

Detecting and Dating Chinese Housing Bubbles: Empirical Evidence from the First Tier Cities

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Abstract

This paper applies a newly developed bubble detecting method, the Sup ADF test (Phillips et al., 2011), to examine the presence of housing bubbles in the first tier cities of China, namely Beijing, Shanghai, Guangzhou and Shenzhen. The empirical results confirm that there have been housing bubbles in Beijing and Shanghai and moreover, two distinct bubbles are detected in the Beijing housing market. In contrast, there is only one long, substantial bubble in Shanghai. However, there is no evidence to support the existence of housing bubbles in Guangzhou and Shenzhen.

Empirical results suggest that Beijing's first bubble originates in 2007M3 and collapses in the 2009M1, and the second bubble lasts between 2009M3 and 2011M9. Shanghai's bubble extends from 2009M4 to 2011M4. The housing bubbles in both Beijing and Shanghai collapsed in between 2011M4 and 2011M9.

Keywords: House prices, Chinese Housing Bubble, Unit root test, Recursive ADF tests

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1. Introduction

Deng Xiaoping's 'Open Up' Policy of 1978 completely reshaped China's economy. The market was gradually transformed from an initial central planning based economy to a mixed system of central planning with market-oriented economy, and the Chinese economy has been growing ever since. In the early 1990's, the real estate market was deregulated, and for the first time a boom was observed in the housing market. The prices of land and commodities were driven up by 1993, which led to inflation and a rising cost of living. In 1993, the Chinese government introduced its first policy aimed to cool-down the booming housing market. Up until 2010, the government attempted four different policies to stabilize the housing market, but these policies failed to stop the rising momentum of house prices. Shen (2012) shows that China's housing affordability index (i.e. the ratio of housing price to average household income) is 9.1 and is the highest among G7 countries.

One of the main reasons for rising house prices is a high Chinese savings rate and very limited investment options. Chinese families see housing as an immovable asset and believe that its value will appreciate over time. Hence investing in real estate is seen as offering a high return and a means to shelter savings from the effect of inflation. Since 2000, the annual growth in real estate investment has been more than 20%, but in the post Great Recession slowdown after 2007-08 this growth rate dropped to 16% in 2009. However, recent fiscal stimulus packages by the Chinese government raised the growth rate of investment in real estate to 36% during 2010.

The Chinese government works with its central bank to cool down the housing market and closely monitors the housing prices. This is not only from a concern that higher house prices could lead to inflation, but also from a financial system risk perspective should a speculative housing bubble result in a crash that affects overall economic

expectations. The collapse of the housing markets in the United States, Ireland and Dubai has been observed by the Chinese government.

According to Lexis-Nexis, the term ‘housing bubble’ started to become very common in major English language newspapers in 2002. Whether a housing bubble exists in the Chinese housing market has been and will continue to be a hot topic. Abraham and Hendershott (1996), Case and Shiller (2003), Mikhed and Zemčik (2009), find evidence of housing bubbles in the United States in the lead-up-to the Great Recession. In contrast, evidence of Chinese housing bubbles is mixed. Hui and Yue (2006), Hou (2010), Hwang et al. (2012) and Chen et al. (2013) support the existence of Chinese housing bubbles. However, Ren et al. (2012) and Chen and Funke (2013) remain sceptical of the existence of housing bubbles in China. Therefore, establishment of the existence of Chinese housing bubbles is of current economic interest.

This paper applies a newly developed bubble detecting method, the Sup Augmented Dickey–Fuller test (SADF), which was proposed by Phillips et al. (2011) to examine whether there is evidence of Chinese housing bubbles. The SADF test is designed to overcome Evans’ (1991) critique on periodically collapsing bubbles. The SADF test has been employed to detect housing bubbles in the four major cities in China and the eight important regions in Shanghai.

Chinese house prices are published by two private data companies, one is Wind Information Co., Ltd (Wind Info) based in China, and the other is CEIC Data based in the United States. House prices from these two data sources are used to detect housing bubbles for China’s four first tier cities, namely Beijing, Shanghai, Guangzhou and Shenzhen. It also allows us to robustness check the empirical results by using two data sources.

Our empirical results suggest that the presence of housing bubbles in Beijing and Shanghai. Based on results using the CEIC data, there have been two distinct bubbles in Beijing's housing market. The first bubble originated in 2007M3 and collapsed in 2009M1, and the second bubble occurred from 2009M3 to 2011M9. Whereas, there was only one bubble in the Shanghai housing market, which occurred between 2009M4 and 2011M4. Interestingly, both cities' bubbles collapsed in the period of between 2011M4 and 2011M9. In addition, the evidences from Shanghai's eight regions suggest that those regions are located near the city centre exhibited housing bubbles while those regions further away from the city centre showed little evidence of a housing bubble.

The paper is organized as follows. Section 2 is a literature review of the methodology for detecting housing bubbles and recent research on Chinese housing bubbles. Section 3 presents the SADF test methodology for testing explosive behaviours. Section 4 presents general information on the data sources and some descriptive statistics of the datasets. Section 5 presents the empirical results of detecting housing bubbles and the robustness checks on those results. Section 6 draws conclusions of the paper.

2. Literature Reviews

In the past two decades, the global housing market has experienced a tremendous rise in housing prices. A number of studies focus on the housing markets in the United Kingdom and the United States, as these two countries experienced a dramatic rise in housing prices. Since 2000, a substantial growth in the Chinese housing prices has attracted global attention and a large number of studies have examined the Chinese housing market, although there are still some gaps that need to be filled. This paper intends to add to the existing literature and to implement new econometric methodology to assess the presence of bubbles in the Chinese housing market.

There are intensive debates on whether a speculative bubble exists in the housing market. Many economists have developed advanced econometric models to detect housing bubbles and there is significant evidence of the existence of housing bubbles in the U.S. and the U.K. housing markets. In contrast, there is mixed evidence in the literature on the Chinese housing bubbles. The literature reviews mainly focus on the methodologies for detecting housing bubbles and evidence of Chinese housing bubbles.

2.1 Methodologies for Detecting Housing Bubbles

In the asset pricing literature, the price of an asset (such as housing) can consist of two components: the fundamental component and the bubble component. An asset price is denoted as

$$P_t = P_t^f + B_t, \quad (1)$$

where P_t is the asset price at time t , P_t^f is the fundamental price component at time t and B_t is the bubble component at time t .

Blanchard and Watson (1982) suggest that the rational bubbles are speculated by investors, since they are willing to pay more money than the fundamental price to buy an asset (e.g. housing property) in the rational expectation that the value of the asset will grow over time and they can make profit by buying the asset at the present price. This could be a good explanation of the current housing market in China. There is a lack of alternative investment options in the Chinese financial market, many investors seek to invest in housing property as they see it as a secure and high return investment. Hence the housing bubble will be built up by rational speculative investment.

Shiller (1981) proposes an early method of detecting rational bubbles, by comparing the variance of asset prices to the variance of fundamental prices. If the variance of asset

prices exceeds the variance of fundamental prices, then it can be concluded that there is a rational bubble in the asset prices. This approach received strong criticisms for giving little structure to the bubble component and the differences between the variance of asset prices and the variance of fundamental prices could be caused by other factors rather than the bubble component.

To overcome this criticism, Campbell and Shiller (1987) propose another approach which is to test whether the gap between asset prices and fundamental prices (i.e. the bubble component, $B_t = P_t - P_t^f$) exhibits explosive behaviour during the process of forming a bubble. Hence, a standard unit root test is recommended by Campbell and Shiller (1987). If the bubble component B_t is non-stationary, then there are two possibilities that can be considered. The first possibility is that the asset prices are non-stationary and the fundamental prices are stationary. The second possibility is that both the asset prices and the fundamental prices are non-stationary. However, in the second case, it is not a sufficient condition for explosive behaviour of the bubble. For example, if P_t and P_t^f follow an integration order 1 process, i.e. I(1), and are cointegrated, then the bubble component is stationary. Hence, a cointegration test needs to be performed as the second step in examining the asset prices and the fundamental prices cannot be cointegrated. This combined left-tailed unit root test and cointegration test is supported by Diba and Grossman (1988). Therefore, this combination test is widely used and has become a standard method for detecting bubbles.

Evans (1991) criticizes this methodology and shows the detection power will be reduced if the time series data manifests 'periodically collapsing bubbles', which is a more complex bubble characteristics. The standard left-tailed unit root test and the cointegration test might fail to detect the periodically collapsing bubbles. The periodically collapsing bubbles in the data series are more likely to be tested as a unit root

or stationary process rather than an explosive behaviour. Evans (1991) proves that the unit root test fails to capture periodically collapsing bubbles by using samples from Blanchard (1979).

To overcome Evans' critique, Phillips et al. (2011) propose a recursive right-tailed ADF test on asset prices, which they call the Sup ADF (SADF) test. This method is different from the conventional left-tailed ADF test. A sub-sample of the data series will be right-tailed ADF tested and then the size of the sub-sample will be increased by one observation for the next right-tailed ADF test. The process will be finished by completing the whole sample. Phillips et al. (2011) show that this method is capable of capturing the periodically collapsing bubbles in NASDAQ stock prices, whereas, the conventional ADF test fails to do so. Another feature of SADF test is its ability to determine the origination date and the collapse date of the bubble. The SADF test will be used for detecting Chinese housing bubbles in this paper and the details of this methodology will be outlined in the following section 3.

