ISSN: 1648-715X / eISSN: 1648-9179

VILNIUS TECH
Vilnius Gediminas Technical University

INTERNATIONAL JOURNAL OF STRATEGIC PROPERTY MANAGEMENT

2025
Volume 29
Issue 1
Pages 1–15
https://doi.org/10.3846/ijspm.2025.23234

DOES CHINA'S HOUSING SUPPLY-DEMAND RELATIONSHIP IMPACT URBAN INNOVATION CAPABILITY

Juanfeng ZHANG [1], Ning HAO[1], Guochao ZHAO[2], Lele LI[1], Xiaoyi XIANG[1], Rui HAN [1*]

[1] *College of Management, Zhejiang University of Technology, Hangzhou, China*
[2] *China Academy of Housing & Real Estate, Zhejiang University of Technology, Hangzhou, China*

Article History:
- received 30 April 2024
- accepted 5 December 2024

Abstract. Unlike existing literature that explores the impact of house prices on urban innovation, this paper skillfully examines the relationship between the housing market and urban innovation from the perspective of the housing supply-demand (S-D) relationship. Utilizing panel data from 284 prefecture-level cities in China spanning from 2005 to 2020, this study investigates the respective impacts of housing supply, housing demand, and their interplay on urban innovation capacity (UIC). Our findings indicate that housing supply positively influences UIC, with a coefficient of 0.060; specifically, for every 1% increase in housing supply, UIC increases by 0.06%. Similarly, housing demand also significantly affects UIC, with a coefficient of 0.060, suggesting that a 1% increase in housing demand corresponds to a 0.060% rise in UIC. However, we observe a significant negative effect of the housing S-D relationship on UIC, with a coefficient of –0.049, indicating that an increase in the housing S-D ratio detrimentally impacts urban innovation. Furthermore, our analysis reveals that as the housing supply-demand ratio rises, house prices also tend to increase. Additionally, we identify heterogeneity in our results, indicating variations in the housing supply-demand ratio's impact on the innovation capacity of cities across different regions.

Keywords: innovation, capability, housing market, supply and demand ratio, China.

*Corresponding author. E-mail: *2096955143@qq.com*

1. Introduction

Since 2016, the Chinese government has introduced a new housing policy emphasizing that "houses are for living, not for speculation," aimed at regulating the real estate market. Under this framework, housing prices increasingly fail to accurately reflect the true supply and demand dynamics (Wang, 2011; Yu & Cai, 2021; Arora et al., 2020). However, this policy has not fundamentally altered the underlying relationship between supply and demand in the housing market. In several major cities, including Beijing, Shanghai, Guangzhou, Shenzhen, Hangzhou, and Chengdu, housing supply continues to be constrained. In response, these cities have implemented lottery allocation systems to address housing shortages and enforce price controls. For instance, in 2017, the Shanghai Municipal Commission of Housing and Construction (SMCHC) issued the "Notice on Further Strengthening Real Estate Market Supervision in the City to Standardize Commodity Housing Pre-sale Behavior," making Shanghai the first city to introduce a "housing lottery" policy aimed at monitoring and regulating the local housing market while standardizing the pre-sale of commercial properties.

Specifically, in 2023, Shanghai reported a total housing construction area of 172,157,300 square meters, with 23,736,000 square meters of new construction initiated, reflecting a decrease of 19.3%. Conversely, the completed construction area was 20,963,600 square meters, marking an increase of 25.1%. The city's new commercial housing sales area amounted to 18,080,300 square meters, representing a decline of 2.4% from the previous year. The average sales price of new homes was RMB 45,977 per square meter. These statistics further underscore the tightness of Shanghai's housing market and suggest that elevated prices may be constraining the development of UIC (Gao, 2023; Chen et al., 2021). Banerjee and Roy (2014) explores the role of human capital and technological progress in long-term growth, delving into the impact of housing policy on urban innovation.

In this context, while distortions in housing prices may influence innovation, their impact is not direct. Consequently, the relationship between housing prices and innovation may not be fully elucidated by merely examining the effects of constrained housing prices on innovation. To address this gap, this paper investigates the connection

between housing markets and urban innovation through the lenses of housing supply, housing demand, and the housing S-D relationship. We contend that a more comprehensive understanding of how housing policy affects urban innovation potential can be attained by conducting an in-depth analysis of the dynamics of supply and demand within the housing market (Gan, 2007).

In recent years, China has accelerated its innovation and development efforts, significantly optimizing its innovation environment. The country has steadily increased its innovation inputs and achieved faster growth in innovation outputs, further demonstrating the effectiveness of its innovations and providing strong support for the promotion of high-quality development. Concurrently, China's housing prices have experienced substantial volatility due to factors such as government intervention, urbanization, land policies, and financial regulations. This instability may pose challenges to urban innovation, particularly in the context of implementing the innovation-driven development strategy, where the stability of the housing market is crucial. In their study, Grimes and Aitken (2010) discuss the role of housing supply and land costs in price adjustment, emphasizing the importance of these factors in maintaining market stability. Therefore, to ensure that innovations can effectively drive economic growth, it is essential to focus on and address the stability of the housing market.

To gain a deeper understanding of the relationship between the housing market and UIC, this study explores the operational mechanisms and influencing factors of the housing market from a novel perspective. While traditional research on housing markets primarily emphasizes economic indicators such as house prices and rents, this paper seeks to go beyond these conventional metrics to analyze the potential impact of the housing market on UIC in greater detail. Through this multi-dimensional analysis, the paper aims to provide new insights and methodologies for studying the relationship between the housing market and urban innovation capacity, thereby offering valuable references for relevant policy formulation.

The rationality of the housing S-D relationship significantly impacts the living conditions and utility of urban residents, which, in turn, influences their willingness to innovate. A balanced housing S-D ratio can attract talent, foster a livable environment, enhance residents' satisfaction with their quality of life, and create a favorable atmosphere for innovation. Conversely, an imbalance between housing supply and demand often leads to rising housing prices, which directly affects housing affordability for households. As a result, households may incur higher debt burdens to purchase housing, leaving less disposable income for essential areas such as education, skills upgrading, and entrepreneurial activities–key drivers of UIC (Luo & Chen, 2019; Hou, 2022; Jalali et al., 2022).

Decreased housing affordability restricts financial resources available for innovation and personal development. Additionally, high housing prices may contribute to brain drain, particularly among young, skilled professionals, who may opt to relocate to cities with more affordable housing and lower living costs. The innovative capacity of cities relies heavily on the concentration of talent, especially highly skilled and innovative individuals. When talent migrates due to high housing costs, the innovative vitality and potential of these cities are adversely affected.

Research has indicated that rising housing prices dampen both the advancement of industrial structures and urban innovation. Excessive increases in housing prices inhibit improvements in the quality and scale of urban innovation, with more pronounced effects observed in central and western regions (Luo & Chen, 2019). The rapid escalation of housing prices can lead to a mismatch of resources, resulting in diminished allocation efficiency–one of the crucial factors inhibiting urban innovation capacity. Therefore, exploring the link between the housing S-D relationship and UIC is essential for understanding how to better balance the housing market and promote urban innovation.

A review of existing literature reveals that many scholars believe that high housing prices and high rents inhibit cities' innovation abilities (Lin et al., 2021; Glaeser & Nathanson, 2017). Therefore, this paper examines UIC from the perspective of the supply and demand in the housing market. In line with the data availability and the actual situation in China, the paper selects the measurement indicators of housing supply, housing demand, and the housing S-D ratio, respectively, examining their distinct effects on UIC. It also investigates whether housing prices have heterogeneity in the process of the housing S-D ratio's effect on UIC.

The contributions of this study are two-fold. Firstly, it provides a system framework for understanding the interaction between supply and demand in the housing market and innovation capacity. This framework is constructed by integrating innovation theory and supply and demand theory, thereby providing a powerful tool for researchers and decision-makers. The aim is to better understand the key factors in the housing market that promote innovation. Secondly, due to China's unique housing market context, which includes government intervention and rapid urbanization, among others, this paper highlights the impact of the S-D relationship on innovation in this unique context. Through in-depth research on how housing price distortion affects the market, and how these distortions affect the dynamics of supply and demand, we can contribute to the development of more concrete policies.

2. Literature review

2.1. Measuring and influencing factors of urban innovation capacity

Regarding urban innovation capacity, Hamidi et al. (2019) pointed out that innovation capacity usually refers to the productivity or outcome level of innovative activities, which is a widely recognized definition. In this paper, UIC is thus understood as a city's ability to innovate scientifically and technologically, as well as economically and socially, which

reflects the potential and actual performance of a city in coping with changes, promoting economic growth and improving comprehensive competitiveness.

