Judicial auction housing discounts and housing segments interaction: Evidence from China

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ABSTRACT

The urban resale housing market has seen an increasing influence from the judicial auction housing segment. This study delves into judicial auction housing discounts and the underpinning mechanisms from the standpoint of buyer risk preference and market interplay. Transaction data from 11 prominent cities in China, spanning July 2017 to October 2020, were analyzed. Principal empirical outcomes suggest an average economic depreciation for China's judicial auction housing market of approximately 14%, corroborated by our neighbor-matched sample. Key findings suggest a substitution effect between the judicial auction and regular resale segments and highlight the significance of purchasing risk as a determinant for this channel. Moreover, an increase in uncertainty about the overall market environment could intensify demand flowing out of the judicial auction market as well as its economic depreciation. The results offer insightful implications for policy designers, emphasizing the enhancement of judicial auction housing quality and the need for improving transparency of information in the resale housing market.

1. Introduction

Housing auctions, as a method of housing transactions, have garnered attention in various studies (Frino et al., 2012; Shi & Kabir, 2018). Particularly, housing from judicial auctions—commonly recognized as foreclosed housing in numerous countries (Vanderporten, 1992)—is emerging as a notable component of the resale housing supply. While the judicial auction market experiences growth, the regular resale market still surpasses it in terms of transaction volumes and prices in many countries.[1] In reality, transaction prices of properties, even when sharing comparable locations and features, can differ significantly, especially when comparing judicial auction houses to regular houses. This external intangible loss of housing value is often termed economic depreciation (Leigh, 1980; Malpezzi et al., 1987). Measuring economic depreciation in residential real estate is important for our interpretation of individual housing preferences and housing market inefficiency (Malpezzi et al., 1987; Yoshida, 2020).

However, there is little discussion about the drivers of economic depreciation in the housing sector. Concerning the rapid demolition during urban renewal, Suzuki and Asami (2022) indicate that the

depreciation of resale houses relative to newly built houses emerges from both the outdated structure standards of older houses and the psychological or economic preference for newly built houses, both of which make existing houses not in demand. A similar situation occurs between judicial auctions and regular resale housing markets. Evidence from Western countries suggests that the physical structure (Campbell et al., 2011; Frame, 2010; Lambie-Hanson, 2015) and psychological resistance (Clauretie & Daneshvary, 2009; Harding et al., 2012) of judicial auction houses are the causes of the depreciation. Whether this is true in Asian countries as well and how the value diminution in the judicial auction market relates to the interplay between the two housing sectors are the main questions this study focuses on.

This study is unique in that it uses a matched sample from both China's regular resale and judicial auction housing markets, innovatively building a logical chain from buyer's preference and purchase risk to the cross-market flow of housing demand and finally the formation of the relative prices of judicial auction houses. Based on data in 11 cities in China between July 2017 and October 2020, the findings indicate that the economic depreciation in the judicial auction housing market is approximately 14%, which will change as demand flows between

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[1] In Australia and New Zealand, auctioning is a common or even preferred property sales method, and auctioned houses sell at a price premium (Dotzour et al., 1998; Lusht, 1996; Newell et al., 1993).

submarkets. It was also found that risks to both property and the market affect judicial auction housing discounts by influencing demand flows. Insights into this dynamic can enrich our understanding of housing market segment relationships and how home values are realized.

The remainder of the paper is organized as follows: Section 2 presents a review of relevant literature. Section 3 presents the background of the judicial auction housing market in China and research hypotheses. Sections 4 and 5 present the data, methods, and findings, followed by discussion in Section 6. Section 7 concludes the study.

2. Literature review

An escalating emphasis on housing market research has broadened the literature surrounding the judicial auction housing market. A predominant focus of these studies has been the foreclosure impact on housing prices, with most detecting a significant economic depreciation in the judicial auction sphere. Shilling et al. (1990) pioneered the study of discounts for foreclosed residential properties. Subsequently, this prompted a plethora of studies from the United States, most converging on discount rates between 15% and 25% (Forgey et al., 1994; Springer, 1996). Mayer (1998) also examined residential foreclosure discounts in Los Angeles (9% discount) and Dallas (9%–21% discount). Allen and Swisher (2000) analyzed a sample of 170 real estate transactions in Florida, identifying a marked discount rate, ranging from 13% to 21.5%, for houses auctioned owing to foreclosures. Expanding this scope, Loberto (2023) discerned in the Italian housing market that foreclosed listings considerably depress regular sale neighboring property prices, a sentiment echoed by Immergluck and Smith (2006) and Hartley (2014). Furthermore, house foreclosures also adversely affect nearby housing liquidity (Zhang et al., 2016; Bian, Brastow, Waller, & Wentland, 2021). Much of the present literature hones in on micro-level auction mechanisms and their influence on auction prices. Notably, higher initial bids tend to elevate final bid amounts, while excessively high opening bids can result in auction failure (McAfee & Vincent, 1992). In more competitive auctions with numerous bids, participants are typically driven to propose higher prices (Ooi et al., 2006).

However, two significant gaps persist in this literature. First, most studies focus narrowly on singular markets, often overlooking the intrinsic diversity and interconnectedness of real estate. These investigations tend to spotlight specific foreclosure market mechanisms or employ theoretical models to evaluate micro-individual factors like foreclosure timing or property attributes (Aroul & Hansz, 2014; Harding et al., 2012). The interplay between the judicial auction and regular resale market is an interesting and meaningful question; however, little empirical research has examined it. Two recent papers from China provide us with important inspiration. First, Xu et al. (2022) examine the role of the information disclosure quality of online judicial auction platforms in attracting buyers. They do not directly study the outcomes of judicial auctions but provide us with an enlightening perspective; that is, a more mature or larger judicial auction market can attract more buyers to bid, thereby potentially increasing the value of judicial auction assets. Second, Zheng et al. (2023) study the spillover effect of the purchase restriction policy in the regular housing market on the judicial auction market. They discover that after the implementation of purchase restrictions in the regular resale housing market, prices at judicial auctions rise significantly.

Second, there is a dearth of causal evidence linking judicial auctions to economic depreciation in housing. Contradictory findings in some studies weaken the overall reliability of current conclusions (Carroll et al., 1997). This inconsistency often stems from omitted covariates, leading to considerable variations in foreclosure discounts (Frame, 2010). Two main sources of endogeneity may invalidate the assumption in our setting: omitted variable bias and out-of-treatment selection. Some researchers have attempted to navigate this issue by employing alternative methodologies, such as pairing each judicial auction property with similar traditional properties (Conklin et al., 2023) or

incorporating more comprehensive controls (Clauretie & Daneshvary, 2009). Though these methods yield more precise outcomes, it is uncertain whether they completely mitigate the omitted variable bias.

The marginal contribution of this study to the literature is mainly in three aspects. First, considering that real estate is significantly systemic, it is essential to introduce the substitution effects between regular resale and judicial auction segmentations into the analytical framework of housing discounts. Specifically, judicial auction discounts result from the cross-market demand flow. In addition, this study focuses on the heterogeneity and microscopic interpretation of this market interplay and judicial auction housing discounts, particularly from buyer-side purchase risks, whether it is from the ownership risk of the house itself, the subjective psychological exclusion of buyers, or the overall market depression. Finally, we provide causal evidence on the formation of judicial auction discounts, which is rare in existing research. To partially address the omitted variable bias issue, the spatio-temporal lags are introduced into the model to control potential micro-factors that are difficult to observe (Liu & van der Vlist, 2019; Pace et al., 1998). To alleviate systematic bias in observable variables, we use propensity score matching (PSM) to select a matched control group from the regular resale sample.

