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Testing for Multiple Bubbles in the 35 Large and Medium Cities of Real Estate Price in China

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Abstract. *Identifying explosive bubbles that are characterized by periodically collapsing phenomenon over time has been a major concern among researchers in finance and marketing. The paper advances a new date-stamping strategy for identifying the existence, as well as the origination and termination points of multiple bubbles, by using the generalized version of the sup ADF test (GSADF, hereafter) backwardly, which was originally introduced by Phillips, Shi and Yu (PSY, hereafter, 2012). This new method is more effective in identifying the existence of bubbles than the date-stamping strategy (SADF) when multiple bubbles occur. The backward GSADF test is as a rolling window of the ADF test with a double-sup window selection criterion that significantly improves its discriminatory power in simulations. This paper, thus, employs the backward GSADF test to identify housing bubbles in China by using the quarterly data of the real estate price index of 35 large and medium cities from 1998Q1 to 2013Q4. After running the test, we find statistical evidence of real estate bubbles that exist in the price indexes of Beijing, Tianjin, Shanghai, Yinchuan, Shenzhen, Urumqi, and Shenyang. These bubbles are either short-term bubbles or extremely short-term bubbles. We also discover that the ratio of city with housing bubbles is higher in the eastern region than in other regions in China.*

Keywords: Date-stamping strategy, Generalized sup ADF test, Multiple bubbles, Real Estate Price Index.

JEL Classification: C15; G01; G12; R31.

1. Introduction

Since 1998, with the end of the welfare allocating house policy and the beginning of the housing commercialization, the real estate industry in China has come to a new stage of continuous development. In the meantime, the real estate price has gone up rapidly. According to the government statistic, the national real estate price for residential buildings has being rising gradually since 2000. There were a 4% increase in 2002, a 5.7% increase in 2003, an 18.6% increase in 2004, and a 15.1% increase in 2005. In the period of 2007 to 2008, due to balance of payment surplus and many speculators expectation of the appreciation of the Chinese Yuan in the near future, a huge amount of "hot money" flooded into China real estate market. Recently, as the China exports were affected by the Subprime Crisis, in order to keep a higher level of investment growth and to simulate the Chinese economy, the China government adopted a loose monetary policy which led to credit expansion. Moreover, in November 2009, the government further instilled a total of 4 trillion Chinese yuan to boost the economy. Mishkin (2011) believes that the rise of asset prices caused by the credit expansion may contribute to the formation of a real estate price bubble. Kindelberger et al. (2011) think that money supplies and credit expansion may exacerbate speculation and thus cause the formation of a real estate price bubble; the tightening of money supply, in response, will prick the asset bubble. As the warning of having a real estate market bubble in China is getting louder, whether or not there is a bubble in the price variable of the real estate market and how to identify the beginning point and ending point of the bubble have become hot debate topics among the intellectuals.

Among the existing ways in testing real estate bubbles, there are two major categories: indicator approaches and statistical test methods. The indicator approaches are the methods that based on one or some specific numerical indicators to judge whether bubbles exist in the real estate market or not. The commonly used indicators include the proportion of the investments in real estate to the investments in fixed assets, the proportion of real estate development loans to the total bank loans, the ratio of housing price to income, the vacancy rate, the ratio of housing price to rent, etc. Case and Shiller (2003) used mainly the indicator method to study whether real estate bubbles exist in the US. Statistical test methods include variance limit test, intrinsic bubble test, West's two-step test(1) Unit Root test, and Cointegration test, etc. Hamilton and Whiteman (1985) and Hamilton (1986) suggest researchers to use Unit Root test to determine whether bubbles exist. Meese (1986), Diba and Grossman (1988) believe that in order to accurately identify the existence of bubbles, in addition to the usage of Unit Root test, researchers should run the Cointegration test as well. The methods suggested by them were used by Lim (2003), Mikhed and Zemčík (2009) in the study of real estate market.

Although there are so many arguments about the real estate price bubble in China, there is still no obvious conclusion. Moreover, there are serious disagreement and inconsistence over the results of the bubbles obtained through these methods. More importantly, researchers confront what Evans (1991) has warned about, the bubble test trap, which is the failure of discovering a periodically collapsing bubble accurately. It important to note that the existence of a bubble is usually not in a stable condition: it may involve the process of expansion, contraction, re-expansion, and re-contraction. All the above-mentioned approaches and methods, including those which incorporate the periodically collapsing property and derive from the unit root and co-integration based test, failed to avoid the bubble test trap (among others, Phillips, Wu and Yu, PWY, hereafter, 2011; Gürkaynak, 2008). One of the prevalent methods is the sup ADF test (SADF, hereafter) in forward recursive regressions, proposed by Phillips, Wu and Yu (PWY, hereafter, 2011) to implement the right-tail ADF test repeatedly. Their research shows that compared to the standard right-tail ADF test, the sup SADF test improves the power significantly in the presence of periodically collapsing bubbles. However, as the complexity of the nonlinear structure increases, in particular when the sample period includes multiple collapsing episodes, the SADF test may fail to reveal the existence of bubbles.

To overcome this pitfall of the SADF test, we propose an alternative method named as the generalized version of the sup ADF (GSADF, hereafter) test (PSY, 2012). The GSADF test is also based on the idea of repeatedly implementing the right-tail SADF test; however, it extends the sample sequence to a broader range by changing the starting point of each sample over a feasible range. Additionally, the GSADF is suggested further by PSY to use the new date-stamp method to identify points of the origination of bubbles, the expansion of the bubbles, and the termination of bubbles because the date-stamping strategy based on the SADF test may fail to identify some of the bubble periods.

