Extrapolative Households and Strategic Firms: Evidence from China's Land and Housing Market

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Abstract

This paper investigates households' extrapolative behaviors and developers' responses in China's land and housing markets. Our stylized model predicts that when households extrapolate in the housing market, developers with nearby land stocks strategically bid higher, capitalizing on households' mistakes. Leveraging the exogeneity of land auctions' dates, we show that higher land premiums lead to increased transaction prices and volumes of nearby houses. Furthermore, developers with land stocks near the auctioned land paid higher premiums. We implement various tests and exploit a policy reform to rule out alternative explanations to support the notion of developers manipulating homebuyers' behaviors.

Keywords: Housing Market; Land Auctions; Developers' Strategies

JEL Classification Numbers: R30; R31; R10

1 Introduction

Individuals with limited sophistication often make suboptimal financial decisions, thus susceptible to exploitation by more experienced counterparts (Bayer et al., 2021). This dynamic is especially pronounced in the housing market, where households frequently base their future price expectations on past housing price trends, a practice known as extrapolation (Case et al., 2012). Extrapolators mistakenly believe that housing demand grows as fast as past housing price changes, while the actual level of demand may be much smaller (Glaeser and Nathanson, 2017; Barberis et al., 2018; DeFusco et al., 2022). More sophisticated market actors, such as real estate developers, may exploit these misconceptions, leveraging less experienced households' errors to their advantage.

This paper examines whether real estate developers in China can influence housing prices by taking actions that manipulate homebuyers' expectations regarding those prices. China offers a unique setting to study these issues. First, in China, local governments own all urban land and permit leasing land parcels to real estate developers through auctions. The prices of auctioned land are widely publicized, particularly for parcels that achieve record-high prices. The land price shocks help us empirically identify extrapolations in the housing market. Second, local governments heavily rely on revenues from land sales; at the same time, they aim to stabilize housing prices in alignment with the central government's principle that *houses are for living in, not for speculation*. Facing these conflicting objectives, local governments rolled out several policies to anchor homebuyers' expectations regarding house prices. By observing whether developers' strategies in land auctions change when they can influence homebuyers' house price expectations, we can identify whether developers manipulate homebuyers' behaviors.

To guide our empirical analysis, we construct a stylized model to examine households' and developers' strategies in the housing and land markets. Central to our model is the assumption that when a land parcel is sold at a price higher than the price predicted based on the housing market fundamentals, it triggers an increase in the demand for nearby houses. While our model does not directly specify the underlying mechanism of this assumption, Appendix A demonstrates that when nearby land prices positively influence households' expectations of future housing prices, the demand for local housing increases when the nearby land is auctioned at a high premium. Based on this assumption, we show that when developers possess additional housing stocks near the auctioned land parcel, they are willing to pay a higher price for the land compared to developers without nearby land assets. This group of developers benefits from the cross-subsidy effect, where the land premium hike increases demand for existing housing development and increased profits attributable to local market power. Our concept of auction-based manipulation aligns with the theoretical model discussed in Benabou and Laroque (1992), describing how insiders with access to imperfect private information may use skewed public statements to manipulate stock prices.

We begin our empirical analysis by examining whether the assumption that households extrapolate from high land prices holds. Since we do not observe the fundamental factors of the housing market, we measure land premium as the difference between the growth rate of land price and the local housing price trend, quantifying the shock to local households. To gauge how land premium impacts housing demand, we examine the change in housing prices pre- and post-land auctions. Specifically, we compare the price change for properties within 3 km of the auctioned land parcel and those located more distant. If the exact month the land got auctioned is not correlated with local housing demand shocks, sharper changes in nearby housing prices after the land auction suggest that local households respond to the auction outcomes. However, as land parcels were auctioned at different times over our sampling period, and the effect of the auctions may vary across cities and years, the traditional DID estimation could be biased in our setting, according to several recent studies (Goodman-Bacon, 2021; Callaway and Sant'Anna, 2021). Therefore, we used the estimation method proposed by De Chaisemartin and d'Haultfoeuille (2020) to report the results.

Before the land auction, the housing prices near the auctioned land were similar to those further away, and the difference is small and statistically insignificant. The pre-treatment trend validates our use of the DID strategy. In the month of the auction, a one standard deviation increase in the land premium leads to a 0.5 percent change in the transaction price of houses located within 3-km of the land parcel relative to those located further away. This response exhibited strong momentum, continuing for four months after the auction, after which the local housing price began adjusting downwards. For newly-built houses, we find similar patterns. The inverse U-shape pattern is also present in housing transaction volumes. The initial positive return followed by a subsequent reversal and the rise in transaction volumes are hallmarks of financial bubbles, suggesting possible market manipulations.

Leveraging a unique survey eliciting respondents' beliefs about future housing prices, we provide direct evidence that the increased demand is driven by households becoming more optimistic about future housing prices. We find that households living near land parcels auctioned at a higher premium are more optimistic about both short-term and long-term housing prices, after controlling a rich set of individual and time fixed effects.

This extrapolation from land premiums by households incentivizes developers with housing stocks near the auctioned land to inflate the land price. We find that developers with land stocks within 3-km of the auctioned land paid a 3.9 percent higher premium after conditioning on a rich set of city and year fixed effects. Similar effects prevail even when accounting for changes in local market share as a proxy for increased profits from higher local market power.

The challenge lies in identifying this effect as developers' attempts to manipulate and capitalize on homebuyers' extrapolation behaviors. We implement a direct test leveraging a policy that explicitly regulates the price of houses built on the auctioned land parcel. Though this regulation violates the basic principles of a competitive economy, it allows us to study developers' auction strategies when both households and developers have identical beliefs about future housing prices. In cities that adopted this policy, households would not extrapolate, and developers would have little incentive to inflate the land price. We separate the sample into two groups based on whether a city adopted the price limit policy. We find that developers with land stocks near the auctioned parcel paid a 6.6% higher price in cities without the policy. In contrast, we do not observe this pattern in cities where the price limit was effective. We further investigate the policy's dynamic impacts on the land premium, separately for developers with and without nearby land parcels. We find that developers with nearby land parcels significantly lowered the premium after adopting the price limit policy. In contrast, the premium paid by developers without nearby housing stocks is unaffected by the policy. This direct test boosts our confidence that the developers are changing their auction strategy to exploit households' extrapolative housing demand.

Moreover, we conducted several additional exercises to show that alternative explanations do not fully explain the heightened premium. One possibility is that larger firms with better financing resources may bid higher to drive smaller firms out of the market. We restrict our sample to firms not listed on China's stock market and not listed as the top 100 developers by independent real estate consulting firms. Our findings are robust after limiting our sample to firms with similar financing resources. Another possibility is that developers with land stocks near the auctioned land may be familiar with the local infrastructure plan and expect higher future housing prices. To examine this interpretation, we separate the samples based on whether a new school or metro line is built within 3-km of the auctioned land two years after the auction. We find similar responses in both samples and rule out the alternative hypothesis. These results strongly support our hypothesis that developers utilize high land auction bids to influence households in the housing market.

Our findings complement the theoretical literature on extrapolative households in housing markets. Glaeser and Nathanson (2017) introduced naive homebuyers, who neglect to account that previous buyers were learning from prices and instead take past prices as direct measures of demand. They find that when all agents follow their behavioral theory, their calibrated model closely matches the empirical value of one- and two-period auto-correlations in housing prices. Other works in this vein include Barberis et al. (2018), Burnside et al. (2016), DeFusco et al. (2022), Guren (2018), and Piazzesi and Schneider (2009). Despite the theoretical success, empirical work on homebuyers' irrationality and implications is scarce. Armona et al. (2019) is a rare exception. They investigated how consumers' home price expectations respond to past home price growth and found that year-ahead home price expectations are revised in a way consistent with short-term momentum in home price growth. In contrast, we identify homebuyers' irrationality without eliciting their subjective beliefs by examining how they respond to unexpected price movements from land auctions. Chan et al. (2016) compared homeowners' house valuations and market estimates and found that homeowners were reluctant to promptly adjust their valuations downwards amidst market downturns. Our findings suggest that during market downturns, homebuyers are less responsive to land auction premiums, thereby contributing to the existing literature by providing empirical evidence derived from quasi-experimental variations.

The analysis in this paper contributes to a growing literature on manipulative behavior in less developed markets. A key feature of market manipulation is a predictable pattern of price reversal. For example, Khwaja and Mian (2005) examines the trading records of brokers in the Pakistan stock exchange and identifies wash trades that generate temporary price appreciation and reversal patterns. Similarly, Chen et al. (2019) documented evidence of manipulation around price limits in China, demonstrating how large investors artificially inflate prices to reach trading limits, subsequently selling at elevated prices to unsophisticated retail investors. Titman et al. (2022) pinpointed a cohort of "suspicious" firms engaging in stock splits to boost their share prices spuriously. Leveraging account-level data from the Shanghai Stock Exchange, their findings revealed that small retail investors tend to buy into firms announcing dubious splits, whereas more seasoned investors build up positions before such announcements and liquidate them in the aftermath. Our study diverges from prior research by examining the manipulative tactics of developers in the land market and their repercussions on housing prices. Using ex-ante information, we identify a group of developers that artificially inflate land prices in auctions and show that housing prices near the auctioned land parcels subsequently experience temporary price appreciation and reversals. This focus not only differentiates our work from existing studies but also sheds light on the broader implications of land market manipulations on housing market dynamics.

Lastly, our research builds on the literature studying China's land market. Since the revenue from transferring the land use rights constitutes almost 80% of the county budgets, existing studies have studied the land market primarily from the political economy perspective. For example, there is ample evidence linking land revenue with corruption (Cai et al., 2013; Chen and Kung, 2016; Chen and Kung, 2019; Chen et al., 2023). Du and Peiser (2014) examined local governments' land hoarding behavior. We provide an alternative perspective and focus on the households' extrapolation from land prices and developers' strategic responses. Chang et al. (2023) is closely related, and they shared our intuition that land prices shape residents' and firms' expectations and confidence regarding the local economy. However, they focused on local governments' active management of land prices after the Covid-19 pandemic shock.

The rest of the paper is organized as follows. We describe the institutional background and data in Section 2. Section 3 describes the conceptual framework, which provides a hypothesis for the empirical analysis in Section 4. Section 5 concludes.

