Regulatory Tax, Land, and Housing Markets: Theory and Evidence from China*

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Abstract

Supply-side constraints are important drivers of housing market dynamics. This paper proposes a new "regulatory tax" measure to capture taxes, fees, and administrative costs during the process of real estate development. Incorporating the regulatory tax into a spatial equilibrium framework, I find that in response to higher taxes and fees, developers bid less for land parcels and reduce housing construction, leading to higher housing prices. Combining 14,571 residential projects with rich information on land parcel transactions, construction cost, and developer profit, I find that regulatory tax accounts for, on average, 34% of total house prices and varies substantially across 115 major cities in China. Exploiting exogenous variations generated from local dialects, government tax enforcement, and historical amenities, I show that regulatory taxes push up housing prices, reduce housing construction, and get capitalized into land prices. Further quantitative exercise indicates that regulatory taxes are essential for house price appreciation in superstar cities. Eventually, new home buyers and local governments need to bear the costs of excessive development taxes and fees.

JEL classification: H71, R21, R31, R38, R52.

Keywords: regulatory tax, housing supply constraints, housing affordability, land use regulations, housing market dynamics

1. Introduction

The lack of unaffordable housing is a global issue under heated policy debate. Supply-side constraints, introduced by geographical scarcity and excessive regulatory restrictiveness, tend to reduce housing construction and push up housing prices. A growing strand of literature has investigated the determinants of housing supply constraints and their impacts on housing markets, labour markets, productivity, and economic growth (*e.g.*, Mayer and Somerville 2000, Saks 2008, Saiz 2010, Hilber and Robert-Nicoud 2013, Hilber and Vermeulen 2016, Hsieh and Moretti 2019, Gyourko and Krimmel 2021, Baum-Snow and Han 2023, Duranton and Puga 2023, Yu 2024). Given the important role of housing supply constraints in economic development, there is another strand of literature proposing different approaches to measure the regulatory restrictiveness of housing supply (*e.g.*, Glaeser *et al.* 2005, Gyourko *et al.* 2008, Brueckner *et al.* 2017, Brueckner and Singh 2020, Tan *et al.* 2020, Gyourko *et al.* 2021, Zhang 2023). However, as real estate development is usually a lengthy and complicated process (Ball *et al.* 2024), the literature to date contains few attempts to comprehensively measure the taxes, costs, and fees imposed from the government side and during the development process, neither the impacts of these costs on housing and land markets.

Meanwhile, the impacts of supply-side constraints are understudied in the context of developing countries, largely due to a lack of high-quality data and a vague understanding of the local development process. Over the past decades, China has experienced a rapid process of urbanization and house prices have risen staggeringly in major cities. The National Bureau of Statistics in China records that the average nominal housing price increases by 313% in 35 major cities between 2003 and 2018. Previous studies find that demand-side factors such as income growth and economic openness drive up housing prices in China (*e.g.*, Wang *et al.* 2011, Wu *et al.* 2016, Liu and Xiong 2018, Garriga *et al.* 2020). Nevertheless, there is limited research investigating the role of supply-side factors in housing markets in China.

This paper sets out to propose a new measure of regulatory restrictiveness on real estate development and investigates its impacts on housing and land markets. I first develop a spatial equilibrium framework, featuring household migration and developer production decisions, to explore how an increase in local government's regulatory costs will influence housing construction, housing prices, and land prices. I show that when local governments introduce higher development taxes and fees, developers respond by bidding less for land parcels and producing fewer housing units, leading to higher housing prices. I then empirically extend the "regulatory tax" measure, first proposed by Glaeser *et al.* (2005), to evaluate regulatory

restrictiveness in 115 major Chinese cities.[1] Exploiting a unique dataset of 14,571 spatially matched residential projects with rich information on site size, land cost, construction cost, housing price, and developer profit, I estimate a regulatory tax that can capture different types of costs, taxes, and fees imposed from the government side and during the process of real estate development. I find that regulatory tax accounts for on average 34% of total house price and varies substantially across Chinese cities. In line with expectation, the proposed regulatory tax measure is negatively correlated with local housing supply elasticity and positively correlated with population size.

This paper then utilizes this new regulatory tax estimate and a geographic scarcity measure to explore the impacts of supply-side constraints on housing and land markets in China. The main empirical challenge is that both regulatory and geographical supply constraints are likely to be endogenously determined and correlated with local housing market conditions. To address this endogeneity concern, I apply an instrumental variable- and fixed effects-strategy. Exploiting the exogenous variations generated from the local government tax enforcement before the 1998 housing reform, number of dialects, and the distance to historical amenities, I find that local housing demand shock, measured by the average real salary, increases real housing price in an average Chinese city. This impact is stronger for places with more restrictive regulatory and geographical constraints. This paper's IV estimates suggest that a 1% increase in real salary will increase real house price by 0.24%. If an average city observes a one standard deviation increase in its regulatory tax rate, a 1% increase in real salary will increase real house price by 0.29% instead of 0.24%. In a similar vein, a one standard deviation increase in the geographical constraint will lead to a 0.35% instead of a 0.24% increase in real housing price. The main findings are robust when I apply a Bartik-type predicted local employment as the demand shifter and when I use two alternative estimates of the regulatory tax rate. I also find that local demand shock will stimulate more new construction, but less so for places with more restrictive supply constraints. Based on the main estimates, I conduct different quantitative exercises, which suggest that supply-side constraints are important for house price appreciation in China, especially in superstar cities. I also find that higher regulatory taxes lead to lower land transaction prices. These empirical findings are consistent with the propositions from the theoretical framework.

This paper relates to the literature discussing the measurement, determinants, and consequences of housing supply constraints (e.g., Gyourko *et al*. 2008, Saiz 2010, Hilber and Vermeulen

[1] In this paper, a city refers to a 'prefecture', which is an administrative jurisdiction in China.

2016, Brueckner *et al*. 2017, Yu 2024), and the risks and conditions of housing markets in China (Wu *et al.* 2012, Wu *et al.* 2016, Fang *et al.* 2016, Glaeser *et al.* 2017, Liu and Xiong 2018). Gyourko *et al*. (2008) use the responses from a nationwide survey of residential land use regulation in over 2,600 communities across the US to develop a series of indexes that capture the stringency of local regulatory environments. Brueckner *et al*. (2017) develop a new approach for measuring the stringency of a major form of land use regulation, building height restrictions, and apply it to a dataset of land-lease transactions from China. Glaeser *et al.* (2005) propose that the gap between observed housing market price and the marginal cost of building up an additional floor could be interpreted as a 'regulatory tax' imposed by local administrations. Cheshire and Hilber (2008) and Cheung *et al.* (2009) follow this method to evaluate regulatory tax in the UK and in the US, respectively.

This paper's contributions are threefold: First, this paper extends the classic spatial equilibrium framework by incorporating the role of regulatory tax. The model helps us to better understand how development costs can influence developers' production decisions and their implications for housing and land markets. Second, while most previous studies focus on measuring the regulatory restrictiveness imposed by building height regulations (*e.g.*, Glaeser *et al.* 2005, Cheshire and Hilber 2008, Brueckner *et al.* 2017, Brueckner and Singh 2020) and usually *before* the real estate development process, this paper proposes a new supply constraint measure that captures different types of regulatory costs, taxes, and fees imposed from the government side and *during* the development process. This paper thus provides additional insights into a more comprehensive understanding of regulatory restrictiveness introduced by governments. Third, previous research finds that demand-side factors, including income growth, rapid urbanization (Garriga *et al.* 2020), and a deeper integration with the global market (Wang *et al.* 2011), lead to a housing market boom in China. To the best of the author's knowledge, this paper is the first to provide a comprehensive estimate of regulatory restrictiveness that covers over 100 major Chinese cities and explain housing price dynamics in China from a supply-side perspective.

The rest of this paper is structured as follows. Section 2 describes the details of housing markets and real estate development in China and proposes a stylized theoretical framework to guide the empirical analysis. Section 3 presents the data sources, descriptive statistics, and how I estimate the regulatory tax rate. Section 4 discusses the identification strategy and presents main empirical results. Section 5 concludes.

2. Background and Theory

2.1. Housing Price Appreciation in China

Chinese cities have been urbanizing rapidly since the major economic reform in 1978. According to the National Bureau of Statistics, the share of the urbanized population in China rises from 17.9% in 1978 to 65.2% in 2022. The rapid process of urbanization stimulates a massive demand for housing. Followed by a national housing market reform in 1998, real estate development has become a booming industry and housing prices have raised staggeringly in major cities. As shown in Panel A of Figure 1, the average nominal housing price in Tier-1 cities has raised from 6,224 RMB per square meter to 35,732 RMB per square meter between 2005 and 2018, with an annual growth rate of 12.7%. Even for a group of Tier-2 cities, the average nominal housing price has increased from 2,840 RMB per square meter to 11,656 RMB per square meter during the same period, with an annual growth rate of 9%.[2]

There is a heated debate in China about whether the house price appreciation is driven by strong demand-side fundamentals (*e.g.*, income growth, economic development, and rural-urban migration) or just irrational exuberance. As shown in Panel A of Figure 2, while the ratio of average salary relative to the average housing price has been increasing in Tier-2 cities and lower-Tier cities during 2005 and 2018, it has been declining in Tier-1 cities during the same period, suggesting that houses become less and less affordable in superstar cities. Meanwhile, Panel B of Figure 2 shows that the ratio of construction cost relative to house price has been decreasing in major cities between 2005 and 2018, which indicates that the house price appreciation is not mainly driven by the increase in construction cost in these cities.

An alternative explanation for high housing prices in major Chinese cities is a lack of land supply and new construction activity. As shown in Panel B of Figure 1, the average local government land supply in Tier-1 cities has become lower than other major cities since 2008 even though housing demand is much stronger in these superstar cities. The reduced land supply will then lead to few new constructions and thus high housing prices. To investigate the role of supply-side factors in housing markets, it is essential to understand the functioning of the land supply system and the process of real estate development in China, which will be introduced in the following section.

[2] Tier-1 cities refer to Beijing, Shanghai, Guangzhou, and Shenzhen. There are different classifications of Tier-2 cities (or 'New Tier-1 cities' in some cases), but in general these classifications include similar cities. In this paper, Tier-2 cities refer to all sub-provincial ('fushengji') cities and two municipalities ('zhixiashi').

2.2. Land Supply and Real Estate Development in China

Since 1988, the city land bureau has gotten the authority to allocate the use rights (leaseholds) of vacant urban land plots to developers and homebuyers. After 2004, all urban land leases for private development need to be allocated through public auctions in order to control for the corruptions occurred during the negotiations between local governments and developers. Developers bid for land plots in the auction markets and then build out residential projects upon the land parcels. A typical residential project in China contains hundreds to thousands of dwellings and can be constructed by either one or several developers. After acquiring land plots, developers need to make construction plans and apply for different approvals from the local governments. Once a construction permit is granted, developers can start to build with the aim to meet governments' requirements to list new properties (pre-sale permits). For instance, Figure 3 presents a residential project in Shanghai and the land use plan associated with the corresponding land plot. The land use plan also contains different criteria for the residential development, such as the construction density, green coverage ratio, building height, and so on.

In terms of the time when developers can start to receive the proceeds from the residential project, a national policy regulates developers to be permitted to list new properties only if they achieve at least 25% of their total investment and have a detailed construction and completion plan. After getting the pre-sale permits, developers will sell properties, continue building out sites till the completion, and transfer properties to homebuyers.

During the real estate development process, there are different types of costs imposed from the government side. First, there is a cost related to the inefficiency of local administration, as applying for planning and construction approvals requires a significant amount of time and efforts for developers. For instance, according to a proposal to the People's Congress of Hainan Province (Hainan Provincial Government, 2014), there are over 30 approvals that need to be applied for during the development process, which takes 272 approval days. Some local governments have tried to improve the administration efficiency of granting approvals. For instance, Hainan province has optimized the approval process and reduced the total approval time from 799 days to 37 days (Sichuan Provincial Government, 2014). However, inefficient administration remains as a cause for construction delay and introduces additional financial costs for developers. Second, different types of taxes and administrative fees are required to be paid during the development process (e.g., urban land use tax, value-added tax, urban maintenance and construction tax, stamp duty, educational surcharge, and so on). According to an interview with a Congress representative, there are as many as 12 taxes and 50 fees related

to the real estate industry, and these taxes and fees all together account for between 30% and 40% of real estate prices based on a sample survey (Tencent News, 2010). Figure 4 uses national-level data of five taxes that are specifically related to the real estate industry (i.e., stamp duty, land value-added tax, urban land use tax, farmland occupation tax, and property tax) and shows a strong growth between 2005 and 2020. Figure 5 further demonstrates that these five taxes account for around 10%-15% of total property sales in China. Third, some local governments introduce restrictive land use regulations such as low floor area ratio (FAR) limits. Developers need to either comply with these regulations or negotiating with local governments to change these regulations, which further increases the costs of real estate development. This paper proposes a regulatory tax measure that could hopefully capture most regulatory and administrative costs during the real estate development process. The details of the data and method will be discussed in section 3.

2.3. Theoretical Framework

In this sub-section, I develop a static spatial equilibrium model with households and developers to explore the impacts of regulatory tax on housing and land markets and to guide the empirical analysis. The model is built on the spatial equilibrium framework developed by Rosen (1979) and Roback (1982) and aims to illustrate how developers respond to increasing costs during the development process.

Households

Suppose that there is an urban system which consists of multiple cities. Homogenous households with wage w can move across cities with no migration cost and make their location decision based on the expected utility level. Each household's utility U is determined by the consumption of housing h, the consumption of tradable goods c, and local amenity θ divided by city population N. Suppose that p represents housing price per square meter. The utility function and budget constraint for each household are thus:

$$U = h^{\alpha} c^{1-\alpha} \left(\frac{\theta}{N}\right) \tag{1}$$

$$s.t. \quad w = ph + c \tag{2}$$

Where $0 < \alpha < 1$. To maximize individual utility level, each household will consume housing h and tradable goods c as below:

$$\frac{h}{c} = \frac{\alpha}{(1-\alpha)p} \tag{3}$$

Developers

Let Q denote the total floor area of new builds constructed by developers. Under the assumption of housing market clearing:

$$hN = Q \tag{4}$$

Housing price p, housing consumption h, and tradable good consumption c are thus determined as below:

$$p = \frac{w\alpha N}{Q} \tag{5}$$

$$h = \frac{Q}{N} \tag{6}$$

$$c = \frac{(1-\alpha)Qp}{\alpha N} \tag{7}$$

Suppose that m homogeneous developers bid for mL land parcels released by the local government and let r denote the land price per square meter. The total capital input for each developer is K with unit price i. Developer's production function for q quantity of housing units is thus given by:

$$q = AK^{\beta}L^{1-\beta} \tag{8}$$

Where $0 < \beta < 1$, $mq = Q$, and A represents the production productivity.