3. Background and theoretical predictions

3.1. Judicial auction housing market in China

As urbanization and the stock housing market in China have advanced, judicial auction housing has emerged as a significant component of the resale residential supply, garnering interest across various societal sectors. In 2021, judicial auction housing listings in China totaled 398,700. Out of these, 236,000 were residential homes, comprising over half of the listings. Beijing recorded the highest surge in new judicial auction listings, with a monthly growth rate of 21.19% and a turnover rate of 54.2%. Of the sold judicial auction houses, 93,000 were residential units, making up 67.3% of the total, and their transaction value represented 42.0% of the overall figure.[2] This marked escalation commenced in 2017. The online judicial auction sector in China began its development in 2012. By January 2017, legislation mandated that all judicial auctions in mainland China take place on designated online platforms. Consequently, all judicial auctions transitioned into open auctions overseen by the court on these online platforms, with properties awarded to the highest bidder. This transformation bolstered both the market's fairness and its growth.

Similar to other nations, a judicial auction house in China refers to a property auctioned under the court's authority. Typically, judicial auctions involve the court publicly disposing of a debtor's property based on compulsory execution procedures in civil cases to settle the creditor's debts. A significant portion of these execution properties are foreclosed collateral stemming from bank loans or private loan contracts. The remainder originates from condemned properties in criminal cases or unclaimed assets. While there are not official statistics detailing the breakdown of judicial auction properties in China, estimations can be made using data from the Alibaba platform—the country's largest online judicial auction platform. Between 2017 and 2022, 909,686 judicial auction houses were listed on this platform for the first time. Among them, 887,040 were foreclosed assets, which included personal or corporate mortgage defaults (approximately 65%) and bankruptcy liquidations (around 32%). A mere 3% of execution properties were tied to criminal cases or classified as unclaimed assets.

When juxtaposed with the regular resale housing market, the judicial

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auction housing market exhibits distinct characteristics. First, judicial auction sellers are compelled to liquidate their properties—they do not do so voluntarily. Second, the vast majority of judicial auction transactions occur via online auction platforms, as supported by Xu et al. (2022). Third, a discernible price discount seems prevalent when compared to the regular resale market. As illustrated in Fig. 1(a) and (b), average prices of judicial auction houses tend to be lower and more volatile than those in the regular resale housing market in China. Furthermore, Fig. 1(c) and (d) show that the growth trend in judicial auction houses is more pronounced, signifying a growing scale for the judicial auction housing market—particularly post-pandemic. These observations underpin our research focus on the economic depreciation of judicial auction houses, examined through the lens of home purchase risks and market interaction.

3.2. Theoretical framework and hypotheses

Previous studies have highlighted the need for submarket housing analysis (Leishman, 2009; Zhang & Hui, 2013), but there is no standard definition for the subdivision of housing market. In general, a submarket is defined as a homogeneous housing stock within a geographical area (Palm, 1978), but some studies offered alternative views of defining housing submarkets such as housing price substitutability (Gibler & Tyvimaa, 2014) and the social and economic characteristics (Bangura & Lee, 2022). Submarkets can also be comprised of non-contiguous pieces of real estate with similar features and attributes (Biswas, 2012; Grigsby, 1971). In this study, we pay more attention to the resale market segmentation caused by the exogenous factors. It is conceivable that initially, all the resale properties may be evenly distributed in terms of geographical space, socio-economic attributes and housing qualities, and then some of them are artificially converted into foreclosed properties, resulting in changes in supply, demand and prices, forming another submarket that is separated from other regular properties. Therefore, the resale housing market can be bifurcated into two distinct sectors: regular and judicial auction markets.

Specifically, the regular market is the main market, which has a larger scale of supply and demand than that of the secondary market, judicial auction market housing. Additionally, sellers in the judicial auction market are under compulsion to liquidate their assets, preventing them from easily transitioning between markets. This means that the conversion of supply between the two markets is relatively limited: the judicial auction houses can only flow into the regular market through sale and the regular houses can only be converted into judicial auction houses by court seizure. However, buyers face no such restrictions, and the price movements are mainly affected by the flow of demand. The buyer's market nature of the judicial auction market also makes it particularly crucial to study buying behavior. The submarket substitution effect is an important manifestation of consumer preferences and behavioral outcomes. In the consumer choice theory of microeconomics, if one commodity can replace the other to meet people's consumption needs, then the two goods have substitution. Households purchasing a home is actually purchasing a bundle of housing attributes and neighborhood characteristics (Biswas, 2012), and in general, they tend to move in the same submarket that consists of dwellings with close substitutions due to search costs and information constraints (Grigsby, 1971; Jones et al., 2004). That is to say, home buyers do not restrict their search necessarily to one submarket, when the segmentation between submarkets is caused by exogenous factors rather than housing characteristics and there is no additional cost. Whether it is a regular or a judicial auction house, it can meet consumers' needs for residence and future investment in terms of function; thus, it is theoretically alternative. We imagine two scenarios: increased supply and limited demand in the regular housing market. When the regular housing supply rises and prices fall, the demand for judicial auction housing decreases; when regular housing demand is restricted, the alternative judicial auction market can perform a part of the demand that cannot be met.

Furthermore, this cross-market flow of demand will bring about changes in the relative prices of the two markets. Therefore, we propose:

Hypothesis 1. There is a substitution effect between the regular market and judicial auction market. Specifically, the change in supply and demand in the regular market will affect the economic depreciation of the judicial auction market by affecting judicial auction housing demand.

In most cases, however, household mobility across submarkets is not without additional costs, which threatens the realization of substitution effect between the two submarkets. Risk factors and transaction costs should not be excluded from housing studies. According to the consumer expectation utility theory, risk is the uncertainty of future returns, and risky assets bring different utilities to consumers with different risk attitudes. Housing is both a consumer commodity and a risky asset. On the one hand, from the perspective of capital gains, there is uncertainty about future housing prices, which will affect household wealth and lifetime utility (Zanetti, 2014). On the other hand, from the perspective of maintenance costs, the additional costs brought by the purchase of different homes are different, which affects the buyer's future net income. For judicial auction houses, once the auction is successful, they will re-enter the regular market and face the same price risk as other houses. Thus, compared to a regular house, the relative risk of buying a judicial auction house mostly comes from the uncertain additional costs. Observable characteristics are often incorporated into traditional housing price models; therefore, when we control the common characteristics of houses, some intangible attributes can be key factors in determining the risk of judicial auction houses. Some studies have indicated that incomplete property rights affect housing prices (He et al., 2019). Classical property rights theories presume that uncertain and insecure housing rights are associated with limited transaction activity and higher transaction costs (Coase, 2023). Certain studies even highlight the stigma effect associated with those so-called haunted properties (Clauretie & Daneshvary, 2009). These peculiarities, distinct to the judicial auction segment, can potentially tarnish its reputation and amplify the perceived risk and psychological burden costs (fear or insecurity) for prospective buyers. The above-mentioned objective or subjectively additional home purchasing costs will reduce buyers' demand for judicial auction houses or require greater discounts to offset these risks. Based on these insights, we posit:

Hypothesis 2. The ownership defects and stigma effects of judicial auction houses bring greater purchasing risks, reduce demand, and increase the economic depreciation of the judicial auction market, weakening the substitution effect between the two submarkets.

4. Methodology

4.1. Data source

We derive our principal results from an expansive micro-level dataset that encompasses the resale housing transactions across 11 Chinese cities between July 2017 and October 2020. This data is sourced from Lianjia, a leading real estate agency in China.[3] Concurrently, our secondary dataset is procured from "Alibaba's Taobao online judicial auction" platform,[4] the largest online judicial auction platform in China. The sample cities come from three different geographical regions in

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[3] According to an in-depth research report on the real estate industry released by one of the leading brokerages in China, Lianjia's market share in the resale housing market increased from 12.30% in 2017 to 26.22% in 2020. https://pdf.dfcfw.com/pdf/H3_AP202104131484337561_1.pdf?1618325004000.pdf.