The index measuring a city's innovation ability can be either a single core index method or a comprehensive index system method. When choosing a single index, patent data is usually used to measure UIC (Komikado et al., 2021; Lu & Li, 2010; Fan & Li, 2022; Addie et al., 2018; Wang et al., 2020; Anthopoulos et al., 2022; Audretsch & Feldman, 1996). In this regard, Wang and Rong (2014) used the output value of new products to measure enterprises' innovation activities and study the impact of rising housing prices on these. However, urban innovation includes a variety of main and non-main factors, and a single index is not comprehensive. Due to this substantial limitation, a single index cannot fully reflect the UIC.

In contrast, the comprehensive index system method can reflect a city's innovation ability more comprehensively. Existing studies mainly use a multi-index system to measure UIC from the perspectives of innovation carriers, innovation input, innovation activities, innovation output, innovation environment and innovation performance (Sohn et al., 2016; Lopez-Carreiro & Monzon, 2018; Kurcheeva & Klochkov, 2018; Adam & Woodford, 2021). Regarding the innovation-driving force, scholars take innovation-driven environmental factors, effect factors, resource factors, and main factors as indicators to measure UIC (Edquist & Zabala-Iturriagagoitia, 2012; Carayannis et al., 2016; Yoo & Jeon, 2024; Lee, 2022; Zhang et al., 2022a). Yu and Cai (2021) used patent data from the State Intellectual Property Office and newly registered enterprise data from the State Administration for Industry and Commerce to measure urban innovation vitality.

To sum up, measuring UIC, both domestically and abroad, can involve both a single index and a comprehensive evaluation index. Recent research has mainly measured UIC using the innovation capability index of each city (Lee, 2013, 2024; Strange et al., 2006; Zhang et al., 2022a) and the Innovation and Entrepreneurship Index compiled by the Enterprise Big Data Research Center of Peking University. Considering that the timeliness of the data is particularly important, to conduct a better empirical analysis, this paper selects the innovation and entrepreneurship index compiled by the Enterprise Big Data Research Center of Peking University as the measurement index for UIC.

Numerous factors affect cities' innovation ability, whereby both the analysis perspective and the influencing factors are different. Adler and Florida (2021) studied the impact of population flow on regional innovation ability from the perspective of population flow. Ramzi and Salah (2018) found that economic growth, foreign direct investment and R&D employment are the positive factors promoting innovation in 11 European countries along the Mediterranean coast. Furman et al. (2002) believed that the level of innovation is affected by human capital, capital, the intensity or density of innovation investment, the protection of intellectual property rights, the level of education investment, and the degree of economic development, among others. Xue (2022) found that the innovation capability of cities in the Yellow River Basin is jointly affected by government financial input, talent factors, economic base, informatization level, financial environment and economic externality. Urban innovation theory – the basis of many studies on innovation and development – contends that spatial openness is an indispensable feature of urban-centered areas. Only through this can the various elements be continuously generated and re-developed in the spatial system, thus driving regional development. Additionally, Hu et al. (2024) and others have noted that metro construction stimulates urban economic growth, which in turn raises house prices from both the demand and supply perspectives by increasing the disposable income of urban residents and driving up the purchase price of residential land. Furthermore, metro construction positively influences the stability of the housing market and the agglomeration of human capital, which indirectly impacts UIC. Moreover, based on the findings by Luo and Chen (2019) and Li et al. (2022), rising house prices and elements mismatch significantly influence urban innovation capacity, indicating that the dynamics of the housing market are vital for understanding UIC. The study by Medina et al. (2020) looks at housing inequality in Salt Lake County, Utah, specifically analyzing local eviction patterns. Housing inequality, as an important aspect of the housing market, may potentially impact the city's ability to innovate by affecting, among other factors, the residential stability of its residents and, in turn, the city's ability to innovate. For example, unstable housing conditions may make it difficult for residents to devote themselves to innovation activities, or make the mobility of talent limited, indirectly affecting situations such as the agglomeration of human capital needed for urban innovation.

2.2. Housing market's impact on UIC

The dynamic interplay between the housing market and UIC has received significant scholarly attention. Some researchers have delved into the intricate relationship between a city's housing market volatility and its capacity for innovation. For instance, Wang and Wen (2011) discovered that a surge in real estate investment can produce a misallocation of regional resources, creating a crowding effect on long-term investment that is detrimental to the overall development of regional innovation. Brown et al. (2012) emphasized the pivotal role of an enterprise's internal financing channels in supporting innovation activities. Their findings suggested that the escalation of real estate investment tends to crowd out resources earmarked for innovation, hindering enterprises' research and development endeavors and subsequently impeding overall innovation capabilities.

In the context of the US real estate bubble, Chaney et al. (2012) observed a concerning trend where escalating housing prices prompt a significant proportion of real

estate investment to flow into bank loans. This diversion of funds adversely impacts other industries, obstructing their access to necessary loan financing and hampering technological innovation. Taking a spatial perspective, Zhu et al. (2019) employed a spatial econometric model to analyze provincial-level data in China. Their study revealed that regional innovation faces not only internal constraints from real estate investment but also external constraints from surrounding areas, introducing regional heterogeneity into the innovation landscape. Building upon this foundation, Zhang et al. (2022b) conducted a comprehensive analysis using data from companies listed on the Shanghai and Shenzhen stock markets from 2012 to 2021. Utilizing fixed-effect and mixed regression models, their study demonstrated a significant crowding-out effect of real estate investment on enterprise resources, impeding these enterprises' technological innovation capabilities. Notably, the existing disparities in housing access and social class divisions within cities may exacerbate the uneven distribution of innovation resources, adding a layer of complexity to the already intricate relationship between the housing market and UIC.

In addition, some studies have emphasized the impact of housing prices on urban innovation. Yao et al. (2020) found a high positive correlation between the housing price and the vitality of urban innovation, while Beracha et al. (2022) found a statistically and economically significant positive correlation between the innovation quality of the US housing market and the subsequent housing price appreciation. Similarly, Marmolejo-Duarte and Chen (2022) argue that insufficient control of architectural quality can lead to spurious conclusions regarding the relationship between energy performance ratings and residential prices, further complicating the dynamics between housing prices and urban innovation.

Based on data from 253 prefecture-level cities in China from 2003 to 2018, Yang and Wang (2023) found that the impact of rising regional housing prices on innovation and entrepreneurship is characterized by an "inverted" pattern of first promoting and then inhibiting. The review of the literature shows that the relationship between the housing market and innovation ability has been examined in detail; however, further work is needed to explore the impact on innovation ability from the perspective of the housing S-D relationship. Specifically, studying how changes in the housing S-D ratio affect the housing price changes will help us better grasp the subsequent changes to UIC. Puglisi and Celani (2017) point out that reasonable housing supply has an important impact on urban quality, which in turn is closely related to the city's ability to innovate, and that good urban quality is likely to attract more talent and provide human capital to support urban innovation.

In light of the above, this paper contends that two aspects need to be further explored. Firstly, the impact of housing supply and demand on UIC requires further study. Urban innovation is greatly influenced by financial support, and research shows that government funds and the financial development level significantly affect urban innovation. Market supply and demand theory points out that the S-D relationship of the housing market affects housing price fluctuations. When the supply of housing is fixed and the demand is too high, the demand exceeds the supply, pushing up the housing price. The housing market's high yield and opportunities for prosperity attract a large amount of capital and talent, which may crowd out corporate innovation funds and inhibit urban innovation. Analyzing the impact of real estate investment on urban innovation from the perspective of the housing supply, this paper finds that excessive investment may produce a crowding-out effect that is not conducive to urban innovation. However, the concrete impact of housing supply and housing demand on urban innovation needs further empirical testing.

In the study of how housing market characteristics impact UIC, the theory of innovation posits that UIC is a critical factor in promoting high-quality economic development. The housing S-D relationship is a primary determinant of housing price fluctuations, which are closely linked to housing affordability. As housing prices rise, affordability diminishes, particularly when incomes remain constant. Human capital is a vital element for urban innovation, and residents often weigh housing affordability when deciding where to live. Consequently, the housing S-D relationship affects affordability, which in turn relates to human capital levels. Research by Murray (2022) highlights the essential role that housing supply absorption rates play in influencing housing prices, which directly ties into the broader conversation about housing affordability and innovation. Therefore, the S-D dynamics in the housing market may influence UIC by shaping the pooling and retention of human capital.

