR regulations, in which there are two prominent features regarding its impact on firms' locations: 1) strengthening of CLR regulations to screen out firms when firms compete for a location; 2) weakening of CLR regulations to recruit firms when localities compete for firms. Together with the use of the other two instruments, land price and subsidy, our model characterizes the allocation mechanism of newly available industrial land. The model's basic idea is that, on the one hand, local governments use CLR regulations and land prices to maximize the net benefits brought by the firm and screen out unwanted firms; on the other hand, they use subsidy (or a reduction in land prices or a relaxing of CLR regulations) to win the firm due to regional competition for moving industrial capital.

We model the use of CLR regulations in the public land supply, aiming to make the model setting consistent with the institutional background in China. We analyze how these three types of instruments are used to adapt to the institutional and economic constraints faced by county governments, which mainly refer to 1) the sharing scheme of tax revenues regarding industrial production; and 2) the relative economic (dis)advantage of

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69 See (Agrawal, Hoyt, and Wilson 2020) for a recent literature review.
70 The tax scheme is determined by upper-level governments; thus, land is the main tool that county governments use to achieve their goals. Related regulatory policies determined by upper-level governments consist mainly of the land quota system, which regulates only the total amount of land use and leaves much room for county governments to manipulate how land should be allocated.
their rivals in terms of recruiting industrial firms. Our model is informed by a survey of the land supply practice of local governments in China and is closely related to the theory put forward by Cheung (2014) and Slattery (2020).

Specifically, local governments obtain the tax revenue and land price and value all positive and negative externalities. When industrial land is supplied, the tax scheme and state-owned land system lead to a share tenancy contract between county governments and firms. Furthermore, we model the regional competition for industrial firms as a private value open-outcry ascending scoring auction. Specifically, firms pick a location from different regions in terms of obtaining the highest payoff, including various forms of subsidies. To recruit the firm, local governments have to offer a subsidy higher than the subsidies offered by competitors.

We distinguish two types of benefits for the local government. The first is the land price and tax revenue, both of which can be affected by the number of capital inputs. The other includes various forms of externalities, which are related only to the locating of the firm and are independent of the number of capital inputs. Therefore, to maximize the net benefits for the local government, the firm can increase its capital inputs in one location to the extent that the marginal product of the capital (rather than the marginal production gained by the firm) equals the capital interest. It should be noted that in that case, the marginal production gained by the firm is below the capital interest, which implies that the firm bears a certain amount of loss due to the increase in capital inputs. Besides, since the marginal product of the capital is no smaller than the capital interest, the increased tax revenue is larger than the induced losses for the firm. To compensate the firm for the loss, the local government must use a lower land price or other forms of compensation. We define this compensation as a regulation-induced subsidy. We assume that local governments can be more or less efficient in achieving subsidizing. Therefore, the optimal minimum CLR for a local government can be smaller if they are less efficient in achieving subsidizing.

Furthermore, facing competition from its rivals, the local government has to offer an additional subsidy to win the firm. This competition-induced subsidy needs to be larger than the maximum one its rivals could afford. Given the maximum competition-induced subsidy determined by its rivals, the local government uses the minimum CLR to maximize net benefits, resulting in a smaller CLR than would be the case without regional competition.

Our research differs from that of Slattery (2020) in two aspects. First, we generalize the model to include the locating choice of small firms. Small firms tend to closely attach themselves to one locality and rarely have an interest in other localities, which means that there is no bidding for small firms among localities. We achieve this by allowing the firm’s productivity to vary with locality.

We empirically test one important proposition derived from the model: how the tax scheme can impact CLR regulations. Specifically, we explore whether the value-added
tax (VAT) scheme in China affects fixed assets investment intensity (FAII) regulations. Although the VAT rate is the same across regions, as regulated by the central government, the sharing scheme regarding VAT revenue for local governments is determined by their upper-level governments. Therefore, county-level governments’ sharing percentage of VAT revenue may be different due to the tax-sharing scheme. We argue that county governments are incentivized more if they are assigned a larger percentage of VAT revenue. We identify the impact on FAII regulations by using the two-way fixed effects model, which utilizes the post-2011 change in the VAT-sharing scheme in place between province and sub-province governments and the post-2016 change in the VAT-sharing scheme in place between the central government and sub-national governments to measure the variation in VAT-sharing percentage by county governments. The estimated results show that if the sharing percentage of VAT revenue by county governments increases by 10%, the FAII they impose will be increased by 7.8%. The positive impact is consistent with our theory and implies that a more decentralized tax-sharing scheme can help improve land-use efficiency. Besides, we show that our baseline results are robust to the variation in tax schemes resulting from either provincial or national reform and to the specification that instruments the tax-sharing percentage by county governments with regional inequalities. Last, by using the land price as the dependent variable to implement a falsification analysis, we show that our baseline result is not likely to be driven by industrial land’s supply or demand forces.

This paper is structured as follows. Section 5.2 reviews the literature on the use of firm-specific tools and the impacts of the tax scheme on land-use regulations (LURs). Section 5.3 introduces CLR regulations and the tax-sharing scheme in China. In section 5.4, we establish a theory to characterize how local governments use CLR regulations, the land price, and subsidies to allocate industrial land. Next, we empirically test the impact of the tax-sharing scheme on CLR regulations in section 5.5. Section 5.6 concludes.

5.2 Literature review

5.2.1 The use of firm-specific policy tools when intervening in local industrial development

Our research is closely related to the use of firm-specific policy tools when intervening in local industrial development. Firm-specific policy tools are driven by the fact that a firm can be more valuable than other firms to one region if it has a larger productivity or brings more positive externalities. They include a variety of business incentives and regulatory policies. Of all incentives, firm-specific incentives have received most attention in the literature.

Subsidy-giving to a firm is justified when increased tax revenues exceed the marginal cost of providing public goods (Black and Hoyt 1989). Moreover, firm-specific incentives can have many advantages because of targeting. For example, offering firm-specific incentives allows local governments to recruit a single (or group of) attractive firm(s) instead of subsidizing all firms, contract with the firm regarding investment and
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employment (Slattery and Zidar 2020), or price-discriminate firms that are more responsive to tax rates and raise revenues more efficiently (Ramsey 1927). On the other hand, firm-specific incentives can have significant disadvantages. Not only is evaluating the necessary subsidies difficult for local governments, but the policymaking process can also be strongly influenced by political reasons rather than economic rationales due to a lack of transparency (Slattery and Zidar 2020). These two opposite forces are notably reflected in the fact that the incentives favor larger establishments in manufacturing, technology, and high-skilled service industries (Slattery and Zidar 2020). For example, as pointed out by Bartik (2019), dealing with a few larger firms is more efficient in terms of administrative costs per job, and subsidizing larger firms rewards politicians through media attention.

The evidence on the impacts of firm-specific incentives is highly controversial. The first type of evidence concerns the firm’s location. Slattery (2020) documents a positive effect on location choice among the largest establishments, while Mast (2020) finds little impact for mobile firms within New York State. Moreover, although direct employment gains from offering subsidies to attract firms are observed (Slattery and Zidar 2020), there is no obvious evidence that firm-specific tax incentives increase broader economic growth at the state and local level (Slattery and Zidar 2020).

Moreover, land supply is used as an important policy tool in intervening in industrial development in China. It has been reported that local governments in China compete fiercely for industrial firms, using various policy tools in terms of industrial land supply, such as reducing land prices (Kajitani and Fujii 2016, Wu et al. 2014), leasing land through negotiation (Yang and Peng 2015), or increasing the land supply area (Zhang, Zhang, and Chen 2016).

This paper contributes by characterizing how CLR regulations, as well as firm-specific subsidies and land price, are used to intervene in industrial development and the allocation of industrial land. We model the interaction between firm-specific subsidies and CLR regulations by introducing the friction costs of subsidizing firms, which are rarely investigated, and characterize how CLR regulations are used to not only attract but also screen out industrial firms.

5.2.2 Impacts of the tax scheme on land-use regulations

Our research is also related to the literature concerning the impacts of tax schemes on LURs. This literature has examined different types of tax schemes. Using the change in the additional sales tax levied by county governments in Florida, Burnes, Neumark, and White (2014) find that a higher sales tax rate leads to more employment in larger stores and shopping malls and less employment in manufacturing, which suggests that those jurisdictions with higher sales tax rates tend to zone more land for business than for manufacturing. Given the constant tax rate in China, a decline in the sharing percentage

Friction costs of engaging in regional competition can be impacted by restrictions on fiscal competition among lower-level governments (Agrawal, Hoyt, and Wilson 2020), as well as many other policy constraints from upper-level governments.
of the enterprise income-tax revenue by local governments motivates them to shift efforts from fostering industrial growth to developing the real estate and construction sectors (Han and Kung 2015), and an increase in VAT revenue shared by local governments leads to an increase in industrial land supply (Xie, Zhu, and Li 2019). Moreover, Cheshire and Hilber (2008) evaluate the impact of the Uniform Business Rate reform in the UK, which decrees a national rate and accrues revenues to the central government, and find that the stringency of commercial LURs (measured by regulatory tax) has increased significantly after the reform. A very interesting point is that this reform was intended to prevent local governments from penalizing entrepreneurship by imposing a too high property tax; in the end, it increased the costs of office space. In addition, some research has investigated the impact of fiscal equalization policies that inversely relate fiscal transfer to tax revenue. This policy weakens local governments’ incentives to expand their tax base. Fraenkel and Krumholz (2019) examine the school finance equalization reforms enacted by states in the US. These state reforms not only greatly increased the degree to which state transfers were tied to local property wealth but also regulated tax ceilings and floors. They find that both manufacturing employment and the number of large manufacturing establishments decreased greatly after the reforms. Another such tool is the equalization grant in Germany, which is larger for municipalities with lower fiscal capacity and is the key instrument for fiscal redistribution. Büttner (2021) documents that both commercial and residential land use expand more slowly in municipalities exposed to the policy.

Our research contributes by focusing on the impact of tax schemes on CLR regulations for industrial activities. This type of regulations is different from the amount of land supply or regulatory tax that are explored by the existing literature and supplements the regulatory tools caused by the change in the tax scheme. For example, together with Xie, Zhu, and Li (2019), our results show that when they are allowed to obtain a larger share of VAT revenue, local governments in China on the one hand make more industrial land available and on the other hand try to improve land-use efficiency by requiring a higher minimum CLR.

5.3 Institutional background

The LURs system in China is highly centralized, and CLR regulations are no exception. Since 2004, the central government has started to stipulate the minimum or maximum CLR for different counties regarding floor area ratio (FAR), the proportion of land occupied by the administrative office and living service facilities, the coefficient of building occupation, the percentage of green space, and the minimum fixed assets investment (FAI) per unit of land. Among these, FAI is the most important, as it includes construction, structure and auxiliary facilities, equipment investment, and land-leasing fees and varies according to the grades of counties. The central government increased the regulated value in 2008. Moreover, it recently announced that this policy would be revised again. The exposure draft was posted in March 2021 and decreed the index of minimum production value and tax revenue as well. Local governments must follow the above policies when determining their own ILURs.
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Besides, provincial governments also issue minimum-CLR policies for the counties within their jurisdictions.\textsuperscript{72} We have observed a total of 26 events of provincial minimum-CLR policy adoption after 2003. Provincial CLR regulations may just raise the value of CLR specified in the national policy or impose more detailed restrictions. In terms of the latter, for example, the regulatory policy by Jiangsu Province in 2014 stipulated the plant capacity per unit of land, which differed with four-digit industries and firm size (the plant capacity).

County governments have the autonomy to use more stringent CLR regulations than upper-level governments. They may stipulate different minimum CLR for different locations within their jurisdictions, for different (more specific) industry types, or even for different firms. They may also regulate more aspects of CLR, such as tax payment by the firm. The key reason that these detailed regulations are possible is that county governments are both policymakers and land suppliers. They can thus impose discretionary regulations parcel by parcel when supplying the land, in the form of the land-leasing contract and investment agreement. The land-leasing contract is generally the same across counties and covers only the regulations required by the central government,\textsuperscript{73} including the minimum FAII. The investment agreement varies greatly across firms within a county, according to surveys conducted in Nanjing and Wuxi city in Jiangsu Province, and Yiwu city Zhejiang Province. A typical investment agreement will stipulate the minimum value for a given parcel of land regarding total investment (including FAI), plant capacity, tax payment, and employment, although the default clause is generally vague. We learn from the investment agreement that the CLR regulations imposed by county governments include rich information; however, given data availability, in the empirical analysis we can analyze only the required minimum FAII that most counties announce on the official land market website.

Apart from regulatory policies, subsidy-giving is argued to also be widely used by local governments in China in order to compete for industrial firms, although direct evidence is limited. Our survey of investment agreements offers two types of evidence. The first is that subsidy-giving items are mentioned ambiguously in the default clause of CLR regulations. The other is that if the land price after auction is higher than a certain value agreed to beforehand, the gap will be returned to the firm as an investment subsidy. Similarly, the negative relationship between land price and investment is also found in the provincial policy of Guizhou from October 2011, which decrees that the land price can be reduced by 25% if the FAII is raised by more than 40%.

VAT and corporate income tax (CIT) are two main tax payments by industrial firms in China. The rate of both taxes is constant across the country. For example, the VAT rate is mostly 17% for industrial sectors (except for some agricultural sectors). They are both shared among vertical governments (VAT since 1994, CIT since 2001), and the tax-sharing scheme is implemented in a top-down way. First, the central government decides on the tax share

\textsuperscript{72} We also find that some municipalities enacted minimum-CLR policies spontaneously, such as Shenzhen city in 2006 and Chengdu city in 2010.