[4] "Alibaba's Taobao online judicial auction" platform was built in November 2016, which was one of the five online platforms that were first included in the list of online service providers for judicial auctions by the Supreme People's Court of China. https://sf.taobao.com/.
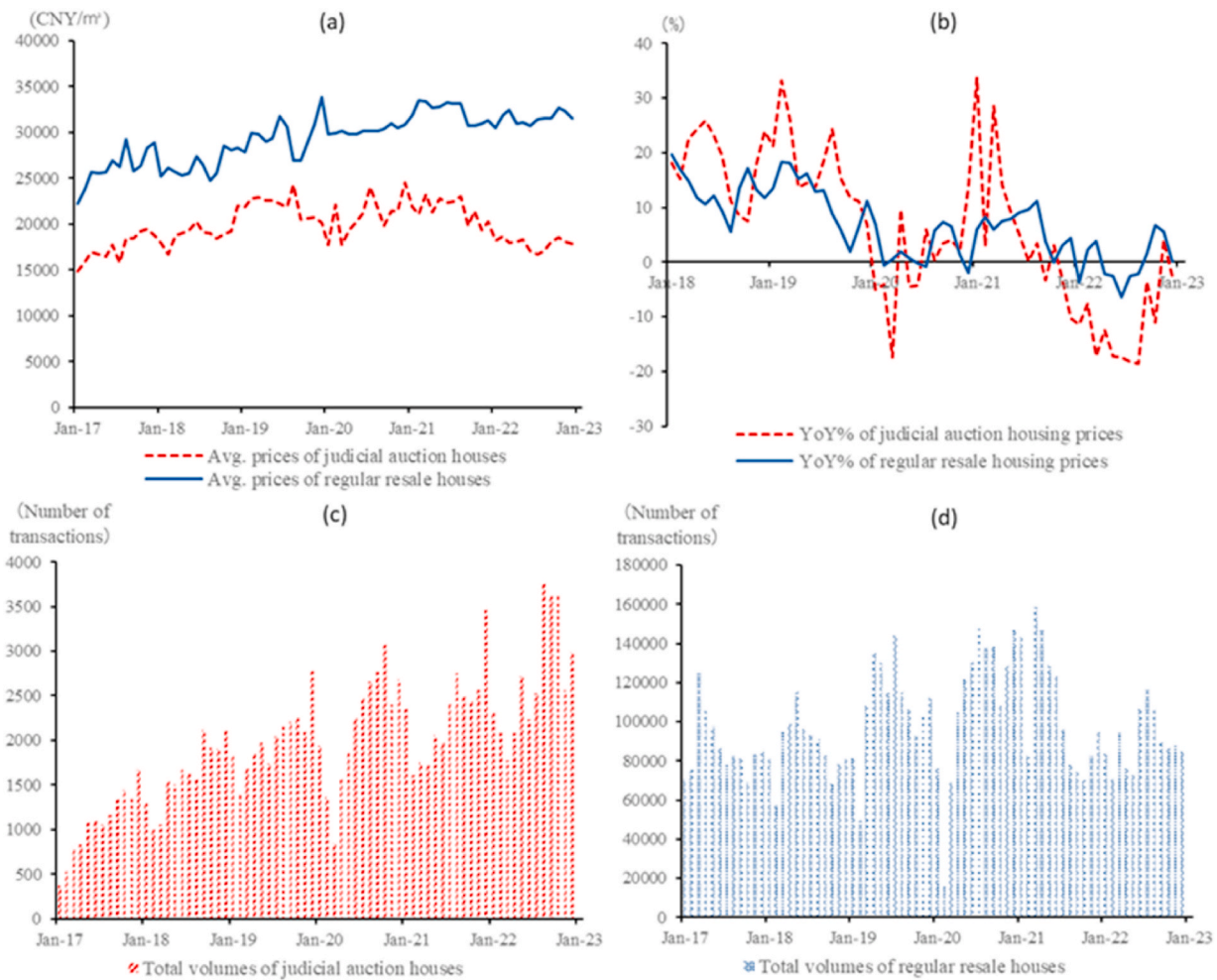
Fig. 1. Trend of resale housing prices and volumes in China.
Note: It is drawn by summarizing the monthly data of the sample cities. The judicial auction data is from the Alibaba platform and the regular resale transaction data is from the China Real Estate Information dataset.

China and are regionally representative in terms of socio-economic and housing market development levels (the sample size for each city is shown in Table A1).

Both of these datasets provide comprehensive transaction details: price, transaction date, property attributes, and the full address. Utilizing these addresses, we fashioned a unique property identifier that facilitated a neighborhood-level matched sample analysis. We acquired GPS coordinates for each property to determine its proximity to the respective city center. As Feng and Lu (2013) show that the presence of an additional high-quality school (such as the Experimental Model Senior High School in China) per square kilometer increases housing prices significantly, this study measures access to quality public education by setting the dummy of whether there is a key primary or secondary school within 1 km of the property. Additionally, referring to Li et al. (2019), we also set a dummy of whether there is a subway within 1 km of the property to measure the level of accessibility (See Table 1 for definitions and selection references of variables). We obtained the list of key primary and secondary schools in each city from the official website of the Municipal Commission on Education and collected the location sites of schools and subway stations based on the points of interest (POI) service

of Baidu Map, complemented by Google Earth. Pertinently, the judicial auction dataset also discloses the rationale behind each auction, which provides an important basis for our grouping test.

To accurately gauge market-level dynamics, we incorporate data from multiple additional sources. The China City Housing Index (CCHI)[5] provides a monthly index of resale housing volumes across varied cities, acting as a barometer for regular market activity. Moreover, to ascertain the local market conditions and governmental regulation in the regular resale market, we assembled a monthly consolidated report of four-type primary housing policies—purchase restrictions, price caps, sales restrictions, and loan restrictions—which were implemented only in the regular resale housing market during our sample period. These policies were sourced directly from official city websites and mainstream media channels. The relative scope of the judicial auction housing market is represented by the annual ratio of judicial housing auctions to regular resale volumes within each city. Aggregate data for judicial auctions was sourced from the Alibaba platform, while the number of regular resale transactions was extracted from each city's Statistical Office Bulletin. To ensure data integrity, entries with missing data were excluded, and outliers in house prices were trimmed at the 1% quantile on both ends.

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[5] China City Housing Index was co-founded by the China Institute of Real Estate Appraisers and Agents (CIREA) and the Hang Lung Center for Real Estate of the Tsinghua University. The index to measure the relative rise and fall of the overall second-hand housing market in cities over a period was used.

Table 1
Definition and statistics of the variables.