In addition, developers also need to pay the regulatory t per housing unit that they produce, which refers to all the costs and taxes imposed from the government side and during the development process. Developer's total profit π is thus given by:

$$\pi = pq - rL - iK - tq \tag{9}$$

This paper assumes an 'open city' scenario, meaning that households can move freely across cities to achieve the highest utility level and there is no migration cost. When the urban system reaches a spatial equilibrium, every household will have the same utility $\bar{U}$ and no incentive to move out. The population N within a city is thus endogenously determined as follow:

$$N = \left[\frac{(w-w\alpha)^{1-\alpha}\theta}{\bar{U}}\right]^{\frac{1}{1+\alpha}} Q^{\frac{\alpha}{1+\alpha}} \tag{10}$$

Let $\psi = \left[\frac{(w-w\alpha)^{1-\alpha}\theta}{\bar{U}m}\right]^{\frac{1}{1+\alpha}}$. Each developer's profit is thus given by:

$$\pi = qw\alpha\psi\, q^{\frac{-1}{1+\alpha}} - rL - iK - tq \tag{11}$$

Developers decide on the optimal capital input and housing production to maximize their profit π. The optimal capital input is determined by:

$$\frac{\partial\pi}{\partial K} = 0 = A\frac{\alpha\beta}{1+\alpha}K^{\beta-1}L^{1-\beta}w\alpha\psi\left(AK^{\beta}L^{1-\beta}\right)^{\frac{-1}{1+\alpha}} - i - tA\beta K^{\beta-1}L^{1-\beta} \tag{12}$$

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Based on equation (12), it is easy to prove that:[3]

$$\frac{\partial Q}{\partial t} < 0 \tag{13}$$

$$\frac{\partial p}{\partial t} > 0 \tag{14}$$

Inequalities (13) and (14) lead to the two propositions to be tested in this paper:

Proposition 1 – Higher regulatory tax leads to fewer housing units being constructed by developers.

Proposition 2 – Higher regulatory tax leads to higher housing prices.

Intuitively, if local governments impose a higher regulatory tax during the development process, developers will respond to the higher costs by producing fewer quantities of housing. The reduced housing supply will push up housing prices, making it possible for developers to bear with the higher regulatory costs.

Under the assumption of perfect competition and free entry and exit, developers make zero profit π. Therefore, land price r is given by:

$$r = AK^{\beta}L^{-\beta}w\alpha\psi\left(AK^{\beta}L^{1-\beta}\right)^{\frac{-1}{1+\alpha}} - \frac{iK}{L} - tAK^{\beta}L^{-\beta} \tag{15}$$

It is easy to prove that:[4]

$$\frac{\partial r}{\partial t} < 0 \tag{16}$$

If local government imposes a higher regulatory tax, developers will respond to the higher development costs by bidding less for the land plots. In this case, the owners of undeveloped land parcels will need to bear with this loss of land value driven by the regulatory tax.

Inequality (16) leads to the third proposition to be tested in this paper:

Proposition 3 – Higher regulatory tax leads to lower land prices.

In section 4, I will empirically test propositions (1) to (3) regarding the impacts of regulatory tax on housing and land markets.

3. Data and Descriptive Statistics

3.1. Data and Spatially Matched Residential Projects

This paper uses two main datasets for the empirical analysis. The first one comes from Fang.com, which is a leading real estate agency in China. It provides information on over 50,000 residential projects in 150 major cities. For each residential project, the dataset records average house price per square meter in 2018, the land area of the project, the total construction area, floor area ratio, developer, address, and the time when the developer first lists new

[3] See the proof in appendix C.
[4] See the proof in appendix C.

properties. Each project is geocoded using its address information. Another main dataset used in this paper covers over 200,000 residential land transactions in 287 Chinese cities between 2005 and 2018. The data source is the official website of China land market.[5] The land transaction dataset records detailed information at the plot level including land transaction price, address, the date of transaction, the upper limit and the lower limit of floor area ratio, land area, the type of auction, and the land bidder. Each land plot is geocoded based on its address information.

I follow two steps to spatially match the land transaction dataset with the residential project dataset so that I can estimate the land cost for each project: First, as shown in Figure 6, I draw a buffer with a 3 km radius for each residential project and select all the land plots that are within this buffer and released in the same year when the first dwelling of the residential project is listed. Second, I compute the average land price per square meter for all the selected land plots within the 3-km-radius buffer. This spatial matching approach allows me to have an accurate estimate of the land cost for each residential project based on the land transaction records occurred nearby and in the same time period.[6] I then follow the method that will be discussed in section 3.2 to estimate regulatory tax rate at the project level. I drop the top 1% and the bottom 1% of observations in terms of regulatory tax rate to mitigate the potential bias caused by extreme values. In the baseline estimation sample, I also drop projects with negative regulatory tax rates and cities with fewer than 10 matched pairs.

In addition, this paper applies a stricter one-to-one matching method by selecting residential projects and land plots that are geographically close to each other, have a similar land area, and when the name of the land plot bidder is the same as the residential project developer. In this case, each residential project is accurately matched with its corresponding land plot. This one-to-one matching dataset is not used in the main analysis because only 2,476 projects can meet the strict criteria and will thus reduce the spatial coverage of the dataset. However, sections 3.3 and 4.4 will show that both matching methods produce similar estimates of regulatory tax rates, and the empirical results are robust regardless of the matching methods applied.

This paper also collects city-level characteristics from different sources including China City Statistical Yearbook, China Financial Statistics of Cities and Counties, China Real Estate Statistical Yearbook, China Financial Statistical Yearbook, China Historical Geographic

[5] www.landchina.com

[6] The average land price per square meter equals the land transaction price divided by the 'jirong' area, which is defined as the land area multiplied by the upper FAR limit. I use the 'jirong' area instead of the land area to compute land price per square meter so that I can take into account the effect of FAR design on land value.

Information System, and prefecture-level statistical yearbooks. The city-level average housing price is computed as the ratio of the total housing sales relative to the total housing sales area for each prefecture each year. I collect global land cover maps from the European Space Agency to identify local built-up areas. The financial information of over 10,000 local developers in China is acquired from Orbis to estimate local developer profit margin.

Basic summary statistics computed for the matched dataset of land plots and residential projects are detailed in Panel A of Table 1. There are in total 14,571 matched residential projects between 2005 and 2018. The average house price is 11,379 RMB (around 1,335 GBP[7]) per square meter, the average land cost is 2,644 RMB per square meter, and the average construction cost is 2,850 RMB per square meter. These residential projects are usually large in size and contain 1,246 dwellings per site on average. The average regulatory tax rate at the project level is 1.9. Panel B of Table 1 shows the descriptive statistics for a panel of 103 cities. Both the nominal house price and nominal salary are deflated by the national retail price index in order to obtain a real house price and salary at the 2005 level. The average house price is 4,656 RMB per square meter and the average annual salary is 36,890 RMB. The average regulatory tax rate at the city level is 1.8. Panel C reports the descriptive statistics for the city-level instruments, including fiscal revenue relative to GDP in 1997, number of dialects within a city, and the distance to major lakes and rivers in 1820. I will discuss my identification strategy in detail in section 4.

3.2. Estimate Regulatory Tax Rate in China

The concept 'regulatory tax' is first proposed by Glaeser *et al.* (2005) as a measure of housing regulatory restrictiveness. The intuition of this measure is that in a housing market with perfect competition among developers and free entry and exit, housing price per square meter will equal to the construction cost per square meter. Since the marginal construction cost rises with building height, in the absence of height limits, buildings should rise to a point where the marginal construction cost of adding an extra floor equals the market housing price. Any gap between the market housing price and the marginal construction cost can be interpreted as a 'regulatory tax', which represents the costs for developers to negotiate with local governments and get the planning approval to add an additional floor.

I follow and extend this approach to estimate regulatory tax in the context of China's housing markets. Table A1 provides a breakdown of different types of development costs from an anonymous developer in China. As the table suggests, the costs of real estate development in

[7] Based on the currency exchange rate in January 2022.

China can be categorized into 3 main items: land cost (the price that developers pay to bid for the land plot), construction cost (the cost of labour and raw materials to build out sites), and regulatory tax (administrative fees and taxes during the development process, developers' commitments to provide public facilities, the costs of inefficient administration, and the costs for developers to comply with restrictive land use regulations). Under a market with perfect competition among developers, the total sales of a residential project should equal to the total costs. However, to reflect the fact that developers normally achieve some profits in China, I include a 'profit' component in the calculation. Regulatory tax can thus be computed by:

$$Regulatory\ Tax = Total\ Sales - Land\ Cost - Construction\ Cost - Profit \quad (17)$$

Since large developers might operate in different provinces and cities, and their financial data will capture the profit margin in cities across the country, I only use local developers for the profit margin estimate by selecting developers that don't have subordinates in cities other than their registered cities. I then compute the average profit margin at the city level by using a sample of over 10,000 local developers between 2012 and 2019. The local profit margin estimate is shown in Figure B1. Perhaps not surprisingly, superstar cities such as Beijing (8.9%) and Shanghai (11.7%) tend to have higher profit margins compared with the national mean level (3%).

Following Cheshire and Hilber (2008), I divide the regulatory tax by construction cost to normalize this measure. Regulatory tax rate can thus be computed by:

$$Regulatory\ Tax\ Rate = \frac{Total\ Sales - Profit - Land\ Cost - Construtcion\ Cost}{Construtcion\ Cost} \quad (18)$$

The spatially matched dataset provides sufficient information for me to estimate equation (18) at the project level. I compute the total sales by multiplying the average house price per square meter with the total sellable area of the project.[8] The estimated profit margin is based on the financial information from local developers and varied at the city level. I also estimate the land cost by multiplying the average land price per square meter with the total sellable area. Finally, I compute the construction cost of each project by multiplying the total construction area with the average construction cost per square meter. The data for construction cost per square meter is time-varying at the city level. Every year, developers are required to report their total construction area and total construction cost to local governments. The construction costs data

[8] The dataset provides the average house price per square meter of each residential project in 2018. I adjust the house price to the year when the residential project starts to list properties using city-level price index in order to stay consistent with the year to estimate land cost and construction cost. Total sellable area is defined as the total land area of a residential project multiplied by its floor area ratio. This is a more realistic estimate of the total sellable area compared with the total construction area, which includes unsellable areas such as driveways, heating boiler rooms, the basement used for civil air defense, etc.

is computed based on the information provided by developers, and this measure includes the costs of both materials and labours.[9]

The regulatory tax rate computed from equation (18) captures a series of taxes and administrative fees that occur during real estate development. In addition, if a local government introduces restrictive land use regulations such as low FAR limits, the costs for developers to comply with or negotiate to change these regulations will be captured into the regulatory tax rate measure. The construction delay caused by inefficient administration will be included in the measure as well. The comprehensive feature of this paper's regulatory tax estimate makes it different from the measures in previous studies (e.g. Glaeser *et al*. 2005, Cheshire and Hilber 2008, Bruekner *et al*. 2017), which mainly focus on the costs introduced by the building height regulation. I then compute the average regulatory tax rate in 115 cities to get a measure of local regulatory restrictiveness.

This paper also conducts two alternative estimates of regulatory tax rate: The first one is computed based on the stricter one land parcel-to-one residential project matching sample. The second one is estimated by following the literature and assuming perfect competition among developers. In this case, developers will make zero profit, and the regulatory tax rate is estimated as below:

$$Regulatory\ Tax\ Rate = \frac{Total\ Sales - Profit - Land\ Cost - Construtcion\ Cost}{Construtcion\ Cost} \quad (19)$$

3.3. Descriptive Statistics of Regulatory Tax Rate

Following the estimation strategy as discussed in section 3.2, this paper first computes the regulatory tax rate at the project level. The distribution of the estimated regulatory tax rate is presented in Figure 7. There are in total 14,571 projects and most of them have a regulatory tax rate below 5. Figure 7 also shows that the residential projects in my estimation sample usually contain many dwellings. By simply aggregating the 11,391 projects with information about the number of dwellings, I find that the matched dataset covers in total 14,198,263 dwellings, which provides a good coverage of residential developments in major Chinese cities. I then compute the average regulatory tax rate at the city level to measure local regulatory restrictiveness and the results are shown in Table 2. Three Tier-1 cities, Beijing, Shanghai, and Guangzhou, have relatively high regulatory tax rates among 115 cities. This is in line with expectation because these cities tend to design more restrictive land use regulations and thus introduce additional costs for real estate development. For instance, Beijing has a strict building

[9] In my dataset, occasionally the construction cost data is not available for some cities in some years. In this case, I impute the missing value by taking the average of the construction cost per square meter in this city between 2005 and 2018.

height limit in the central area to protect historical architectures and cultural heritages. Besides, this paper's estimated regulatory tax rate also captures taxes that are computed based on local land value and housing price, which tend to be high in superstar cities. The regulatory tax estimates in Beijing and Shanghai are also comparable with the estimates in major European cities.[10]

However, it is not always the case that cities with high housing prices also have high regulatory taxes. For instance, Shenzhen, another Tier-1 city in China with the highest average housing price among all Chinese cities in 2018, has a regulatory tax rate of 1.8, which is even below the sample mean value and is ranked as the 48th of all 115 cities. The relatively low regulatory tax rate in Shenzhen, despite of high housing price there, is also reasonable, as Shenzhen is a fast-growing city and is famous for its efficient administration and the so-called 'Shenzhen speed' for new development.

The rich information of the matched dataset also allows me to disentangle the relative importance of different components that contribute to house price (regulatory tax, land cost, construction cost, and developer profit). Figure 8 presents the decomposition of house prices in four Tier-1 cities and Jiaxing, which is a medium-size city close to Shanghai and is reckoned as an example of cities with relaxed supply constraints. The decomposition in Figure 8 shows that regulatory tax accounts for the largest proportion of house price in Tier-1 cities among all the components. The ratio of regulatory tax relative to house price is 53% in Beijing, 50% in Shanghai, 56% in Guangzhou, and 39% in Shenzhen, respectively. Conversely, construction cost and land cost contribute more to the house price in Jiaxing, where land use regulations are less restrictive compared with Beijing and Shanghai. Figure 9 then presents the average house price decomposition in Tier-1 cities, Tier-2 cities, and other cities in China. We can observe that regulatory tax accounts for a larger proportion of house price in Tier-1 cities compared with lower-Tier cities. At the nation level, on average, regulatory tax, land cost, and construction cost account for 45%, 20%, and 32% of house price, respectively.

