Essays on Land Allocation and Foreign Direct Investment Policies

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ABSTRACT

The first chapter argues that the dramatic population decline in China in recent years is partly an unintended consequence of local governments' land allocation decisions, driven by industrial discounts in the land market. I provide institutional background and empirical evidence on land allocation in China. Three novel empirical findings illuminate land allocation behavior over the past decade: First, using detailed records of urban land transactions, I find that industrial land is leased at an average discount of 47% relative to residential land. Second, this pro-industrial discount varies across cities and is particularly pronounced in more developed coastal areas, indicating a stronger prioritization of industrial use in those regions. Third, using microdata from the China Census Survey, I document a negative relationship between city-level fertility rates and the share of industrial land. These empirical patterns lay the foundation for the theoretical analysis in the next chapter, which examines how government land allocation decisions influence household fertility behavior.

Chapter Two develops a theoretical model to analyze the comparative statics of fertility decisions in response to housing prices, which are endogenously shaped by land allocation policies. A central feature of the model is the trade-off between industrial and residential land: to boost economic output, local governments allocate more land to industrial usage, thereby reducing the supply of residential land, driving up housing prices, and ultimately suppressing fertility. I employ a numerical approach to investigate the interactions between land allocation, population control policies, and public expenditure policies, and to evaluate their effects on equilibrium outcomes. The model yields two main findings. First, under the One-child Policy, China's fertility rate was substantially below the replacement level. However, a shift to a market-based land allocation system without price distortion could have increased the fertility rate. Second, consistent with the "quantity-quality" trade-off, an increase in fertility leads to a decline in per-child educational investment. However, increased public investment in education can reduce the financial burden on parents, thereby mitigating this trade-off and simultaneously raising both education levels and fertility rates.

The third chapter is an empirical analysis of a Foreign Direct Investment (FDI) preferential policy in China, which grants corporate income tax reductions to firms with foreign equity shares of at least 25%. I document two novel empirical facts that reveal the behavioral response to this notch-based tax scheme. First, a significant number of joint ventures bunch precisely at the 25% foreign ownership threshold, resulting in a 20.8% increase in total FDI. Second, joint ventures at the 25% threshold exhibit a notable discount in both firm size and total factor productivity, suggesting a performance cost associated with meeting the tax incentive threshold. These findings speak to the policymaker that when taking the cost into consideration, the consequence of utilizing tools such as tax subsidies to manipulate foreign investors' acquisition in multinational enterprises may be complicated to interpret. Therefore, this empirical research motivates a future extension to explore how different tax schemes shape the ownership structures of joint ventures, particularly in the context of incomplete contracts.

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Chapter 1

LAND ALLOCATION AND POPULATION DECLINE: EMPIRICAL EVIDENCE FROM CHINA

Qiaohairuo Lin* Chunru Zheng†

1.1 Introduction

In 2022, 9.56 million people were born in China, while 10.41 million died, resulting in a decline of 850,000 in population, and marking the first population decline since the early 1960s. This was the sixth consecutive year of a declining fertility rate since the cancellation of "One-child Policy" in 2016. This population decline occurred ten years earlier than the Chinese government's official prediction, which could have far-reaching implications for the country's economy and social structure.[1] This highlights the need for further analysis and understanding of the factors contributing to the fertility decline.

In this chapter, we connect the low fertility rate in China with high housing prices and explore its correlation with the government's land allocation from an empirical perspective. The 2019 China Fertility Report identifies high housing costs as one of the most significant factors discouraging young people from having children, alongside other reasons such as the high costs of education, medical care, retirement burdens, and the opportunity cost of child-rearing.[2] Although housing privatization in China only began in 1998, housing prices have since risen nearly twice as fast as national income. We step back to explore the deeper causes of soaring housing prices, focusing on land market allocation, which is entirely controlled by the Chinese government.

The novel ingredient linking fertility rate with land allocation is a trade-off between industrial land (for business) versus residential land (for housing). This allocation affects housing affordability and, consequently, the cost of living, thereby shaping local households' family planning decisions. This process mirrors zoning policies in other countries (Hsieh and Moretti, 2019; Gyourko and Molloy, 2015a), and offers a context to explore

[0]This chapter is co-worked with Qiaohairuo Lin. I am grateful to him for collaborating on the exploration of China's land market datasets and for the insightful discussions on related topics. I thank Jose Asturias, Luis Baldomero-Quintana, Simon Fuchs, Brian Cevallos Fujiy, Martín García-Vázquez, Gaurav Khanna, Daisoon Kim, and Kei-Mu Yi for their helpful comments. I thank Jorge Luis García for generously sharing datasets and codes related to China's One-child Policy. However, all errors are our own.

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[1]For instance, in 2019, the United Nations released the *"World Population Prospects (2019)"*, forecasting that China's population will reach its peak in 2031. Additionally, the China Academy of Social Science projected that China's population will begin to decline after 2029, eventually falling to 1.44 billion, as outlined in the *"Reports on China Population and Labor (2019)"*.

[2]Zeping Ren, Chai Xiong, Zhe Zhou. (2019). The Approaching Demographic Crisis - China Fertility Report 2019, *Evergrande Wealth*. http://pdf.dfcfw.com/pdf/H3_AP201901041282086287_1.pdf

how macro-level land policies influence household behavior.

In this chapter, we begin by introducing the institutional background of land allocation and population policy in China. First, we provide an overview of China's land policy and urban land use patterns. Unlike many other countries, where zoning policies typically emerge from the bottom up and property owners seek to maximize rental values, urban land in China is solely owned by local governments. These governments hold exclusive legal ownership and have the discretionary power to allocate land for various uses through long-term lease arrangements. Second, in the context of population growth, the One-child Policy stands out as a uniquely important policy tool that directly shaped fertility rates in China. We therefore detail the historical background of this policy and examine the demographic patterns that emerged under its enforcement.

We then present three novel empirical findings to shed light on land allocation behavior in China over the past decade. First, using granular records of urban land transactions, we find that industrial land is leased at an average discount of 47% compared to residential land. Second, this pro-industrial-land discount differs across cities and is even larger in more developed coastal areas, indicating a higher priority for industries in land allocation. This suggests that the industrial land discount observed from the empirical datasets might point to a general land misallocation in China.[3] Third, using microdata from the China Census Survey, we find a negative relationship between city-level fertility rates and the share of industrial land. This negative correlation remains robust and significant even after controlling for the differentiated enforcement of the One-child Policy at the city level.

This chapter serves as a motivation for the theoretical framework developed in the next chapter. The primary objective here is to empirically establish the correlation between land allocation and fertility rates. Building on this empirical foundation, the following chapter will introduce a theoretical model to examine the comparative statics of fertility decisions in response to changes in land allocation. Together, these two chapters provide a comprehensive exploration of the interactions between government land allocation, population control, and public education policies.

1.2 Literature Review

This research closely links to four strands of literature. The first is to evaluate the impacts of land misallocation, where distortion is usually measured as a wedge between prices, as in Hsieh and Klenow (2009); Gyourko and Molloy (2015a). Concerning land policy, prior research, such as that by Gyourko and Molloy (2015a), indicates that stringent land-use policies push up housing prices, which reduces resident welfare and, at the macro level, impedes the efficient reallocation of labor across regions by restricting the movement of workers to more productive cities (Hsieh and Klenow, 2009). Typically, these papers

[3]Theorectically, under the "One-price Rule" in a laissez-faire market with identical homothetic households, we prove in Appendix VIII that to maximize worker utility, residential land prices should be equal to or lower than industrial land prices. For example, in the U.S, where the land market is not predominantly controlled by local governments, there is no statistically significant price difference between the unit price of industrial land and multi-family apartments, as supported by Kok *et al.* (2014) using a subsample of land transactions in the San Francisco Bay Area.

assume that the national aggregate labor is fixed or take the population growth within an economy as given. Our work expands upon this body of literature by integrating dynamic population growth and demographic transitions into a spatial model, specifically accounting for variations in fertility rates and educational distributions.

Secondly, this paper contributes to the empirical literature on land market distortions in China, building on previous work by Tian *et al.* (2019), Fei (2020), and Tian *et al.* (2020). These studies provide extensive evidence that Chinese local governments offer industrial discounts to attract large firms with significant tax revenue potential, or industries with notable spillover effects. Lin and Zheng (2024) explains this phenomenon by calculating the Nash equilibrium and cooperative land allocation strategies when local governments are bidding for firms and labor across regions. In this paper, we identify consistent empirical patterns in industrial land discounts and treat them as a source of the rapidly increasing housing prices in China. We contribute to this literature by developing a unified framework that investigates the interplay between governments' land and population policy, thereby explaining multiple empirical patterns observed in China.

Thirdly, our paper builds on the family economics literature to examine the effects of macro policy on demographic features (Baird *et al.*, 2009; Becker, 1960). Various studies have demonstrated that housing wealth has a positive income effect on fertility rates in developed economies like the United States (Lovenheim and Mumford, 2010), Canada (Clark and Ferrer, 2016), and Denmark (Daysal *et al.*, 2021). However, when it comes to developing countries like China, the empirical evidence regarding the influence of housing wealth on fertility rates has yielded different results. For instance, Liu *et al.* (2023) found that higher housing prices significantly reduce the fertility probability among renter families and those with self-built homes, while the response was non-significant for homeowners. Additionally, Liu *et al.* (2020) discovered that among home-owning women, a 100,000-yuan increase in housing wealth was associated with a 14% decrease in the likelihood of giving birth among home-owning women. However, a recent study by Tan *et al.* (2023) found that housing wealth increased fertility likelihood by a significant margin of 3.6%. One possible reason for the perplexing outcomes is the strict One-child Policy in China, which heavily affected the household's realized fertility choices. While there was variation in the implementation of this policy across different regions and for certain ethnic groups (García, 2022), the vast majority of individuals in urban areas were constrained by this policy until 2016. In this paper, we formalize the price of the One-child Policy and explore the effects of population policies under counterfactual scenarios.

Moreover, this project contributes to the literature evaluating the "Quantity-Quality" trade-off in fertility decisions within a spatial framework (Delventhal *et al.*, 2021; Greenwood and Seshadri, 2002). Most research on the declining fertility rate in developing countries overlooks this trade-off, resulting in less persuasive arguments regarding the welfare implications of long-term human capital accumulation. Our study focuses on this trade-off in child-rearing, which resonates with the One-child Policy's objective of promoting "fewer and better births". We aim to assess the outcomes of this population policy and its interaction with public education policy.

1.3 Institutional Background and Data

1.3.1 Land Allocation Policy

In 1988, the "Law of the People's Republic of China on Land Administration" authorized city governments to seize agricultural land from collectives and farmers and convert it into construction land for sale to firms. The cost of this conversion consists of two main components: compensation for the previous land users (typically rural collectives and farmers) and the cost of preparing the land for construction and installing necessary infrastructure such as roads, green spaces, water, electricity, and natural gas. Construction land is used for a variety of purposes, including urban and rural residential and public facilities, industrial land, transportation and water conservancy facilities, tourism land, and military facilities.

Urban Land Expansion and Quota Restriction Local governments in China have significant discretion over land supply, determining allocations for industrial and residential land. In 2004, the revised "Law of the People's Republic of China on Land Administration" introduced an approval process for land use: first, the central government formulates an overall plan for land use, controls the total amount of construction land at the provincial level, and provides special protection for agricultural land.[4] Subsequently, provinces, cities, and counties then create their land usage plans accordingly and seek approval from their upper-level governments. These plans set targets for the total amount of construction land available, including both industrial and residential land. Once prepared, local governments can transfer land use rights through various ways, including one-to-one negotiation, bidding, auction, and listing. Over recent decades, there has been considerable growth in urban land areas as local governments have actively converted rural lands on city outskirts into urban districts, thereby expanding urban boundaries (see Figure A5).

Urban Land Use In this paper, we concentrate on the two most crucial types of land usage: residential and industrial. Residential land is primarily utilized for real estate, especially multifamily apartments, while industrial land is used for factories and industrial parks. We focus on these two types for two main reasons. First, these two categories constitute the major uses of urban land in China (23.94% for industrial land and 31.53% for residential land from 2007 to 2019) and display considerable variations in their distribution ratios across cities, as shown in Figure A6. Second, unlike land designated for roads, transportation, and public utilities, which typically take a steady share of urban space, industrial outputs are less bound to local constraints. This allows for industries to be concentrated in specific areas while serving global markets, giving local governments motivation to strategically prioritize industrial land. In this paper, we use the areas of residential and industrial land to define the total land endowment and calculate their area ratio to define the land allocation.

To investigate urban land allocation in China, we employ two datasets. The first dataset, "China Urban Construction Statistical Yearbooks" from the Ministry of Housing and Urban-

[4] For reference to the document, please see http://www.gov.cn/zxft/ft149/content_1144625.htm

Rural Development of China, represents the annual "STOCK" of urban land and helps illustrate the aggregate land allocation patterns and quantify the model. The second dataset, used in the empirical analysis section, consists of web-scraped data on urban land transactions over the past decade and represents the "FLOW" of urban land. This dataset records the unit price of each land parcel and is critical to identifying the urban land misallocation in the empirical section. Details about the regulations in land expansion and allocation are in Appendix I.

1.3.2 Population Policy

Common wisdom often attributes China's declining population growth to the unique and stringent One-child Policy (OCP), implemented from 1979 to 2015. The strict enforcement of this policy directly restricted the realized fertility rate during that period. Since this study focuses on changes in fertility rates in China, it is essential to account for confounding factors due to population control policies. In this section, we provide historical background on the One-child Policy and explain its relevance to this research. In the empirical analysis, we will construct a numerical proxy to capture the monetary cost imposed by the policy on parents having a second or third child. In the next chapter, we will incorporate this cost into the theoretical model and uncover the counterfactual fertility rate in the absence of the One-child Policy.

The One-child Policy in China was a population control policy that was introduced by the Chinese government in 1979 and lasted until 2015. The policy was implemented in response to concerns about the rapidly growing population in China and the strain it placed on the country's resources (e.g, land) and economy. Under this policy, couples were free to have only one child, and had to pay heavy penalties for having a second or third child, such as fines, loss of employment, and even forced abortions or sterilization (García, 2022; Ebenstein, 2010). The policy was strictly enforced, with several exceptions for ethnic minorities, scarcity of males in families, disabled first children, or types of jobs.[5] There is a consensus about its unintended consequences, for example, a gender imbalance driven by a preference for male offspring, an increasingly aging population, and a looming shortage of workers needed to support the elderly.

However, debates continue regarding the causal relationship between this policy and the declining birth rate in China. For example, García (2022) argues that fertility rates in China and its surrounding countries were already decreasing even before 1979, and this decline persisted smoothly following the implementation of the policy. Various other elements, such as rising wages, improved educational levels, and agricultural reforms, might have also contributed to the continued reduction in fertility rates after 1979 (Huang *et al.*, 2021). In this project, we model the implementation of the "One-child Policy" as a pricing system that increases the child-rearing cost for women to have multiple children. This approach allows us to explore the potential human capital outcomes in a counterfactual scenario without this policy.

In 2015, the Chinese government announced that it would relax the One-child Policy,

[5] According to government documents, there were seventeen individual characteristics qualified for "exemptions", see Scharping (2002) and García (2022) for details.

allowing couples to have two children if either parent was an only child. However, this has not led to a significant increase in the birth rate. Instead, China's birth rate kept falling. The Chinese government is now urging couples to have more children to address the country's demographic challenges: in 2015, China's fertility rate had dropped to 1.199 children per married woman, compared with 2.355 in the 1970s. This is below the replacement level of 2.1 children per married woman, which is needed to maintain a stable population. Moreover, compared to a country with a reputation for its low fertility rate and aging structure, in 2020, with a per capita GDP that is only 26% of Japan's, China's birth rate started to be lower than Japan's (Figure 1.1).

1.4 Empirical Analysis

In this section, we display three empirical facts found in the Chinese market: First, industrial land is priced significantly lower than residential land. Second, this industrial discount varies across cities, with industrial regions exhibiting a larger price gap between land parcels. Third, the share of industrial land in each city is negatively correlated with fertility rates.

1.4.1 Stylized Fact 1: Industrial Land is Priced at a Discount relative to Residential Land

Figure 1.2 compares the average price of industrial land with commercial-residential land. We aggregate the average price for all land sales via public auctions from the year 2007 to 2019. This figure displays a striking industrial discount in land transactions.

To further explore the price discount of industrial lands, we run regressions at the level of land parcels as follows:

$$log(P_{ict}) = \beta_0 + \beta_1 IndD_{ict} + \beta_2 log(dcity_{ict}) + \beta_3 X_{ict} + \alpha_{ct} + \varepsilon_{ict} \tag{1.1}$$

Here, $log(P_{ict})$ is the unit price ($RMB10,000/ha.$) of the land parcel i in city c and year t, which is calculated as the transaction price divided by the total area of the land parcel. $IndD_{ict}$ is a dummy variable that indicates whether the land is zoned for industrial usage. Location is a key determinant of housing prices and land values. To account for this, we explicitly control for the logarithm of the distance to the city center, $\log(dcity_{ict})$. Specifically, we use the location of the government office building as the city center. X_{ict} is a vector of other parcel characteristics for each land sale, including the area of land $log(area_{ict})$, the rank of land quality [6], floor-area ratio (FAR) restrictions[7], the format of transactions(including government allocation, English auction, sealed-bid auction, and two-stage auction, with negotiation as a comparison), the source of land (new construction land, new construction land from the stock pool, and existing construction land). All

[6]City governments categorize the urban land into different tiers based on the amenity quality of land, which is an indicator of the quality of the land.

[7]Floor-area ratio (FAR) refers to the building capacity per unit area of land, i.e., the ratio of building area to site area. Local government imposes restrictions on both the upper and lower bounds of FAR when leasing the land.

columns control for the fixed effect of city-year, and standard errors are clustered at the level of city-year.

Panel A of Table 1.1 shows the results of Specification 1.1. In column (2), we assume that residential developers would fully utilize the floor-area ratio (FAR) of land, thus taking the unit price of residential land over the upper bound of FAR and comparing it with the unit price of industrial land.[8] Column (3) takes into account the difference in official leasing time of these two lands: 70 years for residential land and 50 years for industrial land. All of these regressions provide valid evidence for the industrial discount in the land market. Take the coefficient of column (2) in Panel A as an example, industrial lands are leased at an average discount of 47% compared to that of residential land ($exp(-0.755) = 47\%$).

More robustness checks are detailed in Appendix II. We refine the sample to focus exclusively on transactions via public auctions, excluding land designed for other usages, such as public service, transportation, and water facilities. To manage variations from the demand side, we also categorized buyers into four groups: firms, governments, urban construction investment enterprises, and others. Submarkets with extreme concentrations (where a single agent holds more than 10% of land area) or with scarce samples (fewer than 100 transactions) are excluded from the analysis. Results are robust and significant as shown in Table A5 and A6 in Appendix II.

1.4.2 Stylized Fact 2: The Industrial Discount is Greater in More Developed Regions

To explore the spatial distribution of the price gap, in this reduced-form part, we use the city's distance to the nearest port, $Dport_c$, as a proxy for the development level of a city and interact it with the industrial dummy as below:

$$log(P_{ict}) = \beta_0 + \beta_1 IndD_{ict} + \beta_2 IndD_{ict} \times Dport_c + \beta_3 log(dcity_{ict}) + \beta_4 X_{ict} + \alpha_{ct} + \varepsilon_{ict} \tag{1.2}$$

A natural reason is that after joining the WTO in 2000, China's rapid growth was mainly driven by the reduction of external costs, and the effects of globalization are uneven among regions due to their proximity to the coast. For example, the comparative-advantage industries tend to locate closer to international gateways, and large pools of workers move toward

[8] A potential concern of this regression is that if land use differs between residential and industrial purposes, where residential use can build up and have a higher floor space on the same unit of land, people should be willing to pay more for the same plot of land. Then it would be reasonable for the price of a residential lot to be higher than a commercial lot of the same size. So the density of development, the ratio of floor space to ground area, matters. In reality, it is usually not the optimal design for most production processes to build up as tall as residential buildings due to indivisibility on the factory floor. In a few special cases, such as labor-intensive textiles, production could in principle take place in an "apartment" like setting where each worker sits on a table with a sewing machine, but that is likely a small fraction of industry nowadays. Therefore, we deal with the "floor-area ratio" in column (2).

fast-growing coastal regions (Cosar and Fajgelbaum, 2016; WorldBank, 2009). Therefore, the distribution of local development is highly correlated with the spatial advantage of engaging in trade liberalization.

Panel B in Table 1.1 reports the interactive effects of the industrial dummy along with the city's distance to the nearest port. The coefficients of interaction terms are positive and highly significant in all specifications, which means that inland cities have a smaller price gap. The prediction is that, keeping everything else equal, cities with higher productivity attract more firms to locate, thus incentivizing local governments to supply more industrial land. To give a sense of the economic importance of the results, we use the interaction coefficient of 0.117 in column (2) of Panel B as an example. Moving inland by 463 km – the median distance from the ports across prefectures – the unit price of industrial land per floor (relative to residential price) would increase by 136% ($exp(0.117 * log(463)) = 1.36$). This implies that the price gap between industrial and residential land narrows as one moves further inland.

Figure 1.3 demonstrates the spatial distribution of the price gap across cities in China. We run regressions in column (2) according to Equation 1.2 for each city, and display the exponential of the coefficient of industrial dummy ratio = $1/e^{\beta_1}$ in the map.[9] Firstly, the eastern regions display a larger discount in the industrial land price, which fades out along the inner land. Secondly, the price ratio of residential-commercial land over industrial land ranges from 0.211 to 10.247, with the top quarter ranging from 3.25 to 8.04 (excluding the highest 1%). The lowest quarter ranges from 0.26 to 1.37 (excluding the lowest 1%), mainly lying in the northeastern area of China, which is regarded as a less-developed region for economic development.

1.4.3 *Stylized Fact 3: Land Allocation and Fertility Rate across Cities*

We first provide an overview of the relationship between land allocations, housing prices, and the aggregated fertility rate.

Figure 1.4-(a) presents a scatter plot with a linear fit line, illustrating the negative relationship between the industrial land share and the married female fertility rate across 285 prefecture-level cities in China. The information on the Fertility Rate comes from the 2010 China National Census, which is calculated by the average number of live births in 2010 among married women aged 15-49 residing in urban areas at the prefecture level. The information on housing prices is sourced from the Economic Statistics Yearbook in 2010. We restrict the analysis to urban areas.