Hence, our paper, which uses a new date-stamping strategy based on the GSADF test, (also known as backwards GSADF), is successful in identifying multiple bubble periods. Based on the real estate prices of the 35 large and medium cities in China covering the period from 1998Q1 to 2013Q4, we ran both the SADF test and the GSADF test to examine the existence of bubbles and then applied the new date-stamping strategy to locate the bubble expansion periods. We have conducted the backward GSADF test in two ways: one is in the window size 19 (r_0=0.3) and the other is a smaller window size 13 (r_0=0.2). The later method is a robust test for supporting the stability of our results. We believe that this new approach to identifying growing bubbles and their collapses will have a significant impact on the construction of early warning systems. The results reveal the existence of real estate bubbles in seven Chinese cities: Beijing (2007Q4), Tianjin (2003Q4-2004Q3), Shanghai (2003Q2-2004Q1), Shenyang (2003Q3-2004Q1) and Yinchuan (2008Q1-Q3), Shenzhen (2006Q2), Urumqi (2007Q3-2008Q2). In Section 2, we explain the similarities and differences between SADF and GSADF and review how to employ a rolling window in the GSADF test procedure to identify multiple bubbles. Then, we describe the source of our data and analyze the results in Section 3. Afterwards, we report the empirical results and explain our findings in Section 4. Finally, we conclude our discussion in Section 5.

2. A Rolling Window for Identifying Bubbles

2.1 Models and Specification

A real estate bubble is a possibility that the housing prices in an area may systematically deviate from their fundamental values (Flood and Hodrick, 1990; Case and Shiller, 2003). It means that there can be a divergence between a house price and its fundamental value.

The ultimate result of an uncontrolled real estate bubble is an upward movement of the housing price to the extent that it goes beyond its holding capacity and bursts eventually. The analysis of real estate price bubbles can be represented as follows:

$$H_t = (\frac{1}{1+r})E_t(R_t + H_{t+1}) \quad (1)$$

where H_t is the fundamental house prices, R_t is the rental value, E_t is the expectations operator, r is the discount rate. The below H_t^F is the fundamental house price under rational expectations by repeated forward substitution. This implies at the equation (2), which house market prices contain expectations of future rents.

$$H_t^F = \sum_{j=1}^{\infty}(\frac{1}{1+r})^j E_t(R_{t+j}) \quad (2)$$

The rational bubble components B_t seen at the equation (3)

$$B_t = (\frac{1}{1+r})E_t(B_{t+1}) \quad (3)$$

The H_t is yielded finally

$$H_t = H_t^F + B_t \quad (4)$$

Equation (4) breaks up house price into a "fundamental" and a "bubble" component. Without a bubble, house prices equal the fundamental value H_t^F .Under bubble conditions house prices may show an explosive behavior inherent in B_t. If B_t is strictly positive, it means that rational investors are willing to buy an "overpriced" house because future prices increase will sufficiently compensate them for the extra payment.

An asset price bubble is a price acceleration that cannot be explained in terms of the underlying fundamental economic variables (Flood and Hodrick, 1990; Case and Shiller, 2003). The most important non-fundamental element driving price increases is the belief that prices will continue to rise in the future (Shiller, 2005).

2.2. Identifying Bubbles: New Date-stamping Strategies

Although the standard left-tailed unit root and co-integration tests have been widely used in empirical research, there is a serious limitation within the methodology as pointed out by Evans (1991), who has demonstrated that the traditional left-tailed and right-tailed unit root and co-integration tests are not capable of detecting explosive bubbles when there are periodically collapsing bubbles in the sample. To deal with the Evans critique, the SADF method has been recently proposed that have some power in detecting periodically collapsing bubbles (PWY, 2011). Based on the above equation (4), the empirical regression model is

$$\Delta H_t = \mu + \rho H_{t-1} + \sum_{j=1} \phi_j \Delta H_{t-j} + \varepsilon_t \tag{5}$$

In the test, the null hypothesis is $H_0 : \rho = 0$, which implies that H_t is a unit root behavior (ΔH_t is stationary). The alternative hypothesis is $H_1 : \rho > 0$, meaning that H_t is explosive (ΔH_t is non-stationary). Different from the standard left-tailed unit root test, both the SADF test and the GSADF test for evidence of nonlinear explosive behavior. The innovation in the SADF test is that it calculates the right-tailed ADF statistics in forward recursive regressions as equation (6), that is, the initial observation of each regression is fixed to be the first observation of the full sample ($r_1 = 0$), but the number of observations used in each regression expands until the full sample is utilized ($r_2 \in [r_0, 1]$).

$$SADF(r_0) = \sup_{\substack{r_2 \in [r_0, 1] \\ r_1 = 0}} \{ADF_{r_1}^{r_2}\} \tag{6}$$

However, a limitation in the PWY methodology is that it is designed to analyze a single bubble episode, if there are two bubbles in a time series of which the duration of the second bubble is less than that of the first one, the SADF procedure cannot consistently estimate the origination date and the termination date of the bubble. To overcome the weakness, PSY (2012) suggests the GSADF method recently. The GSADF test continues the idea of repeatedly estimating the ADF model on a sample sequence as the following:

$$GSADF(r_0) = \sup_{\substack{r_2 \in [r_0, 1] \\ r_1 \in [0, r_2 - r_0]}} \{SADF_{r_1}^{r_2}\} \tag{7}$$