\textsuperscript{73} After 2014, Shanghai city adds more detailed regulations into the contract, such as restrictions on tax payment, employment, and environmental pollution.
between national and sub-national levels (including the provincial and sub-provincial governments). Next, provincial and municipal governments determine the tax share between themselves and sub-regional governments in turn. The tax-sharing arrangement varies across provinces and municipalities and changes with time, especially for VAT. Since May 2016, the sharing percentage of VAT by the central government has changed from 75% to 50%, as part of the reform that replaces business tax with VAT. The tax-sharing scheme can determine the tax revenues obtained by county-level governments. Given that the VAT rate stays the same, a larger tax-sharing percentage by county governments means a larger benefit from the firm’s production and thus a larger incentive.

5.4 Theory

In this section, we establish a model to characterize how local governments use CLR regulations, land price, and subsidies to allocate industrial land (and screen out or attract firms) when faced with tax-sharing schemes, friction costs related to subsidizing firms, and regional competition. We first introduce the structure of the land transaction under a tax-sharing scheme and state-owned land system consistent with settings in China and then consider the impact of regional competition for moving capital.

Our model is based on the theory of China’s economic system established by Cheung (2014). In our model, local governments gain the tax revenue and land price and value all positive and negative externalities, and the tax-sharing scheme and state-owned land system lead to a share tenancy contract between county governments and firms when supplying industrial land. Our model is closely related to the theory on bidding for firms using discretionary policy tools (Slattery 2020). Like Slattery (2020), we model the bidding as a private value open-outcry ascending scoring auction. Specifically, firms choose a location from among regions to obtain the highest payoff, which includes various forms of subsidies. To recruit the firm, local governments have to offer subsidy that is higher than that of competitors.

We distinguish two types of benefits for the local government according to the relationship between the benefits and capital inputs per unit of land. The first is the land price and tax revenue, which can be affected by capital inputs. The other includes various forms of externalities, which are related only to the locating of the firm and are independent of the number of capital inputs.

Therefore, to maximize the net benefits for the local government, the firm can increase its capital inputs in one location to the extent that the marginal product of the capital (rather than the marginal production gained by the firm) equals the capital interest. It should be noted that in this case, the marginal production gained by the firm is below the capital interest, which implies that the firm bears a certain amount of loss due to the increase in capital inputs. Besides, since the marginal product of the capital is no smaller than the capital interest, the increased tax revenue is larger than the induced losses for the firm. To compensate the firm for the loss, the local government must use a lower
land price or other forms of compensation. We define this compensation as a regulation-induced subsidy. We assume that local governments can be more or less efficient in achieving subsidizing. Therefore, the optimal minimum CLR for a local government can be smaller if they are less efficient in achieving subsidizing.

Furthermore, facing competition from its rivals, the local government has to offer an additional subsidy to win the firm. This competition-induced subsidy needs to be larger than the maximum subsidy its rivals could afford. Given the maximum competition-induced subsidy determined by its rivals, the local government uses the minimum CLR to maximize net benefits, resulting in a smaller CLR than would be the case without regional competition.

5.4.1 Basic setup

We have two types of agents. Local governments, \( c \in \{1, \cdots, C\} \), also being the landowners in their jurisdictions, supply locations and recruit firms with subsidies. Firms, \( j \in \{1, \cdots, J\} \), demand locations and receive subsidies. The volume of each location is assumed to be one.

Firms are taxed on their production, and the tax rate is the same across regions. Therefore, firms’ production after tax is the same, no matter where they are located. We set the after-tax production function as \( A_{cj}y(k_{cj}) \), where \( A_{cj} \) is the productivity of the firm \( j \) in region \( c \), and \( k_{cj} \) is the capital input. Firms’ productivity can vary across regions. The capital interest for all firms is \( k \). We assume that the after-tax production increases with the capital input in a decreasing way, that is, \( \frac{\partial y(k_{cj})}{\partial k_{cj}} > 0 \) and \( \frac{\partial^2 y(k_{cj})}{\partial k_{cj}^2} < 0 \).

The tax-sharing scheme, which regulates how the tax revenue is shared between local governments and their upper-level governments, is determined by upper-level governments completely. The tax revenue obtained by local governments is a fixed percentage of the total tax revenue and is thus also a fixed percentage of the firms’ after-tax production. We denote the latter percentage as \( t_c \) and allow it to be different across regions; then, the tax revenue shared by local governments is \( t_c A_{cj} y(k_{cj}) \). It is reasonable to assume that only this part of tax revenue can offer an incentive for local governments in their policymaking, while the tax revenue obtained by upper-level governments offers no incentive. In other words, under the assumed tax scheme, the firm’s production function from the perspective of local governments is \((1 + t_c)A_{cj}y(k_{cj})\).

The land price, \( r_{cj} \), is fully obtained by local governments. Besides, the local government puts a valuation on externalities brought by firms,\(^{74}\) \( v_c(e_{cj}) \), where \( e_{cj} \) indicates a set of externalities and \( v_c(\cdot) \) is the valuation function. The valuation function for externalities can differ by region, and firms can generate heterogeneous externalities.\(^{75}\) We assume

\(^{74}\) These externalities include many types of benefits, such as increasing attraction for other firms and residents (and thus higher land revenues); they also contain negative impacts brought by the firm, such as more congestion, a higher cost of raising funds, and increasing demand for public services.

\(^{75}\) Following Slattery (2020), one can think of the valuation of a firm to be a function of location and firm characteristics.
that externalities are independent of the number of capital inputs. Moreover, the local government is faced with costs when supplying locations, $c_e$, such as the cost of acquiring and servicing land or the cost of offering public services consumed by the firms.

### 5.4.2 Firms’ competition for locations

We first characterize how firms compete for locations. We achieve this by introducing a location transaction model in which the firm gains zero profit and reaches a land contract with the local government that stipulates the minimum capital input, land price, and subsidies offered to firms.

Since the local government obtains a fixed percentage of industrial production according to the tax scheme, the structure of the location transaction can be abstracted as a share tenancy contract between the local government and the firm, and this share tenancy has a constant sharing percentage $\frac{t_e}{1+t_e}$. Given this share tenancy contract, the local government is supposed to impose a minimum CLR that is larger than the optimal one from the perspective of firms (Cheung 2014, 1968). This minimum CLR is also the capital input, given our setting in which the area of each location is 1, denoted as $k_{cj}^*$. We will rationalize the use of $k_{cj}^*$ in this section.

First, we consider the situation that there are no CLR regulations imposed by local governments. In this case, the firm will invest capital to the degree that the marginal after-tax production equals capital interest, that is, the firm’s optimal capital input $k_{cj}^{*(f)}$ satisfies the following equation:

$$\frac{\partial y(k_{cj}^{*(f)})}{\partial k_{cj}^{*(f)}} = \frac{i}{A_{cj}} \quad (5-1)$$

For the local government, right now, the tax revenue is $t_eA_{cj}y(k_{cj}^{*(f)})$ and the land price is maximized, denoted as $r_{cj}^{*(f)}$, and $r_{cj}^{*(f)} = A_{cj}y(k_{cj}^{*(f)}) - ik_{cj}^{*(f)}$.

However, the firm’s optimal capital input may not be optimal for the local government, since improving capital input can increase production and thus increase the tax revenue. Therefore, we allow the local government to impose minimum-CLR regulations that are larger than the firm’s optimal capital input in order to maximize net benefits for the local government.

According to our settings, the local government gains the tax revenue and land price, values the externalities brought by the firm, and bears the costs related to the location supply. In addition, another type of cost for the local government is induced by CLR regulations. Specifically, a larger capital input (than the firm’s optimal one) makes the marginal after-tax production of the capital smaller than the capital interest and causes a certain amount of losses for the firm. The local government must compensate the firm for
these losses. We define the compensation for the firm’s losses as a subsidy and denote it as \(s_{cj}\). This regulation-induced subsidy equals the gap between the revenue that the production factors (capital and land) should gain and the after-tax production, that is:

\[
s_{cj} = ik_{cj} + r_{cj}^*(f) - A_{cj}y(k_{cj})
\]  
(5-2)

Note that here, we use the maximum land price in a situation without CLR regulations to measure the return to land. Given the above benefits and costs, the local government’s net benefits, denoted as \(b_{cj}\), are as follows:

\[
b_{cj} = (1 + t_c)A_{cj}y(k_{cj}) + v_c(e_{cj}) - c_c - ik_{cj}
\]  
(5-3)

The local government is supposed to choose a specific capital input to maximize net benefits. The first derivative of \(b_{cj}\) with respect to \(k_{cj}\) is:

\[
\frac{\partial b_{cj}}{\partial k_{cj}} = \frac{(1 + t_c)A_{cj}\partial y(k_{cj})}{\partial k_{cj}} - i
\]  
(5-4)

According to the first order condition, \(\frac{\partial b_{cj}}{\partial k_{cj}} = 0\), we can derive that the optimal capital input, \(k_{cj}^*\), satisfies the following equation:\(^{76}\)

\[
\frac{\partial y(k_{cj}^*)}{\partial k_{cj}^*} = \frac{i/A_{cj}}{(t_c + 1)}
\]  
(5-5)

It is clear that \(\frac{\partial y(k_{cj}^*)}{\partial k_{cj}^*} > \frac{\partial y(k_{cj}^*)}{\partial k_{cj}^*}\), implying that the local government’s optimal capital input \(k_{cj}^*\) is larger than the firm’s optimal capital input \(k_{cj}\), consistent with the share tenancy theory (Cheung 2014, 1968).

So far, we have not asked in which way the firm is subsidized. An obvious policy tool in our model is lowering land prices; however, other subsidizing channels may also be used. Which specific tools are available and what the cost of using them play a role in the local government’s choice. Possible forms of subsidies include a lump sum cash subsidy, a long-run cash subsidy, a lower land price, tax credit, tax holiday, or other additional services valuable to the firm (Slattery 2020, Bartik 2019). It is reasonable to argue that the total costs of subsidizing the firm may differ depending on these policy tools and may also vary across regions. Therefore, the policy tools that the local government eventually chooses can be influenced by local economic constraints that impact the total costs of subsidizing the firm. For example, limited fiscal revenue may prevent the use of direct subsidies in the short term; instead, the local government can lower land prices, allow a tax holiday in the long run, or offer additional services. Besides, the choice of policy tools can also be affected by policy constraints from upper-level governments. For example, if any form of tax reduction is forbidden, local governments have to rely more on other

\(^{76}\) If subsidizing the firm is too costly due to economic and policy constraints, the local government will have to accept a lower capital input than the optimal one in order to reduce subsidies that it should pay to the firm. It seems that the marginal production is now smaller than the capital interest, but if we add the cost of subsidizing the firm into the local government’s marginal production function, then the lower capital input can be regarded as a new equilibrium.
tools, such as reducing the land price or offering services. Based on the above analysis, we assume that the total costs of subsidizing the firm are a function of the subsidy required by the firm, denoted as $S_c(s_{cj})$; specifically, the total costs of subsidizing the firm are larger than the subsidy required by the firm and increase with the subsidy in an increasing way,\footnote{A similar idea is shown by Bartik (2019), who finds that the economic costs of incentives are higher than their dollar costs.} that is, $\frac{\partial S_c(s_{cj})}{\partial s_{cj}} > 1, \frac{\partial^2 S_c(s_{cj})}{\partial s_{cj}^2} > 0$.

Replacing the subsidy required by the firm with the total costs of subsidizing, we can obtain the new function of the local government’s net benefits, which is as follows:

$$b_{cj} = t_c A_{cj} y(k_{cj}) + r_{cj}^* + v_c(e_{cj}) - c_c - S_c(s_{cj}) \quad (5-6)$$

Again, according to the first order condition, $\frac{\partial b_{cj}}{\partial k_{cj}} = 0$, we can derive that the optimal capital input satisfies the following equation:

$$\frac{\partial t_c A_{cj} y(k_{cj}^*)}{\partial k_{cj}^*} = \frac{\partial S_c(s_{cj}^*)}{\partial s_{cj}^*} \times \frac{\partial s_{cj}^*}{\partial k_{cj}^*} \quad (5-7)$$

Since $\frac{\partial s_{cj}}{\partial k_{cj}} = i - A_{cj} \frac{\partial y(k_{cj})}{\partial k_{cj}}$, this equation can also be written as:

$$\frac{\partial y(k_{cj}^*)}{\partial k_{cj}^*} = \left( \frac{t_c}{\frac{\partial S_c(s_{cj}^*)}{\partial s_{cj}^*} + 1} \right)$$

As $\frac{\partial S_c(s_{cj})}{\partial s_{cj}} > 1$, we can learn that taking the frictions costs of subsidizing into consideration leads to a larger $\frac{\partial y(k_{cj}^*)}{\partial k_{cj}^*}$, which indicates a smaller optimal capital input for the local government.

### 5.4.3 Regional competition for moving capital

Prepared by the structure of the land transaction in the above analysis, we further introduce regional competition for firms into the theoretical model by using an example of two regions bidding for one firm. As we mentioned at the beginning of section 5.4, we model the bidding as a private value open-outcry ascending scoring auction.

Consider that there are two regions $c \in (c, -c)$. According to the model in section 5.4.2, the firm can gain capital cost only and have no profits in both regions; therefore, there is no difference for the firm in locating in either region. We assume that the firm will
locate in a region that can offer a higher additional subsidy (apart from the regulation-induced subsidy) than the others. To recruit the firm, two regions compete to offer higher additional subsidies. For example, following the private value open-outcry ascending scoring auction, region _c may first promise to give the firm a subsidy \( s \), region _c then learns about the rival’s offer and gives the firm a higher subsidy \( s + \varepsilon \), and region _c will bid again using a subsidy higher than \( s + \varepsilon \). The subsidy in the equilibrium is an \( s + \varepsilon \), that makes the maximum net benefits equal to zero for one region and larger than zero for the other region. For instance, \( b^*_c = 0 \) while \( b^*_c > 0 \), which means that the firm locates in region _c. We also learn that the equilibrium subsidy \( s + \varepsilon \), is slightly larger than the highest bidding \( s \) that region _c is willing to offer; in other words, the equilibrium subsidy is determined by the winner’s rival.

