National Accounting Review

NAR, 6(2): 195–219.
DOI: 10.3934/NAR.2024009
Received: 30 December 2023
Revised: 27 March 2024
Accepted: 07 April 2024
Published: 16 April 2024

https://www.aimspress.com/journal/NAR

Research article

The measurement of financial support for real estate and house price bubbles and their dynamic relationship: An empirical study based on 31 major cities in China

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Abstract: In recent years, China's real estate prices have continued to rise, preventing the bursting of the house price bubble, and the various risks it triggers has become an important issue that governments at all levels have to face. In this paper, the backward sup ADF (BSADF) method was used to dynamically portray the evolution of real estate price bubbles in 31 large and medium-sized cities in China over a period of 11 years, from 2013 to 2021, and the dynamic relationship between the degree of financial support for real estate (hereinafter referred to as financial support) and house price bubbles in cities was investigated by employing a panel vector autoregressive (PVAR) model with panel data. The results showed that: Multiple cyclical bubbles significantly existed in the real estate markets of the cities during the study period, and in general, house price bubbles appeared earlier in the more economically developed regions than in the less economically developed regions and have spread to the less economically developed regions. Financial support contributed to house price bubbles, supporting the theory of excessive financial support. Furthermore, the results of the sub-sample showed that financial support contributed most strongly to house price bubbles in cities in the northern region.

Keywords: house price bubbles; BSADF; financial support for real estate; PVAR; GMM

JEL Codes: C12, C23

1. Introduction

In recent years, China's real estate price have continued to rise, and all sectors of society are highly concerned about China's high property prices. Additionally, whether there is a bubble in real estate price and the severity of the bubble is more controversial, but it is generally believed that once property prices have fallen sharply to a certain extent, it will lead to systemic financial risks. Therefore, preventing the bursting of the house price bubble and the various risks it triggers has become an important issue that governments at all levels have to face. Thus, this paper is written to detect the existence of house price bubbles, the point in time of the survival cycle, the evolution process, and to test two hypotheses. Hypothesis 1: There is a bubble in China's property market, and there is an inter-regional diffusion effect of the house price bubble. Hypothesis 2: Financial support contributes to house price bubbles supports the hypothesis that financial support is excessive and that there is regional heterogeneity in the contribution.

Excessive financial support for real estate refers to the excessive credit support provided by banks for real estate development and sales activities, which has led to serious group speculation in the society, resulting in the continuous rise of real estate prices deviating from the market-based prices. Excessive financial support is one of the most prominent characteristics in the process of housing price bubble bursting, and it is also the direct cause of the real estate bubble. There is a close relationship between excessive financial support and information asymmetry. Banks, real estate enterprises, and home buyers have information asymmetry among each other, so it is difficult to grasp each other's behavior, resulting in over-loan and over-development of developers. Furthermore, under the inducement of interests, financial institutions can easily give up the loan principle and lend a large amount of money to real estate enterprises, resulting in excessive financial support. Under the condition that the borrower's non-performing loan behavior has little impact on the bank's income, the equilibrium solution is that the borrower takes the action with low credit and the bank takes the action with high financial support. When the bank has sunk costs, this equilibrium is also difficult to change in the short term, which directly promotes the formation of the real estate bubble, but in the long run, this equilibrium will be broken because of the reversal of participants' confidence in the market boom. The final equilibrium solution is that borrowers take low-credit actions, and banks also take low financial support actions, leading to the complete bursting of the real estate bubble. The measure of financial support for real estate in this paper is obtained by adding loans from banks as a source of funding for real estate firms to 70 per cent of the total sales of commercial properties by real estate firms. Data are sourced from the China Real Estate Statistics Yearbook.

Financial Support for Real Estate = Bank Loans to Housing Enterprises + 0.7* Total Sales of Commercial Properties by Housing Enterprises

Coefficient of financial support for real estate = annual growth rate of financial support for real estate = (financial support for real estate in the current period − financial support for real estate in the base period)/financial support for real estate in the base period. The innovation of this paper lies in the real estate bubble measurement method and the financial support metric. In articles related to the study of the relationship between financial support and house price bubbles in the Chinese property market, the measurement of the house price bubble through most of the indicators, models, statistical tests and other methods involving the fundamentals of house prices or the basic value of the subjective judgement of the method, or the direct use of the commodity house sales price or commodity house sales price boom index as a house price bubble indicators and financial support was conducted through empirical analysis. We adopt the BSADF precise measure of house price bubble as a metric to enter the empirical analysis model. Researchers have used domestic loans as the financial support provided by banks to real estate enterprises, but in fact, part of the domestic loans are bank loans, and the other part is loans from non-bank financial institutions. Thus, we used bank loans as a substitute for the financial support of real estate enterprises in the measurement method, so as to make the results of the measurement more accurate.

2. Literature review

2.1. The measurement of house price bubbles

In the aspect of house price bubble measurement, there are mostly four kinds of house price bubble detection methods in China, which are house price bubble detection method based on comprehensive index, house price bubble detection method based on local equilibrium model, house price bubble detection method based on West model, and house price bubble detection method based on Markov system transformation. The first is a house price bubble detection method based on a comprehensive indicator, where Li and Qu (2002) proposed a comprehensive indicator for early warning of real estate bubbles, which consists of four major sub-indicators: Financial indicators, transaction indicators, production indicators, and consumption indicators. The construction of this early warning indicator relies on the measurement of the real estate boom and contains too many sub-indicators, which makes it inconvenient to operate in practice. The second method of house price bubble detection is based on partial equilibrium models, in which Yuan and Song (2008) measure urban house price bubbles by calculating the deviation of equilibrium prices from their average prices in 35 large and medium-sized cities in China from 2001 to 2005. The findings suggest that high urban house prices do not equal high bubbles, and that there are regional differences and regional contagion effects in domestic house price bubbles. The third is the West model-based house price bubble detection approach, where Han (2005) argues that the fair price of real estate is the capitalization of rents, and applies the West model to test the existence of a domestic housing bubble in Beijing, Shanghai and Shenzhen. The results of the study show that there is a house price bubble in the residential market of the three first-tier cities, while there is no house price bubble in the office market of the three first-tier cities. The fourth is a house price bubble detection method based on Markov zone transformation, in which Shi and Zhou (2014) propose a more efficient autoregressive model with regime switching to analyze the housing bubbles in municipalities in China. It was found that Beijing and Shanghai have significant house price bubbles, while Tianjin and Chongqing have insignificant house price bubbles. Shi (2013) and Shen et al. (2019) also used Markov zone transformation to detect bubbles. Phillips et al. (2015b) proposed the BSADF bubble dynamic monitoring method, which can detect multiple asset cyclical bubbles at the same time. Among these methods, the BSADF method proposed by Phillips et al. (2015a) has obvious advantages: First, the method can reveal multiple cyclical bubbles that may exist throughout the study period at one time. Second, the method relies only on the house price index to measure house price bubbles, thus avoiding subjective judgements involving house price fundamentals or underlying values, and making the measurement of house price bubbles uniform and comparable across regions. Third, it can fully demonstrate the value of house price bubble and its dynamic change process at each point in time. Therefore, we adopt the BSADF methodology to dynamically monitor the house price bubbles in 31 large and medium-sized cities in China. Chen and Funke (2013) and Guo (2016b) employ the recursive unit root series of bubble tests proposed by Phillips et al. (2011, 2015a, 2015b) to measure and analyze a series of asset bubbles.

2.2. The dynamic relationship between financial support and house price bubbles

In terms of the dynamic relationship between the degree of financial support and house price bubbles, Renaud (1995) argues that illegal lending by financial institutions and the accumulation of financial risks accelerate the formation and bursting of real estate bubbles. Mishkin (1996) argues that information asymmetry between financial institutions and borrowers will generate bubbles. Allen and Gale (1998) argue that agency problem caused by the intermediary role of financial institutions is a key factor in the formation of asset bubbles. Zhou (2006) puts forward the theory of excessive financial support, which means that financial system changes, uncertainty and information asymmetry have led to the excessive expansion of real estate credit, and real estate market participants have thus formed a serious speculative mentality and risk-shifting behavior, which have directly contributed to the production and bursting of real estate bubbles. Wang and Feng (2012) analyzes the dynamic relationship between financial support, house price bubbles and the effectiveness of monetary policy at the national and provincial levels, and concludes that it is important to control the excesses of financial support and at the same time prevent an excessive squeeze on house prices at the national level by tightening monetary policy. Levin and Wright (1997) and Homm and Breitung (2012) believe that the imbalance of information between buyers and sellers has led to the creation of speculative bubbles. Wang et al. (2022) argue that land finance and financial support have a significant positive impact on house price bubbles, and the impact of both on bubbles has a distinctive double-threshold feature based on the level of house prices; excessive financial support enters the real estate industry through two channels, namely, developers and consumers, and has a positive impact on house price bubbles. Liu (2023) argues that the development of China's real estate market also has great regional differences, measured by the equilibrium house price model of China's real estate market in recent years, there is a certain degree of price bubbles, and the degree of bubbles in different regions varies significantly. The expansion of the credit scale of the banking sector has a significant role in promoting the formation of housing price bubbles.