On the other hand, the cointegration-based test for bubbles may result in finding pseudo stationary behavior; therefore, PSY recommend performing a backward SADF test to improve identification accuracy. The backward SADF statistic is defined as the sup value of the ADF statistic sequence, denoted by

$$BSADF_{r_2}(r_0) = \sup_{\substack{r_1 \in [0, r_2 - r_0] \\ r_2 \in [r_0, 1]}} \{BSADF_{r_2}^{r_1}\} \tag{8}$$

Where $r_1 \in [0, r_2 - r_0]$. The above test statistics refer to PSY (2012) for the proof. With a fixed $r_2 = 1$ while the limit distribution of the BSADF statistic is a special case of the GSADF test, that is, the BSADF and GSADF is equal as follows

$$GSADF(r_0) = \sup_{\substack{r_2 \in [r_0, 1] \\ r_1 \in [0, r_2 - r_0]}} \{BSADF_{r_2}^{r_1}\} \tag{9}$$

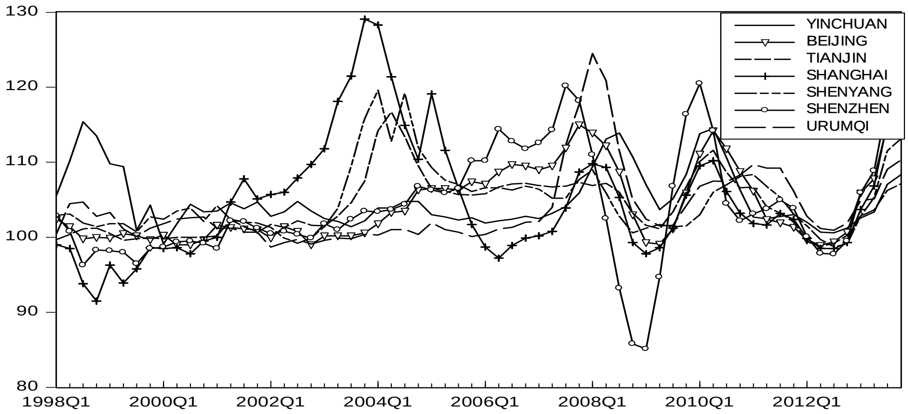
As stated, the GSADF test is a repeated implementation of the backward SADF test for each observation $r_2 \in [r_0, 1]$. Thus, the PWY date-stamping strategies correspond to the SADF test, and the new date-stamping strategies correspond to the GSADF test. Therefore, the GSADF test procedure in this paper is implemented backwardly.

3. Data

Concerning the selection of our data, we focus on the data from major Chinese cities instead of the whole country. Due to a huge imbalance in regional development in China, the real estate prices between cities and rural areas vary greatly. According to a report by the IMF (International Monetary Fund) on July 29, 2010, to look at the national level of China, there was perhaps no real estate market bubble in comparing the current housing prices to the fundamental values, but the conclusion of this report is contestable because when the average in the report was taken based on the national data, there is a high possibility of averaging bias. The real estate price index data of the 35 large and medium cities in China from 1998Q1 to 2013Q4 used in this study was obtained from *China real estate Statistical Yearbook* (中國房地產統計年鑑), published by the National Bureau of Statistics of the People's Republic of China (國家統計局). In order to remove the influence of the time trend in the Jarque-Bera test, before we test the data, we first took the natural logarithm. Then, we used the SADF and GSADF tests to test whether there is any explosive long-term bubble. The finite sample critical values are obtained via Monte Carlo simulations with 2000 iterations in this paper. In our empirical application, we use $r_0 = 0.3$ and 64 observations in this paper and the minimal window size is 19, so that we will not miss any opportunity to capture the explosive phase. Additionally, here it is assumed that the duration of the bubble should exceed the minimal time span $\delta \log(T)$, refer to PSY (2012); δ is a frequency dependent parameter.(2) In this paper, the value of $\delta \log(T)$ is about 4 because δ is 2. According to this calculation, the implication of this number is that if the duration of the bubble is less than 4, it reflects that the local (or national) government is able to control the growth of the housing price and succeed in controlling the rise within a safe range.

In Figure 1, when we examine the changes of the house price indexes of the seven cities in China (Beijing, Shanghai, Tianjin, Shenyang, Yinchuan, Shenzhen and Urumqi), it shows three major peaks. Around 2000, it starts to show a gradual and stable increase. The first strong and drastic surge appears in 2003 and 2004. During 2007 and 2008, there comes the second wave. At the last quarter of 2009, the third rise kicks in.

Figure 1. *The real estate price index for 7 cities in China (1998Q1-2013Q4)*



4. Empirical results

In this paper, in order to show the effectiveness of this backward GSADF test in catching multiple bubbles in comparing to the SADF test, we ran both tests by using the same set of data. The results of both tests show that there is statistical evidence of the existence of housing bubbles in various Chinese cities. The major difference, however, is that SADF statistic test at the 5% significant level can identify only five out of 35 cities: Beijing, Shanghai, Tianjin, Shenyang, and Urumqi. In addition to these five cities, the GSADF test can catch two more cities: Yinchuan and Shenzhen (see Table 1). We believe the GSADF statistic of the logarithmic real estate price index is also more rigorous than the SADF statistic, because critical values for the GSADF statistic are larger than those of the SADF statistic. The followings are the descriptions, illustrations, and explanations of the results of these two tests and the robust test.