Numeric Variables	Variable definition	References	Full Sample (N = 181,894)		Regular resale sample (N = 178,785)		Judicial auction Sample (N = 3109)	
			Mean	St. Err.	Mean	St. Err.	Mean	St. Err.
lnHP	The logarithm of housing transaction price (CNY/m²)	Zheng et al. (2023)	10.70	0.56	10.72	0.54	9.90	0.81
lnRM	The logarithm of the number of reminders	Xu et al. (2022)					1.35	0.87
lnRG	The logarithm of the number of registered auction participants	Xu et al. (2022)					4.20	1.05
D	The discount of judicial auction property (%)	Loberto (2023)					0.14	0.18
AREA	House area (m²)	Zheng et al. (2023)	82.09	36.60	81.19	34.50	133.90	84.95
HOUSE_AGE	The age of house (year)	Sun and Ong (2014)	18.17	9.40	18.24	9.40	13.66	7.86
ROOM	Number of bedrooms	Sun and Ong (2014)	2.08	0.79	2.07	0.77	2.87	1.27
DIS_CENTER	Distance from the house to city center (km)	Conklin et al. (2023)	27.79	20.61	27.93	20.64	20.00	17.52
LIST	The monthly index of resale housing listings in the city (Year₂₀₁₅=100)	Novy-Marx (2009)	135.84	79.06	135.04	78.09	181.64	113.61
SCALE[a]	City-level relative scale of the judicial auction housing market	Xu et al. (2022)	0.02	0.02	0.02	0.02	0.02	0.01
POLYCY	The number of types of regulation policies implemented only in regular resale market	Zheng et al. (2023)	3.75	0.51	3.75	0.50	3.70	0.56
DEC_HARD	Dummy equals to 1 if the property has simple decoration, 0 otherwise	Hayunga and Pace (2017)	0.55	0.50	0.55	0.50	0.46	0.50
DEC_SOFT	Dummy equals to 1 if the property has delicate decoration, 0 otherwise	Hayunga and Pace (2017)	0.40	0.49	0.40	0.49	0.41	0.49
FLOOR_TOP	Dummy equals to 1 if the property is on the top floor, 0 otherwise	Sun and Ong (2014)	0.27	0.44	0.27	0.44	0.34	0.47
FLOOR_MID	Dummy equals to 1 if the property is on the middle floor, 0 otherwise	Sun and Ong (2014)	0.34	0.48	0.34	0.47	0.66	0.47
SCHOOL	Dummy equals to 1 if the property is within 1 km from high-quality schools, 0 otherwise	Feng and Lu (2013)	0.23	0.44	0.28	0.45	0.19	0.41
SUBWAY	Dummy equals to 1 if the property is within 1 km from subway station, 0 otherwise	Li et al. (2019)	0.63	0.48	0.63	0.48	0.80	0.40
TOM	Number of dates between the start of the listing and the closing of the transaction	Levitt and Syverson (2008); Zheng et al. (2023)	73.45	8.23	91.01	8.32	26.87	6.36

[a] This index is calculated by the annual proportion of the amount of judicial auction houses to the regular resale housing transactions.

For empirical modeling, we use the logarithm of variables such as house prices, areas, and distances.

Table 1 reports the descriptive statistics of our main variables. The sales data includes 181,894 observations, out of which 178,785 are sold in the regular resale housing market and 3109 are judicial auction houses. The average price of judicial auction houses is 38,769 CNY/m², about 21% lower than that of regular resale homes, which is 49,011 CNY/m². Although property attributes and location metrics were comparably distributed between the two groups, it is noteworthy that judicial auctions predominantly feature larger, newer properties. In light of these findings, covariates such as property size and age will be factored into our PSM process, subsequently informing a nuanced analysis of how diverse housing structures influence judicial auction discounts through heterogeneity testing.

4.2. Identification strategy

Basically, we build a housing hedonic price model:

$$lnHP_{i,n,s,t} = \alpha_0 + \alpha_1 A_{i,t} + \alpha_2 C_{i,t} + \sigma_n + \delta_s + \gamma_t + \varepsilon_{i,n,s,t} \quad (1)$$

In this equation, $lnHP_{i,n,s,t}$ represents the logarithm of housing sales price for house i transacted in neighbor n, city s, and year t. $A_{i,t}$ is a dummy variable and equals to 1 if house i is a judicial auction house, otherwise 0. $C_{i,t}$ denotes control variables such as property characteristics and time on market. σ_n, δ_s, and γ_t are neighborhood fixed effects, city fixed effects, and transaction year fixed effects, respectively. $\varepsilon_{i,n,s,t}$ denotes the error term of the model. We focus on α_1, which reflects judicial housing discount rates. The interaction mechanism of the regular and judicial auction markets is shown in models (2) to (4):

$$lnR_{i,n,s,t} = \beta_0 + \beta_1 P_{s,t} + \beta_2 C_{i,t} + \sigma_n + \delta_s + \gamma_t + \varepsilon_{i,n,s,t} \quad (2)$$

$$D_{i,n,s,t} = \gamma_0 + \gamma_1 P_{s,t} + \gamma_2 C_{i,t} + \sigma_n + \delta_s + \gamma_t + \varepsilon_{i,n,s,t} \quad (3)$$

$$D_{i,n,s,t} = \tau_0 + \tau_1 lnR_{i,n,s,t} + \tau_2 P_{s,t} + \tau_3 C_{i,t} + \sigma_n + \delta_s + \gamma_t + \varepsilon_{i,n,s,t} \quad (4)$$

Where $lnR_{i,n,s,t}$ represents the logarithm of potential or actual buyers for house i transacted in neighbor n, city s, and year t. $D_{i,n,s,t}$ is the judicial auction discount of house i. $P_{i,t}$ is the supply and demand condition of the regular market, such as the volume of listings and the number of regulation policies in city s and year t. We focus on coefficients β_1 and γ_1, which indicate the total effect of regular market on judicial auction housing discounts and demand, respectively; $\gamma_1\tau_1$ indicates the mediating effect of regular market supply and demand on judicial auction discounts through the flow of housing demand.

Based on models (2) and (3), we add the purchasing risks of judicial auction houses, $Risk_{i,t}$, to test its moderating effect on judicial demand substitution effect and economic depreciation, respectively, as expressed by models (5) and (6):

$$lnR_{i,n,s,t} = \delta_0 + \delta_1 P_{s,t} \times Risk_{i,t} + \delta_2 C_{i,t} + \sigma_n + \delta_s + \gamma_t + \varepsilon_{i,n,s,t} \quad (5)$$

$$D_{i,n,s,t} = \theta_0 + \theta_1 P_{s,t} \times Risk_{i,t} + \theta_2 C_{i,t} + \sigma_n + \delta_s + \gamma_t + \varepsilon_{i,n,s,t} \quad (6)$$

The primary objective of our identification strategy is to account for potential disparities in the structures of judicial auctions and regular resale houses, ensuring that value depreciation is solely attributable to extraneous determinants. Notably, ordinary least squares (OLS) regression on a hedonic model is susceptible to endogeneity pitfalls, particularly sample self-selection and omitted variable biases. Given the potential non-random segmentation of judicial auctions and regular housing samples, transaction prices may be systematically influenced. To rectify biases stemming from this non-random sample distribution, we employ PSM, creating a counterfactual analytical framework inspired by Rosenbaum and Rubin (1983). Specifically, we use $A =$

$\{0, 1\}$ to divide the sample into two groups: judicial auction treatment group ($A = 1$) and regular resale control group ($A = 0$). $H_{A=0}$ and $H_{A=1}$ are the mean housing prices of the judicial auction group and the regular group, respectively. The difference in housing prices between the two groups can be expressed as the average treatment effect of the treatment group:

$$ATT = E(H_{A=1} - H_{A=0} \mid A = 1) = E(H_{A=1} \mid A = 1) - E(H_{A=0} \mid A = 1) \quad (7)$$

In reality, we cannot observe the regular market price of the judicial auction house at the same time. Therefore, we provide a counterfactual estimate of the price differences between the two groups by finding an efficient proxy, $E(H_{A=0} \mid A = 0)$, for a control group that is as similar as possible to $E(H_{A=0} \mid A = 1)$. We include covariates that may affect the property being a judicial auction house or not in the logit model to calculate the propensity score. To further ensure matching accuracy, we use 1:1 nearest neighbor matching without replacement and set the caliper to 0.05.