Although no rigorous academic research has estimated regulatory tax rate in China before, China Real Estate Chamber of Commerce has conducted a survey on 81 real estate projects in 9 major cities in 2008 with the aim to understand why housing prices are so high in some cities (Sohu Finance, 2009). The survey suggests that on average, land cost, taxes, and fees account

[10] Cheshire and Hilber (2008) estimate regulatory tax rate in major European cities. For instance, in 2005, the regulatory tax rates in City of London, Stockholm, Frankfurt, and Barcelona are 4.31, 3.3, 3.31, and 3.16 respectively. These estimates are comparable with the regulatory tax rates in Beijing (5.42), Guangzhou (3.71), and Shanghai (3.32).

for 37.36% of total sales. This ratio is higher in Shanghai (61.84%) and Beijing (42.42%). Their findings are in line with this paper's estimates and suggest that high regulatory cost is one of the main reasons for high housing prices in major cities.

Figure 10 presents regulatory tax rate at the city level and shows substantial spatial variations in regulatory restrictiveness across 115 Chinese cities. Cities along the South-eastern coast such as Shanghai and some core cities in the North such as Beijing have higher regulatory tax rates compared with other cities. Regarding the accuracy of this paper's measure, Panel A of Figure 11 presents the correlation between the regulatory tax rate based on the estimated land value sample and the regulatory tax rate based on the one-to-one matching sample. The correlation coefficient is high and positive. Besides, Panel B of Figure 11 shows that there is a positive correlation between population and local regulatory tax rate, suggesting that larger cities tend to be more restrictively regulated.

3.4. Housing Price Supply Elasticity and Regulatory Tax Rate

In this section, I measure the city-level housing supply elasticity and explore its correlation with the regulatory tax rate. I first estimate the following specification using OLS:

$$Ln(New\ Construction_{ct}) = \beta_c \phi_c \times Ln(Price)_{ct} + \phi_c + \delta_t + \varepsilon_{ct} \quad (20)$$

where c indexes each city and t indexes year. A vector of city fixed effects is represented by ϕ_c. δ_t is a set of time dummies (year fixed effects). The dependent variable represents the natural logarithm of the total area of new housing construction in city c and year t. The variable $Ln(Price)_{ct}$ represents the natural logarithm of house price in city c and year t. The parameters of interest are β_c, measuring the housing supply elasticities at the city level.

As housing price appreciation is likely correlated with local housing demand and supply conditions and thus endogenous to new construction, I follow the method proposed by Bartik (1991) to construct a shift-share type predicted local employment measure that could be used as local housing demand shifter. To do so, I exploit the city-level variation in industry composition of employment in 2003, the earliest year with available data, and the changes in employment by industry at the national level between 2005 and 2018 to construct this labour demand shock variable. I then use the annual change in the predicted employment as the demand shifter and re-estimate a specification similar to equation (20) to measure housing supply elasticity at the city level.

The correlation between regulatory tax rate and supply elasticity is shown in Figure 12. Both panels A and B present negative correlations, suggesting that cities with higher regulatory tax rates also have more inelastic housing supply. This is in line with expectations, as higher

regulatory tax rates imply more regulatory and administrative costs faced by developers, which will delay house builders' construction process or even reduce their incentive to invest in new projects.

4. Empirical Analysis

In this section, I formally test the main propositions from the theoretical framework and explore the impacts of supply-side constraints on housing markets in major Chinese cities between 2005 and 2018. I use the period between 2005 and 2018 because it is the same period as the spatially matched dataset covers. Figure 13 presents a graphical illustration of the impacts of positive demand shocks, in conjunction with supply-side constraints, on housing markets. Panel A shows a housing market with restrictive supply conditions. In this market, a strong local demand shock will not stimulate much construction, and housing price will increase significantly. Conversely, Panel B presents a housing market with lax supply constraints and shows that a strong demand shock will lead to a significant increase in housing construction and housing price will stay relatively stable.

4.1. Empirical Specification and Identification Strategy

To test for the main proposition, I apply two variables to measure local supply conditions: Frist, the regulatory tax rate as discussed in section 3.3 provides a comprehensive measure of local regulatory restrictiveness and administrative efficiency at the city level. Second, I use the share of developable land that is already developed in 2005, the beginning year of my sample period, as a measure of local geographical constraint for cities to expand horizontally.[11] This paper then estimates the following specification using OLS:

$$Ln(House\ Price_{ct}) = \beta_1 Ln(Salary)_{ct} + \beta_2 Ln(Salary)_{ct} \times RTR_c + \beta_3 Ln(Salary)_{ct} \times Geography_c + \phi_c + \delta_t + \varepsilon_{ct} \quad (21)$$

where c indexes each city and t indexes year. A vector of city fixed effects is represented by ϕ_c. δ_t is a set of time dummies (year fixed effects). The dependent variable represents the natural logarithm of real housing price in city c and year t. The variable $Ln(Salary_{ct})$ represents the natural logarithm of average real salary in city c and time t. Both the average housing price and the average salary measures are adjusted to the 2005 level using the national retail price index. RTR_c represents the regulatory tax rate in city c, and $Geography_c$ denotes the share of developable land that is developed in city c in 2005. The parameters of interest are β_2 and β_3, measuring the impact of supply constraints on house price-salary elasticity. Both supply constraints measures are standardised so that I could easily interpret the estimated coefficients.

[11] Figure B2 presents the share of developed land for the 105 cities used in my estimation.

I subtract the sample mean of each measure from the measure itself and divide this difference by the standard deviation of the measure. This transformation allows me to interpret the estimated coefficient as an increase in the price-salary elasticity due to a one standard deviation increase or decrease in the supply constraint measure.

One important caveat with the OLS estimates of equation (21) is that the key explanatory variables are likely endogenously determined. First, there is a concern of reverse causality. Regulatory tax rate captures taxes that are correlated with local house prices. If regulatory tax rate is positively correlated with housing price, the OLS estimate will underestimate the impact of regulatory constraint on house price-salary elasticity. Second, unobserved spatial and administrate features such as local amenities, corruption, and government quality might influence the share of developed land, regulatory tax rate, and housing prices simultaneously. To addresses these endogeneity issues, this paper first control for city fixed effects and year fixed effects to mitigate the concerns of unobserved time-invariant local factors and the macro trends. However, the concerns of reverse causality and unobserved time-varying confounding features are still not fully addressed.

This paper then proposes three sets of instruments for the supply constraint measures to address these endogeneity issues. The first instrument is the number of dialects within a city. The identifying assumption is that more dialects within a city will reduce the efficiency of communication between local governments and developers and thus increase the administrative costs and regulatory tax. However, there is no direct correlation between the number of dialects and the current house prices, as dialects are usually formed by historical and cultural features.[12] The second instrument for the regulatory tax rate is the level of local tax enforcement in 1997. Real estate industry in China starts to be marketized after a major housing reform in 1998, and before 1998, local fiscal revenue was lightly relied on housing markets. I use the local fiscal revenue relative to local GDP in 1997 as a proxy for local tax enforcement before the development of real estate industry in China. The identifying assumption is that local governments' ability to collect taxes and administrative fees is positively correlated with regulatory tax rate, but it doesn't have a direct impact on housing prices today because real estate industry had a negligible influence on local fiscal revenue and GDP before 1998.

I also propose an instrument for the share of developable land that is developed in 2005. As shown in Figure B4, I compute the distance between a city's geometric centroid and the major

[12] Figure B3 presents the number of dialects for 105 cities that are included in the baseline estimation.

lakes and rivers in 1840 and apply this distance as an instrument for the geographical constraint measure. The identifying assumption is that places close to the major rivers and lakes in 1840 tend to be developed earlier and thus have a higher share of land developed in 2005. However, the distance to the historical amenities should not have a direct and systematic influence on house price today, after I control for city fixed effects in the specification.

4.2. Main Results

Table 3 summarizes the main findings for estimating equation (21). Column (1) reports the results for the naïve OLS specification controlling for both year and city fixed effects. The coefficient on the house price-salary elasticity is highly statistically significant and positive, suggesting that in a city with average supply constraints, a 1% increase in local real salary increases local real housing price by 0.19%. The coefficients on the salary-interactions with the regulatory tax rate and the share developed-measure are also positive and statistically significant, implying that if an average city observes a one standard deviation increase in its regulatory tax rate, a 1% increase in local salary will increase house price by 0.21% instead of 0.19%. In a similar vein, a one standard deviation increase in the share developed land leads to a 0.27% instead of a 0.19% increase in housing price.

The OLS specification ignores endogeneity concerns about local regulatory restrictiveness and the share of developed land. In column (2) of Table 3, I estimate the same regression by Two-Stage Least Squares (2SLS), instrumenting the regulatory tax rate-salary and the share developed-salary interactions. Consistent with the OLS estimates, the coefficients on the real salary, the regulatory tax rate-salary, and the share developed-salary interactions are all positive and statistically significant. While the IV estimated coefficient of the share developed-salary interaction is close to the OLS estimate, column (2) reports a larger impact of regulatory tax rate on house price-salary elasticity compared with the OLS result, suggesting that a 1% increase in local salary will increase house price by 0.29% instead of 0.24%. This is in line with the expectation that reverse causality will cause an underestimate of the variable of interest and the instrumental variable strategy can mitigate this endogeneity concern.

Regarding the validity of the instruments, the Kleibergen-Paap F statistic indicates that weak identification is not a problem. I also report the first-stage regression results in Panel B of Table 3. Column (3) of Table 3 suggests that both local tax enforcement and the number of dialects are positively and significantly correlated with regulatory tax rate. In addition, column (4) suggests that the distance to major rivers and lakes in 1840 has a negative and statistically significant correlation with the share of developed land. All first-stage results in Table 3 show that the instruments are relevant to the endogenous variables in expected ways.

4.3. Quantitative Analysis

This section presents a counterfactual analysis based on the IV results reported in Table 3. The TSLS specification yields a prediction of real house price conditional on the real salary, regulatory constraint, geographical constraint, as well as city and year fixed effects. Based on the estimated coefficients, I first obtain counterfactual scenarios by predicting local real housing price with supply constraints set to zero sequentially. I then also remove the independent effect of real salary, in order to identify the counterfactual housing price holding constant all relevant local demand and supply measures. This exercise allows me to understand the quantitative importance of the variables of interest.

Removing all supply constraints in housing markets are of course unrealistic scenarios in practice. Therefore, I explore an alternative exercise, where I remove one standard deviation of regulatory constraint and geographical constraint sequentially. I then also remove the independent effect of the real salary to obtain the predicted housing price for a city absent of fluctuations in local housing demand. I first conduct this exercise for each city separately and then take the average of the predicted housing prices over all cities to derive a counterfactual scenario for the 'average' Chinese city. To explore the relative importance of geographical and regulatory constraints, I also conduct two exercises by separately removing these two supply constraints, and by separately lowering them by one standard deviation.

The results of these quantitative exercises are summarized in Table 4. The corresponding Figures 14 and 15 illustrate the predicted housing prices between 2005 and 2018 for the 'average' Chinese city under two scenarios: variables of interest set to zero and reduced by one standard deviation. Figure 16 illustrates the scenarios for a few distinctive cities with tight or comparably relaxed planning constraints: Beijing and Shanghai are cities with more restrictive land use regulations. Shenzhen is a Tier-1 city with high housing price, geographical scarcity, but relatively lax regulatory environment. Jiaxing is a medium-size city with few regulatory and geographical constraints.

The counterfactual exercises suggest a substantial impact of supply constraints on house prices in China. Panel A of Table 4 suggests that, based on the baseline estimates, in 2018 the house price in the 'average' city in China (with average housing demand shocks) would be 17 percent lower if all regulatory constraints were completely relaxed. Panel B then shows that reducing the restrictiveness by one standard deviation were to lead to a 16 percent reduction in housing prices. If I completely remove both supply-side constraints and the independent effect of real salary, the housing price in the 'average' Chinese city in 2018 would be 34 percent lower.

As Figure 16 illustrates, the impacts of regulatory constraints and physical (scarcity related) constraints vary significantly across locations. Physical constraints matter most in the densely developed city, Shenzhen, while regulatory constraints are most important in Beijing and Shanghai. In Jiaxing, both regulatory and geographical constraints have relatively small impacts on housing price, and the independent effect of real salary is more important for house price appreciation.

4.4. The Impacts of Regulatory Tax on Land Prices

Using the matched residential project dataset, I investigate the impacts of regulatory tax rates on land prices. The estimated results are reported in Table 5. Columns (1) and (2) correspond to the results about land price, and columns (3) and (4) correspond to the results about land price per square meter. In the more rigorous specifications, columns (2) and (4), when year fixed effects, district fixed effects, and developer fixed effects are included, I find regulatory tax rates decrease land prices developers pay. The estimated coefficients are statistically significant at the 1% level. This finding is consistent with Proposition (3), which suggests that developers will respond to higher regulatory costs by reducing the bidding prices for land parcels. Table 5 also reports that land price is higher when the land parcel is closer to CBD and has a higher Floor Area Ratio upper limit.

4.5. Additional Results and Robustness Checks

4.5.1. Supply Constraints and Construction

In this sub-section, I study the impacts of supply constraints on new construction by changing the dependent variable in equation (21) and re-estimating the specification. Columns (1) and (2) of Table A2 report the OLS and IV estimates for the impact of supply constraints on the total area of new construction at the city level. Both columns show that real salary has a positive and statistically significant impact on new construction. The preferred IV estimate in column (2) suggests that both the regulatory tax rate and the share of developed land have negative and significant impact on construction-salary elasticity. This is in line with expectation as local governments and developers will respond to strong demand shocks by releasing more land plots and by building out more properties, but this demand effect is weaker for cities with more restrictive supply constraints.

4.5.2. Project Characteristics and Regulatory Tax Rate

What types of residential projects are associated with high regulatory taxes? To answer this question, I exploit project-level variations in regulatory taxes and residential project characteristics. I include year fixed effects, city fixed effects, district fixed effects, and

developer fixed effects in the empirical specifications to control for unobserved macro-economic conditions, local economic and social factors, and developer characteristics.

The results are reported in Table A3, and different fixed effects are included sequentially in columns (1) to (4). The estimated coefficients for the natural logarithm of distance to CBD are always negative and statistically significant, suggesting that projects close to CBD are associated with higher regulatory taxes. This result is plausible as projects in city centre tend to have closer proximity to historical buildings, educational and medical facilities, etc., and local governments would implement more restrictive planning regulations to protect the neighbourhoods. Meanwhile, Table A3 also indicates that projects with larger land areas are also associated with higher regulatory taxes. This is probably driven by more complex physical structure and more lengthy development procedure of such projects. If a project has a higher difference between the actual project FAR and the upper FAR limit set for its underlying land plot, there will also be a higher regulatory tax for this project. As documented in Cai *et al.* (2017), more than 20% of developers built above the regulatory FAR limits in the ex-post land development. The results from Table A3 show that developers need to pay additional costs to local governments if they choose to apply for the FAR limit adjustments.