We first solve the maximum competition-induced subsidy problem for the winner’s rival _c_. Imaging that region _c_ first selects a magnitude of the subsidy \( s \), then adjusts the capital input regulation to maximize its net benefits \( b_c \). The first derivative of \( b_c \) with regard to \( k_c \) is,

\[
\frac{\partial b_{cj}}{\partial k_{cj}} = t_c A_{cj} \frac{\partial y(k_{cj})}{\partial k_{cj}} - \frac{\partial S_c(s_{cj} + s)}{\partial (s_{cj} + s)} \left( i - A_{cj} \frac{\partial y(k_{cj})}{\partial k_{cj}} \right) \\
= A_{cj} \left( t_c + \frac{\partial S_c(s_{cj} + s)}{\partial (s_{cj} + s)} \right) \frac{\partial y(k_{cj})}{\partial k_{cj}} - i \frac{\partial S_c(s_{cj} + s)}{\partial (s_{cj} + s)}
\]

(5-9)

According to the first-order condition (FOC), the \( k^*_c \) that maximizes \( b_c \) satisfies:

\[
\frac{\partial y(k^*_c)}{\partial k^*_c} = \frac{i/A_{cj}}{\left( \frac{t_c}{\partial S_c(s^*_c + s)} + 1 \right)}
\]

(5-10)

Furthermore, we can derive that \( \frac{\partial^2 y(k^*_c)}{\partial k^*_c \partial s} > 0 \),

\[
\frac{\partial^2 y(k^*_c)}{\partial k^*_c \partial s} = \frac{t_c i/A_{cj}}{\left( t_c + \frac{\partial S_c(s^*_c + s)}{\partial (s^*_c + s)} \right)} \times \frac{\partial^2 S_c(s^*_c + s)}{\partial (s^*_c + s)^2}
\]

(5-11)

and this means that the marginal after-tax production of the capital in equilibrium increases with the competition-induced subsidy, and thus the regulated capital input decreases with the competition-induced subsidy.
The Use of Capital-Land Ratio Regulations in Allocating Industrial Land

We then obtain the first derivative of $b_{cj}^*$ with regard to $s$:

$$\frac{\partial b_{cj}^*}{\partial s} = t_c A_{cj} \frac{\partial y(k_{cj}^*)}{\partial k_{cj}^*} \frac{\partial S_c(s_{cj}^* + s)}{\partial s} - \frac{\partial S_c(s_{cj}^* + s)}{\partial s} \left( i - A_{cj} \frac{\partial y(k_{cj}^*)}{\partial k_{cj}^*} \frac{\partial k_{cj}^*}{\partial s} + 1 \right)$$

$$= A_{cj} \left( t_c + \frac{\partial S_c(s_{cj}^* + s)}{\partial (s_{cj}^* + s)} \right) \frac{\partial y(k_{cj}^*)}{\partial k_{cj}^*} \frac{\partial k_{cj}^*}{\partial s} - \frac{\partial S_c(s_{cj}^* + s)}{\partial (s_{cj}^* + s)} \left( i \times \frac{\partial k_{cj}^*}{\partial s} + 1 \right)$$

(5-12)

According to equation (5-10), the $\frac{\partial b_{cj}^*}{\partial s}$ can be rewritten as:

$$\frac{\partial b_{cj}^*}{\partial s} = i \times \frac{\partial S_c(s_{cj}^* + s)}{\partial (s_{cj}^* + s)} \times \frac{\partial k_{cj}^*}{\partial s} - \frac{\partial S_c(s_{cj}^* + s)}{\partial (s_{cj}^* + s)} \left( i \times \frac{\partial k_{cj}^*}{\partial s} + 1 \right)$$

(5-13)

Next, we know that $\frac{\partial b_{cj}^*}{\partial s} < 0$, indicating that the maximum net benefits decrease with the competition-induced subsidy. Therefore, if the local government keeps raising the magnitude of subsidy $s$, the maximum net benefits can reach zero, that is, $b_{cj}^* = t_c A_{cj} y(k_{cj}^*) + r_{cj}^*(f) + v_c(e_{cj}) - c_c - S_c(s_{cj}^* + s)$. Then, the maximum competition-induced subsidy $s$ satisfies the following equation:

$$s = S_c^{-1} \left( t_c A_{cj} y(k_{cj}^*) + r_{cj}^*(f) + v_c(e_{cj}) - c_c \right) - s_{cj}^*$$

(5-14)

Combined with equation (5-10), we can derive the maximum competition-induced subsidy for region $c$.

One important implication of the above analysis is that regional competition induces a smaller regulated capital input. From another perspective, this implication also means that less stringent capital input regulations are chosen to help maximize the subsidy induced by regional competition, suggesting that CLR regulations can play an important role in regional competition. The intuition behind this relationship is not very straightforward, but we try to illustrate it as follows. Keep in mind that the total cost of realizing the subsidizing grows increasingly with the total subsidy. If the regulation-induced subsidy is put in the margin of total subsidies, the total costs of realizing the regulation-induced subsidy become larger, making it more profitable to relax the regulation. The economic and policy constraints that prevent the use of subsidies determine the cost function of realizing the subsidizing, thus impacting the loosening of CLR regulations' stringency.
According to equation (5-10), the that region $C$ maximizes its net benefits given the minimum competition-induced subsidy $S$. According to the FOC, the optimal $k_{cj}^*$ satisfies the following equation:

$$\frac{\partial y(k_{cj}^*)}{\partial k_{cj}^*} = \frac{i/A_{cj}}{\left( \frac{t_c}{\partial S_c(s_{cj}^* + S)} + 1 \right)}$$ (5-15)

### 5.4.4 Impacts of tax-sharing scheme, friction cost of subsidizing, and regional competition

In this section, we analyze how tax-sharing schemes, friction cost of subsidizing, and regional competition impact the regulated capital input. Since $\frac{\partial y(k_{cj})}{\partial k_{cj}^*}$ decreases with $k_{cj}$, we infer the change in $k_{cj}$ using the change in $\frac{\partial y(k_{cj})}{\partial k_{cj}^*}$. First, we explore the impact of the tax-sharing scheme. The first-order derivative of $\frac{\partial y(k_{cj})}{\partial k_{cj}^*}$ with respect to $t_c$ is as follows:

$$\frac{\partial^2 y(k_{cj}^*)}{\partial k_{cj}^* \partial t_c} = \frac{\left( \frac{\partial S_c(s_{cj}^* + S)}{\partial(s_{cj}^* + S)} \right)^2}{\left( \frac{t_c}{\partial S_c(s_{cj}^* + S)} + 1 \right)^2} \frac{\partial y(k_{cj}^*)}{\partial k_{cj}^*}$$ (5-16)

Since $\frac{\partial S_c(s_{cj} + S)}{\partial(s_{cj} + S)} > 0$ and $\frac{\partial^2 y(k_{cj})}{\partial k_{cj}^*} < 0$, we can learn from this equation that $\frac{\partial^2 y(k_{cj}^*)}{\partial k_{cj}^* \partial t_c} < 0$. This negative relationship means that $\frac{\partial y(k_{cj}^*)}{\partial k_{cj}^*}$ decreases with the local government's sharing percentage of the tax revenue, and thus the regulated capital input increases with this sharing percentage. In fact, the positive impact of the local government's tax-sharing percentage is consistent from simple to relatively complicated model settings. The equation also shows that the magnitude of the effect is influenced by the friction of subsidizing the firm and regional competition.
Second, we explore the impact of friction in subsidizing the firm. As we mentioned in section 5.4.2, the friction cost of realizing the subsidizing is impacted by a variety of economic and policy constraints. Thus, offering the same volume of subsidies can be more costly for the region faced with more constraints; that is, \( \frac{\partial S_c(s_{cj}^* + \delta)}{\partial(s_{cj}^* + \delta)} \) is higher for the same \( s_{cj}^* \) and \( s \). If we suppose that the change in \( \frac{\partial S_c(s_{cj}^* + \delta)}{\partial(s_{cj}^* + \delta)} \) is caused by these economic and policy constraints, we can derive the first-order derivative of \( \frac{\partial y(k_{cj}^*)}{\partial k_{cj}^*} \) with respect to \( \frac{\partial S_c(s_{cj}^* + \delta)}{\partial(s_{cj}^* + \delta)} \) as the following equation:

\[
\frac{\partial^2 y(k_{cj}^*)}{\partial k_{cj}^* \partial s} = \frac{i/A_{cj}}{(\frac{\partial S_c(s_{cj}^* + \delta)}{\partial(s_{cj}^* + \delta)} )} \frac{t_c}{(\frac{\partial S_c(s_{cj}^* + \delta)}{\partial(s_{cj}^* + \delta)} )^2} \frac{t_c}{(\frac{\partial S_c(s_{cj}^* + \delta)}{\partial(s_{cj}^* + \delta)} )^2} (5-17)
\]

It is clear that \( \frac{\partial^2 y(k_{cj}^*)}{\partial k_{cj}^* \partial s} \rightarrow 0 \), meaning that the regulated capital input is smaller if the local government is faced with more of these economic and policy constraints. For example, if the national government prohibits the local government from offering certain forms of subsidies to firms, as has happened very often, the local government will have to lower its regulated capital input.

Finally, we show how regional competition impacts the regulated capital input. The maximum competition-induced subsidy offered by the winner’s rival can be influenced by the rival’s local characteristics, such as local productivity and valuation of externalities, and can also be impacted by the firm’s productivity. Since the firm’s productivity also impacts the winner’s capital input and makes it difficult to distinguish its impact, here we consider only the situation in which a change in the competition-induced subsidy is caused by local characteristics. By deriving \( \frac{\partial y(k_{cj}^*)}{\partial k_{cj}^*} \) with respect to the competition-induced subsidy, we can get the following equation:

\[
\frac{\partial^2 y(k_{cj}^*)}{\partial k_{cj}^* \partial s} = \frac{t_c}{(\frac{\partial S_c(s_{cj}^* + \delta)}{\partial(s_{cj}^* + \delta)} )^2} \frac{\partial^2 S_c(s_{cj}^* + \delta)}{\partial(s_{cj}^* + \delta)^2} \]

(5-18)
\[
\frac{\partial^2 y(k^*_s)}{\partial k_c^s \partial \beta_s} > 0,
\]

then we know \( \frac{\partial k^*_c}{\partial \beta_s} \), implying that the local government has to stipulate a smaller capital input if its rival can afford a higher competition-induced subsidy.

In addition, we are able to derive that there is strategic interaction among local governments in terms of the regulated capital input. Imagine that region \( C \) experiences a positive shock to regulated capital input. The maximum competition-induced subsidy before the shock leads to the current local government's net benefits being below zero, because the regulated capital input differs from the equilibrium input. Therefore, region \( C \) can bid only for the firm using a smaller subsidy. According to equation (5-18), region \(-C\) can now stipulate a larger capital input to maximize its net benefits.

The main implications of the theory are summarized as follows: 1) when local governments share a larger percentage of tax revenue, they tend to impose a larger minimum CLR; 2) when local governments are confronted with higher friction costs (policy or economic barriers) in subsidizing firms, they tend to impose a smaller minimum CLR; 3) regional competition for moving capital incudes smaller regulated capital input, and there is strategic interaction among local governments in terms of the stringency of CLR regulations; specifically, when one region experiences a positive shock to the minimum CLR, its competitors will also raise the minimum CLR.

5.5 Estimating the impact of the tax-sharing scheme on CLR regulations

5.5.1 Data

In this section, we empirically examine the impact of the tax-sharing scheme on CLR regulations. Three datasets were used for the analysis: 1) a land supply dataset from the official land market website, https://www.landchina.com; 2) a sub-province tax-scheme dataset compiled from provincial policy documents, Financial Statistics of Cities and Counties, and the China Statistical Yearbook for Regional Economy; and 3) a socioeconomic dataset from China Statistical Yearbook (County Level) and China City Statistical Yearbook.

Since 2011, most county governments in China have published detailed information on the characteristics of and regulations for each available land parcel (Churang Gonggao). We collected this information from 2011 to 2018 and called it the “pre-announced dataset.” There are 356,917 parcels for industrial use in the raw dataset. The pre-announced dataset includes the basic parcel information for each parcel, such as detailed location, land area, land use, and land-leasing duration. It also includes a variety of regulations, such as the minimum land price, FAR, building density, and the FAIL. It should be pointed out that the FAIL is mainly regulated for parcels designed for industrial use, while it is rarely regulated for other land uses. After dropping the parcels that were missing information on the FAIL, we obtained 198,671 observations.
However, the pre-announced dataset does not contain one important variable for our analysis, namely which industry type is allowed on a specific parcel. We have learned from the national and provincial policy that within one county, the FAII varies significantly according to industry type. In fact, the allowed industry type is probably determined in this pre-announcement procedure. We find the industry type for each parcel by connecting to another land supply dataset: transaction data (Jieguo Gonggao), which has been intensively used in the literature (Wang, Zhang, and Zhou 2020, Chen and Kung 2019). The transaction data is generated after the land transaction is completed; county governments then publish detailed information on the parcel and land user. We collected this information for the years 2011 to 2018 and obtained information on 325,496 parcels for industrial use. This dataset includes the detailed location, land area, land use, and land-leasing duration; for regulations, however, it has only the FAR. The land user’s information includes the land user’s (or firm’s) name, project name, and two-digit industry type. We matched the transaction data with the pre-announced data by using the fuzzy match method based on the string of county, location, year, and land area, and we managed to get 188,671 matched observations.

We furthermore dropped the parcels that 1) are missing information on four key variables, which include the FAII, land price, land area, land-leasing duration, and industry types; and 2) have abnormal value in terms of the FAII and land price (bottom and top 1%). Besides, we discarded those parcels of which the land-leasing duration is shorter than 10 years, since these parcels are more likely to be temporarily rented to industrial firms who are unlikely to invest in them in the long run. We also manually collected the location of each county’s Central Business District (CBD), which is identified by the seat of the local government, enabling us to measure the distance of the parcel to the county’s CBD. We first obtained the coordinates of the parcels and the CBD according to the detailed address and then calculated great-circle distances using the haversine formula. The observations with abnormally large distances were dropped according to the criterion that the distance is larger than the double value of the square root of county size. In the end, we obtained 102,957 observations. See the summary statistics of parcel characteristics in Table 5.1.