Traditional hedonic models might omit micro-factors swayed by preceding transaction outcomes of proximate properties, as posited by Clapp et al. (1995). Building upon foundational research (Gelfand et al., 1998; Pace & Gilley, 1998), we incorporate a spatial model to accommodate spatial/temporal influences encapsulated within error terms. Specifically, the Spatio-Temporal Autoregressive (STAR) model, as proposed by Pace et al. (1998) and validated for its predictive accuracy in housing price contexts by Liu and van der Vlist (2019) and Qu et al. (2021), is employed. The error term in Model (1) undergoes an autoregressive error process to elucidate correlated errors:

$$\varepsilon = W\varepsilon + \epsilon \quad (8)$$

In this equation, W, represents a $(n \times n)$ vector of the spatial weighting matrix with temporal dimension to retain previously sold properties as the possible neighbors to the target property, and ϵ is the white noise. Integrating Model (8) into Model (1), the transaction price can be specified as:

$$lnHP = WlnHP + (\beta - W\beta)X + \epsilon \quad (9)$$

In this equation, X represents the $(n \times k)$ vector composed by k influencing factors with β as its corresponding coefficient vector. Following Pace et al. (2000), optimal neighbors are discerned by gauging the Euclidean distances between target properties and antecedent transactions, procuring spatio-temporal price lags within each city.

5. Results

5.1. Economic depreciation in judicial auction houses

Table 2 presents the regression results and the impact of a judicial auction dummy on transaction prices using the PSM matched sample. Column (1) reveals a pronounced negative correlation, which is statistically significant. Columns (2) through (5) feature stepwise regressions. Although the magnitude of the judicial auction discount lessens across these columns, a significant negative correlation persists, even after controlling for housing attributes, market-level factors, and city and time trends. This pattern suggests that a universal discount for judicial auction properties, in comparison to regular resale properties, exists. By incorporating spatio-temporal lags into the model in Column (4), we still observe a substantial 15% discount on the judicial auction sample, aligning with prior studies (Clauretie & Daneshvary, 2009; Just et al., 2019). Considering that the average time on market for the regular resale and the judicial auction houses are approximately 3 months (91 days) and 1 month (27 days), respectively (see Table 1), this systemic difference in TOM may have an important impact on transaction prices. Thus, column (5) reports the results after controlling TOM, where the discount reduces to 14% but remains significant.

Moreover, column (6) shows the regression results using the full sample, where the judicial auction discount increased to 24%. This apparent discrepancy suggests that controlling common features is crucial in estimating the discount of judicial auctions. Figure A1 in the appendix indicates how covariate standard deviations evolved before and after matching, revealing that post-matching deviations are all below 10%. This demonstrates a significant reduction in between-group variance. Additionally, Figure A2 depicts the propensity score distributions before and after matching, revealing increased alignment between the two groups. This indicates that part of the higher discounts of the full sample comes from the inherent defects of judicial auction properties (Campbell et al., 2011; Frame, 2010; Lambie-Hanson, 2015); thus, after controlling the differences between the housing attributes and reducing the self-selection bias, the PSM matched sample obtains smaller and more accurate results.

Figure A3 reports the results of the placebo test. To safeguard against the influence of overlooked variables, we first randomized our samples, forming a pseudo treatment group. This group was then randomly selected for regression, and the outcomes were juxtaposed with those in Table 2. After 500 iterations of random selection, Figure A3 reveals that most coefficients hover around zero, significantly differing from the coefficient (−0.1379) in Table 2. The majority of these P values also lack significance at the 10% threshold. These findings bolster the robustness of our model and results. In conclusion, a discernible economic depreciation exists in China's judicial auction housing market. Table A2 in the

Table 2
Regression results of judicial auction discounts.

	(1)	(2)	(3)	(4)	(5)	(6)
	lnHP	lnHP	lnHP	lnHP	lnHP	lnHP
AUC	−0.1823***	−0.1855***	−0.1608***	−0.1458***	−0.1379***	−0.2367***
	(-9.07)	(-6.07)	(-5.10)	(-4.19)	(-5.03)	(-11.03)
N	14,077	14,077	14,077	14,077	14,077	174,790
R^2	0.9571	0.9633	0.9642	0.9643	0.9701	0.9531
Control variables		Yes	Yes	Yes	Yes	Yes
City FE			Yes	Yes	Yes	Yes
Time FE			Yes	Yes	Yes	Yes
ρ				Yes	Yes	Yes
TOM					Yes	Yes
Sample	PSM Matched	PSM Matched	PSM Matched	PSM Matched	PSM Matched	Full

Note: t statistics in parentheses, *p < 0.1, **p < 0.05, and ***p < 0.01. Standard errors are clustered at the neighborhood level. The dependent variable is the logarithm of the housing transaction price, *lnHP*. City FE and Time FE denote city and time (yearly) trends, respectively. ρ refers to the spatio-temporal lags, which are obtained within each city. Columns (1) to (5) use the PSM matched sample, while column (6) uses the full sample.

appendix provides an overview of the judicial auction discounts in different cities, ranging approximately from 6% to 21%.

5.2. Demand flows and substitution effect

As mentioned in Section 3, housing demand can flow across markets, resulting in a substitution effect between judicial auctions and regular resale housing. Therefore, we first used the judicial auction sample and focused on two crucial dependent variables: the logarithm of the number of potential buyers setting reminders, *lnRM*, and the logarithm of the number of registered auction participants, *lnRG*, which can respectively represent the potential and actual demand in the judicial auction market. Buyers who participate in the auction must register in advance and pay a deposit to the court, which means that they pay the cost even if they do not participate in the auction subsequently (Xu et al., 2022); thus, the number of registered buyers can be regarded as the actual demand for judicial auction houses; the people who only set up auction reminders do not need to pay costs, and they are the only potential demand in the judicial auction market.

Table 3 shows the impact of changes in the local regular resale housing market on the demand for judicial auction houses. Columns (1) and (2) underscore an intriguing observation: as the regular resale market flourishes, the demand in the judicial auction market narrows, and potential demand declines more than actual demand; conversely, a more regulated regular market correlates with an increased demand in the judicial auction segment, and potential demand also increases more than actual demand. This lends weight to our substitution hypothesis, suggesting a degree of interchangeability between the judicial auction and regular resale markets. It also highlights the spillover effects of local regulatory interventions in the regular sector. Furthermore, a more prominent judicial auction market scale significantly diminishes its economic depreciation. After considering the development stage of the judicial auction market, Columns (3) and (4) reveal that a larger judicial auction housing market would amplify the substitution effects of housing demand observed with the regular market. Specifically, the increased prominence of the judicial auction market makes it more sensitive to regular market fluctuations.

We further explored the price results of the demand substitution between the two submarkets. In Table 4, we examined the mediating mechanism: local changes in the regular resale housing market affect the demand flow, which influences the relative prices of the judicial auction houses. We retained the judicial auction samples, which have their matching samples, for regression. The dependent variable, *D*, is the price discount, which is calculated from the price of each judicial auction

property relative to the average price of its matched regular resale samples. Considering that there may be an inverse causal relationship between the demand and the price of each transaction, in the mediating regression, this study uses the city-level monthly average, *mlnRM* and *mlnRG,* to measure the demand for judicial auction houses. The results in Table 4 indicate that the supply scale and policy regulation of the regular resale market affect the relative price directly or affect by influencing the demand of the judicial auction market. This confirms the existence of substitution effects in the two submarkets and suggests that judicial auction discounts are the result of demand flowing across markets, supporting Hypothesis 1. Moreover, the coefficients of *lnRM* and *lnRG* suggest that the mediation effect of the actual demand on the judicial auction discount is greater than that of the potential demand.

5.3. Moderating effects of buyers' purchasing risk

Although there is a substitution effect between the two submarkets, it may not always remain the same. The demand flow is a manifestation of the buyers' behavior, reflecting changes in preferences. Section 3.2 discussed the risk of purchasing in the judicial auction housing market, and the discount is compensation for such a potential risk. Following this assumption, Tables 5 and 6 show the impact of purchasing risk on the substitution effect of the judicial auction housing market from two aspects: objective ownership defects and subjective stigma effects.