Kuang and Yu (2019) demonstrate that homeownership influences innovation primarily through house prices, rather than population mobility, emphasizing the need to mitigate the negative impact of house price volatility on innovation. They also find that the inhibitory effect of homeownership on innovation is more pronounced in cities with lower human capital compared to those with higher human capital, highlighting the importance of fostering innovation in lower-capital cities. Similarly, Zhang (2019) investigates the impact of foreign human capital on urban innovation and concludes that foreign human capital plays a significant role in promoting urban innovation, particularly in its effectiveness. This suggests that the housing market's influence on urban innovativeness may be linked to the mobility and diversity of human capital. Collectively, these studies indicate that home-ownership, house prices, and levels of human capital are critical factors affecting urban innovation. Therefore, housing policies and market regulations should consider these elements to promote innovation and sustainable development in cities.

Therefore, this paper investigates the impact of housing market supply and demand on UIC by examining the S-D relationship within the housing market. The aim is to move beyond traditional research methodologies that focus primarily on house prices and to explore

new connections between the housing market and UIC. Through this multi-dimensional analysis, this paper seeks to offer fresh insights and methodologies for studying the relationship between the housing market and urban innovation capacity, ultimately providing valuable references for the formulation of relevant policies.

In summary, there exists a complex interlocking mechanism between the S-D relationship of the housing market and a urban innovation capacity, influencing factors such as affordability, human capital formation, and housing stability. Exploring this mechanism not only enhances our understanding of how the housing market impacts urban innovation but also provides policymakers with valuable insights to promote urban innovation through effective housing market policies. Furthermore, buyers and sellers with lower constructs are more likely to engage in secondary transactions. When the level of constructs is diminished, it tends to separate the focus of buyers and sellers, leading sellers to become more concerned about the negative attributes of the items being traded (Sun et al., 2024; Reed & Ume, 2017; Torab, 2018; Warren-Myers & Heywood, 2018; Yunus, 2015; Yan & Feng, 2019). This shift may indirectly affect both the stability and innovativeness of the housing market.

3. Theoretical models

3.1. The framework of the housing market's impact on innovation

The augmentation of the housing supply can be assessed through the lens of real estate development investment and the total completed housing area. Simultaneously, housing demand can be gauged by examining the commercial housing sales area and the urban population. The synergy between the surges in housing supply and demand signifies an enhancement in the urban housing market's developmental status, serving as a reflection of a city's overall economic prosperity.

An escalation in the urban housing supply suggests heightened overall demand or potential demand for housing. Conversely, an upswing in the housing demand can instigate an increase in the housing supply. This symbiotic relationship between supply and demand is indicative of a city's favorable development status, as shown in Figure 1. Such positive indicators attract more talent and

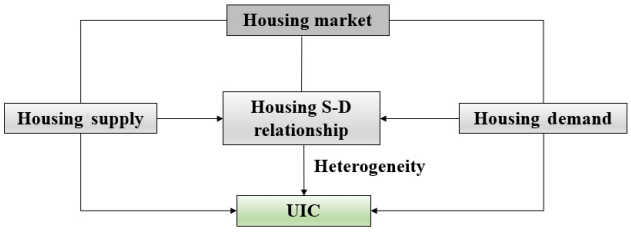

Figure 1. The framework of housing S-D relationship's impact on UIC

resources, bolster government fiscal revenue, and amplify investments in innovation. This, in turn, enables enterprises to secure more financing loans, alleviate their capital constraints, and intensify their investments in innovation, research and development, thereby enhancing their core competitiveness, production efficiency, and overall innovation capabilities.

As a key determinant of social development, the interaction between housing market dynamics and urban communities has become a compelling focus of academic research. Existing studies exploring the relationship between housing market dynamics and UIC have provided multifaceted insights. For instance, Kuang and Yu (2019) demonstrate that housing market stability is closely tied to S-D ratios, with high S-D ratios often indicating an oversupply of housing. This oversupply can lead to house price volatility, ultimately impacting urban innovation. These findings underscore the importance of housing market stability for enhancing UIC.

Additionally, Zhang (2019) investigates the effect of foreign human capital on urban innovation, revealing that it significantly contributes to urban innovation, particularly in advanced fields like technology and patent innovation. This suggests that the housing market's influence on urban innovativeness may be linked to the mobility and diversity of human capital. However, studies examining UIC from the perspective of the housing S-D relationship remain limited, highlighting the urgent need for more in-depth research on how this relationship specifically impacts UIC. The housing S-D ratio serves as a barometer of market stability; higher ratios indicate that housing supply substantially exceeds demand, creating market imbalances. An increase in the housing S-D ratio can trigger price volatility, negatively affecting urban innovation. Moreover, variations in supply and demand levels and UIC across different regions may lead to differing impacts. Thus, examining how regional differences in housing supply and demand affect UIC is crucial for a comprehensive understanding of this intricate relationship. Based on this analysis, the following research hypotheses are proposed.

Hypothesis H1: The urban housing S-D ratio has a significant impact on UIC.

In exploring the impact of urban housing supply-demand ratios on urban innovation capacity, we must acknowledge the significant heterogeneity present in housing markets and innovation environments across different regions. This heterogeneity is reflected not only in the levels of economic development, industrial structure, and demographic characteristics but also in the strength and effectiveness of housing policy implementation. For instance, He et al. (2017) highlight that the spatio-temporal patterns of innovation capacity among Chinese cities exhibit clear disparities across economic zones, with a gradual decline from the east to the central and western regions, further reinforcing the east's dominant position over time.

He et al. (2017) also note that regional differences in housing prices can influence labor mobility and industrial

upgrading, which in turn affect cities' innovative capacity and housing demand. High housing prices may deter the inflow of low-skilled labor while attracting high-skilled talent, fostering innovation in urban areas. Similarly, Mao et al. (2019) observe that the policy of "grabbing people with housing" significantly enhances cities' innovative capacity, with the most pronounced effects seen in the eastern regions, followed by central and western areas, while the northeast region experiences minimal or even negative impacts. This suggests that when formulating housing policies, it is crucial to consider the region's economic development level, industrial structure, demographic profile, and specific housing market conditions to ensure the effectiveness of these policies in promoting urban innovation. Thus, it is essential to hypothesize that the impact of urban housing supply-demand ratios on urban innovation capacity is heterogeneous.

Hypothesis H2: The influence of the urban housing S-D ratio on UIC is heterogeneous.

3.2. The impact of the S-D relationship on UIC

Based on the above theoretical analysis and data collation, this paper uses panel data from 284 prefecture-level cities in China to build a model of the housing S-D relationship and the impact of housing affordability on UIC. To eliminate the influence of heteroscedasticity and increase data comparability, all variables are treated logarithmically in this paper, with the regression model as follows:

Model 1: Housing supply model

$$\ln inn_{it} = \alpha_0 + \alpha_1 \ln hs_{it} + \alpha_2 C_{it} + \delta_{it} + \varphi_{it} + \varepsilon_{it}. \quad (1)$$

Model 2: Housing demand model

$$\ln inn_{it} = \beta_0 + \beta_1 \ln hd_{it} + \beta_2 C_{it} + \delta_{it} + \varphi_{it} + \varepsilon_{it}. \quad (2)$$

Model 3: Housing supply and demand ratio model

$$\ln inn_{it} = \gamma_0 + \gamma_1 \ln std_{it} + \gamma_2 C_{it} + \delta_{it} + \varphi_{it} + \varepsilon_{it}. \quad (3)$$

where: i represents the city; t represents the year; $\ln inn_{it}$ represents the logarithmic form of the UIC index; $\ln hs_{it}$, $\ln hd_{it}$ and $\ln std_{it}$ respectively represent the logarithmic form of the housing supply level, housing demand level, and housing supply and demand ratio; C_{it} represents the control variables (including the level of economic development, the level of financial development, etc.); δ_{it} represents the individual effect; φ_{it} represents the time effect; ε_{it} represents the error term; α_{0-2}, β_{0-2}, γ_{0-2} represent the coefficients, respectively.

4. Variable selection and data description

4.1. Variables and index construction

Based on the literature review and theoretical analysis, this paper takes INN as the dependent variable, and housing supply (HS), housing demand (HD) and housing supply/demand ratio (STD) as the independent variables. Economic development level (PGDP), financial development level (FIN), industrial structure (IND), urbanization level (URB), openness to the outside world (OPEN), government intervention (GOV), science and technology level (TEC), infrastructure level (INF) and other variables are selected as the control variables. Due to our large research area and time span, and considering the data availability, appropriate indicators are selected to measure the relevant variables. The specific variables and measurement indicators are as follows:

(1) Dependent variables

According to the literature review regarding the index measurement of UIC in 2.1, most past studies used patent data to measure UIC. As a single index often has great limitations, scholars have built a comprehensive evaluation index system of innovation capability from the perspectives of innovation input, output and innovation environment. The comprehensive evaluation index system can more comprehensively reflect the level of UIC. At present, most studies use an innovation index to measure UIC. Considering the timeliness of the data, this paper uses the Innovation and Entrepreneurship Index compiled by the Enterprise Big Data Research Center of Peking University to measure UIC. The index constructs a comprehensive evaluation system comprising five dimensions, such as the number of new enterprises attracting foreign investment, and seven indicators, such as the number of new enterprises registered, to better and more comprehensively reflect the level of UIC.