2 Background and data

2.1 Institutional background of China's land and housing market

Several features of China's land and housing market make it particularly suited for this study. First, land sales can be observed separately from housing units. Unlike most countries, including the United States, where almost all housing market transactions involve sales of both land and buildings simultaneously, the local government in China owns all urban land and permits leasing land parcels to developers. The developers who win the auctions proceed to build housing units on the parcels transferred and sell those units to households.

The local planning bureau is responsible for long-term land-use planning. Based on these plans, the land-use allocation committee decides the development (e.g., floor-to-area ratio) restrictions and the sequencing of sales of properties available each year. The allocation committee typically consists of the mayor and heads of relevant local bureaus (e.g., planning and land bureaus). The allocation committee sets the reserve price for each property based on appraisals from independent appraisers, and the land bureau chooses the auction type. There are mainly two types of auctions used in China's land market. About 97% of sales in major cities are accounted for by two-stage auctions (guapai) and English auctions (paimai). (See Cai et al. (2013) for more details on China's land market auctions.)

Both types of auctions are public events, often recorded on video with press coverage. The prices of auctioned land are widely publicized, particularly for parcels that achieve record-high prices. For instance, a significant land auction took place in Guangzhou on November 16, 2020, attracting substantial attention in local newspapers as it sold a land parcel for 4.8 billion yuan, setting a new record with a value exceeding fifty thousand yuan per square meter[1]. Numerous anecdotal accounts highlight how the outcomes of land auctions significantly impact local housing prices. For example, in the aftermath of the aforementioned record-setting land auction, the listing prices of houses in close proximity experienced a sudden surge. Figure A1 shows a snapshot of one such listing from Lianjia, a prominent real estate brokerage firm in China. The listing prices exhibited an 8.5 percent increase on the same day the nearby land was sold at a record price, indicating an immediate and substantial supply-side response to the land auction outcomes. In the empirical analysis below, we use a Difference-in-Differences (DID) approach to causally identify the impacts of land auction outcomes on the housing market.

2.2 Data

Our analysis builds on four unique datasets. These datasets provide rich information about China's land and housing market.

The land auction dataset We construct the land auction dataset from the Land Bureau of China (`www.landchina.com`). The data set includes about 56,000 land parcel transactions from 35 cities in China between 2008 and 2017, recording detailed information about the transaction, including the area, auction type (two-stage auction or English auction), floor-to-area ratio, sale price, sale date and developer names who won the auction. We collect each parcel's longitude and latitude information from its name and address. Figure 2 plots the number of land parcels supplied and the average growth rate of land prices between 2008 and 2017 separately for each city. The costs of land skyrocketed in this sampling period. The average annual growth rate of land prices in the 35 cities of China is 17%. This suggests that China experienced a prolonged housing boom market during this period, consistent with the patterns documented in Fang et al. (2016).

The existing housing transactions dataset We obtained the housing transaction data set from

[1] Source: Guangzhou Public Resources Trading Center. http://www.gzggzy.cn.

Lianjia [2], one of China's largest real estate brokerage firms in China. This dataset includes about 0.7 million housing transactions from 13 cities between 2010 and 2017. Each record provides the transaction price, transaction date, the name of the residential compound and detailed housing characteristics, such as the number of bedrooms. Unfortunately, the dataset does not record the detailed listing price adjustments and number of visits to the house. Therefore, we focus on the housing transaction prices instead of the listing price.

The newly-built housing projects transactions dataset We use the sales information of newly-built housing projects from the China Index Academy(CIH), a real estate information and analytical service platform. This dataset covers about 0.6 million records of newly built houses from 35 major cities between 2008 and 2017. Each record includes the name and address of the housing project, developer names, and the monthly average transaction prices and volumes.

House Price Expectation and Home Purchase Behavior of Chinese Urban Households (HPES) We use the HPES, a survey designed to elicit households' expectations of future housing prices, to investigate the channels of land auctions on local housing markets. HPES was conducted quarterly during 2012-2013 in seven metropolitan cities (Beijing, Shanghai, Tianjin, Chengdu, Shenyang, Wuhan, and Xi'an) in China by the National Bureau of Statistics of China. Each quarter, households were interviewed with questions measuring their expectations of short-term and long-run housing prices. [3] Households also report detailed information about household demographic characteristics, with additional data on income and assets portfolio holdings. Notably, this survey employed a yearly tracking approach, interviewing the same respondents across four quarters each year. This allows us to observe how individuals change their short-term and long-run housing price expectations when observing the land auction outcomes.

These datasets facilitate our analysis in several ways. First, when we study the impact of land auction outcomes on the housing market, it is critical to distinguish houses located near an auctioned land from those located further away. This distinction is at the heart of the identification strategy.

[2] https://bj.lianjia.com/ershoufang/

[3] Respondents were asked, "How much do you think the house price in your city will increase in the next year (in percentage)?" and "How much do you think the house price in your city will increase in five years from now (in percentage)?". These two questions measure households' expectations of short-term and long-term housing prices.

We exploit the longitudes and latitudes in the land and housing datasets to calculate the distances between each land and houses and classify if houses are located within a concentric ring of an auctioned land. [4] Similarly, when analyzing developers' strategies in land auctions, we need to differentiate developers with other housing projects near the auctioned land from those who do not. Again, we utilize the longitudes and latitudes in the land and newly-built housing datasets for this task.

Moreover, the key variable in our analysis is the premium that developers paid for the land. We need to construct a measure that proxies as signals of developers' high willingness to pay for the land. We define the premium as the differences between the average monthly growth rates of land and housing prices. [5] Specifically, we first calculate the average monthly growth rate of land prices by comparing the land prices from each auction to the average prices from previous auctions in the preceding year on land parcels situated within 3 km. We then calculate the average monthly growth rate of house prices within a 3 km radius of the land auction by comparing their current prices with those from the preceding year. The premium is defined as the differences between these growth rates. [6] A positive premium suggests that the land price grows faster than nearby housing prices and could alter housing market participants' expectations of future housing prices.

Table 1 reports the summary statistics of the land premium. The mean and standard deviation of the premium are 0.028 and 0.116, respectively. Figure 3 plots the kernel density of the premium index. We can see that a substantial fraction of land is sold with a positive premium. Figure 4 plots the average premium separately for each city. We find that the highest premium, 12.7%, is found in Urumqi, while Chengdu has the lowest premium, -0.33%.

[4]We choose the bandwidth of the concentric ring as 3 km by investigating the spatial attenuation pattern of the auctions' impacts on the housing market. Appendix B discusses this procedure in detail.

[5]We use the prices of newly-built houses to calculate the average monthly growth rate of housing prices. The reason is that the land auction and the newly-built housing projects transactions dataset cover the same 35 major cities in China. In contrast, the existing housing transactions dataset only covers 13 cities in China.

[6]An alternative way to define the land premium is to subtract the reserve price of the land from its transaction price. News reports covering land auction outcomes often highlight this statistic when discussing the unexpectedly high land price. However, the land auctions dataset does not record the reserve price for each land. Moreover, this alternative measure introduces an unobserved confounding factor: the local government's decision on each land's reserve price. As a result, we do not pursue this approach.

3 Conceptual framework

We use a simple model to illustrate the mechanisms that developers attempt to use land auction bids to strategically influence the housing market and how this depends on home buyers' reactions to land auction results.

Consider two land parcels and two property developers: land a was already acquired by developer i (the incumbent), and land b is being auctioned where both developers i and j (the entrant) are interested. We assume that the cost of acquiring land b is $c_0 + c_1 d_b$ which consists of two components: c_0 is the cost of acquiring the land at the prevailing market price, and $c_1 d_b$ is the extra cost that is increasing in the premium of the bid, where d_b is the premium relative to the prevailing market price paid by the winning developer in acquiring land b and c_1 is a fixed parameter. We assume a linear housing demand function from households for the local market of land parcels a and b:

$$h_a = h_a(p_a; p_b; d_b) = q_a + p_a \quad + p_b \quad + d_b \quad {}_a; \tag{1}$$

$$h_b = h_b(p_a; p_b; d_b) = q_b + p_a \quad + p_b \quad + d_b \quad {}_b; \tag{2}$$

where p_a and p_b are house prices in deviation from the prevailing market price. The housing demand equals q_a and q_b when there are no deviations in housing or land prices from the market prices, and we interpret q_a and q_b as measuring the fundamentals in housing demand. < 0 is the own price effect on demand. The housing demand model is an oligopolistic competition model with heterogeneous products and linear price effects (Mobley, 2003).

In contrast to standard demand functions, we make the key assumption that housing demand increases with higher auction premium of nearby land, measured by positive ${}_a$ and ${}_b$. We do not directly model the underlying force driving this effect but provides a micro-foundation in Appendix B based on extrapolative beliefs. Intuitively, housing serves both as consumption good and financial asset. As a result, extrapolative households may believe that future housing price would increase after observing high land price and increase their housing demand. We investigate whether this assumption holds in our empirical analysis exploiting the exogeneity of the auction dates in China's land market.

Assumption 1 (Extrapolative housing demand)**.** *Assuming that* $_a > 0$ *and* $_b > 0$*, housing demand and house prices increase with nearby land premium.*

Given how home buyers react to land premium, we now turn to the strategies of developers in land auctions. The profit functions of developers are

$$
\begin{aligned}
{}_a &= (p_a \quad c)h_a(p_a; p_b; d_b);\\
{}_b &= (p_b \quad c)h_b(p_a; p_b; d_b);
\end{aligned}
$$

where c is the marginal cost. Developers choose prices to maximize profits from property development.

If the new land b is acquired by developer i which already owns nearby land a, the developer acts like a monopoly in the local housing market and chooses p_a and p_b simultaneously to maximize profits:

$$
{}_{a;b} = \arg\max_{p_a;p_b} \; {}_a + \; {}_b:
$$

On the other hand, if the new land b is acquired by developer j (entrant) which does not own land nearby, developers i and j will act like a duopoly in the local housing market and engage in oligopolistic price competition. Developer i chooses p_a to maximize $_a$ given p_b, and similarly developer j chooses p_b to maximize $_b$ given p_a. In equilibrium, the prices satisfy

$$
\begin{aligned}
2 \; p_a + \; p_b &= c \quad d_b \; {}_a \quad q_a;\\
p_a + 2 \; p_b &= c \quad d_b \; {}_b \quad q_b:
\end{aligned}
$$

The equilibrium profits under duopoly are denoted by $_a$ and $_b$ for developers i and j, respectively. is the cross price effect on demand. We make the following assumption on the value of .

Assumption 2 (Cross price effect)**.** *Assuming that* $\neq 0$.