In Table 5, the coefficients of *LEASE* and *POLYCY×LEASE* are both significantly negative, which means that incomplete or uncertain ownership of judicial auction housing will reduce the potential demand and actual demand in the market, increase the judicial auction discounts, and also hinder the demand flow from the regular resale housing market. The judicial auction house with an unexpired lease will have a two-percentage point higher economic depreciation rate than that with a clean and full title, as well as 17% and 4% lower potential and actual demand, respectively. A similar story occurs with buyers' subjective perceptions of risk in the judicial auction housing market. Table 6 reports that the coefficients of *CRIMINAL*, *LIST×CRIMINAL* and *POLYCY×CRIMINAL* are all significantly negative, which means that judicial auction houses related to criminal cases will face more severe impairment in value (four percentage points higher in economic depreciation rates) and will be less attractive to the demand in the regular market (both potential and actual demand fell by 11%). Some buyers are reluctant to look at or bid on judicial auction houses out of stigma, even if they lose qualifications for purchasing regular resale houses. These findings validate Hypothesis 2, supporting objective ownership defects and subjective stigma effects weakening the substitution effect of the judicial auction market on the regular market. Compared with the ownership risk, the subjective perceived risk has a stronger negative effect on housing demand, bringing greater economic depreciation to judicial auction housing.

5.4. Results of further checks: what happens to overall market depression?

Theoretically, in addition to the risks associated with housing and individual home buyers because of the existence of risk aversion, the impact of buyers' purchase risk may be amplified by the negative impact of the overall market. The result may be calls for greater discounts or demand flowing out of the judicial auction market, with a weakening of the substitution effect between the submarkets. One of the direct ways to test this change is to analyze the impact of COVID-19.

The COVID-19 pandemic, which began its onslaught in early 2020, introduced profound shocks to the global economy, with the real estate sector enduring significant disruptions in supply and demand. Conceptually, the plummet in housing demand driven by the pandemic would invariably affect both the regular resale and judicial auction sectors, thereby reducing property values. A parallel narrative is that the economic downturn, characterized by heightened unemployment, credit defaults, and even a surge in criminal activities, could amplify the

Table 3
Demand flow under the market interaction mechanism.

	(1)	(2)	(3)	(4)
	lnRM	lnRG	lnRM	lnRG
LIST	−0.2497***	−0.2049***	−0.2482***	−0.1908***
	(-3.23)	(-3.09)	(-2.51)	(-2.93)
POLYCY	0.1479	0.1158*	0.1321*	0.0976**
	(1.17)	(1.78)	(1.81)	(2.28)
SCALE	0.5541***	0.4749**	0.5022***	0.5209*
	(7.83)	(2.36)	(7.56)	(1.88)
LIST×SCALE			−0.0137	−0.0039**
			(-1.53)	(-2.31)
POLYCY×SCALE			0.0078*	0.0102*
			(1.74)	(1.80)
N	3109	3109	3109	3109
R^2	0.9752	0.9622	0.9752	0.9623

Note: t statistics in parentheses, *p < 0.1, **p < 0.05, and ***p < 0.01. Standard errors are clustered at the neighborhood level. The results are from the judicial auction sample. *LIST×SCALE* and *POLYCY×SCALE* are interactions of *SCALE* and *LIST, POLYCY*, respectively. All models control the housing attributes, market-level factors, city and time-fixed effects, spatio-temporal lags, and *TOM*.

Table 4
Price results of the market interaction.

	(1)	(2)	(3)	(4)	(5)
	D	mlnRM	D	mlnRG	D
mlnRM			−3.7568**		
			(-2.32)		
mlnRG					−4.5435**
					(-2.07)
LIST	1.3549**	−0.2501***	1.3321**	−0.2035***	1.3107*
	(2.17)	(-4.11)	(2.11)	(-2.51)	(1.83)
POLYCY	−1.0072**	0.1368*	−1.0079**	0.0903*	−1.0053**
	(-2.07)	(1.73)	(-1.98)	(1.81)	(-2.09)
SCALE	−2.5236***	0.6732***	−2.5287***	1.0371***	−2.6074***
	(-6.55)	(6.39)	(-6.55)	(9.87)	(-6.54)
LIST×SCALE	1.0770*	−0.0078	1.0872*	−0.0052*	1.0875*
	(1.68)	(-1.02)	(1.68)	(-1.72)	(1.69)
POLYCY×SCALE	1.6551	0.0121*	1.6721	0.0221*	1.6436
	(0.43)	(1.84)	(0.45)	(1.83)	(0.44)
N	1139	1139	1139	1139	1139
R^2	0.3401	0.9768	0.3499	0.9752	0.3521

Note: t statistics in parentheses, *p < 0.1, **p < 0.05, and ***p < 0.01. Standard errors are clustered at the neighborhood level. The results are from the judicial auction sample. Both *lnRM* and *lnRG* are logarithms of the number of buyers. *LIST×SCALE* and *POLYCY×SCALE* are interactions of *SCALE* and *LIST, POLYCY*, respectively. All models control the housing attributes, market-level factors, city and time-fixed effects, spatio-temporal lags, and *TOM*.

Table 5
Regression results of moderating effect of uncertainty in ownership.

	(1)	(2)	(3)
	lnRM	lnRG	D
LIST	−0.2624***	−0.2079***	1.3451**
	(-3.13)	(-2.42)	(2.18)
POLYCY	0.1352*	0.0871**	−1.0023**
	(1.92)	(2.21)	(-2.11)
LEASE	−0.1727***	−0.0407***	2.2137**
	(-2.69)	(-2.60)	(2.09)
LIST×LEASE	−0.0031	−0.0036	0.1537
	(-0.16)	(-0.19)	(0.08)
POLYCY×LEASE	−0.0159***	−0.0175***	0.8872***
	(-2.73)	(-2.82)	(3.76)
N	3109	3109	1139
R^2	0.9754	0.9753	0.3517

Note: t statistics in parentheses, *p < 0.1, **p < 0.05, and ***p < 0.01. Standard errors are clustered at the neighborhood level. The results are from the judicial auction sample. *LIST×LEASE* and *POLYCY×LEASE* are interactions of *LEASE* and *LIST, POLYCY*, respectively. All models control the housing attributes, market-level factors, city and time-fixed effects, spatio-temporal lags, and *TOM*.

Table 6
Regression results of moderating effect of the stigma effect.

	(1)	(2)	(3)
	lnRM	lnRG	D
LIST	−0.2629***	−0.2079***	1.3312*
	(-3.39)	(-2.60)	(1.83)
POLYCY	0.1207**	0.0645**	−1.0109**
	(2.17)	(2.31)	(-2.37)
CRINIMAL	−0.2037***	−0.2125**	3.5724***
	(-2.95)	(-1.98)	(3.56)
LIST×CRINIMAL	−0.0029***	−0.0028***	0.0879*
	(-2.81)	(-2.70)	(1.77)
POLYCY×CRINIMAL	−0.1171**	−0.1122**	1.0372***
	(-2.41)	(-2.38)	(3.32)
N	3109	3109	1139
R^2	0.9766	0.9742	0.3623

Note: t statistics in parentheses, *p < 0.1, **p < 0.05, and ***p < 0.01. Standard errors are clustered at the neighborhood level. The results are from the judicial auction sample. *LIST×CRIMINAL* and *POLYCY×CRIMINAL* are interactions of *CRIMINAL* and *LIST, POLYCY*, respectively. All models control the housing attributes, market-level factors, city and time-fixed effects, spatio-temporal lags, and *TOM*.

Table 7
Results of heterogeneity in judicial auction discounts before/after the COVID-19.

	(1) Before COVID-19 (pre-2020)	(2) After COVID-19 (post-2020)
AUC	−0.1037***	−0.1689**
	(-2.69)	(-6.63)
N	11,290	2787
R^2	0.9702	0.9750
Empirical p-value	0.027	

Note: t statistics in parentheses, *p < 0.1, **p < 0.05, and ***p < 0.01. The dependent variable is lnHP. Standard errors are clustered at neighborhood level. The results are from the PSM matched sample. We divide the samples into two groups, before and after COVID-19, according to the year 2020. All models control the housing attributes, market-level factors, city and time-fixed effect, spatio-temporal lags, and *TOM*.

supply of properties for judicial auctions. Given this dual dynamic of suppressed demand and potentially augmented supply, it is pertinent to ask: How did judicial auction housing prices respond during the pandemic? Does the substitution effect between the two submarkets still exist?