The sub-province tax scheme dataset refers to the tax-sharing scheme of VAT, which is found to significantly vary across regions and time. This information was acquired mainly from three sources. The provincial policies that regulate the sharing scheme in place between provincial and municipal governments were collected by searching the government official website of each province. In total, we managed to find 33 policies covering 26 provinces from July 1994 to January 2017, a collection that is possibly incomplete. We supplemented it with data from the China Statistical Yearbook for Regional Economy, which contains the VAT obtained by municipal and provincial governments and is available from before 2013. Combining the data from these two sources, we obtained the ratio of VAT obtained by the municipal government to VAT obtained by the provincial government (including the part obtained by the sub-provincial government) for each municipality from 2011 to 2018. We furthermore used data from the Financial Statistics
of Cities and Counties to infer the ratio of VAT obtained by the county government to VAT obtained by the municipal government (including the part obtained by the county government), as suggested by Liu, Jia, and Ding (2019). This yearbook contains the VAT obtained by county, municipal, and provincial governments and the total VAT generated in each county and municipality, and is available from before 2007. We used the information from 2006 due to data availability. We also exploit the reform that changed the sharing percentage of VAT by the sub-central government from 25% to 50%, which started in May 2016. See the summary statistics of the sharing percentage of VAT in Table 5.1.

The socioeconomic dataset covers the period from 2011 to 2018 and contains the population, secondary industry GDP, primary industry GDP, jurisdiction’s area, fiscal revenue, and fiscal expenditure. We obtained the data for the counties mainly from the China Statistical Yearbook (County Level). As the data of most districts under municipality is not available in this yearbook, we obtained the data of the districts under municipality as a whole from the China City Statistical Yearbook. We dropped the observations of some newly established counties that are missing during most periods. Besides, some variables in several counties are missing for several years, and we replaced them with the value before or after that year. See the summary statistics of county characteristics in Table 5.1.

Table 5.1: Summary statistics.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Observations</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parcel characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum FAII (Yuan/m²)</td>
<td>102957</td>
<td>2229</td>
<td>1931</td>
<td>19</td>
<td>18900</td>
</tr>
<tr>
<td>Land price (Yuan/m²)</td>
<td>102957</td>
<td>217</td>
<td>130</td>
<td>18</td>
<td>860</td>
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<td>Land-leasing duration (year)</td>
<td>102957</td>
<td>50</td>
<td>1</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Distance to CBD (km)</td>
<td>102957</td>
<td>13</td>
<td>34</td>
<td>0</td>
<td>2967</td>
</tr>
<tr>
<td>Parcel area (hectare)</td>
<td>102957</td>
<td>3</td>
<td>7</td>
<td>0</td>
<td>314</td>
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<tr>
<td><strong>Sub-province tax scheme</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Sharing percentage of VAT by municipal</td>
<td>49840</td>
<td>0.78</td>
<td>0.18</td>
<td>0.09</td>
<td>1</td>
</tr>
<tr>
<td>governments to sub-national governments</td>
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<td></td>
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<tr>
<td>Sharing ratio of VAT by county</td>
<td>49824</td>
<td>0.92</td>
<td>0.18</td>
<td>0.01</td>
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<td>governments to sub-province governments</td>
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<tr>
<td>**Provincial capital-land ratio</td>
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<tr>
<td>regulations</td>
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<tr>
<td>County-level minimum FAII (Yuan/m²)</td>
<td>92064</td>
<td>1219</td>
<td>868</td>
<td>440</td>
<td>5442</td>
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<td><strong>County characteristics</strong></td>
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<tr>
<td>County area (sq. km)</td>
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<td>3745</td>
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<tr>
<td>Population (10^4)</td>
<td>18158</td>
<td>64</td>
<td>86</td>
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<tr>
<td>Primary GDP (10^6 Yuan)</td>
<td>18158</td>
<td>2673</td>
<td>2800</td>
<td>26</td>
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<tr>
<td>Secondary GDP (10^6)</td>
<td>18158</td>
<td>16037</td>
<td>46239</td>
<td>14</td>
<td>996250</td>
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<tr>
<td>General budget revenue (10^6 Yuan)</td>
<td>18158</td>
<td>30447</td>
<td>17836</td>
<td>5</td>
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<tr>
<td>General budget expenditure (10^6 Yuan)</td>
<td>18158</td>
<td>52657</td>
<td>21114</td>
<td>53</td>
<td>835154</td>
</tr>
</tbody>
</table>

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5.5.2 Empirical strategy

Based on the introduction in the institutional background section, the tax-sharing scheme in China can be represented by the equation \( t^c_i = t^m_i \times t^p_i \times t^n_i \), where \( t^c_i \) is the sharing percentage of VAT by the county government. \( t^m_i \) refers to the ratio of VAT obtained by the county government to VAT obtained by the municipal government (including the part obtained by the county government), \( t^p_i \) refers to the ratio of VAT obtained by the municipal government to VAT obtained by the provincial government (including the part obtained by the sub-provincial government), and \( t^n_i \) refers to the ratio of VAT obtained by the municipal government to VAT obtained by the national government (including the part obtained by the sub-national government). Based on this tax-sharing scheme, we can measure the change of the tax-sharing percentage for county governments by using the change of tax-sharing among different levels of governments, such as the change of \( t^p_i \) or \( t^n_i \). Our baseline specification is the following two-way fixed effects model:

\[
\ln K_{ijt} = \delta \ln T a x_{jt} + \beta_1 \ln \text{Parcel}_{ij} + \beta_2 \ln X_{jt} + \beta_3 \ln \text{Parcel}_{ij} \times u_t + \beta_4 \ln X_{jt} \times u_t \\
+ \sum_{\tau=0}^{5} \theta_{\tau} \ln \text{Pro}_{j.t-\tau} + u_t + \alpha_j + \epsilon_{ijt}
\]

(5-19)

Here \( i, j, t \) index parcel, county, and time (six months) in turn, and our research period is from 2011 to 2018. \( \ln K_{ijt} \) is the (log) minimum FAI of parcel \( i \) in county \( j \) in time \( t \). As the minimum FAI in the districts under the municipality is largely determined by the municipal government, we excluded them from our sample. \( T a x_{jt} \) is the tax-sharing percentage of VAT by county governments and equals \( t^m_i \times t^p_i \times t^n_i \). Since \( t^m_i \) data is not available, we used data in 2006 from the Financial Statistics of Cities and Counties, which is inspired by Liu, Jia, and Ding (2019). For the \( t^n_i \) data, we first collected the provincial reform policies and supplemented them using data from the China Statistical Yearbook for Regional Economy from 2011 to 2013. \( t^n_i \) changes from 25% to 50% because of the national reform starting in May 2016.

\( \text{Parcel}_{ij} \) controls for a group of parcel characteristics, which contain land-leasing ways, land-leasing duration, the previous use of the parcel (farmland, building land, or both), and location. \( X_{jt} \) controls for a group of county characteristics, including population, urban employment, secondary industry GDP, primary industry GDP, land area, fiscal revenue, and fiscal expenditure. We also control for the period FEs \( u_t \) and allow it to differ by county and parcel characteristics. \( \text{Pro}_{j,t-\tau} \) controls for the minimum CLR change caused by the provincial policies regarding the minimum CLR, and we allow their effects to exist in the next three years. \( \alpha_j \) controls for the county fixed effect.

Note that the variation in \( t^c_i \) exploited by us comes from two sources. From 2011 to 2015, the variation is caused by the provincial reform, while after 2015, the variation is mainly the result of the national reform. We also estimate by using two sub-periods separately.
CHAPTER 5

to test whether our results are robust to two different variation sources. We also use the instrumental variable method to mitigate the concern that tax reforms used by us are driven by unobservable variables. Last, we estimate the impact on the land price to implement a falsification analysis.

5.5.3 Results

We estimate the baseline specification by introducing period fixed effects, upper-level government policies, parcel characteristics, county characteristics, county fixed effects, the interaction between parcel characteristics and period fixed effects, the interaction between county characteristics and period fixed effects, respectively. The results are shown in Table 5.2. As we can see, the estimated coefficients in all models are positive and statistically significant, although their magnitude varies slightly. The results mean that when county governments can obtain a larger share of the VAT, a larger minimum FAII will be imposed. This implication is consistent with our theory.

The change in the coefficients’ magnitude may indicate a relationship between the control variables and the tax-sharing scheme. For example, after we control for the county fixed effects in Column (6), the magnitude becomes slightly larger, possibly implying that some time-unvarying county characteristics can contribute to a smaller FAII and higher tax-sharing percentage by county governments, such as a less developed economy. Moreover, after we allow the impact of parcel and county characteristics to vary according to periods in Column (7) and (8), the magnitude also becomes significantly larger, especially for the county characteristics. The implication is that a change in the tax-sharing scheme can be driven by time-varying unobservables that affect the FAII in the opposite direction; after controlling for these unobservables through introducing the interaction terms, we can obtain a more precise estimation. Taking 0.917 in Column (8) as an example, the implication of the estimated coefficients is that if the sharing percentage of VAT by county governments increases by 10%, the FAII they impose will increase by 9.17%, which indicates a great impact of the tax-sharing scheme on FAII regulations.

Table 5.2: Impacts of the tax decentralization on CLR (baseline).

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
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<tr>
<td>Minimum fixed assets investment (log)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>County VAT share</td>
<td>0.193** (0.087)</td>
<td>0.358** (0.176)</td>
<td>0.243* (0.138)</td>
<td>0.278** (0.129)</td>
<td>0.343*** (0.131)</td>
<td>0.467*** (0.150)</td>
<td>0.598*** (0.161)</td>
<td>0.917*** (0.173)</td>
</tr>
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<td>Yes</td>
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<tr>
<td>Province Regulations</td>
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<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>County Controls</td>
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<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>County FE</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
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The Use of Capital-Land Ratio Regulations in Allocating Industrial Land

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<tr>
<th>Parcel Controls-Period</th>
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<th>No</th>
<th>No</th>
<th>No</th>
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<th>No</th>
<th>Yes</th>
<th>Yes</th>
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<tbody>
<tr>
<td>County Controls-Period</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>R²</td>
<td>0.006</td>
<td>0.037</td>
<td>0.063</td>
<td>0.100</td>
<td>0.160</td>
<td>0.589</td>
<td>0.605</td>
<td>0.625</td>
</tr>
<tr>
<td>Observations</td>
<td>91767</td>
<td>91767</td>
<td>91767</td>
<td>91158</td>
<td>88258</td>
<td>88179</td>
<td>88172</td>
<td>88172</td>
</tr>
</tbody>
</table>

Notes: The table reports results from estimating equation (5-19) by adding period fixed effects, provincial regulations, parcel characteristics, county characteristics, county fixed effects, the interaction between parcel characteristics and period fixed effects, and the interaction between county characteristics and period fixed effects, respectively. The mean value of minimum FAII is 240 ha. The sharing percentage of VAT by county governments is 1. Standard errors in parentheses are clustered on county fixed effects. * p < 0.10, ** p < 0.05, *** p < 0.01.

We first test whether our results are robust to the different sources of variation. As we mentioned in section 5.5.2, the variation in the tax-sharing scheme from 2011 to 2015 came from the provincial reform, while the variation after 2016 came mainly from the national reform. We estimate using two sub-populations from two different periods separately, the results of which are shown in Columns (1) and (2) in Table 5.3. We observe two statistically significant results as the baseline model, both with a slightly smaller coefficient (0.621 vs. 0.917, 0.649 vs. 0.917). Moreover, we test whether our results are robust to the population including the parcels in districts under the municipality. As is shown in Column (3), the estimated result remains statistically significant, and the magnitude is significantly smaller (0.457 vs. 0.917).

We then mitigate the concern that tax reforms are driven by unobservable variables by using the instrumental variable method. Specifically, we instrument the county’s tax-sharing percentage with different measures of regional inequalities. It has been found that tax decentralization of sub-province governments is negatively impacted by the motivation to reduce regional inequalities (Liu, Jia, and Ding 2019, Zhou and Wu 2015, Fang, Lu, and Su 2020, Bellofatto and Besfamille 2021). Besides, since we are currently using variations in the provincial policies, we estimate using only the sub-population from 2011 to 2015. In Column (4), we measure regional inequalities by using the Gini coefficient of the fiscal revenue per capita, while in Column (5), we use the Gini coefficient of the GDP per capita (municipality) or secondary GDP per capita (county) constrained by data availability. In each type, we calculate three Gini coefficients: counties within the province, counties within the municipality, and municipalities within the province. As shown in Columns (4) and (5), the underestimation and weak estimation test show that both of our two types of instruments are strong predictors of tax-sharing reform, and the overestimation test shows that our instruments are exogenous. The estimated coefficients are positive and statistically significant as the baseline model, supporting the robustness of our results. However, it should be noted that the magnitude is significantly greater than that of the baseline results (3.468 vs. 0.917, 3.078 vs. 0.917). This difference indicates that we may underestimate the impact of the tax-sharing scheme in our baseline
CHAPTER 5

specification due to some time-varying unobservables.

We also estimate the heterogeneous impact of the tax-sharing scheme on large or small firms. We define the parcel as large if it is larger than the mean area of the parcels within one county supplied in the same half year. By introducing the interaction term between the tax-sharing measure and firm size measure in Column (6), we find that the impact of the tax-sharing scheme can be smaller if the firm is large. This result is reasonable, since large firms are generally more mobile and are bid for more intensely by local governments, which is consistent with the regional competition story in our theoretical model.

Table 5.3: Impacts of the tax decentralization on CLR (robust).