With Assumption 2, monopoly profit ($_{a;b}$) is greater than duopoly probit ($_a$ + $_b$). First, because the monopoly can implement the pricing strategies of duopolies, $_{a;b}$ $_a$ + $_b$. The strict inequality holds because the monopoly can internalize the external effect of one unit's price on the demand of other nearby units.

Our model provides direct implication of developers' willingness to pay for the land parcel *b*. Figure 1 compares the revenue and cost of developers *a* and *b*, for a set of reasonable parameter values. The vertical lines (1) and (2) show the maximum premium that the entrant and that the incumbent developer *i* are willing to pay, respectively. For the entrant firm, it is willing to increase the bids until the cost of acquiring the new land *b* equals the profit from land *b*. For the incumbent developer *i*, its willingness to pay depends on the difference between the monopoly profit from owning *a* and *b* jointly and the duopoly profit from owning only *a*, net of the additional cost of acquiring *b*. It is clear that the incumbent developer *i* bids higher than the entrant *j*. This heightened willingness to pay stems from two sources: the cross-subsidy effect, where the land premium hike increases demand for existing housing development, and increased profits attributable to a local market monopoly.

The predictions in Figure 1 remain valid under a wider range of parameter values, provided that Assumptions 1 and 2 hold. We formalize these results in the following hypothesis:

Hypothesis 1. *Assuming that Assumptions 1 and 2 hold, and an interior equilibrium exists, the developer who already owns land near the land being auctioned is willing to pay higher premium to acquire the land compared with developers which do not have nearby land holdings ($d_{b;2} > d_{b;1}$ in Figure 1). The higher willingness to pay is due to two reasons: cross-subsidy where land premium from the new land auction increases demand for existing housing development* ***(Hypothesis 1A)*** *and higher profits for developers with greater local market power* ***(Hypothesis 1B)****.*

4 Empirical analysis

In this section, we empirically examine the assumption of extrapolative households in the housing market and the model's prediction of developers' strategic responses. First, we describe the identification strategy of households' extrapolative behaviors, and present the key results, including changes in the housing market and households' subjective beliefs of future housing prices after a land auction. We then present evidence of developers' strategic efforts to exploit households' mistakes. The section concludes with an analysis of policy implications.

4.1 Local housing market responses to nearby land auctions

Central to our model's prediction is Assumption 1, positing that households exhibit increased demand for housing when a nearby land parcel is sold at a high auction premium. However, straightforwardly comparing housing prices near land parcels with high auction prices against those further away doesn't suffice to validate Assumption 1. The reason is that houses near land parcels sold at high premiums are more likely to enjoy better amenities. We can control for some of the differences in attributes, but should be concerned that these homes also differ along unobserved attributes. One way to address this issue is to compare sales prices before and after the auction. This is the approach used in Campbell et al. (2011) to study the effect of foreclosure on local housing prices. However, this introduces an additional potential source of endogeneity. For example, land parcels auctioned at high premiums tend to be located in a neighbourhood that is increasing in price at a faster-than-average rate. Endogeneity and causal effect both create a correlation between the presence of a land parcel auctioned at a high premium and neighborhood price increases, so this approach cannot be definitive on whether high land premium causally affects neighboring prices.

To address these concerns, we follow Anenberg and Kung (2014) to look at the changes in local housing prices in the few months surrounding a new nearby land auction. If the exact month the land got auctioned is not correlated with a local shock that causes nearby sellers to adjust their list prices, then any movement in transaction prices is strong evidence that both local buyers and sellers are responding to the auction outcomes. In general, our identification assumption is reasonable because the specific timing of an auction is primarily influenced by exogenous factors, such as the timing of various stages of the auction process.

Based on the conceptual framework and the discussions above, we examine the effect of land auctions on housing prices using the following equation:

$$y_{ikjt} = \beta_0 + \sum_{n \neq -1} \beta_1^n premium_k \times land_{it}^n + \beta_2 Z_k + \beta_3 X_{it} + \mu_k + \lambda_t + \omega_{jt} + \varepsilon_{ikjt} \qquad (3)$$

where the dependent variable is the log price of housing unit i in residential compound k in city j and month t, the $premium_k$ is the index formally defined in section 2.2, measuring the relative growth rate of the land price near the residential compound k, $land_{it}^n$ is the dummy variable indicating whether the housing unit i is located within a 3-km of any land auction in n months relative to the month t of the auction, Z_k controls the log of the total amount of land auctioned within 3-km of residential compound k, X_{it} controls various characteristics of the housing unit i, [7] μ_k is the fixed effect for the residential compound k, λ_t is the year-month fixed effect, and w_{jt} measures the city by year fixed effect. Using this empirical specification, we can examine the response dynamics of housing prices to land auctions. [8] The parameters of interest are β_1^n, measuring the change in the housing located within 3 km of the land auction in months relative to the auction date, compared to the price of those located further away. As assumed in our conceptual framework, we should observe positive β_1^n when $n > 0$.

Equation (3) represents a Difference-in-Differences identification strategy, augmented with additional control variables. Recent studies have highlighted the potential bias in traditional DID estimates due to heterogeneous treatment effects—when a single treatment impacts various samples or at different times in different ways. This issue arises particularly when treatments are introduced in a staggered fashion across a lengthy panel data set (Callaway and Sant'Anna, 2021; Goodman-

[7] These characteristics include the square feet, direction, number of bedrooms, the number of floors of the house, and the total number of floors of the building.

[8] We choose the bandwidth of the concentric ring as 3 km by investigating the spatial attenuation pattern of the auctions' impacts on the housing market. Appendix B discusses this procedure in detail.

Bacon, 2021; De Chaisemartin and d'Haultfoeuille, 2020). Traditional DID approaches typically use the groups treated earlier as comparison cohorts for those treated later, presupposing a constant treatment effect over time. However, if the treatment effect varies—increasing or decreasing—over the years, the traditional DID methodology may mistakenly attribute some of this variation to the fixed effects of the years, leading to an underestimation or overestimation of the actual treatment effect. To mitigate this bias, we have employed the two-way fixed effects estimator introduced by De Chaisemartin and d'Haultfoeuille (2020).

Figure 5 plots pre-treatment and post-treatment trends separately for existing and newly-built housing transactions. First, before the land auction, the housing prices near the auctioned land are similar to those further away, and the difference is small and statistically insignificant. The pre-treatment trend validates our use of the DID strategy. Second, during the precise month of an auction, there's a notable surge in housing transaction prices. In the month of the auction, a one standard deviation increase in the land premium leads to a 0.5 percent change in the transaction price of houses located within 3-km of the land parcel, relative to those located further away. [9] This effect demonstrates considerable momentum, persisting for four months post-auction before a subsequent adjustment downwards. The initial positive return followed by a subsequent reversal is a distinguishing feature that separates market manipulation from other opportunistic behavior.

Splitting our sample periods into upturn and downturn periods, depicted in Figure 6, starkly contrasts the effects. [10] Positive and significant effects are evident in upturn periods, while fluctuations around insignificance characterize downturn periods. [11] The robust responses of local housing markets to land auction outcomes can be interpreted as households expecting local housing prices to increase and demanding more local housing after observing high land auction premi-

[9] The complete set of regressions results used to plot Figures 5, 6 and 7 are reported in Appendix B. The standard deviation for the land premium is 0.12. The 1.4 percent price increase is calculated by multiplying the standard deviation of the land premium with the corresponding coefficient, 0.0390, reported in Table A3.

[10] The housing upturn period is defined when a city's housing price growth rate is higher than the city's GDP growth rate. And the housing downturn period is defined as the opposite.

[11] Figure 6 only reports the results using the newly-built housing dataset. We do not include the results using the existing houses dataset due to its limited sample coverage of a representative set of cities. More than 50% of the observations in the existing houses dataset are transactions in Beijing. Therefore, when separating the sample into housing upturns and downturns, the effect in different housing cycles in Beijing dominates other cities. The results for the existing houses are available upon request.

ums. Developers, perceived as industry experts, possess significant forecasting advantages. As a result, households closely monitor land auction outcomes as indicative signals of housing values, a common trait observed in markets grappling with severe information asymmetry issues (Yung and Zender, 2010). Auction signals reinforce optimistic beliefs about future housing prices among local market participants. However, these signals may not be enough to reverse pessimistic beliefs in real estate downturn markets. In other words, homeowners tend to incorporate market signals more readily during periods of housing market upturn, which is consistent with the observations made by Chan et al. (2016) and Shen et al. (2022) through comparisons of homeowners' self-reported home values and market estimates.

To corroborate this intuition, we investigate if higher land premiums make households more optimistic about future housing prices. Specifically, we link households' expectation of future housing prices in the HPES with the land auction outcomes and estimate the following regression

$$y_{ct} = {}_0 + {}_1 premium_{ct} \quad land_{ct} + {}_c + {}_t + {}_{ct}; \tag{4}$$

where the dependent variable is individual c's expectation of future housing price growth rate measured in percentage terms in quarter t, the $premium_{ct}$ is the average land premium within 3-km of individual c's home address in quarter t, $land_{ct}$ is the dummy variable indicating whether individual c's home is located within 3-km of any land auction in quarter t, ${}_c$ and ${}_t$ are individual and quarter-by-year fixed effects. Table 2 suggests that households exposed to land auctions with higher premiums are more optimistic about short-term and long-run housing prices.

Figure 7 illustrates that higher land auction premiums are also associated with a significant increase in the purchases of newly-built houses post-auction, suggesting a possible link to financial bubble dynamics. [12] This rise in transaction volume, a hallmark of financial bubbles, has prompted researchers to adapt the extrapolative framework to account for such high volumes. For instance, Barberis et al. (2018) propose that investors with "wavering" beliefs—shifting attention between

[12] The existing houses data only include housing transactions brokered through the real estate agency of Lianjia. Since Lianjia's market share varies in different cities, we do not use this source to calculate the land auctions' impacts on transaction volumes.

signals over time—exhibit more volatile demand for assets during market run-ups, leading to frequent changes in asset holdings. Similarly, Liao et al. (2022) integrates the concept of realization utility, a type of nonstandard preference, with extrapolative beliefs to elucidate the observed high transaction volumes in bubbles. Nevertheless, these theoretical models are mainly pertinent to highly liquid markets and may not directly apply to the less liquid housing market. Our analysis more closely aligns with DeFusco et al. (2022), who suggest that a substantial portion of the transaction volume can be attributed to short-term speculation. This speculation is likely bolstered by the high visibility of land auctions, as discussed in the background section, which potentially draws new speculators into the local housing market, amplifying transaction volumes.