(2) Independent variables

The main explanatory variables of this paper are housing supply (HS), housing demand (HD) and the housing supply-demand ratio (STD). This paper selects investment in residential commercial housing development as the index of housing market supply. The sales area of residential commercial housing is selected as the index of housing market demand; the greater the sales area of residential commercial housing, the greater the housing demand. The index of the housing S-D ratio refers to the calculation method, which is derived from the ratio of housing construction area to the average sales area of residential commercial housing. This index truly reflects the stability of the housing market from the perspective of commercial housing. The higher the ratio, the more unbalanced the housing market, indicating that the supply of commercial housing market is far greater than the demand.

(3) Control variables

Economic development level (PGDP). Gross National Product (GDP) is the final result of the production activities of all resident units in a country (or region) over a certain period of time. GDP is the core index of national economic accounting, and also an important indicator for measuring the economic status and development level of a country or region. This paper selects per capita gross regional product (PGDP) to measure the level of economic development.

Financial development level (FIN). The level of financial development plays a crucial role in the social and economic development of a city. In the process of economic

activity, individuals, enterprises and countries all need the support of funds and the most important role of finance is to realize the allocation of funds in all walks of life within the social scope and help large and small economic entities complete the financing of funds. This paper uses the proportion of financial deposits and loans in GDP to measure the level of financial development.

Industrial structure (IND). Industrial structure plays an important role in the development of the national economy and the allocation of resources. The optimization and upgrading of the industrial structure can ensure economic growth and improve the allocation efficiency of economic resources. This paper uses the ratio of output values of tertiary industry and secondary industry to measure industrial structure.

Urbanization level (URB). A city is the center of regional science, technology and culture, and the level of urbanization is an important embodiment of the overall development level of a region. This paper uses the urbanization rate to measure the level of urbanization, which is calculated using the ratio of the permanent urban population to the year-end permanent population.

Degree of openness. Opening to the outside world plays a vital role in the development of a city. Opening to the outside world can promote exchanges between various countries and regions, including culture, technology, production and other aspects. The level of opening up of a city can reflect its level of development. In this paper, the proportion of total imports and exports in GDP is used to measure the degree of opening to the outside world.

Government intervention (GOV). Government intervention plays an important role in urban economic development and resource allocation. The higher the proportion of a city's government's participation in the local economy, the stronger the role played by the government in economic development and the more capable it is of mobilizing social resources. This paper uses the ratio of government expenditure to current GDP to measure the degree of government intervention.

Technical level (TEC). Science and technology represent the concentrated embodiment of advanced productive forces, and they also encompass the primary productive force. The level of science and technology of a city has an important impact on the city's innovation ability. This article uses the proportion of science and technology expenditure to the current fiscal expenditure to measure the level of science and technology.

Infrastructure level (INF). The level of infrastructure is an important factor in urban development. Considering the influence factors of the dependent variables, this paper chooses the number of library books per 10,000 people to measure the level of infrastructure.

4.2. Data description

Data from 284 prefecture-level cities in China from 2005 to 2020 are selected in this paper. In addition to the innovation and entrepreneurship index compiled by the Enterprise Big Data Research Center of Peking University, the other data are derived from the statistical yearbooks of various provinces and cities, the China City Statistical Yearbook, China Regional Economic Statistical Yearbook and EPS database. Due to the large study area and time span, there are some missing data, which this paper completes using linear interpolation. Table 1 lists the specific description of each variable.

Table 1. Descriptive statistics of the variables

Variable type	Variable	Symbol	Unit	Mean	Standard Deviation	Min	Max
Dependent variable	*UIC*	*INN*	/	70.121	21.074	7.527	100.000
Independent variable	*Housing supply level*	*HS*	Ten thousand yuan	1785627.000	3230283.000	2934.000	32467660.000
	Housing demand level	*HD*	Ten thousand yuan	234.100	489.017	0.166	5268.850
	Housing supply and demand ratio	*STD*	/	8.191	11.261	1.013	183.218
Control variable	*Level of economic development*	*PGDP*	yuan	42068.710	31509.950	2396.000	256877.000
	Financial development level	*FIN*	%	225.555	115.289	50.806	2130.150
	Industrial structure	*IND*	%	95.086	54.531	9.432	948.222
	Urbanization level	*URB*	%	51.127	16.948	11.410	100.000
	Degree of openness	*OPEN*	%	19.464	34.248	0.003	349.886
	Government intervention	*GOV*	%	17.982	10.185	4.262	148.516
	Scientific and technological level	*TEC*	‰	140.399	151.730	2.650	2068.350
	Infrastructure level	*INF*	Volume and parcel	5420.187	9000.206	134.818	440109.000

Note: The data in the table are calculated using Stata software. The data come from the Enterprise Big Data Research Center of Peking University, China City Statistical Yearbook, China Regional Economic Statistical Yearbook, EPS database and statistical yearbooks of various provinces and cities.

5. Empirical results

5.1. The regression results

Based on the findings from the panel unit root test, cointegration test, and Hausman test, this paper employs a two-way fixed effects model for empirical analysis. The regression results for both the mixed regression (OLS) and the two-way fixed effects model (Tw-FE) are presented in Table 2.

According to columns (2), (4), and (6) of Table 2, the coefficient of ln*hs* is 0.060, which is significant at the 1% level. This indicates that the level of housing supply has a significant positive impact on urban innovation capacity at the national level; specifically, a 1% increase in housing supply results in a 0.06% increase in urban innovation capacity. Similarly, the coefficient of ln*hd* is also 0.060 and significant at the 1% level, suggesting that the level of housing demand positively influences the urban innovation capacity, with every 1% increase in housing demand leading to a 0.060% increase in innovation capacity. In contrast, the coefficient of ln*std* is –0.049, also significant at the 1% level, indicating that the ratio of housing supply to demand has a significant negative impact on urban innovation capacity. Specifically, a 1% increase in this ratio results in a 0.049% decrease in innovation capacity.

These findings align with previous studies that suggest an increase in housing supply and demand enhances urban innovation capacity. However, as the supply-demand ratio continues to rise, it may lead to escalating housing prices, which can hinder the concentration of urban talent and resources, ultimately inhibiting the city's innovative capacity. These results further validate hypothesis H1.

From the perspective of control variables, the coefficient of ln*pgdp* is positive in all three models and significant at the 1% level. This indicates that the level of regional economic development significantly enhances urban innovation capacity; thus, a solid economic foundation is essential for improving a city's innovative capabilities.

The coefficient of ln*fin* is also positive, demonstrating that the level of financial development positively impacts urban innovation capacity. This finding aligns with the majority of existing research, suggesting that

Table 2. Overall empirical test results

Variable	Housing supply model		Housing demand model		Housing supply and demand ratio model	
	(1) OLS	(2) Tw-FE	(3) OLS	(4) Tw-FE	(5) OLS	(6) Tw-FE
ln*hs*	0.050*** (15.68)	0.060*** (11.12)				
ln*hd*			0.046*** (15.12)	0.060*** (11.23)		
ln*std*					–0.010** (–2.52)	–0.049*** (–9.60)
ln*pgdp*	0.344*** (43.20)	0.443*** (23.45)	0.346*** (43.34)	0.434*** (22.72)	0.408*** (58.01)	0.491*** (27.09)
ln*fin*	0.121*** (12.16)	0.203*** (11.08)	0.127*** (12.88)	0.206*** (11.25)	0.173*** (17.53)	0.192*** (10.43)
ln*ind*	–0.045*** (–6.07)	–0.022* (–1.74)	–0.048*** (–6.48)	–0.026** (–2.08)	–0.022*** (–2.91)	–0.024* (–1.94)
ln*urb*	0.096*** (7.18)	0.144*** (8.71)	0.090*** (6.74)	0.138*** (8.35)	0.046*** (3.41)	0.131*** (7.85)
ln*open*	0.022*** (9.32)	0.023*** (5.12)	0.021*** (8.66)	0.022*** (4.88)	0.027*** (11.00)	0.020*** (4.46)
ln*gov*	0.145*** (19.47)	0.184*** (10.36)	0.144*** (19.31)	0.180*** (10.10)	0.124*** (16.10)	0.201*** (11.35)
ln*tec*	–0.017*** (–4.48)	–0.076*** (–15.91)	–0.018*** (–4.65)	–0.080*** (–16.59)	0.005 (1.25)	–0.071*** (–14.93)
ln*inf*	–0.028*** (–5.53)	0.016*** (2.65)	–0.030*** (–5.98)	0.017*** (2.71)	–0.043*** (–8.53)	0.019*** (3.11)
Constant	–0.556*** (–9.23)	–2.433*** (–10.25)	–0.528*** (–8.50)	–2.304*** (–9.60)	–1.104*** (–22.00)	–2.603*** (–11.01)
Obs	4544	4544	4544	4544	4544	4544
Individual fixation effect		Yes		Yes		Yes
Time-fixed effect		Yes		Yes		Yes
R^2	0.789	0.812	0.788	0.812	0.778	0.810

Note: The data in the table is computed using Stata. The symbols *, **, and *** represent significance at the 10%, 5%, and 1% levels, respectively, with *t*-values provided in parentheses.

improvements in financial aspects attract both capital and talent, thereby enhancing the urban innovation capacity. Conversely, the coefficient of ln*ind* is negative and significant across all models, indicating that the industrial structure has a detrimental impact on urban innovation ability. On the other hand, the coefficient of ln*urb* is positive and significant at the 1% level, suggesting that urbanization significantly contributes to enhancing the urban innovation capacity.