We then validate the channel through the rapidly escalating housing prices in Figure 1.4-(b). It demonstrates a positive correlation between higher housing prices and higher industrial land shares. The "Housing Price to Wage" ratio, calculated as house prices divided by the average wages of employed workers at the prefecture level, serves as a measure of homeownership affordability for the working population in each city. Many previous studies attributed the rapid housing price growth in China to the limited supply of *total*

[9] Denotes the ratio of the average residential land price to industrial land price in each city, after controlling the characteristics of land parcels.

urban land imposed by the central governments (Fang and Huang, 2022; Deng *et al.*, 2020) and the revenue-maximizing behavior of local governments in *allocating* the land usage (Henderson *et al.*, 2022; He *et al.*, 2022). Indeed, strict land use policies are also found to push up housing prices in the U.S (Gyourko and Molloy, 2015b) and hinder the efficient allocation of labor across regions (Hsieh and Moretti, 2019).

Due to the stringent enforcement of the One-child Policy, fertility intentions during this period were likely constrained. One possible concern is that the variation in fertility rates across cities was primarily driven by the differentiated implementation of the One-child Policy, which might make the relationship depicted in Figure 1.4 less robust. To address this concern, we construct a variable to capture the implementation of the One-child Policy at the city level, measured as the average permit price for having a second or third child.[10] We then run regressions at both the city and individual level to revisit the relationship between land allocation and fertility rate after controlling for the implementation of the One-child Policy in each city, and find a consistent, robust negative correlation between industrial land allocation and fertility rates. All empirical results are detailed in Appendix II.

In summary, the empirical analysis indicates a general oversupply of industrial land in China, which negatively affects fertility rates, even after accounting for variations in the implementation of the One-child Policy.

1.5 Concluding Remarks

In this chapter, we examine a distinctive policy instrument available to local governments in China: the allocation of urban land between industrial and residential use, subject to the constraint of a fixed total land area. The chapter yields two key findings. First, generally, local governments in China tend to oversupply industrial land while restricting residential land use, evidenced by significant price disparities in the empirical analysis. This pattern is prevalent in many Chinese cities, particularly in the more economically developed eastern regions. Second, this industrial land discount, and so the land allocation pattern, is significantly correlated with fertility rates across cities. This empirical relationship lays the groundwork for exploring how government land allocation influences household fertility decisions in the next chapter.

It is important to note that the empirical relationship between industrial land share and fertility rate should be interpreted as a correlation rather than as evidence of causal inference. Due to limitations in the time span and availability of the fertility and land allocation data, we do not attempt to establish a causal relationship in this analysis. To address this limitation, the next chapter develops a theoretical model and uses a numerical simulation approach to explore the interplay between government land allocation, population control policies, and public education expenditure. This framework allows us to investigate questions such as: How would fertility rates respond to alternative land allocation schemes? What would happen in the absence of the One-child Policy? How might governments simultaneously promote higher fertility and educational attainment to strengthen long-run

[10] We thank García (2022) for providing the datasets and codes for this measurement. However, all errors are our own.

human capital?

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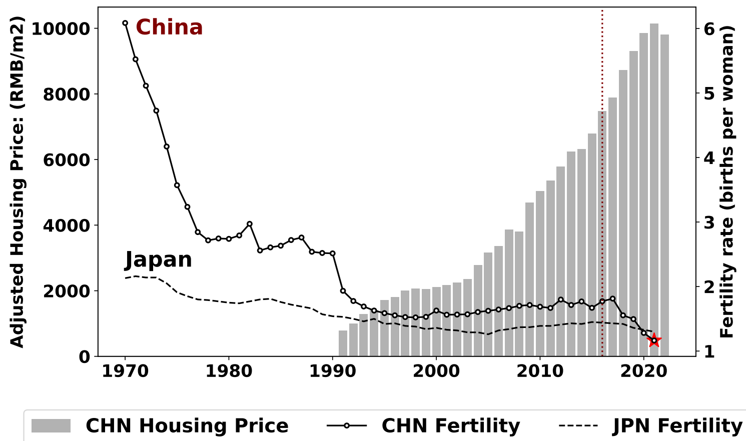
Table 1.1: Unit Price of Land on the Parcel Characteristics

	(1)	(2)	(3)
VARIABLES	$log(P_{ict})$	$log(P_{ict}/floor)$	$log(P_{ict}/time)$
Panel A: Average Industrial Discount			
$IndDummy_{ict}$	-1.510***	-0.755***	-1.091***
	(-45.589)	(-26.714)	(-38.622)
$log(dcity_{ict})$	-0.177***	-0.165***	-0.165***
	(-19.207)	(-22.664)	(-22.664)
Observations	206,788	287,101	287,101
R-squared	0.661	0.618	0.620
Panel B: Spatial Distribution of the Industrial Discount			
$IndDummy_{ict} \times Dport_c$	0.093***	0.117***	0.117***
	(4.449)	(5.460)	(5.460)
$IndDummy_{ict}$	-2.655***	-2.190***	-2.526***
	(-10.255)	(-8.058)	(-9.296)
$log(dcity_{ict})$	-0.176***	-0.164***	-0.164***
	(-18.804)	(-22.291)	(-22.291)
Observations	206,788	287,101	287,101
R-squared	0.662	0.619	0.621
Other Charteristics	Y	Y	Y
City-Year FE	Y	Y	Y

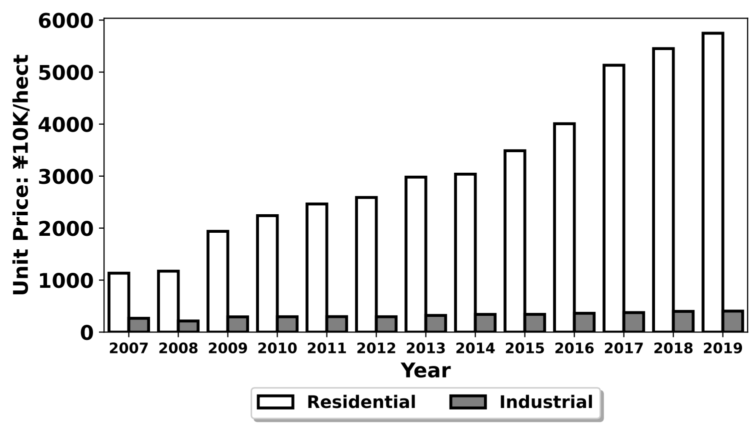
Notes. This table displays the price gap between industrial land and commercial-residential land, controlling for the information of each land parcel inclduing the distance to the city center ($dcity_{ict}$), the land area, the rank of land quality, floor-area ratio (FAR) restrictions, transaction methods, and source of land. Transaction records from 2007 to 2019 are used. Column (2) takes the unit price of residential lands over the upper bound of FAR and compares it with the unit price of industrial land. Column (3) further takes the unit price of industrial lands over the lower bound of FAR.

Figure 1.1: Fertility Rate v.s Housing Price: 1970-2022



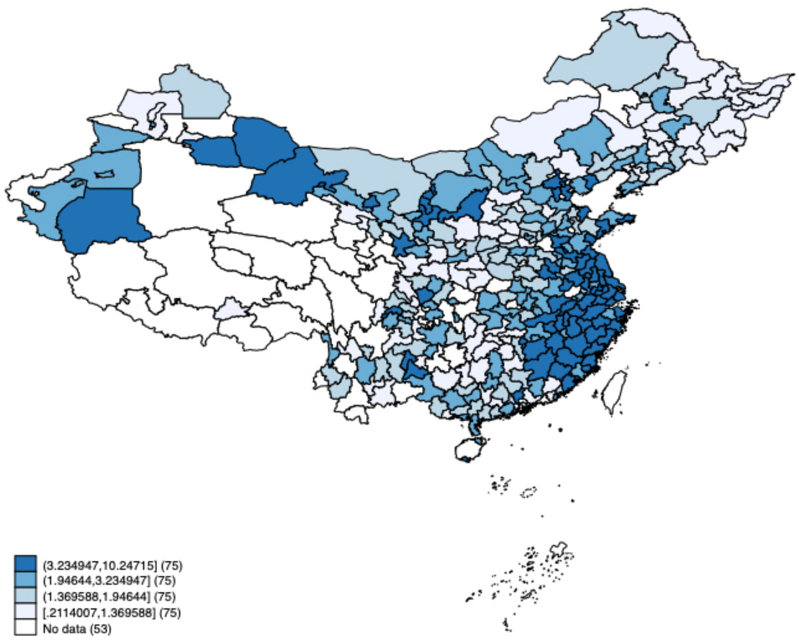
Data Source: The World Bank. See https://data.worldbank.org/indicator/SP.DYN.TFRT.IN.

Figure 1.2: Unit Price of Industrial and Residential Land, via Public Auction



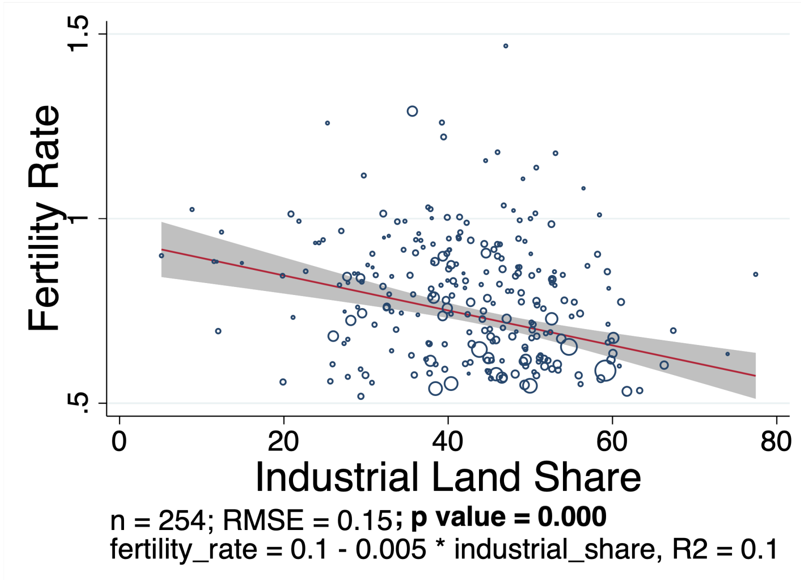
Notes. The figures display the price gap between industrial land and residential land. Here, we use the subsamples of land sales via public auctions.

Figure 1.3: Geographical Distribution of Price Gap in China

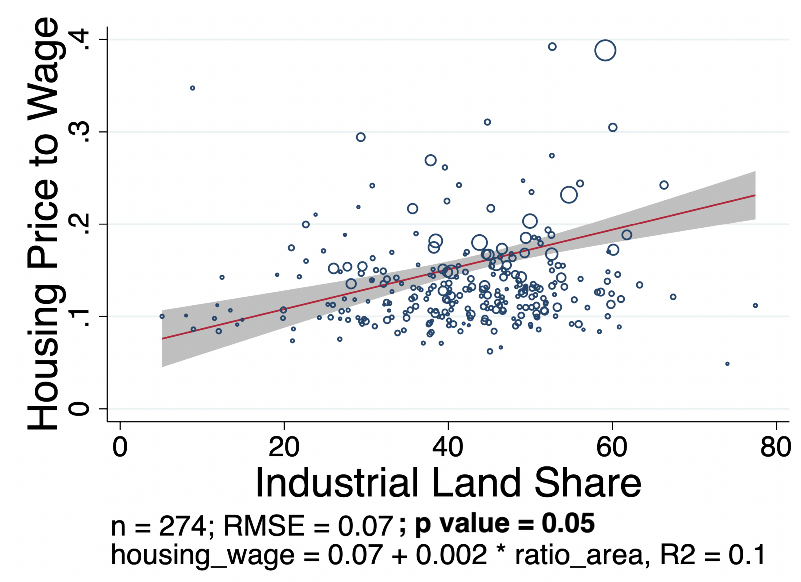


Notes. This map demonstrates the spatial distribution of the industrial discount of land prices across cities in China. We run regressions according to Equation 1.2 for each city and display the inverse exponential of the coefficient of the industrial dummy $1/e^{\beta_1}$ in the map.

Figure 1.4: Fertility Rate, Housing Price and Land Allocation in China, 2010



(a)



(b)

Notes: The information on the Fertility Rate comes from the 2010 China National Census, which measures the average number of live births among married women aged 15-49 residing in urban areas at the prefecture level. Urban housing prices and wages are sourced from the Economic Statistics Yearbook in 2010, and "Housing Price to Wage" is calculated by the house prices over average wages of employed workers at the prefecture level and is utilized to assess the affordability of homeownership for the working population in a particular city. Urban industrial land shares are sourced from the Urban-Rural Construction Statistical Yearbook (2010).

Chapter 2

LAND ALLOCATION AND HUMAN CAPITAL: A NUMERICAL SIMULATION APPROACH

2.1 Introduction

Chapter One establishes an empirical negative correlation between the share of industrial land in China and fertility rates, highlighting the need for further investigation to clarify the underlying theoretical mechanisms and explore counterfactual outcomes under alternative policy scenarios. In this chapter, I develop a static model for a representative city to analyze how fertility decisions and educational investments respond to government land allocation.

First, geographic variations are abstracted away, as the central focus is the local determinants of fertility decisions in response to housing prices in a representative location. Future work could extend this framework to incorporate spatial dynamics and examine how migration barriers and forward-looking behaviors influence household fertility choices. Second, this model focuses exclusively on urban areas, excluding rural regions, migration flows, and broader urbanization processes. This restriction is motivated by the empirical analysis in Chapter One, which relies on land transaction data available only for urban China.

This model encompasses three primary dimensions of government behavior: land allocation, population control policies, and public policy tools aimed at promoting fertility or education. In this context, "population control" refers to China's One-child Policy, in effect from the 1970s to 2016. I model this policy as an additional child-rearing cost for families choosing to have a second child, capturing its deterrent effect as a financial penalty. The role of public policy tools in shaping human capital formation is emphasized in this chapter for three key reasons.

First, from a microeconomic perspective, the channel incorporates the well-documented "Quantity-Quality" trade-off in fertility choices, especially in developing countries (Becker, 1960; Becker *et al.*, 1990). When fertility is constrained – either by population control policies or rising housing costs – parents often opt to have fewer children while increasing investment in each child's education.

Second, from an empirical perspective, Kim *et al.* (2024) documents the phenomenon of "education fever" in East Asia, where escalating educational costs have become a major financial burden limiting fertility rates of the current generation. My model incorporates education investment concerns directly into parental fertility decisions. Ultra-low fertility rates, high housing costs, and intense educational competition are prevalent in East Asian economies such as China, Japan, and Korea, making this framework applicable to a broader

[0] This chapter builds on a co-authored paper with Qiaohairuo Lin, whose insights during idea formulation and extensive contributions to the programming work are gratefully acknowledged. However, all errors are my own.

set of countries facing similar demographic-economic challenges.

Third, from a macroeconomic perspective, both the “quantity” and “quality” of the population are critical for long-term economic development and structural transformation. As fertility decline becomes inevitable in many countries’ development trajectories, increases in labor productivity – driven by higher education investment – become essential for sustaining aggregate output. In this chapter, I will explore how the decisions in children’s “quantity” and “quality” influence a country’s overall industrial evolution.

In this chapter, I first simulate a baseline equilibrium in a representative city where the local government allocates land for different uses and collects rental revenues from both industrial and residential land. In this baseline, I assume that the fiscal government revenue would be simply wasted and so does not directly affect market outcomes. Policy variation arises solely from land allocation decisions, which are treated as exogenous. I explore how fertility rate, education investment, industrial output, and worker utility respond to changes in land allocation.

The simulation yields two key findings. First, both limited residential land and the One-child Policy restrict the fertility rate. When the policy fine is removed, variation in fertility rates across different land allocations increases, suggesting that the effects of land allocation and housing prices will become more pronounced now that the policy has been lifted. Second, land allocation reveals a trade-off between the interests of firms (industrial land) and workers (residential land). Transitioning to a “one-price” land scheme, where land is allocated without distortion, can raise fertility rates and improve worker utility, helping sustain long-term population growth.

I then examine two policy tools aimed at promoting fertility and education. Rather than wasting land revenue, the government can either redistribute it to local residents through lump-sum transfers or invest it in public education to reduce education costs. I find that refunding all land revenue as lump-sum payments tends to raise housing prices, thereby limiting its effectiveness in improving fertility and education outcomes in equilibrium. In contrast, if the quality of public education is sufficiently high, allocating land revenue to education-specific public funding can directly lower the cost of skilled education, simultaneously boosting both the education rate and fertility rate.

In summary, I provide a unified framework to capture the interplay between government land allocation, population control, and public education policy on household family planning decisions. Within this framework, this chapter answers the following questions: How would fertility rates respond to alternative land allocation schemes? What would fertility patterns in China look like in the absence of the One-child Policy? Is there policy space for the government to simultaneously promote higher fertility and greater educational attainment to strengthen long-run human capital?

2.2 Model

I develop a static model set in a representative city to analyze how fertility decisions and educational investments respond to government land allocation. The model features two types of individuals based on education: those with a high school degree, classified as skilled (s), and those without, classified as unskilled (u). A representative adult agent chooses how to allocate time between work and family, earns wage income, and decides on consumption and housing expenditures. There are two life stages in the model: childhood and adulthood. However, all major decisions, including consumption, housing, fertility, and educational investment, are made by adults. Children passively receive the educational investment determined by their parents. Education is modeled in two tiers: higher and lower. And it determines the child's future skill type, either skilled or unskilled.

In this study, the distinction between skilled and unskilled labor is defined by educational attainment, with high school graduation set as the threshold. This classification aligns with the structure of China's education. First, college enrollment rates in China remain relatively low. Second, high school education is neither mandatory nor publicly funded. As shown in Table A9 of 3.4, I calculate high school attainment rates by cohort using a dataset comprising 4 million individual records from the 2010 National Population Census.[1] The data show that from 1980 to 2010, only 33.43% of 15-year-olds were enrolled in high school. Given this relatively low participation rate, high school graduation serves as a meaningful and empirically grounded benchmark for defining skilled labor in the context of this study. For consistency, I classify children by their education level into skilled-educated (secondary education or above) and unskilled-educated (below secondary education). This classification maps directly to adult skill types in the model.

2.2.1 Production

In a representative city, homogeneous firms use the following Cobb-Douglas technology to produce numeraire goods from efficiency labor units N and industrial land K:

$$Y = K^{1-\alpha} N^{\alpha} \tag{2.1}$$

where Y is the total output. Note that the total efficiency units of labor supplied to firms, denoted by N, differ from the total adult population L, as it subtracts the time spent on family responsibilities. This reflects the opportunity cost of child-rearing, which will be discussed in detail in the next section. In a competitive labor market, the wage and industrial land

[1] In this analysis, a cohort includes all individuals born within one year, from September to August. Cohorts are defined by the year in which the majority of members turn 15. The typical age at which students decide whether to pursue high school. For example, the 2008 cohort comprises individuals who turned 15 in 2008. In China, students generally begin primary school at age six, complete six years of primary education, follow by three years of middle school. High school decisions are therefore typically made at age 15, though some variation exists. I constructed a panel dataset of city-level cohorts from 1980 to 2008, defining a city's high school education rate as the share of individuals within a cohort who attained at least a high school education.

price will be equal to their marginal production, and firms earn zero profit:

$$p^k = (1-\alpha)\left(\frac{N}{K}\right)^{\alpha} \tag{2.2}$$

$$w = \alpha\left(\frac{K}{N}\right)^{1-\alpha} \tag{2.3}$$

$$w_e = A_e w \tag{2.4}$$

where p^k denotes the rent of industrial land, and w_e represents the labor income of individuals with education level e. The term A_e captures the exogenous, skill-specific productivity level, which also determines the wage premium, as shown in Equation 2.4.

2.2.2 Adult's Decision Making

For an individual in a representative city with skill type e, her preference is given by:

$$U(c,h,n,e') = (1-\gamma)\log(c) + \gamma\log(h) + \chi\left[\log(n) + \varepsilon_{e'}\right] \tag{2.5}$$

This utility function is a simple logarithm Cobb-Douglas form, combining consumption utility (with a total weight of 1) and child-rearing utility (weighted by χ). Consumption utility is derived from both numeraire goods c and housing space h, while child-rearing utility depends on the number of children n and their education level e'. Specifically, I assume that parents derive increasing utility from having more children and exhibit idiosyncratic preferences for their children's education, denoted by $\varepsilon_{e'}$. This allows for heterogeneity in education choices even among parents with the same education level e, enabling the derivation of the distribution of children's education types in a representative city. I assume that all children within a household receive the same level of education. The household budget constraint is given by:

$$c + p^h(h + \tau^h n) = w_e[1 - n(\tau^w + \tau^d_{ee'} + f * \mathbb{1}\{n > \overline{n}\})] \tag{2.6}$$

Child-rearing costs fall into two broad categories: childbirth costs and educational investments. First, there is the opportunity cost of time, as raising children reduces labor supply. I assume each household is endowed with one unit of time, which can be allocated to either labor or family. Consequently, a fixed proportion τ^w of the wage income w_e is deducted for each child to reflect this trade-off. Second, each child takes a fixed unit of housing space τ^h, capturing the inelastic relationship between child-rearing and housing demand. Third, under the enforcement of China's One-child Policy (OCP), households incur a financial penalty f for having more than a certain number of children, represented by the indicator function $\mathbb{1}\{n > \overline{n}\} = 1$. There are two points regarding this penalty that merit clarification.

First, each household in the model includes only one parent, implying the policy threshold should be halved (e.g., a limit of 0.5 children). However, real-world enforcement of the OCP varied significantly across regions and household types. For example, according to Ebenstein (2010) and Yin (2023), in 1.5-child zones, rural couples could have a second child if the first was a daughter. These authors compute a weighted average of the child quota using 1982 provincial employment shares, yielding national-level quotas of 1.78 for rural and 1.04 for urban couples. Since the model assumes a single parent per household, I divide these quotas by two and set the policy threshold at $\overline{n} = 0.52$ for a representative city.

Second, the penalty f is assumed to be proportional to the household's annual income, consistent with regulatory practices during the OCP period. As documented by Yin (2023), fines are proportional to parental income and vary across provinces and over time. For example, in Shanxi province in 2000, a couple who had a second child would incur a fine equivalent to 1.29 times their annual income. The method for converting these monetary penalties into time-equivalent costs within the model framework will be discussed in the next section on parameterization.

Finally, the educational cost of children in the model, denoted by $\tau^d_{ee'}$, depends on both the parents' skill level e and the child's education level e'. Specifically, I assume that raising an unskilled child incurs no cost for either type of parent, i.e., $\tau^d_{su'} = \tau^d_{us'} = 0$. However, unskilled parents face higher costs than skilled parents when raising a skilled child, with both types incurring positive expenses: $\tau^d_{us'} > \tau^d_{ss'} > 0$.