4.2 Developers' strategies in land auctions

Building on the analysis in section 4.1, we use the following specification to investigate whether Hypothesis 1 holds:

$$y_{ljt} = {}_0 + {}_1 \quad Z_{dlt} + {}_2 \quad X_l + w_{jt} + {}_{dljt} \tag{5}$$

where the dependent variable is the index of land premium formally defined in section 2.2, measuring the relative growth rate of the land price, Z_{dlt} denotes whether the developer d has other land stock within 3-km of the land l, X_l measures the total number of housings supplied by land l, and w_{jt} measures the city by year fixed effect. The parameter of interest is ${}_1$ and the Hypothesis 1 in our conceptual framework predicts a positive ${}_1$, suggesting that developers with land stock near the land l bid more aggressively.

Table 3 reports the estimation results of equation 5. In the first three columns, we check whether land auctions won by developers with other land stock near the auctioned parcel are more likely to be sold at higher premiums. These columns differ in the types of fixed effects controlled. In our most preferred specification, where we control city and years, land type and land transfer type fixed effects, we find that developers with other land stock near the auctioned parcel paid a 3.9 percent higher premium. [13] As discussed in our conceptual model, we can break down this effect into two channels: the cross-subsidy effect where the land premium hike augments demand for existing housing development and increased profits attributable to higher local market power. Columns 4 and 5 in Table 3 augment the empirical specification by adding interactions between the log area of housing held by the developer near the auctioned land and whether it holds land stock in the neighbourhood, and interactions between the change in market share after winning the land auction and whether it holds land stock in the neighbourhood. [14] We find that both interaction terms are positively significant, suggesting that developers with land stock near the auctioned land pay a higher premium in the land auctions for higher cross-subsidies and monopoly profits. Column 6 controls these two interactions simultaneously and suggests that developers with housing stock near the auctioned land, on average, pay 2.2% higher premium. This suggests that the cross-subsidy effect accounts for more than half of the increase in the land premium when a developer with nearby land stock wins the land auction. [15] Columns 7 and 8 report estimation results restricting samples to cities that are in a real estate market upturn and downturn, respectively. We find that developers with nearby land stock only pay higher prices in a boom market, consistent with the observation that higher land premium increases the demand of local housing only in a market boom.

Price regulation policy There are a few identification challenges regarding whether we can use this empirical specification to causally identify the developers' responses in their auction strategy. It is possible that developers with nearby land parcel pay higher premium driven by other motives, such as economies of scale. To address this, we first implement a direct test leveraging a policy reform that explicitly regulates the price of houses built on the auctioned land parcel. As discussed in the background section, each land parcel is allocated with a reserve price. The final price of land

[13] The land type refers to the designated use of the land, including middle and low-priced, medium and small-sized ordinary residential land, ordinary residential land, public rental housing land, other residential land, other ordinary residential land, urban residential land, affordable rental housing land, economical applicable housing land, and high-end residential land. The land transfer type includes the methods used to auction land discussed in section 2.1.

[14] The market share of the developer after the land auction is calculated as the ratio of (developer's saleable area + newly-auctioned area) divided by (total saleable area + newly-auctioned area).

[15] The average effect is calculated as the combination of the main effect and the interaction term with the average log(area of nearby housing stocks). The average log(area of nearby housing stocks) is 14.46 and the average change in market share is 0.16.

is determined by the auction process. Beginning in 2011, cities began to adopt the policy of fixing the price of homes before auction while the land price is still determined by auctions, known as "limit on housing prices, competition for land prices (*xianfangjia, jingdijia*)." This seemingly contradictory policy arises from the conflicting objectives of local governments. Local governments heavily rely on the revenue from land auctions and seek to maximize the land price. Gyourko et al. (2022) found that city governments' revenues derived from land, including the land sale proceeds and auxiliary property taxes, weighed over 40% of the cities' total budgetary incomes in 2018. At the same time, they aim to stabilize housing prices in alignment with the central government's principle that houses are for living in, not for speculation. This unique policy setting offers a rare opportunity for researchers to observe developers' strategies in an environment where both developers and housing market participants possess an identical and precise perception of future housing prices. With regulated future housing prices, homebuyers are less inclined to project speculative trends. [16] As anticipated within our conceptual framework, developers with land holdings near auctioned land exhibit diminished incentives to bid higher in cities implementing this regulation. We categorize our sample into two groups based on whether each city has adopted the sale price limit policy and conduct separate analyses for these cohorts. As per our conceptual model, we anticipate observing solely positive $_1$ values in cities that have not embraced this policy.

Following this intuition, we classify our sample into two groups based on whether a city has adopted the sale price limit policy and repeat the exercises above separately for these two samples. Table 4 shows that developers with other land stock near the auctioned parcel paid a 6.6 percent higher premium in cities without the price limit, whereas the premium disappeared in cities with the price limit. Figure 8 further investigates the policy's dynamic impacts on the land premium, separately for developers with and without nearby land parcels. Panel A shows that developers with nearby land parcels significantly lowered the premium after adoption of the price limit policy. In contrast, panel B suggests that the premium paid by developers without nearby housing stocks is unaffected by the policy. These direct tests boost our confidence that the developers are changing

[16] The detailed list of cities that adopted the housing price control policy is included in Appendix B.

their auction strategy to exploit households' extrapolative housing demand.

Alternative mechanisms We conduct several additional exercises to show that alternative explanations does not fully explain the heightened premium. First, it may be possible that developers save more in marketing costs when they develop multiple land stock near each other. As a result, they bid more aggressively due to the reduction in costs, not because of the spillover effect. To address this concern, we collected the financial statements between 2008 and 2017 for all real estate firms listed in China's stock market and found that marketing costs only consist of 2.26% of firms' total costs. As a result, it is unlikely that a reduction in marketing costs can substantially influence firms' bidding strategy in land auctions.

Another concern is that large firms are more likely to own more land stocks so the $onsale_{dlt}$ could be an indicator of firm size. Since larger firms usually have better financing resources, they are capable of using higher bidding prices to drive smaller firms out of the market. Therefore, the coefficient $_1$ would capture the premium that larger firms are willing to pay arising from their financial advantages. To ensure that $_1$ captures the developers' responses to the spillover effect on the housing market, we implement a robustness check excluding large developers. We define large developers as either listed on China's stock market or listed as the top 100 developers by independent real estate consulting firms. In column 1 in Table 5, we re-estimate Equation 5 using a sample excluding large developers defined above. We find that, in this sample of developers with homogeneous financing abilities, developers with other land stock near the auctioned parcel paid about a 4 percent higher premium.

A more challenging identification concern is that firms may be heterogeneous in their ability to obtain information from the local government about the infrastructure development plan near the auctioned land. Firms with land stocks near the auctioned land may be already familiar with these plans and have higher expectations of future housing prices. Therefore, the coefficient $_1$ could capture these firms' higher subjective belief of future housing prices resulting from their better access to the infrastructure plan near the auctioned land. Even though we cannot observe developers' subjective beliefs, we provide a test to rule out the alternative interpretation of the coefficient $_1$. The intuition of the test is straightforward. Metro lines and schools are at the core of local infrastructure developments (Zheng et al., 2014, Sun et al., 2017). We can separate samples based on whether a new school or metro line is built within 3 km of the auctioned land two years after the auction and verify whether the adjustments of the developers in the auction strategy are similar in both samples. If we find similar responses in both samples, we can rule out the hypothesis that $_1$ captures firms' higher subjective belief of future housing prices due to their better access to the infrastructure plan near the auctioned land.

4.3 Discussions

This synthesis of evidence highlights a stark contrast in sophistication and potential returns between households and developers in the housing market. Households, drawing inferences from land auction outcomes, potentially face significant losses. Although quantifying these losses is challenging without datasets of repeated housing transactions, our event-study analysis unveils the dynamic effects of elevated land premiums, offering insights into the well-being of households prone to extrapolation. Following auctions where land parcels command high premiums, nearby housing prices initially surge, only to subsequently enter a downward trajectory. Consequently, households enticed by the local housing market experience capital depreciation mere months post-auction. This phenomenon aligns with findings from previous research, indicating that investors influenced by neighborhood dynamics at market entry generally under-perform compared to other investors (Bayer et al., 2021). Unlike stock market participants who have opportunities for learning, households engage in housing transactions infrequently, thus having limited chances to correct their errors. In contrast, developers with housing stock within a 3-kilometer radius of auctioned land often bid higher premiums, likely as a strategic move to capitalize on households' extrapolative tendencies.

The disparity in costs borne by households and profits accrued by developers, a consequence of household extrapolation, underscores the need for government intervention in land auctions. In response, local governments in China implemented price ceilings in land auctions in 2016, resorting to a lottery system upon reaching these ceilings. However, the housing market downturn commencing in 2021 has drastically reduced land sale revenues. In 2023, total land sale revenue stood at 4,203 billion yuan, marking a 45% decrease from 2019. With local government budgets heavily reliant on these revenues, the prolonged housing market slump has strained governmental financial capacities. Consequently, many cities have abolished land price ceilings to rejuvenate the land and housing markets. Reverting to a purely market-driven approach in land auctions may not ensure a fair playing field for less experienced households and savvy developers. This highlights the complex interplay between market dynamics, governmental interventions, and the welfare implications for behaviorally biased households.

5 Concluding remarks

This study has provided a comprehensive analysis of the impact of land auctions on housing market dynamics in China. Our findings reveal significant spillover effects from land auctions to the housing market, particularly in areas proximate to auctioned land parcels. Developers' strategies are evidently influenced by their existing housing stock near auctioned land parcels, which affects the bidding behavior and the resulting auction premiums. We observed that in cities with a more pronounced housing market upturn, the effect of land auctions on housing prices and demand was more substantial. Conversely, during downturns, the influence of land auctions appeared to be mitigated.

The research also highlights the role of local government policies in shaping market dynamics. In cities with fixed housing price policies, developers' strategies differ notably from those in cities without such policies. This finding indicates the significant impact of regulatory environments on market behavior and outcomes.

Overall, this study contributes to the understanding of the interplay between land auctions and housing markets, offering insights into developer strategies and the effects of policy interventions. It underscores the importance of considering the localized nature of real estate markets and the varying impact of external factors across different economic cycles. The implications of this study are valuable for policymakers, developers, and investors in formulating strategies and policies that align with market dynamics and trends.