2.2 Literature on Chinese Housing Bubbles

The tremendous growth in Chinese housing prices since 2000 has continued despite Chinese government efforts to stabilize the housing market. Housing prices continue to grow much faster than wage growth. The issue of housing affordability has becoming more severe and Shen (2012) shows that housing affordability in Beijing and Shanghai is worse than New York and London by around 3% to 4% using the ratio of housing price to current income. Hence, the literature continues to debate the existence of housing bubbles in China.

2.2.1 Evidence in Favour of Chinese Housing Bubbles

Hui and Yue (2006) use the cointegration method to exam abnormal interactions between

housing prices and the fundamental prices in the cities of Beijing and Shanghai in 2003 using monthly data. They find that 22% of Shanghai house prices are attributed to the bubble component and conclude that there is a housing bubble in Shanghai. There is no evidence to suggest the existence of a housing bubble in Beijing in 2003. This is the first empirical study on housing bubbles in mainland China.

Hou (2010) uses a multi-indicator analysis to re-examine the results from Hui and Yue (2006) comparing housing prices with rational expectation prices, mortgage loans, ratios of housing price to income and ratios of housing price to rent. Hou finds evidence of a housing bubble in Beijing from 2005 to 2008 but no clear evidence in Shanghai's housing market.

Chen et al. (2013) investigate the disagreement between Hui and Yue (2006) and Hou (2010). They focus on the housing market in Beijing and use quarterly data on income, inflation, interest rate and construction cost to construct the equilibrium value of house prices. They find that Beijing's housing price indices are significant above the equilibrium house prices during 2004 and 2007, which theoretically indicates a bubble period for Beijing.

Hwang et al. (2012) estimate Chinese housing bubbles through Estimate Maximum Likelihood of a state-space model. This alternative approach reveals housing price bubbles do exist in the housing markets in Beijing and Shanghai. Moreover, a housing bubble exists in the whole of China's housing market. The results are consistent to Dreger and Zhang (2010), who use the panel cointegration method to test the relationship between real housing prices and a set of fundamentals for 35 major cities in China. They show that 25% of the equilibrium housing price is the bubble component for the 35 major cities at the end of 2009. The bubbles are significant for those cities locate in the

southeast coast region and special economic zones.

2.2.2 Evidence against Chinese Housing Bubbles

Ren et al. (2012) apply rational expectation bubbles theory (Blanchard and Watson, 1982) to 35 major cities in China and find no evidence to support the existence of housing bubbles. Similar conclusions are drawn from Chen and Funke (2013), who apply the SADF test on Chinese national house price to rent ratios. They find the evidence to support the existence of housing bubbles is weak for the whole of China.

2.3 Limitations of Previous Research

In general, reliable Chinese time series data is short, especially for housing prices given the relatively recent deregulation of the housing market. Many researchers experience difficulties from lack of data to perform robust econometric investigation. Chen and Funke (2013) use national price to rent ratios from 2003Q1 to 2011Q4 to perform the SADF test. There are two main shortcomings of this data. Firstly, the low frequency of the data may affect the results significantly. Secondly, the national data might not be able to capture city or regional housing bubbles. Therefore, to overcome the similar problems that Chen and Funke (2013) face, we collect monthly house prices for Beijing, Shanghai, Guangzhou and Shenzhen as well as house prices for Shanghai's eight regions to examine the possible existence of housing bubbles.

The price to rent ratio is usually taken as a key indicator of the fundamental value of house prices. However, it is not a valid indicator to determinate bubbles. This is because signing a rental contract will lead to a temporary rigidity of rental price, and how long the rigidity will be last, will depend on the length of the contract. Furthermore, the rental prices or rental indices are not easy to obtain for China. Therefore, using the ratio of price to rent to analyse housing bubbles is unreliable. Hence, the real house price in this paper

is calculated as the nominal house price deflated by the national Consumer Price Index (CPI)¹.

Based on the literature reviews, it is necessary to estimate the fundamental housing price and to separate the asset price into its fundamental and bubble components. However, fundamental price is difficult to define and measure properly and different researchers have used their own interpretations of fundamental price. For example, Hui and Yue (2006) define the fundamental variables of housing price as GDP, the stock market index, consumption expenditure, net operating income, office vacancy rate, CPI and interest rate. Hou (2010) defines the fundamental variables as interest rate, rent, income and per capita GDP. Chen and Funke (2013) define the fundamental variables as interest rate, inflation and the supply cost of housing. Therefore, each study has its own definition method of estimating the fundamental price. A different approach is used by Phillips et al. (2011) who look at a sufficient condition, which is to investigate the explosive behaviour of asset prices while taking fundamental prices into account. If explosive behaviour of the asset price can be detected, then it is evidence to indicate the existence of a housing bubble.

3. The SADF Bubble Testing Methodology

Evans' critique (1991) on the shortcoming of the standard unit root test is that it fails to capture the periodically collapsing bubbles. He explains that the explosive behaviour in asset price tends to be observed only for a temporary period and reflects a periodically collapsing bubble. The length of the bubble period depends on the strength of the bubble but it will inevitably collapse. In this case, the series tend to be similar to an I(1) process or even stationary, so the standard unit root test will not be able to capture such

¹ The National Bureau of Statistics of China publishes the regional CPI figures are calculated as year over year. Since the base year is changed each year, it is not compatible with the housing price datasets. The accessible CPI figures that based on standard single base year is the national CPI.

periodically collapsing bubbles. Phillips et al. (2011) propose the SADF test to overcome Evans' critique. They show that recursive regression techniques effectively capture the periodically collapsing bubble. The SADF test is explained below, with equations in this section taken from Phillips et al. (2011).

Phillips et al. (2011) implement the right-tailed ADF test for unit root test against the alternative hypothesis of explosive roots. The time series of price assets are estimated by ordinary least squares (OLS) using the following autoregressive equation

$$P_t = c + \theta P_{t-1} + \sum_{i=1}^k \alpha_i \Delta P_{t-i} + \mu_{p,t}, \quad \mu_{p,t} \sim N.I.D(0, \sigma_p^2) \quad (2)$$

where P_t is house price at time t ; k is the number of lags of the first difference of house prices; the error term is a normally independent distributed variable with zero mean and variance σ_p^2 .

So the time series of house prices (P_t) is tested by the unit root for the null hypothesis, $H_0: \theta = 1$ (i.e. a unit root in house prices) against the right tailed alternative hypothesis, $H_0: \theta > 1$ (i.e. explosive behaviour of house prices).

The SADF test is performed via forward recursive regressions. Equation (2) is regressed forward recursively, by setting r_0 percentage of the whole sample as the initial subsample for the first regression, where $r_0 \leq r \leq 1$. We set $r_0 = 10\%$ for most of the time. For the next following regression, one extra observation will be added to the initial subsample until the whole sample is completed. Under the null hypothesis, for a given r proportion of sample size, the test statistics of ADF_r and $SADF_r$ are calculated as follow:

$$ADF_r \Rightarrow \frac{\int_0^r \tilde{W} dW}{\sqrt{\int_0^r \tilde{W}^2}} \quad \text{and} \quad SADF_r \Rightarrow \sup_{r \in (r_0, 1)} \frac{\int_0^r \tilde{W} dW}{\sqrt{\int_0^r \tilde{W}^2}} \quad (3)$$

where W is a standard Brownian motion or Wiener process; $\tilde{W}(r) = W(r) - \frac{1}{r} \int_0^1 W$, is the demeaned Brownian motion.

In order to locate the bubble's origination and collapse dates, equation (2) is forward recursive regressed and the time series test statistics are recorded and plotted against the critical value of the test statistic, which are obtained from a Monte Carlo simulation involving 2,000 iterations. In other words, the Wiener process is approximated by partial sums of independent standard Normal distribution (i.e. $N(0,1)$) with 2,000 steps. The asymptotic critical values of each sample is calculated by Monte Carlo simulation to serve each specific sample. Hence, the critical values will be different from sample to sample. The explosive alternative critical values follow the asymptotic distribution of the Dickey-Fuller test statistic. The origination date is the first data point for which the test statistic is above the critical value, and the collapse date is the first data point subsequent to the origination date for which the test statistic is below the critical value. The origination date \hat{r}_s , and the collapse date \hat{r}_f can be denoted as

$$\hat{r}_s = \inf_{r \geq r_0} \{r: ADF_r > cv_{\beta_n}^{adf}(r)\}, \hat{r}_f = \inf_{r \geq \hat{r}_s} \{r: ADF_r < cv_{\beta_n}^{adf}(r)\} \quad (4)$$

where $cv_{\beta_n}^{adf}(r)$ is the right tailed critical value of ADF_r with significance level of β_n .

In general, the greater is the value of the test statistic, or the lower is the associated p-values, the stronger is the evidence to reject the null hypothesis of the SADF test, which implies stronger empirical evidence that the asset prices exhibit explosive behaviours.

This paper employs the SADF test on Chinese housing prices with robustness checks. Robustness checks are found in section 5, Empirical Results.