To address this, we first bifurcate our samples into two periods: 2017–2019 (pre-epidemic) and 2020–2021 (post-epidemic) to discern variations in judicial auction discounts. The data presented in Table 7 echoes the trends visualized in Fig. 1: Post-pandemic, the judicial auction discount swelled from 10% to 17%, which signifies an accentuated economic depreciation of foreclosure housing during the pandemic. The empirical p-value also supports that the pandemic deepened the economic depreciation of judicial auction properties at the 5% significance level. Two primary factors, as posited by our conceptual framework, elucidate this trend. First, there was a palpable expansion in the supply of judicial auction houses. Second, in an environment riddled with uncertainty and overarching economic despondence, buyers manifested a diminished appetite for riskier assets. Consequently, the relative valuation of judicial auction properties declined. We further examine these internal causes of the loss of judicial auction properties under the pandemic.

Table 8
Buyer's purchase risk and the market interaction under COVID-19.

	(1)	(2)	(3)
	lnRM	lnRG	D
COVID	−0.2175	−0.2367**	2.0257**
	(−1.05)	(−1.97)	(2.21)
LIST	−0.2451**	−0.2147***	1.3238*
	(−2.54)	(−2.91)	(1.95)
POLYCY	0.1271**	0.1227*	−0.0066**
	(2.22)	(1.83)	(−2.37)
SCALE	0.5257*	0.4663*	−2.0721***
	(1.77)	(1.76)	(−5.14)
CRIMINAL	−0.0776**	−0.1104**	3.7571***
	(−2.47)	(−2.42)	(7.78)
LEASE	−0.0180*	−0.0223*	2.0519**
	(−1.70)	(−1.83)	(2.08)
COVID×LIST	−0.0005	−0.0004	0.5736
	(−1.87)	(−1.03)	(0.44)
COVID×POLYCY	−0.0732*	−0.0554*	0.0379*
	(−1.82)	(−1.78)	(1.68)
COVID×SCALE	1.8322	1.5743	1.5048**
	(0.84)	(1.03)	(2.37)
COVID×CRIMINAL	−0.0303**	−0.0557***	1.2027**
	(−2.25)	(−2.68)	(2.10)
COVID×LEASE	−0.0001**	−0.0003*	1.7966***
	(−2.01)	(−1.87)	(3.24)
N	3109	3109	1139
R^2	0.9628	0.9633	0.3521

Note: t statistics in parentheses, *$p < 0.1$, **$p < 0.05$, and ***$p < 0.01$. Standard errors are clustered at the neighborhood level. The results are from the judicial auction sample. Both *lnRM* and *lnRG* are logarithms of the number of buyers. Column (3) uses judicial auction samples, which have their matched regular resale samples, and *D* is the price discount of the judicial auction property to its matched sample. All models control the housing attributes, market-level factors, city and time-fixed effects, spatio-temporal lags, and *TOM*.

Using the *COVID* dummy variable, Table 8 further shows the effect of the pandemic on the demand flows and relative prices between the two submarkets. After the outbreak of COVID-19, both the potential and actual demand in the judicial auction market have decreased, and the discount has increased significantly. The coefficients of interaction terms *COVID×LIST* and *COVID×POLYCY* indicate that the impact of supply and demand in the regular resale market on the demand in the judicial auction market is weakened, that is, the cross-market mobility of housing demand is reduced. Moreover, the coefficients of *COVID×CRIMINAL* and *COVID×LEASE* show that stigma effects and tenure defects on judicial auction houses have been reinforced after the outbreak of the pandemic. These findings indicate that increased risk aversion among buyers will promote demand outflow from the relatively high-risk judicial auction market and increase its discount.

6. Discussion: implications of findings

The empirical results confirm that there is a significant economic depreciation in China's judicial auction housing market, which is consistent with previous studies (Clauretie & Daneshvary, 2009; Forgey et al., 1994; Just et al., 2019; Springer, 1996). Compared with previous studies, we focus on the relative discount of the judicial auction market and the substitution effect of this sub-market on the regular market. The supply and demand of the regular market will be transmitted to the judicial auction market, showing the substitution effect between the two submarkets. The results indicate that ownership defects and the stigma effect of the judicial auction market are crucial factors that impede the inflow of housing demand. This enriches the study of risk in the real estate market (Lin et al., 2012). From the perspective of risk aversion, the economic depreciation of judicial auction houses is a risk compensation for the uncertain loss after housing purchases. To some extent, this is also the price that buyers are willing to pay for a complete, clear title and a good reputation for a house. This also means that in addition

to the external attributes that we generally focus on, invisible factors like ownership and psychological feelings will also affect whether the value of housing assets can be realized.

Furthermore, some issues deserve further discussion. One is that China's online auction makes potential demand play an important role in the formation of judicial auction market prices. In the second-hand housing market, where information is asymmetric, online auctions convey additional information to buyers in the market (Xu et al., 2022). The results of this study imply that the strengthening of the regulation in the regular market promotes some buyers becoming the potential demand in the judicial auction market, which can also reduce the judicial auction discounts. A possible explanation is that the online platform facilitates potential buyers to set reminders for judicial auction houses of interest, while they can also see how many reminders have been set for each house, which is a useful signal of demand. This direct, public signal of demand may be more attractive than real estate agents' advertisements.

Another issue is recognizing the potential relationship between the judicial auction housing market and the full-recourse nature of mortgages in China. The results indicate that the average discount in China's foreclosure market is 14%, and even after the outbreak of COVID-19, this value has only risen to 16%, which remains less than results in many Western countries. This may be related to whether the supply of judicial auctions fluctuates significantly. Some studies have shown that housing markets with non-recourse mortgages are more expensive and volatile than those with full-recourse mortgages (Bao & Ding, 2015; Reed et al., 2018). Unlike non-recourse mortgages in the United States, mortgages in mainland China are recourse mortgages, which means that the borrowers have unlimited liability with the mortgage. Thus, in times of real estate depression, relatively few borrowers choose to forgo their collateral; therefore, there is less likely to be a large supply of foreclosed houses in the short term.

7. Conclusion

The urban resale residential market has always been of interest, yet the judicial auction segment within it has often been overlooked in research, particularly regarding its causal relationship with housing economic depreciation and interplay with the regular market. Our study, centered around residential transactions from 17 Chinese cities between July 2017 and October 2020, delves into judicial auction housing discounts and the underpinning mechanisms.

Three research disparities were addressed in the study: (1) The findings provide evidence that the average judicial auction discount in China is 14%, which is the result of the demand flow between the judicial auction market and the regular resale housing market. (2) Ownership defects and the stigma effect of the judicial auction market are crucial factors that impede the inflow of housing demand. The judicial auction discount is compensation for the buyer's purchasing risk. (3) The economic depreciation of the judicial auction market has intensified during the pandemic, meaning that housing demand is more inclined to flow out of the riskier market against the backdrop of rising overall market risks. These findings provide insights into resale housing market interactions and economic depreciation formation. Housing policymakers must emphasize the quality of judicial auction houses and the transparency of information for resale housing transactions. The complex interaction mechanisms of buyers, psychological preferences, and cross-market choices remain to be further explored.

CRediT authorship contribution statement

Weidong Qu: Funding acquisition, Investigation, Project administration, Supervision, Writing – review & editing. **Yiqi Huang:** Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

Table A1
List of sample cities.