The coefficients for ln*open* are consistently positive and significant at the 1% level, implying that the degree of openness to the outside world positively affects urban innovation capacity. A higher degree of openness facilitates domestic and international exchanges, attracting more foreign capital, talent, and technology, which are beneficial for enhancing innovation.

Furthermore, the coefficients for ln*gov* are also positive and significant at the 1% level, indicating that government intervention plays a crucial role in urban innovation capacity. Government actions are vital for resource allocation in the market, as they provide more innovative inputs to activities, thereby improving urban innovation capacity.

In contrast, the coefficients for ln*tec* are negative and significant in all three models, indicating that science and technology expenditures significantly impact urban innovation capacity. Lastly, the coefficient of ln*inf* is positive and significant at the 1% level, highlighting that a higher level of infrastructure positively influences urban innovation capacity. Good infrastructure is more attractive to innovative enterprises and talent, thereby fostering improvements in the city's innovation capabilities.

5.2. Robustness test

5.2.1. Change the estimation method

Given the endogeneity concerns within the model, a bidirectional relationship may exist between the housing market supply-demand dynamics and urban innovation capacity. Specifically, the housing market supply-demand relationship can influence urban innovation capacity, while urban innovation capacity can also affect the housing market supply-demand conditions. To enhance the robustness of the regression results, this section employs the Two-Stage Least Squares (IV-2SLS) method for re-estimation. The lagged variables of housing supply and housing demand serve as instrumental variables for their respective models, while the housing supply-demand ratio model utilizes the lagged supply-demand ratio, residential real estate development investment, and residential property sales as instrumental variables.

It is important to address potential issues of weak correlation and endogeneity in the instrumental variables, necessitating thorough testing. A weak instrument test was conducted to verify the validity of the instrumental variables. Regression analyses using Stata software revealed that all F-statistics from the tests exceed 10, with a *p*-value of 0.000, significantly rejecting the null hypothesis of "weak instruments." Additionally, in the first-stage regression, the *p*-value for the relationship between the instrumental variables and the endogenous explanatory variables was also 0.000, indicating robust correlation. Hence, the selected instrumental variables are deemed appropriate, and no issues of weak instruments are present.

An over-identification test on the housing supply-demand ratio model yielded a *p*-value of 0.000, significantly rejecting the null hypothesis that all instrumental variables are exogenous. This result suggests that at least one instrumental variable is not exogenous and is correlated with the disturbance term. The results in Table 3 for columns (1), (2), and (3) indicate that, when employing the Two-Stage Least Squares (IV-2SLS) estimation method, the coefficient signs and significance of the core explanatory variables align with the outputs from OLS and Tw-FE, thereby confirming the overall robustness of the empirical findings.

5.2.2. Replace variables

This section replaces the explained variables with the China Urban and Industry Innovation Index, jointly published by the Fudan University Institute for Innovation and Digital Economy (RIDE) and the Fudan University Industrial Development Research Center (FIND) (Kou & Liu, 2020). Additionally, all variables are subjected to winsorization to stabilize the data before conducting another bidirectional fixed effects regression. The results presented in Table 3 for columns (4), (5), and (6) indicate that, following the replacement of the explained variables, the coefficients for housing supply level, housing demand level, and housing supply-demand ratio, although differing in magnitude, retain consistent signs, directions, and significance levels compared to the baseline regression analysis results. This consistency suggests that the baseline regression results are indeed robust.

Table 3. Robustness test results

Variable	Change the estimation method			Replace variable		
	(1) Housing supply model	(2) Housing demand model	(3) Housing supply and demand ratio model	(4) Housing supply model	(5) Housing demand model	(6) Housing supply and demand ratio model
ln*hs*	0.052*** (14.59)			0.089*** (4.37)		
ln*hd*		0.047*** (13.58)			0.078*** (3.42)	

End of Table 3

Variable	Change the estimation method			Replace variable		
	(1) Housing supply model	(2) Housing demand model	(3) Housing supply and demand ratio model	(4) Housing supply model	(5) Housing demand model	(6) Housing supply and demand ratio model
ln*std*			–0.009* (–1.80)			–0.034* (–1.66)
Control variable	YES	YES	YES	YES	YES	YES
Constant	–0.494*** (–6.24)	–0.477*** (–5.76)	–1.041*** (–14.04)	–3.591*** (–4.69)	–3.956*** (–5.23)	–4.022*** (–5.28)
Obs	4260	4260	4260	4,544	4,544	4,544
Individual fixation effect				YES	YES	YES
Time-fixed effect				YES	YES	YES
R^2	0.775	0.774	0.763	0.569	0.568	0.567

Note: The data in the table is calculated using Stata. *, *** indicate significance at the 10%, and 1% levels, respectively, with *t*-values shown in parentheses.

5.3. Heterogeneity test

Due to the great differences in population, resources and technology in prefecture-level cities across the country, this paper analyzes the impact of the S-D relationships in different urban housing markets on the innovation ability of cities through a heterogeneity test. The heterogeneity test is carried out using two classification methods. One is the heterogeneity test of different regions, which divides cities into eastern, central, western and northeastern regions and respectively conducts empirical testing and analysis. The other is the heterogeneity test of different types of cities, which divides the national cities into innovative pilot cities and non-innovative pilot cities and respectively carries out empirical testing and analysis.

5.3.1. Regional heterogeneity analysis

Based on the division criteria for the eastern, central, western and northeast regions of the National Bureau of Statistics and the empirical data of this paper, we may conclude that the eastern region comprises Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan provinces, with a total of 86 prefecture-level cities and 1376 observed values. The central region encompasses Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan provinces, with a total of 80 prefecture-level cities and 1280 observed values. The western region is Inner Mongolia Autonomous Region, Guangxi Zhuang Autonomous Region, Chongqing Municipality, Sichuan Province, Guizhou Province, Yunnan Province, Shaanxi Province, Gansu Province, Qinghai Province, Ningxia Hui Autonomous Region and Xinjiang Uygur Autonomous Region, with a total of 84 prefecture-level cities and 1344 observed values. Finally, the northeast region represents Liaoning, Jilin and Heilongjiang provinces, with a total of 34 prefecture-level cities and 544 observed values.

Drawing insights from the descriptive statistics presented above, Table 4 provides specific results. First and foremost, the empirical findings of the housing supply model (models 1–4) are examined. The influence coefficient of the housing supply level on urban innovation ability is positive across the eastern, central, western, and northeast regions. Significance is noted at the 1% level in the eastern and western regions and at the 5% level in the northeast region, aligning with the overall empirical test results. This underscores the substantial positive impact of the housing supply level on UIC. Analyzing the impact across regions, the central region exhibits the most pronounced influence, followed by the eastern region, with comparatively smaller effects in the western and northeast regions.

Moving on to the empirical results of the housing demand model (models 5–8), the influence coefficient of the housing demand level on UIC is positive in the eastern, central, and western regions, reaching significance at the 1% level. However, no significant influence is observed in the northeast region. Regionally, the eastern region stands out with the most substantial impact, followed by the central region, while the western region displays the smallest effect. Lastly, the empirical results of the housing S-D ratio model are considered. Based on the outcomes of models (9)–(12), it is evident that the housing S-D ratio yields no significant impact on UIC in the eastern region. Conversely, it exerts a significant negative influence in the central and western regions, while displaying a notable positive impact in the northeast region. Notably, the adverse effect in the central region surpasses that in the western region.