4. Data

Data sources are well-documented in terms of continuity, length and frequency in developed countries such as the United States, United Kingdom and Canada. By contrast, Chinese data is more challenging and much data is not publicly accessible. If the data are accessible, then the length might contain less than the past ten years. Furthermore, some data is collected by several different institutions and each institution releases its own version of the data. Hence, it is difficult for researchers to find a dataset to produce sound and robust empirical results. Interestingly, Chinese data on house prices are published by two private companies, one in China (Wind Information), and the other in the United States (CEIC). Both datasets provide monthly nominal house prices for Chinese cities, so that real house prices can be calculated via deflating using the CPI² from the National Bureau of Statistics of China³ (NBSC). These two data sources allow us to perform robustness checks for the empirical results.

4.1 Wind Information Data

Wind Information Co. Ltd⁴ (Wind Info) is China's leading provider of financial data, information and software. The length of the nominal house prices for China's first tier cities (Beijing, Shanghai, Guangzhou and Shenzhen) are from 2005M2 to 2014M5.

4.2 CEIC Data

CEIC Data⁵ offers a wide range of macroeconomic data, industry data as well as regional data. CEIC provides longer length and better details of data on China's house prices. In addition, Shanghai's regional house prices (2005M1 – 2011M1) are also available which

² $Real\ Price_i = Nominal\ Price_i \times \left(\frac{CPI_{base\ year}}{CPI_i}\right)$, where i represents month i .

³ National Bureau of Statistics of China Website: <http://www.stats.gov.cn/english/>

⁴ Data source website: <http://www.wind.com.cn/En/>

⁵ CEIC Data website: <http://www.ceicdata.com/en/countries/china>

allow us to separate the megacity into small regions and investigate the possible presence of regional housing bubbles. However, CEIC data does not provide house prices on all of the four first tier cities and instead provides house prices for Beijing, Shanghai and Guangdong Province⁶ (2001M1 – 2014M7).

4.3 Descriptive Statistics

Figure 1 graphs Wind Info's real house price trends for the four first tier cities⁷. All the prices display an increasing trend and there is evidence of several humps in the data which could suggest possible bubbles. Shenzhen's house prices have the fastest growth rate and reached the highest level amongst the four cities, followed by Beijing, Shanghai and Guangzhou. In contrast, the housing prices from CEIC data (Figure 2), Beijing's house prices having the fast growth and the highest level compared to Shanghai and Guangdong Province. Figure 2 also depicts that several humps which suggest possible housing bubbles.

Table 1 shows some selected annual real house prices from two data sources. The comparable data for Beijing and Shanghai are very similar, suggesting that the two sources of data are reasonably consistent and reliable. In addition, the correlation between two data sources for the house price of Beijing and Shanghai are 0.9999 and 0.9997, respectively.

The detection of Chinese housing bubbles is more appropriate using regional house prices instead of national aggregate house prices. The gaps between cities in terms of economic development are huge, so that the boom and bust of the bubbles will be averaged out in the national data by the relative stability of less developed and slower growing cities.

⁶ The Cities of Guangzhou and Shenzhen are located in Guangdong Province. The house prices of Guangdong Province contains other less developed cities, so the average house prices of Guangdong Province will be lower than for Guangzhou City and Shenzhen City.

⁷ House prices are shown in terms of the price per square meter of living space in Renminbi.

Therefore, the house prices for China's largest four cities are preferred and used in this paper.

Moreover, the CEIC data for eight sub-regions of Shanghai allows further investigation of the spatial concentration of Chinese housing bubbles. Shanghai is one of the biggest cities in the world, so the house prices are expected to differ greatly across different regions. These eight Shanghai regions are: East Nanjing Road⁸, Old Urban Area, Lujiazui (Financial Centre)⁹, Century Park, Huaihai Road¹⁰, Dapujiao Road, Longhua Road and Xinhua Road. Figure 3 depicts the house price trends for these regions from 2005M1 to 2011M1. All the prices start to rise in 2007M4 and the dramatic growth lasts for more than one year. After 2008M7, the growth rates of the eight regions slow down. In 2011M1, the region with lowest house prices has reached around RMB 15,000 (around CAD\$ 2,700) per square meter, and the region with highest house prices is above RMB 27,000 (around CAD\$ 4,900) per square meter.

5. Empirical Results

Firstly, the SADF test results on house prices for the Shanghai's eight regions are presented. Secondly, the same methodology is employed to test China's first tier cities by using Wind Info data. This will give us preliminary results on the first tier cities, especially, in the case of Shanghai. Finally, a longer length of time series data from the CEIC data will be used to do the robust checks against the preliminary results. As the CEIC data has no house prices for Guangzhou City and Shenzhen City, then the robust checks will be focused on Beijing and Shanghai.

⁸ Nanjing Road is formerly known as "Nanking Road" during the former Shanghai International Settlement period.

⁹ Lujiazui is one of the financial centres in Asia and it has most iconic landmarks of Shanghai.

¹⁰ Huaihai Road is located in former French Concession, also well-known by its former French name, "Avenue Joffre".

In the following results, real house prices in level form and in logarithm form will be presented following the approach of Phillips et al. (2011). Real house prices are the ratio of nominal house prices to CPI. Hence, real house prices do not necessarily follow a continuous trend for a given period of time. So there is no need to take the logarithm of the real house prices. However, log of real house prices are tested and presented in the text for comparison purpose. This provides some more information on the test results in both level and logarithm forms. In the paper of Phillips et al. (2011), they present the logarithmic real asset prices in their main body. Nevertheless, they state that tests are also conducted by using level form and the conclusions remain qualitatively unchanged in the footnote of 11 of Phillips et al. (2011). The reason not to report their results in level is to save space.

5.1 Decision Rules for Hypothesis Tests

The null hypothesis for the $Sup_{r \in [r_0, 1]} ADF_r$ or SADF test is the presence of a unit root, i.e. $H_0: \theta = 1$, and the alternative hypothesis is explosive behaviour, i.e. $H_1: \theta > 1$. This is the right tailed ADF test, which is different from the conventional left tailed ADF test for testing stationarity ($H_1: \theta < 1$). We set $r_0 = 0.1$, that is 10% of the full sample is used as the initial window size to perform recursive right-tailed ADF tests. If the p-value is less than 0.05 for the null hypothesis, then we reject the null hypothesis at a 5% level of significance, or if the test statistic is greater than the critical value of the test statistic at the 95% confidence level, then the null hypothesis is rejected in favour of the alternative hypothesis i.e. that house prices show evidence of a bubble or explosive price behaviour. Critical values for 90%, 95% and 99% confidence level are calculated by Monte Carlo simulation with 2,000 replications. To locate the origination date and the collapse date of the bubbles, time series of the test statistics that are generated from each recursive right-tailed of ADF test and are recorded and plotted against the critical value of test statistic for 95% confidence level. Then the first data observation for which the observed

test statistic is above the critical value is the origination date of the bubble and the first, subsequent, data observation below the critical value is the collapse date of the bubble. Therefore, the duration of the bubble can be tracked in this fashion.

5.2 Tests on House Prices of Shanghai's 8 Regions

Table 2 summarize the p-values and test statistics for the SADF tests on real house prices for Shanghai's eight regions. Several conclusions can be drawn. The tests for five of the regions at the city centre, namely East Nanjing Road, Old Urban Area, Lujiazui, Century Park and Huaihai Road reject the null hypothesis. Furthermore, the strength of failing to reject the null hypothesis (i.e. no evidence of a housing boom) increases for the three regions located further away from the city centre. For instance, the p-value of Dapuqiao Road is 0.049 and the p-value increases to 0.196 for Xinhua Road¹¹.

To locate the origination date and the collapse date of bubbles, time series of test statistics are plotted against the critical value at the 95% confidence level (Figure 4). Interestingly, the origination dates of the bubbles for East Nanjing Road, Old Urban Area, Lujiazui, Century Park and Huaihai Road are in the same month (2007M8). Furthermore, East Nanjing Road experiences the longest bubble period (till 2010M6). Nanjing Road is the busiest street in Shanghai, and likely in mainland China, so the test results reflect the high housing price expectation for that area. An interesting result presents for Old Urban Area is that, two bubbles are detected but with only a single month gap between two bubbles in 2009M1, which is the same month that the bubbles collapse at the regions of Lujiazui, Century Park and Huaihai Road. In contrast, there is no evidence of housing bubbles in the region of Longhua Road and Xinhua Road. The null hypothesis for Dapuqiao Road is rejected by only 0.001, so it is not strong evidence of a housing bubble.

¹¹ Dapuqiao Road is some distant from the city centre, and Xinhua Road is further away than Dapuqiao Road.

The SADF tests are also employed to log of real house prices. Table 3 reports the test results and the same conclusions can be drawn from Table 2 and Table 3. Dapujiao Road, Longhua Road and Xinhua Road have no evidence of a housing bubble with the test, and for the other five regions all reject the null hypothesis at the 99% confidence level.

The comparison between Figure 4 and Figure 5 shows a small difference for the East Nanjing Road and Old Urban Area regions. The housing bubbles detected with the log of real house price end three months earlier than the bubbles detected with the level of real house price. The timelines of bubbles for the regions of Lujiazui, Central Park and Huaihai Road are identical across the two forms of the dependent variable.