Now, given that parents have decided to give their education type e', we can solve the decision-making problem for adults as follows:

$$c = \frac{1-\gamma}{1+\chi} w_e; \tag{2.7}$$

$$h = \frac{\gamma}{1+\chi} \frac{w_e}{p^h}; \tag{2.8}$$

$$n_{ee'} = \frac{\chi}{1+\chi} \frac{w_e}{(\tau^w + \tau^d_{ee'} + f * \mathbb{1}\{n > \overline{n}\}) w_e + \tau^h p^h}; \tag{2.9}$$

Note that the first two choice variables – consumption of numeraire good c and family housing space h – do not depend on children's education type e', but on parents' wage income w_e and housing price p^h. The number of children $n_{ee'}$ increases with parent's preference for children χ and their income w_e, and decreases with the child-rearing cost τ^w, the education cost $\tau^d_{ee'}$, [2] and the housing price p^h. Intuitively, higher housing price restricts fertility, since each child takes up an inelastic housing space τ^h. Based on these

[2]The superscript denotes education-specific costs, while the subscripts e and e' indicate the types of parents and children, respectively.

decisions, I can derive the adult's indirect utility function as follows:

$$
\begin{aligned}
V = &(1+\chi)log(w_e) - \gamma log(p^h) \\
&- \chi log[(\tau^w + \tau^d_{ee'} + f * \mathbb{1}\{n > \overline{n}\})w_e + \tau^h p^h] + \epsilon_e
\end{aligned} \tag{2.10}
$$

Note that only the second-line component of the direct utility function depends on the choice of children's education type, e'. In this model, education is a discrete choice. Therefore, the probability that a parent chooses "skilled" education for their child, $\pi_{ee'}$, corresponds to the probability that the utility from doing so exceeds that of choosing "unskilled" education, i.e., $\Pr(V_{es'} > V_{eu'})$. I assume that the idiosyncratic preference shock ϵ^o_e follows an i.i.d. Gumbel distribution with scale parameter $\frac{\sigma_E}{\chi}$ across all adults, and that this shock is realized before the fertility decision is made. Therefore, the children education ratio $\pi_{ee'}$ would be:

$$
\begin{aligned}
\pi_{ee'} &= \text{Prob(parents of type } e \text{ giving children education type } e'\text{)} \\
&= \frac{\text{number of type } e \text{ adults giving children education type } e'}{\text{number of type } e \text{ adults}} \\
&= \frac{[(\tau^w + \tau^d_{ee'} + f_j \cdot \mathbb{1}\{n > \overline{n}\})w_e + \tau^h p^h]^{-\frac{1}{\sigma}}}{\sum_{e'=u,s}[(\tau^w + \tau^d_{ee'} + f_j \cdot \mathbb{1}\{n > \overline{n}\})w_e + \tau^h p^h]^{-\frac{1}{\sigma}}}
\end{aligned} \tag{2.11}
$$

Derivation details are provided in Appendix 3.4. Intuitively, the distribution of educational investment – that is, the probability that parents choose "skilled" education for their children – depends on the relative cost of doing so, $\tau^d_{ee'}$. Since the cost of unskilled education is assumed to be zero ($\tau^d_{su'} = \tau^d_{us'} = 0$), the probability that parents invest in skilled education decreases as the costs $\tau^d_{ss'}$ and $\tau^d_{us'}$ become sufficiently high.

Given the educational choices ("Quality") and fertility decisions ("Quantity"), I can now derive the total efficiency units of labor supplied to firms, denoted by N, as used in the production function in Equation 2.1:

$$
N = \sum_{e=u,s} A_e L_e [1 - \sum_{e'=u,s} n_{ee'} \pi^E_{ee'} (\tau^w + \tau^d_{ee'})] \tag{2.12}
$$

where $e = u, s$ denotes the two parental skill types (unskilled and skilled), and A_e represents the labor productivity of individuals with education type e. To account for the opportunity cost of parenting, I subtract from each worker's effective labor supply the time spent on child-rearing and education activities – specifically, the child-rearing time τ^w and the education time $\tau^{s}_{ee'}$ per child. These time costs are weighted by both the number of children of each education type, $n_{ee'}$, and the corresponding probability of choosing that education type, $\pi_{ee'}$. The utility maximization in Equation 2.5, subject to the budget constraint in Equation 2.6, ensures a positive labor supply for each household. This labor efficiency unit is used to clear the labor market and determine the equilibrium wage, as shown in Equation 2.3.

2.2.3 Land Market Clearings

I assume that in a representative city, there is an exogenous total land endowment (or quota restricted from the upper governments), $\bar{X}$, and local governments allocate a proportion into industrial use k, such that:

$$K = k\bar{X}; \quad H = (1-k)\bar{X} \tag{2.13}$$

For now, I assume that the government simply wastes the revenue collected from the land market; thus, land revenue does not directly affect the equilibrium outcomes in this baseline setting. In the next section, I will explore the fiscal expenditure system and the government's budget balance. Both the industrial and residential land markets will be cleared within the city, allowing me to derive the following:

$$(1-\alpha)Y = p^{k}K \tag{2.14}$$

$$p^{h}H = \frac{\gamma}{1+\chi}\sum_{e=u,s} w_e N_e + p^{h}\tau^{h}\sum_{e=u,s}\sum_{e'=u,s}\pi_{ee'}n_{ee'}L_e \tag{2.15}$$

$$\text{where} \quad N_e = A_e L_e\Big[1 - \sum_{e'=u,s} n_{ee'}\pi^{E}_{ee'}(\tau^{w} + \tau^{d}_{ee'})\Big]$$

In Equation 2.14, the total revenue in the industrial land market equals firms' expenditure on industrial land, which – under the Cobb-Douglas production function in Equation 2.1 – amounts to a $(1-\alpha)$ share of total output. In Equation 2.15, the government's total revenue from the residential land market includes two components: (i) parents' expenditure on enjoyable housing h, and (ii) the inelastic housing space required for children, denoted by τ^{h}. Due to the Cobb-Douglas utility function in Equation 2.5, the share of household expenditure allocated to enjoyable housing h is $\frac{\gamma}{1+\chi}$ for each type of worker e. Similar to Equation 2.12, the effective labor supply of each type of worker, N_e, is equal to the total labor unit endowment subtracting from the time spent on child-rearing and education activities. The expenditure on child-specific housing is calculated as the weighted sum of the number of children and the probability of each education type, multiplied by the housing price and the fixed housing space τ^{h} per child.

2.2.4 Equilibrium

Definition Given government policies – including land allocations H, K and the population control policy with one-child fine f – and fundamentals of labor productivity A_e, a competitive equilibrium consists of a set of prices w_e, p^h, p^k (labor wages, housing price, and industrial land price, respectively) and household allocations $c, h, n_{ee'}$ such that firms maximize profits, households maximize utility, and both labor and land markets clear.

Algorithm Here I detail the algorithm to compute the equilibrium outcome above, taking all fundamentals (land allocations H, K, total labor $\{L_u = 1, L_s = 0.5\}$, skill premium $\{A_u = 1, A_s = 1.5\}$) as given. This is not trivial, since the children number $n_{ee'}$ and education investment $\pi_{ee'}$ also appear in labor supply, education expenditure, and residential land market clearing conditions. Thus, I solve them using an iterative procedure:

1. Initialize a guess of $n^0_{ee'}$ and $\pi^0_{ee'}$;
2. Plug the initial guess to Equation 2.12 and obtain total labor supply N, and hence the wage w_e from Equation 2.3 and 2.4; then from the residential land market clearing condition in Equation 2.15, I can obtain residential land price p^h.
3. Calculate the industrial land price p^k from Equation 2.2.
4. Plug in all child-rearing cost, wage, and residential land price to Equation 2.9 and 2.11, I can update the value for child-rearing numbers $n^1_{ee'}$ and education investment $\pi^1_{ee'}$.
5. Iterate the above procedures until $n_{ee'}$ and $\pi_{ee'}$ both converge.

Moreover, all outcomes can be conducted once I obtain converged values of child-rearing decisions, $n_{ee'}$ and $\pi_{ee'}$. The outcomes include labor supply N, wage level w_e, residential land price p_h from steps (2) and (3), and so the industrial outputs Y from Equation 2.1 and social welfare V from 2.10.

2.3 Comparative Static Analysis

In this section, I compare outcomes in a static equilibrium of a representative city, focusing on fertility rates, education composition, industrial output, and social welfare. The total population of each skill type is exogenously given and fixed at $L_u = 1, L_s = 0.5$, with labor productivity levels (or skill premiums) set as $A_u = 1, A_s = 1.5$. The only varying parameter is the share of land allocated to housing, which ranges from 0.01 to 0.99.

2.3.1 Parameterization

I set some parameters to their data counterparts or borrowed them from other studies, as shown in Table 2.1.

First, the land intensity of production, $1 - \alpha$, is set to 0.08. Valentinyi and Herrendorf (2008) takes the land share of 0.05 for the industry in the United States, and Henderson *et al.* (2022) increases it to 0.07. I further increase it to 0.08 to capture the more land-intensive nature in China's industry between 2000 to 2020. The child preference parameter χ is adopted from Yin (2023) and set to 0.3, reflecting a consumption-to-childrearing utility weight ratio of $1 : 0.3$, or equivalently, $3.3 : 1$ in favor of parental consumption.

Housing expenditure γ is calculated using data from the National Bureau of Statistics of China, indicating that real estate constitutes 23% of household consumption. Specifically, household consumption consists of household expenditure on 1) food, tobacco and liquor; 2) clothing; 3) residence; 4) household facilities, articles, and services; 5) transport and communications; 6) education, cultural and recreation; 7) health care and medical services; 8) miscellaneous goods and services. Housing-related consumption here refers to household expenditure on residence. If we also include expenditure on household facilities, articles, and services, this ratio would rise to 30%. According to Liu *et al.* (2023), this ratio is slightly higher than an average of around 22% in OECD and European Union countries in 2019 (OECD 2021).

There are two child-rearing costs to estimate in this model. The first component denotes the cost to raise a child, no matter what type of child they have. It contains three parts: the opportunity cost of working time, denoted as τ_t^w in Equation 2.6; the unit of housing space for each child τ_t^h; and the fine for an extra child if violate the One-child Policy f. I adopt the opportunity cost from Yin (2023) and set $\tau^w = 0.15$. The housing space cost τ^h is a unique parameter in our model, representing the additional housing space required per new child. I regressed city-level per capita living space against fertility rates derived from China's 2010 census data, resulting in a coefficient of $\tau^h = 0.08$. I bring the weighted average fine rate of the One-child Policy in China between 1979 and 2000 from Ebenstein (2010) and Yin (2023), which is $f = 0.1594$.

As noted by Yin (2023), One-child Policy fines are proportional to parental income and vary across provinces and over time. In this model, to convert monetary fines to time-equivalent costs, consider this example: In Shanxi Province in 2000, a couple would incur a fine equivalent to 1.29 times their annual income for a second child. Since the model is based on a single-parent household, the equivalent fine becomes $1.29 \times 2 = 2.58$ times the annual income of an individual parent. Assuming a 20-year working life, this corresponds to a time-equivalent cost of $2.58/20 = 0.129$. Using provincial fine data from 1979 to 2000 compiled by Ebenstein (2010), I compute a national average fine rate of 0.1594 by weighting each province's fine by its employment share in 1982.

The second component, educational expenses for children – denoted by $\tau_{ee'}^d$ in Equation 2.6 – are specific to both the parents and the child's education type. Specific direct counterparts for these parameters are limited in previous literature, so I calibrate them to values that yield reasonable and empirically consistent outcomes in the model. For example, education costs are zero for unskilled-educated children, regardless of whether their parents are skilled or unskilled, $\tau_{uu'}^d = \tau_{su'}^d = 0$. For skilled-educated children, the baseline education costs for skilled and unskilled parents are set at $\tau_{ss'}^d = 0.1$ and $\tau_{us'}^d = 0.2$, respectively, to reflect the difficulty that unskilled parents face in educating their children in practice.

2.3.2 *Comparative Static Analysis*

First, I isolate the comparative static effects of land allocation by **shutting down the channels of public education, lump-sum transfer, and the One-child Policy**. I set $f = 0$ to eliminate the effects of the One-child Policy and assume that the government simply wastes the revenue generated from the land market. In the next section, I will simulate counterfactual policy tools where governments can either refund the land revenue to local residents through a lump-sum transfer or reallocate it to public education services to reduce child-rearing costs.

In this section, I present the equilibrium fertility rates by parental skill type and the birth rates by children's education type, as defined below. The fertility rate by parental skill type, F_e in Equation 2.16, is aggregated at the parent level by summing their number of children, both skilled (s') and unskilled (u'), weighted by the probability of each child type. In contrast, the birth rate by children's education type, $B_{e'}$ in Equation 2.17, is aggregated at the child type level: it sums the total number of children of a given type (skilled or unskilled), born from both skilled (s) and unskilled parents (u), and divides this total by the number of their respective parents.

$$F_e = \sum_{e'=u,s} n_{ee'} \pi_{ee'} \tag{2.16}$$

$$B_{e'} = \frac{\sum_{e=u,s} L_e * n_{ee'} * \pi_{ee'}}{\sum_{e=u,s} L_e} \tag{2.17}$$

Figure 2.1 shows the equilibrium fertility rate by parental skill type as the residential land share increases from 0.01 to 0.99. Two key takeaways emerge from this figure. First, increasing the share of residential land raises fertility rates for both skilled and unskilled parents. This is because greater availability of residential land reduces housing costs, making it more affordable for parents to have more children. Second, the income effect plays a dominant role in fertility decisions: skilled parents consistently have more children than unskilled parents, reflecting their higher earning capacity to bear child-rearing costs.

It is worth noting, however, that skilled-educated children are more costly to raise than unskilled-educated ones. Therefore, when parents have a strong preference for providing high-quality education, their fertility rates may decline – a reflection of the classic "quantity-quality" trade-off. For example, skilled parents in large cities, such as in Korea or China, tend to invest heavily in their children's education, especially intensive after-school tutoring, which is proven to discourage fertility in Kim *et al.* (2024). In this model, however, educational preferences are subject to an idiosyncratic shock $\varepsilon_{e'}$ that is drawn independently across households. Therefore, systematic difference in education preference between skilled and unskilled parents is removed, thereby reinforcing the dominance of income effects in shaping fertility outcomes.

Figure 2.2 presents the equilibrium birth rate by children's education type as the residential land share increases from 0.01 to 0.99, aggregating newborns from both skilled and unskilled parents.[3] Still, increasing the share of residential land raises the birth rates for both skilled- and unskilled-educated children. Additionally, the cost effect plays a dominant role in educational investment: the number of skilled-educated children remains consistently lower than that of unskilled-educated ones, reflecting the higher cost burden associated with children's education.

2.3.3 Effects of One-child Policy

In this section, I simulate the impact of population control policy by comparing the aggregate fertility rate with and without the One-child Policy fine. The channels of public education or lump-sum transfer are still muted. Aggregate fertility is defined in Equation 2.18, where the total number of children – disaggregated by children's education level and parental skill type – is summed and then divided by the total adult population. This yields the aggregate fertility rate for the economy:

$$\text{Aggregate Fertility Rate} = \frac{\sum_{e=u,s} L_e \sum_{e'=u,s} n_{ee'} \pi_{ee'}}{\sum_{e=u,s} L_e} \tag{2.18}$$

Figure 2.3 compares aggregate fertility rates with and without the One-child Policy fine ($f = 0.1595$), across a range of residential land shares from 0.01 to 0.99. Three key takeaways emerge from this figure. First, the fertility rate increases with the residential land share in both scenarios and rises further when the One-child Policy fine is removed.

Second, under the One-child Policy, the fertility rate remains below 0.5 across the residential land share spectrum. In reality, each household typically includes two parents, so the "One Child" policy penalizes a second child is actually punishing fertility rates exceeding 0.5 children per parent. In this model, where each household includes only one parent, I adjust the penalty threshold to $\bar{n} = 0.52$, as specified in Equation 2.7. The curve of fertility under this policy is discontinuous with respect to land allocation because the penalty is applied discretely–only when fertility exceeds the 0.52 threshold would create a sharp change in child-rearing decision.

Third, variation in fertility rates across different land allocation schemes becomes more pronounced after the One-child Policy fine is removed, indicating that the effects of land allocation and housing prices could be amplified in the absence of fertility restrictions. This pattern is consistent with the empirical evidence in Figure 2.4, which shows that in 2010 – when the One-child Policy was still in effect – the city-level birth rates exhibited a lower median and smaller standard deviation. In contrast, during the period from 2017 to 2019, following the relaxation of fertility restrictions, the distribution of birth rates became more

[3]For comparison, Figure 2.1 aggregates newborns at the parent level, while Figure 2.2 aggregates them at the child level. In this model, the distribution of parents by skill type is exogenously given, and Figure 2.1 reflects the fertility decisions of different types of parents. In contrast, children's education outcomes are endogenously determined, and Figure 2.2 is a representation of education outcomes in the economy. This education distribution would determine the skill composition of the workforce in the next period.

dispersed and shifted to the right.

Note that the definition of birth rate in Figure 2.4 differs slightly from that used in the model. In Equation 2.18, the model's aggregate fertility rate represents the total number of children an adult has over their lifetime. For example, if a couple has one child over their life, the fertility rate under this definition is 0.5. In contrast, real-world data can only measure fertility at a point in time: I only observe whether a woman gives birth in a specific year, without information on past or future child-rearing. Consequently, the birth rate in Figure 2.4 is calculated as the average number of live births among married women aged 15-49 living in urban areas, based on data from the 2010 China National Census. For example, with 1000 married women in a city having 20 newborns in 2010, the birth rate would be calculated as 20/1000 = 2%. This means the absolute levels of fertility in the model and in the data are not directly comparable. However, the relative trends and cross-city variations – such as shifts in the distribution and changes in dispersion – remain meaningfully comparable across the two figures.

2.3.4 Trade-off between Industrial Outputs and Worker Utility

In this section, I compare equilibrium outcomes in industrial output and worker utility under varying land allocation schemes, to illustrate the trade-off local governments face in the interests between firms and workers in a representative city. **The channels of public refund, education system, and One-child Policy are still shut down.** The only variation across simulations is the residential land share, which ranges from 0.01 to 0.99.

Figure 2.5 displays industrial output and worker utility with variations in the residential land share. First, industrial output declines as the share of residential land increases. This result helps explain why, in reality, governments often allocate a relatively lower share of land to residential use: as noted in Chapter 1, the national average residential land share is approximately 0.58.

In the model, this negative relationship is driven by two channels. The first is a direct channel: a larger industrial land share directly contributes to a higher output through the Cobb-Douglas production function in Equation 2.1. The second is an indirect channel: a lower residential land share raises housing prices, which discourages fertility. As shown in the previous section, reduced fertility leads households to allocate more time to work instead of family, effectively increasing labor supply. Consequently, both industrial land (K) and effective labor input (N) rise with the industrial land share, resulting in greater industrial output. It is important to note that this is a peculiar short-term effect driven by the static structure of the model. In a dynamic, multi-period setting, a limited number of children today would eventually lead to a shortage of labor supply in the future, ultimately constraining industrial output in subsequent periods. Therefore, sacrificing family time to boost industrial output represents an unsustainable growth strategy in the long run.

Second, in contrast to industrial output, worker utility increases with the share of residential land. As shown in Equation 2.10, the welfare of a representative agent depends on the relative changes in the wage level (w) and housing price (p^h). Figure 2.6 shows the realized trend of housing price and wage, to help understand the changes in real income.

The effect of housing prices is relatively straightforward: as more land is allocated to residential use, the housing supply expands, leading to a decline in p^h. The effect on wages, however, is trickier.

According to Equation 2.3, the wage level is determined by the relative availability of industrial land (K) and effective labor supply (N). On the one hand, increasing the residential land share from 0.01 to 0.99 reduces the industrial land share from 0.99 to 0.01, which lowers wages due to reduced industrial input (K). On the other hand, as residential land expands, individuals allocate more time to family activities, reducing labor supply (N). This decline in labor availability would push the wage upward. As shown in Figure 2.6, overall, the effect of reduced industrial input dominates and leads to a decreasing trend in wage.

Intuitively, while wages decline as the residential land share increases, they do so at a slower rate than housing prices, at least before reaching the turning point. This pattern arises because the industrial land intensity in the production function (Equation 2.1), given by $1 - \alpha = 0.08$, is much lower than the labor intensity, $\alpha = 0.92$. Consequently, real income, measured by the housing-adjusted price index $\frac{w}{(p^h)^\gamma}$, increases with the residential land share, which also enhances workers' utility. As a comparative exercise, increasing the industrial land share $1 - \alpha$ shifts the turning point of the real income curve to the left.

2.4 Counterfactual Experiments

2.4.1 A Benchmark Comparison: an Equalized Land Price

I consider a counterfactual equilibrium where land allocations are determined by landlords (could still be governments), who aim to maximize the total revenue from land sales. **The resulting revenue is then redistributed evenly to all residents through a lump-sum transfer.** Assuming a perfectly competitive land market in a representative city, revenue maximization implies that land prices should equalize across uses, such that $p^K = p^H$. To identify this corresponding allocation, I will perform a grid search over residential land shares ranging from 0.01 to 0.99, recalculating land prices at each point to find the allocation where industrial and residential land prices converge.

Before identifying this "efficient" allocation scheme, I first built an intuition around this land market allocation. Let's conduct a simple decomposition. First, recall the market-clearing conditions in the industrial land market (Equation 2.14) and the residential land market (Equation 2.15), for which I re-emphasize as below:

$$(1 - \alpha)Y = p^k K,$$

$$\alpha Y = \sum_{e=u,s} w_e N_e,$$

$$p^h H = \frac{\gamma}{1+\chi}\left[\sum_{e=u,s} w_e N_e + p^h H + p^k K\right] + p^h \tau^h \sum_{e=u,s}\sum_{e'=u,s} \pi_{ee'} n_{ee'} L_e \qquad (*)$$

where Equation * represents the market-clearing condition for the residential land market in this setting. Compared to Equation 2.15, households now receive a lump-sum transfer from the government equal to the total land revenue, $p^h H + p^k K$. This transfer supplements their labor income and expands their overall budget. Given the Cobb-Douglas utility function in Equation 2.5, the share of household expenditure allocated to housing consumption h remains fixed at $\frac{\gamma}{1+\chi}$. Intuitively, a portion of the transfer will ultimately return to the housing market through increased demand.

