

A Study on the Measurement of Real Estate Bubble Based on GSADF: A Case Study of Four Super First-tier Cities in China

Zeyang Gu*

School of Economics and Management, Hebei University of Technology, Tianjin, China

*Corresponding author: steveng917@163.com

Abstract. The problem of high house prices is particularly prominent in super first-tier cities, and real estate bubbles are affecting the healthy development of the real estate industry. This paper applies the GSADF model to measure the year-on-year sales price indices of new commercial dwellings in four super first-tier cities in China, Beijing, Shanghai, Guangzhou, and Shenzhen, from 2011M01 to 2022M08, to examine the time points when their bubbles occur and burst. Results show that the bubbles in the four cities mainly appear in six time periods, and the maximum values of GSADF statistics all appear in 2013M03-2013M05, and the peak and frequency of the bubbles decrease significantly after 2018. Therefore, this paper suggests that we continue to adhere to the principle of "no speculation in housing"; improve the land use policy and build a multi-level housing supply system and continue to implement city-based regulation and control.

Keywords: Real Estate Bubble, GSADF, Super First-tier Cities.

1. Introduction

As an important part of the national economy, the real estate industry has provided a strong impetus for the rapid development of the Chinese economy over the past two decades. After a period of industrialization in which commercialization opened and drove economic growth, the real estate industry has entered a period of returning to the dwelling nature of residences from 2015 to the present [1]. However, relative to income, housing prices are still unattainable for most people, and the Wind database shows that the average price of commercial dwelling transactions in four super first-tier cities in China, Beijing, Shanghai, Guangzhou, and Shenzhen, has reached 55,000, 61,000, 38,000 and 67,000 respectively in August 2022. In the midst of this, whether the real estate bubble exists has been the subject of controversy, and if so, when did it start and when did it end?

The measurement of real estate market bubbles has been the focus of academic research. Peng Junhua et al. (2018) [2] divided house prices into two parts: base value and bubble component to construct a bubble metric model, and the analysis found that the real estate bubble varies significantly across cities and the high and low house prices are not necessarily related to the real estate bubble. Wang Hao et al. (2017) [3] suggest that current researchers using factor analysis for measurement tend to do so with a low KMO, thus measuring an approximate boom index rather than a real estate bubble index. Zhan Song et al. (2021) [4] studied the real estate market bubble in Shenyang from 2000-2019 using factor analysis and made relevant recommendations. After the subprime mortgage crisis in the U.S., many new bubble detection methods emerged. Phillips et al. (2011) [5] proposed the supremum Augmented Dickey-Fuller (SADF), and in 2015 also proposed the generalized SADF (GSADF) [6]. With the continuous promotion of these two methods, some scholars have applied them to the real estate market. Juan Huang et al. (2017) [7] used GSADF and dynamic probit models to measure the bubble in Hong Kong real estate market and find out the causes of bubble generation. Pan W F et al. (2019) [8] used SADF and GSADF to test the existence of bubbles in the Chinese real estate market from 2005-2016 and finally found that most of the Chinese urban real estate markets during this period had bubbles. Yuan Yarui et al. (2020) [9] used GSADF and BSADF models to examine the emergence of bubbles in the new commercial and second-hand residential markets in Xiamen.

In the current studies on China's real estate market bubble, the regions examined are mainly 35 large and medium-sized cities, the Beijing-Tianjin-Hebei region, 70 major cities, first-tier cities, etc.

There are no specific studies on China's super first-tier cities, Beijing, Shanghai, Guangzhou, and Shenzhen. The data released by the National Bureau of Statistics show that these four cities are among the top four in the ranking of China's urban GDP in 2021 and greatly impact China's political economy and other aspects. Therefore, this paper takes four super first-tier cities in China, Beijing, Shanghai, Guangzhou, and Shenzhen, as examples, and chooses GSADF to test the existence of bubbles and the time point of bubbles occurrence and bursting, and then analyzes the difference of real estate bubbles among different cities and the influencing factors, to provide some empirical support for home buyers as well as policy makers' decisions.

2. Research Methodology

2.1. Theory of real estate market bubble

Real estate bubbles are a situation in which the actual price of the real estate market is seriously deviated from the basic theoretical price due to real estate speculation in the market, and the market price is seriously detached from the socio-economic able theoretical support. The bursting of the bubble has a negative impact on the country's macro economy and even a social crisis.