In view of this, we put forward two hypotheses. Hypothesis 1: There are bubbles in China's real estate market, and the price bubble has an inter-regional diffusion effect. Hypothesis 2: Financial support plays a role in promoting the housing price bubble to support the excessive financial support hypothesis, and the promoting effect is regional heterogeneity.

3. The measurement and analysis of house price bubbles

3.1. House price bubbles measurement model

The traditional ADF method is suitable for examining only a single foam, and the SDAF method is a superior detection method to the ADF method. The SADF method proposed by Phillips et al. (2011) determines the period of existence of bubbles generated by the resulting asset by detecting the trend of the asset price, specifically by observing the coefficients of the ADF model of the price:

$$p_t = \mu + \rho p_{t-1} + \sum_{j=1}^{J} \varphi_t \Delta p_{t-1} + \varepsilon_t, \varepsilon_t \sim iid(0,\sigma^2) \tag{1}$$

When the autoregressive coefficient $\rho \leq 1$ indicates that there is no asset bubble at this time, and vice versa, a bubble is considered to exist. The empirical process is a forward window-shifting recursion: In the first step, the window and the step size p_t are determined (t = 1, 2, ..., [Tr], 0 < r < 1, [.] indicates rounding); in the second step, the coefficients of the formula are parametrically estimated using the data from the first step to obtain the t-statistic of the parameter; in the third step, the data are moved forward by one step to obtain new samples and parametrically estimated again until all the samples have been used up, and finally a sequence of the ADF statistics of the parameter is obtained, which is bounded by the SADF value.

$$SADF(r_0) = \sup_{r \in [r_0,1]} \frac{\widehat{\rho_r} - 1}{se(\widehat{\rho_r})} \tag{2}$$

However, when the sample period includes multiple boom and crash segments, the SADF method may then suffer from decreased detection efficiency or inconsistency, which may not accurately reveal the presence of bubbles. In order to overcome the shortcomings of the traditional ADF method and the SADF method, and to effectively deal with multiple bursts of booms and crashes, Phillips et al. (2015a) further proposed the GSADF method. Although the GSADF test method continues the practice of running the ADF test repeatedly in a recursive manner on a subsample of the data, instead of fixing the recursive starting point at the first observation, GSADF expands the coverage of the sample by increasing the flexibility of the width of the window to allow the starting point r_1 to move between 0 and $r_2 - r_0$, and to allow the end point r_2 to move between r_0 and 1, which makes the sample more suitable for analysing long historical time series. Its statistics, optimal window, and asymptotic distribution are denoted by $GSADF(r_0)$, as shown in Equation (3), where r_0 is the minimum window width, r_1 and r_2 denote the regression start and end points of the subsamples, respectively, $r_w = r_2 - r_1$, and W is the standard Wiener process:

$$GSADF(r_0) \rightarrow \sup_{\substack{r_2 \in [r_0,1] \\ r_1 \in [0, r_2 - r_0]}} \left\{ \frac{\frac{1}{2} r_w [W(r_2)^2 - W(r_1)^2 - r_w] - \int_{r_1}^{r_2} W(r)dr[W(r_2) - W(r_1)]}{r_w^{\frac{1}{2}} \left\{ r_w \int_{r_1}^{r_2} W(r)^2 dr - \left[\int_{r_1}^{r_2} W(r)dr \right]^2 \right\}^{\frac{1}{2}}} \right\} \tag{3}$$

To further improve the ability to identify multiple bubbles and increase the accuracy of the detection results, Phillips et al. (2015b) further proposed the reverse SADF (BSADF) method, which has fixed subsample endpoints but in the opposite direction to GSADF compared to the GSADF method. However, BSADF suffers from a delay bias in detection and only allows for sudden crises, making the bubble generation process subject to real-world factors. Compared to the SADF method, first, unlike SADF which fixes the window length, the window length in BSADF is not fixed; second, unlike SADF which can only be recursive forwards, the BSADF method can be recursively forwards and backwards at the same time; and third, the results obtained by the BSADF method are more robust compared to those obtained by the SADF method. The BSADF method has an additional step of recursive backwards recursion compared to that of the SADF method. The BSADF method obtains a statistic $BSADF_{r_1}^{r_2}$ for each parameter estimation on the windowed sample data, and when the sample is exhausted, a complete test series $\{BSADF_{r_1}^{r_2}\}_{r_1 \in [0, r_2 - r_1]}$ is obtained; the BSADF statistic is considered as the upper bound of the series $BSADF_{r_2}(r_0)$. The criteria for determining the point at which a house price bubble survives are:

$$\widehat{r_{ie}} = \inf_{r_2 \in [r_0, 1]} \left\{ r_2 : BSADF_{ir_2}(r_0) > scv_{r_2}^{\beta_T} \right\}$$
$$\widehat{r_{if}} = \inf_{r_2 \in [\widehat{r_{ie}} + \delta \log(T), 1]} \left\{ r_2 : BSADF_{ir_2}(r_0) < scv_{r_2}^{\beta_T} \right\} \tag{4}$$

where $scv_{r_2}^{\beta_T}$ is the critical value of SADF at 100 % confidence level with sample size $[T_{r_2}]$. $\hat{r}_{ie}$ denotes the point at which the bubble occurs, and $\hat{r}_{if}$ denotes the point at which the bubble disappears.

3.2. Selection of indicators and descriptive statistical analysis

Based on the availability of house price data for each city, 31 large and medium-sized cities across the country were finally selected from 4 regions. Guo (2016a), Liu and Jiang (2014) and Liu et al. (2016) also divides the property market at different levels and then conducts empirical analyses at different levels of division. The eastern region includes 10 cities: Shanghai, Nanjing, Hangzhou, Ningbo, Hefei, Fuzhou, Xiamen, Nanchang, Jinan, and Qingdao; the northern region includes 9 cities: Beijing, Tianjin, Shijiazhuang, Taiyuan, Hohhot, Shenyang, Changchun, Harbin, and Dalian; the south-central region includes 6 cities: Zhengzhou, Wuhan, Changsha, Guangzhou, Nanning, Haikou, and 6 cities: The western region includes 6 cities: Chongqing, Kunming, Guiyang, Xi’an, Lanzhou, and Yinchuan. The data comes from China Real Estate Statistical Yearbook, and this paper adopts the monthly data of house prices in 31 large and medium-sized cities from November 2011 to July 2021 for empirical analysis. Table 1, Table 2, Table 3, and Table 4 below give the descriptive statistics of the city house prices in each region during the study period.

Table 1. Descriptive statistics of house prices in nine northern region cities.

	Beijing	Tianjin	Shijiazhuang	Taiyuan	Hohhot	Shenyang	Changchun	Harbin	Dalian
MAX	61613	25183	19362	12132	11852	10362	9689	10278	15851
MIN	24308	12363	7169	6905	4464	7177	6497	5576	9514
MEAN	47196.67	18137.71	12203.35	9345.29	8199.92	8430.26	7771.87	8597.92	11476.65
STD	11823.19	4013.09	3885.58	1715.30	2208.42	985.23	1204.92	1151.22	1815.81
SKEWNESS	−0.3872	0.0476	0.1309	0.5000	0.6273	0.6555	0.6461	−0.0629	1.1743
KURTOSIS	1.7425	1.5294	1.3748	1.6002	1.7756	2.1694	1.6482	1.6364	2.9905
JB	10.63	10.59	13.21	14.43	14.98	11.74	17.05	9.142	26.89
P	0.0049	0.0050	0.0014	0.0007	0.0006	0.0028	0.0002	0.0103	0.0000
N	117	117	117	117	117	117	117	117	117

Among the nine cities in the northern region, the skewness of the house prices in Beijing and Harbin is less than 0, showing a slight left-skewed distribution, and the skewness of the house prices in the remaining seven cities is greater than 0, showing a slight right-skewed distribution, but with a small kurtosis and without the characteristics of the spiked distribution. The JB statistic shows that the house price in Harbin rejects the original hypothesis at 5% confidence level, and the rest of the cities reject the original hypothesis at 1% confidence level, indicating that all house prices do not obey normal distribution. The standard deviation of Beijing's house prices is much higher than that of the other eight cities, indicating that the degree of fluctuation of house prices in Beijing is much larger than that of the other cities, among which the standard deviation of Shenyang's house prices is the smallest, and the degree of fluctuation of Shenyang's house prices is the smallest among the nine cities in the northern region.