Consider a simplified case where children do not require any housing space, i.e., $\tau^h = 0$, and so the last term in Equation * can be ignored. By combining these three equations and imposing the equilibrium condition $p^k = p^h$, I obtain:

$$\frac{H}{K} = \frac{1}{1-\alpha} \cdot \frac{1}{1+\chi-\gamma} \tag{2.19}$$

Intuitively, the land allocation in the "efficient" equilibrium depends on three key parameters: the land intensity in the production function, $1-\alpha$; the housing expenditure share in household preferences, γ; and the preference for child-rearing, χ. Given the parameter values in this numerical simulation, the resulting market equilibrium features a residential land share of 0.758.

When the inelastic housing space required for children is taken into account, i.e., $\tau^h = 0.08$, additional land must be allocated for residential use to accommodate family needs. I conduct a grid search over residential land shares ranging from 0.01 to 0.99, repeatedly calculating the prices of each land type to identify the allocation where the price of industrial land equals that of residential land. This "one price" condition characterizes the laissez-faire market equilibrium. The resulting residential land share is 0.829, compared to the real-world average of approximately 0.58 in China. As shown in Figure 2.5, the actual land allocation in China yields higher industrial output but lower social welfare relative to the one-price market outcome. This underscores the trade-off local governments face between subsidizing firms and enhancing household welfare.

2.4.2 Policy Tools to Promote Fertility or Education

Education has become a significant financial burden in many East Asian countries, leading to declining fertility rates among the current generation. As shown in Figure 2.2, the number of skilled-educated children increases much more slowly than that of unskilled-educated children as the residential land share rises. This indicates that the overall fertility increase is primarily driven by births of unskilled-educated children. In other words, when parents choose to have more children, they tend to reduce investment in each child's education.

Intuitively, land allocation variations in this model – the increased share of residential land – only lower the cost of living and child-rearing, while not altering the marginal return to education. Specifically, skills are perfectly complementary with an exogenous skill premium. As a result, when more residential land reduces the housing price in a city, the number of children $n_{ee'}$ in Equation 2.9 reacts more when $\tau^d_{ee'} = 0$. This feature is depicted as blue in Figure 2.7, that with the increase of residential land, the education ratio in a representative city would decrease, even though the aggregate fertility rate is increasing.

Counterfactual 1: Lump-sum Transfer To explore the public tools for promoting fertility or education, I first explore the effects of refunding the land revenue to households via a lump-sum transfer, allowing parents to decide the usage of this additional income. Specifically, under the budget constraint in Equation 2.6, each household now receives a lump-sum transfer equal to $\frac{p^h H + p^k H}{\sum_{e=u,s} L_e}$, which also alters the residential land market clearing condition. As discussed above in Equation *, this transfer would expand the household budget, increasing housing demand and, consequently, housing prices.

As shown in Figure 2.7, while the lump-sum transfer leads to a modest increase in education investment relative to the baseline (with no refund), the overall effect remains limited. This is because the preference for children's education, the skill premium, and education costs remain unchanged in this counterfactual scenario. Thus, the increase in education investment is driven solely by a mild income effect, much of which is offset by rising housing prices.

Counterfactual 2: Public Education Service To promote long-run human capital accumulation, I now introduce a public education tool to directly reduce the cost of children's education without proportionally increasing housing prices. I assume that local governments would spend their land rent revenue on public education services, such that governments' budget constraints could be:

$$L^c E = p^h H + p^k K \tag{2.20}$$

Here, E denotes the per-student expenditure by local governments on public education services, and L^c represents the total number of children in this representative city. It is assumed that public education resources are evenly distributed across all children, regardless of their own or their parents' skill type. This mechanism is supported by two key features of China's local public finance system.

First, land revenue is the primary source of local government budgets in China. Since 2002, the central government has claimed 50% of local income tax revenues (including both corporate and individual income taxes), increasing this share to 60% in 2003. However, local governments retain 100% of the revenue from urban land sales. As shown in Figure A9 in Appendix 3.4, from 1999 to 2016, land sale revenues accounted for an average of 40.78% of total local fiscal revenue. During the sample period of 2007-2013, this proportion rose to 53.43%. According to Ding (2003), approximately half of these revenues were used to finance physical infrastructure investment – such as transportation and education zones – while the other half was funded through loans collateralized by land assets.

Second, local government budgets are the primary source of public education funding in China. According to the 2022 national education report, approximately 80% of total education funding originates from state financial education funds, making government investment the dominant source of educational financing. Of these funds, 80% is drawn from the general public budget for education, where education consistently represents the largest expenditure item. Notably, 80% of the general public education budget is funded by local governments, making them the principal actors in financing educational services [4]. Since this model focuses on local public education expenditures before college, it relies heavily on local fiscal capacity, and so on local land revenue. Figure A10 in Appendix 3.4 illustrates the distribution of local land revenues across cities and their positive correlation with per-student K-12 public education spending.

I then assume that these public education services can reduce the financial burden on parents in educating their children. As previously discussed, education costs are both parent- and child-specific. An unskilled child incurs no cost for either type of parent, i.e., $\tau^d_{su'} = \tau^d_{uu'} = 0$. However, when raising a skilled child, unskilled parents face higher costs than skilled parents, and both bear a positive expense. Equation 2.21 defines the education cost for a skilled child (s').

$$\tau^d_{es'} = \tau^{d0}_{es'} - \tau^{d1} logE \tag{2.21}$$

The intercept term τ^{d0} captures the baseline cost of educating a child, and so $\tau^{d0}_{us'} > \tau^{d0}_{ss'} > 0$. As consistent with the parameterization in the last section, I still set $\tau^{d0}_{us'} = 0.2$ and $\tau^{d0}_{ss'} = 0.1$. The coefficient τ^{d1} reflects the extent to which public education services provided by local governments offset these costs, and is assumed to be identical across parent types. Here, I set $\tau^{d1} = 0.05$, which converts the nominal government land revenue into the "efficiency" of public education – interpreted as the reduction in the share of time parents allocate to their children's education. For example, with the same public education expenditure per child, a higher coefficient τ^{d1} means that the efficiency of this fiscal policy is higher, and so it significantly reduces the cost to educate a child.

Figure 2.7 illustrates the introduction of public education funding. First, the share of skilled-educated children was consistently increased, compared to the lump-sum transfer scheme. The skilled education ratio curve is now shifting upward. So the share of skilled-educated children under this education tool is generally increasing, over the whole land allocation scope.

However, as the residential land share increases, the education attainment ratio still declines along this curve. This pattern can be explained by the diminishing marginal impact of public funding: the reduction in the financial burden of skill education becomes trivial as residential land expands. To better understand this process, I next show the changes in both the total public education expenditure and the competitiveness of education resources.

[4]See details in https://www.gov.cn/xinwen/2022-09/28/content_5713042.htm

First, in this model, fiscal expenditure is funded entirely by land revenue, and so I examine how the prices of each land type change with the residential land share. Intuitively, as the residential land share increases, the price of industrial land rises while the price of residential land falls. However, as discussed above, the contribution of industrial land to output is relatively low, with $1 - \alpha = 0.08$. Consequently, the decline in residential land price outweighs any modest increase in industrial land price, leading to an overall decrease in total land revenue, as shown in Figure 2.8. As a comparative exercise, if the industrial land intensity were flipped to 0.92, the total land revenue would exhibit an upward trend in this figure. Thus, under the current setting, a shrinking land revenue base implies that the government faces a constrained fiscal budget for funding public education.

Second, as shown in Equation 2.20, public education resources are evenly distributed among all children in a representative city. As a result, the level of public service per child, E, is also influenced by the total number of children – the "congestion" effect in public service provision. Figure 2.9 shows that as the residential land share increases, the number of resident children rises (mirroring the fertility trend in Figure 2.1). This increase intensifies competition for public education resources, thereby reducing the per-child public education expenditure E. Consequently, the reduction in education costs described in Equation 2.21 slows down, making it more expensive for households to invest in their children's education in cities with higher residential land shares.

Furthermore, Figure 2.10 illustrates the impact of public education services on fertility rates. When combined with insights from Figure 2.7, two key patterns emerge. First, the classic "quantity-quality" trade-off still holds: as the residential land share increases, the aggregate fertility rate rises while the education ratio declines. Second, the introduction of public education funding proves effective in systematically shifting both curves upward – enabling higher fertility without sacrificing educational attainment. This highlights the potential of public investment in education to simultaneously support demographic and human capital objectives.

It is important to note that under the education funding approach, the government subsidy does not refund money directly to households, as in the lump-sum transfer scheme. Instead, it converts the government subsidy to the time cost of children's education through a logarithmic function, $\log(E)$, scaled by the efficiency coefficient τ^{d1}. [5] Therefore, these two policy channels are not directly comparable. The effectiveness of the education sub-

[5] There are several practical reasons for this setup: (1) Only a portion of land revenue would be allocated to education in reality, and τ^{d1} captures both the scale or the efficiency, whether low or high of this funding. (2) The log form ensures that post-subsidy education costs remain positive and stable across varying revenue levels. (3) Directly redistributing all land revenue to families with skilled-educated children could result in negative education costs, which is not desirable. For example, in an economy with 100 parents and 50 children, if only 10 children pursue high school and above, distributing all revenues to these few households would lead to a negative education cost, which is not desirable in this model. To avoid such extremes, I use a milder functional form, $\tau^{d1}\log(E)$. Therefore, this formulation would be highly sensitive to the choice of τ^{d1}. In the current calibration, I set $\tau^{d1} = 0.05$ to make the policy's effect visible, thus appearing more effective than the lump-sum transfer. With smaller values like $\tau^{d1} = 0.005$ or 0.001, the lump-sum transfer would likely yield stronger effects overall.

sidy depends heavily on the efficiency parameter τ^{d1} in Equation 2.21. In Figure 2.7, I set $\tau^{d1} = 0.05$ to demonstrate a noticeable reduction in education costs. When τ^{d1} is lower (e.g., 0.01), the impact of the education subsidy diminishes and becomes comparable to the lump-sum scheme. Nevertheless, even with this reduced effectiveness, the education subsidy still achieves a higher increase in fertility and education outcome because it avoids inflating housing prices, which is a key drawback of the lump-sum transfer under the Cobb-Douglas utility framework.

In summary, the key takeaway of this comparison is that lump-sum transfers tend to flow into the housing market and may dilute their intended effect, while the education subsidy directly reduces the cost of skill education without directly distorting housing demand.

2.5 Concluding Remarks

Population decline has been a common problem throughout history in many countries, particularly in developed nations such as Japan, Korea, and several European countries. This chapter provides a framework to attribute the dramatic population decline in recent years in China to an unintended consequence of local governments' land allocation decisions. I provide a unified framework to capture the interplay between government land allocation, population controls, and the public education system on household family planning decisions.

The numerical results in this paper are estimated under a static equilibrium with variations in land allocation. These results are best interpreted as partial equilibrium estimations of land allocation, as they abstract from an explicit analysis of governments' land allocation decisions. Previous literature offers several explanations for the motivations of pro-industrial land allocation in China, including corruption (Cai *et al.*, 2013), fiscal revenue maximization (He *et al.*, 2022), and spatial competition to bid for firms and promote local economic growth (Tao *et al.*, 2010; Henderson *et al.*, 2022). My project significantly differs from theirs by treating governments' local land allocation as given and exploring the effects on households' decisions, focusing primarily on the "Consequence" side. The reason for this focus is to strike a balance between tractability and complexity, and clarify the connections between land allocation and fertility decisions via a comparative static analysis. [6]

Although the state-owned land ownership system in China is unique and differs from that in many other countries, land-use restrictions are common in numerous nations. This framework can be extended to a broader context to quantify the impact of governments' land policies on household behavior. For example, it would be valuable to conduct a cross-national comparison by examining land market behavior in other countries, investigating whether a similar price gap between industrial and residential land exists, and exploring the possible reasons, such as zoning policies.

[6] My other project, co-authored with Qiaohairuo Lin, focuses on the endogenous land decisions driven by local governments aiming to maximize industrial output, addressing primarily the "Cause" side (Lin and Zheng, 2024). We explore the non-cooperative Nash equilibrium of government competition without considering the long-run effects on human capital. For the full text, please see this link: `https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4867308`.

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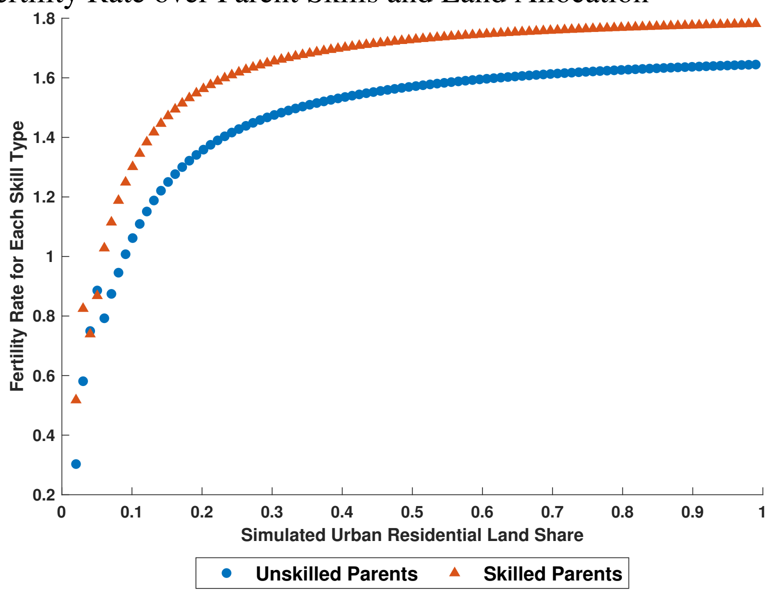
Table 2.1: Parameters Calibrated Externally

Parameters	Definition	Value	Source
α	Land intensity in production	0.08	Henderson *et al.* (2022)
γ	Expenditure share on housing	0.23	National Bureau of Statistics (2010)
f	Fine with One-child Policy	0.1595	Yin (2023)
χ	Child-rearing Preference	0.3	Yin (2023)
τ^w	Opportunity cost for child-rearing	0.15	Yin (2023)
τ^h	Housing space per child	0.08	China Census Data (2010)
$\{\tau^d_{ss'}, \tau^d_{us'}\}$	Intercept term	$\{0.1, 0.2\}$	
τ^{d1}	Coefficient term	0.05	

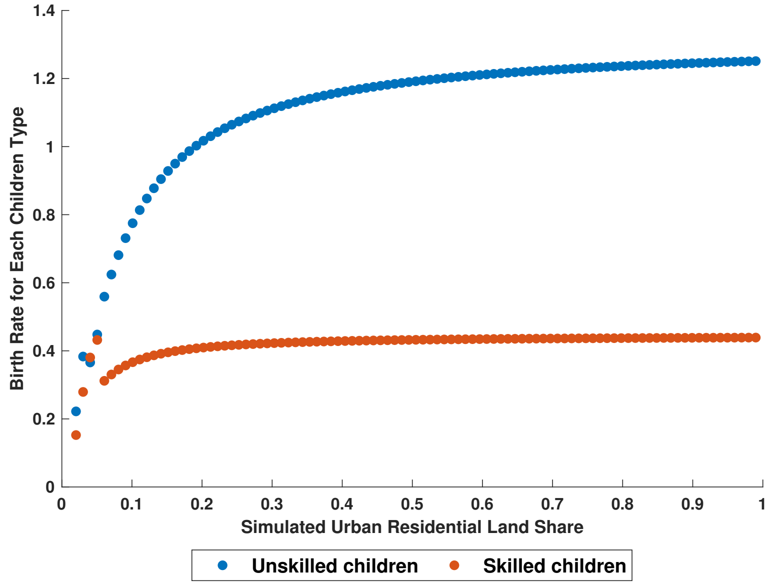
LIST OF FIGURES

Figure 2.1: Fertility Rate over Parent Skills and Land Allocation



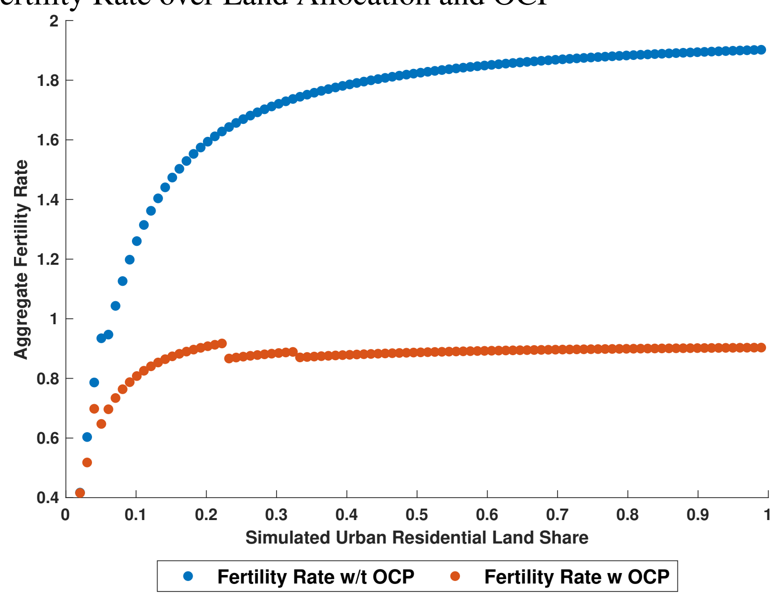
Notes. This figure shows the fertility rates for each parent skill type as the residential land share varies from 0.01 to 0.99. The number of newborns is aggregated at the parent level. Channels of public education expenditure, lump-sum transfer, and One-child Policy are shut down.

Figure 2.2: Birth Rate over Children Education and Land Allocation



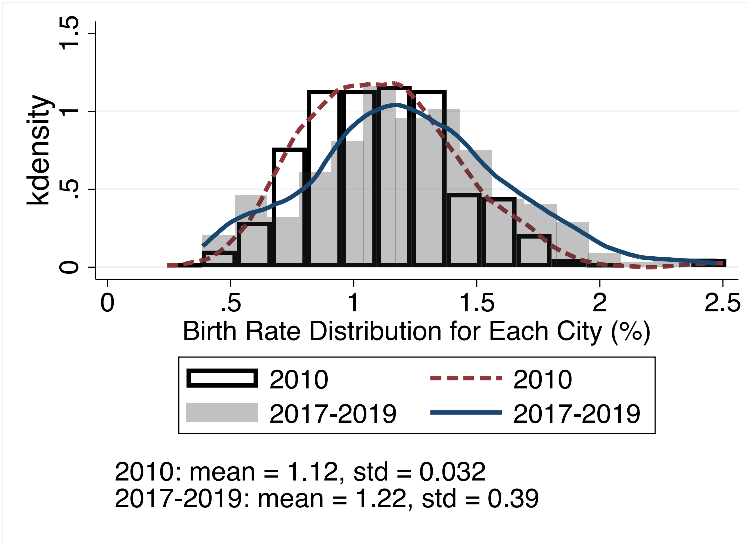
Notes. This figure shows the birth rates for each children's education type as the residential land share varies from 0.01 to 0.99. The number of newborns is aggregated at the child level. Channels of public education expenditure, lump-sum transfer and the One-child Policy are shut down.

Figure 2.3: Fertility Rate over Land Allocation and OCP



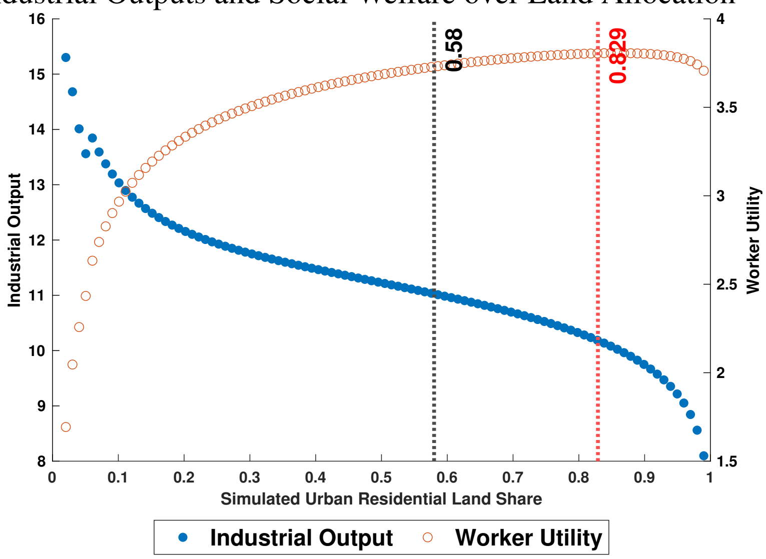
Notes. This figure displays the aggregate fertility rate in the economy as the residential land share ranges from 0.01 to 0.99. The cost of the One-child Policy (OCP) is set at 15.95% of household income. Channels of public education expenditure and lump-sum transfer are shut down.

Figure 2.4: Birth Rate Distribution in 2010 and 2017-2019



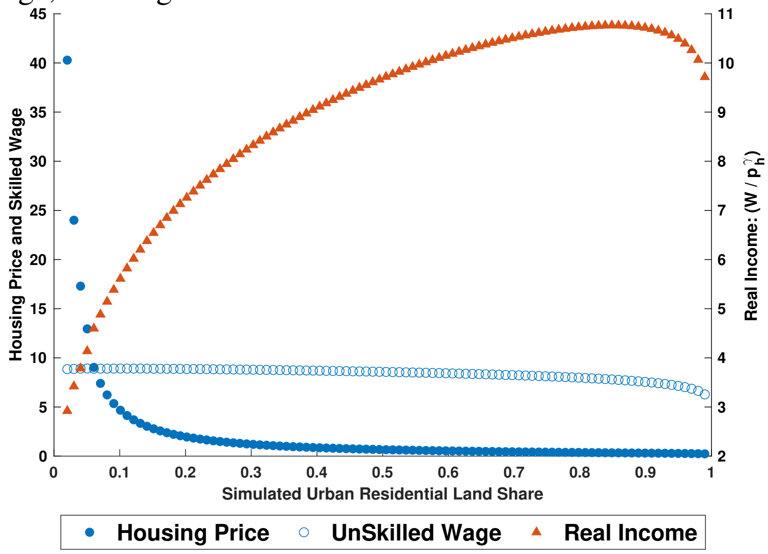
Notes. This figure compares the fertility rate in 2010 (when the One-child Policy was in effect) with that in 2017-2019 (following the relaxation of OCP restrictions). The birth rate is calculated as the average number of live births among married women aged 15-49 living in urban areas, based on data from the 2010 China National Census.