The real estate asset pricing equation can be expressed as

$$P_t = \sum_{i=0}^{\infty} \left(\frac{1}{1+r_f} \right)^i E_t(D_{t+i} + U_{t+i}) + B_t \quad (1)$$

Where, P_t denotes the price of a real estate asset at moment t , r_f denotes the risk-free rate, D_t denotes the real estate asset return at moment t , U_t denotes the unobservable factor at moment t , and B_t denotes the real estate asset bubble component at moment t . B_t satisfies the following properties.

$$E_t(B_{t+1}) = (1+r_f)B_t \quad (2)$$

When there is no bubble in the real estate market, real estate asset prices depend on D_t and U_t . When there is a bubble in the real estate market, asset prices are explosive.

2.2. GSADF-based bubble test

Phillips et al. (2011) [5] proposed a shift from testing whether there is a bubble in the asset price series P_t to a SADF test that tests whether there is an explosive process in the price series. The SADF method obtains a series of ADF statistics from a stepwise regression of the ADF model. The exact upper bound of this column of ADF statistics is used to construct a special ADF statistic, the SADF statistic. The values of the SADF statistic are.

$$SADF(r_0) = \sup_{r_2 \in [r_0, 1]} ADF_0^{r_2} \quad (3)$$

Where, r_0 denotes the minimum window length ratio, r_1 denotes the initial sample point, and r_2 denotes the sample endpoint.

When the value of the SADF statistic is greater than the critical value, a real estate asset price bubble is considered to exist, i.e., a bubble is considered to exist in the real estate market.

The SADF model with the initial point fixed at the first sample observation can detect the periodic foam, but the foam may be missed. Phillips et al. (2015) [6] improved the SADF model by proposing the GSADF model with an initial unfixed point.

The value of r_1 in this model takes values from 0 continuously close to $r_2 - r_0$. For each given r_1 , the GSADF model performs the corresponding SADF test. As a result, the value of the GSADF statistic can be expressed as

$$GSADF(r_0) = \sup_{\substack{r_2 \in [r_0, 1] \\ r_1 \in [0, r_2 - r_0]}} \{ADF_{r_1}^{r_2}\} \quad (4)$$

GSADF test is to compare the value of GSADF statistic with the critical value. When the value of the GSADF statistic is greater than the critical value, it is considered that there is a bubble in real estate asset prices, i.e., a bubble is considered to exist in the real estate market. Figure 1 visually represents the sample selection process of the GSADF test.

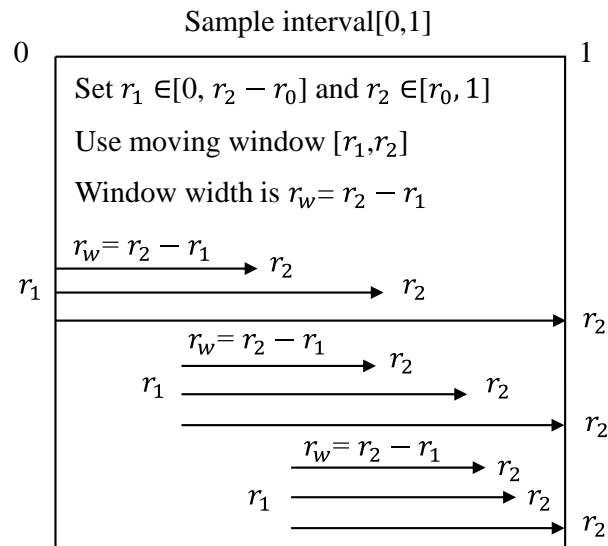


Figure 1. GSADF test

3. Empirical Analysis

3.1. Data source

Real estate asset prices are an important reference indicator for changes in the real estate market and can also be used as an indicator for examining real estate market bubbles. The year-on-year sales price indices of new commercial residential properties in Beijing, Shanghai, Guangzhou, and Shenzhen of CEInet Statistics Database were selected for the period from 2011M01 to 2022M08, and a total of 4 sets of 560 data were obtained. The descriptive statistics of the house price index are shown in Table 1.