Table 2. Descriptive statistics of house prices in ten eastern cities.

	Shanghai	Nanjing	Hangzhou	Ningbo	Hefei	Fuzhou	Xiamen	Nanchang	Jinan	Qingdao
MAX	53919	30074	31629	28112	15891	27088	50124	12532	17900	20992
MIN	21804	14138	16025	11694	6327	10476	13815	7371	8289	11743
MEAN	40760.89	22284.47	22777.09	17417.91	11196.88	18851.28	34399.21	10297.79	12317.65	14854.08
STD	11667.28	5503.50	5007.63	4490.22	3557.70	5814.93	12418.30	1642.36	3517.22	2818.62
SKEWNESS	−0.3505	−0.0762	0.1353	0.8035	−0.1752	0.0252	−0.1596	0.0015	0.2179	0.537447
KURTOSIS	1.4008	1.4132	1.3409	2.4854	1.1710	1.2753	1.3898	1.4909	1.2396	1.897005
JB	14.86	12.39	13.78	13.88	16.91	14.51	13.14	11.1	16.03	11.56
P	0.0006	0.0020	0.0010	0.0010	0.0002	0.0007	0.0014	0.0039	0.0003	0.0031
N	117	117	117	117	117	117	117	117	117	117

Among the ten eastern cities, Shanghai, Nanjing, Hefei, and Xiamen have a house price skewness of less than 0, showing a slight left-skewed distribution, while the remaining six cities have a house price skewness of more than 0, showing a slight right-skewed distribution, but with a small kurtosis and no spike distribution. From the JB statistic, it shows that all the house prices do not obey normal distribution. The standard deviation of Shanghai and Xiamen house prices is much higher than that of the other eight cities, indicating that the degree of volatility of house prices in Shanghai and Xiamen is much larger than that of other cities, among which the standard deviation of Nanchang house prices is the smallest, and the degree of volatility of Nanchang house prices is the smallest among the ten cities in the eastern region.

Table 3. Descriptive statistics of house prices in six south central region cities.

	Zhengzhou	Wuhan	Changsha	Guangzhou	Nanning	Haining
MAX	13867	17874	11064	35269	11639	16628
MIN	6439	7748	6320	14677	6183	6776
MEAN	10576.21	12665.44	8199.15	24406.53	8520.56	10428.41
STD	2720.24	3840.53	1826.72	6745.50	1875.35	3654.35
SKEWNESS	−0.1183	0.0171	0.2581	0.1382	0.4297	0.4787
KURTOSIS	1.3253	1.2054	1.2150	1.3929	1.4114	1.3922
JB	13.94	15.71	16.83	12.96	15.90	17.07
P	0.0009	0.0004	0.0002	0.0015	0.0004	0.0002
N	117	117	117	117	117	117

Among the six cities in the south-central region, the house price skewness of Zhengzhou is less than 0, presenting a slight left-skewed distribution, while the house price skewness of the remaining five cities is greater than 0, presenting a slight right-skewed distribution, but with a small kurtosis and not with a sharp distribution. From the JB statistic, all house prices do not obey normal distribution. The standard deviation of house prices in Guangzhou is the highest among the cities in the central and southern regions, indicating that the degree of fluctuation of house prices in Guangzhou is much larger than that in other cities, among which the standard deviation of house prices in Changsha is the smallest, and the degree of fluctuation of house prices in Changsha is the smallest among the ten cities in the eastern regions.

Table 4. Descriptive statistics of house prices in six western cities.

	Chongqing	Kunming	Guiyang	Xian	Lanzhou	Yinchuan
MAX	12966	13701	10659	13739	13088	7394
MIN	6289	7911	4578	6286	7881	4630
MEAN	8772.61	10015.09	7039.95	8899.69	9950.06	5654.95
STD	2370.27	2088.43	1764.71	2724.23	1782.92	603.28
SKEWNESS	0.3992	0.7190	0.4388	0.6065	0.6347	1.0173
KURTOSIS	1.3798	1.7608	1.6094	1.5043	1.8116	3.6577
JB	15.9	17.57	13.18	18.08	14.74	22.29
P	0.0004	0.0002	0.0014	0.0001	0.0006	0.0000
N	117	117	117	117	117	117

Among the six western cities, the skewness of house prices in all cities is greater than 0, showing a slight right-skewed distribution, the kurtosis of house prices in Yinchuan is greater than 3 with the characteristics of spiky distribution, and the kurtosis of the rest of the cities is smaller and does not have the characteristics of spiky distribution. From the JB statistic, all house prices do not obey normal distribution. The standard deviation of Shanghai and Xiamen house prices is much higher than that of the other eight cities, indicating that the degree of volatility of house prices in Shanghai and Xiamen is much larger than that of other cities, among which the standard deviation of house prices in Nanchang is the smallest, and the degree of volatility of house prices in Nanchang is the smallest among the ten cities in the eastern region.

3.3. Existence test for house price bubbles in 31 cities

In this paper, STATA software is used to test and determine whether there is a bubble in the house price series of 31 large and medium-sized cities. Applying the GSADF test, the initial window was calculated according to $r_0 = 0.01 + \frac{1.8}{\sqrt{T}}$ and Monte Carlo simulations were used 199 times to obtain critical values at 1 per cent, 5 per cent, and 10 per cent confidence levels to test for the existence of a bubble in house prices over the study period. The final test results are as follows: Table 5, Table 6, Table 7, and Table 8. From the test results, it can be obtained that at the three confidence levels, except for Chongqing, where the GSADF statistic value is equal to the SADF statistic value, the GSADF statistic value of all other cities is significantly larger than the SADF statistic value, which indicates that the GSADF test can detect the cyclical price bubbles that cannot be detected by the SADF.

Table 5. Existence tests for bubbles in nine northern region cities.

City	Beijing	Tianjin	Shijiazhuang	Taiyuan	Hohhot	Shenyang	Changchun	Haebin	Dalian
SADF	0.5087	2.2115	4.1878	3.2095	0.9694	1.2887	4.08	1.9746	3.3707
GSADF	2.5603	3.0816	4.5939	4.8707	10.5525	2.7249	6.5531	2.5534	6.131
1%SADF critical value	3.279	3.9224	4.9154	3.6172	2.9978	3.7198	2.4684	2.5939	4.4122
5%SADF critical value	2.5963	3.5192	4.4122	2.6115	1.8897	2.219	2.0494	1.5771	3.3801
10%SADF critical value	1.7972	3.0909	4.1878	2.2309	1.3737	1.8994	1.6365	1.365	3.0046
1%GSADF critical value	5.2234	5.5721	6.8605	6.0302	4.0769	4.7644	5.8654	6.3387	5.3384
5%GSADF critical value	3.3349	4.8203	5.472	4.4947	3.5409	3.4842	4.8354	3.6013	4.2934
10%GSADF critical value	3.1029	4.2998	5.1178	4.172	2.7296	2.9117	4.387	2.971	3.958

Among the nine northern region cities, the GSADF statistics of Hohhot, Changchun, and Dalian are all significantly larger than their critical values at the 1 per cent confidence level, indicating that at the 1 per cent confidence level, prices in these two cities were significantly cyclical bubbles during the study period. The BSADF statistics for Taiyuan are all significantly larger than their critical values at the 5 per cent confidence level, indicating that at the 5 per cent confidence level, prices in Taiyuan were significantly cyclical bubbles during the study period.

Table 6. Existence tests for bubbles in ten eastern region cities.

City	Shanghai	Nanjing	Hangzhou	Ningbo	Hefei	Fuzhou	Xiamen	Nanchang	Jinan	Qingdao
SADF	1.9494	1.9946	1.4708	2.3596	2.2036	4.3351	1.9689	0.5883	3.4349	2.8904
GSADF	5.8728	4.2241	3.0651	4.1617	3.6457	5.2415	2.9457	3.1628	3.5208	4.4487
1%SADF critical value	3.3638	3.77	3.2045	1.9226	4.6531	5.4731	3.82	2.3992	4.547	3.2803
5%SADF critical value	2.6516	2.9976	2.5125	1.3306	3.8347	4.635	3.0869	2.0275	3.6483	2.777
10%SADF critical value	2.3561	2.6974	2.1351	1.0001	3.5831	4.1276	2.6225	1.6294	3.1915	2.3939
1%GSADF critical value	5.545	5.5086	4.835	2.6315	5.9553	6.2234	4.7143	4.668	5.3653	4.7877
5%GSADF critical value	4.6156	3.9719	3.9166	2.0475	4.6588	5.4809	4.1142	3.3505	4.5628	4.0379
10%GSADF critical value	4.0358	3.6437	3.5563	1.7598	4.3509	4.8995	3.8789	2.9097	4.1449	3.4345

Among the ten northern region cities, the GSADF statistics of Shanghai and Ningbo are significantly larger than their critical values at the 1 per cent confidence level, indicating that at the 1 per cent confidence level, the prices of these two cities have significant cyclical bubbles in the study period. Similarly, the prices in the two cities of Nanjing and Qingdao have cyclical bubbles at the 5% level of significance during the study period. The prices of Fuzhou and Nanchang have cyclical bubbles at 10 per cent level of significance.