Drawing conclusions from the empirical findings of the aforementioned models, it becomes apparent that the diverse impacts of housing supply and demand on UIC are influenced by the developmental disparities among regions. As the housing supply and housing demand escalate, there is a varying degree of a positive impact on the city's innovation ability. However, when the housing S-D ratio continues to rise, it acts as a catalyst for enhancing UIC in the northeast region. In contrast, for the eastern, central, and western regions, an escalating S-D ratio does not contribute favorably to the improvement of UIC. This underscores the nuanced relationship between housing

dynamics and urban innovation across different regional contexts.

Following the empirical examination of the remaining control variables, noteworthy patterns emerge. The level of regional economic development and government intervention exhibit a substantial positive influence on UIC across all four regions. In contrast, the level of science and technology demonstrates a significant negative impact on UIC in these regions, while the industrial structure has no noteworthy effect on UIC.

Moreover, the impact of additional variables varies across regions. The level of financial development wields a significant positive impact on UIC in the central and western regions, but its influence is not significant in the eastern and northeast regions. The urbanization level demonstrates a significant positive effect on UIC in the eastern, central, and western regions, whereas its impact is not statistically significant in the northeast region. The degree of openness to the outside world has a significant positive impact on the eastern and central regions, but no significant impact is observed in the western and northeast regions. Furthermore, the level of infrastructure displays no significant impact on UIC in the eastern region, but it exerts a substantial positive influence in the central, western, and northeast regions. These nuanced findings underscore the multifaceted nature of the factors shaping UIC, with region-specific dynamics playing a crucial role in determining their impact.

5.3.2. Analysis of urban heterogeneity

Based on the classification of innovative pilot cities in 2020, 75 innovative pilot cities were obtained after excluding Lhasa, with a total of 1200 observations; there are 209 non-innovative cities, with a total of 3344 observed values. According to the aforementioned data description, separate tests are conducted for innovative pilot cities and non-innovative pilot cities, and the regression results are detailed in Table 5. Models (1) and (2) signify the heterogeneity test outcomes for the housing supply model, models (3) and (4) represent the heterogeneity test results for the housing demand model, and models (5) and (6) encapsulate the heterogeneity test results for the housing S-D ratio model. The findings reveal a consistent pattern across both types of pilot cities. Specifically, the housing supply and demand levels exhibit a statistically significant positive impact on UIC, while the housing S-D ratio demonstrates a significant negative impact on UIC.

Analyzing the influence effects further, it is discerned that the impacts of the housing supply model and demand model on non-innovative pilot cities surpass those on innovative pilot cities. This implies that in non-innovative pilot cities, enhancing the housing supply is more effective in enhancing the innovation ability. The upswing in the housing supply indicates a flourishing real estate market, which, in turn, contributes to the advancement of urban economic development. This growth translates into increased government financial revenue, enabling greater investment in innovation and thereby elevating the city's innovation ability.

Table 4. Results of the heterogeneity test

Variable	Housing supply model				Housing demand model				Housing supply and demand ratio model			
	(1) Eastern region	(2) Central region	(3) Western region	(4) Northeast region	(5) Eastern region	(6) Central region	(7) Western region	(8) Northeast region	(9) Eastern region	(10) Central region	(11) Western region	(12) Northeast region
ln*hs*	0.093***	0.109***	0.048***	0.023**								
ln*hd*	–10.530	–10.940	–3.900	–2.120								
ln*std*					0.111***	0.105***	0.069***	0.004				
ln*pgdp*					–12.580	–9.620	–5.850	–0.390				
ln*fin*									–0.013	–0.078***	–0.061***	0.024**
ln*ind*									(–1.54)	(–8.59)	(–5.36)	–2.490
ln*urb*	0.228***	0.365***	0.500***	0.232***	0.202***	0.342***	0.461***	0.252***	0.277***	0.393***	0.538***	0.249***
ln*open*	–10.020	–9.950	–10.630	–5.110	–8.870	–9.080	–9.770	–5.610	–11.910	–10.600	–12.250	–5.660
ln*gov*	0.006	0.191***	0.294***	0.011	0.004	0.191***	0.283***	0.023	0.006	0.194***	0.303***	0.037
ln*tec*	–0.200	–5.720	–6.750	–0.340	–0.140	–5.680	–6.570	–0.760	–0.170	–5.700	–7.060	–1.230
ln*inf*	–0.011	0.035	–0.016	–0.017	–0.013	0.036	–0.028	–0.019	–0.024	0.017	–0.019	–0.021
Constant	(–0.57)	–1.340	(–0.65)	(–0.74)	(–0.64)	–1.350	(–1.11)	(–0.83)	(–1.16)	–0.630	(–0.76)	(–0.89)
Obs	0.169***	0.112***	0.111***	–0.029	0.147***	0.082***	0.110***	–0.020	0.146***	0.075**	0.117***	–0.019
Individual fixation effect	–6.960	–3.810	–3.140	(–0.71)	–6.180	–2.790	–3.160	(–0.49)	–5.560	–2.530	–3.360	(–0.47)
Time-fixed effect	0.041***	0.038***	0.008	0.003	0.041***	0.033***	0.009	0.003	0.030***	0.044***	0.006	0.003
R^2	–4.300	–4.300	–1.020	–0.350	–4.400	–3.670	–1.070	–0.320	–3.030	–4.860	–0.770	–0.410

Note: The data in the table are calculated by Stata. **, and *** are significant at 5%, and 1% significance levels, respectively, with *t*-values in parentheses.

Table 5. The heterogeneity in different types of cities

Variable	Housing supply model		Housing demand model		Housing supply and demand ratio model	
	(1) Innovative pilot city	(2) Non-innovative pilot city	(3) Innovative pilot city	(4) Non-innovative pilot city	(5) Innovative pilot city	(6) Non-innovative pilot city
ln*hs*	0.029***	0.053***				
ln*hd*	–3.470	–8.960				
ln*std*			0.040***	0.050***		
ln*pgdp*			–5.030	–8.330		
ln*fin*					–0.047***	–0.030***
ln*ind*					(–7.40)	(–5.26)
ln*urb*	0.231***	0.428***	0.223***	0.422***	0.243***	0.481***
ln*open*	–11.990	–18.320	–11.780	–17.720	–13.680	–21.360
ln*gov*	0.116***	0.163***	0.114***	0.167***	0.096***	0.160***
ln*tec*	–4.760	–7.910	–4.710	–8.090	–4.010	–7.690
ln*inf*	0.012	–0.008	0.015	–0.014	0.012	–0.007
Constant	–0.690	(–0.60)	–0.840	(–1.00)	–0.690	(–0.48)
Obs	0.262***	0.084***	0.257***	0.081***	0.244***	0.080***
Individual fixation effect	–12.850	–4.520	–12.700	–4.320	–12.170	–4.230
Time-fixed effect	0.046***	0.022***	0.046***	0.021***	0.048***	0.019***
R^2	–6.730	–4.430	–6.880	–4.180	–7.190	–3.850

Note: The data in the table are calculated by Stata. *** are significant at the 1% significance levels, respectively, with *t*-values in parentheses.

The advancement of the real estate industry serves as a catalyst for enhancing urban economic development by bolstering government financial revenues and fostering increased innovation investment. Consequently, this synergy contributes to the overall improvement of UIC. Furthermore, a rise in the housing demand signifies an augmented capacity among residents to purchase homes, thereby elevating the city's overall developmental status. This positive trajectory attracts a greater influx of innovative talents to the city, thereby amplifying its innovation capacity.

Intriguingly, the adverse impact of the housing S-D ratio on UIC is more pronounced in innovative pilot cities compared to their non-innovative counterparts. The escalation of this ratio disrupts the stability of the housing market, particularly in innovative pilot cities, leading to fluctuating housing prices. This volatility, in turn, impedes the influx of innovative talents and resources, challenging the enhancement of UIC. Consequently, maintaining equilibrium in the housing S-D ratio emerges as a crucial factor for sustaining innovation and fostering a conducive environment for the development of UIC.

In both innovation-oriented pilot cities and non-innovation-oriented pilot cities, various factors play crucial roles in influencing UIC. Notably, regional economic development level, financial development level, urbanization level, opening-up degree, and government intervention all demonstrate significant positive effects on UIC, aligning with the overarching empirical test results. This underscores the interconnected nature of urban innovation and the broader economic and policy contexts. The findings suggest that the enhancement of UIC is intricately linked to factors such as regional economic development and the degree of urbanization. Interestingly, industrial structure and infrastructure level do not exhibit significant influences on UIC across different regions. This implies that while economic and urban development are pivotal, the specific sectors and physical foundations might not be as directly correlated with innovation capacity.