4.5.3. Labour Demand Shock as Demand Shifter

In the baseline estimation, I use city-level real salary as the local housing demand shifter. However, this measure might be endogenously determined, as housing supply conditions might directly affect local labour market and thus local salary (Saks 2008). To address this endogeneity concern, this paper follows the method proposed by Bartik (1991) to construct a shift-share type predicted local employment measure that could be used as local housing demand shifter. I exploit the city-level variation in industry composition of employment in 2003, the earliest year with available data, and the changes in employment by industry at the national level between 2005 and 2018 to construct this labour demand shock variable.

Figure B5 presents the national trend of employment by industry series, where the 2003 level has been set to 1. There are in total 19 industries as classified by the National Bureau of Statistics in China, and Figure B5 highlights a significant rise of employment in the information technology sector as well as in the finance sector, and a decline of the mining and agriculture employment between 2003 and 2018. For each city and industry, employment was multiplied with the corresponding national trend and the result was aggregated over industries. This yields the predicted employment in each city that would have resulted given its industry composition in 2003, if employment in each industry follows the national trend. This paper argues that this labour demand shock variable is exogenous to local housing demand and supply conditions, as

local labour supply shocks have a negligible impact on industry employment at the national level.

This paper then applies the natural logarithm of the labour demand shock variable (LLDS) as the demand shifter and re-estimates equation (21). The results are reported in Table A4. Columns 1 and 2 present the OLS and IV estimates respectively, and both columns report positive and statistically significant coefficients for the regulatory tax rate-LLDS and the share developed-LLDS interactions, which are in line with the baseline estimation results. This exercise suggests that this paper's main findings are robust after I mitigate the potential endogeneity concern of the local demand shifter.

4.5.4. Alternative Estimates of Regulatory Tax Rate

The regulatory tax rate used in the main analysis is computed based on the estimated land price within the 3 km radius buffer and the assumption that developers will make 'normal' profits. In this sub-section, I change these two assumptions separately and estimate alternative regulatory tax rates to test for the robustness of the main results.

I first use the one-to-one matching sample to re-estimate regulatory tax rate at the city level. As discussed in section 3, the one-to-one matching sample contains residential projects with their corresponding land plots. This sample thus provides a more accurate estimate of the land cost. The drawback of using this sample is that the city-level regulatory tax rate is estimated based on fewer observations due to the stricter selection criteria. The one-to-one matching sample provides an alternative estimate of regulatory tax rate for 60 cities and I re-estimate equation (21) using this alternative measure. The results are reported in columns (1) and (2) of Table A5. In line with the baseline findings, all the estimated coefficients have the expected signs and are statistically significant.

I then follow the literature and assume perfect competition among developers when estimating regulatory tax rate. Under this scenario, developers will make zero profit, and the regulatory tax rate is estimated based on equation (19). I then apply this alternative measure of regulatory tax rate to re-estimate equation (21). The results are reported in columns (3) and (4) of Table A5 and are consistent with the main findings.

5. Conclusion

This paper proposes a new regulatory tax measure for housing supply restrictiveness, covering different types of costs, taxes, and fees during the process of real estate development. Using a unique dataset of spatially matched residential projects in China, this paper estimates that on average, regulatory tax accounts for 34% of house prices, and there are substantial spatial

variations in regulatory restrictiveness across Chinese cities. Further empirical and quantitative analysis suggest that supply-side constraints are important for house price appreciation in China and especially in superstar cities such as Beijing and Shanghai.

The lack of affordable housing adversely impacts local economic development and the well-being of residents. Figure B6 presents city-level housing affordability conditions in China in 2018. It shows that, on average, it takes at least 8 years' salaries to buy a 100-square-meter property in most cities along the south-eastern coast. Based on international standards, many of these cities are classified as 'severely unaffordable'.[13] This paper finds that regulatory restrictiveness during the housing development process is an essential driver of reduced housing construction and unaffordable housing prices. Eventually, new homebuyers have to bear the excessive regulatory costs, while existing homeowners can benefit from the appreciation of their house values.

Meanwhile, local governments don't necessarily gain from development taxes and fees, as they need to sell land parcels at a discount. Under decentralised fiscal systems (e.g., in China and some European countries, as documented in Ehrlich et al. 2018), local governments usually have the fiscal incentive to allow real estate developments and are sometimes fiscally reliant on taxes and fees generated from new construction. For future research, it will be interesting to explore how local authorities can balance fiscal conditions and housing affordability to finance local public goods sustainably.

[13] For instance, Cox (2022) in the Demographia international housing affordability report uses the 'median multiple' (i.e. median house price divided by median household income) to rate middle-income housing affordability and proposes that housing markets are 'severely unaffordable' if the corresponding median multiple is higher than 5.

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Tables

Table 1:
Descriptive Statistics

	Obs.	Mean	SD	Max	Min
Panel A: Matched project characteristics					
Average house price (RMB/m^2)	14571	11378.5	8862.5	194258	1705.9
Average land price (RMB/m^2)	14571	2643.6	3339	54040	101.2
Average construction cost (RMB/m^2)	14571	2850.1	895.2	9289	839
Regulatory tax rate	14571	1.9	2.3	20.3	0
Land area (m^2)	14571	88216.4	114555.6	999900	1044
Construction area (m^2)	14571	221616.5	259740.7	3500000	2475
FAR	14571	2.9	1.5	10	0.1
Number of dwellings	11391	1246.4	1450.1	36325	1
Panel B: City-level characteristics					
House price in 2005 level (RMB/m^2)	1416	4655.8	3617	43080.1	869.6
Average salary in 2005 level (RMB)	1416	36889.7	15724.4	116434.7	8051.3
Regulatory tax rate	1416	1.8	0.8	5.6	0.6
% Developed land in 2005 relative to developable land	1416	0.05	0.08	0.4	0.003
Local developer profit margin	115	0.03	0.06	0.14	-0.2
Predicted local employment	1456	881706	1411532	15224861	47621
Construction area (km^2)	888	28.7	25.3	202.9	1
Panel C: City-level characteristics, instruments					
Local tax enforcement (fiscal revenue/GDP in 1997)	103	0.04	0.02	0.1	0.01
Number of dialects	103	2	1.1	6	1
Distance to major lakes and rivers in 1820 (km)	103	63.1	61.6	271.3	0.3

Table 2:
Regulatory Tax Rate at the City Level

Ranking, city, and regulatory tax rate		
1. Beijing 5.62	41. Tianjin 1.99	81. Qingyuan 1.4
2. Guangzhou 4.03	42. Puyang 1.96	82. Heyuan 1.39
3. Zhumadian 3.4	43. Hangzhou 1.96	83. Changzhou 1.36
4. Xiangyang 3.32	44. Jinhua 1.94	84. Taizhou 1.35
5. Shaoyang 3.29	45. Cangzhou 1.9	85. Sanmenxia 1.34
6. Shanghai 3.28	46. Guiyang 1.87	86. Xingtai 1.32
7. Xinxiang 3.17	47. Urumqi 1.86	87. Yingkou 1.32
8. Nanyang 3.04	48. Shenzhen 1.81	88. Chengde 1.32
9. Xiamen 2.87	49. Jining 1.8	89. Changsha 1.31
10. Zhengzhou 2.75	50. Linyi 1.79	90. Weifang 1.29
11. Fushun 2.72	51. Nantong 1.75	91. Zibo 1.29
12. Baoji 2.64	52. Lanzhou 1.75	92. Kunming 1.26
13. Lianyungang 2.57	53. Tangshan 1.72	93. Zhanjiang 1.25
14. Qingdao 2.54	54. Quzhou 1.72	94. Zhuhai 1.21
15. Wenzhou 2.52	55. Changchun 1.71	95. Zhongshan 1.21
16. Anyang 2.41	56. Hohhot 1.7	96. Yinchuan 1.19
17. Kaifeng 2.4	57. Dongying 1.7	97. Jiangmen 1.17
18. Liaocheng 2.38	58. Hengshui 1.65	98. Shantou 1.14
19. Shijiazhuang 2.32	59. Chengdu 1.64	99. Yichang 1.12
20. Guilin 2.31	60. Heze 1.61	100. Baotou 1.09
21. Luoyang 2.29	61. Taiyuan 1.55	101. Xining 1.09
22. Putian 2.2	62. Shaoxing 1.55	102. Hefei 1.08
23. Xi'an 2.18	63. Fangchenggang 1.55	103. Zhoushan 1.02
24. Nanjing 2.17	64. Binzhou 1.54	104. Foshan 1.01
25. Liuzhou 2.16	65. Jingmen 1.53	105. Zhaoqing 1.01
26. Qinhuangdao 2.15	66. Anshan 1.53	106. Bengbu 0.99
27. Nanning 2.15	67. Harbin 1.53	107. Jiujiang 0.97
28. Baoding 2.12	68. Huaian 1.53	108. Yangjiang 0.97
29. Zhangzhou 2.12	69. Quanzhou 1.52	109. Huizhou 0.88
30. Handan 2.12	70. Fuxin 1.51	110. Zaozhuang 0.82
31. Xianyang 2.11	71. Ningbo 1.48	111. Maoming 0.74
32. Ganzhou 2.1	72. Ningde 1.47	112. Dongguan 0.7
33. Zhoukou 2.07	73. chongqing 1.43	113. Huzhou 0.69
34. Weihai 2.07	74. Wuhan 1.42	114. Xuchang 0.68
35. Shangqiu 2.06	75. Daqing 1.42	115. Jiaxing 0.55
36. langfang 2.05	76. Wuxi 1.42	
37. Nanchang 2.02	77. Shenyang 1.42	
38. Tai'an 2	78. Yantai 1.4	
39. Zhangjiakou 2	79. Dalian 1.4	
40. Jinan 2	80. Hanzhong 1.4	

Table 3:
Supply Constraints and House Price

Panel	Panel A: baseline estimates		Panel B: first-stage results	
Dependent variable	Log (real house price)		Regulatory tax × Salary	Geographical constraint × Salary
Specification	(1)	(2)	(3)	(4)
	OLS	IV		
Log (real salary)	0.1941***	0.2370***	0.2964**	-1.0578***
	(0.0406)	(0.0541)	(0.1449)	(0.1358)
Regulatory tax × log (real salary)	0.0165**	0.0521**		
	(0.0080)	(0.0263)		
Geographical constraint × log (real salary)	0.0797***	0.1215***		
	(0.0128)	(0.0266)		
Local tax enforcement × log (real salary)			0.2760***	0.3261***
			(0.0535)	(0.0442)
Number of dialects × log (real salary)			0.0743**	-0.0790***
			(0.0334)	(0.0176)
Distance to major lakes × log (real salary)			0.0967***	-0.1840***
			(0.0360)	(0.0241)
Year FEs	Yes	Yes	Yes	Yes
City FEs	Yes	Yes	Yes	Yes
Time period	2005-2018		2005-2018	
Number of cities	103		103	
N	1416	1416	1416	1416
R^2	0.9710		0.9989	0.9994
Kleibergen-Paap rk Wald F-statistic	13.86			

Notes: Both supply constraints measures are standardised. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively. Robust standard errors in parentheses.

Table 4:
Effect of Shifts in Real Salary on House Price in Average Chinese City
(Counterfactual Outcomes)

Variable	Value in 2005	Value in 2018	SD	Max	Min
Predicted house price (RMB/m^2)	2378	5228	2747	15380	1912
Panel A: supply constraints and demand shock set to zero sequentially					
Predicted without any regulatory tax	2378	4645	2441	13667	1699
- and share developed set to zero	2378	4332	2276	12743	1584
- and independent effect of salary removed	2378	3430	1803	10091	1254
Panel B: supply constraints lowered by 1 std. dev. and demand shock set to zero sequentially					
Predicted with regulatory tax lowered by 1 std. dev.	2378	4967	2610	14611	1816
- and share developed lowered by 1 std. dev.	2378	4406	2316	12964	1611
- and independent effect of salary removed	2378	3489	1834	10266	1276
Panel C: supply constraints set to zero separately					
Predicted without any regulatory tax	2378	4645	2441	13667	1699
Predicted with % developed set to zero	2378	4874	2562	14340	1782
Panel D: supply constraints lowered by 1 std. dev. separately					
Predicted with regulatory tax lowered by 1 std. dev.	2378	4967	2610	14611	1816
Predicted with % developed lowered by 1 std. dev.	2378	4638	2437	13646	1696

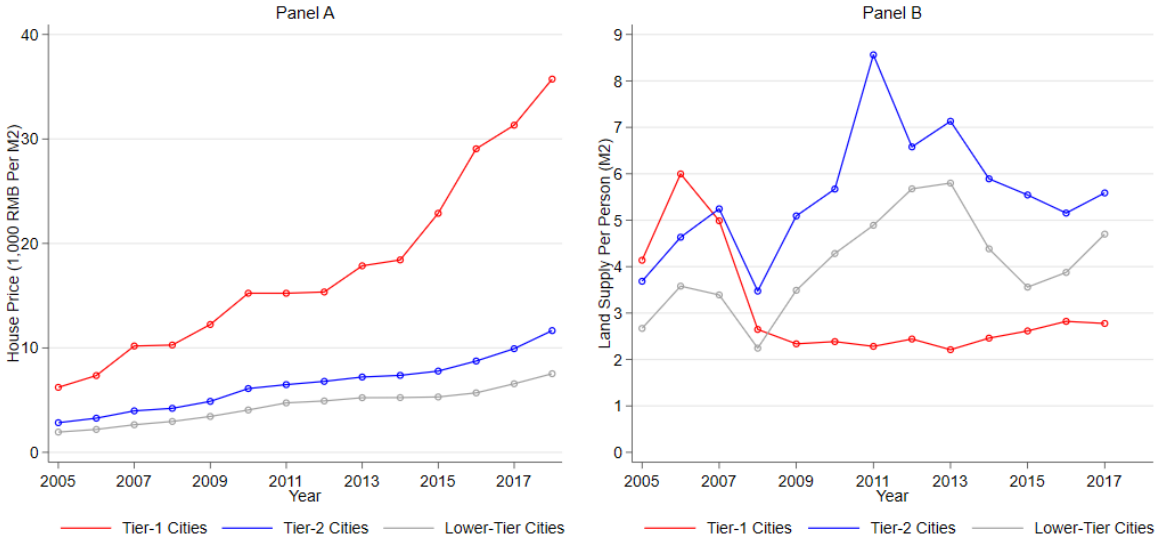
Table 5:
The Impacts of Regulatory Tax Rates on Land Prices

Dependent variable	Log (land price)		Log (land price per square meter)	
Specification	(1)	(2)	(3)	(4)
Regulatory tax rate	-0.0232	-0.0938*	-0.0633***	-0.1167**
	(0.0199)	(0.0484)	(0.0172)	(0.0452)
Log (distance to CBD)	-0.1121***	-0.0550	-0.1298***	-0.0803*
	(0.0162)	(0.0399)	(0.0147)	(0.0419)
Log (land plot area)	0.1289***	0.1190***	-0.0058***	-0.0209***
	(0.0194)	(0.0162)	(0.0021)	(0.0075)
Land plot FAR upper limit	0.0745***	0.0560*	0.1645***	0.1233***
	(0.0157)	(0.0295)	(0.0108)	(0.0311)
Year FEs	Yes	Yes	Yes	Yes
District FEs	Yes	Yes	Yes	Yes
Developer FEs	No	Yes	No	Yes
N	8433	2069	8433	2069
R^2	0.6426	0.8672	0.6037	0.8392

Notes: *, **, and *** represent 10%, 5%, and 1% significance levels, respectively. Robust standard errors clustered at the district level in parentheses. The type of land auction is controlled for in all specifications.