Table 7. Existence tests for bubbles in six south-central region cities.

City	Zhengzhou	Wuhan	Changsha	Guangzhou	Nanning	Haikou
SADF	1.368	2.5517	3.9328	1.6691	1.6369	3.5372
GSADF	3.3315	2.9802	4.9014	3.9964	2.8329	3.817
1%SADF critical value	3.7178	4.6955	4.8067	3.2505	2.5113	4.7583
5%SAD critical value	3.1523	4.0052	4.2903	2.5948	1.7554	4.1768
10%SADF critical value	2.5791	3.5668	3.9338	2.2233	1.4047	3.85
1%GSADFcritical value	5.813	6.102	7.313	4.9415	4.7586	5.6134
5%GSADF critical value	4.8911	5.2188	5.9985	3.8338	2.6176	4.5549
10%GSADF critical value	4.3775	4.7822	5.4267	3.6216	2.3849	4.2195

Among the six south-central region cities, the GSADF statistics of Guangzhou and Nanning are significantly larger than their critical values at the 5 per cent confidence level, indicating that at the 5 per cent confidence level, house prices in these two cities were significantly cyclical bubbles during the study period.

Table 8. Existence tests for bubbles in six western region cities.

City	Chongqing	Kunming	Guiyang	Xian	Lanzhou	Yinchuan
SADF	3.8374	3.5553	−0.545	3.6944	1.2699	−1.5378
GSADF	3.8374	4.9639	6.7505	3.8461	2.8529	3.5093
1%SADF critical value	3.6579	5.3712	2.7426	5.4107	2.0957	4.9902
5%SADF critical value	2.6758	4.8577	1.7572	4.5426	1.7417	1.7679
10%SADF critical value	2.0193	4.4562	1.2281	4.0991	1.2411	1.3958
1%GSADF critical value	4.3348	6.8556	6.4821	5.8399	3.4593	5.3526
5%GSADF critical value	3.5611	6.4702	3.7660	5.2300	2.8667	3.7552
10%GSADF critical value	3.1449	5.7463	3.2513	4.9117	2.4447	3.2103

Among the six western cities, the GSADF statistics of Guiyang are all significantly larger than their critical values at the 1 per cent confidence level, indicating that at the 1 per cent confidence level, the house prices in Guiyang are significantly cyclical bubbles in the study period. The GSADF statistics of Chongqing are all significantly larger than their critical values at the 5 per cent confidence level, indicating that at the 5 per cent confidence level, the house prices in Chongqing are significantly cyclical bubbles in the study period. The GSADF statistics for Lanzhou and Yinchuan are greater than their critical values at the 10 per cent confidence level, indicating that there is a cyclical bubble in residential prices in these two cities at the 10 per cent confidence level.

3.4. Comparison of the existence cycle and bubble degree in 31 cities

3.4.1. The trend chart of house price bubble in each city

In the previous section, the GSADF was used to detect the existence of bubbles in 31 large and medium-sized cities. Next, the BSADF method is used to further detect the number of house price bubbles occurring and the period of existence of the bubbles by comparing the sequence of BSADF statistical values with the sequence of critical values to derive the number of occurrences of house price bubbles and the period of existence of the bubbles. The intervals where the values of the BSADF series for each major city in the figure lie above the critical value series are the intervals where bubbles occur. Stata software is used to plot the charts of house price bubbles in each city. Due to space constraints, only the charts of house price bubbles in the two more economically developed cities in each region are shown here. In the next section, a summary of the house price bubble statistics for the 31 cities is given to give a specific interpretation of the bubble in each city during the study period.

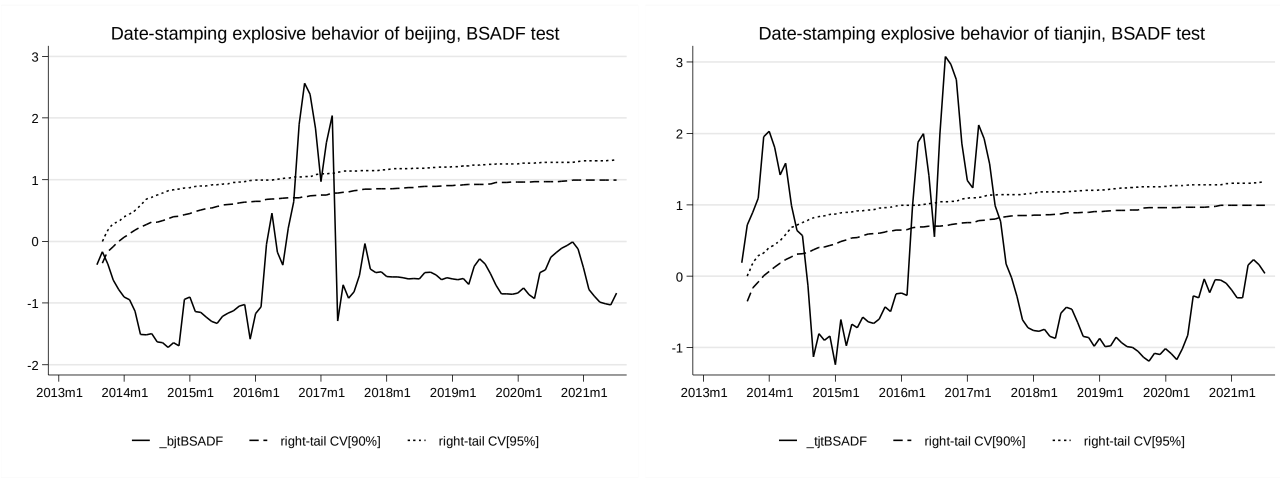

Figure 1. Beijing and Tianjin (northern region) house price bubble chart.

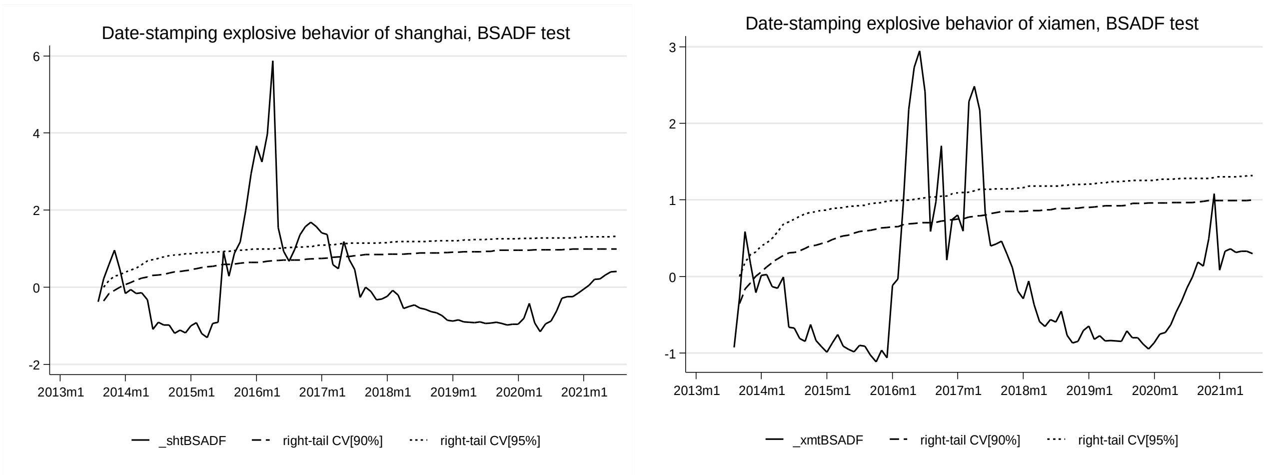

Figure 2. Shanghai and Xiamen (eastern region) house price bubble chart.