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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before 2016</td>
<td>After 2016</td>
<td>Including districts</td>
<td>IV (Fiscal revenue)</td>
<td>IV (GDP)</td>
<td>Large parcels</td>
</tr>
<tr>
<td>County VAT share</td>
<td>0.621*** (0.188)</td>
<td>0.649*** (0.197)</td>
<td>0.457*** (0.172)</td>
<td>3.468*** (1.228)</td>
<td>3.078*** (0.973)</td>
<td>0.944*** (0.172)</td>
</tr>
<tr>
<td>County VAT share *</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.078** (0.038)</td>
</tr>
<tr>
<td>Large parcel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R2</td>
<td>0.689</td>
<td>0.635</td>
<td>0.604</td>
<td></td>
<td></td>
<td>0.626</td>
</tr>
<tr>
<td>Kleibergen-Paap rk LM (P-val)</td>
<td>0.000</td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cragg-Donald F</td>
<td></td>
<td></td>
<td></td>
<td>702</td>
<td>923</td>
<td></td>
</tr>
<tr>
<td>Hansen J (P-val)</td>
<td></td>
<td></td>
<td></td>
<td>0.273</td>
<td>0.754</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>61794</td>
<td>43285</td>
<td>102500</td>
<td>55917</td>
<td>55917</td>
<td>88172</td>
</tr>
</tbody>
</table>

Notes: This table reports the results of the robustness test. Columns (1) and (2) use the sub-population before and after (including) 2016, and Column (3) uses the population including districts under municipalities. Columns (4) and (5) instrument the county's tax-sharing percentage with regional inequalities measured by the Gini coefficient of the fiscal revenue per capita and Gini coefficient of the GDP per capita, both of which calculate three Gini coefficients, including counties within the province, counties within the municipality, and municipalities within the province. Column (6) adds the interaction term between the sharing percentage of VAT by county governments and the parcel size. Standard errors in parentheses are clustered on county fixed effects. * p < 0.10, ** p < 0.05, *** p < 0.01.

Last, we replace the minimum FAII in the baseline specification with the land price to implement a falsification analysis. The idea is that if our baseline results are driven by unobservable supply or demand forces regarding industrial land—such as a change in local productivity, scarcity of available land, or a change in land demand by firms—the land price will probably also be impacted, in the same direction as the minimum FAII. In contrast, our theory implies that a larger tax-sharing percentage by county governments can increase regulation-induced subsidies and may thus negatively impact land prices. We replicate the baseline and robustness test specifications. As shown in Table 5.4, none of the results is statistically significant. These results support that our baseline results are not driven by industrial land's supply or demand forces.
The Use of Capital-Land Ratio Regulations in Allocating Industrial Land

Table 5.4: Impacts of tax decentralization on land price.

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<tr>
<td></td>
<td>Baseline</td>
<td>Before 2015</td>
<td>After 2016</td>
<td>Including districts</td>
<td>IV (Fiscal revenue)</td>
<td>IV (GDP)</td>
<td>Large parcels</td>
</tr>
<tr>
<td>County VAT share</td>
<td>0.043</td>
<td>0.024</td>
<td>0.011</td>
<td>-0.015</td>
<td>-0.231</td>
<td>-0.214</td>
<td>0.051</td>
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<tr>
<td></td>
<td>(0.063)</td>
<td>(0.070)</td>
<td>(0.055)</td>
<td>(0.054)</td>
<td>(0.389)</td>
<td>(0.303)</td>
<td>(0.063)</td>
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<tr>
<td>County VAT share * Large parcel</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td>-0.021**</td>
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<td></td>
<td></td>
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<td>(0.009)</td>
</tr>
<tr>
<td>R2</td>
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<td>0.864</td>
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<tr>
<td>Kleibergen-Paap rk LM (P-val)</td>
<td>0.000</td>
<td>0.000</td>
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<tr>
<td>Cragg-Donald F</td>
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<td></td>
<td></td>
<td></td>
<td>702</td>
<td>922</td>
<td></td>
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<tr>
<td>Hansen J (P-val)</td>
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<td>0.622</td>
<td>0.173</td>
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<td>102402</td>
<td>55893</td>
<td>55893</td>
<td>88085</td>
</tr>
</tbody>
</table>

Notes: This table reports the falsification analysis done by using the industrial land price as the dependent variable. Column (1) is the baseline specification. Column (2) and Column (3) use the sub-population before and after (including) 2016, and Column (4) uses the population including districts under municipalities. Columns (5) and (6) instrument the county’s tax-sharing percentage with regional inequalities measured by the Gini coefficient of the fiscal revenue per capita and Gini coefficient of the GDP per capita, both of which calculate three Gini coefficients, including counties within the province, counties within the municipality, and municipalities within the province. Column (7) adds the interaction term between the sharing percentage of VAT by county governments and the parcel size. Standard errors in parentheses are clustered on county fixed effects. * p < 0.10, ** p < 0.05, *** p < 0.01.

5.6 Conclusions

Local governments worldwide are highly engaged in using various regulatory or incentive policies to intervene in local industrial development. Based on institutional settings in China, this paper has established a theoretical model to characterize how CLR regulations are used as a discretionary policy tool to screen out or attract industrial firms. We model the bidding for firms as a private value open-outcry ascending scoring auction and provide an equilibrium in which 1) a larger sharing percentage of tax revenue motivates local governments to impose a larger minimum CLR; 2) higher friction costs (policy or economic barriers) in subsidizing firms induce a smaller minimum CLR; 3) regional competition for moving capital induces a smaller regulated capital input. There is also strategic interaction in terms of the stringency of CLR regulations among local governments. Empirically, we have found that when county-level governments are allocated a larger share of VAT revenue, they tend to impose a larger minimum FAll on the firm.

Our research may help governments develop better tax schemes. We demonstrate that an increase in the sharing percentage of tax revenue by local governments can improve land-use efficiency (a higher CLR). When putting the tax-sharing scheme into a broader perspective, our research implies that a more decentralized tax scheme should be used to improve land-use efficiency. On the other hand, upper-level governments may increase tax centralization for justifiable and perhaps more important reasons, such as easing regional inequality within their jurisdictions; in this case, the choice of tax scheme...
is faced with a trade-off between land-use efficiency and other, conflicting objectives. Our model also suggests that upper-level governments' policies aimed at prohibiting subsidy competition among regions can ultimately induce less efficient land use. In other words, when subsidy instruments are prohibited, land supply is alternatively used as a tool to attract moving capital. Moreover, our model supports the use of the direct higher standard of CLR determined by upper-level governments due to the existence of strategic interaction in terms of CLR regulations. Nevertheless, we should point out that the rationalization of direct intervention relies on compliance with CLR regulations by local governments, which is difficult to supervise by upper level governments if they are inclined to comply and conspire with firms on this. Therefore, direct intervention should be used accompanied by incentives.

However, implementing firm-specific incentives presents many challenges (Slattery and Zidar 2020). What has been done in this research is only a start in the investigation of firm-specific CLR regulations and their role in intervening in industrial development and allocating industrial land; there is still much to learn. Future work should consider the political forces involved in using CLR regulations. For example, policymakers may overly value increased GDP growth or employment due to the political incentive scheme and be willing to offer exceedingly high competition-induced subsidies, which forces them to relax CLR regulations. Besides, landownership may prevent the use of discretion CLR regulations. In the case of privately owned industrial land or industrial land supplied by rural collectives in China, like in many countries, the friction involved in reducing the land price as a subsidy can be costly and thus induce less stringent CLR regulations. Last, the theoretical implications of our model should be examined empirically.
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CHAPTER 6

Conclusions
Land-use regulations (LURs) are widely used to remedy the side effects of economic activities (Cheshire 2013, Cheshire and Sheppard 1995). They vary across regions and have been increasingly adopted in recent years. Nevertheless, it has been documented that LURs lead to many unwanted outcomes, such as expensive housing or lower productivity (Hilber and Vermeulen 2016, Cheshire, Hilber, and Kaplanis 2015). To better evaluate and design LURs, many researchers have turned to exploring the origins of LURs. They consider a variety of agents who are impacted by different types of LURs and highlight the political process of determining LURs. Most research is about residential land, while industrial land receives relatively less attention. Restrictions on industrial land use might harm manufacturing and warehousing firms considerably, since their activities require vast areas of land (Dempwolf 2010, Nathan and Overman 2011), and the substitution of non-land capital for land might prove more difficult (Needham, Louw, and Metzemakers 2013). To explain the causes of LURs regarding industrial activities, Fischel (1974) and his followers have proposed a community site theory (Erickson and Wollover 1987, Fox 1978). This theory argues that through screening out unwanted firms, LURs are used by communities to balance economic benefits and environmental losses induced by industrial activities. Some empirical research has verified this theory, especially concerning the relationship between the existing tax system and industrial land supply (Krumholz and Fraenkel 2019, Burnes, Neumark, and White 2014, Xie, Zhu, and Li 2019, Han and Kung 2015). However, there has been only a limited investigation into how the political economy impacts the industrial land supply. Besides, community site theory does not clarify how density restrictions on industrial land are used, although density regulations have been extensively explored regarding residential land use. Finally, research concerning public landownership remains limited. Profits from selling land can affect not only land supply but can also be used in exchange for industrial investments (Needham 1992, Kajitani and Fujii 2016).

This thesis has aimed to fill these gaps by investigating the causes of LURs regarding industrial activities in China. China provides an excellent experimental field in which to explore the topic of ILURs. Local governments (and local officials) have a large stake in industrial land development. The existing tax-sharing scheme enables local governments to benefit greatly from the tax generated by industrial firms, and the land tenure scheme confers land-selling profits on local governments as a result of local governments’ actual ownership of urban land. In addition, although the LURs system is highly centralized in China, local governments enjoy substantial autonomy in allocating the annual quota for industrial uses and can make intensive use of density restrictions and contractual duration regulations to help allocate industrial land. Actually, various forms of ILURs have been used by local governments and have become even more stringent recently.

I have focused on the motivations behind a variety of ILURs used by local governments, including restrictions on density, contractual duration, and the amount of available land. I first conducted an in-depth investigation into how and why a variety of ILURs are used by local governments in China when supplying newly available industrial land, and then focused on two specific types of ILURs—the amount of available industrial
land and capital-land ratio (CLR) regulations—to explore the motivations behind using them. Specifically, I asked the following questions: 1) Why are different forms of firms’ inputs and outputs (FIOs) regulations and different contractual durations used by local governments when supplying industrial land? 2) How is the adjustment of industrial land supply affected by changes in the political incentive scheme? 3) How do CLR regulations impact the land price? 4) How are CLR regulations used as a firm-specific policy tool to intervene in industrial development?

This chapter is structured as follows. Section 6.1 summarizes the main findings. Section 6.2 presents my contributions to the literature. Section 6.3 puts forward recommendations for policymaking. Section 6.4 acknowledges the limitations of my research, and section 6.5 discusses directions for future research.

6.1 Main findings

6.1.1 Why are various restrictions on FIOs and contractual duration used?
To explore the questions of whether and how FIOs and contractual duration regulations are used to allocate publicly owned land for industrial use and how they vary across regions and even firms, I have proposed an analytical framework in which FIOs and contractual duration regulations are integrated into a land-leasing contract between the firm and the local government, based on the work of Cheung (2014). I have theorized this contract as a share tenancy with an exogenous rental percentage and argued that FIOs and contractual duration regulations are used to minimize transaction costs. In this framework, the stringency of regulations is predicted by industrial land scarcity, the redevelopment costs of stock industrial land within one region, and the characteristics of the individual firm. These three factors affect FIOs and contractual duration regulations through changing transaction costs, including rent dissipation, the costs of negotiation and enforcement, the costs of transferring firms’ specific assets, and renegotiation costs. This framework leads to three key propositions: first, controls on FIOs will be stipulated in industrial land-leasing contracts; second, a higher scarcity of industrial land or higher redevelopment costs of stock industrial land will lead to the imposition of shorter leasing durations and tighter controls on FIOs; third, the higher the anticipated firm productivity, the longer the land-leasing duration that will be offered.

In the case studies, I have distinguished two types of ILURs: public law and private law (Ellickson 1973). Public law refers to local governments’ policies that restrict industrial land use generally, while private law refers to contractual arrangements between local governments and firms, which regulate the specific land use of each parcel. I used three comparative cases to explore the variation in public law and analyzed 86 industrial land-leasing contracts drawn up in Shanghai in 2017 to explore the variation in private law. I found that FIOs and contractual duration regulations are used in all case regions to a different extent. Regions with a higher scarcity of industrial land or higher redevelopment costs of stock industrial land tend to impose more stringent FIOs and contractual duration regulations, in which stringency refers to the types of FIOs, the length of the contract, and
the enforcement of these stipulations. Moreover, I have shown that firms with a higher anticipated productivity tend to be offered a longer leasing term, both in the local policy and in the land-leasing contract analysis.

6.1.2 How is the adjustment of industrial land supply affected by political incentive scheme?

Fischel (1974) has put forward the community site theory, in which zoning land for industrial use is aimed at establishing a trade-off between the benefits and costs of allowing industrial activities and at maximizing local communities’ utilities. This theory highlights the role of political incentive schemes by showing that local residents’ preferences can impact the zoning decision. However, how the political incentive scheme impacts the industrial land supply in a centralized political scheme is not clear. To examine the impact of China’s political incentive scheme on the amount of industrial land supply, I first built a simple one-city model based on community site theory. In my model, a municipality owns all industrial locations and has a monopoly on supplying them to external firms who possess heterogeneous technology. The city leader determines the amount of industrial land supply to the degree that the utility from added financial benefits equals the disutility from added environmental decay in a marginal location. By allowing the city leader’s valuation of environmental amenity to be influenced by both the political incentive for environmental protection and the magnitude of the city’s wealth and environmental amenities, I derived the testable proposition that an identically positive shock to the political incentive for environmental protection makes dirty cities experience a larger reduction in industrial land supply than clean cities.