Table 1. Descriptive statistics of the house price index

	Beijing	Shanghai	Guangzhou	Shenzhen
Mean	106.556	106.968	107.344	108.892
Std. Dev.	8.102	10.359	7.687	14.630
CV	0.076	0.097	0.072	0.134
Maximum	130.4	139.5	124.3	163.4
Minimum	95.3	94.1	93.5	96.2
Skewness	1.248	1.567	0.545	2.086
Kurtosis	0.826	1.671	-0.482	3.832

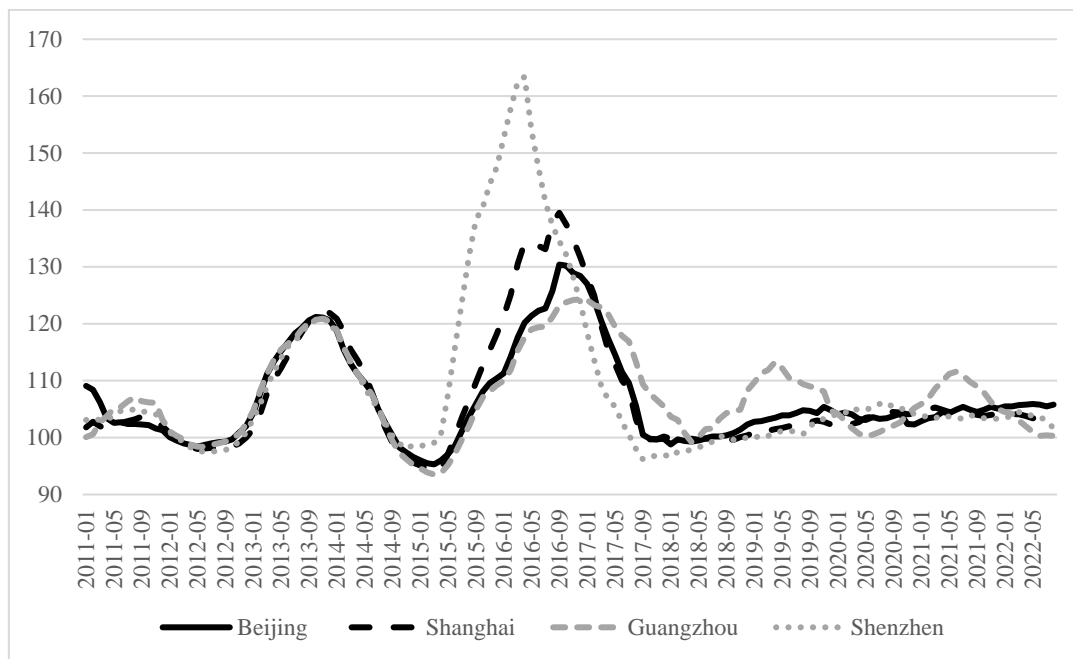


Figure 2. The year-on-year sales price index of new commercial, and residential units in Beijing, Shanghai, Guangzhou, and Shenzhen

The year-on-year sales price indices of newly built residential units in Figure 2 show that the four cities have similar trends from 2011M01-2015M03, and after 2015M04, the house price indices of different cities have risen, with Shenzhen's house price index rising the most, reaching 163.4 in 2016M04. In the subsequent period (2018M03-2022M08), the price indices of the remaining three cities, except Shenzhen, remained stable with a slight increase. The price index in Shenzhen fluctuated up and down, with two significant peaks of 100.7 (2019M04) and 103.9 (2021M04).

3.2. Model Parameters

Based on the GSADF test proposed by Phillips et al. [6], the house price indices of four super tier 1 cities in China, Beijing, Shanghai, Guangzhou, and Shenzhen, were tested by Eviews. In the testing process, the sample size of the house price index is 140, and the minimum window width is $r_0 = 14/140 = 0.1$, which means the minimum window sample size is 14. Phillips et al. (2015) [6] found that adding more lags in the tests of GSADF and SADF would lead to distortion of statistics and critical values. Therefore, this paper sets the number of lags to zero. Moreover, 2000 times of Monte Carlo simulation tests were used to derive the final results.

3.3. Empirical Implementation

First, the existence of house price bubbles in four cities, Beijing, Shanghai, Guangzhou, and Shenzhen, is judged. As can be seen from Table 2, the SADF statistics of the four cities' real estate price index sample data series are 1.86, 3.63, 1.57, and 3.90, respectively, and the GSADF model statistics are 6.65, 4.40, 4.26 and 3.96, respectively. When the significance level is equal to 5%, the critical value of the SADF test statistic is 1.44, and the GSADF test statistic It can be seen that the SADF and GSADF model statistics for both indicators are greater than their critical values at 5% significance level. It is indicated that both the SADF and GSADF model tests can conclude that a certain degree of price bubbles existed in the real estate markets of these four cities during the observation period at the 5% significance level.