Moreover, the study reveals a noteworthy negative impact of the science and technology level on urban innovation ability in diverse cities. This counterintuitive result prompts further investigation into the nuanced relationship between technological advancement and the overall innovation landscape. Additionally, the heterogeneity test results indicate that a positive housing S-D ratio has inconsistent effects on UIC in different regions and city types. This significant heterogeneity aligns with hypothesis H2, emphasizing the need for nuanced and context-specific approaches when considering the role of housing dynamics in fostering or hindering urban innovation. These insights contribute to a more comprehensive understanding of the multifaceted factors influencing UIC across diverse contexts.

6. Conclusions and policy implications

This paper has performed a theoretical analysis and empirical testing of the relationships between the housing market supply, the housing market demand and UIC. After sorting and analyzing data from 284 prefecture-level cities from 2005 to 2020, the empirical results are as follows: (1) Both the housing supply level and the housing demand level have a significant positive effect on UIC, while the housing S-D ratio has a significant negative effect on UIC; both effects display significant heterogeneity. (2) The heterogeneity test results show that the housing supply level has a significant positive impact on UIC in the eastern, central, western and northeastern regions, as well as in innovative pilot cities and non-innovative pilot cities, but especially in central and non-innovative pilot cities. The positive impact of the housing demand level on UIC is significant in all regions and cities except northeast China, whereby the effect is most significant in eastern and non-innovative pilot cities. The housing S-D ratio has no significant impact on UIC in the eastern region, but it has a significant positive impact in the northeast region and a significant negative impact in the other regions and cities. (3) The growth of the urban S-D ratio reflects an imbalance of supply and demand in the housing market, causing housing prices to rise and diminishing residents' affordability; as this is not conducive to the concentration of talents, it inhibits cities' innovation ability. In addition, the regional economic development level, financial development level, urbanization level, openness to the outside world, government intervention and infrastructure level all have significant positive effects on UIC.

Regarding policy recommendations, our research shows that to promote the stable development of the housing market and enhance UIC, the government should optimize housing market policies to stabilize housing prices and ensure a balance between supply and demand. Especially in some cities with lagging development, reasonable talent or house purchase subsidy policies should be formulated to attract and retain talents and enhance UIC. For cities with low innovation levels, the government should increase investment in innovation, rationally allocate resources and funds, and weaken the adverse impact of the talent crowding-out effect. Simultaneously, it is important to improve a city's economic and financial levels, accelerate infrastructure construction, and improve the city's image. Strengthening opening-up, promoting inter-regional exchanges, and absorbing innovative technologies from abroad and other regions will help bring in more quality enterprises and resources, improving the city's innovation capacity.

Acknowledgements

This work was supported by National Social Science Fund of China (23FJYB009), The Ministry of education of Humanities and Social Science project (23YJA630130, 23YJC630247).

Conflict of interests

The authors declare no conflict of interests.

References

Adam, K., & Woodford, M. (2021). Robustly optimal monetary policy in a new Keynesian model with housing. *Journal of Economic Theory, 198*, Article 105352. https://doi.org/10.1016/j.jet.2021.105352

Addie, J.-P. D., Angrisani, M., & De Falco, S. (2018). University-led innovation in and for peripheral urban areas: New approaches in Naples, Italy and Newark, NJ, US. *European Planning Studies*, *26*(6), 1181–1201. https://doi.org/10.1080/09654313.2018.1459505

Adler, P., & Florida, R. (2021). The rise of urban tech: How innovations for cities come from cities. *Regional Studies*, *55*(10–11), 1787–1800. https://doi.org/10.1080/00343404.2021.1962520

Anthopoulos, L. G., Pourzolfaghar, Z., Lemmer, K., Siebenlist, T., Niehaves, B., & Nikolaou, I. (2022). Smart cities as hubs: Connect, collect and control city flows. *Cities*, *125*, Article 103660. https://doi.org/10.1016/j.cities.2022.103660

Arora, A., Belenzon, S., Patacconi, A., & Suh, J. (2020). The changing structure of American innovation: Some cautionary remarks for economic growth. *Innovation Policy and the Economy*, *20*(1), 39–93. https://doi.org/10.1086/705638

Audretsch, D. B., & Feldman, M. P. (1996). R&D spillovers and the geography of innovation and production. *The American Economic Review*, *86*(3), 630–640.

Banerjee, R., & Roy, S. S. (2014). Human capital, technological progress and trade: What explains India's long run growth? *Journal of Asian Economics*, *30*, 15–31. https://doi.org/10.1016/j.asieco.2013.12.003

Beracha, E., He, Z. Z., Wintoki, M. B., & Xi, Y. Y. (2022). On the relation between innovation and housing prices – a metro level analysis of the US market. *The Journal of Real Estate Finance and Economics*, *65*, 1–27. https://doi.org/10.1007/s11146-021-09852-2

Brown, J. R., Martinsson, G., & Petersen, B. C. (2012). Do financing constraints matter for R&D? *European Economic Review*, *56*(8), 1512–1529. https://doi.org/10.1016/j.euroecorev.2012.07.007

Carayannis, E. G., Grigoroudis, E., & Goletsis, Y. (2016). A multilevel and multistage efficiency evaluation of innovation systems: A multiobjective DEA approach. *Expert Systems with Applications*, *62*, 63–80. https://doi.org/10.1016/j.eswa.2016.06.017

Chaney, T., Sraer, D., & Thesmar, D. (2012). The collateral channel: How real estate shocks affect corporate investment. *American Economic Review*, *102*(6), 2381–2409. https://doi.org/10.1257/aer.102.6.2381

Chen, F. A., Wu, J. R., Chen, X. H., & Nielsen, C. P. (2021). Disentangling the impacts of the built environment and residential self-selection on travel behavior: An empirical study in the context of diversified housing types. *Cities*, *116*, Article 103285. https://doi.org/10.1016/j.cities.2021.103285

Edquist, C., & Zabala-Iturriagagoitia, J. M. (2012). Public procurement for innovation as mission-oriented innovation policy. *Research Policy*, *41*(10), 1757–1769. https://doi.org/10.1016/j.respol.2012.04.022

Fan, X. L., & Li, Q. F. (2022). Urban innovation behavior, economic development and environmental pollution: Empirical analysis based on panel threshold model. *Science & Technology Review*, *40*(4), 64–73.

Furman, J. L., Porter, M. E., & Stern, S. (2002). The determinants of national innovative capacity. *Research Policy*, *31*(6), 899–933. https://doi.org/10.1016/S0048-7333(01)00152-4

Gan, J. (2007). Collateral, debt capacity, and corporate investment: Evidence from a natural experiment. *Journal of Financial Economics*, *85*(3), 709–734. https://doi.org/10.1016/j.jfineco.2006.06.007

Gao, X. M. (2023). Modern design of rural green buildings based on big data technology. *Cities*, *141*, Article 104387. https://doi.org/10.1016/j.cities.2023.104387

Glaeser, E. L., & Nathanson, C. G. (2017). An extrapolative model of house price dynamics. *Journal of Financial Economics*, *126*(1), 147–170. https://doi.org/10.1016/j.jfineco.2017.06.012

Grimes, A., & Aitken, A. (2010). Housing supply, land costs and price adjustment. *Real Estate Economics*, *38*(2), 325–353. https://doi.org/10.1111/j.1540-6229.2010.00269.x

Hamidi, S., Zandiatashbar, A., & Bonakdar, A. (2019). The relationship between regional compactness and regional innovation capacity (RIC): Empirical evidence from a national study. *Technological Forecasting and Social Change*, *142*, 394–402. https://doi.org/10.1016/j.techfore.2018.07.026

He, S. H., Du, D. B., Jiao, M. Q., & Lin, Y. (2017). Spatial-temporal characteristics of urban innovation capability and impact factors analysis in China. *Geography Science*, *37*(07), 1014–1022.

Hou, L. Q. (2022). Study on the impact of innovative city construction on urban innovation capacity. *Innovation*, *16*(06), 40–53.

Hu, C. G., Cai, D. C., & Wen, Y. Y. (2024). Does subway mileage affect urban housing prices? An economic growth perspective. *Applied Economics*, *56*(50), 6158–6170. https://doi.org/10.1080/00036846.2023.2268323

Jalali, D., MacDonald, H., Ahmadian Fard Fini, A., & Shi, S. (2022). Effects of planning regulations on housing and land markets: A system dynamics modeling approach. *Cities*, *126*, Article 103670. https://doi.org/10.1016/j.cities.2022.103670

Komikado, H., Morikawa, S., Bhatt, A., & Kato, H. (2021). High-speed rail, inter-regional accessibility, and regional innovation: Evidence from Japan. *Technological Forecasting and Social Change*, *167*, Article 120697. https://doi.org/10.1016/j.techfore.2021.120697

Kou, Z., & Liu, X. (2020). *FIND report on city and industrial innovation in China* (*2020*). Fudan Institute of Industrial Development, School of Economics, Fudan University. https://ride.fudan.edu.cn/info/1020/1274.htm

Kuang, W. D., & Yu, J. W. (2019). Homeownership and innovation: Evidence from China's 69 large-and middle-sized cities. *Journal of East China Normal University* (*Philosophy and Social Sciences*), *51*(05), 60–66+237.