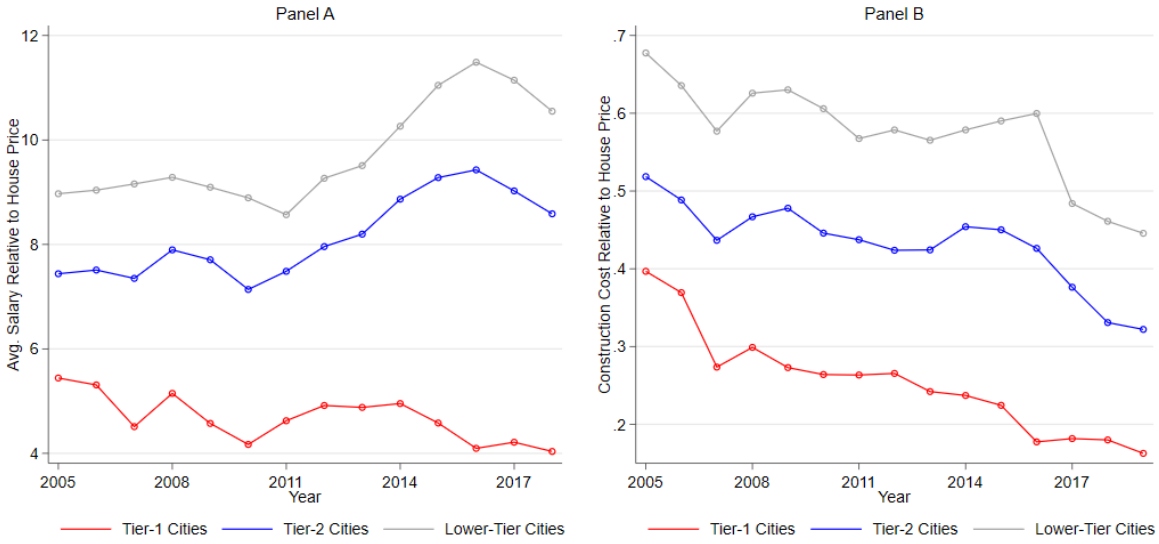
Figures

Figure 1:
Housing Price and Land Supply in Chinese Cities



Notes: Tier-1 cities refer to Beijing, Shanghai, Guangzhou, and Shenzhen. Tier-2 cities refer to sub-provincial ('fushengji') cities and two municipalities ('zhixiashi').

Figure 2:
Housing Affordability and Construction Cost in Chinese Cities



Notes: Tier-1 cities refer to Beijing, Shanghai, Guangzhou, and Shenzhen. Tier-2 cities refer to sub-provincial ('fushengji') cities and two municipalities ('zhixiashi').

Figure 3:
Land Use Plan and Residential Project



Notes: The left-side figure shows the land use plan for a residential project, and the right-side figure shows the actual project that is built upon the land plot. Sources: Government of Putuo District, Shanghai, and Google Earth.

Figure 4:
Real Estate Related Taxes and Land Sale Revenue

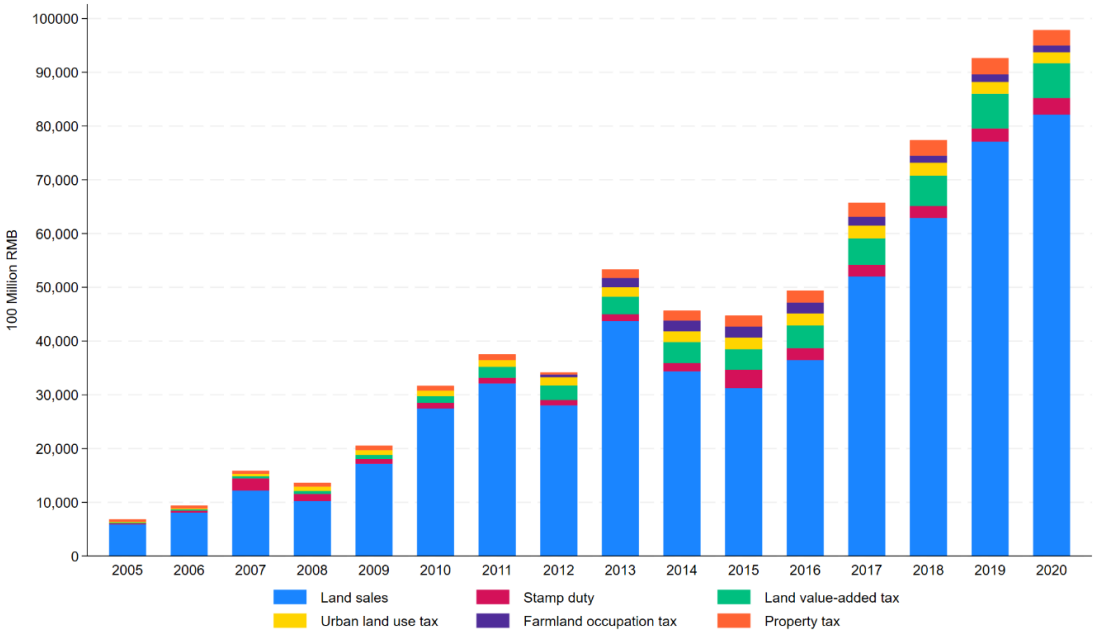


Figure 5:
Real Estate Related Taxes, Land Sale Revenue, and Total Property Sales

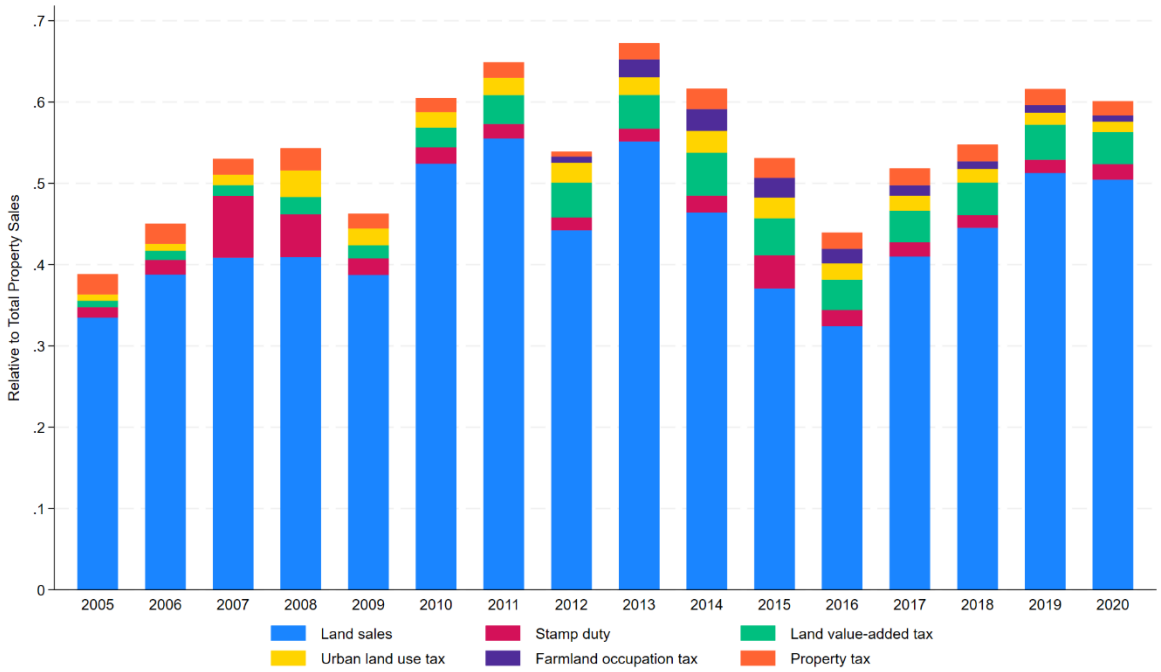
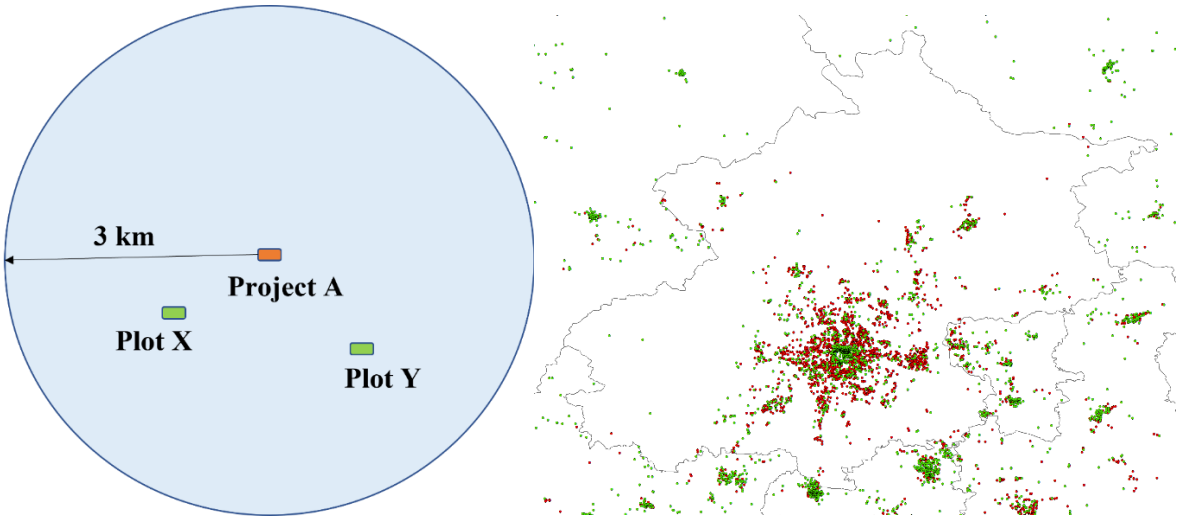


Figure 6:
Regulatory Tax Estimate at the Project Level



Note: The right-side figure presents the geocoded land transactions (green dots) and residential projects (red dots) in Beijing and nearby cities.