Table 1. *SADF and GSADF test of the real estate price in 35 Chinese cities*

Region	City	r_0 =0.3			r_0 =0.2 (Robust test)	
		SADF	GSDAF		SADF	GSDAF
Eastern	Beijing	1.640**	1.650**		1.638**	1.638*
	Shanghai	1.815**	2.140**		1.815**	2.307**
	Tianjin	4.672***	4.782***		4.672***	4.783***
	Shenyang	2.326***	2.326***		2.326***	2.326**
	Ningbo	1.021*	1.021		1.021*	1.021
	Shenzhen	1.065*	1.657**		1.065*	1.657*
	Hangzhou	-0.952	-0.352		-0.952	-0.031
	Jinan	0.648	0.648		0.648	0.832
	Nungi	-0.042	0.614		-0.042	0.874
	Qingdao	-0.917	-0.129		-0.917	1.629
	Fuzhou	-1.878	0.676		-1.878	0.676
	Shihkiachwang	-0.601	0.678		-0.601	0.931
	Guangzhou	-0.886	0.327		-0.886	1.247
	Xiamen	-0.217	0.334		-0.217	0.334
	Haikou	0.234	0.489		0.234	0.489
Northeast	Dalain	-1.690	0.104		-1.690	0.275
	Harbin	-2.000	-0.330		-2.000	-0.245
	Changchun	-2.440	0.465		-2.440	0.582
Central	Changsha	0.096	0.984		0.096	1.109
	Wuhan	-1.933	-0.521		-0.670	0.149
	Nanchang	-0.552	0.032		-0.352	0.553
	Hefei	-0.919	-0.403		-0.919	-0.039
	Taiyuan	-1.581	0.780		-1.581	1.144
	Zhengzhou	-2.109	-0.177		-1.983	0.849
Western	Nanning	-1.984	-0.094		-1.984	0.061
	Urumqi	3.722***	5.030***		3.722***	5.030***
	Xian	0.104	0.451		0.104	1.135
	Guiyang	-1.864	1.501*		-1.668	1.501
	Kunming	-2.170	-0.890		-2.048	-0.502
	Chongqing	-0.833	-0.200		-0.832	0.223
	Yinchuan	-1.513	2.894***		-1.358	5.646***
	Xining	-1.812	-0.269		-1.812	0.493
	Chengdu	-1.307	0.675		-1.307	1.704
	Lanzhou	-1.222	-0.652		-1.222	-0.496
	Hohhot	-0.944	0.635		-0.944	1.053

Note: (1) r_0 =0.3, the smallest window size has 19 observations. The test statistics are in parentheses. The symbols of ***, **, and * indicate the SADF statistical significance at the 1%, 5% and 10% level is 1.905, 1.176, and 0.860 respectively. And the GSADF statistical significance is 2.150, 1.650, and 1.365 respectively.

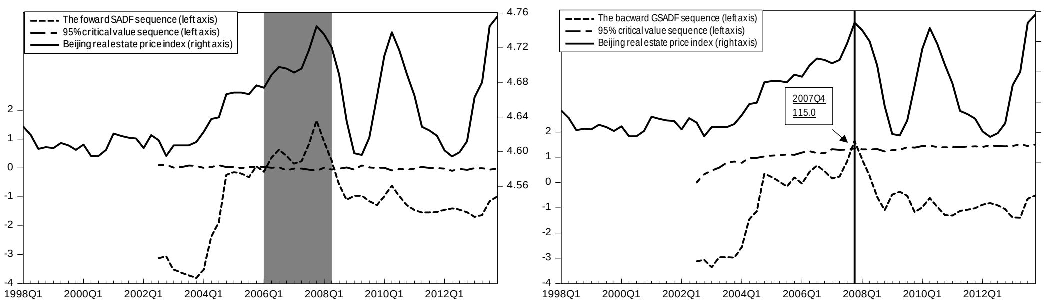
(2) r_0 =0.2, the smallest window size has 13 observations. The symbols of ***, **, and * indicate the SADF statistical significance at the 1%, 5% and 10% is 1.870, 1.226, and 0.914 respectively. And the GSADF statistical significance is 2.573, 1.964, and 1.642 respectively.

4.1. The differences between SADF and GSADF test for r_0 =0.3

(1) Recursive calculation of the SADF and the GSADF test for Beijing

In Figure 2, which is the result of the GSADF test (at r_0 =0.3), Beijing real estate investment is going upward rapidly in 2007Q4. The beginning and ending of the bubble is at the 115.0 level. The GSADF statistic of the logarithmic real estate price index is 1.650, which passes the same critical value 1.650 at 5% significant level. The periodic bubble period is an extremely short-term bubble. (3) This finding is in line with Wang et al (2011). Wang's result shows that exchange rate reform has an impulse on the forming of housing price bubbles by using the method of unit root and cointegration analysis. Nevertheless, after 2008, the expectation of *yuan*'s rise becomes less dominant; the bubble tends to shrink.