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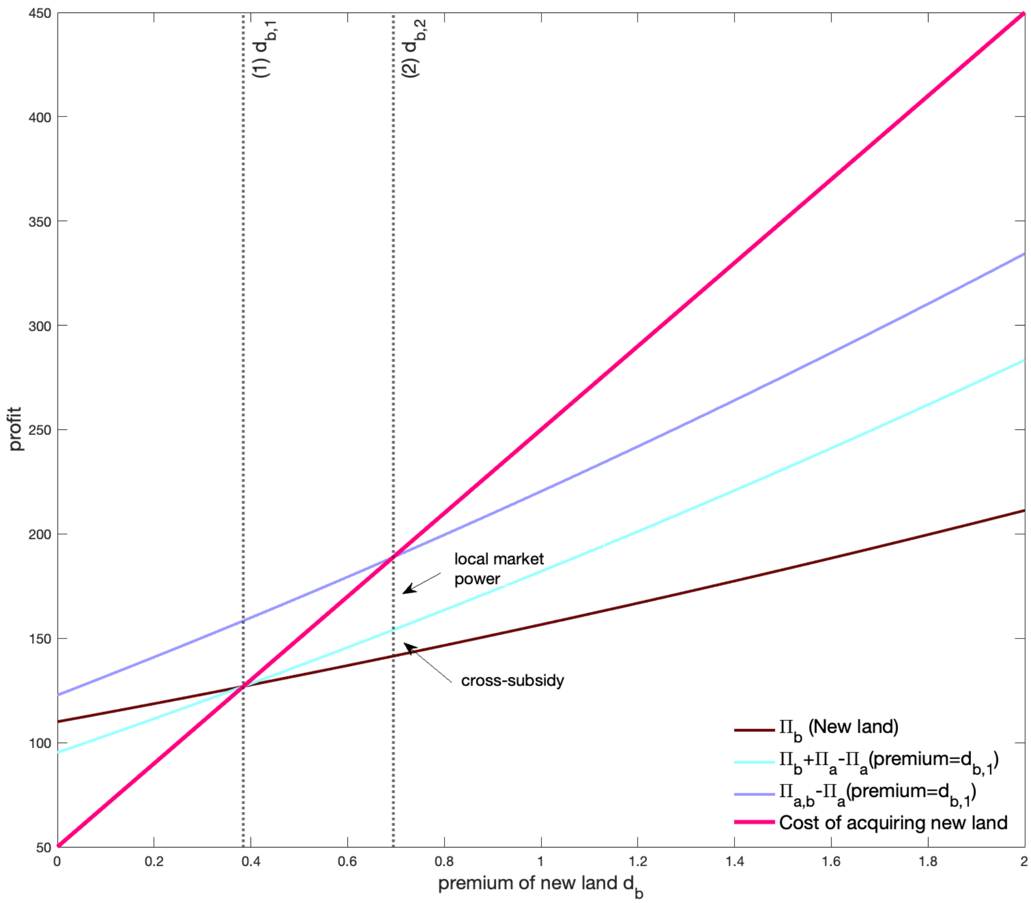


Figure 1: Profits and costs of land auction bids

Note: Parameter values: $q_a = q_b = 5$, $= 0{:}1$, $= 0{:}05$, $_a = 0{:}8$, $_b = 1$, $c = 0{:}5$, $c_0 = 50$, $c_1 = 200$. The brown line ($_b$) is the profit of an entrant from land development b assuming that the entrant and the incumbent engage in oligopolistic competition, which is increasing in the land premium d_b because $_b > 0$. The purple line ($_{a;b}$ $_a$(premium $= d_{b;1}$)) indicates the profit from an incumbent which owns both land development a and b, relative to owning land a only assuming that the incumbent will pay $d_{b;1}$ premium in acquiring land b. The light blue line indicates the additional profit for an incumbent but assuming that it is choosing p_a and p_b independently. The qualitative results regarding $d_{b;1}$ and $d_{b;2}$ still hold for other parameter values if an interior equilibrium exists. To see this, assuming that the interactions between the profit functions and the cost functions exist. Because when $_a > 0$ and $\neq 0$, $_{a;b}$ $_a$(premium $= d_{b;1}$) $_b >$ $_a +$ $_b$ $_a$(premium $= d_{b;1}$) $_b >$ $_a$ $_a$(premium $= d_{b;1}) > 0$ when premium $> d_{b;1}$, the net monopoly profit is above the incumbent profit to the right of $d_{b;1}$, hence $d_{b;2} > d_{b;1}$. The light blue line is between the purple and the brown line to the right of $d_{b;1}$, because $_{a;b} >$ $_a +$ $_b$ and $_a$ $_a$(premium $= d_{b;1}) > 0$ when premium $> d_{b;1}$.

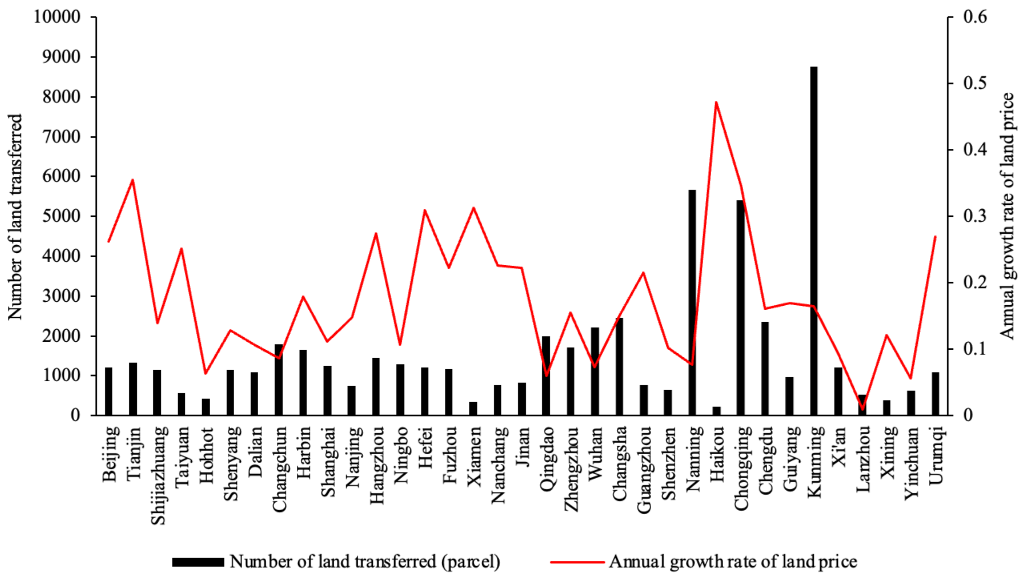


Figure 2: The Number of land parcels transferred and the growth rate of the land price by city

Note: This figure shows the number of residential land parcels transferred in 35 cities in China between 2008 and 2017, and the average annual growth rate of residential land prices.

Figure 3: The density plot of the land premium

Note: This figure shows the density distribution of the land premium. The premium is defined as the differences between the average monthly growth rate of land and housing prices. To be specific, we calculate the average monthly growth rate of land prices by comparing the land price from each auction to historical prices of nearby lands, and the average monthly growth rate of newly-built housing prices. The premium is defined as the differences between these growth rates.

Figure 4: The average premium of land parcels by city

Note: This figure plots the the average land premium separately for the 35 cities in China between 2008 and 2017. The premium is defined as the differences between the average monthly growth rate of land and housing prices. To be specific, we calculate the average monthly growth rate of land prices by comparing the land price from each auction to historical prices of nearby lands, and the average monthly growth rate of newly-built housing prices. The premium is defined as the differences between these growth rates.

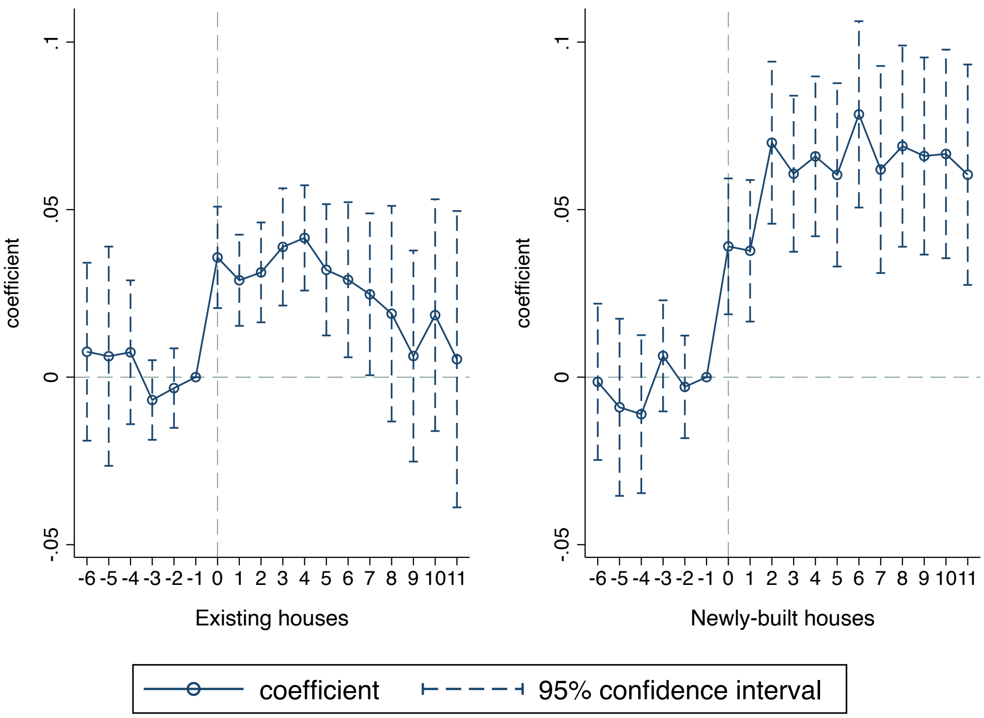


Figure 5: The effect of land auction premiums on the local housing prices

Note: This figure reports the value of $^{n}_{1}$ from estimating Equation 3 using the two-way fixed effects estimator in De Chaisemartin and d'Haultfoeuille (2020) separately for existing and newly-built houses. The y-axis is the coefficient value and the x-axis is the number of months relative to the month where the land auction is held. For existing houses, we control the residential compound, year-month, and city by year fixed effects, and various housing characteristics including square feet, direction, number of bedrooms, the number of floors of the house, and the total number of floors of the building. For newly-built houses, we control the residential, year-month, and city by year fixed effects.