Figure 2.5: Industrial Outputs and Social Welfare over Land Allocation



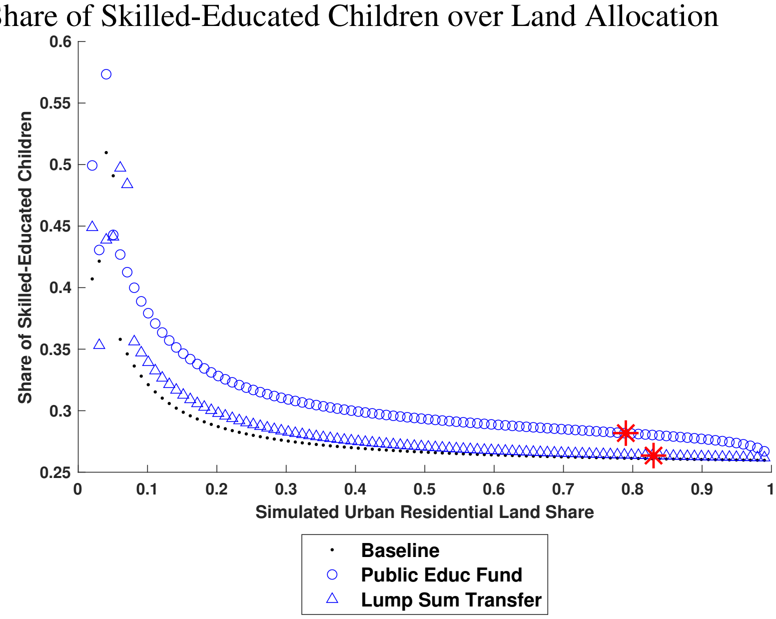
Notes. This figure displays industrial output and worker utility in the equilibrium as the residential land share varies. The channels of public education expenditure, lump-sum transfer, and One-child Policy are shut down. A residential land share of 0.58 reflects the average realized level in urban China from 2008 to 2019, while a share of 0.829 represents the level required to equalize industrial and residential land prices when all land revenue is refunded to households via a lump-sum transfer.

Figure 2.6: Wage, Housing Price and Real Income over Land Allocation



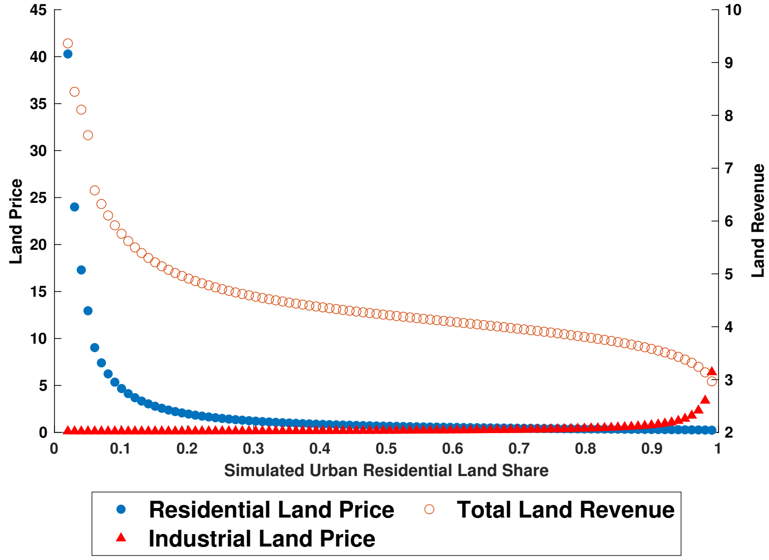
Notes. This figure displays the wage, housing price, and real income in the equilibrium as the residential land share varies. The channels of public education expenditure, lump-sum transfer and the One-child Policy are shut down.

Figure 2.7: Share of Skilled-Educated Children over Land Allocation



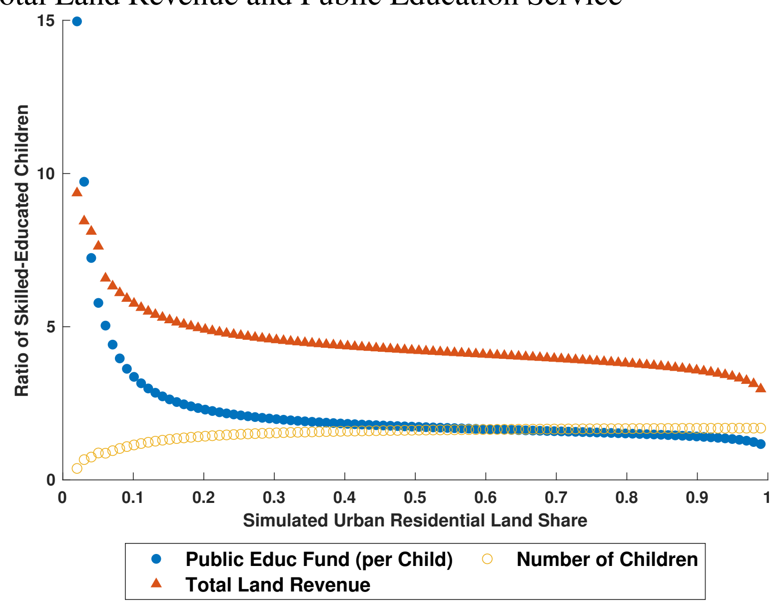
Notes. This figure compares the equilibrium education ratio of children under different policy schemes as the residential land share varies. Red stars indicate the residential land share levels required to equalize land prices under each scheme.

Figure 2.8: Land Prices and Total Land Revenue



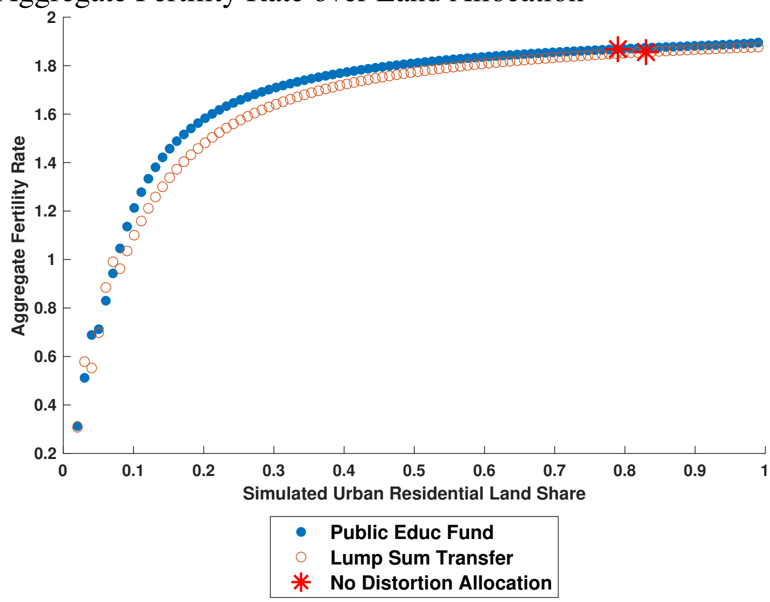
Notes. This figure displays the change of land price and land revenue in the equilibrium under the public education expenditure channel. The channels of lump-sum transfer and the One-child Policy are shut down.

Figure 2.9: Total Land Revenue and Public Education Service



Notes. This figure displays the change of total land revenue and public education spend per child in the equilibrium as the residential land share varies. The channels of lump-sum transfer and the One-child Policy are shut down.

Figure 2.10: Aggregate Fertility Rate over Land Allocation



Notes. This figure compares the equilibrium fertility rate under different policy schemes as the residential land share varies. Red stars indicate the residential land share levels required to equalize land prices under each scheme.

Chapter 3

CORPORATE INCOME TAX CUTS AND MULTINATIONAL JOINT VENTURES' OWNERSHIP STRUCTURE

Phil Huang* Rui Zhang† Chunru Zheng‡

3.1 Introduction

Developing countries have implemented various preferential policies to attract foreign investment with the belief that Foreign Direct Investment (FDI, henceforth) could benefit the domestic economy by bringing in advanced capital, technology, and managerial know-how. The most predominant preferential policies adopted are perhaps corporate income tax cuts offered to foreign-invested firms,[1] aiming at attracting foreign capital to establish joint ventures (JVs henceforth) with domestic partners (Jiang *et al.*, 2024; Lu *et al.*, 2017; Eppinger and Ma, 2024; Holmes *et al.*, 2015a). According to the property-rights theory, the ownership structure of a JV is supposed to maximize its own net value by incentivizing both the domestic partner and the foreign partner (Grossman and Hart, 1986; Hart and Moore, 1990; Antras, 2003; Antras and Helpman, 2004; Antras, 2014; Eppinger and Ma, 2024).

However, the aforementioned FDI-preferential policies might inadvertently encourage JVs to deviate from their optimal ownership structures in the attempt to qualify for the corporate income tax cuts, hence leading to inefficiency losses. Such responses of ownership structures raise questions regarding the effectiveness of the FDI-preferential policies: How do these policies shape the ownership decisions of JVs? Are certain JVs more responsive than the others? What are the subsequent effects on firm performance?

In this chapter, we answer these questions by investigating an important FDI-preferential policy in China, which grants firms with foreign equity shares no less than 25% a significant lower corporate income tax rate (ranging from 15% to 24%) than the statutory tax rate of 33%. This FDI-preferential policy was first introduced in 1991 and remained in effect until the tax harmonization reform in 2008 established a common corporate income tax rate

[0]This chapter is co-authored with Phil Huang and Rui Zhang. We thank Costas Arkolakis, Eric Bond, Kerem Cosar, James Harrigan, Roxanne Jaffe, Daisoon Kim, John McLaren, Joel Rodrigue, Kamal Saggi, Liugang Sheng and Lex Zhao for their helpful comments. Rui Zhang thanks the National Natural Science Foundation of China (No.72303254) and the Fundamental Research Funds for the Central Universities, Sun Yat-sen University (23wkqb06) for financial support. This chapter includes only the empirical analysis. For the complete version of the paper, please refer to https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4831172. All errors are my own.

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[1]Official documents in 1999 and 2007, see https://chinareal.nankai.edu.cn/info/1033/3404.htm and http://www.gov.cn/zwgk/2007-07/19/content_689538.htm for details.

of 25%.[2] Therefore, this policy provides JVs with substantial incentives to manipulate their foreign equity shares in exchange for the tax benefits before the 2008 tax harmonization reform.

We begin our analysis in Figure 3.2 by reporting the distributions of effective tax rates for different groups of firms.[3] Before 2008, with the notch-based tax scheme, the effective tax rates of firms with zero foreign equity share (domestic firms) were highly concentrated at 33%, the statutory corporate income tax rate during this period. In contrast, the effective tax rates of firms with foreign equity shares beyond 25% were concentrated at 15% and 24%, corresponding to preferential income tax rates. For firms with foreign equity shares between 0 and 25%, the effective tax rates are intermediary, with the mode at 33% and the average at 22.5%.[4] To compare, we also display the effective tax rate distributions for different groups of firms after the 2008 tax harmonization reform. The effective tax rates for different groups were concentrated at 25%, the revised statutory corporate income tax rate after the 2008 reform.

In Section 3.3, we show that the notch-based tax scheme shapes the foreign ownership structures of JVs and induces significant bunching in foreign equity share. First, we show that a large number of JVs bunch their foreign equity shares at the notch of 25%. Following the bunching estimation approach in Kleven and Waseem (2013) and Chen *et al.* (2021), we find that the notch-based tax scheme leads to an average percentage increase in the foreign equity share of around 20%.

To further explore whether certain JVs are more responsive to the notch-based tax scheme, as well as the effect of foreign ownership structure on firm performance, we display a cross-sectional comparison of JVs with different foreign equity shares. Using the Annual Survey of Industrial Firms from 1998 to 2007, we uncover a sizeable and sharp "performance discount" at the notch in all measures of firm performance, including employment, fixed assets and sales. The performance discount indicates that smaller and less productive firms are more responsive to the notch-based tax scheme, and are hence more likely to bunch their foreign equity shares at the notch.

Our research speaks to the policymaker that when taking the cost into consideration, the consequence of utilizing tools such as tax subsidies to manipulate foreign investors' acquisition in multinational enterprises may be complicated to interpret. On the one hand, this policy does serve the purpose of bringing in more foreign direct investment. However,

[2]The common corporate income tax rate of 25% applies to all except for those covered by China's "West Development program", which grants a corporate income tax rate of 15% to all firms located in West China and operating in certain state-encouraged industries.

[3]In the dataset, we observe the amount of payable tax and total profit at the firm level, and we define the effective tax rate to be the ratio of these two. Since firms are in different tax brackets and have different deductibles in each year, the constructed effective income tax rate exhibits a continuous empirical distribution in the data.

[4]Although these firms were not eligible for the tax reduction for foreign-invested firms, they may still enjoy some other tax reduction. For example, firms with an R&D intensity (R&D investment over revenue) above 5% could qualify for a lower average tax rate of 15% granted to high-tech firms. See Chen *et al.* (2021) for more details.

what is the meaning of the extra FDI that comes as a consequence? Does it benefit the domestic firms or the market through channels such as technology spillovers or management practices? These need careful examination and further work. This chapter serves as an empirical motivation for future extension aimed at quantifying the extent of bunching and performance discounts, and at evaluating the broader impact of the notch-based FDI preferential tax scheme.

3.2 Literature

This paper is closely related to the literature that investigates the ownership structure decisions of international JVs and how these decisions affect firm performance. Yet, compared to the existing studies, our focus on the notch-based FDI preferential tax scheme is novel. The pioneering work of Antras (2003) develops a model based on the property-rights theory to interpret the variations of intra-firm trade at the industry level. In this model, a firm is a joint production process formed by a headquarter and a supplier, both supplying non-contractible inputs and subject to hold-up problems. Subsequent literature has followed and expanded the model of Antras (2003) to understand the outsourcing/integration decisions at the firm level (Acemoglu *et al.*, 2007; Antràs and Chor, 2013; Antras, 2014; Schwarz and Suedekum, 2014; Alfaro *et al.*, 2019; Eppinger and Kukharskyy, 2021), with a particular focus on whether a headquarter integrates/acquires its foreign supplier of intermediate input.

Regarding the determination of foreign ownership in JVs, Lin and Saggi (2004) point out that developing countries tend to restrict the degree of foreign ownership of JVs, which may lead to efficiency losses. Eppinger and Ma (2024) posit that a domestic partner and a foreign partner form a JV in the same way as in Antras (2003), and the optimal ownership structure of the JV is the foreign equity share that minimizes its inefficiency resulted from hold-up problems (and hence maximizes the profit of the JV). Using China's FDI liberalization upon its WTO accession as a policy shock, Eppinger and Ma (2024) documents that such a reform removes the upper bounds on foreign equity shares in certain industries and increases output and productivity of JVs that are prevented from their optimal ownership structures before the reform.

Our paper also relates to a broader literature that evaluates the benefits and costs of attracting FDI inflows, and previous studies generally focus on the "spillover" effects of FDI on domestic markets and firms. Related empirical investigations indicate that such spillover effects could be positive due to technology transfer, inter-sectoral linkages, and within-firm productivity improvement (Javorcik, 2004; Haskel *et al.*, 2007; Keller and Yeaple, 2009; Alfaro and Chen, 2018; Bao and Chen, 2018; Jiang *et al.*, 2024), or negative due to increased competition caused by the entry of more productive foreign rivals (Haddad and Harrison, 1993; Aitken and Harrison, 1999; Konings, 2001; Hu *et al.*, 2002; Lu *et al.*, 2017). Another literature focuses on the "*quid pro quo*" policy in China, which requires multinational firms to transfer technology in exchange for market access, and finds that this policy significantly increases the productivity of domestic partners (Holmes *et al.*, 2015b; Bai *et al.*, 2021). Overall, existing studies tend to consider the increased competition pressure caused by FDI inflows as a cost of FDI preferential policies. We contribute to the literature by highlighting JVs' deviated ownership structures and the associated costs as other sources of potential losses of such policies. Our analysis thus complements the existing literature in understanding the complex trade-offs of designing policies to attract FDI.

Finally, our paper contributes to the growing body of literature using bunching methods to estimate behavioral responses to discontinuities in taxation. Kleven (2016) provides a comprehensive survey of a surge of applied work using bunching approaches, investigating a broad spectrum of responses from individuals and businesses to factors such as taxes, transfers, social security, social insurance, welfare programs, education, regulation, private sector pricing, and reference-dependent preferences (Kleven and Waseem, 2013; Chen *et al.*, 2021; Diamond and Persson, 2016). To the best of our knowledge, this is the first paper to quantify the bunching behavior in terms of foreign ownership shares.

3.3 Evidence of Firms' Responses to Tax Notch

In this section, we conduct an empirical analysis to quantify firms' bunching behaviors and the impact of the tax program on firms' outcomes. We start by introducing the tax policy. Then we describe the data we use in the analysis, and show the bunching patterns of firms in response to the tax reduction policy. Specifically, we first provide evidence that firms' foreign equity shares are bunched around the tax notch, and then we carry out a cross-sectional comparison of firm-level outcomes between firms with different levels of foreign ownership shares. We propose hypotheses to elucidate the empirical patterns we've observed, which form the foundation for a future structural model.

3.3.1 Policy Backgrounds

As part of the process to develop a foreign-oriented economy, the "Income Tax Law of the People's Republic of China on Enterprises with Foreign Investment and Foreign Enterprises" was promulgated on July 1st, 1991, which laid the legal foundation for preferential tax policies towards foreign-invested enterprises (FIE). According to the law, the statutory income tax for firms is 33% in general. Meanwhile, substantial tax cuts are granted for some foreign-invested enterprises. For industries that are open to foreign direct investment, as long as the joint venture meets the prerequisite that the foreign capital share is no less than 25%, it can enjoy a lower corporate income tax of 15% or 24%.

This tax program lasted until 2007, when the new "Enterprise Income Tax Law of the People's Republic of China" was promulgated, aiming to eliminate the dual-track statutory corporate tax rate. According to the new law, both domestic and foreign firms are required to pay a corporate income tax of 25%. [5] Firms that enjoy the tax cuts granted by the old enterprise income tax law are given a grace period of three years to comply with the new law. Figure 3.2 shows the effective corporate tax of firms before and after the tax reform. From

[5] Except for the western provinces, where the statutory tax rate stays at 15%, which was set in 2001 by China's Western Development Program. Out of concern that these foreign-invested firms may have received different subsidies on the foreign capital shares, we exclude them from our sample. In the dataset, for all non-wholly-domestic-owned firms, only 7.83% are located in the west.

the graph, we can see the following two facts: (1) Before the reform in 2008, most of the FIEs were granted tax cuts, and we can see the peak of the distribution for FIEs' effective tax rate falls on 15%. Only a small portion of FIEs pay the tax rate of 33%. Meanwhile, the effective tax rates for domestic firms are concentrated around 33%. (2) After the tax reform, the majority of FIEs are now accompanied by effective tax rates that are around 25%, and only a small portion of them are paying no more than 15% of corporate income tax. Meanwhile, most domestic firms also pay an effective income tax of around 25%. Overall, the tax benefit for FIEs has been drastically reduced.

3.3.2 Data

The main data we use is the Chinese Annual Survey of Industrial Firms (ASIF), conducted by the Chinese government's National Bureau of Statistics. ASIF provides data on detailed firm characteristics and, most importantly for our research here, the ownership structure of firms previous to 2008, and from 2011 onward. [6] Before 2008, ASIF was a census of all non-state-owned firms with more than 5 million yuan in revenue (about $\$700,000$) plus all state-owned firms. After 2011, the threshold for the scale of the surveyed non-state-owned firms was raised to more than 20 million yuan in revenue (about $\$3,000,000$). In our qualitative analysis, including the empirical analysis and our structural model, we focus on the pre-tax-reform period, which spans from 1998 to 2007.

During the sample period, we have approximately 1.85 million observations.[7] We categorize all firms into four groups based on their ownership structures [8]: domestic firms (firms with zero FDI), firms with foreign ownership that's less than 25%, firms with foreign ownership between [25%, 100%), and wholly-foreign-owned firms (firms whose shares are 100% held by foreign capital). The descriptive statistics of all four groups of firms are shown in Table 3.1. Around 80% of the observations (1.5 million) are comprised of domestic firms. For the rest of the sample, which covers firms with at least some foreign capital, 54.37% are wholly foreign-owned firms, 6.65% are firms with foreign ownership shares that fall below 25%, and 38.98% have [25%, 100%) of shares held by foreign companies. We focus on those joint ventures in our following analysis since they correspond to continuous choices of the ownership structure, and the tax notch is at the 25% threshold.

Table 3.1 also displays various measurements of firms' size, to provide a better picture

[6]In 2008, as we have mentioned above, China carried out this tax reform to eliminate the tax differences between foreign and domestic firms. Companies are given a three-year grace period to comply with the new policy, and thus the survey does not report on the ownership structure during that period.

[7]In some industries, foreign direct investment is prohibited or restricted, or the government places additional restrictions on the foreign ownership share. We exclude firms in these industries from our analysis to prevent our estimate from being contaminated by other FDI restrictions or policies. Since 2002, there have been only 22 out of 425 industries that are restricted or prohibited to FDI, and the number of firms takes up a small portion (6.36%) of total firms.

[8]In the data, we can observe firms' total paid-in capital, and how much of it is paid by state-owned capital, collective capital, corporate investors, individual investors, capital from Hong Kong, Macao and Taiwan (HMT), and capital from the rest of the world (labeled as foreign capital in the dataset). We follow the literature and define the share of the summation of HMT capital and foreign capital in the total paid-in capital as the foreign ownership share.

of the characteristics of firms in each category. The dataset offers information on firms' annual industrial sales (measured in each year's current price), total profits before tax, industrial output (measured in fixed price), number of employees, and the amount of fixed assets as indicators of firms' sizes. The summary statistics show that firms with FDI shares that fall within 0% and 25% are the biggest in size, with an average pre-tax profit of 3556 thousand RMB. Firms on the right side of the tax notch with more than 25% of foreign ownership are smaller than the former firms, and the domestic firms are the smallest, as expected.

3.3.3 Effective Tax Rate for Firms before 2008

In this section, we provide more details on the relationship between the industries in which the firms are and the tax breaks they can enjoy. In the "Income Tax Law of the People's Republic of China on Enterprises with Foreign Investment and Foreign Enterprises", FIEs in an "encouraged industry", such as energy, transportation and so on, are all accompanied by a lower tax rate of 15%, and no clear tax policies were placed on firms from other industries.