Table 2. SADF and GSADF model test results

	Beijing	Shanghai	Guangzhou	Shenzhen	90%	95%	99%
SADF	1.86	3.63	1.57	3.90	1.15	1.44	2.00
GSADF	6.65	4.40	4.26	3.96	2.13	2.45	3.23

Second, the bubble occurrence and bursting points are determined. The sequence of GSADF statistics is compared with the 95% critical value sequence, which obtains a consistent estimate of the point in time when the real-time house price bubble arises and bursts. It determines the time when the bubble occurs and bursts: when the GSADF statistic changes from below the critical value CV to above CV, it represents the bubble arising; when the GSADF statistic is below CV again, it indicates the bubble bursting. In this paper, referring to the study of PWY (2011) [5], the minimum price bubble length is set to two months, i.e., a price bubble is considered to have occurred when the GSADF is greater than the CV for more than two consecutive months. The results of the GSADF test are shown in Figure 3.

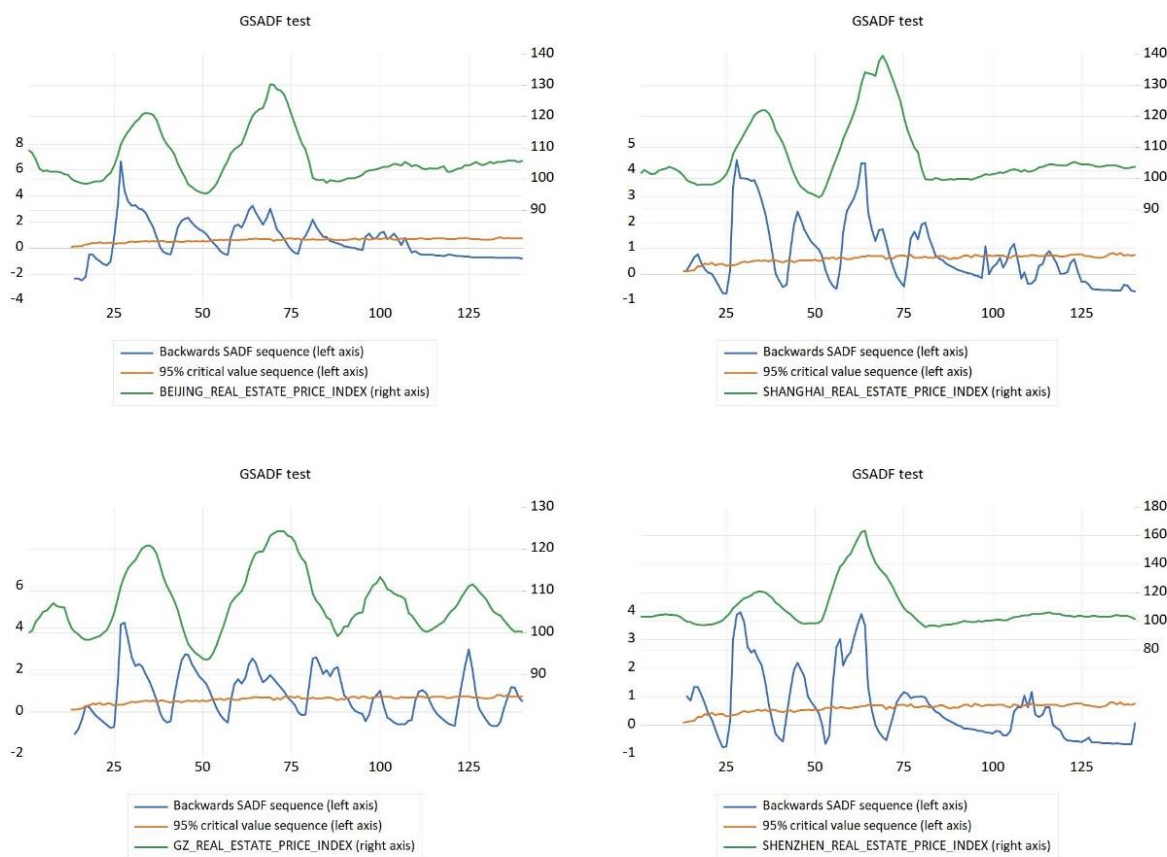


Figure 3. China's super tier 1 cities real estate price bubble (2011M01-2022M08)

From the GSADF test results, bubbles can be roughly divided into the following six periods: 2012M02-2012M08, 2013M01-2014M02, 2014M06-2015M05, 2015M07-2018M06, 2018M12-2020M05, 2020M07-2022M07, with detailed bubble distribution information, is shown in Table 3. In the three periods from 2013M01-2018M06, the real estate price bubbles in the four cities show substantial similarity, while there are some differences in the real estate price bubbles in the four cities before 2018M08 and after 2018M12 in different periods.