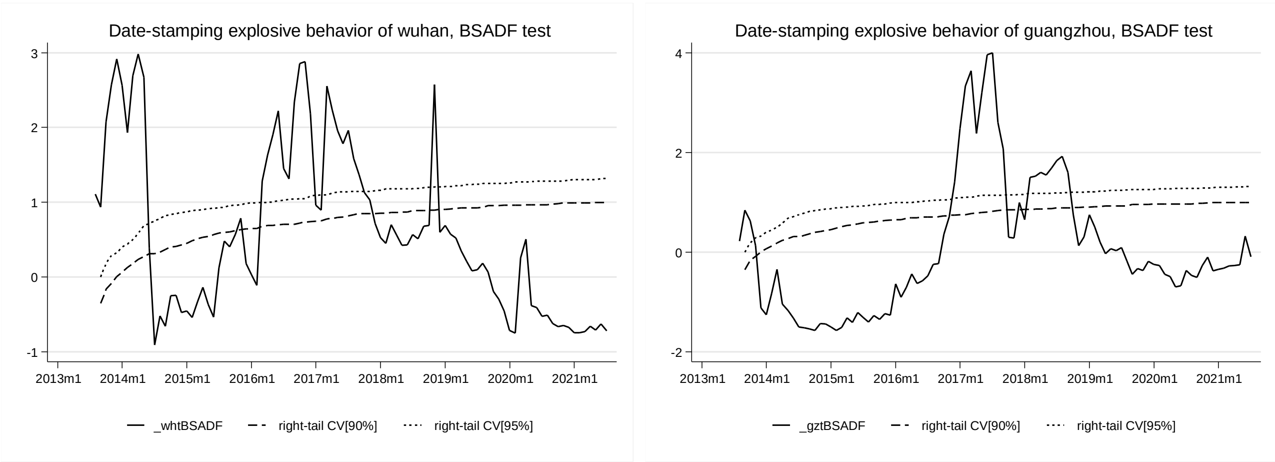

Figure 3. Wuhan and Guangzhou (south central region) house price bubble chart.

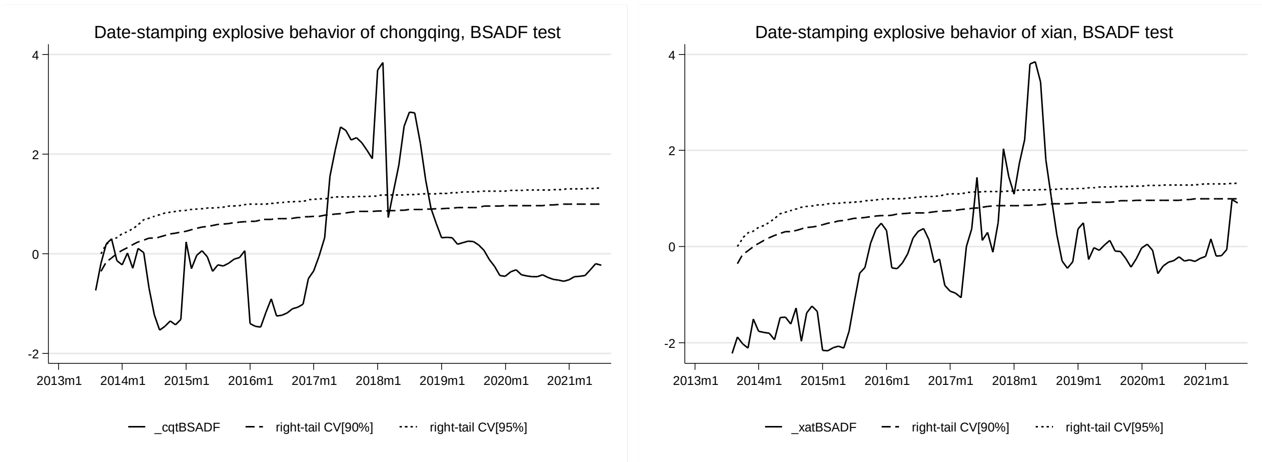

Figure 4. Chongqing and Xian (western region) house price bubble chart.

3.4.2. Summary comparison of house price bubble statistics for 31 cities

A summary comparison of the number of bubbles, the longest bubble cycle and the most serious bubble degree in each city during the study period is shown in tables 9, 10, 11, and 12. From the following four tables, it can be seen that multiple cyclical bubbles have occurred in all 31 cities in China, but there is a significant difference in terms of the severity of the bubbles, the number of times they have occurred and their duration cycle.

Among the nine northern region cities, in terms of the average value of house price bubbles in each city, the order from large to small is Dalian > Changchun > Hohhot > Shenyang > Taiyuan > Tianjin > Shijiazhuang > Beijing > Harbin. Among them, the bubble in Dalian is the most serious, and the bubble in Harbin is the smallest. As for the peak of the bubble and its survival cycle, Dalian had the longest-lasting bubble in March 2020, with a peak bubble of 6.1310, and this bubble has not yet burst since it began to appear in July 2018, lasting for more than three years. The most serious house price bubble in the first-tier cities of Beijing and Tianjin mainly occurred during 2016, while the most serious bubbles in second- and third-tier cities such as Taiyuan and Hohhot mainly occurred during 2018, which shows that the house price bubble in the cities in the northern region has been spreading from first-tier cities to some non-first-tier cities.

Table 9. Summary of bubbles statistics for the nine northern region cities.

Bubble statistics	Beijing	Tianjin	Shijiazhuang	Taiyuan	Hohhot	Shenyang	Changchun	Harbin	Dalian
Number of bubbles	2	3	2	2	3	4	3	3	2
Mean value of bubbles	−0.5490	0.0238	−0.0617	0.1528	0.5293	0.4785	1.0519	−0.7483	1.3108
Max BSADF statistic	2.5603	3.0817	4.5939	4.8707	10.5525	2.7249	6.5531	2.5534	6.1310
Moment of max BSADF occurrence	Oct 2016	Sep 2016	Nov 2016	May 2018	Jul 2018	Aug 2018	Aug 2018	Jul 2018	Mar 2020
Longest bubble (months)	4	10	15	14	27	26	30	7	37
Duration of the longest bubble	Sep 2016–Dec 2016	Aug 2016–May 2017	Apr 2016–Jun 2017	Nov 2017–Dec 2018	Sep 2017–Dec 2019	May 2018–Jun 2020	Jun 2017–Nov 2019	May 2018–Nov 2018	Jul 2018–Jul 2021

Table 10. Summary of bubbles statistics for the ten eastern region cities.

Bubble statistics	Shanghai	Nanjing	Hangzhou	Ningbo	Hefei	Fuzhou	Xiamen	Nanchang	Jinan	Qingdao
Number of bubbles	4	4	2	5	3	2	4	4	5	3
Mean value of bubbles	0.0478	0.3271	0.0424	1.0334	0.0859	0.2294	−0.0845	−0.3679	0.1831	−0.4940
Max BSADF statistic	5.8728	4.2241	3.0651	4.1617	3.6457	5.2415	2.9457	3.1628	3.5208	4.4487
Moment of max BSADF occurrence	Apr 2016	Jun 2016	Jan 2017	Jul 2017	Mar 2014	May 2017	Jun 2016	Jan 2017	Apr 2017	Apr 2017
Longest bubble (months)	8	11	8	24	12	24	4	4	10	5
Duration of the longest bubble	Oct 2015–May 2016	Mar 2016–Jan 2017	Oct 2016–May 2017	Dec 2016–Nov 2018	Nov 2015–Oct 2016	Apr 2016–Mar 2018	Apr 2016–Jul 2016	Nov 2013–Mar 2014	Mar 2017–Dec 2017	Jan 2017–May 2017

Among the ten cities in the eastern region, in terms of the average value of house price bubbles in each city, the order from large to small is Shanghai > Fuzhou > Qingdao > Nanjing > Ningbo > Hefei > Jinan > Nanchang > Hangzhou > Xiamen. Among them, Shanghai has the most serious degree of bubble, and Xiamen has the smallest degree of bubble. As for the bubble peak and its survival period, Shanghai had the most serious bubble in April 2016, with a peak of 5.8728. Ningbo had the longest-lasting bubble in July 2017, with a peak of 4.1617, which lasted 24 months from December 2016 to November 2018, when the bubble began to appear and disappeared.

The most serious house price bubble in the first-tier city of Shanghai mainly occurred during 2016, while the most serious bubble in second- and third-tier cities such as Ningbo and Jinan mainly occurred during 2017, which shows that the house price bubble in cities in the eastern region has spread from first-tier cities to some non-first-tier cities.

Table 11. Summary of bubbles statistics for the six south-central region cities.