Kurcheeva, G. I., & Klochkov, G. A. (2018). Comprehensive approach to smart urban development based on Big Data application. *International Conference Information Technologies in Business and Industry*, *1015*, Article 042025. https://doi.org/10.1088/1742-6596/1015/4/042025

Lee, C. (2022). Forecasting spatially correlated targets: Simultaneous prediction of housing market activity across multiple areas. *International Journal of Strategic Property Management*, *26*(2), 119–126. https://doi.org/10.3846/ijspm.2022.16786

Lee, C. (2024). Train stations and house prices: A local perspective. *Transportation Planning and Technology*, *47*(1), 27–41. https://doi.org/10.1080/03081060.2023.2252397

Lee, C. F. (2013). Human resource development and innovation in China: State HRD policies, organizational practices, and research opportunities. *Journal of Chinese Human Resource Management*, *4*(2), 144–150. https://doi.org/10.1108/JCHRM-05-2013-0016

Li, N., Li, R. Y. M., & Nuttapong, J. (2022). Factors affect the housing prices in China: A systematic review of papers indexed in Chinese Science Citation Database. *Property Management*, *40*(5), 780–796. https://doi.org/10.1108/PM-11-2020-0078

Lin, X., Ren, T., Wu, H., & Xiao, Y. (2021). Housing price, talent movement, and innovation output: Evidence from Chinese cities. *Review of Development Economics*, *25*(1), 76–103. https://doi.org/10.1111/rode.12705

Lopez-Carreiro, I., & Monzon, A. (2018). Evaluating sustainability and innovation of mobility patterns in Spanish cities. Analysis by size and urban typology. *Sustainable Cities and Society*, *38*, 684–696. https://doi.org/10.1016/j.scs.2018.01.029

Lu, L. C., & Li, Y. (2010). A research on Chinese renovation urban system based on urban renovation function. *Acta Geographica Sinica*, *65*(2), 177–190.

Luo, S. C., & Chen, W. M. (2019). House price rises, elements mismatch and development of innovative cities in China. *Shanghai Journal of Economics*, *3*, 38–47.

Mao, F. F., Zheng, F., & He, H. Z. (2019). Do housing policies of "Robbing people" improve urban innovation capabilities? *Journal of Finance and Economics*, *7*, 109–121.

Marmolejo-Duarte, C., & Chen, A. (2022). The effect of energy performance ratings over residential prices or how an insufficient control of architectural-quality may render spurious conclusions. *Cities*, *126*, Article 103674. https://doi.org/10.1016/j.cities.2022.103674

Medina, R. M., Byrne, K., Brewer, S., & Nicolosi, E. A. (2020). Housing inequalities: Eviction patterns in Salt Lake County, Utah. *Cities*, *107*, Article 102804. https://doi.org/10.1016/j.cities.2020.102804

Murray, C. K. (2022). A housing supply absorption rate equation. *Journal of Real Estate Finance and Economics*, *64*(2), 228–246. https://doi.org/10.1007/s11146-020-09815-z

Puglisi, V., & Celani, A. (2017). Market innovation, rational housing supply and urban quality at the neighborhood scale. *Materials Science and Engineering*, *245*, Article 062050. https://doi.org/10.1088/1757-899X/245/6/062050

Ramzi, T., & Salah, A. B. (2018). The determinants of innovation capacity in the less innovative countries in the Euro-Mediterranean region. *Journal of the Knowledge Economy*, *9*, 526–543. https://doi.org/10.1007/s13132-015-0347-3

Reed, R. R., & Ume, E. S. (2017). Housing and unemployment: The search for the "American Dream". *Journal of Macroeconomics*, *48*, 72–86. https://doi.org/10.1016/j.jmacro.2016.01.001

Sohn, S. Y., Kim, D. H., & Jeon, S. Y. (2016). Re-evaluation of global innovation index based on a structural equation model. *Technology Analysis & Strategic Management*, *28*(4), 492–505. https://doi.org/10.1080/09537325.2015.1104412

Strange, W., Hejazi, W., & Tang, J. (2006). The uncertain city: Competitive instability, skills, innovation and the strategy of agglomeration. *Journal of Urban Economics*, *59*(3), 331–351. https://doi.org/10.1016/j.jue.2005.10.006

Sun, Q. Z., Gao, Q. D., Wu, B., Huang, J. R., Guo, H. Z., & Jiang, C. M. (2024). Sellers and buyers with lower construal levels are more likely to reach second-hand transactions: The focus-separation effect between sellers and buyers. *Acta Psychologica Sinica*, *56*(8), 1141–1156. https://doi.org/10.3724/SP.J.1041.2024.01141

Torab, E. S. (2018). A law or just a hypothesis? A critical review of supply and demand effect on the affordable residential markets in developing countries. *Alexandria Engineering Journal*, *57*(4), 4081–4090. https://doi.org/10.1016/j.aej.2018.10.010

Wang, S. Y. (2011). State misallocation and housing prices: Theory and evidence from China. *American Economic Review*, *101*(5), 2081–2107. https://doi.org/10.1257/aer.101.5.2081

Wang, W. C., & Rong, Z. (2014). A study of the impact of rising house prices on the inhibition of innovation in industrial firms. *Economics*, *13*(02), 465–490. (in Chinese)

Wang, X., & Wen, Y. (2011). Can rising housing prices explain China's high household saving rate? *Federal Reserve Bank of St. Louis Review*, *93*(2), 67–87. https://doi.org/10.20955/r.93.67-88

Wang, X., Duan, Y., Liu, P., & Han, G. (2020). The influence of housing investment on urban innovation: An empirical analysis based on city-level panel data in China. *Sustainability*, *12*(7), Article 2968. https://doi.org/10.3390/su12072968

Warren-Myers, G., & Heywood, C. (2018). A new demand-supply model to enable sustainability in new Australian housing. *Sustainability*, *10*(2), Article 376. https://doi.org/10.3390/su10020376

Xue, B. Q. (2022). Spatio-temporal pattern of urban innovation capacity in the Yellow River Basin and influencing factors. *Journal of Desert Research*, *42*(06), 116–124. (in Chinese)

Yan, J. H., & Feng, L. (2019). Land supply regulation, housing supply elasticity and housing price fluctuation. *Chinese Land Science*, *33*(3), 16–24.

Yang, H. D., & Wang, G. F. (2023). Assessment of the impact of smart city construction on the development of enterprises in high-tech zones. *Science and Technology Management Research*, *43*(02), 65–74. (in Chinese)

Yao, L., Li, J., & Li, J. (2020). Urban innovation and intercity patent collaboration: A network analysis of China's national innovation system. *Technological Forecasting and Social Change*, *160*, Article 120185. https://doi.org/10.1016/j.techfore.2020.120185

Yoo, J., & Jeon, J. S. (2024). Business model transformation of REITs in the senior housing sector. *International Journal of Strategic Property Management*, *28*(1), 64–75. https://doi.org/10.3846/ijspm.2024.21095

Yu, L., & Cai, Y. (2021). Do rising housing prices restrict urban innovation vitality? Evidence from 288 cities in China. *Economic Analysis and Policy*, *72*, 276–288. https://doi.org/10.1016/j.eap.2021.08.012

Yunus, N. (2015). Trends and convergence in global housing markets. *Journal of International Financial Markets*, *Institutions and Money*, *36*, 100–112. https://doi.org/10.1016/j.intfin.2014.12.008

Zhang, C. (2019). High-skilled migrants, cultural diversity and urban innovation in China. *The Journal of World Economy*, *42*(11), 172–192.

Zhang, J. F., Li, L. L., Zhang, D. X., Han, R., Zhou, J. X., & Zhang, L. H. (2022a). Power pyramid, hidden debt, and China's urban expansion. *International Journal of Strategic Property Management*, *26*(6), 424–438. https://doi.org/10.3846/ijspm.2022.18155

Zhang, W., Cong, T., & Ying, H. (2022b). Research on the influence of real estate investment on industrial enterprise innovation. *Industrial Engineering and Innovation Management*, *5*(10), 64–68. https://doi.org/10.23977/ieim.2022.051008

Zhu, C., Zhao, D., & Qiu, Z. (2019). Internal and external effect of estate investment upon regional innovation in China. *Emerging Markets Finance and Trade*, *55*(3), 513–530. https://doi.org/10.1080/1540496X.2018.1530981