5.3 Tests on House Prices of China's 4 First Tier Cities

Table 4 reports the SADF test results for the real house prices of China's four first tier cities, Beijing, Shanghai, Guangzhou and Shenzhen. The test results on the real house prices show that data for Beijing and Shanghai reject the null hypothesis of a unit root in support of explosive behaviour in real house prices at the 95% confidence level. However, this finding is not robust to the log specification for real house prices using Wind Info data. This lack of robustness to specification of the dependent variable contrasts with the result of Phillips et al. (2011) which showed robustness with respect to the use of the logarithm.

As we discuss above, real house price is the price ratio, so there is no need to take the logarithm. Hence, the tests results show that there are housing bubbles in the city of Beijing and Shanghai, and there is no evidence of a housing bubble for Guangzhou and Shenzhen.

Figure 6 and Figure 7 illustrate the timelines of the test statistics for the four cities, and

show the presence of a housing bubble for Beijing (two bubbles) and Shanghai (single bubble) for real house price level. In Figure 6, we can see that two housing bubbles are detected in Beijing. The length of the first bubble (2007M1 - 2008M9) is almost double the second one (2010M1 – 2010M10), but the magnitude of the second one is stronger. In contrast, the Shanghai housing bubble originates in 2009M4 and it collapses in 2011M1. Shanghai's housing bubble (in level data) further confirms that housing bubbles do not only exist at the level of regions within a city, but may also exist for the whole city.

We noted that Shenzhen's housing prices are the highest among the four cities with increasing momentum between 2009 and 2012 (Figure 1). Nevertheless, no housing bubble is detected in Shenzhen¹². This might be due to the shorter available time series which reduced the detecting power. The total observations for Shenzhen and Guangzhou are 75 (2008M1 - 2014M4) compared to 112 for Beijing and Shanghai (Wind Info). In contrast, the data from Chen and Funke (2013) involve only 35 observations (2003Q1 - 2011Q4). Therefore, the test for Shenzhen might suffer from a similar shortcoming where the small number of observations in the data series reduces the bubble detecting power of the SADF test.

We can see in Figure 6 and Figure 7 that each city's house prices have their own distinctive characteristics. Although housing bubbles (in level data) are detected in both Beijing and Shanghai, their housing markets are very different. Hence, the SADF test at a national level would be more likely to fail to capture a national housing bubble if explosive pricing behaviour is spatially concentrated in a city or regional housing market. We believe that this is another shortcoming of Chen and Funke (2013).

¹² Setting $r_0 = 0.2$ and $r_0 = 0.3$ were also tested in SADF with all results failing to reject the null hypothesis of a unit root (i.e. no evidence of a housing bubble).

5.4 Robustness Checks for Housing Bubbles for Beijing and Shanghai

Data from Wind Info exhibited a housing bubble in levels for Beijing and Shanghai. We apply the same SADF test to data for Beijing and Shanghai from CEIC (2001M1 to 2014M7) as a robustness check. The robustness checks will be proceeded by firstly comparing the results that are generated from two different data sources, and secondly comparing the results that are generated by setting different initial windows, r_0 .

Although the time series length of the CEIC data is longer than that for Wind Info, the estimations are very close. Table 5 reports the SADF tests on real house prices for Beijing and Shanghai using CEIC data. The results again demonstrate the existence of housing bubbles in Beijing and Shanghai with real house prices in level but not in logarithm. Table 5 (for both cities), Figure 8 (for Beijing) and Figure 9 (for Shanghai) show four panels of time series of test statistics generated by setting different initial window sizes, (i.e. for 10%, 20%, 30% and 40% of the whole sample, respectively). The p-values from Panel A to Panel D for both cities are all significant at the 99% confidence level for the real house prices in level. For the log of real house prices, the results are all insignificant for Shanghai across different panels. However, in the case of Beijing, the test statistics are very close to the critical values. The results from Panel B and Panel C reject the null hypothesis at 10% significance level, but in Panel D, the null hypothesis is rejected at 5% level of significance. Therefore, if the test statistic is very close to the critical value, the SADF test results can be shifted by setting the initial window size.

Therefore, the SADF test results that are generated from Wind Info. and CEIC data with different initial window sizes all show that, at least for level of real housing prices, there are housing bubbles in Beijing and Shanghai in the past decade.

Setting different initial window sizes allows us to check for robustness in the dating

mechanism for the origination and collapse dates of the bubbles. Figure 8 shows the results for Beijing. Firstly, by setting the initial window size as 10% of the sample, the first bubble is dated between 2007M3 and 2009M1, and the second bubble is dated in between 2009M5 and 2011M9. Comparing with other three settings for r_0 , the SADF tests find the same timelines for Beijing's housing bubbles.

Similarly, Figure 9 shows the results for Shanghai where the 10% initial window size dates a single bubble between 2009M4 and 2011M4. Again, this timing is robust to other initial window sizes.

Furthermore, results in Figure 8 and Figure 9 can be checked with the results in Figure 6. We find there are slight differences between the two data sources in the timelines of the bubbles. In Figure 6 (Wind Info), the first bubble in Beijing is between 2007M1 and 2008M9 (duration of 20 months), and the second bubble is between 2010M1 and 2010M10 (duration of 10 months). In contrast, Figure 8 (CEIC) shows Beijing's first bubble between 2007M3 and 2009M1 (duration of 22 months) and the second bubble between 2009M3 and 2011M9 (duration of 30 months). The lengths of the first bubble similar, but with a 2-4 month delay for the first bubble in the CEIC data. The differences in estimated duration for the second bubble are larger. This suggests that Beijing's housing bubbles are much more significant when using the CEIC data.

In the case of Shanghai, there is a substantial bubble detected by the SADF test (Figure 6 and Figure 9), and the timelines of the bubble are almost the same. In Figure 6 (Wind Info), the bubble originates in 2009M4 and collapses in 2011M1 (duration of 21 months) compared to 2009M4 and 2011M4 (duration of 24 months) in Figure 9 (CEIC data). Therefore, the CEIC data detects a longer Shanghai housing bubble than the Wind Info data although the origination date is the same for both.

Table 6 summarises the origination dates and the collapse dates of the housing bubbles for Beijing and Shanghai using housing price levels. The dates are captured from the two separate data sources. Overall, the combined housing bubbles in Beijing last longer than the single bubble in Shanghai. Beijing's housing bubble originates in early 2007 in both datasets and completely collapses in 2010M10 with Wind Info data, but in 2011M9 with CEIC data. The dating results for Shanghai show more consistency across the two data sources. Both indicate that Shanghai's bubble originates in 2009M4 and collapses in early 2011.

6. Conclusions

This paper applies a newly developed bubble detecting method to detect the presence and duration of housing bubbles for China's four major cities and Shanghai's eight regions. We initially employ the SADF test which proposed by Phillips et al. (2011) to overcome Evans' critique (1991) for periodically collapsing bubbles. The SADF test is used by us to detect housing bubbles in Shanghai regions and for the city as a whole.

The empirical results confirm that there are housing bubbles in Beijing and Shanghai using house price level data and among Shanghai regions using house price in both level data and log data. Furthermore, two distinct bubbles are detected in Beijing's housing market.

There are some minor differences in timing of bubbles depending on the specific data source used. However, we believe (based on the SADF test using CEIC data) that Beijing's first bubble originates in 2007M3 and collapses in the 2009M1, and the second bubble lasts between 2009M3 and 2011M9. There is a prolonged, single bubble in Shanghai's housing market between 2009M4 and 2011M4. Notably, the housing bubbles

of both cities collapse in between 2011M4 and 2011M9. There is no evidence to support the existence of housing bubbles in Guangzhou and Shenzhen.

The empirical results in this paper are in line with the findings of Hou (2010), Chen et al. (2013) and Hwang et al. (2012). Those studies find the existence of housing bubbles in either Beijing or Shanghai, or in both cities. Although the timelines of the bubble periods are not exactly the same between our empirical results and previous findings, some overlapping periods can be noticed. The overlapping periods are sometime during the period between 2007 and 2009.