Figure 2. *Recursive calculation of the SADF and GSADF for Beijing (r_0 = 0.3)*



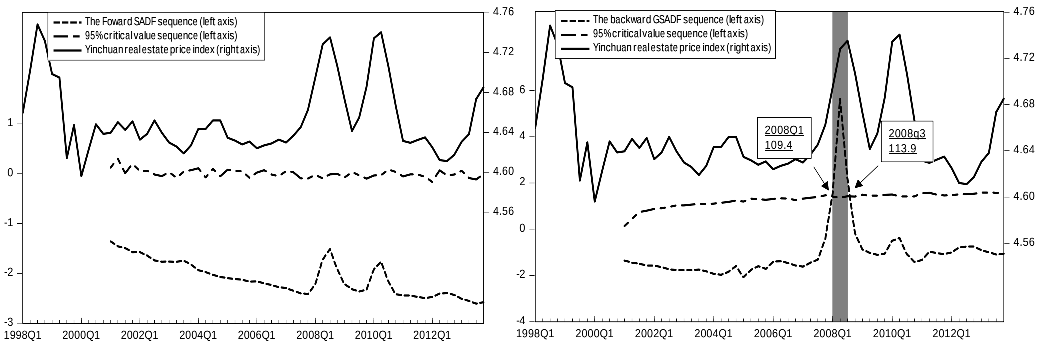
However, the result of the SADF test in Beijing real estate investment is going upward rapidly during the 2004Q3-2008Q2 period. The periodic bubble period is over the 4-quarter period, which can be regarded as a dangerous bubble. The interesting aspect of this finding is that by using different methods, we get slightly different results (in term of the length of the bubble). Here also lies the major controversy among researchers. (Hou, 2010; Jianglin, 2010; Wu et al., 2012; Shen et al., 2005; Chen et al., 2005)

(2) Recursive calculation of the SADF and the GSADF test for Yinchuan

According to the raw data of the real estate price index, we can see that two sharp rise periods appear in the Yinchuan real estate price index: 2008Q2 and 2010Q1. The price index reached the level of 113.1 in 2008Q2 and 114.5 in 2010Q1. But after we ran the

SADF test and the backward GSADF test r_0 =0.3, we can only see the formation of a bubble in the backward GSADF tests (see Figure 3).

Figure 3. *Recursive calculation of the SADF and GSADF for Yinchuan (r_0 = 0.3)*



In Table 1, while r_0 =0.3, the SADF statistic of the logarithmic real estate price index is -1.513, which is smaller than the 5% significant level of 1.176. The GSADF statistic of the logarithmic real estate price index is 2.894, which is also more rigorous than the respective 5% significant level of 1.650. Based on the SADF test, the logarithmic real estate index appears no significant bubble. That is, only the backward GSADF tests succeeds in catching the housing bubble in Yinchuan, whereas the statistic of the SADF test accepts the null hypothesis of no bubble .

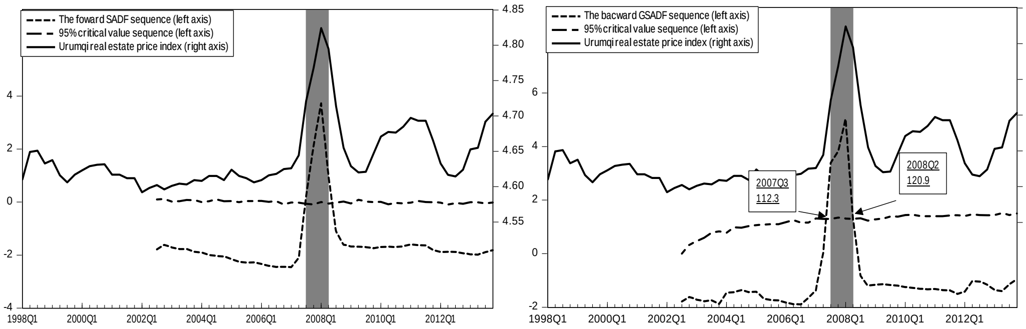
Figure 3 shows the result of the GSADF test. Yinchuan real estate investment is going upward rapidly from 2008Q1 to 2008Q3. The beginning of the bubble is at the 109.4 level and the ending of the bubble is at the 113.9 level. The periodic bubble period is within the 3-quarter period. Therefore, it is clear that the GSADF test has more effective testing power in identifying a bubble in Yinchuan and clearly shows that the periodic bubble is short-term because it lasted less than four quarters.

(3) Recursive calculation of the SADF and the GSADF test for Urumqi

According to Figure 4, when we look at the graph of the GSADF test (at r_0 =0.3), the real estate investment is going upward rapidly from 2007Q3 to 2008Q2 in Urumqi. The beginning of the bubble is at the 112.3 level, and the ending of the bubble is in 2008Q2 at the 120.9 level. The GSADF statistic of the logarithmic real estate price index is 5.030, which passes critical value of 1.650 at 5% significant level. The periodic bubble period is within the 4-quarter period. As for the result of the SADF test in the case of Urumqi, the real estate price index is 3.722, which more than critical value of 1.176 at 5% significant level.

To sum up, due to balance of payment surplus and speculation activities which refer to the influx of hot money, both stock market and housing market in China to expand drastically, setting off another waves of housing bubble formations. Nevertheless, the strength of the waves was not strong at all according to the results of the GSADF test. The real estate price indexes in these cities are affected and the housing bubbles are burst by the 2008 US Subprime mortgage crisis. Thus, the extremely short-term bubble appears in Beijing (2007Q4) and short-term bubbles both in Urumqi (2007Q3-2008Q2) and in Yinchuan (2008Q1-2008Q3). In response to the financial crisis, the China government launches a fiscal stimulus program to trigger the housing boom (Cova et al., 2010) and this observation is similar to the findings of Deng et al. (2011).