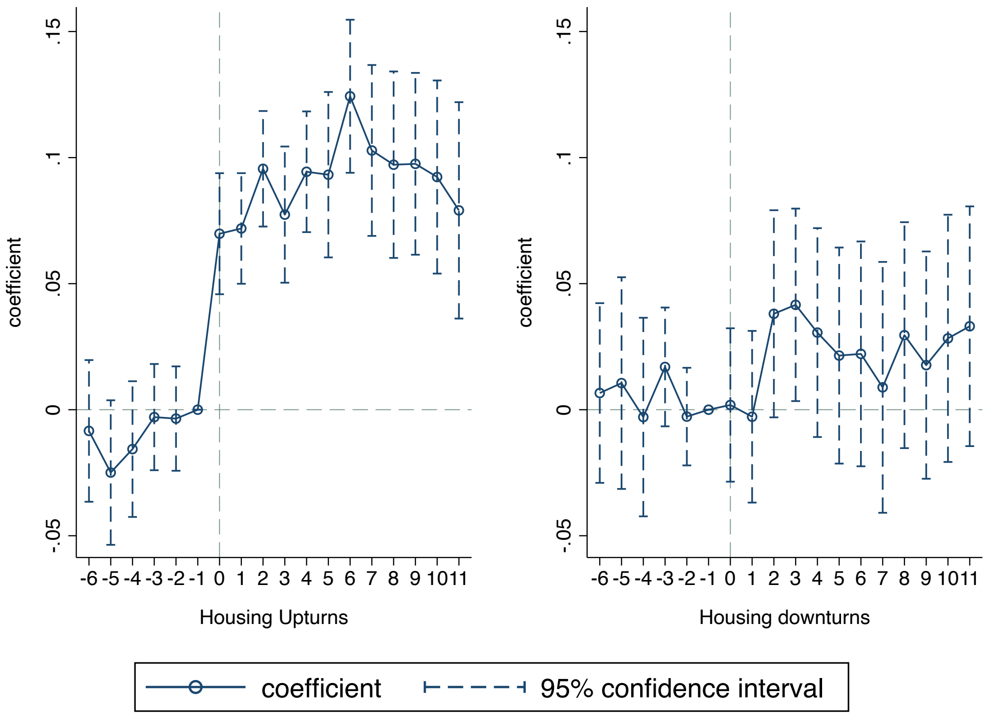


Figure 6: The effect of land auction premiums on the local housing prices in upturn and downturn periods

Note: This figure reports the value of $^{n}_{1}$ from estimating Equation 3 using the prices of newly-built houses in housing upturn and downturn periods separately as the dependent variable. We estimate Equation 3 using the two-way fixed effects estimator from De Chaisemartin and d'Haultfoeuille (2020). The housing upturn period is defined when a city's housing price growth rate is higher than the city's GDP growth rate, and the housing downturn period is defined as the opposite. The y-axis is the coefficient value and the x-axis is the number of months relative to the month where the land auction is held. We control the residential compound, year-month, and city by year fixed effects.

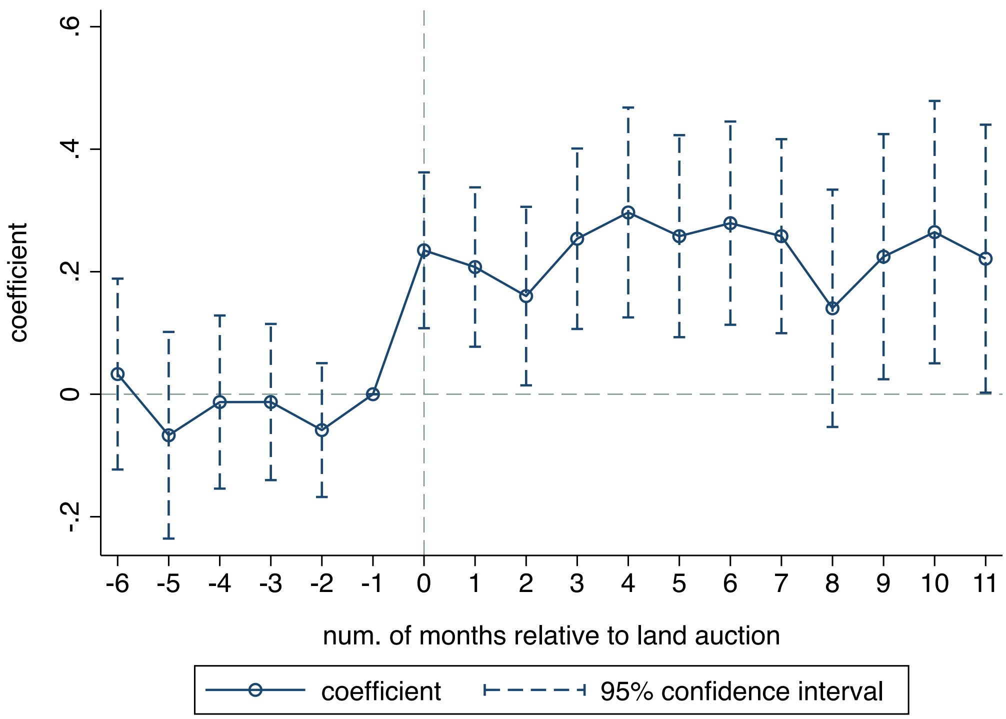
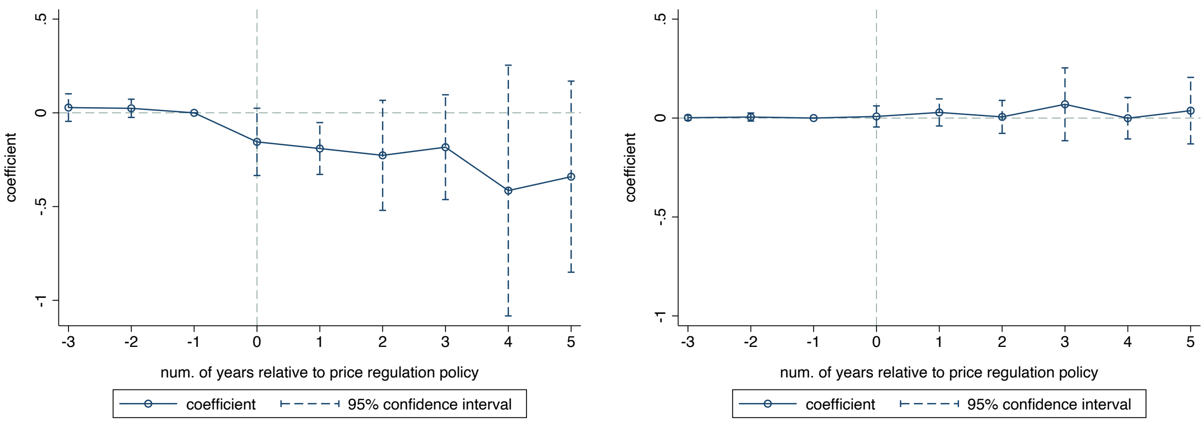


Figure 7: The effect of land auction premiums on the transaction volumes of newly-built housings

Note: This figure reports the value of $^n_1$ from estimating Equation 3 using the number of transactions of newly-built housings as the dependent variable. We estimate Equation 3 using the two-way fixed effects estimator from De Chaisemartin and d'Haultfoeuille (2020). The y-axis is the coefficient value and the x-axis is the number of months relative to the month where the land auction is held. We control the residential compound, year-month, and city by year fixed effects.



Panel A: Developers with nearby land stock   Panel B: Developers without nearby land stock

Figure 8: The housing price limit policy on the land premium by developers' type

Note: This figure reports the price limit policy's dynamic impacts on the land premium, separately for developers with and without nearby land parcels. The dependent variable is defined as the growth rate of the price of auctioned relative to the historical price of other lands within a 3-km radius of the auctioned land, subtracting the growth rate of the housing price located within a 3-km radius of the land. We control city by year fixed effects.

Table 1: Summary Statistics of sample characteristics

Variable	Obs	Mean	Std. Dev.	Min	Max
Panel A. Land auction					
Premium	15,649	0.028	0.116	-0.223	0.520
Has nearby land stock	15,649	0.094	0.292	0	1
Land area (in hectares)	15,648	4.665	5.285	0.001	114
Panel B. Existing housing sales					
Housing prices (RMB per m^2)	338,868	29,786	17,875	161	194,245
Square meters	338,868	86.667	83.469	5	206.13
Number of bedrooms	338,868	2.107	0.814	0	9
Number of living rooms	338,868	1.284	0.564	0	5
Total number of floors in the building	338,868	14.016	9.042	0	65
Panel C. Newly-built housing sales					
Housing prices (RMB per m^2)	432,903	11,054	8,979	1,000	420,705
Transaction volumes	394,167	117.904	443.574	1	27,514
Panel D. Households' expectation					
Housing price expectation (12 months, %)	10,553	2.729	8.109	-50	30
Housing price expectation (5 years, %)	10,553	5.187	16.073	-50	80

Note: This table reports the summary statistics of the main sample. The second row in Panel A reports the summary statistics of land premium, defined as the differences between the average monthly growth rate of land and housing prices. To be specific, we calculate the average monthly growth rate of land prices by comparing the land price from each auction to historical prices of nearby lands, and the average monthly growth rate of newly-built housing prices. The premium is defined as the differences between these growth rates. The second row in Panel A reports the summary statistics for whether the winning developer has other housing projects near the auctioned land parcel.

Table 2: Land premium and households' expectation of future housing price

	(1) Housing price expectation (12 months)	(2) Housing price expectation (5 years)
Premium Ĭ land	3.6565***	4.3348***
	(0.6822)	(1.3659)
Individual FE	X	X
Quarter-year FE	X	X
Observations	9,470	9,470
R^2	0.5996	0.6211

Note: This table reports the value of ${}_1$ in Equation 4, linking households' expectation of future housing prices in the HPES with the land auction outcomes. The *premium* is the average land premium within 3-km of individual's home address in each quarter, *land* is the dummy variable indicating whether individual's home is located within a 3-km of any land auction in each quarter. The dependent variable is respondents' expectation of future housing price growth rate measured in percentage terms. In the HPES, households' short and long term expectation of future housing price are elicited using the following two questions: 1) How much do you think the house price in your city will increase in the next year (in percentages); 2) How much do you think the house price in your city will increase in five years from now (in percentages)? We control individual and quarter by year fixed effects. , , and stand for significance level at 10%, 5% and 1% level.