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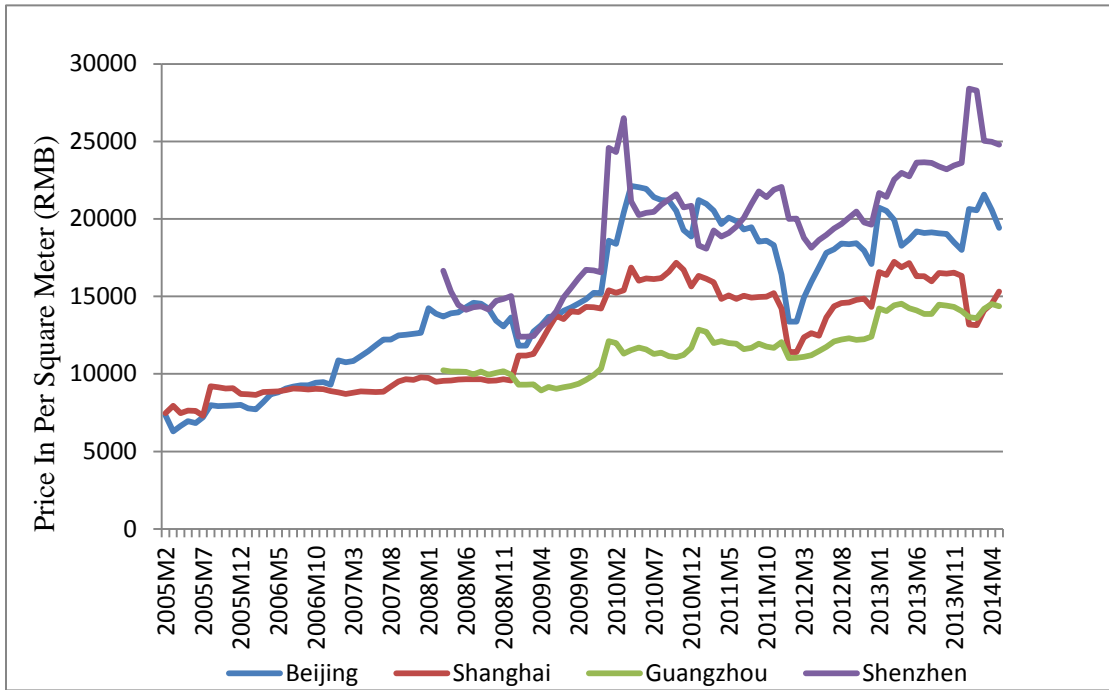
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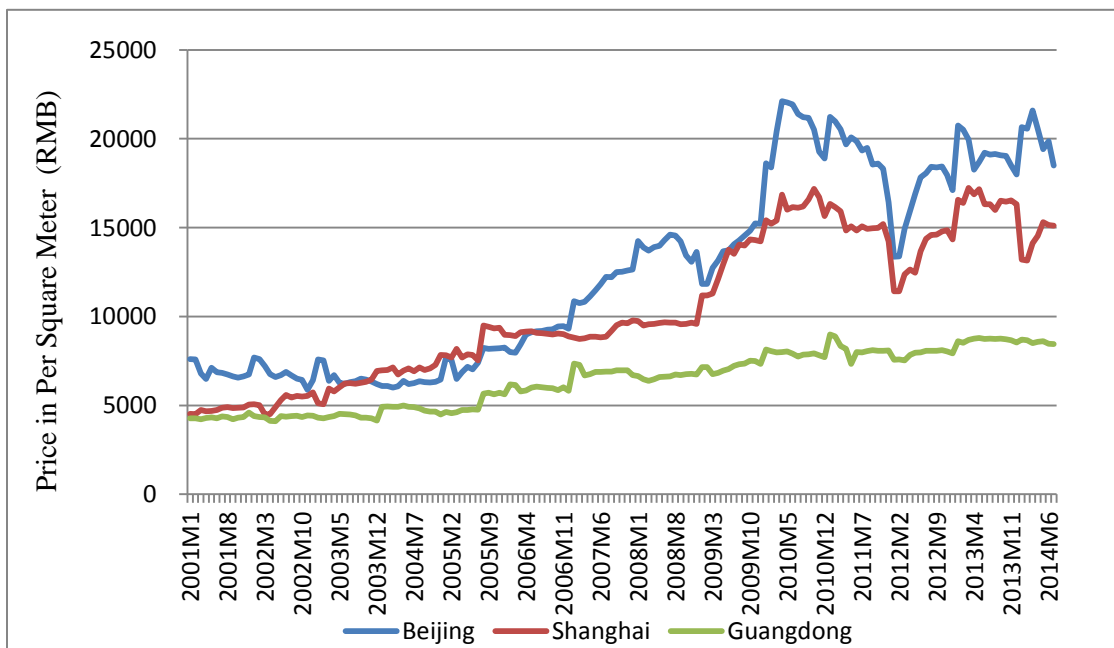
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Figure 1. Real House Prices of the First Tier Cities in China



Data Sources: Wind Info. Data

Figure 2. Real House Prices of Beijing, Shanghai and Guangdong Province



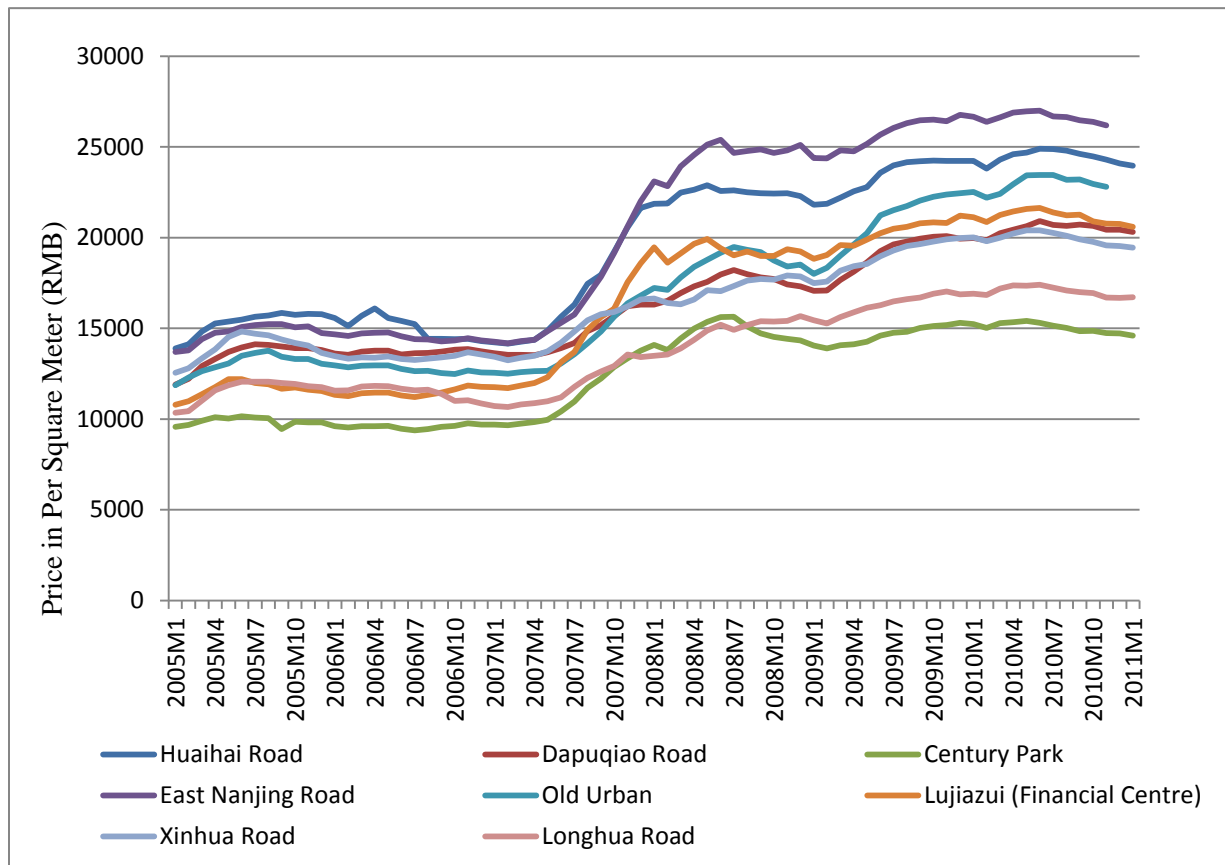
Data Sources: CEIC Data

Table 1. Selected Annual Real House Price of Cities and Guangdong Province

Year	Wind Info. Data				CEIC Data		
	Beijing	Shanghai	Shenzhen	Guangzhou	Beijing	Shanghai	Guangdong
2005	7,599	8,490	NA	NA	7,606	8,435	5,099
2008	13,964	9,615	14,798	10,097	13,964	9,616	6,629
2011	19,422	15,212	20,111	12,030	19,422	15,212	8,177
2014	20,563	14,061	26,305	14,071	20,165	14,366	8,569

Notes: Real house prices in per square meter (RMB), with 2010M1 as base month.

Figure 3. Real House Prices of Shanghai's 8 Regions



Data Sources: CEIC Data

Note: These prices are all much lower than my own observations from local property agencies and my own living experiences in Shanghai. Nowadays, the house prices in those areas could be more than double of the prices presented. However, the trends are more important in my study.