As a vital instrument to implement centralized personnel controls in China, the cadre evaluation system (CES) plays a significant role in determining whether local officers are eligible for promotion and thus influences local officers’ incentives in making policies. Since 2013, the central government has placed a significantly greater emphasis on environmental protection in CES. Guided by the theoretical model, I have identified the impact of the CES reform in 2013 on industrial land supply by using the difference-in-differences (DID) design and the interaction of municipalities’ pre-CES environmental quality with the introduction of CES reform, in which the city with a worse environmental quality experiences a higher treatment intensity. My estimation is based on a municipality-level panel dataset of land supply (2011–2017), and the results indicate that after the 2013 reform, more polluted cities have experienced a significantly larger decline in the amount of industrial land supply. Specifically, cities with a double level of environmental pollution experience a 12.2% reduction in the amount of industrial land supply. I validated the parallel assumption by showing that polluted and clean cities had no significant difference in industrial land supply before the reform. I show that the baseline results are robust to a variation of measures of pollution levels in a city, and that the results are not likely to be driven by the anti-corruption campaign or the entire country’s downward economy through falsification and placebo analysis. Last, the heterogeneous analysis showed that the CES reform may be having a larger impact on dirtier industries and wealthier cities, and that my results are mainly driven by local leaders with stronger promotion incentives.
6.1.3 **How does the capital-land ratio regulation impact the land price?**

To examine the price effect of CLR regulations, I established a simple theory in which there exists one city and one representative firm. I show that if the government imposes a minimum CLR higher than the CLR would be in a setting without regulations, the industrial land price is supposed to be lower. However, this price effect weakens as the optimal density determined by market participants grows in time. Empirically, I exploited the province-level variation in the minimum CLR and used a DID event study design, which used the event dummy as the treatment. I examined land-price changes within a five-year window around 19 province-level minimum-CLR events and found that province-level minimum-CLR regulations have a negative price effect in the first one and half years after the regulatory policy is implemented. Specifically, the land price decreases by 15.8% if the minimum CLR is doubled. My results are robust to specifications adding controls for county-specific linear and quadratic time trends, using different event windows or continuous treatment indicators. In addition, by using several sub-groups to estimate the baseline model, I found that province CLR regulations have a slightly larger impact on the price of large parcels, a slightly larger impact on parcels located farther away from the county center, and a significantly larger impact on counties with higher fiscal revenue per capita and secondary GDP per capita.

6.1.4 **How is the capital-land ratio regulation used as a firm-specific policy tool to intervene in industrial development?**

To examine how CLR regulations are used as a firm-specific policy tool to intervene in industrial development, I have established a theoretical model motivated by a survey of the land supply practice of local governments in China and closely related to the theory put forward by Cheung (2014) and Slattery (2020). This model aims to rationalize the use of discretionary CLR regulations, in which there are two prominent features regarding their impact on firm location: 1) the strengthening of CLR regulations to screen out firms when they compete for a location; 2) the weakening of CLR regulations to recruit firms when localities compete for firms. I modeled the use of CLR regulations in the public land supply, aiming to make the model setting consistent with the institutional background in China. Specifically, local governments gain the tax revenue and land price and value all positive and negative externalities. The tax scheme and state-owned land system lead to a share tenancy contract between county governments and firms when the former supply industrial land, and the regional competition for industrial firms is a private value open-outcry ascending scoring auction. Specifically, firms decide their location among regions to obtain the highest payoff, which includes various forms of subsidies. To recruit the firm, local governments have to offer a subsidy higher than the subsidies offered by competitors.

To maximize its net benefits, the local government imposes minimum-CLR regulations and must compensate the firm for the loss induced by these regulations. I have assumed that local governments can be more or less efficient in achieving subsidizing. Therefore, the optimal minimum CLR for local governments can be smaller if they are less efficient in achieving subsidizing. Furthermore, facing competition from their rivals, local governments have to offer an additional subsidy to win the firm. This competition-induced
subsidy needs to be larger than the maximum subsidy their rivals can afford. Given the maximum competition-induced subsidy determined by their rivals, local governments use a minimum CLR to maximize net benefits, which results in a smaller CLR than would be the case without regional competition. The main implications from the theory can be summarized as follows: 1) when local governments share a larger percentage of tax revenue, they tend to impose a higher minimum CLR; 2) when local governments are confronted with higher friction costs (policy or economic barriers) when subsidizing firms, they tend to impose a smaller minimum CLR; 3) regional competition for moving capital includes smaller regulated capital input, and there is strategic interaction in terms of the stringency of CLR regulations among local governments; specifically, when one region experiences a positive shock to the minimum CLR, its competitors will also raise the minimum CLR.

I empirically tested the impact of the tax scheme on CLR regulations. Specifically, I explored whether the value-added tax (VAT) scheme in China affects fixed assets investment intensity (FAII) regulations. Although the VAT rate is the same across regions, as regulated by the central government, the sharing scheme of VAT revenue for local governments is determined by their upper-level governments. Therefore, county-level governments’ sharing percentage of VAT revenue may be different due to the tax-sharing scheme. I have argued that county governments are incentivized more if they are assigned a larger percentage of VAT revenue. I identified the impact on FAII regulations by using a two-way fixed effects model, which utilizes the post-2011 change in the VAT-sharing scheme in place between the province and sub-province governments and the post-2016 change in the VAT-sharing scheme in place between the central government and sub-national governments to measure the variation in VAT-sharing percentage by county governments. The estimated results show that if the sharing percentage of VAT revenue by county governments increases by 10%, the FAII they impose will increase by 7.8%. The positive impact is consistent with my theory and implies that a more decentralized tax-sharing scheme can help improve land-use efficiency. Besides, I have shown that my baseline results are robust to the variation in tax schemes caused by either the provincial reform or the national reform and the specification that instruments the tax-sharing percentage by county governments with regional inequalities. Last, by using land price as the dependent variable to implement a falsification analysis, I showed that the baseline result is not likely to be driven by industrial land’s supply or demand forces.

6.2 Contributions to the literature

This research contributes to the literature that explores the role of density regulations in the land market. This topic has been extensively explored by estimating how different density regulations impact land market outcomes. It has been found that restrictions on maximum building height (or floor area ratio, hereafter FAR) can reduce the land price (Geshkov and DeSalvo 2012), limit housing supply (Barr 2016), and induce the spatial expansion of cities (Brueckner and Sridhar 2012, Geshkov and DeSalvo 2012). In addition, growing research has been devoted to investigating the rationale behind density
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regulations, such as protecting the urban landscape, limiting interior light reduction from building-induced shadows in earlier times (Barr 2016), and reducing infrastructure costs (Brueckner and Sridhar 2012). Since it focuses on private landownership, the existing literature implies that density regulations are imposed before the land transaction. I have contributed by analyzing the use of density regulations as part of the transaction process under the state-owned land system, focusing on industrial land. Brueckner et al. (2017) have documented the rationale for the upper limit to building height for residential land in China as maximizing the net revenue from land development. I have extended this idea to various types of density regulations and contractual duration regulations in industrial land transactions. I first justified the choice of regulatory stringency, which refers to the stipulation and enforcement of these regulations, by minimizing transaction costs in a share tenancy contract. Then, I focused on FAII regulations and characterized how the strengthening of CLR regulations is used to screen out firms when firms compete for a location and how the weakening of CLR regulations is used to recruit firms when localities compete for firms. Last, I offered direct evidence that there exists a trade-off between the CLR and the land price by documenting a negative land price effect of CLR regulations.

My research also adds knowledge to the literature concerning the impacts of the tax scheme on ILURs. The existing literature has examined different types of tax schemes. Using the change in the additional sales tax levied by county governments in Florida, Burnes, Neumark, and White (2014) find that a higher sales tax rate leads to more employment in larger stores and shopping malls and less employment in manufacturing, which suggests that those jurisdictions with a higher sales tax rates tend to zone more land for business rather than for manufacturing. Given the constant tax rate in China, a decline in the sharing percentage of the enterprise income tax revenue by local governments motivates them to shift efforts from fostering industrial growth to developing the real estate and construction sectors (Han and Kung 2015), and an increase in VAT revenue shared by local governments leads to an increase in industrial land supply (Xie, Zhu, and Li 2019). My research has made a contribution by examining the impact of tax schemes on CLR regulations for industrial activities. This type of regulations is different from the amount of land supply being explored by the existing literature and supplements the regulatory tools created by the change in the tax scheme. For example, together with Xie, Zhu, and Li (2019), my results show that when local governments in China are allowed a larger share of VAT revenue, they on the one hand make more industrial land available and on the other hand try to improve land-use efficiency by requiring a higher minimum CLR.

In addition, I have extended the community site theory put forward by Fischel (1974) by applying it to the public land supply, highlighting the political incentive scheme. In the theory of Fischel (1974), local governments aim to maximize the welfare of citizens by allowing new industrial activities to the extent that the marginal increase in utility from the fiscal benefits generated by these activities equals the marginal decrease in utility from the accompanying environmental decay (Erickson and Wollover 1987). I characterized how local leaders aim to achieve their own objectives by assuming that a city leader’s valuation of environmental amenities is influenced by both the political incentive for
environmental protection and the level of the city's wealth and environmental amenities. Besides, I offered solid evidence by documenting that the CES's higher valuation of environmental amenities leads to a larger decline in the industrial land supply in dirty cities in a centralized political system.

Moreover, I have added knowledge on how firm-specific policy tools are used to intervene in industrial development. The existing literature mainly focuses on firm-specific subsidies. Subsidies to a firm are justified when increased tax revenues exceed the marginal cost of providing public goods (Black and Hoyt 1989). Firm-specific incentives can also have many advantages because of targeting. For example, offering firm-specific incentives allows local governments to recruit a single (or group of) attractive firm(s) instead of subsidizing all firms, contract with the firm regarding investment and employment (Slattery and Zidar 2020), or price-discriminate firms that are more responsive to tax rates and raise revenues more efficiently (Ramsey 1927). On the other hand, performance management has been increasingly used to make the granting of incentives more accountable (LeRoy 2005, Weber 2002, Lindblad 2006, Zheng and Warner 2010). Specifically, local governments use contractual mechanisms to specify and enforce subsidized firms' obligations, such as employment creation and tax payment (Weber 2002). For example, some local governments require subsidized firms that fail to achieve agreed-on employment targets to pay back part of the money they received (Warner and Zheng 2011). The stringency of the accountability of business incentives is found to be affected by the financial pressure and organizational capacity of local governments, structural characteristics of communities, and local political processes (Lindblad 2006, Sullivan 2002). First, I have contributed by characterizing how CLR regulations, as well as firm-specific subsidies and the land price, are used to intervene in industrial development and the allocation of industrial land. I modeled the interaction between firm-specific subsidies and CLR regulations by introducing the friction costs of subsidizing firms, and I characterized how CLR regulations are used to not only attract but also screen out industrial firms. Second, I offered evidence on how FIOs regulations and contractual durations are used as performance management for the incentive offered to firms when the land is publicly owned. I documented the specific types of FIOs stipulated in performance management under a state-owned land system and showed the use of a financial penalty and the expropriation of land-use rights to make the business incentive more accountable. I also explained the variation in accountability stringency from a transaction costs perspective and showed how stringency differs among regional and firm characteristics.

Last, my research contributes to the literature on the determinants of industrial land prices in China. The land price of industrial use is documented to be considerably lower than the price of residential use (Wu et al. 2014). This is mainly attributed to regional competition for moving industrial capital, in which a lower land price is used as subsidy for firms (Kajitani and Fujii 2016, Wu et al. 2014, Xu, Huang, and Jiang 2017). I have reformulated this land-in-exchange-for-capital story from the perspective of the price effect of LURs and offered direct evidence that local governments exchange the land price for a higher density of industrial investment.
6.3 Policy implications

My research can have the following policy implications. First, the evidence from regulations on FIOs and contractual duration suggests that giving local governments the authority to determine ILURs helps increase land-use efficiency and promote local economic development, since they will choose the regulatory arrangement that minimizes transaction costs. Local governments can adjust the types of FIOs to be regulated, making the regulatory stringency adapt to various economic constraints and firm characteristics. However, it should be noted that my recommendations rest on a set of preconditions, such as strict restrictions on industrial land availability set by upper-level governments and an efficient political incentive scheme. In terms of direct national regulatory policies on ILURs, my research suggests that such centralized policies should be imposed with caution, because the heterogeneity of different regions and firms is difficult to grasp for the central government, and the costly supervision of local governments’ enforcement of ILURs may impede the effective implementation of national policies.

Second, emphasizing environmental protection in cadre evaluation criteria could effectively incentivize local officials to reduce the industrial land supply, which probably promotes the quality of economic development. Nevertheless, it should be noted that the CES must be designed elaborately and carefully, since it may induce some cities to assign excessive weight to environmental pollution relative to economic growth. My research has not offered direct evidence related to this question. However, the heterogeneous analysis has shown that there is no significant difference between more or less developed regions, which suggests that the adverse effect of the CES reform may especially exist in less developed regions, as rejecting new firms’ locating can harm the development of the agglomeration economy in the long run.

Third, the negative price effect of provincial CLR regulations suggests that county governments use the lower land price as a subsidy for regulated firms under regional competition. This mechanism highlights the role of the land price in land allocation. Regarding the promotion of the exchange of the land price for firms’ investment intensity, local governments should be empowered with more rights to price industrial land. Therefore, a national minimum land-price policy might prevent the improvement of land-use intensity. Moreover, the heterogeneity analysis on the negative price effect has shown that the provincial government tends to impose more stringent regulations, that is, a higher minimum-CLR value, on developed counties within their jurisdictions. This bias may help reduce regional inequality but is achieved at the cost of relatively inefficient land use in less developed regions. The provincial government should take this cost into consideration when designing CLR-regulation policies.