Bubble statistics	Zhengzhou	Wuhan	Changsha	Guangzhou	Nanning	Haikou
Number of bubbles	3	4	4	3	4	2
Mean value of bubbles	−0.2554	0.6100	−0.0296	0.0539	−0.1992	−0.2061
Max BSADF statistic	3.3315	2.9802	4.9014	3.9964	2.8329	3.8171
Moment of max BSADF occurrence	Oct 2016	Apr 2014	Dec 2016	Jul 2017	Nov 2017	Jul 2018
Longest bubble (months)	9	10	9	10	18	14
Duration of the longest bubble	Apr 2016–Dec 2016	Mar 2016–Dec 2016	May 2016–Jan 2017	Dec 2016–Sep 2017	Jun 2017–Nov 2018	Aug 2017–Sep 2018

Among the six south-central region cities, in terms of the average value of house price bubbles in each city, the order from large to small is Wuhan > Guangzhou > Changsha > Nanning > Haikou > Zhengzhou. Among them, Wuhan has the most serious degree of bubble, while Zhengzhou has the smallest degree of bubble. As for the bubble peak and its survival period, Changsha had the most serious bubble in December 2016, with a peak of 4.9014. Nanning had the longest-lasting bubble in June 2017, with a peak of 2.8329, which lasted for 18 months from the beginning of its appearance in June 2017 to its disappearance in November 2018.

Table 12. Summary of bubbles statistics for the six western region cities.

Bubble statistics	Chongqing	Kunming	Guiyang	Xian	Lanzhou	Yinchuan
Number of bubbles	3	5	1	3	4	3
Mean value of bubbles	0.1289	0.8393	−0.1274	−0.2564	−0.1224	−1.2820
Max BSADF statistic	3.8374	4.9639	6.7505	3.8461	2.8529	3.5093
Moment of max BSADF occurrence	Feb 2018	Aug 2018	Jun 2018	May 2018	Nov 2018	Feb 2020
Longest bubble (months)	11	21	16	6	16	8
Duration of the longest bubble	Apr 2017–Feb 2018	May 2017–Jan 2019	Sept 2017–Dec 2018	Feb 2018–Jul 2018	Aug 2018–Nov 2019	Dec 2020–Jul 2021

Among the six western region cities, in terms of the average value of house price bubbles in each city, the order from large to small is Kunming > Chongqing > Lanzhou > Guiyang > Xi'an > Yinchuan. Among them, Kunming has the most serious degree of bubble, and Yinchuan has the smallest degree of bubble. As for the bubble peak and its survival cycle, Guiyang had the most serious bubble in June 2018, with a peak of 6.7505. Kunming had the longest-lasting bubble in May 2017, with a peak of 4.9639, and this bubble lasted 21 months from its appearance in September 2017 to its disappearance in December 2018, which lasted 21 months in total.

The most serious house price bubbles in cities in the eastern region, cities in the northern region and cities in the south-central region mainly occurred during 2016 and 2017, while the most serious bubbles in cities in the western region mainly occurred during 2018 and 2020, which shows that the domestic urban house price bubbles have been spreading from the more economically developed regions to the economically underdeveloped regions, and thus Hypothesis 1 is verified.

4. Analysis of the causes of the real estate bubble

4.1. Measurement of financial support for real estate

Excessive financial support for real estate means that banks have provided excessive credit support for real estate development and sales activities, which has led to serious group speculation in society and caused real estate prices to deviate from the market-based price and continue to rise. Both the supply and demand sides of real estate need financial support, without which the real estate industry cannot operate normally, but excessive financial support can lead to real estate bubbles and affect the normal operation of the real estate industry. In view of this, to judge whether financial support is excessive, it is necessary to construct a financial support excess measurement index, and to determine the normal range and excessive range of financial support, so that the financial support excess measurement index that we have established is more operable for judging the existence of real estate bubbles.

4.1.1. Metrics

In order to accurately measure the driving factors of the house price bubble, we will examine the bank's support for the funding of real estate enterprises below. The capital of China's real estate enterprises mainly consists of four parts: domestic loans, foreign capital, self-financing, and other funds, of which domestic loans are directly provided by banks. The main source of funds for home buyers to purchase commercial property consists of two parts, one is the down payment, and the other is the bank loan, with the proportion of the first loan being 70 per cent. Therefore, the financial support to the house sector consists of two main components, namely bank loans and bank loans to home buyers. Among them, bank loans to home buyers are measured by multiplying the total sales of commercial properties by 0.7, while the strength of financial support is measured by the annual growth rate of financial support by real estate companies, which is denoted by the letter m. It is generally considered that $m < 0.24$ is normal financial support and $m > 0.24$ is excessive financial support.

Financial support for house enterprises = bank loan of house enterprises + 0.7*total sales of commercial property of house enterprises.

Coefficient of financial support for house enterprises = annual growth rate of financial support for house enterprises = (financial support for house enterprises in the current period − financial support for house enterprises in the base period)/financial support for house enterprises in the base period.

4.1.2. Data sources

We select 31 large and medium-sized cities in China from 2011 to 2021 as the research sample. The data comes from the China Real Estate Statistics Yearbook. It is calculated that the financial support coefficients of banks for real estate enterprises at the national level are 0.2531, −0.0279, 0.1337, 0.2787, 0.0381, 0.0619, 0.0567, 0.0168, and 0.0282, respectively, in 2013–2021. Among them, the financial support coefficients of real estate in 2014 and 2016 are both greater than 0.24, which is excessive financial support.

4.2. PVAR modeling

The PVAR model was first proposed by Hotlz-Eakin et al. (1988) Compared with the traditional VAR model, the PVAR model not only takes into account inter-individual heterogeneity, but also effectively circumvents the problem of endogeneity of model variables. House price bubbles may inversely affect financial support, in order to avoid the endogeneity problem that leads to biased model estimation results, we adopt the PVAR model for the study, based on the above analysis and drawing on existing studies, the PVAR model is constructed as follows:

$$Z_{\mathrm{it}} = \Pi_0 + \sum_{p=1}^{n} \Pi_p Z_{it-p} + f_i + \varepsilon_t + \mu_{it} \tag{5}$$

where i represents the city and t represents the year; Z_{it} is the explained variable, which is a two-dimensional column vector including house price bubble and financial support; Π_0 is the intercept term vector; p is the lag order; Π_p is the parameter matrix corresponding to the lag p-order explanatory variable; f_i and ε_t are individual effect vector and time effect vector, respectively; and μ_{it} is a random error term and satisfies:

$$E(\mu_{it} | f_i, \varepsilon_t, Z_{it-2}, \ldots) = 0 \tag{6}$$

4.3. Description of variables

In this paper, the house price bubble variable bubble is derived from the measurement results of the BSADF method described above, and the financial support variable is selected from the financial support coefficient measurement results above, m. Since the house price bubble measure cannot be derived from the 2011 and 2012 data, and the financial support of the real estate enterprises as an annual growth rate cannot be derived from the 2011 data, the data from 2013–2021 are selected to enter the model. The data for 2013–2021 are chosen to enter the model.

4.4. Empirical process

4.4.1. Stability test

We use Stata software and LLC test to carry out unit root test on the relevant data of house price bubble and financial support coefficient m involved in the sample area, as shown in the table below. The original data series of bubble and m in the whole country, including north, east, central, south, and west, all reject the original hypothesis of "existence of unit root", that is, there is no unit root in the data. That is to say, the two variables bubble and m of each region belong to the same order single integral sequence, which can establish the PVAR model.

Table 13. Variable smoothness tests.

	LLC test	
	Statistic	p-value
bubble	−9.0267	0.0000
m	−6.5165	0.0000
bubble_01	−5.1967	0.0000
m_01	−3.2288	0.0006
bubble_02	−5.7342	0.0000
m_02	−2.8989	0.0019
bubble_03	−3.7248	0.0001
m_03	−2.9372	0.0017
bubble_04	−2.5714	0.0051
m_04	−6.5968	0.0000

4.4.2. Determine the optimal lag order

Before establishing the regression model, the optimal lag order needs to be selected. In this paper, AIC, BIC, and HQIC are used to select the optimal lag order respectively, and the results at the national level are shown in Table 14, which analyses the national level in order lag 1 when BIC has the smallest value, and in order lag 5 when AIC and HQIC have the smallest value.

Based on the principle of minimization of AIC, SC, and HQIC, we determine the lag order for PVAR modelling of the national data to be 5th order, the lag order for PVAR modeling of the data in the northern region to be 5th order, the lag order for PVAR modeling of the data in the eastern region to be 5th order, the lag order for PVAR modeling of the data in the central-southern region to be 4th order, and the lag order for PVAR modeling of the data in the western region to be 1st order.

Table 14. Results of determining the optimal lag at the national level.