Table 2. The SADF Test on Real House Prices in Level for Shanghai's 8 Regions

	East Nanjing Road	Old Urban Area	Lujiazui (Financial Centre)	Century Park	Huaihai Road	Dapuqiao Road	Longhua Road	Xinhua Road
P-value	0.000***	0.003***	0.000***	0.000***	0.001***	0.049**	0.050*	0.196
test-statistic	7.282	3.162	6.175	4.039	3.479	1.410	1.504	0.807
Critical Values for SADF								
99% level	2.246							
95% level	1.480							
90% level	1.148							

Note:

1. $Sup_{r \in [r_0, 1]} ADF_r$ (SADF) test on real house prices in level term. SADF's null hypothesis is having a unit root against the alternative hypothesis of explosive behaviours. By Setting $r_0 = 0.1$, i.e 10% of sample as the initial sample window of the recursive right-tailed ADF tests. The critical values of SADF are obtained by Monte Carlo simulation with 2,000 replications.
2. * notates for 10% level of significance; ** notates for 5% level of significance; *** notates for 1% level of significance in hypothesis test;

Figure 4. The SADF Tests on Real House Prices in Level for Shanghai's 8 Regions

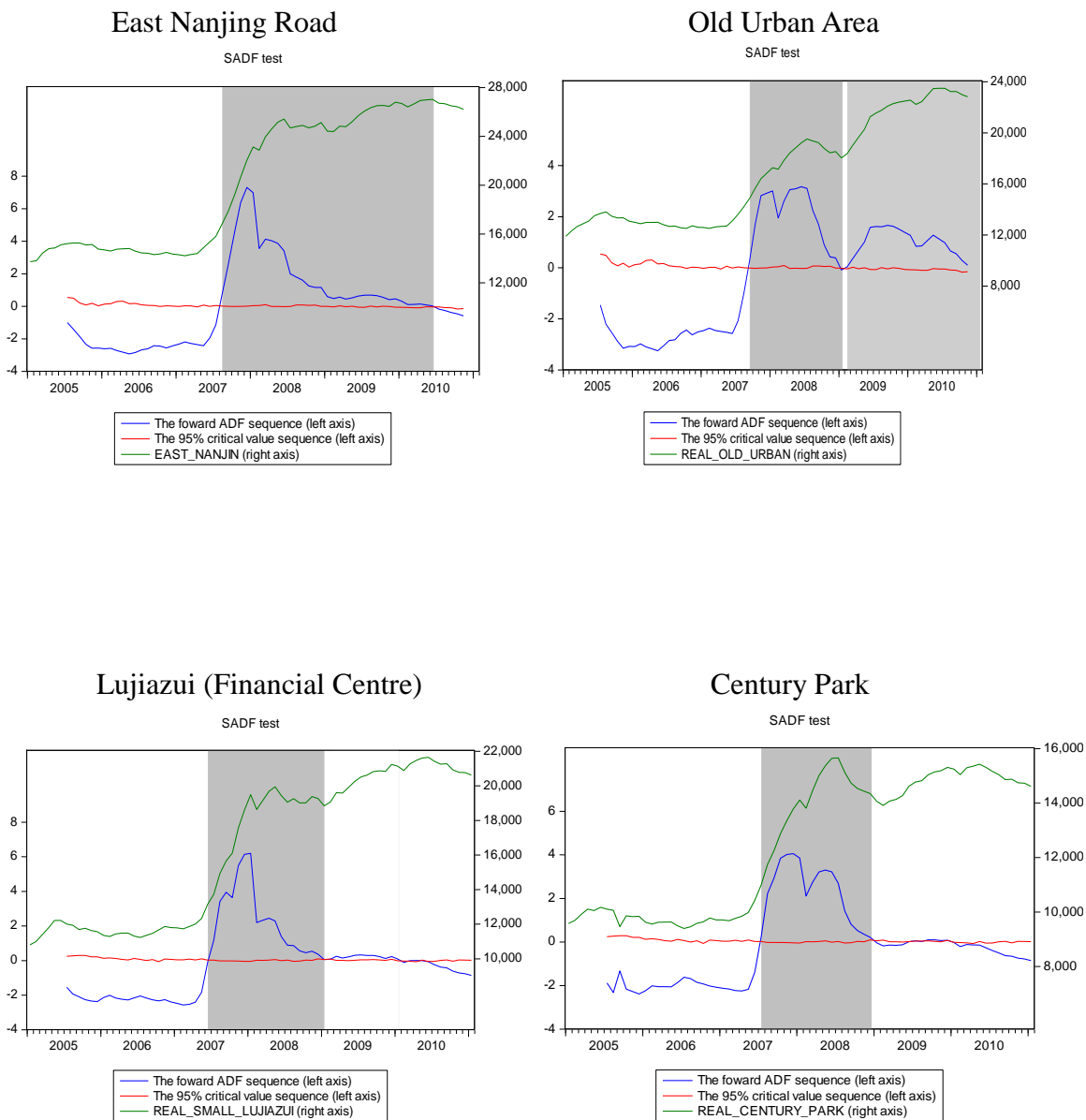
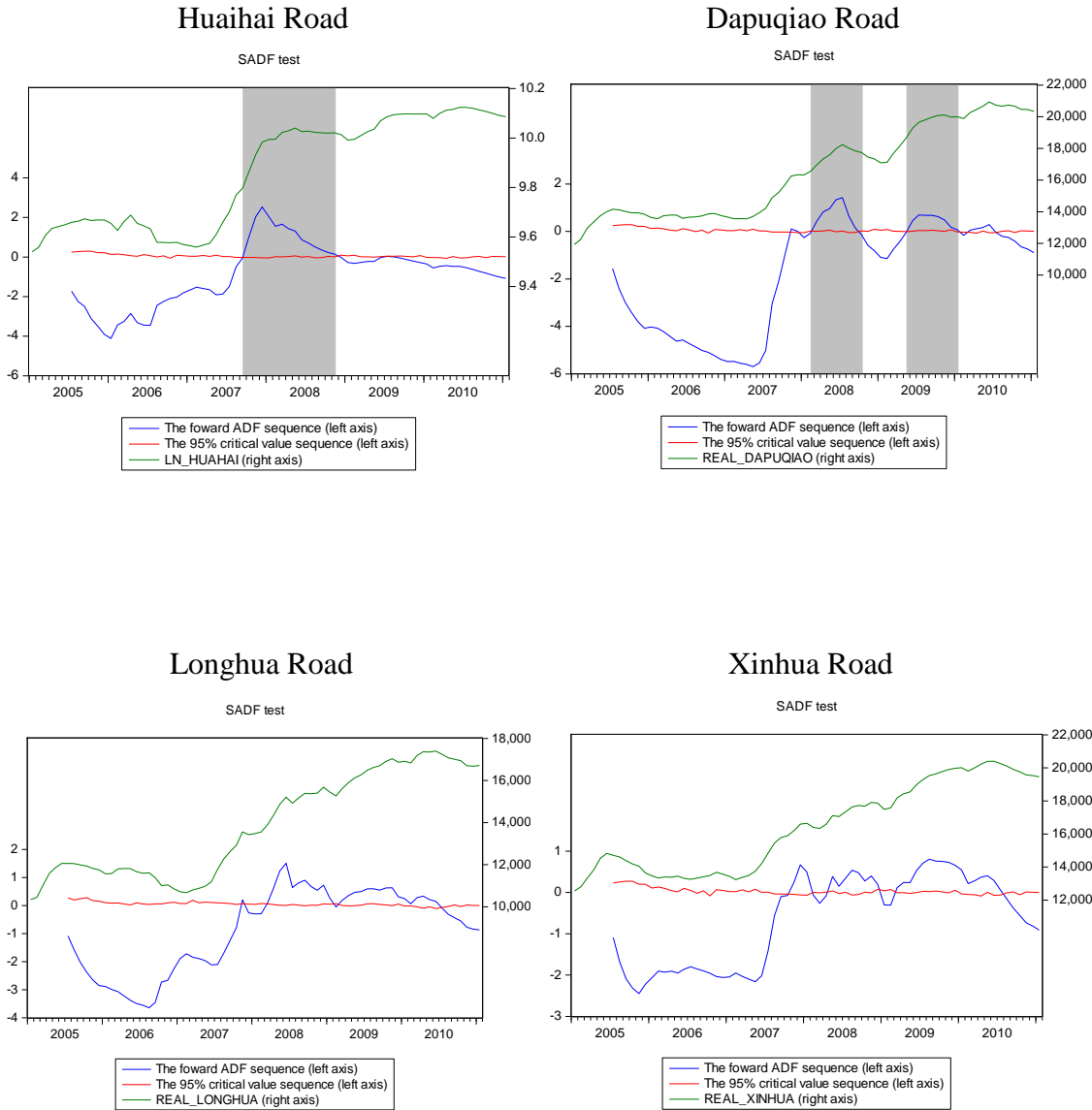


Figure 4 (Continued)



Data Sources: CEIC Data

Note: Time series of test statistic of $Sup_{r \in [r_0, 1]} ADF_r$ (SADF) tests (where the initial window size $r_0 = 0.1$) on real house prices in level are plotted. Green lines are the simple trend line of real house prices in level; Blue line are the test statistic of the SADF tests; and Red line is the critical values of SADF tests which are simulated by Monte Carlo with 2,000 replications.