Figure 7:
Histograms

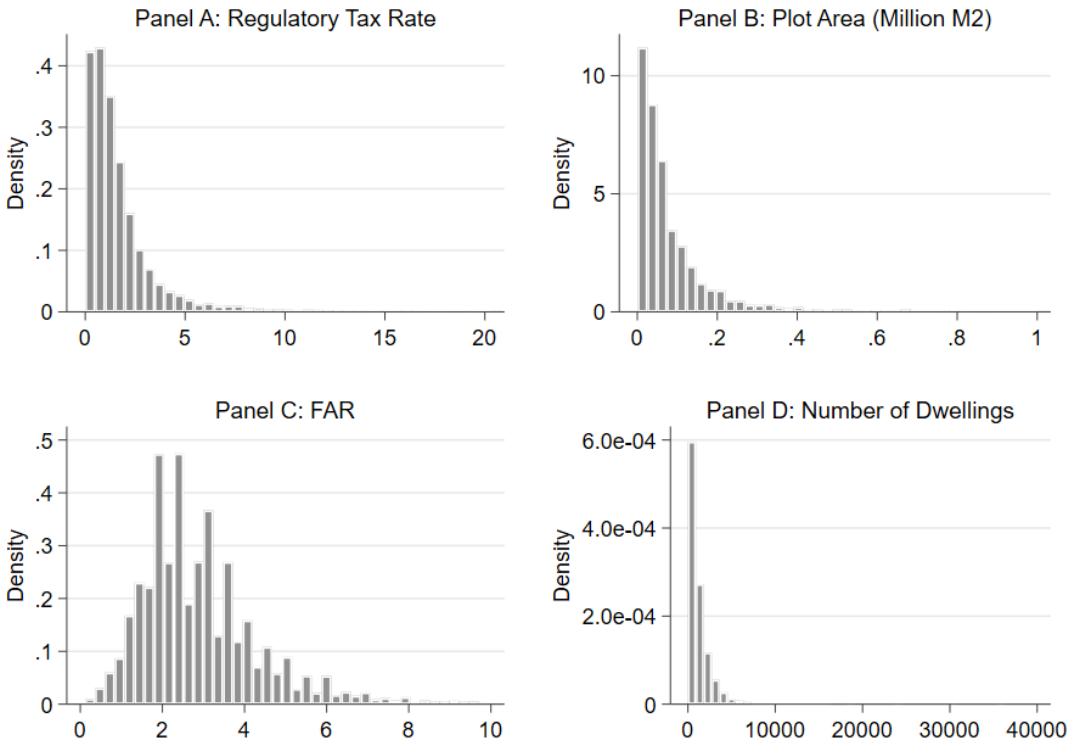


Figure 8:
House Price Decomposition in Tier-1 Cities and Jiaxing

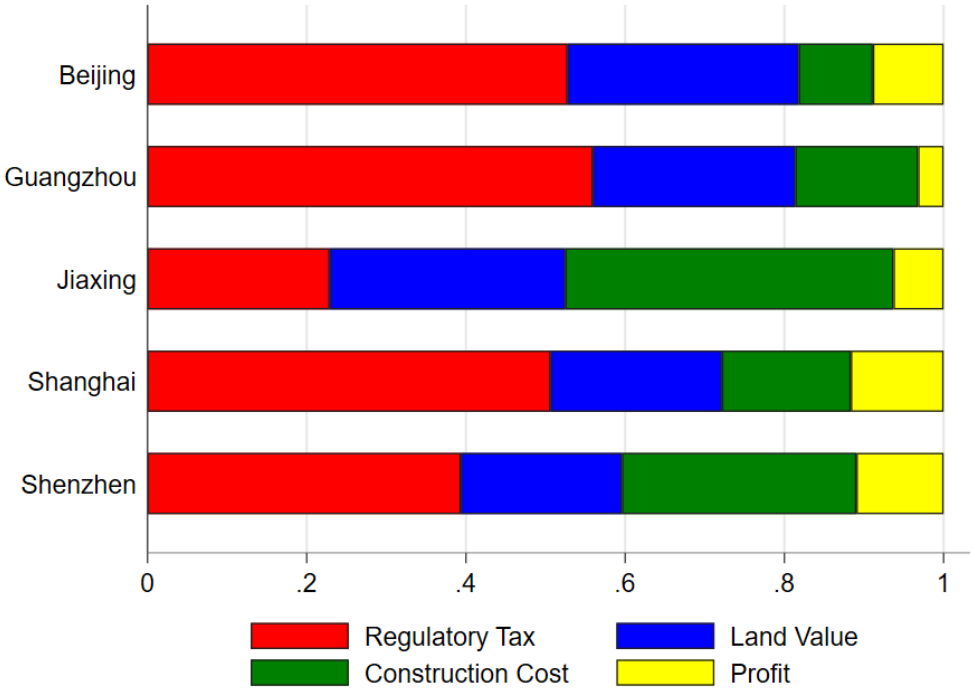


Figure 9:
House Price Decomposition for Different Tiers of Cities

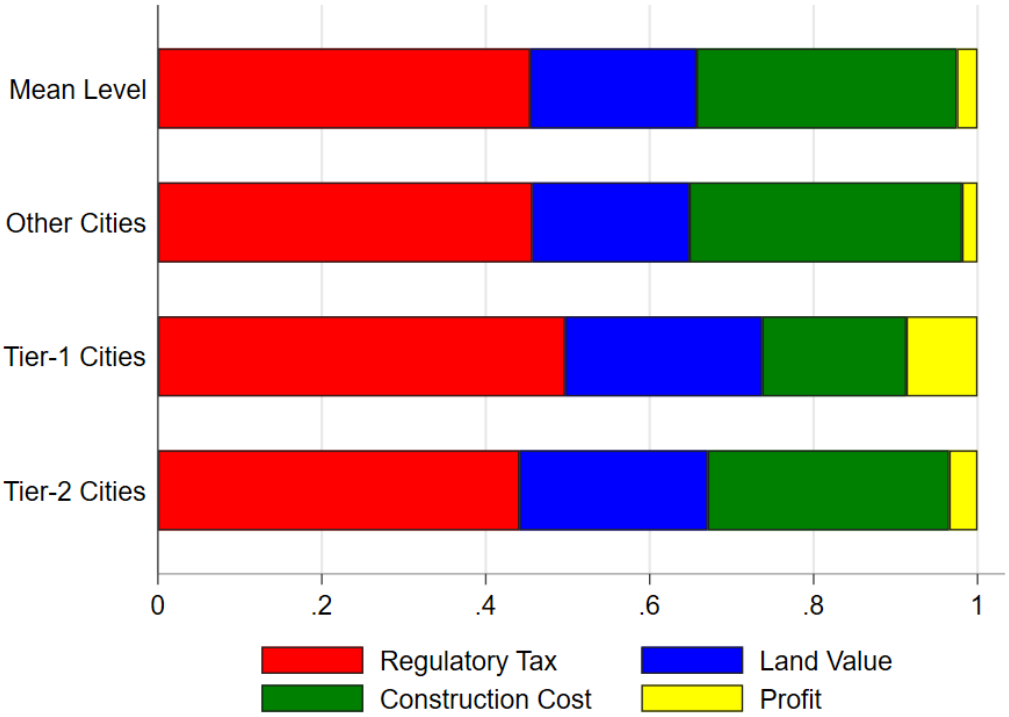


Figure 10:
Regulatory Tax Rate

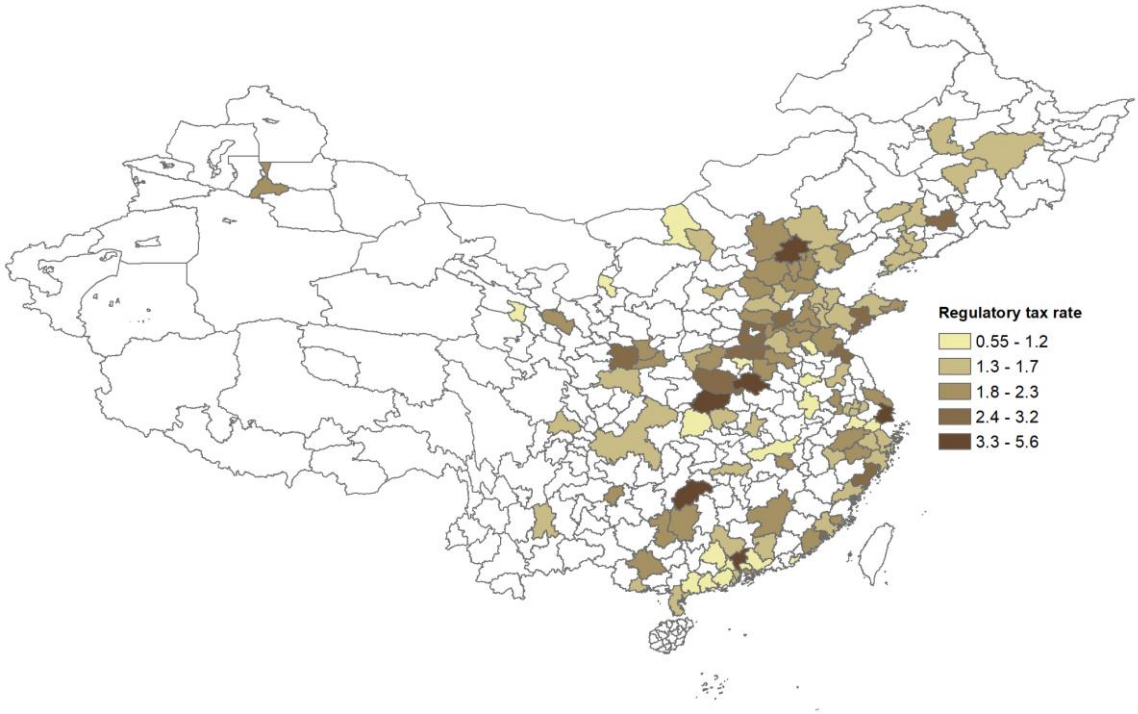


Figure 11:
Regulatory Tax Estimates and Population

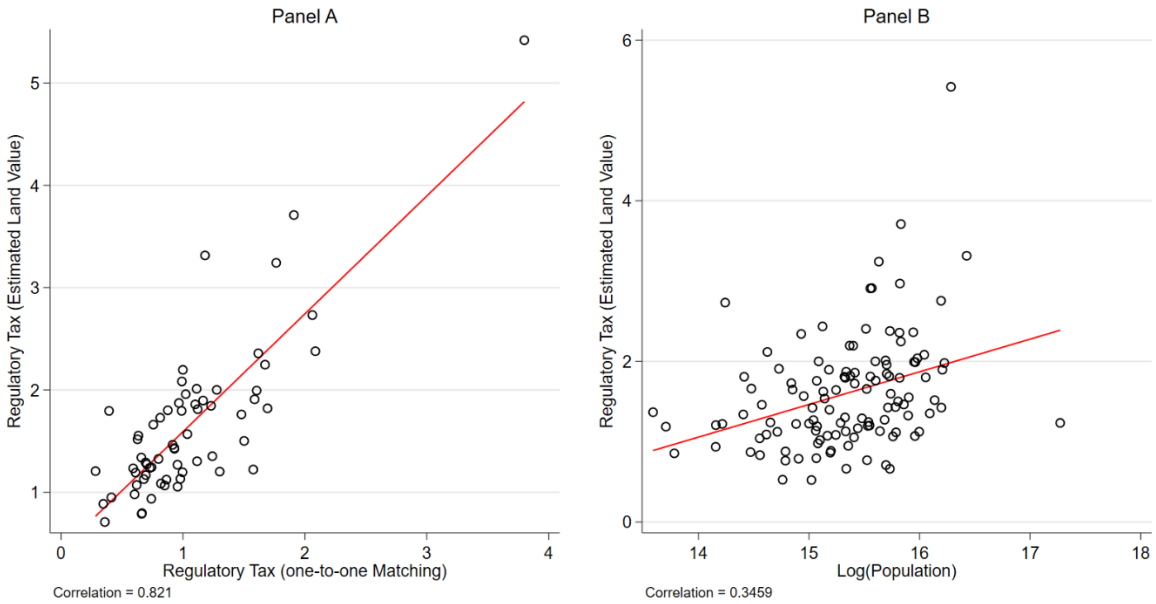


Figure 12:
Regulatory Tax Rate and Housing Supply Elasticity

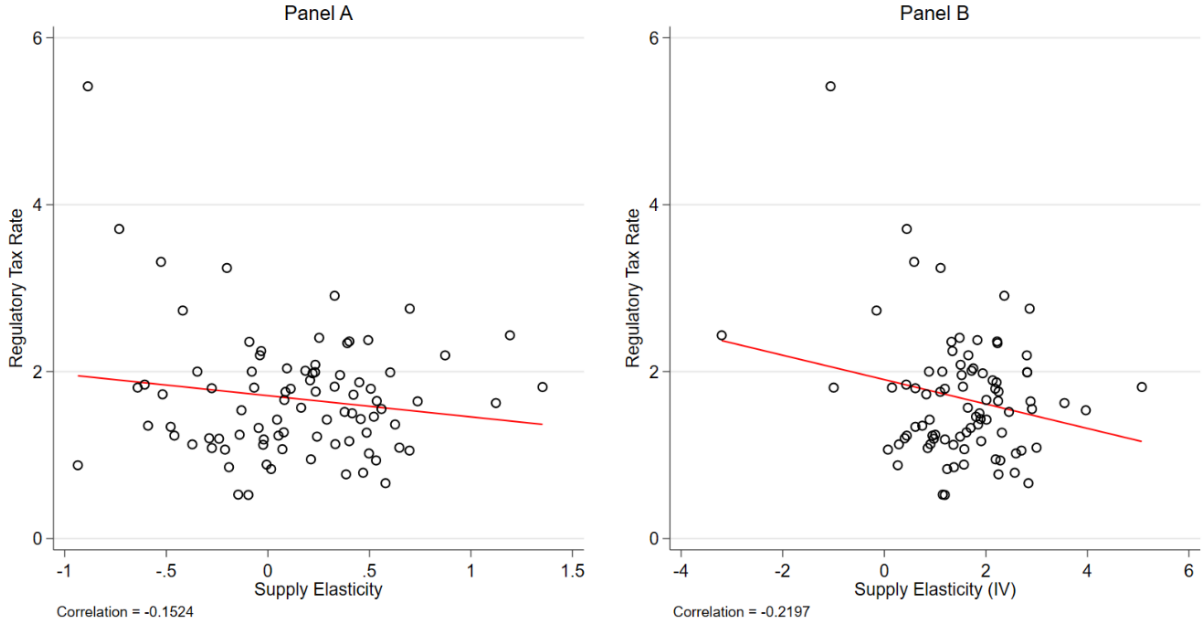


Figure 13:
Demand Shock and Housing Supply Constraints

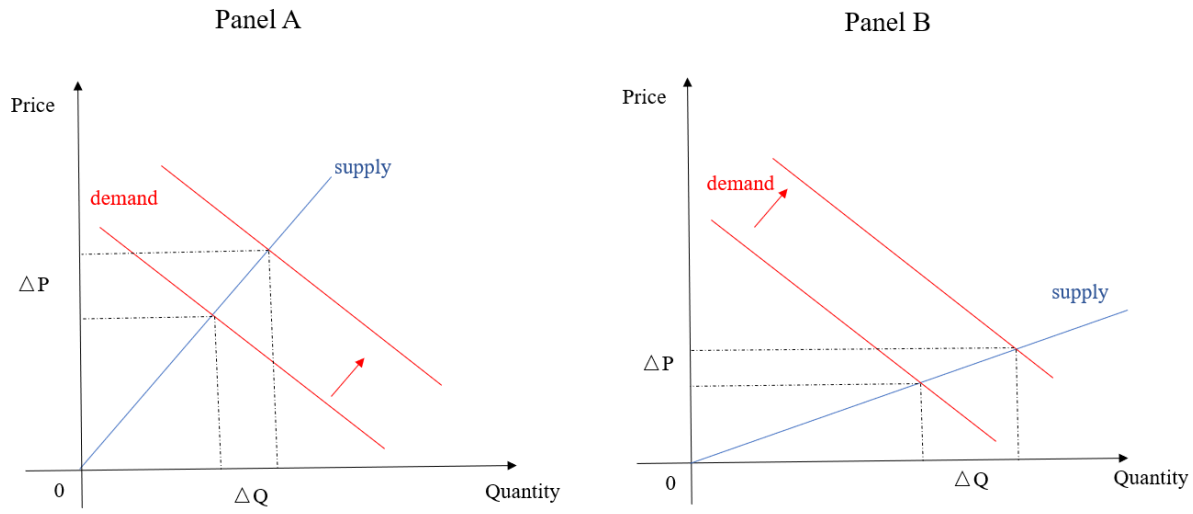


Figure 14:
Impact of Removing Supply Constraints on House Prices in Average Chinese City

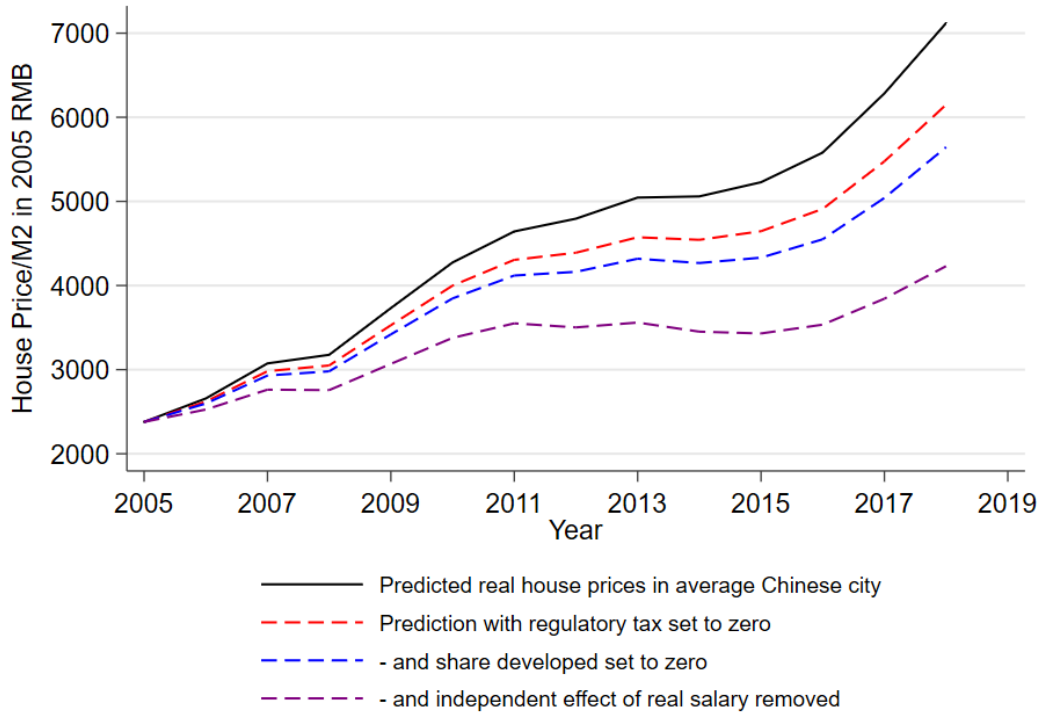


Figure 15:
Impact of Reducing Supply Constraints on House Prices in Average Chinese City