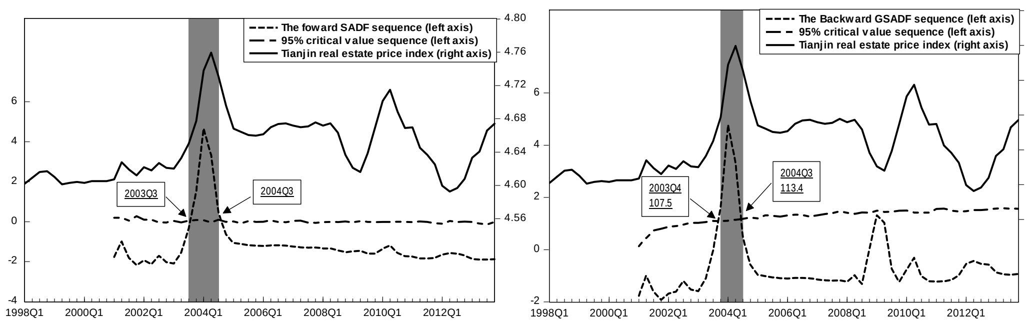
Figure 4. *Recursive calculation of the SADF and GSADF for Urumqi (* r_0 *= 0.3)*



(4) Recursive calculation of the SADF and the GSADF test for Tianjin

According to the raw data of real estate price index, the housing prices in Tianjin reached the highest 116.7 in 2004Q2. After we ran the SADF test and the backward GSADF test, we can see the formation of a bubble in both tests (see Figure 5). In Table 1, while r_0 =0.3, the GSADF and SADF test statistics of the logarithmic real estate price index are 4.782 and 4.672, which are larger than the 5% significant level of 1.650 and 1.176, respectively.

Figure 5. *Recursive calculation of the SADF and GSADF for Tianjin (* r_0 *= 0.3)*

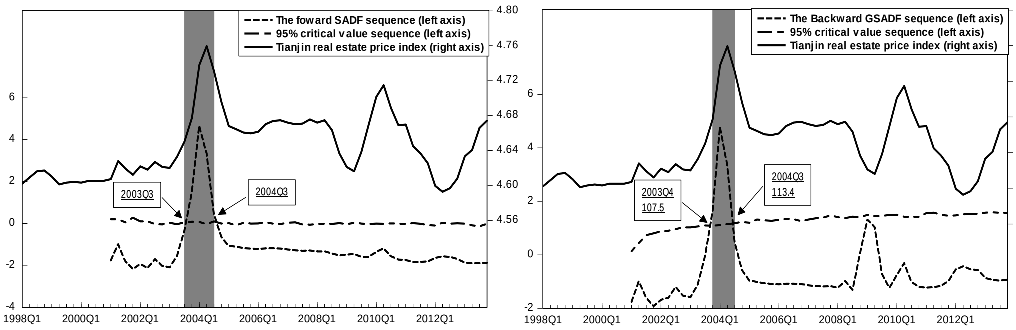


In both graphs in Figure 5, we can observe a climax of the raw data in 2004Q1, but the beginning and the ending point of the bubbles are different in the two tests. According to the graph of the GSADF test, Tianjin's real estate investment is going upward rapidly from 2003Q4 to 2004Q3. The beginning of the bubble is at the 107.5 level, and the ending of the bubble is in 2004Q3 at the 113.4 level. The periodic bubble period is within the 4-quarter period. According to the graph of the SADF test, however, the bubble starts a little early in 2003Q3 and ends in 2004Q3. The periodic bubble period is more than 4 quarters. Therefore, the GSADF test has a more effective testing power in identifying an explosive bubble in Tianjin and clearly shows that the periodic bubble is short-term because it lasted less than four quarters.

(5) Recursive calculation of the SADF and the GSADF test for Shanghai

According to the real estate price index, the housing prices in Shanghai reached the highest 129.1 in 2003Q4. After we ran the SADF test and the backward GSADF test, we can see the formation of a bubble in both tests (see Figure 6). In Table 1, while r_0=0.3, the GSADF and SADF test statistics of the logarithmic real estate price index are 2.140 and 1.815, which are larger than the 5% right-tail critical value of 1.650 and 1.176, respectively.

Figure 6. *Recursive calculation of the SADF and GSADF for Shanghai (r_0 = 0.3)*



In both graphs in Figure 6, we can observe a climax in 2003Q4, but the beginning and the ending point of the bubbles are again different in the two tests. When we examine the graph of the GSADF test, Shanghai real estate investment is going upward rapidly from 2003Q2 to 2004Q1. The beginning of the bubble is at the 118.1 level, and the ending of the bubble is in 2004Q1 at the 128.3 level. The periodic bubble period is within the 4-quarter period. As for the result of SADF test, the bubble again starts a little early in 2003Q1 and ends in 2004Q2. The periodic bubble period is again more than 4 quarters. Therefore, the GSADF test has a rigorous statistic of the logarithmic real estate price index than the SADF test; it has a more effective testing power in identifying an explosive bubble in Shanghai and again clearly shows that the periodic bubble is short-term because it lasts less than four quarters.