Table 3. The SADF Tests on Log of Real House Price for Shanghai's 8 Regions

	East Nanjing Road	Old Urban Area	Lujiazui (Financial Centre)	Century Park	Huaihai Road	Dapuqiao Road	Longhua Road	Xinhua Road
P-value	0.000***	0.009***	0.000***	0.002***	0.005***	0.326	0.188	0.415
test-statistic	5.505	2.319	4.621	3.206	2.503	0.528	0.884	0.329
Critical Values for SADF								
99% level	2.314							
95% level	1.499							
90% level	1.176							

Data Sources: CEIC Data

Note:

1. $Sup_{r \in [r_0, 1]} ADF_r$ (SADF) test on real house prices in logarithm term. SADF's null hypothesis is having a unit root against the alternative hypothesis of explosive behaviours. By Setting $r_0 = 0.1$, i.e 10% of sample as the initial sample window of the recursive right-tailed ADF tests. The critical values of SADF are obtained by Monte Carlo simulation with 2,000 replications.
2. * notates for 10% level of significance; ** notates for 5% level of significance; *** notates for 1% level of significance in hypothesis test;

Figure 5. The SADF Tests on Log of Real House Prices for Shanghai's 8 Regions

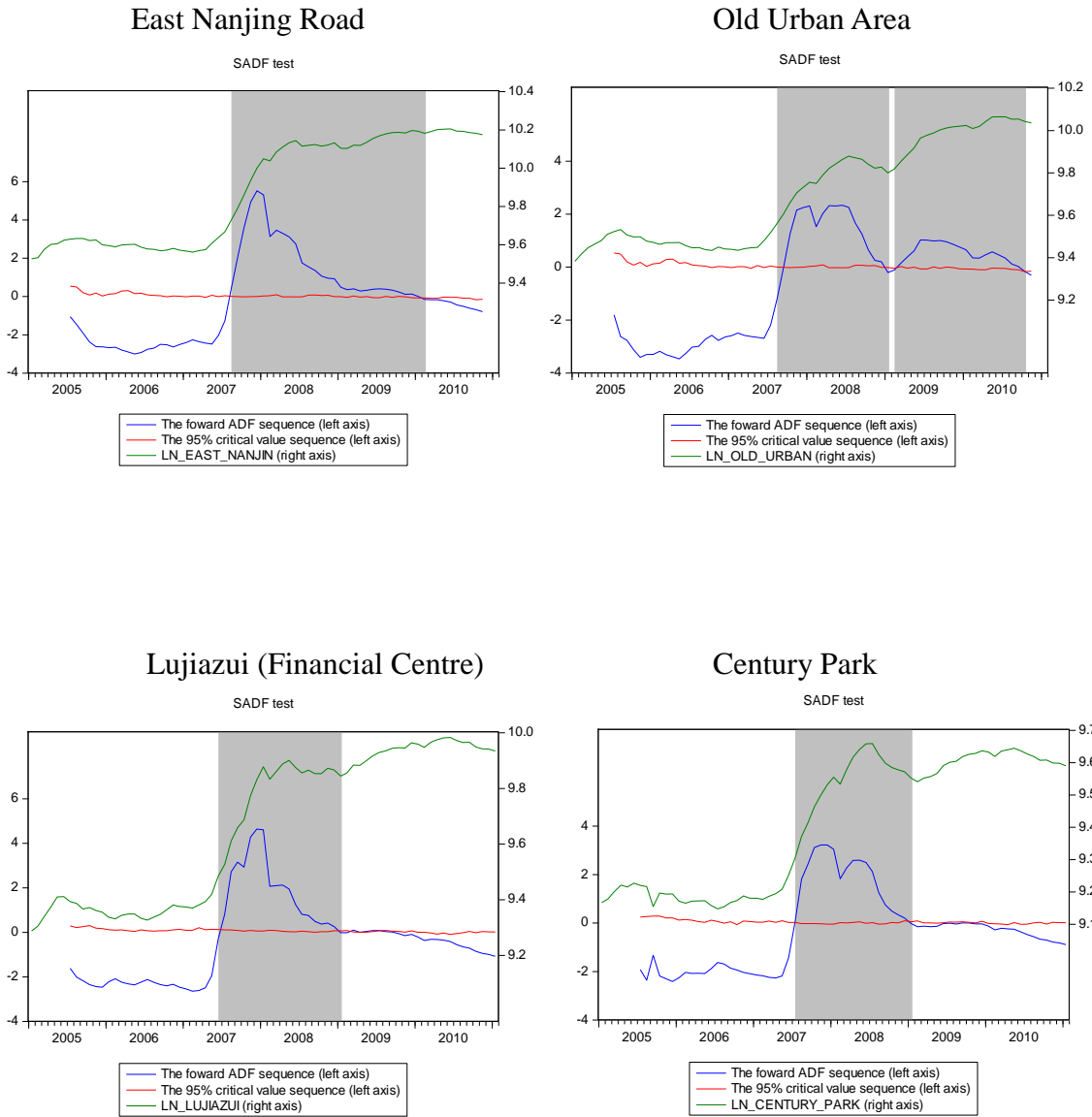
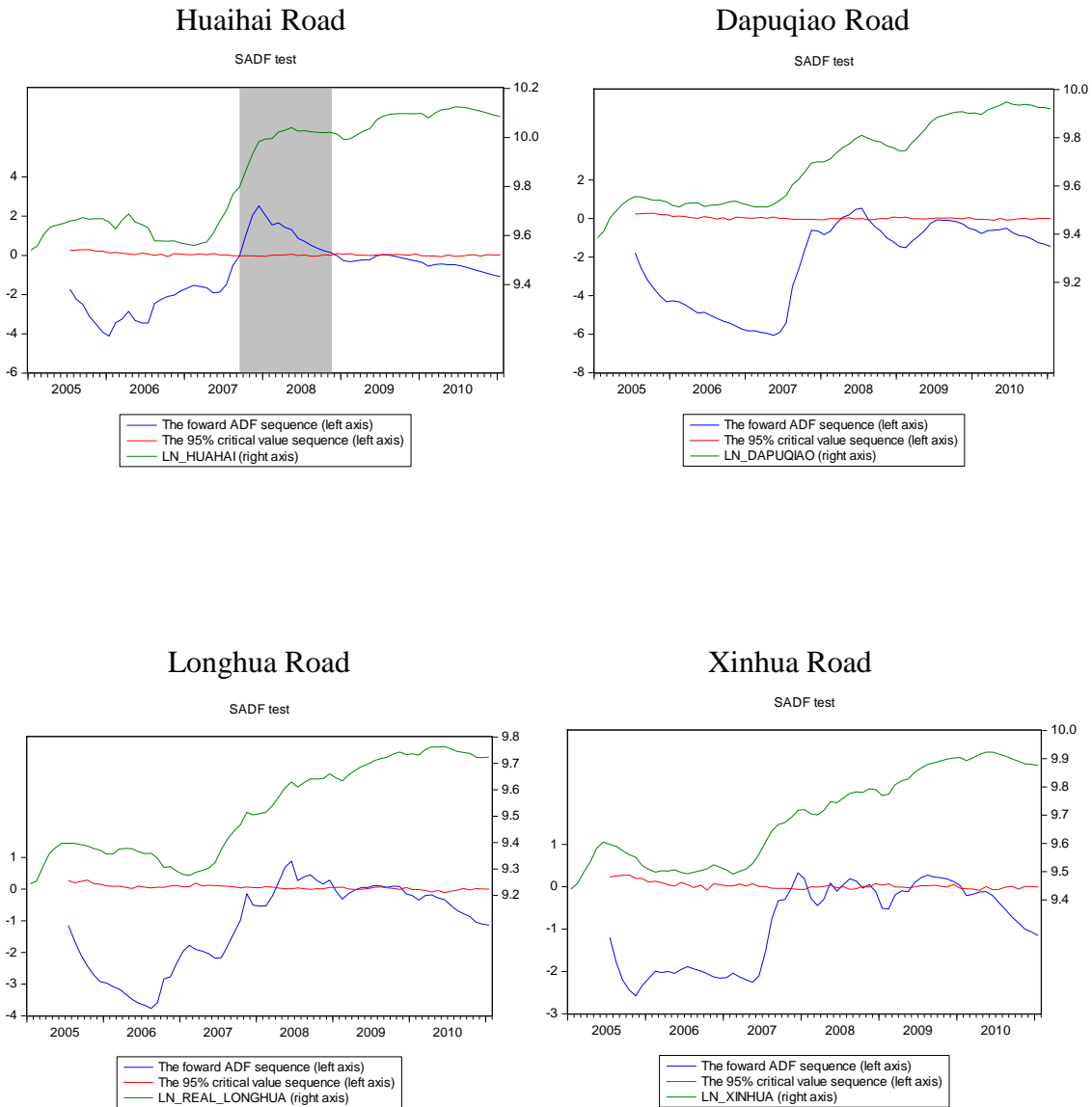


Figure 5 (Continued)



Data Sources: CEIC Data

Note: Time series of test statistic of $Sup_{r \in [r_0, 1]} ADF_r$ (SADF) tests (where the initial window size $r_0 = 0.1$) on log of real house prices are plotted. Green lines are the simple trend line of real house prices in logarithm; Blue line are the test statistic of the SADF tests; and Red line is the critical values of SADF tests which are simulated by Monte Carlo with 2,000 replications.