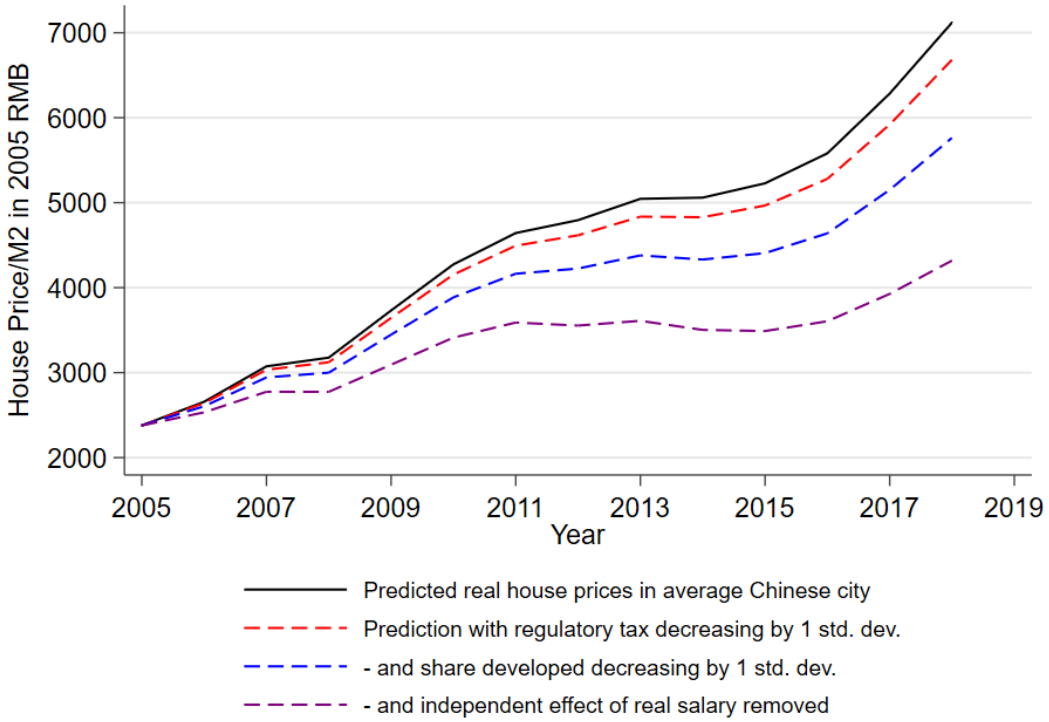
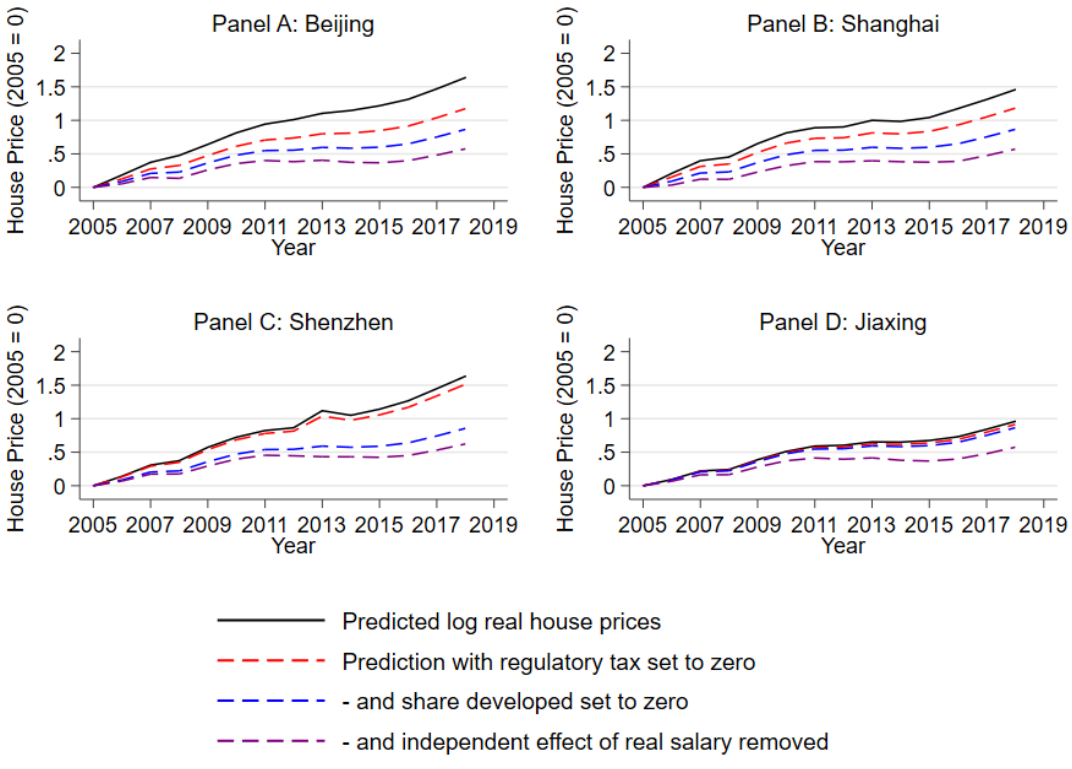


Figure 16:
Predicted Log of Real House Prices in Selected Cities



Appendices

Appendix A: Appendix Tables

Table A1:
Development Cost Breakdown

Cost code	Cost item
1	Land acquisition fees
1.1	Land acquisition fees
1.2	Land premium
1.3	Land taxes and fees
1.4	Other expenses
2	Early-stage engineering costs
2.1	Feasibility study
2.2	Survey and measurement
2.3	Planning and design
2.4	Land clearing and utility connection
2.5	Temporary facility
2.6	Administrative fees
2.7	Other expenses
3	Construction fees
3.1	Foundation
3.2	Main project
3.3	Decoration
3.4	Mechanical and electrical equipment installation
4	Infrastructure fees
4.1	Municipal projects
4.2	Landscape
5	Public facilities fees
5.1	Public infrastructure construction costs
5.2	Other expenses
6	Developer profit

Notes: Different colours represent different components of the house price. The Orange colour represents the land cost. The green colour represents the regulatory and development costs. The blue colour represents the construction cost. The grey colour represents developer profit.

Table A2:
Supply Constraints and Construction

Dependent variable	Log (construction)	
Specification	(1)	(2)
	OLS	IV
Log (real salary)	0.8125***	0.6682***
	(0.1568)	(0.1871)
Regulatory tax × log (real salary)	-0.0517	-0.4121***
	(0.0341)	(0.1224)
Geographical constraint × log (real salary)	-0.1752***	-0.1558*
	(0.0445)	(0.0869)
Year FEs	Yes	Yes
City FEs	Yes	Yes
Time period	2005-2018	
Number of cities	101	
N	888	886
R^2	0.9483	
Kleibergen-Paap rk Wald F-statistic		5.5

Notes: Both supply constraints measures are standardised. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively. Robust standard errors in parentheses.

Table A3:
Project Characteristics and Regulatory Tax Rate

Dependent variable	Log (house price)			
Specification	(1)	(2)	(3)	(4)
Log (distance to CBD)	-0.0767***	-0.0745***	-0.0678***	-0.0850*
	(0.0157)	(0.0281)	(0.0144)	(0.0432)
Log (project land area)	0.0583***	0.0508	0.0902***	0.1150***
	(0.0136)	(0.0370)	(0.0123)	(0.0396)
Project FAR – land plot FAR	0.0378***	0.0242	0.0304**	0.0511*
	(0.0130)	(0.0278)	(0.0127)	(0.0284)
Year FEs	Yes	Yes	Yes	Yes
City FEs	Yes	Yes	No	No
District FEs	No	No	Yes	Yes
Developer FEs	No	Yes	No	Yes
N	8742	2373	8481	2089
R^2	0.2751	0.6389	0.4672	0.7556

Notes: *, **, and *** represent 10%, 5%, and 1% significance levels, respectively. Robust standard errors clustered at the district level in parentheses. The type of land auction is controlled for in all specifications.

Table A4:
House Price and Supply Constraint (Local Labour Demand Shock)

Panel	Panel A: baseline estimates		Panel B: first-stage results	
Dependent variable	Log (real house price)		Regulatory tax × LLDS	Geographical constraint × LLDS
Specification	(1)	(2)	(3)	(4)
	OLS	IV		
LLDS	-0.2263**	-0.2070**	-0.4378**	-0.1150
	(0.0965)	(0.1025)	(0.1790)	(0.1270)
Regulatory tax × LLDS	0.0494***	0.1355**		
	(0.0170)	(0.0568)		
Geographical constraint × LLDS	0.0889***	0.1435***		
	(0.0200)	(0.0362)		
Local tax enforcement × LLDS			0.2555***	0.4276***
			(0.0322)	(0.0514)
Number of dialects × LLDS			0.1213***	-0.1240***
			(0.0263)	(0.0201)
Distance to major lakes × LLDS			0.0643***	-0.2795***
			(0.0248)	(0.0292)
Year FEs	Yes	Yes	Yes	Yes
City FEs	Yes	Yes	Yes	Yes
Time period	2005-2018		2005-2018	
Number of cities	102		104	
N	1416	1416	1416	1416
R^2	0.9703		0.9989	0.9984
Kleibergen-Paap rk Wald F-statistic		35.9		

Notes: Both supply constraints measures are standardised. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively. Robust standard errors in parentheses.

Table A5:
Alternative Estimates of Regulatory Tax Rate

Dependent variable	Log (house price)		Log (house price)	
Specification	(1)	(2)	(3)	(4)
	OLS	IV	OLS	IV
	One-to-one matching		Perfect competition	
Log (real salary)	0.0970*	0.2181***	0.1890***	0.1823***
	(0.0535)	(0.0841)	(0.0396)	(0.0569)
Regulatory tax × log (real salary)	0.0316***	0.0664**	0.0240***	0.1050***
	(0.0119)	(0.0271)	(0.0078)	(0.0355)
Geographical constraint × log (real salary)	0.0531***	0.1340***	0.0744***	0.0773**
	(0.0131)	(0.0430)	(0.0128)	(0.0317)
Year FEs	Yes	Yes	Yes	Yes
City FEs	Yes	Yes	Yes	Yes
Time period	2005-2018		2005-2018	
Number of cities	60		107	
N	831	831	1472	1472
R^2	0.9652		0.9708	
Kleibergen-Paap rk Wald F-statistic		17.3		12

Notes: Both supply constraints measures are standardised. *, **, and *** represent 10%, 5%, and 1% significance levels, respectively. Robust standard errors in parentheses.