Fourth, my research might help governments develop a more effective tax scheme. I have demonstrated that an increase in the sharing percentage of tax revenue by local governments can improve land-use efficiency (a higher CLR). When placing the tax-sharing scheme in a broader perspective, my research implies that a more decentralized tax scheme should be used to improve land-use efficiency. On the other hand, upper-level
governments may tend to increase tax centralization because of justifiable and perhaps more important reasons, such as easing regional inequality within their jurisdictions. In this case, the choice of tax scheme is faced with the trade-off between land-use efficiency and other, conflicting objectives. My model also suggests that upper-level governments’ policies aimed at prohibiting subsidy competition among regions can ultimately induce less efficient land use. In other words, when subsidy instruments are prohibited, land supply is alternatively used as a tool to attract moving capital. Moreover, my model supports the use of the direct higher standard of CLR determined by upper-level governments due to the existence of strategic interaction in terms of CLR regulations. Nevertheless, I should point out that the rationalization of direct intervention relies on compliance with CLR regulations by local governments, which is difficult to supervise by upper level governments if they are inclined to comply and conspire with firms on this. Therefore, direct intervention should be used, accompanied by incentives.

6.4 Limitations

My research has the following limitations. First, a survey regarding the actual enforcement of FIOs and contractual regulations is lacking in my case studies. The regulatory policies in three case regions and land-use contracts in Shanghai used in this project have provided detailed stipulations of default clauses; however, it is not clear to what degree these default clauses will be implemented by local governments in reality, since these policies and land-use contracts had just been formulated when I conducted this research. Supervising the enforcement of these regulations may prove to be costly, which could weaken the local government’s incentive for it. Besides, firms may find a variety of ways to show that any violation of the regulations is caused by unpredictable events, which is probably allowed according to both regulatory policies and land-leasing contracts. If the more stringent regulations observed in the research turn out not to be implemented by local governments, there should be some caveats regarding the validity of the conclusions reached in my investigations.

Second, although I have documented the negative impact of the CES reform on industrial land supply, my results provide limited information on how to design better cadre evaluation criteria and related environmental protection targets. Since rejecting new firms’ locating can harm the development of the agglomeration economy, the adverse effect of the CES reform may be present especially in less developed regions. The heterogeneous analysis has shown that the CES reform may be having a larger impact on wealthier cities, which contradicts this possibility. However, I have also found that the negative impact on industrial land supply is mainly driven by local leaders with stronger promotion incentives, which supports this possibility. More heterogeneous analyses are needed to explore the mechanism behind the CES reform’s negative land supply effect.

Third, although my results imply that the land price is used in exchange for investment intensity, I have not offered direct evidence. The negative price effect of CLR regulations is based on the examination of provincial policies. That is to say, when provincial
governments impose CLR regulations that are tighter than those of county governments, the latter will reduce the industrial land price to recruit firms. However, whether county governments make this trade-off between land price and investment intensity is not sure. Another possibility remains; for example, when county governments raise the minimum-CLR values by themselves, they may tend to compensate firms through other subsidy tools, such as tax holidays, rather than lower land prices. To truly answer this question, I would need to examine the price effect of county- or even parcel-level CLR regulations.

Fourth, although my theory in Chapter 5 suggests that density-regulation tools can play an important role in efficiently allocating industrial land, two important factors are ignored in my theory, which may change the arguments. The first consists of the political forces behind the density regulations. There is probably a political incentive problem for local officials’ decision-making concerning density regulations, especially in a centralized political system like China. Local officers can be motivated to place more weight on short-term goals, which leads to less stringent regulations for long-term land-use density, or they may overly value increased GDP growth or employment and thus be willing to offer exceedingly high competition-induced subsidies, which forces them to relax density regulations. On the other hand, if a higher density is highly valued in the CES, local officers may instead impose overly stringent density regulations. In both cases, the industrial land is not efficiently allocated. The second factor is the cost of the implementation of density regulations. As I discussed in the first limitation, supervising the enforcement of density regulations and justifying that the violation of regulations is not caused by unpredictable events could be costly for local governments. Therefore, the efficiency argument on density regulations should be examined carefully by taking these costs into consideration.

Last, there are some caveats when applying the conclusions on density regulations to settings with private landownership. On the one hand, since tighter density regulations decrease the land price, private landowners are incentivized to prevent tighter density regulations from being adopted. Therefore, this “unfavorable” institutional arrangement may induce additional transaction costs of using density regulations, such as the costs of political competition between landowners and other residents. On the other hand, it is probably difficult for a planning agency to stipulate detailed density regulations and adjust them parcel by parcel. In China, it is not only the planning agency that formulates density regulations; other departments, such as the economic development committee, may also have the authority to impose specific types of density regulations. And the legal validity of these regulations comes from land-leasing contracts and does not necessarily rely on the planning law. Private landownership may reduce this flexibility in imposing density regulations. Nevertheless, it should be pointed out that these two factors do not mean that the conclusions of this research cannot at all be applied to cases with private landownership; they imply only that density regulations may be less responsive in this case.
6.5 Suggestions for future research

Future work should consider the political context involved in using density regulations. The political incentive scheme is quite diverse and may change with time. It can motivate policymakers to assign more importance to short-term goals or total GDP and employment growth, which may induce less stringent density regulations, either in the form of fewer types or a lower value of density regulations. The incentive scheme can also value higher density, and then overly stringent density regulations may be adopted. Researchers could first characterize the specific incentive structure in the regions they will examine and then model the decision-making of density regulations by expanding the theoretical framework put forward in this research.

It is also significant to further investigate how landownership prevents the use of firm-specific density regulations. In the case of industrial land supplied by rural collectives in China or land that is privately owned, as in many countries, the friction cost of using the reduction of the land price as a subsidy can be high and thus induce less stringent density regulations. It will be very interesting to examine this question by comparing the decision-making regarding industrial land supply by rural collectives and local governments in China, since landownership is the main difference between them. For the cases in which land is mainly privately owned, researchers might need to survey not only the typical density regulations drawn up by planning agencies but also the regulatory policies formulated by other government departments or investment agreements reached between governments and industrial firms.

Last, more empirical work is needed to examine the theoretical implications of this research in more detail. For example, researchers can investigate which specific policy increases the friction costs of subsidizing firms and evaluate to what extent these policies will prevent more stringent density regulations from being used. The other arguments that remain to be tested include the extent to which density regulations imposed by county governments in China can lower land prices, the extent to which regional competition for moving capital can induce less stringent density regulations, and whether there exists strategic interaction among regions regarding density regulations.
Conclusions
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List of Notations

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<tr>
<td>CES</td>
<td>Cadre Evaluation System</td>
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<tr>
<td>CLR</td>
<td>Capital-Land Ratio</td>
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<tr>
<td>FAI</td>
<td>Fixed Assets Investment</td>
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<tr>
<td>FAII</td>
<td>Fixed Assets Investment Intensity</td>
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<td>FAR</td>
<td>Floor Area Ratio</td>
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<td>FIOs</td>
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<td>VAT</td>
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Summary (Dutch follows English)

Land-use regulations (LURs) are widely used to remedy the side effects of economic activities. They vary across regions and have been increasingly adopted in recent years. Nevertheless, it has been documented that LURs lead to many unwanted outcomes, such as expensive housing or lower productivity. To better evaluate and design LURs, many researchers have turned to exploring the origins of LURs. They consider a variety of agents who are impacted by different types of LURs and highlight the political process of determining LURs. This thesis continues this strand of research by investigating the causes of LURs regarding industrial activities in China. Industrial land-use regulations (ILURs) are quite popular in China and have recently become more stringent. I ask: what are the motivations behind a variety of ILURs used by local governments, including restrictions on density, contractual duration, and amount of available land?

Chapter 2 explores the question of why different forms of firms' inputs and outputs (FIOs) regulations and different contractual durations are used by local governments when supplying industrial land. I propose an analytical framework that integrates ILURs into a land-leasing contract between the firm and the local government. I have theorized this contract as a share tenancy with an exogenous rental percentage and argued that FIOs and contractual duration regulations are used to minimize transaction costs. In this framework, the stringency of regulations is predicted by industrial land scarcity, the redevelopment costs of stock industrial land within one region, and the characteristics of the individual firm. These three factors affect FIOs and contractual duration regulations through changing transaction costs. Empirically, I used three comparative cases to explore the variation in public law and analyzed 86 industrial land-leasing contracts drawn up in Shanghai in 2017 to explore the variation in private law. I find that FIOs and contractual duration regulations are used in all case regions to a different extent and the patterns are consistent with the theory. Specifically, regions with a higher scarcity of industrial land or higher redevelopment costs of stock industrial land tend to impose more stringent FIOs and contractual duration regulations, in which stringency refers to the types of FIOs, the length of the contract, and the enforcement of these stipulations. Moreover, I have shown that firms with a higher anticipated productivity tend to be offered a longer leasing term, both in the local policy and in the land-leasing contract analysis.

Chapter 3 examines whether and how the political incentive scheme impacts industrial land supply. I establish a simple theoretical model with public landownership to guide the research. The city leader derives utility from both financial revenues and environmental amenities, and firms have to maximize the sum of fiscal revenues and land rent to compete for land. By allowing the city leader's valuation of environmental amenities to be influenced by both the political incentive for environmental protection and the level of the city's wealth and environmental amenities, I derive that an increase in the political incentive for environmental protection makes the cities that are confronted with a lower environmental quality experience a larger reduction in industrial land supply. I empirically investigate this research question by exploiting the recent cadre evaluation system (CES) reform in 2013 in China as a positive shock to local leaders' political incentive for
environmental protection. Using the difference-in-differences (DID) strategy, I document that a dirtier city experiences a significantly larger decline in industrial land supply after the reform. I show that the baseline results are robust to a variation of measures of pollution levels in a city, and that the results are not likely to be driven by the anti-corruption campaign or the entire country's downward economy through falsification and placebo analysis. Last, the heterogeneous analysis showed that the CES reform may be having a larger impact on dirtier industries and wealthier cities, and that my results are mainly driven by local leaders with stronger promotion incentives.

Chapter 4 investigates whether and to what extent a low industrial land price can be explained by tighter density regulations. I establish a simple theory to show that a binding minimum capital-land ratio (CLR) leads to a lower industrial land price. However, this price effect weakens as the optimal density determined by market participants grows in time. I exploit province-level variation in the minimum CLR and use a DID event study design that uses the event dummy as the treatment. I examined land-price changes within a five-year window around 19 province-level minimum-CLR events and found that province-level minimum-CLR regulations have a negative price effect in the first one and half years after the regulatory policy is implemented. The results are robust to the specifications adding controls for county-specific linear and quadratic time trends, using different event windows or continuous treatment indicators. In addition, by using several sub-groups to estimate the baseline model, I found that province CLR regulations have a slightly larger impact on the price of large parcels, a slightly larger impact on parcels located farther away from the county center, and a significantly larger impact on counties with higher fiscal revenue per capita and secondary GDP per capita.

Chapter 5 explores how CLR regulations are used as a firm-specific policy tool to intervene in industrial development. I establish a theoretical model to characterize how local governments use CLR regulations, land prices, and subsidies to allocate industrial land when faced with the tax-sharing scheme, frictions of subsidizing firms, and regional competition. Specifically, local governments gain the tax revenue and land price and value all positive and negative externalities, while firms decide their location among regions to obtain the highest payoff, which includes various forms of subsidies. I model the bidding for firms as a private value open-outcry ascending scoring auction and provide an equilibrium in which the tax revenue incentivizes local governments to strengthen CLR regulations and the friction costs of subsidizing and the competition for mobile capital lead them to weaken CLR regulations. Using parcel-level CLR regulations from 2011 to 2018 in China and a two-way fixed effects model, I empirically document that when county-level governments are allocated a larger share of value-added tax (VAT) revenue, they tend to impose a larger minimum fixed assets investment intensity (FAII) on firms. The baseline results are robust to the variation in tax schemes caused by either the provincial reform or the national reform and the specification that instruments the tax-sharing percentage by county governments with regional inequalities. Last, by using land price as the dependent variable to implement a falsification analysis, I showed that the baseline result is not likely to be driven by industrial land's supply or demand forces.
Samenvatting

Regelgeving inzake grondgebruik (in het Engels ‘Land-use regulations’ of ‘LUR’s’) wordt veel gebruikt om de neveneffecten van economische activiteiten te verhelpen. LUR’s variëren van regio tot regio en worden de laatste jaren steeds vaker toegepast. Desalniettemin is bekend dat LUR’s tot veel ongewenste resultaten leiden, zoals dure huisvesting of lagere productiviteit. Om LUR’s beter te evalueren en te ontwerpen, hebben veel wetenschappers de oorsprong van LUR’s onderzocht. Zij beschouwen een verscheidenheid aan actoren die worden beïnvloed door verschillende soorten LUR’s en benadrukken het politieke proces van het bepalen van LUR’s. Dit proefschrift zet deze onderzoekslijn voort, door de oorzaken van LUR’s met betrekking tot industriële activiteiten in China te onderzoeken. Regelgeving voor industrieel grondgebruik (in het Engels ‘Industrial land-use regulations’ of ‘ILUR’s’) is behoorlijk populair in China, en is recentelijk strenger geworden. Ik stel de vraag: Wat zijn de beweegredenen achter een verscheidenheid aan ILUR’s die door lokale overheden worden gebruikt, inclusief beperkingen op dichtheid, contractduur en hoeveelheid beschikbare grond?

Hoofdstuk 2 onderzoekt de vraag waarom lokale overheden verschillende vormen van FIO’s – regelgeving inzake inputs en outputs van bedrijven (in het Engels ‘firms inputs and outputs’) – en verschillende contractlooptijden gebruiken bij het leveren van industriegrond. Ik stel een analytisch kader voor dat ILUR’s integreert in een grondleasecontract tussen het bedrijf en de lokale overheid. Ik heb dit contract getheoretiseerd als een aandelenhuur met een exogeen huurpercentage, en heb betoogd dat FIO’s en contractuele duurregelingen worden gebruikt om transactiekosten te minimaliseren. In dit kader wordt de strengheid van de regelgeving voorspeld door de schaarste aan industriegrond, de herontwikkelingskosten van de voorraad industriegrond binnen een regio, en de kenmerken van de individuele onderneming. Deze drie factoren beïnvloeden FIO’s en contractduurregelingen door veranderende transactiekosten. Empirisch heb ik drie vergelijkende casussen gebruikt om de variatie in publiekrecht te onderzoeken en heb ik 86 industriële huurcontracten geanalyseerd, die in 2017 in Shanghai zijn opgesteld, om de variatie in privaatrecht te onderzoeken. Ik laat zien dat FIO’s en contractduurregelingen in alle casusregio’s in verschillende mate worden gebruikt en dat de patronen consistent zijn met de theorie. Specifiek hebben regio’s met een grotere schaarste aan industriegrond, of hogere herontwikkelingskosten van de voorraad industriegrond, de neiging om strengere FIO’s en contractduurregelingen op te leggen, waarbij strengheid verwijst naar; de soorten FIO’s, de looptijd van het contract en de handhaving van deze bepalingen. Bovendien heb ik aangetoond dat bedrijven met een hogere verwachte productiviteit een langere huurtermijn aangeboden krijgen, zowel in het lokale beleid als in de analyse van de grondhuurcontracten.