To better conduct the tax policy within "encouraged industries" and guide foreign investment, the National Development and Reform Commission and the Ministry of Foreign Trade and Economic Cooperation (the predecessor of the Ministry of Commerce) published the first "Catalogue for the Guidance of Foreign Investment Industries" in 1995, and revised the content every three to five years.[9] The Catalogue classifies products into four groups: "encouraged", "restricted", "prohibited", and the residual group "permitted". Before 2002, there were 56 out of 397 (14.11%) industries in which foreign direct investment was restricted or prohibited. After the revision of "the Catalogue" in 2002, this number came down to 22 out of 406 (5.42%). Different policies are conducted for FIEs within each product group: FIEs who produce products in the "restricted" group face regulations and restraints on entrance and ownership shares.[10]

In practice, we find that the foreign ownership share determines whether the firm is qualified for the tax break, but the industry only plays a minimal role in it. In Figure 3.1, we list distributions of the effective tax rate for three groups of firms with different levels of foreign ownership shares in four sets of industries. We can observe FDI in industries that are labeled as "restricted" and even "prohibited". This can be caused by the bias when we aggregate the data to an industry level. Information from "The Catalogue" on whether FDI is encouraged, restricted, or prohibited comes at the product level. We then link these products to their corresponding industries. There are a handful of industries that contain both encouraged and restricted or prohibited products. We drop these industries from the whole sample. Then we label all the rest of the industries that have no labels of being encouraged, restricted, or prohibited as "permitted". From the process, we can tell that it is possible that some restricted and prohibited industries also contain products where FDI is "permitted".

[9] Up to now, the Catalogue was revised in the year 1997, 2002, 2004, 2007, 2011, 2015, 2017 and 2022.

[10] Constraints of foreign ownership in the restricted group usually stipulate that wholly-foreign-owned companies are not allowed, or a foreign investor can only own 50% or less of the firm's equity.

More importantly, this figure shows that the distributions of effective tax do not display distinct patterns across different groups of industries. When we compare firms from encouraged and permitted industries, the distributions of effective tax rates are highly similar: for wholly-owned domestic firms and firms with a foreign ownership share that is no less than 25%, the tax rates concentrate around 33% and 15%, respectively, which correspond to the statutory tax rate and the tax notch. For firms with a foreign equity share that is within (0, 25%), the distribution is in between. We can observe a very similar pattern on firms from the restricted and prohibited industries, although now the distribution of effective tax rates for firms that have no less than 25% of foreign investment is slightly flattened out.

Overall, we argue that it is reasonable to incorporate firms from both encouraged and permitted industries into our sample, and leave the difference of industries out at this point. Meanwhile, we drop firms from the restricted and prohibited industries from our analysis, out of concern that they face extra barriers placed on the degree of foreign ownership. However, as we mentioned above, these industries and firms only make up a small portion of the whole sample, especially after 2002, and our results are fairly robust even if we incorporate them into our analysis.

3.3.4 Firms' Bunching Behavior

In this subsection, we look at firms' bunching behaviors. We first look at the distribution of firms' foreign equity shares. In Figure 3.3, we cut the foreign equity share range of [0,1] into 100 bins evenly, and show the portion of firms that fall into each bin.[11] The dashed line shows the empirical distribution of the overall foreign ownership share before 2008. Around 14% of the firms are concentrated in the bin of [0.25, 0.26), which indicates a bunching pattern corresponding to the 25% threshold.

Next, we quantify firms' bunching behavior. One approach to measure the increase in firms' foreign equity share is to compare the observed density of foreign equity share, represented by $f_1(d)$, in the current scenario with the tax notch scheme, to the density that would exist in a hypothetical scenario without the program, represented by $f_0(d)$. This method is based on the assumption that only firms with a certain range (denoted by $[d^{*-}, d^{*+}]$) of original foreign equity shares will be affected by the program. We call the range of $[d^{*-}, d^{*+}]$ the excluded region. Firms with foreign equity shares that are outside of the range should not be affected by this tax notch, and thus we can use the distribution of firms that fall outside of the excluded region to estimate the counterfactual distribution of firms $f_0(d)$ within the excluded range. To do this, we follow the methodology used in Kleven and Waseem (2013); Chen *et al.* (2021); Diamond and Persson (2016), and group the firms into bins based on their foreign equity shares d, and then use a flexible polynomial approach to estimate the counterfactual density of foreign equity share:

[11] Wholly foreign-owned enterprise takes up around 20% of our observations. To better show the distribution of all the other firms, we exclude the wholly foreign-owned enterprises from our graph here.

$$c_i = \sum_{k=0}^{p} \beta_k (d_i)^k + \sum_{j=d^{*-}}^{d^{*+}} \gamma_j \cdot \mathbb{1}[d_i = j] + \sum_{r \in \{5, 10\}} \rho_r \cdot \mathbb{1}\left[\frac{d_i}{r} \in \mathbb{N}\right] + \rho_{0.5} \cdot \mathbb{1}[d_i = 0.5] + \epsilon_i \quad (3.1)$$

where c_i represents the share of firms that fall into a specific bin of foreign equity share level, d_i, and p is the order of the polynomial regressions. γ_j is a bin fixed effect for each bin in the excluded range $[d^{*-}, d^{*+}]$, over which the firms would possibly be affected by the policy and choose to bunch. According to Kleven and Waseem (2013), individuals tend to report their income as multiples of 5K, 10K, or multiples of 12 (the number of months in a year) out of accountability convenience. This phenomenon is referred to as "rounding" or "chopping," which leads to excessive mass in the empirical distribution of foreign equity shares at these points. We observe a similar pattern in firms' ownership structure: joint ventures tend to round the equity share of each party to multiples of 5 and 10. Therefore, we control a fixed effect of equity shares that are multiples of 5 and 10, separately ($\frac{d_j}{r} \in \mathbb{N}$). In addition, we give a perfect fit for the bin of 50% to rule out the effect of absolute share-holdings ($d = 0.5$).

We estimate the parameters in equation 3.1 using data from the non-excluded region, and use $\hat{c_i} = \Sigma_{k=0}^{p}\hat{\beta}_k(d)^k + \sum_{r \in 5,10} \hat{\rho_r} \cdot \mathbb{1}[\frac{d_j}{r} \in \mathbb{N}] + \hat{\rho_{0.5}} \cdot \mathbb{1}[d = 0.5]$ to get the estimate for the counterfactual distribution, $f_0(d)$. We use a 5-fold cross-validation procedure approach to select the excluded region (d^{*-}, d^{*+}) and the degree of the polynomial k. This method is data-driven and ensures that $f_1(d)$ and $f_0(d)$ has the same mass over the excluded region.

Figure 3.3 illustrates the results of this estimation for our sample period 1998-2007. In this plot, the dashed line displays the observed distribution of foreign equity share $f_1(d)$, and the solid line displays the estimated counterfactual density $f_0(d)$. The red vertical dashed lines show the estimated lower and upper bounds of the omitted region, which are denoted as d^{*-}, d^{*+}. Using these two distributions, we calculate the expectation of foreign ownership shares in the excluded region with the tax notch, $\mathbb{E}[d|\text{Notch}, d \in (d^{*-}, d^{*+})]$, and compare it to the counterfactual shares without the tax notch, $\mathbb{E}[d|\text{No Notch}, d \in (d^{*-}, d^{*+})]$. We calculate $\Delta d = \mathbb{E}[d|\text{Notch}, d \in (d^{*-}, d^{*+})] / \mathbb{E}[d|\text{No Notch}, d \in (d^{*-}, d^{*+})] - 1$, which shows the increase of foreign equity shares brought by firms' bunching behaviors. Our estimate shows that $\Delta d = 0.208$, and is statistically significant, which indicates that by bunching to the tax notch, joint ventures increase 20.8% of their foreign equity shares, compared to the case with an absence of the tax reduction program.

In practice, we can see that some firms choose not to participate in this tax program. Given the two distributions of firms for the foreign ownership share $f_1(d)$ and $f_0(d)$, we can calculate the probability of firms falling into the range of $[d^{*-}, notch)$. More specifically, we use a_0 and a_1 to denote the portion of firms that fall into the range of $[d^{*-}, notch)$, if the distribution is $f_1(d)$ and $f_0(d)$, respectively, and denote the ratio of these two to be $a = a_0/a_1$. Then we should observe that $a < 1$, since with the tax notch, many firms will choose to bunch to the tax notch, which is out of the range of $[d^{*-}, notch)$, and thus we should have $a_0 < a_1$. In an extreme occasion where all firms choose to bunch to the tax notch and no firms will choose a foreign equity share below the tax notch, a_0 falls to zero and $a = 0$. On another extreme, if no firm chooses to participate in this tax program, a_0 should be the same as a_1, and $a = 1$. So the bigger a is, the more firms choose to stay than to bunch, and we can use a as an indicator to show how big the friction or cost of bunching is to firms. In our bunching estimation, we find that $a = 0.461$.

Since only firms in the exclusion region respond to the policy, $f_1(d)$ and $f_0(d)$ are supposed to be equal outside the exclusion region. Our result shows that we cannot reject the specification test that $f_0(d)$ has the same mass as $f_1(d)$ over the excluded region for all types of firms. Overall, Figure 3.3 contributes to our understanding of the effects of the tax notch scheme by quantifying the average increase in foreign equity share and the scale of bunching friction.

3.3.5 Detecting Firm's Performance

In this section, we compare firm performance across different levels of foreign equity ownership. It is important to note that this analysis is based on a cross-sectional comparison of firms according to their reported equity shares. As such, the observed differences across groups may reflect either self-selection, where certain joint ventures are more responsive to the notch-based tax scheme; or post-hoc effects, where foreign ownership structures directly influence firm performance. This regression framework does not allow us to distinguish between these two mechanisms. Specifically, we run the following regression:

$$\ln y_{ft} = \beta_0 + \Sigma_{j=1}^{J} \beta_j \cdot \mathbb{1}[d_i = j] + X_{ft} + \alpha_{ct} + \epsilon_{ft} \tag{3.2}$$

where $\ln y_{ft}$ is the logarithm of firm-level outcomes in year t. We select various indicators of firm size, including the number of workers, fixed assets, industrial output (measured in fixed price), total profits, and firms' annual industrial sales, to ensure that our results are fairly robust. $\mathbb{1}[d_i = j]$ indicates whether the foreign ownership share falls into a certain bin of foreign equity share level. We control for industry-year fixed effect α_{ct}, where the industry is measured with a 4-digit-CIC code. We further control the share of exports for each firm, the share of state-owned equity holdings, and a location (city) fixed effect in the regression.

In Figure 3.4, Panel A, we present the outcomes of Equation 3.2, with the width of each foreign-ownership-share bin to be 5%. By incorporating all twenty bins, ranging from (0, 0.05] to (0.95,1], into our regression analysis, we evaluate and compare the performance of firms within each bin against the benchmark group, which is the wholly domestic-owned firm with zero foreign equity shares. This is why the vertical axes in these figures are labeled as "FDI premium" – they represent the performance premium of firms with foreign direct investment relative to those without.

This graph speaks to three key points: First, joint ventures that possess any level of foreign ownership display a significant size premium when compared to domestic firms. They are bigger in size. Second, the size premium distribution across various bins of foreign shares exhibits a "U-shaped" curve, reaching its lowest point around the majority share-holding point, where the foreign partner holds 50% of the shares. This empirical pattern aligns with the theoretical prediction posited in Antras (2014), suggesting that the impact of the hold-up problem is most severe under incomplete contract situations when both parties equally share all equities. This equal share tends to incentivize both parties to under-invest in production, leading to a moral hazard issue and inefficiency in production. Third and most crucial to our research, we observe distinct discontinuities in the (0.25, 0.3] bin. Here, we see a sharp decline in various performance indicators for all firms, including the number of workers, fixed assets, gross output, total profits, and industrial sales, indicating that firms' size sharply drops when they cross the tax notch.

To further validate that the tax notch does have an impact on firms' bunching behavior and performance, we zoom in and look at firms' premiums in each 1% FDI-share bin. Panel B of Figure 3.4 depicts the results. We continue to observe a significant, discontinuous decline in outcomes at the bin of [0.25, 0.26). [12] This notable reduction in size premium at the tax notch suggests the potential effects of the tax scheme on firms' behavior. First, firms of smaller size may be more reactive to this tax policy, adjusting their optimal ownership structures and bunching at the tax notch. That is to say, larger firms respond less to the policy. Second, firms may encounter production inefficiency after altering their optimal ownership, which may not align with their factor intensity in the production process.

3.4 Concluding Remarks

Foreign Direct Investment (FDI) preferential policies are widely implemented in developing countries as a strategic approach to attract foreign investment into their domestic markets. However, these policies can alter the optimal ownership structures of multinational firms and potentially exacerbate production inefficiency under the risks of incomplete contracts. Our paper leverages a preferential FDI tax policy in China to estimate the impacts, especially the cost of such a policy. We provide both graphical and empirical evidence demonstrating that firms' foreign ownership shares are bunched at the tax notch. Besides, we find that the average size of these firms is smaller than those with other ownership structures, indicating that smaller firms are more responsive to the tax policy and more willing to participate in the tax program.

Our research speaks to the policymaker that when taking the cost into consideration, the consequence of utilizing tools such as tax subsidies to manipulate foreign investors' acquisition in multinational enterprises may be complicated to interpret. On the one hand, this policy does serve the purpose of bringing in more foreign direct investment. However, what is the meaning of the extra FDI that comes as a consequence? Does it benefit the domestic firms or the market through channels such as technology spillovers or management

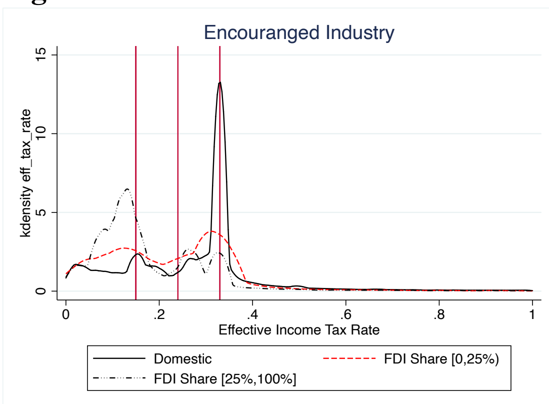
[12] In Panel B of Figure 3.4, we can observe a significant, discontinuous decline in outcomes at the bin of [0.26, 0.27) too, which is closely located at the right of the notch, and then all outcomes "jump back" from the [0.28,0.29) bin afterward. We suspect that there are two reasons for the extra region where the jump-down happens: First is the bias in our data. Since the length of our bin is only 1% of FDI share, some tiny bias in the reported capital data can lead to the result that some firm is grouped into the bin of [0.26.0.27) instead of [0.25, 0.26). Second, some firms might not want to get "busted" and choose to bunch to a location that is a little bit further from the tax notch.

practices? These need careful examination and further work. The difficulty that lies here is the lack of clear identification and limitations in our data. On the other hand, such an increase in foreign investment is accompanied by high fiscal costs, and a substantial portion of the fiscal expense is used to cover the production loss and adjustment costs. This again highlights the importance of having the market determine the ownership structures in multinational firms. The economy benefits from correcting the distortions placed on foreign direct investment, which allows firms to re-optimize their ownership structures. Thus, policymakers should be careful and think twice before they carry out such policies.

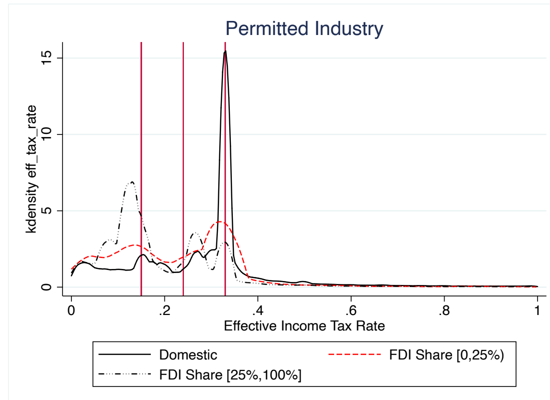
Table 3.1: Summary Statistics

	Mean	Std	P25	P50	P75	Observations
	Domestics Firms					
Log of Industry Sales	9.759	1.337	8.975	9.657	10.506	849,600
Log of Pre Tax Profit	6.245	1.890	5.130	6.292	7.432	807,970
Log of Industry Output	9.386	1.445	8.714	9.389	10.201	413,608
Log of the Number of Workers	4.565	1.091	3.850	4.500	5.220	898,991
Log of Fixed Assets	8.018	1.703	6.978	7.987	9.031	983,802
	Firms with FDI share within range (0,25%)					
Log of Industry Sales	10.763	1.507	9.677	10.607	11.665	19,282
Log of Pre Tax Profit	7.478	2.191	6.131	7.564	8.898	16,929
Log of Industry Output	10.562	1.432	9.536	10.442	11.484	12,582
Log of the Number of Workers	5.482	1.239	4.615	5.398	6.250	19,407
Log of Fixed Assets	9.368	1.750	8.194	9.263	10.448	21,469
	Firms with FDI share within range [25%, 1)					
Log of Industry Sales	10.381	1.341	9.407	10.217	11.164	111,796
Log of Pre Tax Profit	7.147	2.047	5.869	7.152	8.465	97,658
Log of Industry Output	10.131	1.312	9.218	9.971	10.883	65,587
Log of the Number of Workers	5.013	1.077	4.290	4.977	5.704	116,065
Log of Fixed Assets	8.792	1.730	7.644	8.682	9.853	128,372
	Wholly-foreign-owned Firms					
Log of Industry Sales	10.393	1.294	9.445	10.229	11.150	165,052
Log of Pre Tax Profit	7.123	1.950	5.878	7.115	8.410	137,956
Log of Industry Output	10.081	1.240	9.196	9.932	10.811	70,015
Log of the Number of Workers	5.133	1.156	4.369	5.075	5.858	176,249
Log of Fixed Assets	8.717	1.708	7.583	8.702	9.831	193,073

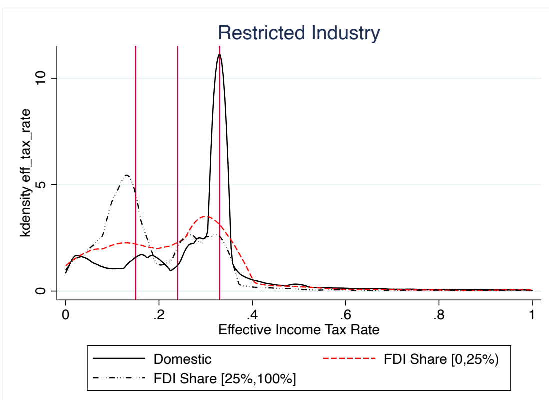
Figure 3.1: Effective Tax Rate for Firms before 2008



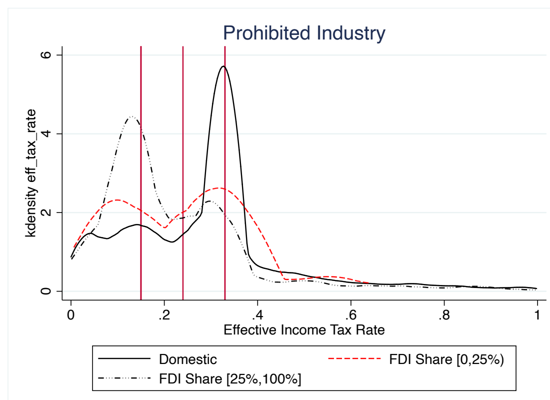
(a) Encouraged Industries



(b) Permitted Industries

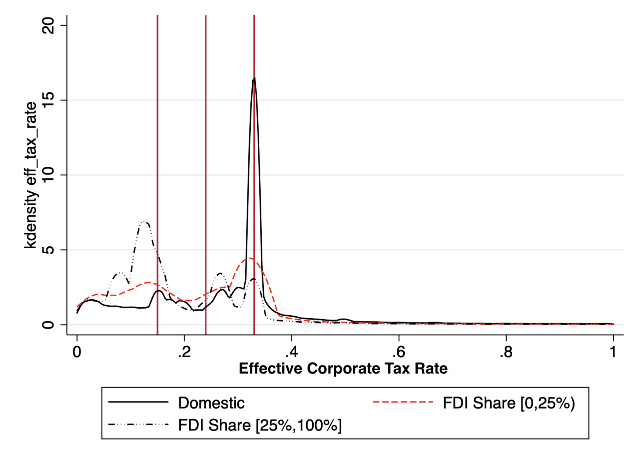


(c) Restricted Industries

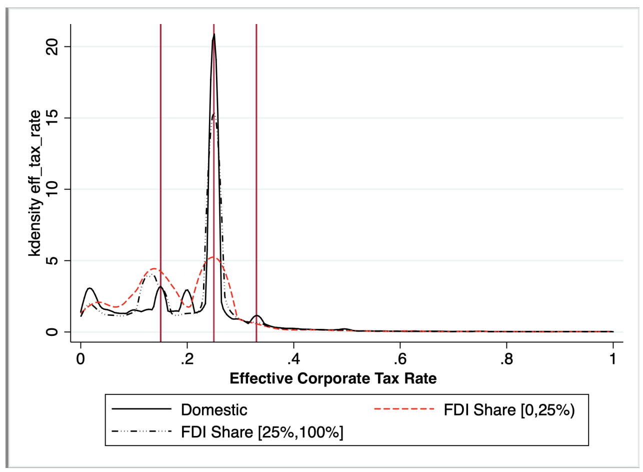


(d) Prohibited Industries

Figure 3.2: Firms' Effective Tax Rates Before and After 2008



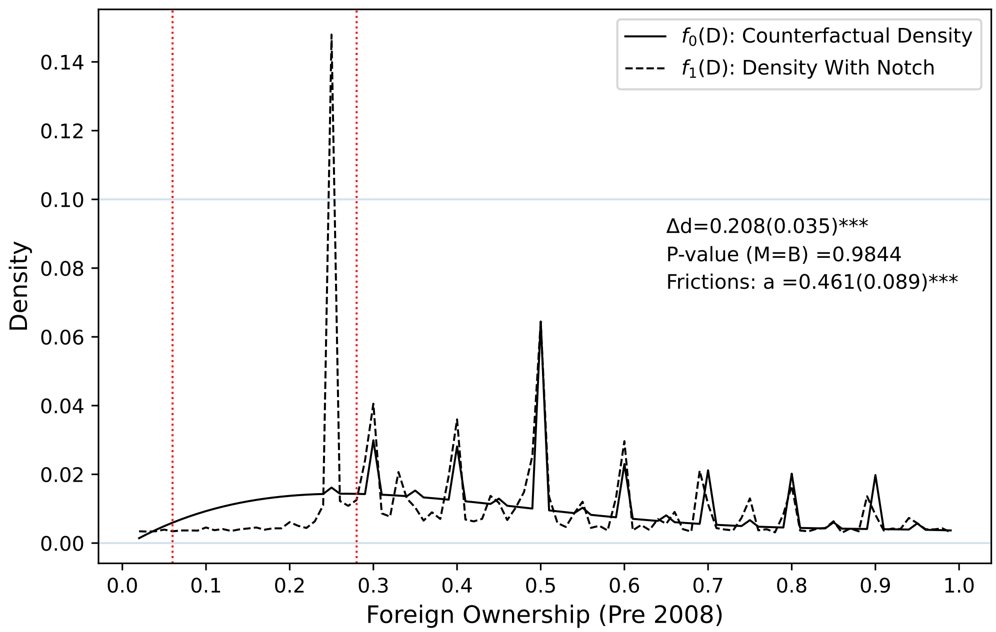
Panel A: Effective Tax Before 2008



Panel B: Effective Tax After 2008

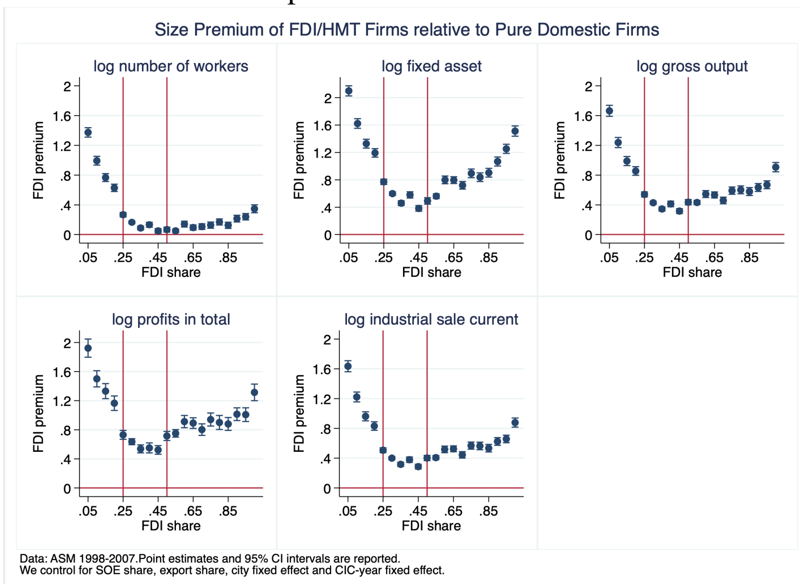
Notes: These figures illustrate the effective income tax rates paid by firms with different levels of foreign ownership, calculated as tax payable divided by annual firm revenue. The black solid line, red dashed line, and black dash-dotted line represent firms with no FDI share, with an FDI share of no more than 25%, and with an FDI share of at least 25%, respectively. Panel A uses ASIF data from 1998 to 2008, and Panel B uses ASIF data from 2011 to 2013. The X-axis shows different levels of foreign ownership; the Y-axis represents the distribution density of firms.