During 2011M01-2022M08, there were five bubbles in Beijing, six bubbles in Shanghai and Shenzhen, and seven bubbles in Guangzhou. Meanwhile, the maximum values of GSADF statistics for the house price indexes of Beijing, Shanghai, Guangzhou, and Shenzhen appear in 2013M03-2013M05, with maximum values of 6.65, 4.40, 4.26, and 3.96, respectively.

Table 3. Bubble Distribution Periods

	2012M02- 2012M08	2013M01- 2014M02	2014M06- 2015M05	2015M07- 2018M06	2018M12- 2020M05	2020M07- 2022M07
Beijing		2013M01- 2014M01	2014M07- 2015M04	2015M10- 2017M01 2017M07- 2018M01 2015M10- 2016M11	2018M12- 2019M09	
Shang -hai	2012M03- 2012M06	2013M03- 2014M02	2014M07- 2015M04	2017M05- 2017M12 2015M11- 2017M02		2020M07- 2020M09
Guang -zhou		2013M02- 2014M01	2014M06- 2015M05	2017M08- 2018M06 2015M07- 2016M05	2020M03- 2020M05	2021M03- 2021M07 2022M05- 2022M07
Shen -zhen	2012M02- 2012M08	2013M03- 2014M01	2014M07- 2015M02	2017M01- 2017M10	2019M12- 2020M03	

3.4. Analysis of results

The reasons for the emergence of real estate price bubbles in the four cities are discussed in the context of their macro policies and the economic conditions of China at different times. Following the introduction of the "New Article 8" in 2011, Premier Wen Jiabao emphasized in his speech at the sixth plenary session of the State Council in 2012 that "we should consolidate the results of real estate market regulation and control, and promote the reasonable return of property prices." In February 2013, the executive meeting of the State Council issued the "National Five Articles" on property market regulation and control, which not only reaffirmed the implementation of the regulation and control policy with purchase and loan restrictions as the core but also resolutely cracked down on investment and speculative house purchase. After 2011, the requirement to publish the annual housing price control target was raised again. In 2014, the new "9.30" mortgage policy lifted purchase restrictions in most cities except Beijing, Shanghai, Guangzhou, Shenzhen, and Sanya. In 2015, the People's Bank of China cut interest rates five times a row, lowering the one-year lending rate to 4.35%. Meanwhile, in 2016, the residential de-conversion cycle in four super first-tier cities had fallen to around 8 months. The pressure of rising house prices did not implement tax relief policies like other cities. In March 2017, Premier Li Keqiang emphasized in the government work report that real estate regulation and control should be based on city policies to remove inventory and adhere to the housing property of housing. In 2018, the "On Further Improving Real Estate Market Regulation and Control Work The Notice on Relevant Issues" repeatedly emphasized the housing attribute of housing. It is pointed out that the regulation and control policy should have continuity and stability, locking the general tone of China's housing policy regulation in the future - insisting on the housing attribute of housing and establishing a housing system with multi-subject supply, multi-channel protection, and rental and purchase. It can also be seen that the real estate bubbles in the four cities decreased one after another after 2018, and the peak and frequency of the bubbles were significantly lower than those in previous years, and this finding is also similar to that of Li Jing et al. (2019) [10].