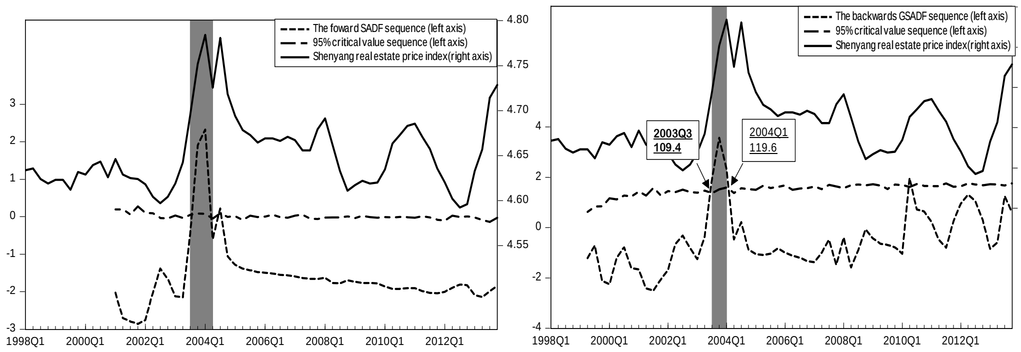
(6) Recursive calculation of the SADF and the GSADF test for Shenyang

According to the real estate price index, we can see that two sharp rise periods appear in the Shenyang real estate price index: 2004Q1 and 2004Q3. The price index reached the level of 119.6 in 2004Q1 and 119.2 in 2004Q3. After we ran the SADF test and the backward GSADF test, we can see the formation of a main bubble in both tests (see Figure 7).

In Table 1, while r_0=0.3, the GSADF and SADF test statistics of the logarithmic real estate price index are the same: 2.326, which is larger than the 5% significant level of 1.650 and 1.176. It means that the GSADF is more rigorous in rejecting the null hypothesis of no bubble, and thus its result is more effective testing power than the SADF test.

In Figure7, according to the graph of the GSADF test (at r_0 =0.3), Shenyang real estate investment is going upward rapidly from 2003Q3 to 2004Q1. The beginning of the bubble is at the 109.4 level and the ending of the bubble is at the 119.6 level. The periodic bubble period is within the 3-quarter period. Therefore, the GSADF test is more effective testing power in identifying a bubble in Shenyang clearly shows that the periodic bubble is short-term because it lasted within two quarters.

Figure 7. *Recursive calculation of the SADF and GSADF for Shenyang (* r_0 *= 0.3)*



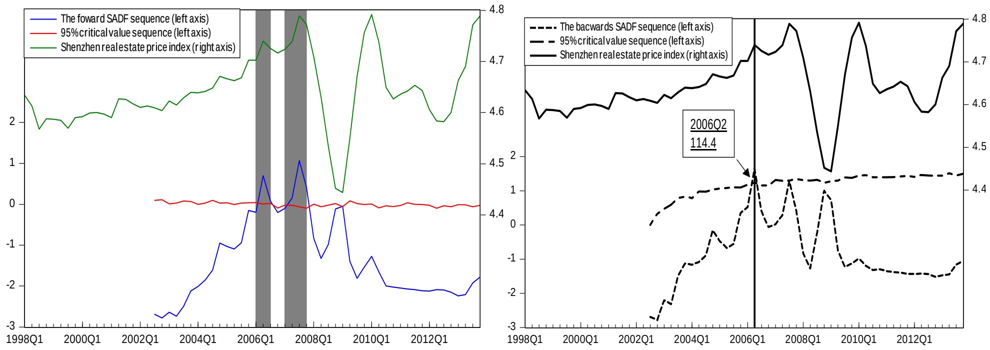
It is also important to note that the GSADF test shows that in the Shenyang case, multiple bubbles appear in both the 2003Q3-2004Q1 and the 2010Q2 periods. Since the 2010Q2 is within only one quarter, we do not study it closely. In Figure 7, the SADF caught an additional bubble right in 2004Q2 which is right after the first bubble. Nevertheless, since the first bubble is longer and the second bubble is very close to the first bubble and is extremely brief, the result of the second bubble may not be accurate (PSY, 2012) , and thus we do not analyze this bubble in our paper. Also, a very small ripple effect appears in Shenyang a year later. If we look at the results of the SADF test, this method even fails to catch those bubbles. In other words, the GSADF test has more effective testing power in these cases.

To sum up, Tianjin, Shenyang, and Shanghai shared similar experiences in having housing bubbles. Following the Reform and Open Policy, the Chinese government implemented a series of housing reforms, putting an end to the traditional housing distribution system in a planned economy, and thus quickening the pace of commercialization of real estate market investment. Due to a high economic growth during the years of 2003 and 2004, millions of Chinese join the middle class each year, thereby contributing to a high housing demand. With the establishment of the mortgage system, the sales of the usage permits of various rural agricultural lands, the adoption of housing security for the low-income residents, etc., these changes were perhaps the major driving forces behind the upswing of real estate prices of Tianjin, Shanghai, and Shenyang during the 2003Q3-2004Q2 period.