Figure 3.3: Bunching at Different Thresholds of Foreign Equity Share

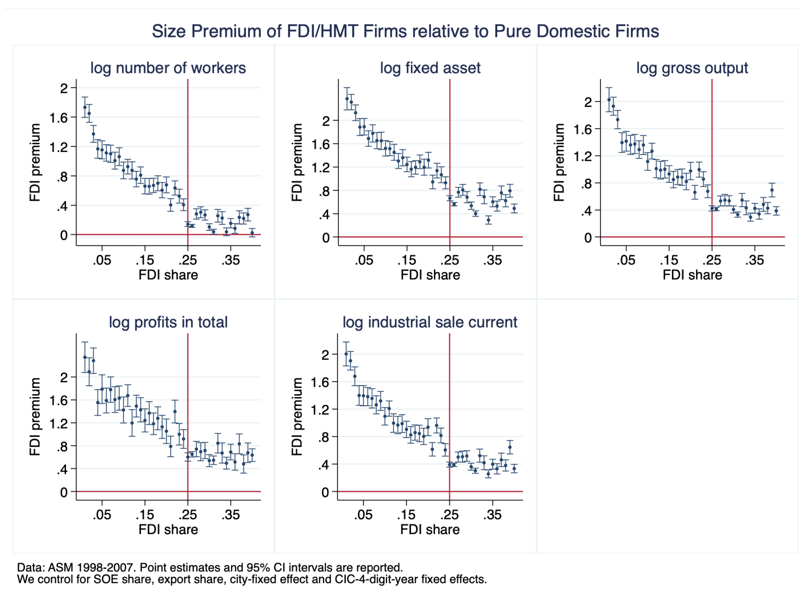


Notes: This figure shows the observed distribution (solid line) of firms' foreign ownership shares and the counterfactual distribution (dashed line). The distribution is calculated by dividing the region (0,1) into 100 bins and calculating the portion of firms within each bin based on their foreign ownership shares. The estimation of the counterfactual distribution is based on equation 3.1 using a flexible polynomial regression and a 5-fold cross-validation method. The dashed vertical red lines depict the lower and upper thresholds of the region where the tax notch is effective for the firms. The Δd is calculated by comparing the conditional expectation of FDI share for firms located below and at the tax notch. The a is calculated by comparing the cumulative distribution of FDI shares for firms located below the tax notch. The data used for this graph is the ASIF database spanning from 1998 to 2008.

Figure 3.4: Cross-sectional Comparison of Size Premium



Panel A: 5% Each Bin



Panel B: 1% Each Bin

Notes: This graph illustrates the estimated βs from equation 3.2, where the independent variables are the logarithm of firm-level outcomes in year t. We use various indicators of firm size, including number of workers, fixed assets, industrial output (in fixed prices), total profits, and annual industrial sales. Both panels use ASIF data from 1998 to 2008, and include city fixed effects, industry-year fixed effects, and controls for the share of state-owned capital and export share. Panels A and B present the cross-sectional comparison of firm outcomes by binning FDI share into 5% and 1% intervals, respectively.

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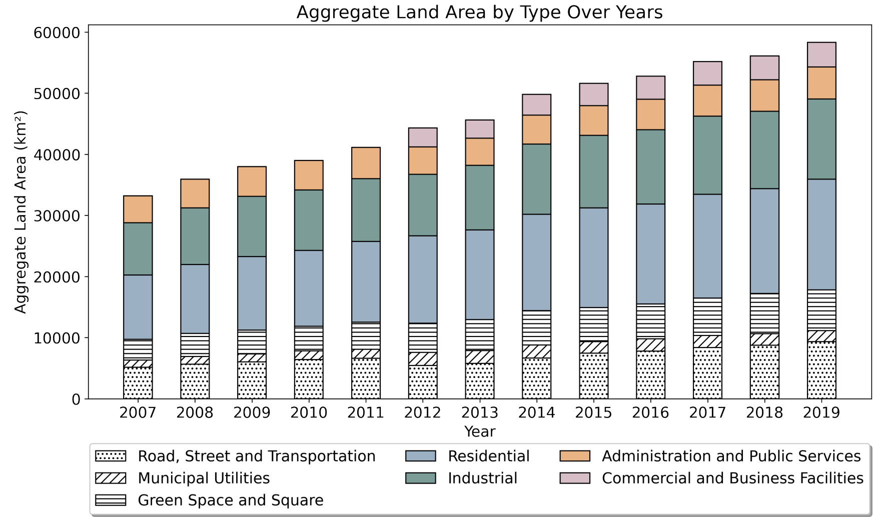
Appendix I: Data Details

To investigate urban land allocation in China, we employ two datasets. The first dataset, "China Urban Construction Statistical Yearbooks" from the Ministry of Housing and Urban-Rural Development of China, represents the annual "STOCK" of urban land and helps illustrate the aggregate land allocation patterns and quantify the model. The second dataset, used in the empirical analysis section, consists of web-scraped data on urban land transactions over the past decade and represents the "FLOW" of urban land. This dataset records the unit price of each land parcel and is critical to identifying the urban land misallocation in the empirical section.

Stock Data From Yearbooks Table A2 summarizes the area of industrial and residential land areas across years. First, both types of land are expanding due to China's ongoing urbanization, with the proportion of industrial land slightly decreasing but remaining above 32%. We illustrate the quantiles of each land type and their ratio over time in Figure A7. The variations in urban land areas across different periods can also be attributed to changes in administrative boundaries, such as annexing or ceding small towns, and shifts in statistical criteria. For example, the noticeable deviation in the growth trend of industrial land area in 2012, shown in Figure A7, is likely due to the implementation of new national land use and planning standards (GB 50137-2011). Furthermore, we mapped the industrial land area ratios in Figure A8, where deeper colors indicate higher industrial land ratios, typically concentrated along the coastline and China's most developed regions.

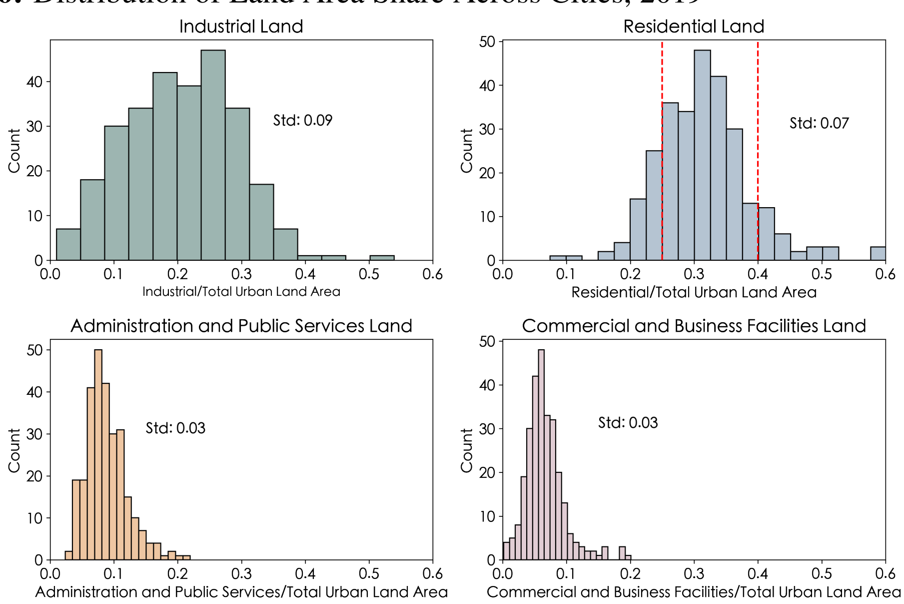
Flow Data From Transaction Records Since 2007, all industrial urban land transactions in China have been required to be auctioned and publicly posted on the Ministry of Land and Resources' website. We web-scrapped all land transaction records from 2007 to 2019, which contain 2,243,010 land transactions, including 501,289 industrial and 1,115,517 residential or commercial land sales. Each transaction record details the characteristics of the land parcels, such as their quality (government-evaluated and categorized into several ranks before auction), area (measured in acres), source (whether the land is newly acquired urban land or existing urban land), and location (calculated as the distance from the land parcel to the city government and the geographical center of the county-level administrative district). It also includes information on transaction methods, prices, and pre-determined land usage. The summary statistics of the dataset are presented in Tables A3 and A4.

Figure A5: Aggregate Urban Land Use by Year (Unit: km^2)



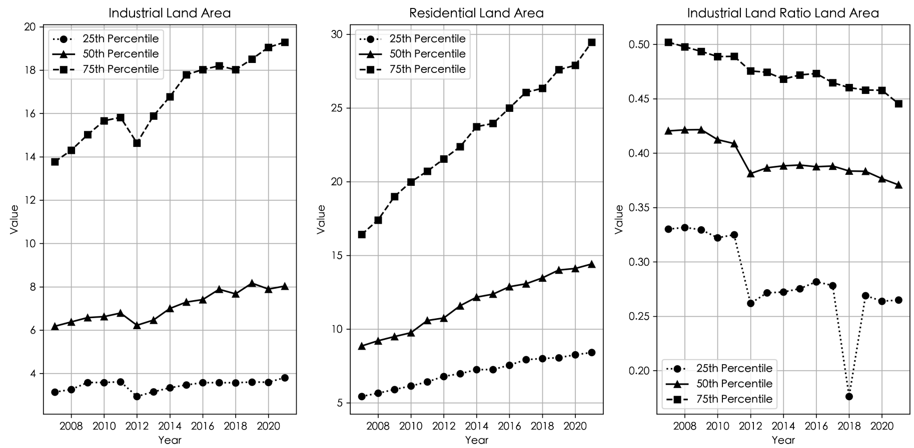
Notes: The data was obtained from the Urban Construction Statistical Yearbook of China (2007 to 2019) and was published by the Ministry of Housing and Urban-Rural Development of China.

Figure A6: Distribution of Land Area Share Across Cities, 2019



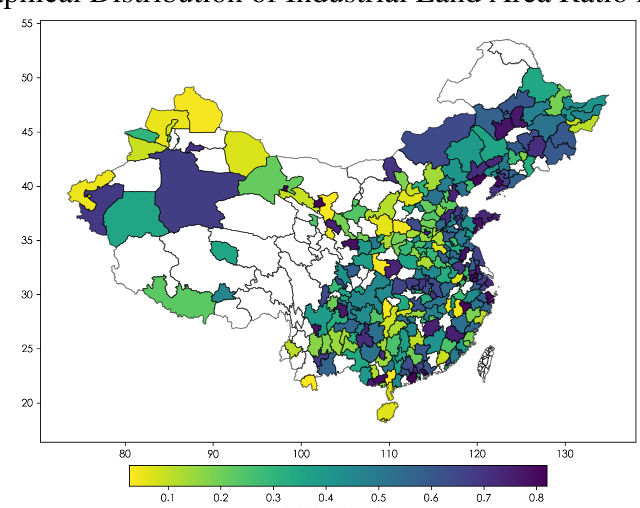
Notes: The data was obtained from the Urban Construction Statistical Yearbook of China (2007 to 2019) and was published by the Ministry of Housing and Urban-Rural Development of China.

Figure A7: Evolution of Land Area and Ratio in Yearbook Data



Notes: Data source is the Ministry of Housing and Urban-Rural Development of China, Urban Construction Statistical Yearbook (2007 - 2019). Industrial Land Ratio is calculated as the ratio between industrial land area and the sum of industrial land area and residential land area.

Figure A8: Geographical Distribution of Industrial Land Area Ratio in 2019



Notes: The data was obtained from the Urban Construction Statistical Yearbook of China (2019) and was published by the Ministry of Housing and Urban-Rural Development of China.

Table A2: Summary Statistics of Statistics Yearbook Data (2007-2021)

	Industrial Land Area		Residential Land Area		Industrial Land Ratio		Number of
Year	Mean	SD	Mean	SD	Mean	SD($\times$100)	Observations
2007	15.182	3.639	22.698	6.399	0.370	0.542	610
2008	16.170	3.716	24.681	7.144	0.368	0.541	611
2009	17.999	4.656	26.084	7.371	0.369	0.539	612
2010	18.816	5.361	26.770	7.459	0.362	0.536	610
2011	19.353	5.883	28.519	8.018	0.356	0.539	609
2012	19.866	5.468	31.643	8.155	0.324	0.629	607
2013	20.864	5.747	32.651	8.538	0.329	0.598	608
2014	22.444	6.249	34.910	9.227	0.328	0.588	615
2015	23.421	6.655	36.251	9.791	0.331	0.596	616
2016	23.818	6.745	36.064	9.862	0.333	0.599	616
2017	25.116	6.739	37.937	9.963	0.332	0.582	614
2018	24.817	6.931	38.058	10.587	0.327	0.582	613
2019	25.713	7.166	39.888	10.979	0.327	0.579	614
2020	26.392	8.081	39.965	11.112	0.326	0.599	613
2021	26.367	8.511	41.122	11.709	0.323	0.574	612

Notes: Data source is the Ministry of Housing and Urban-Rural Development of China, Urban Construction Statistical Yearbook (2007 - 2019). Industrial Land Ratio is calculated as the ratio between industrial land area and the sum of industrial land area and residential land area.

Table A3: Summary Statistics of Land Transaction Database (2007-2019)

		Freq.	Percent	
Number of Transactions	Urban	802,864	35.79	
	Rural	1,440,146	64.21	
Urban Land Transactions				
Land source	New Construction Sites	344,598	42.92	
	New Construction Sites (from Stock Pool)	98,137	12.22	
	Existing Construction Sites	360,129	44.86	
Transaction Saleway	Allocation	251,004	31.26	
	Negotiation	247,625	30.84	
	Auction	38,247	4.76	
	Bidding	4,036	0.5	
	Listing	261,952	32.63	
Land Type	Residential Land	275,432	34.57	
	Industrial Land	161,898	20.32	
	Commercial Land	103,022	12.93	
	Transportation Land	84,569	10.61	
	Public Admin & Service Land	127,048	15.95	
	Other Types	44,782	5.62	
Other Characteristics	**Mean**	**Std.**	**Min**	**Max**
Area of Land Parcel	4.167	80.320	0	42559
Total Price of Land Parcel	16,123.450	5,943,619	0	3.62E+09
Unit Price Per Hectares	1,136.755	2,324.461	0	12750.02
FAR Lower Bound	0.831	0.790	0	5
FAR Upper Bound	1.731	1.473	0	7
Distance to City Center	40.360	153.878	0	2941.959

Notes: This table describes the public land transaction records from the Ministry of Land and Resources via web scraping. This dataset comprises 2,243,010 land transactions, including 501,289 industrial and 1,115,517 residential and commercial land sales.

Table A4: Summary Statistics of Land Transaction Database 2

	New Sites		New Sites from Stock Pool		Existing Sites	
Transaction Saleway	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Allocation	151,556	43.98	36,812	37.51	62,636	17.39
Negotiation	20,549	5.96	24,701	25.17	202,375	56.2
Auction	19,303	5.6	5,515	5.62	13,429	3.73
Bidding	1,818	0.53	475	0.48	1,743	0.48
Listing	151,372	43.93	30,634	31.22	79,946	22.2
	New Sites		**New Sites from Stock Pool**		**Existing Sites**	
Land Usage	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Residential Land	53,528	15.56	35,758	36.44	186,146	52.5
Industrial Land	103,028	29.94	14,571	14.85	44,299	12.49
Commercial Land	35,624	10.35	11,281	11.5	56,117	15.83
Transportation Land	58,760	17.08	13,053	13.3	12,756	3.6
Public Admin & Service Land	73,731	21.43	16,446	16.76	36,871	10.4
Water Facilities Land	1,700	0.49	361	0.37	471	0.13
Public Rental Housing Land	1,536	0.45	347	0.35	1,478	0.42
Low-Rent Housing Land	1,855	0.54	925	0.94	1,512	0.43
Affordable Housing Land	9,985	2.9	4,759	4.85	12,657	3.57
	Residential Land		**Industrial Land**		**Commercial Land**	
Transaction Saleway	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Allocation	15,158	5.5	3,371	2.08	2,259	2.19
Negotiation	157,296	57.11	30,610	18.91	37,705	36.6
Auction	21,793	7.91	6,574	4.06	8,679	8.42
Bidding	1,728	0.63	1,082	0.67	1,068	1.04
Listing	79,457	28.85	120,261	74.28	53,311	51.75
	Residential Land		**Industrial Land**		**Commercial Land**	
Land Source	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
New Construction Sites	53,528	19.43	103,028	63.64	35,624	34.58
New Sites from Stock Pool	35,758	12.98	14,571	9	11,281	10.95
Existing Construction Sites	186,146	67.58	44,299	27.36	56,117	54.47

Notes: This table describes the public land transaction records from the Ministry of Land and Resources via web scraping. This dataset comprises 2,243,010 land transactions, including 501,289 industrial and 1,115,517 residential and commercial land sales.

Appendix II: Robustness Checks on Industrial Discounts

In July 2007, the central government of China implemented public auctions for industrial land transactions, resulting in a significant shift in the format of land transactions. During the main sample periods from 2007 to 2019, 47.55% of commercial and residential lands were sold by public auctions, while only 13.26% of industrial land was sold by negotiation. This regulation can reduce the local government's direct control over land prices, making it less convincing to attribute the industrial discount to the transaction format of "negotiation". However, local governments maintain the discretion to determine the supply of each land type, which could still lead to a price difference. For example, local governments can choose to restrict the quota of residential land but supply more industrial land. Therefore, if all lands were auctioned without prior designations of land use (industrial or non-industrial land), then auctions should give the same price for both types of land.

In Table A5, we refine the sample to focus exclusively on transactions via public auctions, excluding land designed for other usages, such as public service, transportation, and water facilities. This narrowed comparison between industrial and residential land transactions reveals a persistent industrial discount, ranging from 0.34 $(= exp(-1.071))$ to 0.167 $(= exp(1.792))$. Therefore, local governments can manipulate prices by adjusting the allocation of land quotas available for auction. To manage variations from the demand side, we categorized buyers into four groups: firms, governments, urban construction investment enterprises, and others. Submarkets with extreme concentrations (where a single agent holds more than 10% of land area) or with scarce samples (fewer than 100 transactions) are excluded from the analysis. The results are shown in Table A6.

Table A5: Robustness Check 1: Subsamples of TWO lands via public auctions

	(1)	(2)	(3)
VARIABLES	$log(P_{ict}/floor)$	$log(P_{ict}/floor)$	$log(P_{ict})$
Panel A: Average Industrial Discount			
$IndDummy_{ict}$	-1.792***	-1.071***	-1.407***
	(-85.987)	(-56.323)	(-74.022)
$log(dcity_{ict})$	-0.179***	-0.156***	-0.156***
	(-32.938)	(-29.616)	(-29.616)
Observations	147,065	152,081	152,081
R-squared	0.785	0.657	0.707
Panel B: Spatial Distribution of Industrial Discount			
$IndDummy_{ict} \times Dport_c$	0.130***	0.143***	0.143***
	(9.096)	(10.174)	(10.174)
$IndDummy_{ict}$	-3.386***	-2.831***	-3.168***
	(-19.221)	(-16.161)	(-18.082)
$log(dcity_{ict})$	-0.178***	-0.156***	-0.156***
	(-32.776)	(-29.806)	(-29.806)
Observations	147,065	152,081	152,081
R-squared	0.788	0.662	0.711
Other Characteristics	Y	Y	Y
City - Year FE	Y	Y	Y

Notes. This table keeps the subsamples of industrial land and residential-commercial land transactions and excludes all transactions via negotiation or allocation. Control variables in each regression contain the area of land, the format of transactions, the maximum floor area ratio, land quality rank, and the source of land. All standard errors are clustered at the level of city-year.