Table 3: Developer's holding of nearby land stock and the land premium

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Has nearby land stock	0.0389***	0.0475***	0.0389***	-0.0490	0.0274**	-0.1127**	0.0447**	0.0339
	(0.0134)	(0.0136)	(0.0138)	(0.0323)	(0.0132)	(0.0423)	(0.0157)	(0.0228)
Has nearby land stock ×log(area of nearby housing stocks)				0.0061**		0.0093**		
				(0.0029)		(0.0035)		
Has nearby land stock x $Marketshare$					0.0721***	0.1092***		
					(0.0249)	(0.0282)		
log(Land Area)	-0.0011	0.0004	-0.0020*	-0.0022*	-0.0023**	-0.0026**	-0.0029	-0.0015
	(0.0011)	(0.0009)	(0.0011)	(0.0011)	(0.0011)	(0.0011)	(0.0022)	(0.0011)
City×Year FE		X	X	X	X	X	X	X
Land Type			X	X	X	X	X	X
Land transfer Type			X	X	X	X	X	X
Observations	15,648	15,648	15,648	15,648	15,648	15,648	15,648	15,648
R^2	0.0096	0.0842	0.1715	0.1731	0.1732	0.1765	0.1720	0.1677

Note: This table reports developers' adjustment in their strategy in land auctions when they have other housing stock near the auctioned land parcel. The dependent variable is defined as the growth rate of the price of auctioned relative to the historical price of other lands within a 3-km radius of the auctioned land, subtracting the growth rate of the housing price located within a 3-km radius of the land. The first row reports the impact of whether the developer d has other housing projects near the land on the auction premium. log(LandArea) measures the total number of housings supplied by the auctioned land. Market share is calculated as the change in developer's market share after winning the auction. The market share of the developer after the land auction is calculated as the ratio of (developer's saleable area + newly-auctioned area) divided by (total saleable area + newly-auctioned area) Land type includes dummy variables representing the designated use of the land. Land transfer type controls the type of auction used to transfer the land parcel. Column 1 to 3 differ in the type of fixed effects controlled. Column 4 to 6 differ in the type of interactions included. Column 7 and 8 report estimation results restricting samples to cities that are in a real-estate market upturn and downturn, respectively. Heteroscedasticity robust standard errors in parentheses are clustered at the city level. * significant at 10% ** significant at 5% *** significant at 1%.

Table 4: The effect of having nearby land stock on the premium of land parcels by the city's limit on sale price

	No	Yes
	(1)	(2)
Has nearby land stock	0.0660***	-0.0024
	(0.0178)	(0.0063)
City Year FE	X	X
Observations	7,000	8,648
R^2	0.2191	0.1598

Note: This table reports developers' adjustment in their strategy in land auctions in response to the spillover effects separately for cities with and without the fixed housing price policy. The dependent variable is defined as the growth rate of the price of auctioned relative to the historical price of other lands within a 3-km radius of the auctioned land, subtracting the growth rate of the housing price located within a 3-km radius of the land. The first row reports the impact of whether the developer d has other housing projects or land stock near the land on the auction premium. The first column reports the impact of whether the developer d has other housing projects or land stock near the land on the auction premium in cities without the fixed housing price policy. The second column reports the estimation results using sample with the fixed housing price policy. We control city by year fixed effects. Heteroscedasticity robust standard errors in parentheses are clustered at the city level. , , and stand for significance level at 10%, 5% and 1% level.

Table 5: Robustness of developers' strategic responses to extrapolative households

	Excluding listed developers	New schools		New metros	
		No	Yes	No	Yes
	(1)	(2)	(3)	(4)	(5)
Has nearby land stock	0.0362**	0.0352***	0.0409	0.0301**	0.0424***
	(0.0143)	(0.0101)	(0.0242)	(0.0131)	(0.0135)
City Year FE	X	X	X	X	X
Observations	14,553	12,503	3,130	13,060	2,578
R^2	0.1728	0.1532	0.3169	0.1589	0.3240

Note: This table report robustness checks of developers' auction strategies. The first column excludes developers listed in China's stock market or listed as the top 100 developers by independent real-estate consulting firms. Column 2 limits the sample to lands where no new school is built within 3-km of the auctioned land in two years after the auction. Column 3 limits the sample to lands where a new school is built within 3-km of the auctioned land in two years after the auction. Column 4 limits the sample to lands where no new metro line is built within 3-km of the auctioned land in two years after the auction. Column 5 restricts the sample to lands where a new metro line is built within 3-km of the auctioned land in two years after the auction. We control city by year fixed effects and $\log(\text{LandArea})$ measuring the total number of housings supplied by the auctioned land. Heteroscedasticity robust standard errors in parentheses are clustered at the city level. * significant at 10% ** significant at 5% *** significant at 1%.

Appendix A Derivation of the housing demand functions

In this section, we provide a microfoundation of the housing demand functions in Eqs.(1) and (2). We focus on the demand for housing project a, and the derivation for housing project b is similar.

A representative household who has wealth W chooses H_a units in housing project a, where the current price is P per unit. Assuming that the household will hold the purchased housing units for a fixed time period and at the end of the holding period, sell them at price P^{0} per unit. The utility function is a Constant Absolute Risk Aversion utility function with the coefficient of absolute risk aversion $\; > 0$. The household problem is

$$\max_{H_a} \mathsf{E} \quad e^{\quad (W + H_a(P^{0} \quad P))} \quad : \tag{6}$$

P^{0} is a random variable and E denotes the expectation of households, which may not coincide with the expectation under the true conditional distribution of P^{0} if households hold biased beliefs. We make the following assumptions on house price dynamics and household beliefs:

Assumption 3 (House price dynamics)**.** *The fair market value for a housing unit is P' in the current period. The actual price for a housing unit in the current period is $P = P'(1 + p_a)$. The distribution of $P^{0} \quad P$ conditional on current information follows normal distribution with mean $\;$ and variance $\;^2$. Rational and irrational home buyers, which are defined in Assumptions 4 and 5, hold different beliefs on $\;$, but they agree on the same $\;^2$.*

Assumption 4 (Rational home buyers)**.** *At the end of the holding period, the expected value is $\mathsf{E}P^{0} \quad P'(1 + r)$ under the true conditional distribution. We define home buyers who have this expectation rational home buyers.*

Assumption 5 (Irrational home buyers)**.** *Under the subjective belief, the expected value of P^{0} is*

$$\mathsf{E}^s P^{0} = \mathsf{E}P^{0} + P' d_b :$$

The difference between $\mathsf{E}^s P^{0}$ and $\mathsf{E}P^{0}$ is due to home buyers holding extrapolative beliefs: they *expect higher future prices if the land price is higher than expected (d_b). We define these home buyers irrational home buyers.*

The setting is standard in asset pricing models with potentially biased beliefs. Barberis (2018) provides a review on asset pricing models with extrapolative beliefs. We adapt these models to our context of the land and housing markets.

The first order condition of Eq.(6) gives

$$\tilde{\mathbb{E}}\ e^{\ (W+H_a(P^0 - P))}(P^0 - P) = 0: \tag{7}$$

With Assumption 3, Eq.(7) becomes

$$H_a = \frac{1}{\ ^2}\tilde{\mathbb{E}}(P^0 - P):$$

It then follows from Assumptions 4 and 5,

$$\text{rational home buyers:} \qquad H_a = \frac{\bar{P}}{\ ^2}(r - p_a)$$

$$\text{irrational home buyers:} \qquad H_a = \frac{\bar{P}}{\ ^2}(r - p_a + d_b):$$

The effect of the land price premium on housing demand is greater in areas with more irrational home buyers.

The housing demand function (Eq.1) is a parameterized version of the equations above. We add the price of nearby property p_b to capture the spillovers in local housing demand.

Appendix B Spatial attenuation of land auctions' impacts on the local housing market

The influence of land auctions on the housing market exhibits a localized nature. Residences situated in close proximity to a land parcel auctioned at a substantial premium are prone to witness a notable surge in housing demand. This effect is likely to diminish for houses situated at a greater distance from the auction.

However, the pace at which this effect attenuates and the criteria for defining houses as "near the land auction" remain unclear a priori.

To answer these questions, we empirically examine the spatial attenuation pattern of land auctions' premium on local housing prices by estimating the equation below:

$$\ln(hp_{ikjt}) = \beta_0 + \sum_{n=1}^{25} \beta_1^n (\text{premium}_k \times \text{ring}_{it}^n) + \beta_2 \ln(\text{area}_k) + \beta_3 X_{it} + \mu_k + \lambda_t + \omega_{jt} + \varepsilon_{ikjt} \quad (8)$$

where $\ln(hp_{ikjt})$ is the log price of housing i near the land parcel k in city j and year t, ring_{it}^n is a dummy variable denoting whether the house i is located between $(n-1) \times 0.2$km and $n \times 0.2$km from the land parcel and the transaction time t is after the auction, $\ln(\text{area}_k)$ measures the log of the total amount of land auctioned, X_{it} are housing characteristics including square feet, direction, number of bedrooms, the number of floors of the house, and the total number of floors of the building, $\mu_k; \lambda_t; \omega_{jt}$ are land parcel, year by month and city by year fixed effects. The baseline group is housings located 5-km away from the auctioned land parcel.

Figures A2 and A3 plot the estimated values of β_1^n for existing and newly-built houses, respectively. [17] In line with our expectations, the impact of land auctions on the housing market attenuates as houses are situated farther away. The effect effectively diminishes when houses are located 3 km away from the land auction, irrespective of the housing type. Consequently, throughout the paper, we define houses as being near a land auction if they are located within 3 km of the land parcel.

[17] Table A2 reports the detailed estimation results for these two figures.

Appendix C Figures and Tables

Figure A1: Snapshot of a listing from a real-estate brokerage firm

Note: This figure shows a snapshot of one listing from Lianjia, a prominent real-estate brokerage firm in China. The house in the listing is located near a significant land auction which took place in Guangzhou on November 16, 2020.