Appendix B: Appendix Figures

Figure B1:
Local Developer Profit Margin

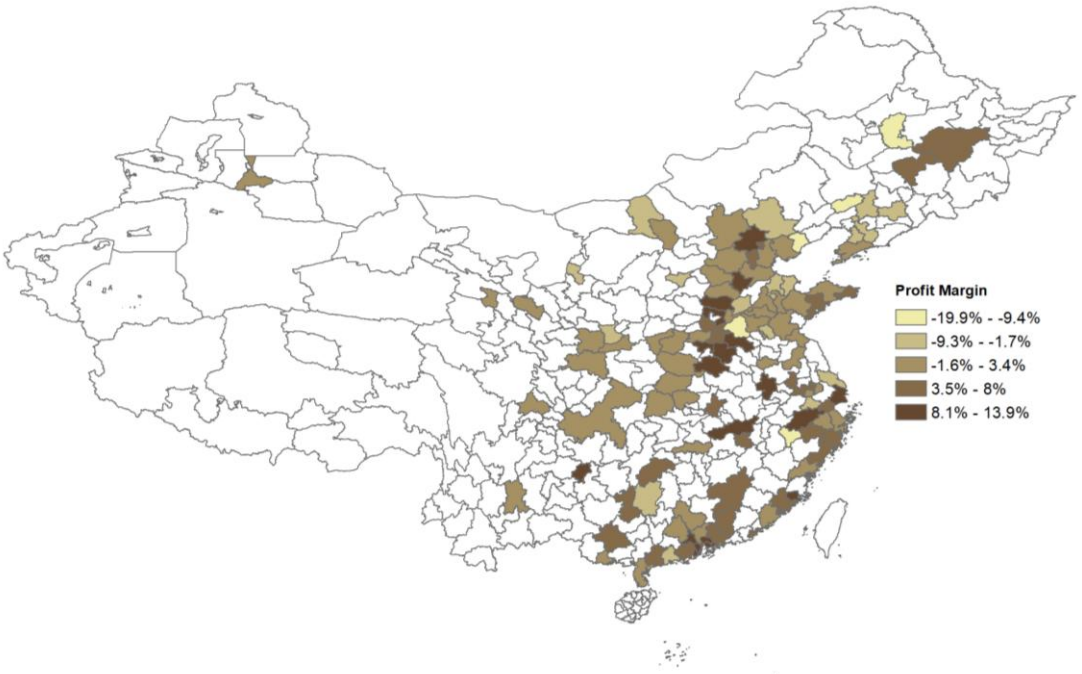


Figure B2:
Share of Developed Land in 2005

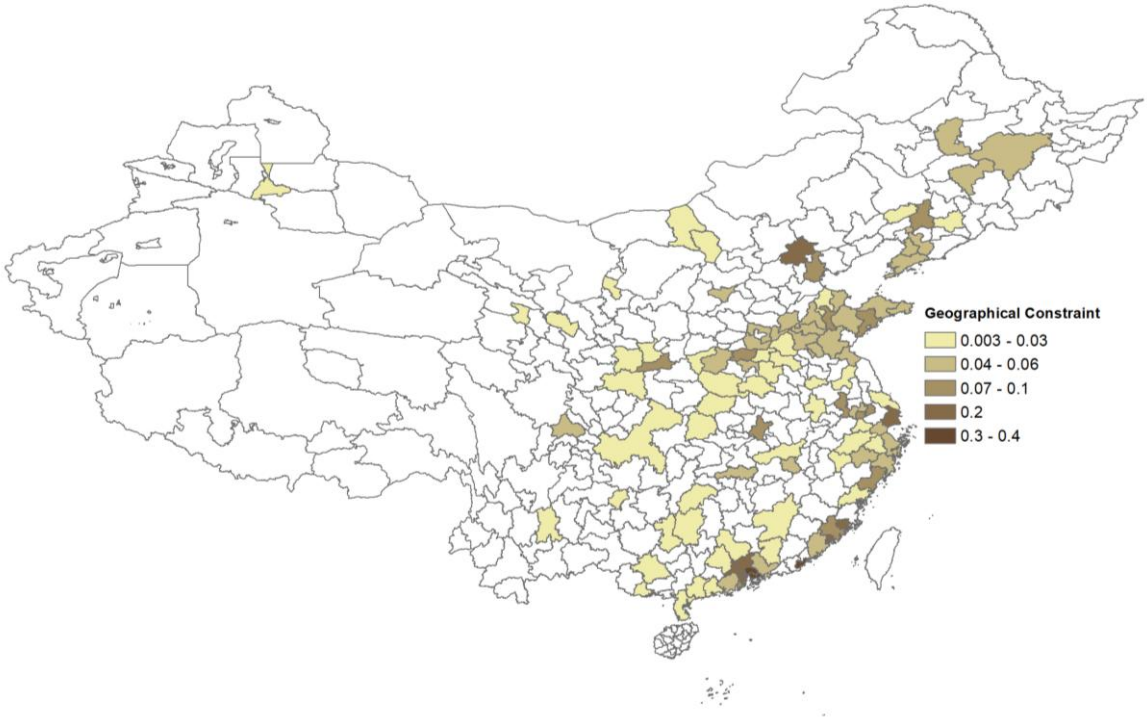


Figure B3:
Number of Dialects

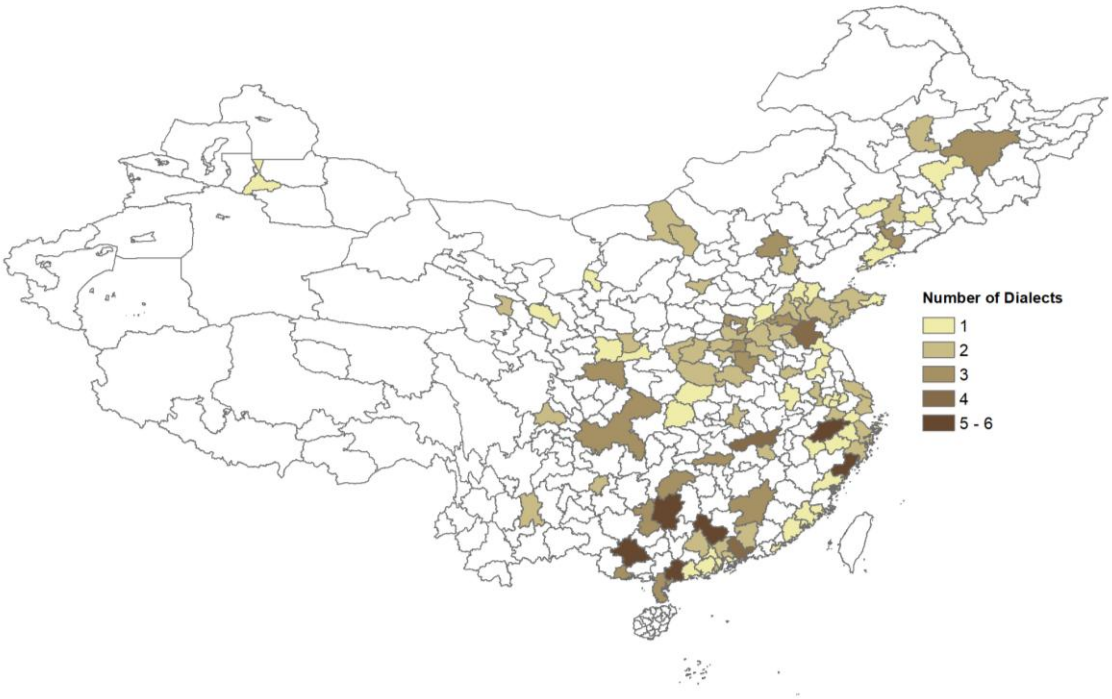


Figure B4:
Major Lakes and Rivers in 1820

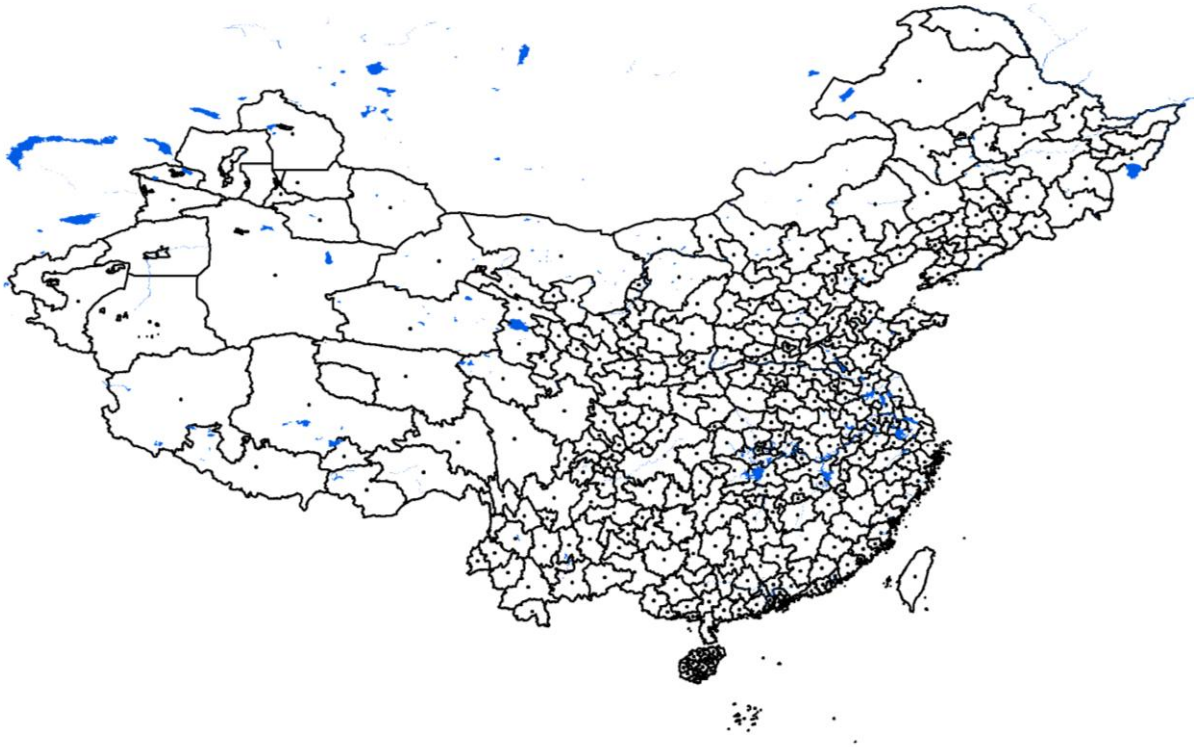


Figure B5:
Industry Index in China

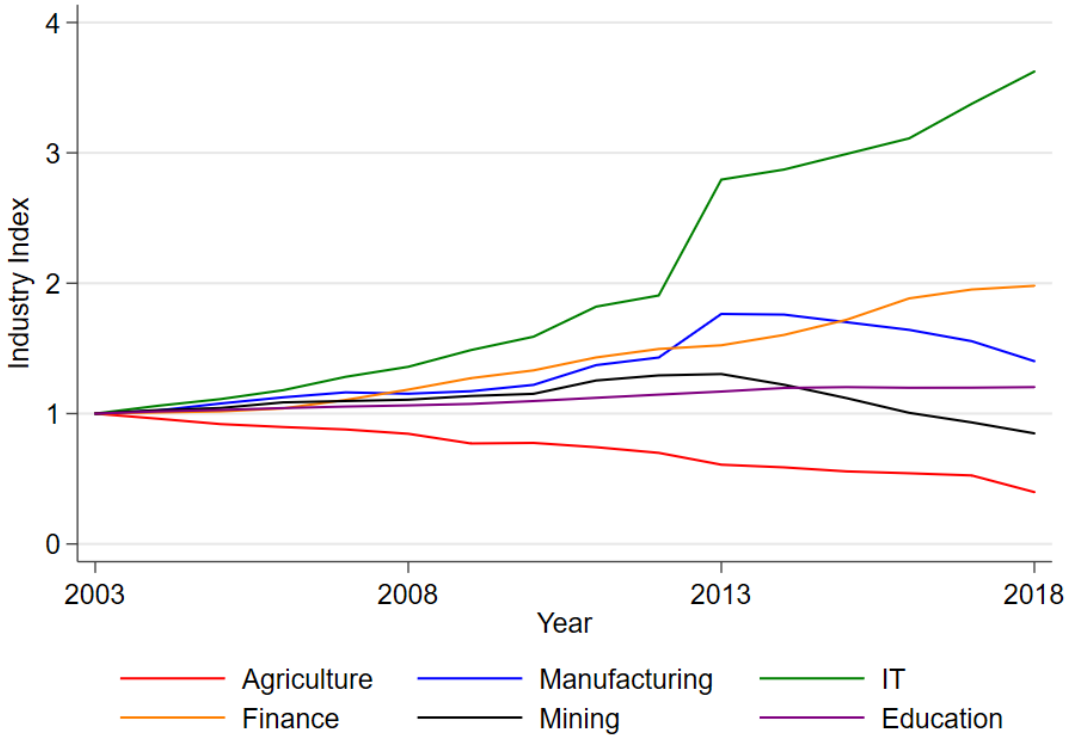
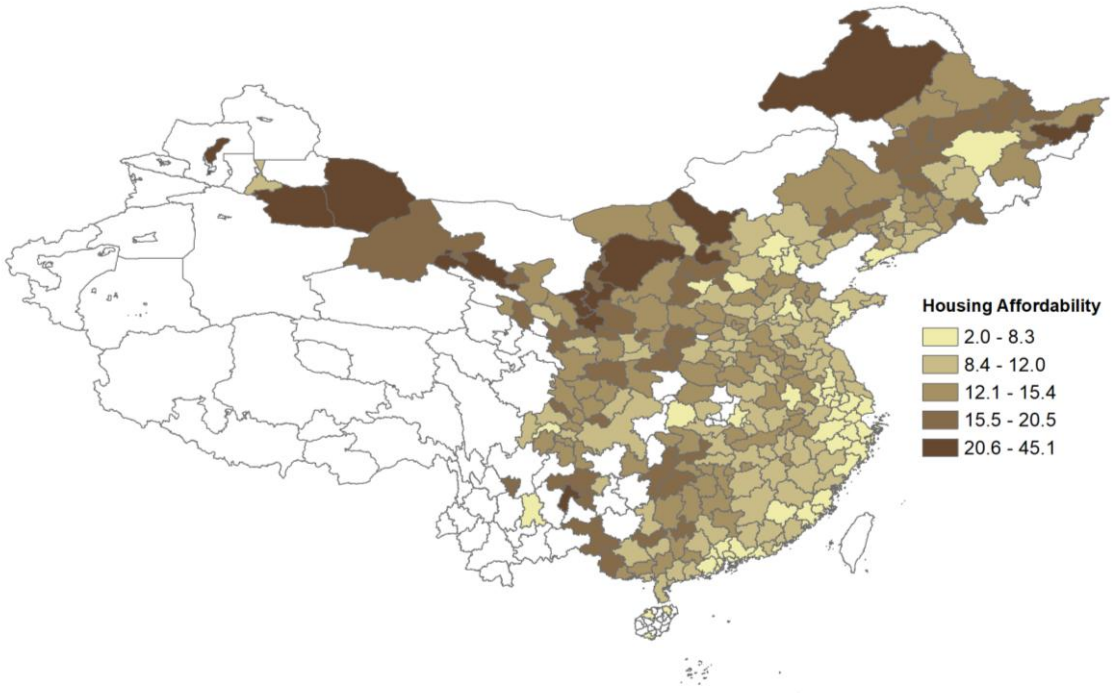


Figure B6:
Housing Affordability in China in 2018



Appendix C: Theoretical Appendix

To prove the impacts of regulatory tax on housing markets:

$$\frac{\partial \pi}{\partial K} = 0 = A\frac{\alpha\beta}{1+\alpha}K^{\beta-1}L^{1-\beta}w\alpha\psi\left(AK^{\beta}L^{1-\beta}\right)^{\frac{-1}{1+\alpha}} - i - tA\beta K^{\beta-1}L^{1-\beta}$$

Take the first order derivative with respect to t on both sides of the above equation:

$$\begin{aligned}0 = A\frac{\alpha\beta}{1+\alpha}(\beta-1)K^{\beta-2}L^{1-\beta}w\alpha\psi\left(AK^{\beta}L^{1-\beta}\right)^{\frac{-1}{1+\alpha}}\frac{\partial K}{\partial t} \\ -\frac{1}{1+\alpha}L^{1-\beta}A\frac{\alpha\beta}{1+\alpha}K^{\beta-2}w\alpha\psi\left(AK^{\beta}L^{1-\beta}\right)^{\frac{-1}{1+\alpha}}\frac{\partial K}{\partial t} + (\beta \\ -1)tA\beta K^{\beta-2}L^{1-\beta}\frac{\partial K}{\partial t} - A\beta K^{\beta-1}L^{1-\beta}\end{aligned}$$

$$\begin{aligned}\beta K = \frac{\partial K}{\partial t}\left[\frac{\alpha\beta}{1+\alpha}(\beta-1)w\alpha\psi\left(AK^{\beta}L^{1-\beta}\right)^{\frac{-1}{1+\alpha}} - \frac{1}{1+\alpha}\frac{\alpha\beta}{1+\alpha}w\alpha\psi\left(AK^{\beta}L^{1-\beta}\right)^{\frac{-1}{1+\alpha}}\right. \\ \left. + (\beta-1)t\beta\right]\end{aligned}$$

Therefore:

$$\frac{\partial K}{\partial t} < 0$$

To prove the impacts of regulatory tax on land markets:

$$r = AK^{\beta}L^{-\beta}w\alpha\psi\left(AK^{\beta}L^{1-\beta}\right)^{\frac{-1}{1+\alpha}} - \frac{iK}{L} - tAK^{\beta}L^{-\beta}$$

$$\frac{\partial r}{\partial t} = \frac{\partial K}{\partial t}\left[\beta AK^{\beta-1}L^{-\beta}w\alpha\psi\left(AK^{\beta}L^{1-\beta}\right)^{\frac{-1}{1+\alpha}}\frac{\alpha}{1+\alpha} - \beta AK^{\beta-1}L^{-\beta} - \frac{i}{L}\right] - AK^{\beta}L^{-\beta}$$

As $\frac{\partial \pi}{\partial K} = 0$, it is easy to prove that $\frac{\partial r}{\partial t} = -AK^{\beta}L^{-\beta} < 0$.