Table A6: Robustness Check 2: Controlling Market Extremes

VARIABLES	(1) $log(P_{ict}/floor)$	(2) $log(P_{ict}/time)$	(3) $log(P_{ict})$
Panel A: Average Industrial Discount			
$IndDummy_{ict}$	-1.709***	-1.011***	-0.675***
	(-76.782)	(-50.520)	(-33.709)
$log(dcity_{ict})$	-0.179***	-0.156***	-0.156***
	(-31.277)	(-28.224)	(-28.224)
Observations	129,462	132,887	132,887
R-squared	0.777	0.647	0.599
Panel B: Spatial Distribution of Industrial Discount			
$IndDummy_{ict}$	-3.439***	-2.907***	-2.570***
	(-19.710)	(-16.821)	(-14.874)
$IndDummy_{ict} \times Dport_c$	0.141***	0.154***	0.154***
	(10.037)	(11.196)	(11.196)
$log(dcity_{ict})$	-0.178***	-0.156***	-0.156***
	(-31.167)	(-28.409)	(-28.409)
Observations	129,462	132,887	132,887
R-squared	0.780	0.653	0.606
Other Characteristics	Y	Y	Y
City - Year FE	Y	Y	Y

Notes. This table keeps only residential and industrial land transaction records, excluding all transactions via negotiation or allocation. Further robustness is checked by controlling for buyer information (firms, governments, or urban construction investment enterprises) and excluding submarkets with extreme concentrations (where a single agent holds more than 10% of the land area) or scarce samples (less than 100 transactions). All parcel characteristics for each land sale are controlled, including the distance to the urban district center or rural county center, the leasing time left, the area of land, the rank of land quality, floor-area ratio (FAR) restrictions, the format of transactions, and the source of land.

Appendix III: Empirical Results Dealing with One-Child-Policy Variations

Due to the stringent enforcement of the one-child policy, all counterfactual real fertility willingness at this period would be covered by it. To alleviate this concern, we construct a variable to capture the implementation of the "One-Child Policy" at the city level, measured as the average permit price for having a second or third child.

Specifically, according to García (2022), a woman i at the age a had to register her pregnancy with the local birth-planning authority and sign a "One-Child Policy contract" with the government. This contract stipulated the cost and payment method for having second or third children, and was varied across provincial governments, with payments set as either a percentage of the household's labor income or as a fixed lump sum fine:

$$\begin{aligned}\Xi_{ia} = \mathbb{1}[\text{proportional-price province}]_{ia} \times \left[\sum_{l=1}^{L_{ia}^{\text{prop}}} \beta^{l-1}(\kappa y_{ia})\right] \\ + \mathbb{1}[\text{lump-sum price province}]_{ia} \times \left[\sum_{l=1}^{L_{ia}^{\text{lump}}} \beta^{l-1}(\tau_{ia})\right]\end{aligned}$$

Here, κ_{ia} is the fraction of household income to be paid in proportional-policy provinces, and τ_{ia} is the amount in lump-sum-policy provinces. β is the discount factor. Ξ_{ia} is set to zero if she was qualified for an exemption from the payments, for reasons such as the death or disability of their first child, job-related difficulties, or a lack of males in the family. Noted that this policy price estimation was based on the China Health and Retirement Longitudinal Study (CHARLES, 2017) and only covers the period from 1979-2000, we adjusted this estimation by incorporating an autoregressive (AR1 and AR3) process prediction and then aggregate this value at the city level as a measurement of "One-Child Policy" implementation, $OCPfine_c$.

At the City Level We run the following regressions at the city level to show the relationship between land allocation and fertility rate:

$$FertilityRate_c = \beta_0 + \beta_1 IndShare_c + \beta_3 OCPfine_c + \alpha_p + \varepsilon_c \tag{A3}$$

$$PopuGrowth_{ct} = \beta_0 + \beta_1 lag.IndShare_{ct} + \alpha_c + \alpha_{pt} + \varepsilon_{ct} \tag{A4}$$

First, $FertilityRate_c$ represents the average number of live births of married women in city c. $IndShare_c$ is the area share of industrial land in her city. And $OCPfine_c$ denotes the city-level permit price from the policy contract. Table A7 presents the regression results. Columns (1) to (3) show that housing prices significantly and negatively impact city fertility rates, even after accounting for provincial fixed effects. Meanwhile, the influence of industrial area share, though less pronounced, is still significantly negative, as indicated in columns (4) to (6). This pattern could be attributed to the multifaceted determinants of housing prices in a city, including economic factors, housing market dynamics, and financial market variations. Overall, this table consistently indicates that both housing prices and industrial area allocation negatively affect fertility rates, even after adjusting for variations in the "One-Child Policy" implementation.

Second, we utilize a city panel that includes the natural population growth rate sourced from city yearbooks from 2000 to 2019. We regress this information on the industrial land area ratio of each city, applying a one-period lag, and control for city-specific fixed effects and province-by-year fixed effects. In Column (1) of table A7, we use the whole sample from the year 2000 to 2019, finding the effects of land allocation on fertility rate to be not significant. Columns (2) and (3) separate the samples into two groups: 2000 to 2013, under the implementation of the One-Child Policy; and 2017 to 2019, when a second child was allowed nationwide. The years between 2013 and 2016 are the policy experiment period when parents who were both single children from their original families were allowed to apply for a second child. We skip this period to avoid the local variation in policy implementation during this period. We exclude the transitional period from 2013 to 2016, a time of policy experimentation where couples, if both were only children from their original families, could apply for a second child. This exclusion helps to mitigate the effects of policy variation during these years. The results indicate that the effect of land allocation on population growth rates was obscured by the One-Child Policy but became significantly negative after the policy was eased. Robustness check in column (4) using the number of newborns in each city as a dependent variable shows a similar result.

At the Individual Level We then use the China National Census 2010 to run the following regressions at the individual level:

$$FertilityDummy_{ic} = \beta_0 + \beta_1 lag.IndShare_c + \beta_3 OCPfine_c + \beta_4 x_{ic} + \varepsilon_{ic} \tag{A5}$$

Here, $FertilityDummy_{ic}$ denotes whether a married woman aged between 15 and 49, living in urban area i within city c, has given birth in the year before the census survey. $lag.IndShare_c$ is the proportion of industrial land in the city c over the past three years. To address potential bias from location self-selection, we exclude individuals who have either changed their residence locations within the past five years or household registration locations (Hukou) from their birthplace. This analysis includes demographic characteristics at the individual level, denoted by x_{ic}, which comprises age, education, dummy variables indicating a minority ethnic group, agricultural Hukou status, and whether the individual has a son before. Results from linear probability regressions are presented in columns (1) and (3) of Table A8, while columns (2) and (4) detail findings from Logit regressions. For columns (3) and (4), age and education variables are converted into dummy variables as a measure of robustness. Similar to city-level regressions, we found that a city's industrial land allocation is associated with a decrease in fertility rates, even after we control for the financial fine of the One-Child Policy.

Table A7: The Effects of Land Allocations on the Fertility Rate: City Level

	(1)	(2)	(3)	
Panel A: Cross-sectional Comparison at Year 2010				
VARIABLES: $FertilityRateofCity_c$				
	Average	AR1	AR3	
$HousingPrice/Wage_c$	-0.942*	-0.925*	-0.920*	
	(-1.779)	(-1.748)	(-1.745)	
$OCPfine_c$	-0.054	-0.393	-3.144	
	(-0.624)	(-1.083)	(-1.225)	
Province FE	Y	Y	Y	
R-squared	0.574	0.575	0.576	
$InduAreaRatio_c$	-0.003***	-0.003***	-0.003***	
	(-3.396)	(-3.523)	(-3.366)	
$OCPfine_c$	-0.105	-0.569	-4.326	
	(-1.055)	(-1.464)	(-1.593)	
Province FE	Y	Y	Y	
R-squared	0.553	0.551	0.554	
Observations	248	248	248	
Panel B: City-level Fixed Effect Regressions				
VARIABLES	$\Delta Popu_{ct}$	$\Delta Popu_{ct}$	$\Delta Popu_{ct}$	$log(NewBorn_{ct})$
	2000-2019	2000-2013	2017-2019	2017-2019
$lag.InduAreaRatio_{ct}$	-0.011	0.002	-0.063*	-0.0039***
	(-1.305)	(0.276)	(-3.543)	(-2.108e+07)
City FE	Y	Y	Y	Y
Province-Year FE	Y	Y	Y	Y
R-squared	0.775	0.766	0.900	0.960
Observations	4,531	2,919	801	803

Notes. This table shows the effects of land allocation on households' fertility decisions. For Panel A, FertilityRate$_c$ is calculated by the average number of live births in 2010 among married women aged 15-49 residing in urban areas at the prefecture level. Housing_wage$_c$ is calculated as house prices divided by the average wage of employed workers at the prefecture level, and serves as a measure of homeownership affordability for the working population in each city. OCP_Price$_c$ captures the implementation of "One-Child Policy" in each city, measured by the average permit price for having a second or third child according to García (2022). We conducted cross-sectional regressions in 2010. Panel B displays city-level regressions controlling for province-year fixed effects.

Table A8: The Effects of Land Allocations on Fertility Rate: Individual Level

VARIABLES: Fertility Dummy at Year 2010_{ic}	(1) Linear	(2) Logit	(3) Linear	(4) Logit
$lag3.InduAreaRatio_c$	-0.010**	-0.457**	-0.009**	-0.452**
	(-2.559)	(-2.074)	(-2.129)	(-2.037)
$OCPPrice_c$	0.002	0.134	0.002	0.107
	(0.665)	(0.873)	(0.691)	(0.692)
$SonDummy_{ic}$	-0.012***	-0.495***	-0.013***	-0.522***
	(-10.778)	(-10.967)	(-10.927)	(-11.621)
$MinorityDummy_{ic}$	-0.000	-0.023	-0.000	-0.014
	(-0.066)	(-0.201)	(-0.158)	(-0.120)
$AgricDummy_{ic}$	0.001	0.008	0.002*	0.099*
	(1.004)	(0.149)	(1.906)	(1.810)
Age_{ic}	-0.023***	-0.175***		
	(-27.679)	(-5.785)		
Age^2_{ic}	0.000***	-0.000		
	(25.708)	(-0.136)		
$HighSchoolDummy_{ic}$	0.000	0.096*		
	(0.341)	(1.933)		
20-24			-0.014	-0.033
			(-0.392)	(-0.105)
25-29			-0.076**	-0.768**
			(-2.074)	(-2.435)
30-34			-0.111***	-1.652***
			(-3.047)	(-5.203)
35-39			-0.126***	-2.609***
			(-3.457)	(-8.139)
40-44			-0.132***	-3.650***
			(-3.616)	(-11.073)
45-49			-0.133***	-4.036***
			(-3.637)	(-11.969)
$PrimarySchool$			0.005	0.490
			(1.468)	(1.049)
$MiddleSchool$			0.002	0.269
			(0.576)	(0.581)
$HighSchool$			0.001	0.246
			(0.404)	(0.530)
$JuniorCollege$			0.005	0.449
			(1.574)	(0.961)
$College$			0.009**	0.596
			(2.567)	(1.270)
$Postgraduate$			0.014**	0.793
			(2.389)	(1.597)
Observations	133,227	133,227	128,693	128,693
R-squared	0.044		0.043	

Notes. This table shows the effects of land allocation on households' fertility decisions at the individual level. Census data for the year 2010 is used.

Appendix IV: Derivation of Probability

We consider the following scenario for Gumbel i.i.d. shock: suppose that we have $Y_1 = X_1 + \epsilon_1$, $Y_2 = X_2 + \epsilon_2$ where X_1 and X_2 are some non-stochastic value, and ϵ's are drawn from Gumbel distribution whose cdf is

$$F(x) = e^{-e^{-\frac{x}{\sigma}}}$$

Therefore, the

1. **What is $Prob(Y_1 < Y_2)$?**

Let $d = X_2 - X_1$, then we have

$$\begin{aligned} Pr(Y_1 - Y_2 < 0) &= Pr(\epsilon_1 - \epsilon_2 < d) \\ &= \int_{-\infty}^{\infty} dF(x_2) \int_{-\infty}^{x_2+d} dF(x_1) \\ &= \int_{-\infty}^{\infty} F(x_2 + d) dF(x_2) \end{aligned}$$

We plug in everyting in (and use x to denote x_2 for simplicity) to have:

$$Pr(Y_1 - Y_2 < 0) = \int_{-\infty}^{\infty} \frac{1}{\sigma} e^{-\frac{x}{\sigma}} \cdot e^{-e^{-\frac{x}{\sigma}}} \cdot e^{-e^{-\frac{x+d}{\sigma}}} dx$$

$$= \int_{-\infty}^{\infty} \frac{1}{\sigma} e^{-\frac{x}{\sigma}} \cdot e^{-e^{-\frac{x}{\sigma}} - e^{-\frac{x+d}{\sigma}}} dx$$

Let $y = e^{-\frac{x}{\sigma}}$, then we have

$$Pr(Y_1 - Y_2 < 0) = \int_0^{\infty} e^{-y(1+e^{-\frac{d}{\sigma}})} dy = \frac{1}{1 + e^{-\frac{d}{\sigma}}}$$

As $d = X_2 - X_1$, we can rewrite it as

$$Pr(Y_1 < Y_2) = \frac{exp(X_2/\sigma)}{exp(X_2/\sigma) + exp(X_1/\sigma)}$$

2. **What is** $\mathbb{E}[max(Y_1, Y_2)]$**?**

Similarly, we consider $d = X_2 - X_1$ and what we need to calculate is $X_1 + \mathbb{E}[\max(\epsilon_1, \epsilon_2 + d)]$. Let $X = [\max(\epsilon_1, \epsilon_2 + d)$, we can firstly specify the distribution of X:

$$\begin{aligned} P(X < x) &= P(\epsilon_1 < x)P(\epsilon_2 < x - d) \\ &= e^{-e^{-\frac{x}{\sigma}}} e^{-e^{-\frac{x-d}{\sigma}}} \\ &= e^{-e^{-\frac{x}{\sigma}}(1+e^{\frac{d}{\sigma}})} \end{aligned}$$

Then we have

$$\begin{aligned} \mathbb{E}[X] &= \int_{-\infty}^{\infty} x d e^{-e^{-\frac{x}{\sigma}}(1+e^{\frac{d}{\sigma}})} \\ &= \frac{1+e^{\frac{d}{\sigma}}}{\sigma} \int_{-\infty}^{\infty} x e^{-\frac{x}{\sigma}(1+e^{\frac{d}{\sigma}})} e^{-e^{-\frac{x}{\sigma}}(1+e^{\frac{d}{\sigma}})} dx \end{aligned}$$

Let $y = e^{-\frac{x}{\sigma}}(1 + e^{\frac{d}{\sigma}})$. Then we have

$$\begin{aligned} x &= -\sigma log y + \sigma log(1 + e^{\frac{d}{\sigma}}) \\ dy &= -\frac{1+e^{\frac{d}{\sigma}}}{\sigma} y dx \end{aligned}$$

Plug them back in, we have

$$\begin{aligned} \mathbb{E}[X] &= \int_0^{\infty} [-\sigma log y + \sigma log(1 + e^{\frac{d}{\sigma}})] e^{-y} dy \\ &= \sigma log(1 + e^{\frac{d}{\sigma}}) \underbrace{\int_0^{\infty} e^{-y} dy}_{1} - \sigma \underbrace{\int_0^{\infty} log y e^{-y} dy}_{Constant} \end{aligned}$$

Let Γ denote that constant, then we have

$$\mathbb{E}[X] = \sigma log(1 + e^{\frac{d}{\sigma}})$$

Therefore, we have

$$\begin{aligned} \mathbb{E}[max(Y_1, Y_2)] &= X_1 + \mathbb{E}[\max(\epsilon_1, \epsilon_2 + d)] \\ &= X_1 + \sigma log(1 + e^{(X_2 - X_1)/\sigma}) \\ &= \sigma log(e^{X_1/\sigma} + e^{X_2/\sigma}) \end{aligned}$$

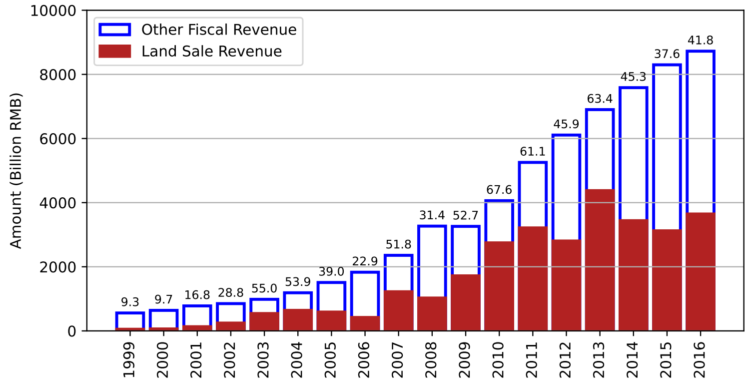
Appendix VII: Extra Tables and Figures

Table A9: The Share of High School Attainment for each Cohort from 1980-2010

Year	Share(%)	Year	Share(%)	Year	Share(%)
1981	18.8	1991	27.2	2001	37.2
1982	18	1992	28.6	2002	39.3
1983	19.9	1993	29.4	2003	42.5
1984	21.5	1994	30.3	2004	45.3
1985	21.8	1995	31.8	2005	48.8
1986	22.3	1996	31.7	2006	53.4
1987	23.2	1997	33.4	2007	59.4
1988	24.1	1998	34.1	2008	60.8
1989	24.4	1999	34.8	2009	56
1990	26.1	2000	35.3	2010	36.3

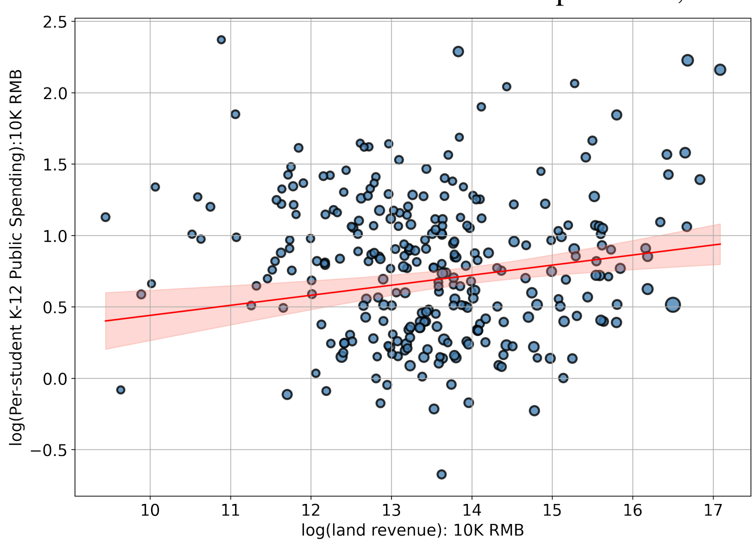
Notes. A cohort includes all individuals born within a one-year span, from September to August. Cohorts are identified by the year in which the majority of the members turn 15 and decide whether to attend high school. For instance, the 2008 cohort consists of individuals who turned 15 in 2008. A city's high school education rate is defined as the ratio of individuals who received at least a high school education to the total population in the same cohort.

Figure A9: Sources of Local Government Revenues and Land Sales



Notes: The fiscal revenue data comes from CCER Economics and Finance Database. Land revenue data comes from the China Land and Resources Statistics Yearbooks. Each bin stands for the local government's total fiscal revenue (measured in 100 million RMB), and the light and dark part stands for fiscal revenue coming from land sales and other sources, respectively. The numbers on top of the bin denote the proportion of fiscal revenue from land sales.

Figure A10: Land Sale Revenue and Public Education Expenditure, 2010



Notes: Data on public education expenditure and the K-12 student population are sourced from the China City Statistical Yearbook (2010). Land revenue data for each city comes from the China Land and Resources Statistical Yearbook (2010).

Appendix VIII: An Efficient Land Allocation in a Parsimonious Model

Before delving into the empirical datasets of the Chinese land market, let us first explore what an efficient land allocation should be in a theoretical world. Here we present a simplified model demonstrating that if local governments do not manipulate the land market, instead, landlords sell the land according to market forces, redistributing the land sales revenues evenly among local workers with identical homothetical preference, [13] then prices between residential and industrial land will equalize, resulting in an "efficient" land allocation.

Generally speaking, the allocation of a fixed total land area, $\bar{X}$, between production, K, and housing, H, is a fundamental element in the classical Rosen-Roback model, which balances the two through price equalization. Consider a city where the total available land $\bar{X}$ is divided into land for production K and housing H. The city's representative firm utilizes the industrial land K and labor L to produce a globally traded numeraire consumption good, without trade costs. Workers supply one unit of homogeneous labor inelastically, earn wages, and spend on consumption goods and local housing. Then, under this efficient land allocation, what should the price ratio of land be?

Note that we assume all land sales revenue will be rebated to local workers, then all industrial output products will be consumed by households, that is, $Y = C$. Consequently, the utility function of workers could be defined as:

$$U = U\left(\frac{Y(K, L)}{L}, \frac{H}{L}\right)$$

where K and H denote the industrial land and residential land, respectively; and L is the workers in the economy. Under an optimal land allocation maximizing the household's utility, the marginal contribution of two lands to utility should be equalized, that is:

$$\frac{\partial U}{\partial H} = \frac{\partial U}{\partial Y}\frac{\partial Y}{\partial K}$$

[13] Equivalently, this setting can also be treated as that each individual as a representative agent in this economy is both a worker and a landlord, with all land rent income automatically accruing to them as part of their labor earnings.

Meanwhile, from the firm's optimization problem, the price of industrial land should equal its marginal product:

$$p^K = \frac{\partial Y}{\partial K}$$

And, from the worker's optimization problem, the price of residential land and consumption goods would be determined by their marginal utility, respectively:

$$\begin{aligned} \lambda p^H &= \frac{\partial U}{\partial H} \\ \lambda p^c &= \frac{\partial U}{\partial C} = \frac{\partial U}{\partial Y} \equiv \lambda \\ \Rightarrow p^H &= \frac{\partial U / \partial H}{\partial U / \partial Y} \end{aligned}$$

where λ is the Lagrangian multiplier for any budget constraints of the household. Therefore, when the two prices are equal, we have:

$$\begin{aligned} \frac{\partial Y}{\partial K} &= \frac{\partial U / \partial H}{\partial U / \partial Y} \\ \Rightarrow \frac{\partial U}{\partial H} &= \frac{\partial Y}{\partial K} \frac{\partial U}{\partial Y} = \frac{\partial U}{\partial K} \end{aligned}$$

That is, when the two prices are equal, we exactly equalize the marginal contribution of residential land and industrial land to worker utility. However, during this process, if any portion of the land revenue is kept by landlords or local governments, it reduces the income available to workers, thereby lowering the price of residential land under the same allocation scheme (derived from the housing market clearing condition). Furthermore, from the illustration above, we can see that this price equalization rule holds not only for the specific Cobb-Douglas (CD) function initially assumed, but also for a more general form of production functions and worker preferences.

To sum up, a generalized spatial framework suggests that to maximize worker welfare, the price of residential land should be equal to or lower than that of industrial land. This finding supports that the price gap (industrial land discount) we found in the empirical section indicates a misallocation of land.