Hoofdstuk 3 onderzoekt of en hoe de politieke stimuleringsregeling van invloed is op het aanbod van industriële grond. Ik stel een eenvoudig theoretisch model op, met openbaar grondbezit, om het onderzoek te sturen. De stadsleider ontleent nut aan zowel financiële inkomsten als milieuvoorzieningen, en bedrijven moeten de som van
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fiscale inkomsten en grondhuur maximaliseren om te strijden om grond. Door de waardering van milieuvoorzieningen door de stadsleider te laten beïnvloeden door zowel de politieke prikkel voor milieubescherming als het niveau van de welvaart en milieuvoorzieningen van de stad, leid ik af dat een toename van de politieke prikkel voor milieubescherming maakt dat de steden die geconfronteerd worden met een lagere milieukwaliteit, een grotere vermindering van het aanbod van industriële grond ervaren. Ik onderzoek deze onderzoeks vraag empirisch door gebruik te maken van de recente hervorming van het kaderevaluatiesysteem (in het Engels ‘cadre evaluation system’ of ‘CES’) in 2013 in China, als een positieve schok voor de politieke stimulans van lokale leiders voor milieubescherming. Met behulp van de Difference-in-Differences (DID)-strategie documenteer ik dat een vuilere stad na de hervorming een aanzienlijk grotere afname van het aanbod van industriële grond ervaart. Ik laat door middel van falsificatie en placeboanalyse zien dat de basisresultaten robuust zijn voor een variatie van metingen van vervuiling niveaus in een stad, en dat de resultaten waarschijnlijk niet worden bepaald door de anti-corruptiecampagne of de neerwaartse economie van het hele land. Ten slotte toonde de heterogene analyse aan dat de CES-hervorming mogelijk een grotere impact heeft op vuilere industriën en rijkere steden, en dat mijn resultaten voornamelijk worden bepaald door lokale leiders met sterkere promotiestimulansen.

Hoofdstuk 4 onderzocht of en in hoeverre een lage industriële grondprijs kan worden verklaard door strengere regelgeving op het gebied van dichtheid. Ik stel een eenvoudige theorie op om aan te tonen dat een bindende minimum kapitaal-grondverhouding (in het Engels ‘capital-land ratio’ of ‘CLR’) leidt tot een lagere industriële grondprijs. Dit prijseffect wordt echter zwakker naarmate de door marktpartijen bepaalde optimale dichtheid in de loop van de tijd toeneemt. Ik benut variatie op provincieniveau in de minimale CLR en gebruik een DID event study design dat de event dummy als de behandeling gebruikt. Ik onderzocht veranderingen in de grondprijs binnen een periode van vijf jaar rond 19 minimum-CLR gebeurtenissen op provincieniveau, en ontdekte dat minimum-CLR-regelgeving op provincieniveau een negatief prijseffect heeft in de eerste anderhalf jaar nadat het regelgevingsbeleid is geïmplementeerd. De resultaten zijn robuust voor de specificaties en voegen controles toe voor district-specifieke lineaire en kwadratische tijdrends, met behulp van verschillende gebeurtenisvensters of continue behandeldsingindicatoren. Door verschillende subgroepen te gebruiken om het basismodel te schatten, ontdekte ik bovendien dat de CLR-regelgeving van de provincie een iets grotere impact heeft op de prijs van grote percelen, een iets grotere impact heeft op percelen die verder weg van het districtscentrum liggen, en een significant grotere impact heeft op districten met hogere fiscale inkomsten per hoofd van de bevolking en secundair BBP per hoofd van de bevolking.

Hoofdstuk 5 onderzocht hoe CLR-regelgeving wordt gebruikt als een bedrijfsspecifiek beleidsinstrument om in te grijpen in industriële ontwikkeling. Ik stel een theoretisch model op om te karakteriseren hoe lokale overheden CLR-regelgeving, grondprijzen en subsidies gebruiken om industriegrond toe te wijzen wanneer ze worden geconfronteerd met de belastingverdelingsregeling, vrijvingen van subsidiërende bedrijven en regionale
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concurrentie. Met name lokale overheden krijgen de belastinginkomsten en de grondprijs en waarderen alle positieve en negatieve externe effecten, terwijl bedrijven hun locatie tussen regio’s bepalen om de hoogste uitbetaling te verkrijgen, waaronder verschillende vormen van subsidies. Ik modelleer het bieden voor bedrijven als een private waarde open-outcry oplopende scoringsveiling, en zorg voor een evenwicht waarin de belastinginkomsten lokale overheden stimuleren om de CLR-regelgeving te versterken, en de frictiekosten van subsidiëring en de concurrentie om mobiel kapitaal ertoe leiden dat ze de CLR-regelgeving verzwakken. Met behulp van CLR-regelgeving op perceelniveau van 2011 tot 2018 in China, en een tweerichtings fixed effects model, documenteer ik empirisch dat wanneer regeringen op districtsniveau een groter deel van de belasting op de toegevoegde waarde (btw) krijgen toegewezen, ze de neiging hebben om een grotere minimale FAII – investeringsintensiteit in vaste activa (in het Engels ‘fixed assets investment intensity’) – voor bedrijven op te leggen. De basisresultaten zijn robuust voor de variatie in belastingregelingen die worden veroorzaakt door ofwel de provinciale hervorming of de nationale hervorming en de specificatie die het percentage belastingdeling door districtsoverheden instrumenteert met regionale ongelijkheden. Ten slotte heb ik, door de grondprijs te gebruiken als de afhankelijke variabele en een falsificatieanalyse te implementeren, aangetoond dat het basisresultaat waarschijnlijk niet wordt bepaald door de vraag- of aanbodkrachten van industriegond.
Acknowledgements

At the beginning of January 2015, I returned from Zhengzhou city in Henan province, where I had already found a job in a real estate company, to Taigu county in Shanxi province to take the photo required by the Shanxi Agricultural University. I visited my supervisor, Prof. Fuzhong Li, sharing my success in finding this nice job and also mentioning an opportunity to apply for the PhD project at Nanjing Agricultural University. He instantly told me that I should apply for this PhD project. “Do not focus on the high salary in the company,” he said, “you will have a larger success by doing a PhD, that is suitable for you.” His words lighted my passion for scientific research again, which occurred to me frequently when I did field interviews in villages for my master thesis one year ago. I only had about one week to prepare for the application, but I managed to submit it. Luckily, several months later, I received a positive reply from Prof. Xiaoping Shi, and luckily again, Prof. Erwin van der Krabben offered me an opportunity to start a PhD project at Radboud University in 2017. When completing the PhD project right now and looking back at the long journey, I am not quite sure about Prof. Li’s prediction of “larger success”, which seems to only work as a lure. But I do find that engaging in research is no doubt suitable for me, and I am just lucky to follow his advice and choose scientific research as the job. Growing in a small village and starting from an unknown university, I cannot make it without these three excellent supervisors.

Erwin and Huub have continuously had meetings with me every two or three weeks since I arrived in the Netherlands in October 2017. Often I did not ask for the meeting due to the delayed research progress. Huub or Erwin will come to ask me and schedule an appointment or ask our dear secretary, Yvonne, to help me plan regular meetings for the coming several months. This is really helpful for a person like me who tends to delay the task for many different reasons. I always received a bunch of feedback from them and realized there were many problems in my research either immediately or later. Sometimes I was really stressed and argued fiercely with them about some ideas, but soon I would regret this. Now I am so glad that we luckily did not fight for those ideas. Besides these formal meetings, Huub often came to my office to check my progress when he was not busy. If I could raise some meaningful questions, he would be excited and discuss with me until very late or a phone call came in. I have gradually learned many things about doing good research from their supervision. Another member of our industrial land research group, Aidong Zhao, who introduced me to Erwin, also helped and inspired me greatly on the research. Yet I had doubted some of his suggestions because I brought a big pan (wok) when coming to the Netherlands according to his advice. I released when it turned out he seldom went shopping during that one year he stayed in Nijmegen. I am also grateful for the one-year funding and two-month job Erwin offers, making the past two years easier for me.

The idea of my thesis originates from one presentation by a master student, Jie Sun, from our research group in Nanjing, which Prof. Shi leads. Before that presentation, I was studying the topic of the agricultural land market, motivated by the field interview in Shanxi. Then I became so interested in this familiar and strange topic, the industrial land market. I
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can’t wait to know how local governments in China are improving land allocation through innovative and flexible contractual arrangements. Prof. Shi was also excited about this topic and devoted a lot to helping me investigate it. He introduced many local officials from related departments to me and funded the interview, which later became rich sources of my idea in the thesis. And Prof. Ma and Prof. Lan helped me a lot at the start of my research. I also benefited considerably from research group meetings when I was in Nanjing, no matter I presented or participated in discussions. During the COVID period, I could rejoin the meeting online, allowing me to talk about my ongoing projects and gain lots of valuable feedback. I should say the meeting helped me live through the most challenging times. The group members are great. Their comments are always critical and constructive, and I frequently exchange ideas with some of them, including Changkun, Zibo, Yan, and Xu. I enjoy the friendship with them.

Aidong told me the best thing to do in the Netherlands was cycling, and I agree. We went cycling to many places in Nijmegen and even to some neighboring towns in Germany. Later Yong and Mingjun joined us. We seem to be never fed up with the water, duck, grass, cow, tree, house, etc. “Beautiful”, Aidong always cried in English when we stopped somewhere. We also loved collecting chestnuts in autumn. Weekend dinner was another exciting thing, although it became a little bit complicated when the chef Aidong fell in love with a girl who is now his wife and had no time to cook for us. I confessed that I kind of liked to see him caught in the middle.

My colleges from GPE are very lovely and helpful. I was always surprised when Yvonne and Jol helped me deal with many complicated things professionally. And I felt very warm when many colleges tried to help each other even our topics were really different. I was also deeply touched when receiving wonderful comments from Marieke L. van Genugten and Lenferink Sander on the research day. I enjoyed talking with Lidya, Theodoros, Iris, Ira, Paulina, Ainul, Cesar, Emma, Federico, Hanna, Maria, Mai, and many other guys in my poor English. I also enjoyed participating in the gathering usually organized by Corinne or Top, usually eating and chatting in a crowded and lovely restaurant. I like playing tennis with Top and Lothar, two strong men, and not surprisingly, I was exhausted every time after the game. The thing that made me surprised was I always thought I had better skill but Top won almost all our games. Colleges from China like me, Keyang, Hao, Jinshuo, and Yueyue, helped me a lot in adapting to life and study in Nijmegen and gave me strong encouragement. Corinne, Ayaka, Top, and I went cycling a lot in the summer of 2021, with many beautiful spots in Nijmegen being explored and many beautiful memories being kept in my mind.

After moving to Vossenfeld 53, I started to increasingly have dinner with neighbors, including Jinshuo, Jinhan, and later Liu. We sometimes walked to places nearby and kept talking on the way. Jinshuo, Jinhan, and I even went hiking in the beautiful city Innsbruck in 2019 Autumn. Gradually I made more friends living here. I played basketball with Fan, Tao, Quan, and later Chuyao. The time after the game was my favorite. I also enjoy the dinners and talking with Jinbiao, Xuan, Xiaolei, and Chao.
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I could always eat some nice food in Jianying’s house and learn some great ideas from his talking. I also hung out with Peng, Tingting, Shuzhen, and Rongkang, during their one-year stay in Nijmegen. Especially, I enjoyed the discussions with Peng about land policies in China, which gave birth to my first published English paper coauthored with him and Jinshuo. I had a good time traveling with Changkun in Barcelona, Yan, Minjie, and Guangcheng in Naples. The scenes and feelings returned to me many times. I also enjoyed the nice talks with Yao, Yan, Yidong, Xue, Zhuoyan, and Lei, from our University, and Fan and Liang, from Wageningen University. Playing tennis with Jiabin and Danni was also a wonderful time for me. Can’t imagine that we have played for three years, and memorably our possibly last game here was ended with my ankle being sprained.

My parents kept asking me whether I was short of money in the last year. Considering my age, this is quite embarrassing. I am delighted they continue farming and stay healthy these years. They and the great minds I learn from the literature inspired me to get through the darkness.

I felt very excited and optimistic when visiting my bachelor roommate Shenghao in Wageningen University in 2017 and recalling the life goals we had talked about before. I believed I was well equipped and able to make a difference at that time. Over these years, it turns out I am just increasingly aware that I know very little, even after completing this thesis. I need to encourage myself very hard in the upcoming new life.

Thank you all.

Vossendijk 53 & Elinor Ostrom Building 02.220
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About the author

Fugang Gao was born in Linzhou city of China in 1988. He studied at Shenyang Agricultural University from 2008 to 2012 and obtained a bachelor's degree in Management, majoring in Land Resources Management and focusing on land use planning. Then he studied at Shanxi Agricultural University from 2012 to 2015 and obtained a master's degree in Management, majoring in Land Resources Management and focusing on the agricultural land market. He started the PhD project at Nanjing Agricultural University in 2015 and the PhD project at Radboud University Nijmegen in 2017. His research interest centers on land and covers land planning and development, regional and urban economics, public economics, and institutional economics.