City	Region	Full Sample (N = 181,894)	
		Judicial auction	Regular resale
Beijing	Eastern	414	114,677
Hangzhou	Eastern	107	10,584
Tianjin	Eastern	149	3599
Jinan	Eastern	147	2530
Nanjing	Eastern	556	9636
Qingdao	Eastern	163	3417
Shanghai	Eastern	393	7081
Suzhou	Eastern	251	5253
Hefei	Central	283	10,771
Wuhan	Central	303	7054
Xi'an	Western	343	4183
Total		3109	178,785

Table A2
Fisher combination test for urban heterogeneity in judicial auction discounts.

City	Beijing	Hangzhou	Hefei	Jinan	Nanjing	Qingdao	Shanghai	Suzhou	Tianjin	Wuhan	Xi'an
AUC	−0.0842***	−0.1024***	−0.0975***	−0.0386	−0.0577*	−0.1572***	−0.0784***	−0.0146	−0.2079***	−0.2165*	−0.1523**
	(-3.01)	(-4.35)	(-4.17)	(-0.51)	(-1.79)	(-6.17)	(-4.59)	(-0.25)	(-6.33)	(-2.12)	(-2.45)
Hangzhou	−0.129										
Hefei	−0.199	−0.328									
Jinan	−0.570	−0.112	−0.311								
Nanjing	0.241*	0.441***	0.018	0.249							
Qingdao	−0.699*	−0.371*	−0.049	−0.094	−0.343***						
Shanghai	−0.811	0.440	0.346***	0.028	−0.321*	0.396**					
Suzhou	0.147	0.112	0.077	0.259	0.022	0.084	−0.062				
Tianjin	−0.490***	−0.448***	−0.378***	−0.468***	0.717***	−0.374**	−0.552***	−0.458***			
Wuhan	−0.414***	−0.227***	−0.356*	−0.561***	−0.655***	0.156	−0.165	0.189	0.292***		
Xi'an	−0.122***	−0.543**	−0.251*	−0.215*	−0.363***	0.127	−0.269***	−0.103**	0.105***	−0.187*	
N	414	107	149	147	556	163	393	251	283	303	343

Note: t statistics in parentheses, *p < 0.05, **p < 0.01, ***p < 0.001. The results are from the judicial auction sample. The dependent variable is *lnHP*. Standard errors are cluster at the neighborhood level. All models control the housing attributes, market-level factors, city fixed effect, time-fixed effect, neighbor fixed effect and spatio-temporal lags. To ensure a valid comparison of regression coefficients across groups—given that they are only directly comparable under uniform model specifications (Cleary, 1999)—we employed the Fisher combination test. This examination of coefficient variances across the 11 cities confirmed the diverse nature of judicial auction discounts. The upper part of the table reports the regression results of the matched samples by cities, and the lower part shows the empirical p-value results of the Fisher's Permutation test for the coefficient differences of the pairwise cities.
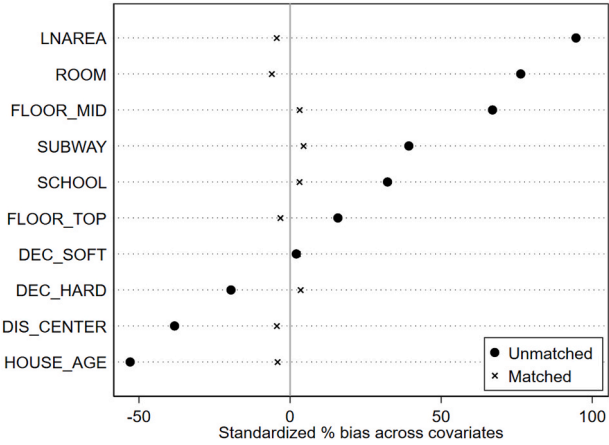
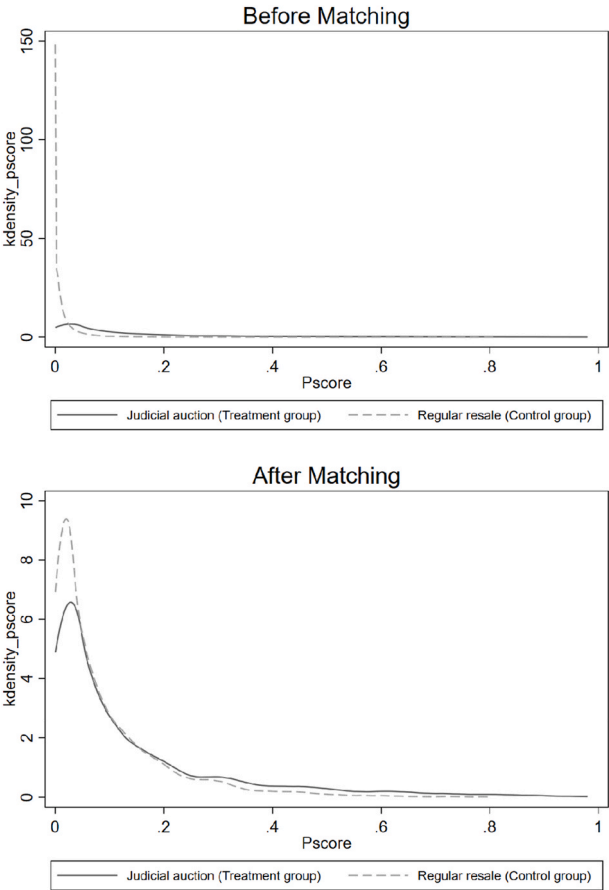**Fig. A1.** Standard deviation of covariates before and after matching.

Fig. A2. K-density of P-scores before and after matching.
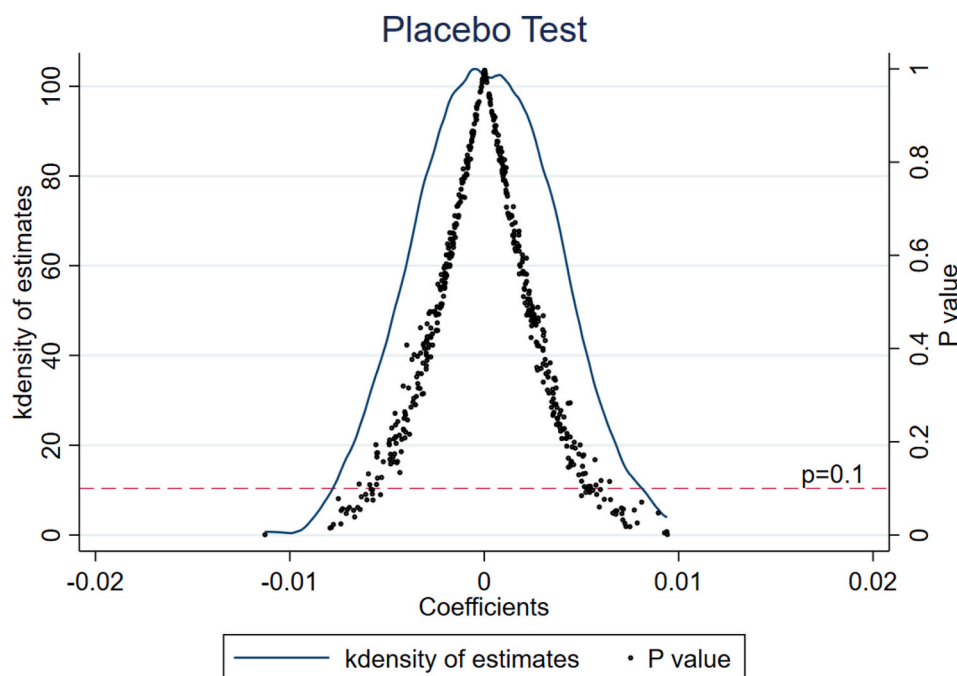
Placebo Test

Fig. A3. Result of placebo test.

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