(7) Recursive calculation of the SADF and the GSADF test for Shenzhen

In Figure 8, when we examine the result of the GSADF test (at r_0 =0.3), it shows that Shenzhen real estate investment is going upward rapidly in 2006Q2. The beginning and ending of the bubble is at the 114.4 level. The GSADF statistic of the logarithmic real estate price index is 1.657, which pass critical value 1.650 at 5% significant level. The periodic bubble period is an extremely short-term bubble. In the result of the SADF test, however, Shenzhen real estate investment is going upward rapidly in 2006Q1-2006Q3 and 2007Q1-2007Q4, these are short-term consecutive bubbles. In comparing to other cities, Shenzhen is a special administrative region; thus, a more complex situation may appear. Various government policies and external environment may affect the development of the real estate market. Its bubbles are unique and their formation and disappearance should be carefully examined in the future.

Figure 8. *Recursive calculation of the SADF and GSADF for Shenzhen (r_0 = 0.3)*



On the whole, while $r_0 = 0.3$, based on GSADF statistic test at the 5% significant level and the test results of Beijing, Tianjin, Shanghai, Yinchuan, Shenzhen, Urumqi and Shenyang, it is clear that the GSADF test is more effective in identifying explosive bubbles than the SADF test. It is also important to note that only seven cities among the data of 35 large and medium sizes Chinese cities have bubbles. These bubbles can be characterized as regional bubbles and they last only briefly in between two to four quarters. It is quite possible that the local governments might have reacted to these sharp rises in housing prices through various administrative means of intervention such as controlling banks mortgage policy, tightening lending conditions, raising the proportion of the down-payment, increasing the interests rate for the second suite, limiting real estate purchases, increasing land supply, and etc., in order to dispel the momentum of rising real estate prices and deter speculations by investors.

4.2. The Robustness of SADF and GSADF test for r_0 =0.2

The GSADF test depends on the window size r_0. In general, r_0 needs to be chosen according the total number of observations T. If T is small, r_0 need to be large enough to achieve estimation efficiency (PSY, 2012). Hence, this study uses these two methods in the sample proportion r_0T =13 to perform the robust test on the above cities to determine whether explosive bubbles exist. The results in GSADF statistic test at the 5% significant level show that five out of seven cities have bubbles (see Table 1). These cities are Tianjin, Shanghai, Urumqi, Yinchuan and Shenyang, and GSADF identified the existence of short-term explosive bubbles in these cities. We observe the following phenomena. Firstly, while the minimum window size r_0 decreases, critical values of the test statistic increase. In addition, we also discover that in both GSADF and SADF test, regardless so of whether r_0=0.3 or r_0=0.2 the ratio of the cities in the eastern region having bubbles (the housing price detach from its fundamental value) is higher than cities in other regions. This finding is also in line with Peng (2008)'s analysis based on China's Province Panel data, showing that bubbles mainly appear in the coastal regions.

5. Conclusion

The GSADF test is a rolling window right-sided ADF unit root test with a double-sup window selection criteria, which it moves the window frame gradually toward the end of the sample and significantly improves discriminatory power in detecting multiple bubbles.

We apply the backward GSADF test (r_0 = 0.3) to the real estate price in 35 major Chinese cities from 1998Q1 to 2013Q4. The test results are consistent with our expectation; that is, the GSADF test suggests that there are explosive bubbles in the real estate prices in Beijing, Shanghai, Shenyang, Tianjin, Shenzhen, Urumqi and Yinchuan. Meanwhile, the robust test (r_0 = 0.2) in GSADF statistic test at the 5% significant level shows that five out of the seven cities have bubbles. They are Tianjin, Shanghai, Urumqi, Yinchuan and Shenyang. Most of these cities are located in the eastern region of China. Nevertheless, it seems to be safe to say that the real estate bubble phenomenon in these Chinese cities is not very serious according to the results of the GSADF test because all these bubbles are regional bubbles and they are basically either short-term or extremely short-term.

We believe that this new backward GSADF approach is powerful and effective in identifying growing multiple bubbles and can estimate the origination and termination points of these bubbles. In running a rolling window for identifying multiple bubbles, the backward GSADF test show consistency in obtaining results. Especially, when the two bubbles are very close to each other and the first one is longer than the others, the backward GSADF test can catch the times of the second bubble which is what the SADF test fails to identify.

The potential usage of this GSADF test is that if government policy-makers can identify clear origination and termination points of housing bubbles, they can be better equip to construct an early warning system to tackle the housing bubble problem. They can also use the GSADF method as a signpost for testing periodically formation of any real estate price bubbles in various places. Nevertheless, when conditional heteroskedasticity exists in the time series, especially in the case of non-linear time series, the SADF or GSADF method may tend to over-reject null hypothesis of no bubble. We suggest researchers to use the generalized version of the sup KSS test (GSKSS) in future researches to examine those cities again backwardly.

The limitation of this research is that we do not try to explain in details why the bubbles appear in these five cities, not the others. Neither do we try to find out the explanations of the short life-span of these bubbles. We leave these to the qualitative researchers to dig up the related government documents and to study the specific economic conditions that may explain the origination and termination of these bubbles.

Notes

(1) Variance limit test was suggested by LeRoy and Porter (1981), and Shiller (1981). Intrinsic bubble test was introduced by Froot and Obstfeld (1991). West's two-step test, which was designed by West (1988) to study the stock market, is rarely applied in the study of real estate market.

(1) In general, we set 0.7 for yearly data, 5 for monthly data, and 2 for quarterly data (PSY, 2012)

(1) The calculated $\delta \log(T)$ value is around 4 which means less than 4 seasons. It is regarded as short-term by definition.

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