Lag	AIC	BIC	HQIC
1	3.1447	4.1726*	3.5599
2	3.3378	4.5518	3.8298
3	3.4823	4.9353	4.0725
4	3.1406	4.9147	3.8613
5	2.5848*	4.8178	3.4864*

4.4.3. Granger causality

The Granger test is a test used to analyze the causal relationship between economic variables. The Granger test is defined as follows: If there are two economic variables X and Y, and the prediction of Y under the condition of including the past information of both variables X and Y will be better than the prediction of Y under the condition of only the past information of variable Y, then we can consider that the variable X is the Granger cause of the variable Y.

Table 15. Granger causality.

H0	chi	Prob > chi2	Results at the 10 per cent significance level
m does not Granger-cause bubble	10.406	0.065	rejected
Bubble does not Granger-cause m	8.495	0.131	supported
M_01 does not Granger-cause bubble_01	8.235	0.144	supported
Bubble_01 does not Granger-cause m_01	10.391	0.065	rejected
M_02 does not Granger-cause bubble_02	13.052	0.023	rejected
Bubble_02 does not Granger-cause m_02	4.184	0.523	supported
M_03 does not Granger-cause bubble_03	27.006	0.000	rejected
Bubble_03 does not Granger-cause m_03	7.031	0.134	supported
M_04 does not Granger-cause bubble_04	0.023	0.879	supported
Bubble_04 does not Granger-cause m_04	0.624	0.429	supported

We continue to use the Granger test to analyze the causal links, as shown in Table 15. At the 10 per cent level of significance, the degree of financial support m in the national, eastern, and south-central regions is the cause of the respective house price bubble.

4.4.4. Dynamic panel GMM estimation of the PVAR model

In this paper, we conduct regression analyses of bivariate PVAR models containing {bubble, m} to examine the dynamic relationship between house price bubbles and financial support in China. In this paper, 31 large and medium-sized cities are divided into four regions, namely, North, East, Central and South, and West, according to the geography, and the group regression is conducted to see whether there is regional heterogeneity in the impact of financial support on house price bubbles, and the estimation results are shown in Table 16. Among them, h _ m and h _ bubble represent the sequences of financial support and housing price bubbles after removing individual effects by the forward mean difference method. L1., L2., L3., L4., and L5. represent the lagging one-phase variable, lagging two-phase variable, lagging three-period variable, lagging four-period variable, and lagging five-phase variable, respectively, corresponding to the original variable. The systematic GMM estimates of the national and northern, eastern, central, southern, and western cities' financial support and housing price bubble PVAR model are shown in Table 16 below.

Table 16. System GMM estimation results for the PVAR model.

variables	entire country		northern region		eastern region		central south		western region	
	h_m	h_bubble	h_m	h_bubble	h_m	h_bubble	h_m	h_bubble	h_m	h_bubble
L1.	−0.0081	0.3823***	−0.0518	0.0333	−0.1003	0.1456	−0.0696*	0.2028	0.0085	0.6712***
bubble	(−0.53)	(2.95)	(−1.40)	(0.13)	(−0.59)	(0.26)	(−1.83)	(1.58)	(0.79)	(5.75)
L1.	−0.0387	0.4903	0.0698	0.2766	−0.0764	0.5030	0.2587	2.3269***	0.3275***	0.2018
m	(−0.43)	(0.61)	(0.73)	(0.32)	(−0.42)	(0.83)	(1.48)	(4.52)	(2.89)	(0.15)
L2.	−0.0078	−0.3100***	−0.0254*	−0.4099***	0.0041	−0.2330**	0.0202	−0.1302		
bubble	(−0.76)	(−3.81)	(−1.81)	(−3.16)	(0.12)	(−2.10)	(0.90)	(−1.33)		
L2.	−0.0009	0.7761**	0.0072	1.4416**	−0.0593	0.7752***	0.2714***	0.5973		
m	(−0.02)	(2.27)	(0.10)	(2.21)	(−0.55)	(3.05)	(2.59)	(1.15)		
L3.	−0.0164*	0.0450	−0.0232	−0.1807	−0.0815	0.0041	−0.0489**	−0.0668		
bubble	(−1.95)	(0.61)	(−1.35)	(−1.2)	(−0.90)	(0.01)	(−2.36)	(−0.60)		
L3.	0.1341***	0.3665	0.2537***	0.9322	0.2757	0.9195	0.3005**	−0.1110		
m	(2.75)	(1.2)	(2.60)	(1.30)	(0.94)	(1.16)	(2.34)	(−0.25)		
L4.	0.0104	−0.0553	0.0010	−0.0819	−0.0092	−0.1158*	0.0378**	−0.0112		
bubble	(1.28)	(−0.97)	(0.03)	(−0.38)	(−0.53)	(−1.74)	(2.5)	(−0.14)		
L4.	−0.0397	−0.2032	0.1771**	0.8957	−0.0286	−0.0562	−0.0080	0.2842		
m	(−0.90)	(−0.83)	(2.15)	(1.58)	(−0.30)	(−0.15)	(−0.1)	(0.53)		
L5.	−0.0134*	−0.0458	−0.0227	−0.1754	−0.0489	−0.0164				
bubble	(−1.69)	(−0.55)	(−1.09)	(−1.36)	(−0.73)	(−0.07)				
L5.	0.0375	0.1102	0.0328	0.0828	0.2289	0.6110				
m	(0.92)	(0.37)	(0.26)	(0.08)	(0.88)	(0.63)				

Note: No. of obs. = 341, No. of panels = 31 *** denotes significance at the 1% level. ** denotes significance at the 5% level. * denotes significance at the 10% level.

The results of the full-sample estimation show that the degree of financial support has a significant contribution to the house price bubble. In terms of the quantitative relationship, each 1 per cent increase in financial support in the first two periods leads to a 0.7761 per cent improvement in house price bubbles and is significant at the 5 per cent level. The sub-sample estimation results for the northern, eastern, south-central and western cities are similar to the full sample, i.e., the financial support degree has a significant promoting effect on house price bubbles, but there are some differences in different regions. In terms of quantitative relationships, for the northern and eastern regions, a 1% increase in financial support in the previous two periods leads to a 1.4416% and 0.7752% increase in house price bubbles in the current period, respectively, and is significant at the 5% and 1% levels; whereas for the south-central region, a 1% increase in financial support in the previous period leads to a 2.3269% increase in house price bubbles in the current period, and is significant at the 1% level; and for the western cities There is no statistically significant relationship between financial support and house price bubbles, thus Hypothesis 2 is verified, confirming that the effect of financial support on house price bubbles supports the financial support excess hypothesis.

4.4.5. Impulse response analysis

Since the PVAR model is a dynamic model, the interactions between the variables are complex, and it is difficult to accurately determine the impact of changes in one variable on other variables. Therefore, in order to illustrate the dynamic relationship between the variables, the impulse response function (IRF) of the PVAR model is analyzed. The IRF refers to the effect of a shock to one variable in the model on each variable in the system, while controlling for the other variables to remain unchanged. With the help of the impulse response function, the dynamic relationship between variables can be visualized. In this paper, 200 Monte Carlo simulations are carried out separately to obtain the impulse response relationship of the house price bubble and financial support m in the country and cities in each region as shown in Figure 5. where the middle curve represents the IRF point estimate, the upper and lower curves indicate the 95% confidence interval boundaries, the horizontal axis represents the number of response lags, and the vertical axis represents the degree of response positive, negative, and strong. In order to better observe the trend of the impulse response, the period of the shock effect is set to 5 periods.