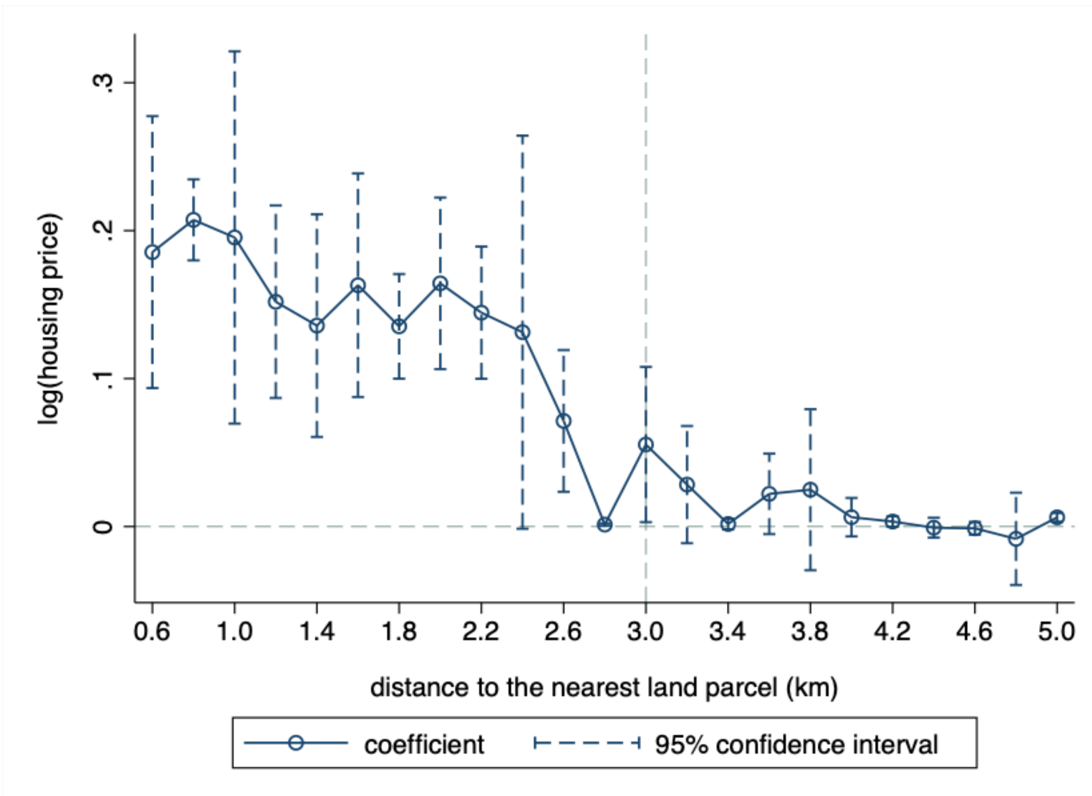


Figure A2: The spatial attenuation pattern of the effect of land auction premiums on the prices of existing houses

Note: This table reports the spatial impacts of land auction premiums on the transaction prices of existing houses. To be specific, we report the values of $^{n}_{1}$ from estimating the equation 8 using the log price of existing houses as the dependent variable, and the $ring^{n}_{it}$ is a dummy variable denoting if the houses are located within (n-1)×0.2km to n×0.2km from the auctioned land parcel. The baseline group is housings located 5-km away from the auctioned land parcel.

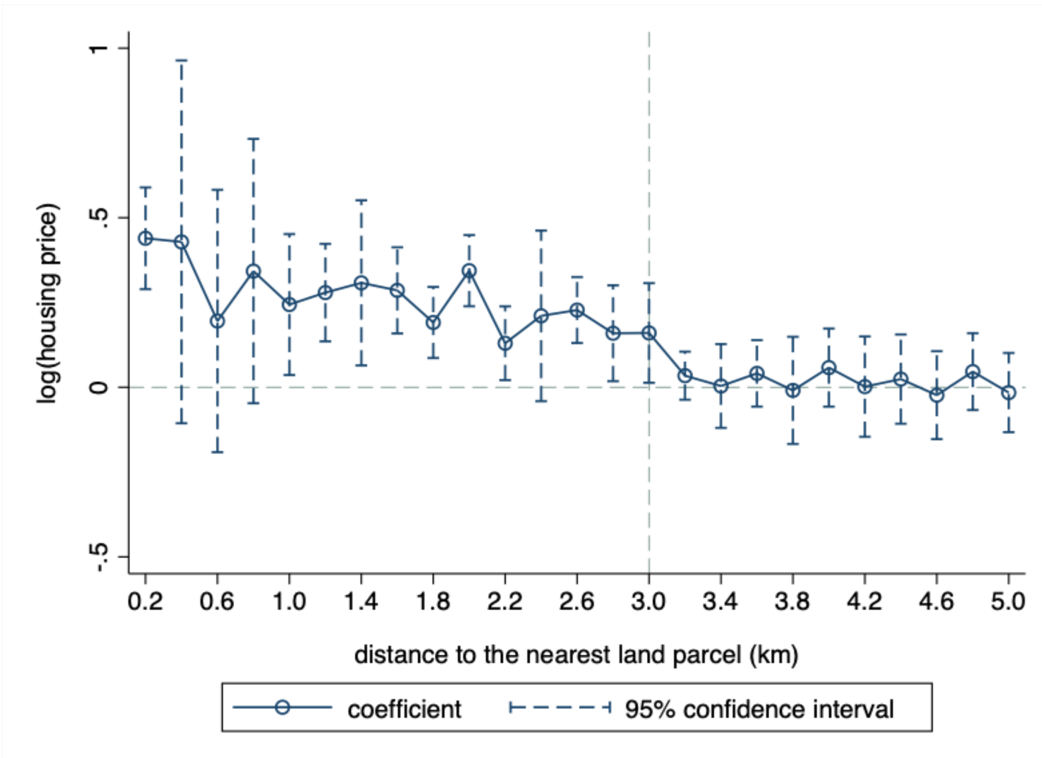


Figure A3: The spatial attenuation pattern of the effect of land auction premiums on the newly-built housing prices

Note: This table reports the spatial impacts of land auction premiums on the transaction prices of newly-built houses. To be specific, we report the values of $^{n}_{1}$ from estimating the equation 8 using the log price of newly-built houses as the dependent variable, and the ring$^{n}_{it}$ is a dummy variable denoting if the houses are located within (n-1)×0.2km to n×0.2km from the auctioned land parcel. The baseline group is housings located 5-km away from the auctioned land parcel.

Table A1: List of cities adopted the housing price control policy

City	Year	City	Year
Beijing	2010	Xiamen	2011
Chengdu	2016	Shanghai	2009
Dalian	2006	Shenzhen	2010
Fuzhou	2006	Shenyang	2017
Guangzhou	2006	Shijiazhuang	2016
Guiyang	2018	Taiyuan	2011
Harbin	2007	Tianjin	2008
Haikou	2012	Wuhan	2006
Hangzhou	2019	Xi’an	2021
Hefei	2016	Yinchuan	2021
Jinan	2018	Changchun	2020
Kunming	2011	Changsha	2017
Lanzhou	2011	Zhengzhou	2009
Nanchang	2006	Chongqing	2008
Nanjing	2020	Hohhot	No
Nanning	2011	Urumqi	No
Ningbo	2019	Xining	No
Qingdao	2005		
Xiamen	2011		

Note: This table reports the list of cities adopted the housing price control policy. This list is constructed by the authors from various news reports and public documents of government policies.

Table A2: The spatial attenuation pattern of the effect of land auction premiums on housing prices

	log(Existing housing prices) (1)	log(Newly-built housing prices) (2)
premium ring1 (0-0.2km)	0.1819	0.4394***
	(0.4472)	(0.0765)
premium ring2 (0.2-0.4km)	0.2875	0.4288
	(0.3519)	(0.2729)
premium ring3 (0.4-0.6km)	0.1855***	0.1954
	(0.0455)	(0.1973)
premium ring4 (0.6-0.7km)	0.2073***	0.3426*
	(0.0136)	(0.1988)
premium ring5 (0.8-1km)	0.1954***	0.2440**
	(0.0623)	(0.1060)
premium ring6 (1-1.2km)	0.1519***	0.2793***
	(0.0322)	(0.0733)
premium ring7 (1.2-1.4km)	0.1358***	0.3080**
	(0.0373)	(0.1241)
premium ring8 (1.4-1.6km)	0.1631***	0.2858***
	(0.0374)	(0.0648)
premium ring9 (1.6-1.8km)	0.1353***	0.1912***
	(0.0175)	(0.0534)
premium ring10 (1.8-2km)	0.1644***	0.3439***
	(0.0287)	(0.0535)
premium ring11 (2-2.2km)	0.1445***	0.1300**
	(0.0221)	(0.0555)
premium ring12 (2.2-2.4km)	0.1314*	0.2107
	(0.0658)	(0.1283)
premium ring13 (2.4-2.6km)	0.0714***	0.2278***
	(0.0237)	(0.0496)
premium ring14 (2.6-2.8km)	0.0013***	0.1594**
	(0.0004)	(0.0721)
premium ring15 (2.8-3km)	0.0554**	0.1603**
	(0.0260)	(0.0749)
premium ring16 (3-3.2km)	0.0283	0.0343
	(0.0196)	(0.0362)
premium ring17 (3.2-3.4km)	0.0017	0.0039
	(0.0018)	(0.0630)
premium ring18 (3.4-3.6km)	0.0221	0.0411
	(0.0135)	(0.0500)
premium ring19 (3.6-3.8km)	0.0249	-0.0091
	(0.0270)	(0.0806)
premium ring20 (3.8-4km)	0.0063	0.0581
	(0.0064)	(0.0587)
premium ring21 (4-4.2km)	0.0034*	0.0019
	(0.0017)	(0.0755)
premium ring22 (4.2-4.4km)	-0.0008	0.0242
	(0.0033)	(0.0671)
premium ring23 (4.4-4.6km)	-0.0012	-0.0233
	(0.0021)	(0.0661)
premium ring24 (4.6-4.8km)	-0.0084	0.0463
	(0.0155)	(0.0578)
premium ring25 (4.8-5km)	0.0062***	-0.0156
	(0.0014)	(0.0596)
log(Land Area)	-0.0063	0.0006
	(0.0041)	(0.0009)
Housing characteristics	X	
City Year FE	X	X
Residential compound FE	X	X
Year-month FE	X	X
No. of Observations	548,550	448,703
R-Square	0.7775	0.8398

Note: This table reports the spatial impacts of land auction premiums on the local housing prices. To be specific, we report the values of $^{n}_{1}$ from estimating equation 8. The dependent variable is the log of housing transaction price, and the $ring^{n}_{it}$ is a dummy variable denoting if the houses are located within (n-1) 0.2km to n 0.2km from the auctioned land parcel. The baseline group is housings located 5-km away from the auctioned land parcel. Column 1 and 2 report the impacts for existing and newly-built housing prices, respectively. Housing characteristics include square feet, direction, number of bedrooms, the number of floors of the house, and the total number of floors of the building. All standard errors are clustered at the city level. * significant at 10% ** significant at 5% *** significant at 1%.