4. Conclusions and Recommendations

This paper uses GSADF to test for bubbles in the year-over-year sales price indices of new commercial, residential properties in four super first-tier cities in China, Beijing, Shanghai, Guangzhou, and Shenzhen, during the period 2011M01-2022M08, and the test is significant. The empirical results of this paper conclude that the real estate markets in Beijing, Shanghai, Guangzhou, and Shenzhen emerged 5, 6, 7, and 6 times during the period 2011M01-2022M08, while the bubble aggregation was roughly distributed over six periods, with the most serious months of the bubble all

in 2013M03-2013M05. The real estate bubbles in the four cities significantly decreased after 2018. Based on above findings, this paper proposes the following recommendations:

First, we should adhere to the "no speculation in housing" principle. It is the guiding ideology of the real estate policy proposed by the Party Central Committee since 2016 according to the main contradictions of the real estate market operation. It is repeatedly mentioned in the "14th Five-Year Plan Proposal" and the 20th National Congress Report that the guiding ideology should not be easily changed. Standardize the management of various types of capital in the real estate market, curb excessive speculation in the real estate market and resolutely combat speculation in housing. A prudent monetary and purchase restriction policy should be implemented according to the actual fluctuation of real estate asset prices to prevent excessive expansion of bank credit and to curb bubble formation to a certain extent.

Second, improve the land use policy and accelerate the establishment of a housing system with multiple main bodies of supply, multiple channels of protection, and rental and purchase. In order to build a multi-level and diversified housing supply system, a new land use policy should be introduced for the housing market of low and middle-income groups further increasing the supply of land for rental housing and affordable housing, and encouraging the use of non-residential stock land for the construction of rental housing or the conversion of non-residential stock housing into rental housing in accordance with regulations, and enterprises and institutions in conditions should be encouraged to join the public rental housing construction team to solve the housing problem of some low-income employees of enterprises and institutions.

Third, it is continued to implement city-based regulation and control, which encourages and guides local governments to continuously improve real estate policies based on the actual conditions of each region. In 2017, real estate policies were tightly regulated, which greatly inhibited the formation of a real estate bubble, consistent with the conclusions drawn in this paper. "During the 14th Five-Year Plan period, the four cities continued to adhere to city-specific policies: Beijing will highlight the core functions of the capital, continue to develop joint property rights housing, focus on meeting the needs of first-time homeless families, and stabilize the real estate market. Shanghai strictly implements the principle of "one city, one policy", optimizes and improves the diversified housing supply structure, and insists on the supply of small and medium-sized ordinary housing. Guangzhou continuously optimizes and adjusts the real estate market regulation and control policies, and maintains a balanced supply and transaction scale in general, effectively meeting the housing needs of the public. Shenzhen strictly implements the linkage mechanism of land price and housing price, and constantly improves the way and policy of residential land grant. From the actual situation of different cities, a reasonable real estate policy is formulated.

References

- [1] Wang Jingbin, Xia Bebe. 40 Years of Real Estate Reform in China: Market and Policy [J]. *Macroeconomic Research*, 2019(10):25-34+168.
- [2] Peng J H, Xu G H, Zhou A M. Research on urban real estate bubble measurement: An analysis based on the screening of underlying values and bubble components [J]. *Price Theory and Practice*, 2018(07):59-62.
- [3] Wang H. The correct method of using factor analysis to measure the current real estate bubble in China: A combination of literature research and empirical research proof [J]. *Macroeconomic Research*, 2017(06):147-157.
- [4] Zhan S, Tang X Y. A study on the real estate market bubble in Shenyang based on factor analysis [J]. *Journal of Shenyang University of Architecture (Social Science Edition)*, 2021,23(05): 470-474.
- [5] Phillips P C B, Wu Y, Yu J. Explosive Behavior in the 1990s Nasdaq: When Did Exuberance Escalate Asset Values? [J]. *Peter C. B. Phillips*, 2011, 52(1).
- [6] Phillips P C B, Shi S P, Yu J. TESTING FOR MULTIPLE BUBBLES: HISTORICAL EPISODES OF EXUBERANCE AND COLLAPSE IN THE S&P 500[J]. *International Economic Review*, 2015, 56(4).

- [7] Huang J, Shen G Q. Residential housing bubbles in Hong Kong: identification and explanation based on GSADF test and dynamic probit model[J]. *Journal of Property Research*, 2017, 34(2): 108-128.
- [8] Pan W F. Detecting bubbles in China's regional housing markets[J]. *Empirical Economics*, 2019, 56(4): 1413-1432.
- [9] Yuan Y F, Qi S J. A Study of Real Estate Market Bubble Measurement Model Based on GSADF and BSADF: Xiamen City as an Example [J]. *The practice and understanding of mathematics*, 2020, 50(18): 76-83.
- [10] Li Jing, Wei Yigang, Chiang Yat Hung. BUBBLES OR CYCLES? HOUSING PRICE DYNAMICS IN CHINA'S MAJOR CITIES [J]. *International Journal of Strategic Property Management*, 2019, 24(2).