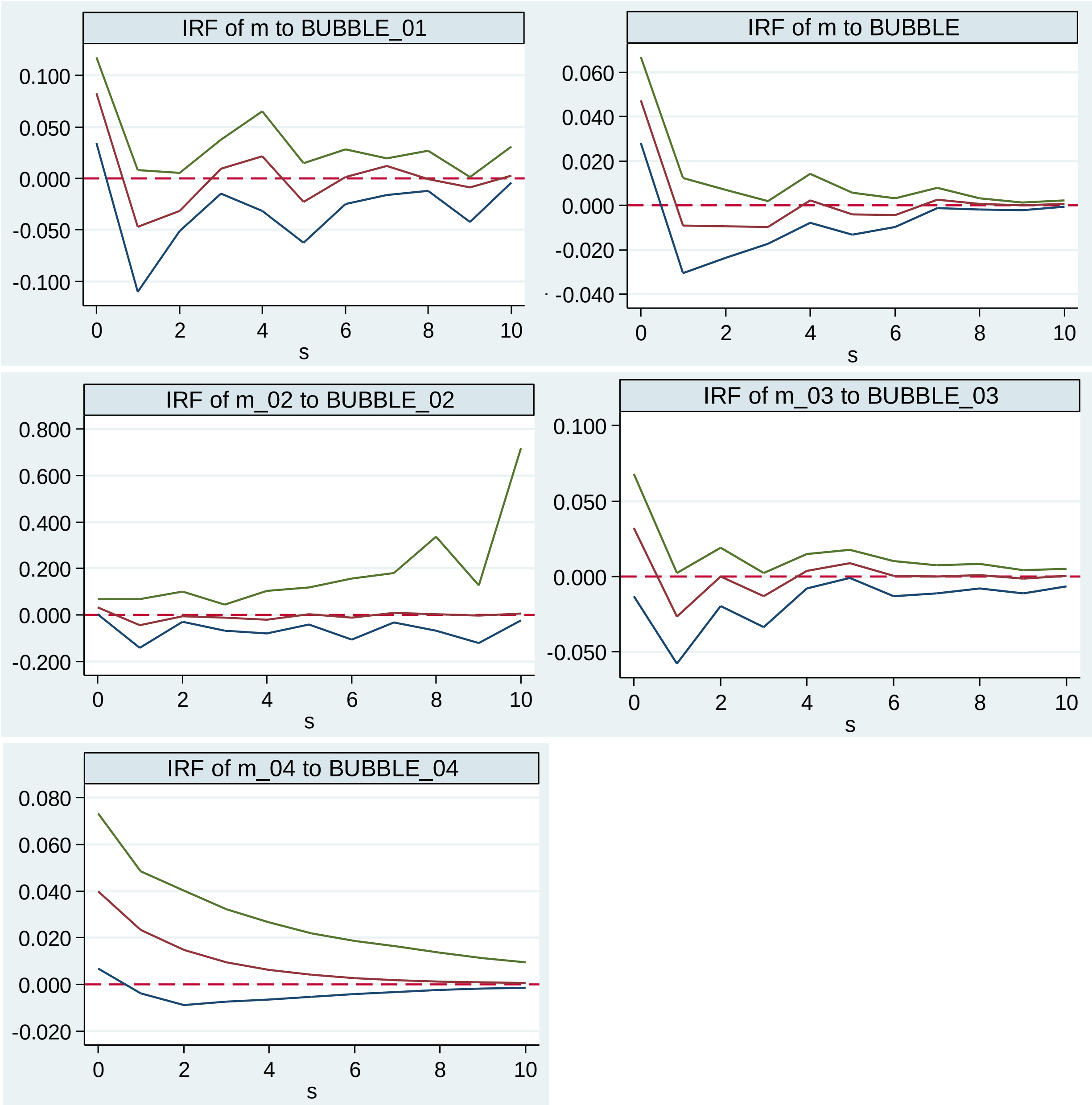

Figure 5. Impulse response plots of the dynamic impact of house price bubbles and financial support across regions.

From left to right, the impulse response plots are shown from top to bottom for the national, northern, eastern, south-central, and western regions. As can be seen from the figure, a positive shock of one unit of financial support brings a large positive effect on house price bubbles in the full sample and reaches a maximum value of 0.05 in the current period, and decreases period by period thereafter. As can be seen from the impulse response plots of each region, financial support degree has an enhancing effect on house price bubbles in the whole, but there is heterogeneity in the degree of influence, which is consistent with the expected theory of hypothesis two.

5. Results and discussion

5.1. Results

Multiple cyclical bubbles were evident in the property markets of all 31 cities, and in general, house price bubbles appeared earlier in first-tier cities than in second- and third-tier cities, and have spread to some of the second- and third-tier cities. House price bubbles appeared earlier in the more economically developed regions than in the less economically developed regions, and have spread to the less economically developed regions. Based on the above findings, the following recommendations are made to curb the house price bubble and prevent the risk of contagion from the bubble. First, the implementation of differentiated and tiered measures to prevent housing price bubbles. The focus of property regulation should be on curbing the over-inflated housing price bubble and preventing the risk of the bubble bursting, rather than focusing only on the level of housing prices. On the one hand, regulators need to adopt appropriate methods to monitor in real time the extent and evolution of housing price bubbles in first-tier cities and some key second-tier cities in China, and take strong measures to curb bubbles in cities where they have just emerged. On the other hand, according to the difference in the degree of the bubble and its survival cycle of each city, we should adopt differentiated and hierarchical strategies to curb the housing price bubble, giving priority to the control of the cities with serious bubbles, and waiting and watching for changes in the cities without bubbles. Therefore, it is necessary to go beyond the individual city level and establish a regional synergy mechanism to curb housing price bubbles by taking into account the regional aggregation of housing price bubbles in each city. This is mostly manifested in the areas of early warning of urban house price bubbles, measures to curb house price bubbles, the timing of implementation, etc. Cities need to share information and co-operate with each other in order to enhance the synergistic effect of regional bubble prevention and control measures.

The creation and rise of house price bubbles in China are closely related to bank financial support. From a national perspective, most of the annual growth rates of financial support for real estate enterprises are over 0.24. An empirical study of the PVAR model with the help of panel data of 31 large and medium-sized cities in China from 2013 to 2021 shows that financial support plays a facilitating role in the house price bubbles, which supports the theory that financial support is over-supporting; the results of the sub-sample show that financial support in cities in the northern region has the strongest facilitating effect on the house price bubbles, and the system GMM results and impulse response plots support the above conclusion. Based on the above research on financial support, there are a few conclusions. First, since most of the funds for real estate investment in China come from banks, and bank loans have a credit expansion effect, banks tend to dominate excessive financial support. In order to keep financial support for real estate at a normal level, the State should take decisive measures at the macro level with regard to the proportion of financial support for real estate to total credit before these indicators are about to reach a critical value, so as to provide a favorable financial environment for the normal operation of the real estate industry. Second, the local government's regulation of local banks should be tailored to local conditions; for areas with high financial support, it should be strictly guarded, closely monitoring the financial support indicator to prevent it from reaching a critical value to generate a housing price bubble, and keeping a wait-and-see approach to areas with high financial support.

5.2. Discussion

Initial studies of the domestic and foreign methods of measuring the real estate bubble such as those based on the comprehensive indicator method to measure the house price bubble, those based on partial equilibrium model to measure house price bubble, those based on the West model to measure house price bubble, those based on the Markov system of conversion to measure the fan house price bubble, and other methods; the above methods have certain defects in different aspects. For example, the comprehensive indicator method can only judge whether there is a bubble and the size of the bubble, but cannot effectively judge the specific point in time when the bubble arises and bursts, and there is a certain degree of subjectivity in the selection of indicators; the West model only identifies the existence of a property bubble and does not provide a further measure of the size of the bubble.

In contrast, Phillips(2015a) has recently developed a series of bubble tests based on the ADF test SADF, GSADF, and BSADF which more objectively and comprehensively portray the existence of bubbles, the point of time when bubbles are created and burst, and the dynamic process of bubbles at each point of time. On this basis, we divide 31 Chinese cities into four regions according to their geographic locations, conducts within-group analyses of the dynamic process of house price bubbles in the four regions, and finally conducts between-group heterogeneity analyses in different regions. The final conclusion is that there are indeed multiple cyclical bubbles in house prices in 31 cities, that inter-city bubbles are contagious, and that house price bubbles are occurring in economically developed areas before less economically developed areas.

Few scholars have studied the dynamic relationship between bank financial support and house price bubbles. Based on the house price bubbles measured by BSADF, this paper adds the measurement results into the panel vector autoregression model PVAR to explore the dynamic relationship between bank financial support and house price bubbles, and concludes that bank financial support for real estate enterprises plays a facilitating role in house price bubbles, and that the promotion of house price bubbles is strongest in cities of the northern region. The conclusion that financial support plays the strongest role in promoting house price bubbles in cities in the northern region supports the financial over-support hypothesis. The results of the study provide a corresponding basis for the macro-control policies of local governments in different regions.

Of course, the article has limitations for the measurement method, as the BSADF measurement method used in this paper is stricter on the time series data heteroskedasticity requirements. Moreover, when the data has heteroskedasticity, using heteroskedasticity correction of the BSADF method will make the results more accurate. However, since the algorithmic package of this method has not yet been improved, the method is not used.

In future research, the theoretical part of the BSADF needs to be further upgraded in terms of heteroskedasticity correction and the algorithm. To measure the house price bubble more accurately, more accurate study of the dynamic relationship between financial support and the house price bubble is needed to provide more effective policy tests for local governments. This may help prevent the occurrence of financial risks.

Use of AI tools declaration

The authors declare that they have not used Artificial Intelligence (AI) tools in the creation of this article.

Acknowledgements

This research has been supported by National Nature Science Foundation of China (Grant No.12001558).

Conflict of interest

All authors declare no conflicts of interest in this paper.

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