Table 4. The SADF Tests on Real House Prices for China's First Tier Cities

	Beijing		Shanghai		Guangzhou		Shenzhen	
	Real House Price in level	Log Real House Price	Real House Price in level	Log Real House Price	Real House Price in level	Log Real House Price	Real House Price in level	Log Real House Price
P-value	0.020**	0.348	0.020**	0.263	0.278	0.334	0.224	0.336
t-statistic	1.733	0.425	1.743	0.609	0.600	0.453	0.731	0.446
	Critical Values for Beijing & Shanghai				Critical Values for Guangzhou & Shenzhen			
99% level	1.919				99% level	2.107		
95% level	1.402				95% level	1.442		
90% level	1.103				90% level	1.125		

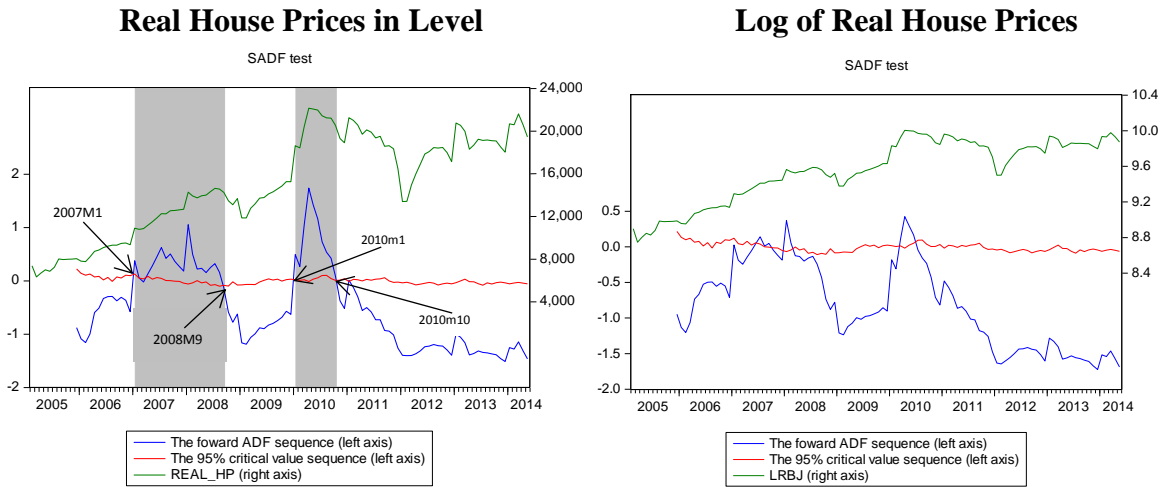
Data Sources: Wind Info. Data

Note:

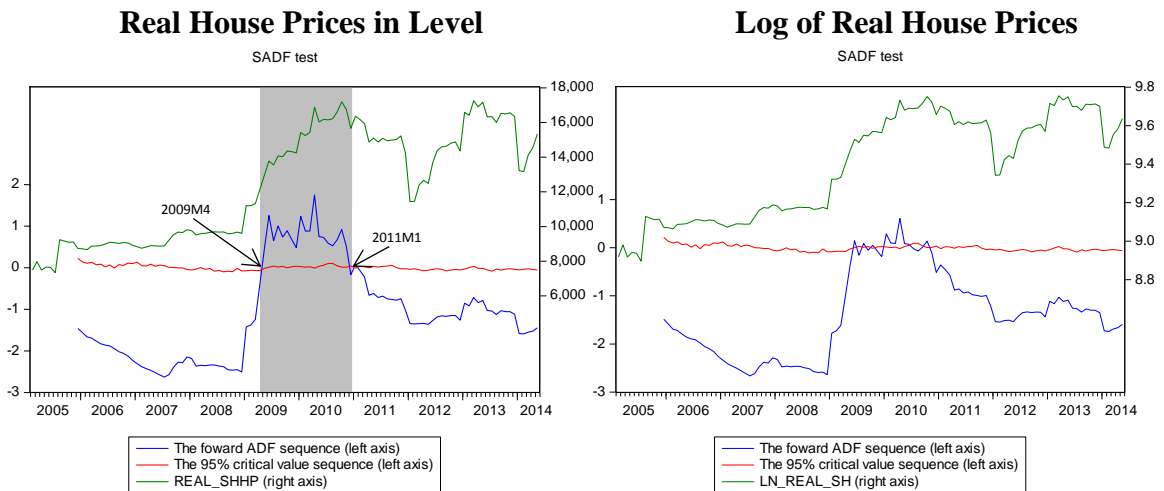
1. $Sup_{r \in [r_0, 1]} ADF_r$ (SADF) tests of the null hypothesis has a unit root against the alternative of explosive behaviours, where set $r_0 = 0.1$, i.e 10% of sample as the initial sample window of the recursive right-sided ADF tests. The critical values for $Sup_{r \in [r_0, 1]} ADF_r$ are obtained by Monte Carlo simulation with 2,000 replications.
2. The critical values are different between Beijing & Shanghai and Guangzhou & Shenzhen is because the total observations of the series are different.
3. * notates for 10% level of significance; ** notates for 5% level of significance; *** notates for 1% level of significance.

Figure 6. The SADF Tests on Real House Prices for Beijing and Shanghai

Beijing:



Shanghai:

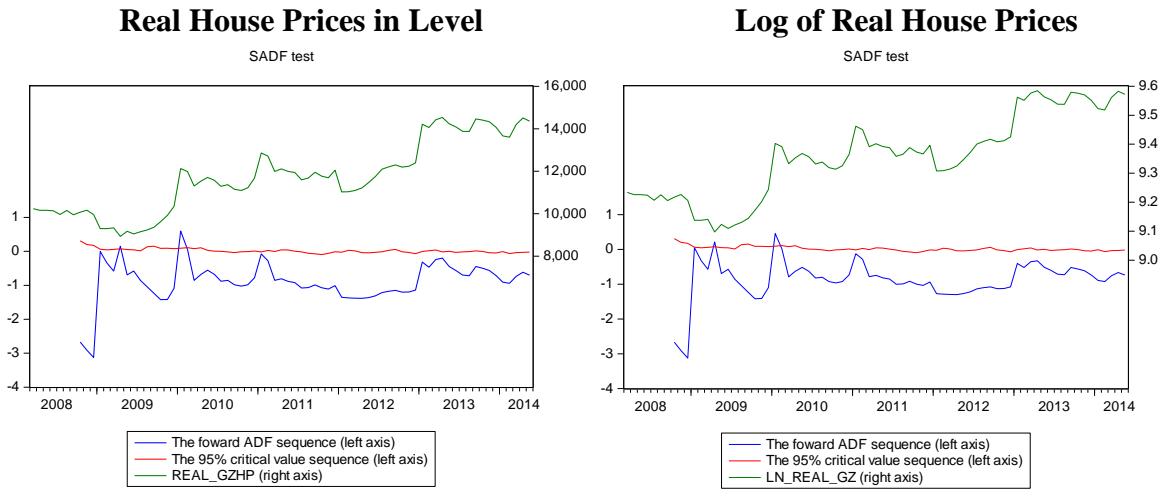


Data Sources: Wind Info. Data

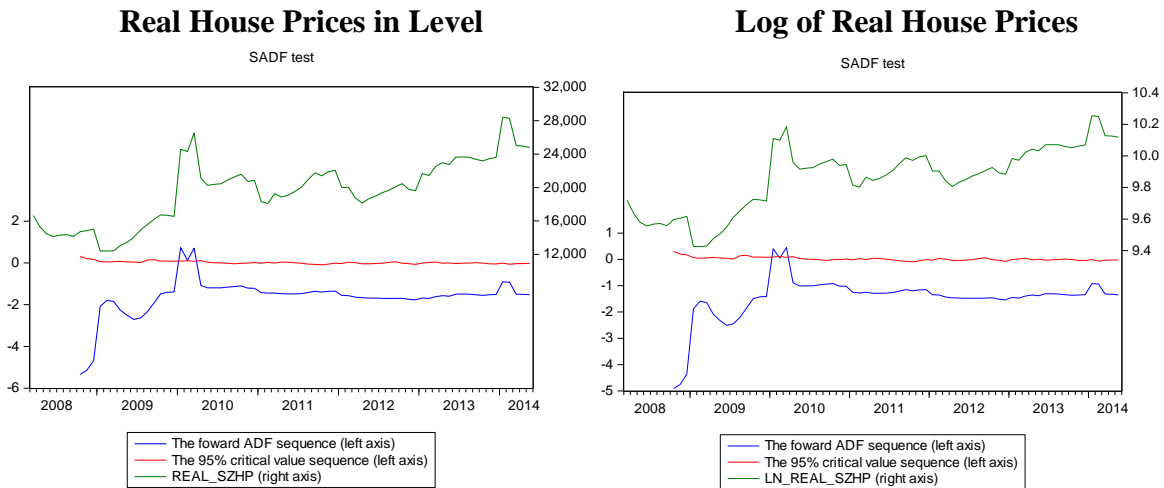
Note: Time series of test statistic of $Sup_{r \in [r_0, 1]} ADF_r$ (SADF) tests (where the initial window size $r_0 = 0.1$) on real house prices in level and in logarithm are plotted. Green lines are the simple trend line of real house prices in level; Blue line are the test statistic of the SADF tests; and Red line is the critical values of SADF tests which are simulated by Monte Carlo with 2,000 replications.

Figure 7. The SADF Tests on Real House Prices for Guangzhou and Shenzhen

Guangzhou:



Shenzhen:



Data Sources: Wind Info. Data

Note: Time series of test statistic of $Sup_{r \in [r_0, 1]} ADF_r$ (SADF) tests (where the initial window size $r_0 = 0.1$) on real house prices in level and in logarithm are plot. Green lines are the simple trend line of real house prices in level logarithm; Blue line are the test statistic of the SADF tests; and Red line is the critical values of SADF tests which are simulated by Monte Carlo with 2,000 replications.

Table 5. The SADF Tests on Real House Prices for Beijing and Shanghai

	<u>Beijing</u>		<u>Shanghai</u>	
	Real House Price in Level	Log Real House Price	Real House Price in Level	Log Real House Price
Panel A: 10% of Sample As Initial Window Size				
P-value	0.002***	0.110	0.007***	0.474
t-statistic	2.762	1.117	2.045	0.234
Panel B: 20% of Sample As Initial Window Size				
P-value	0.002***	0.079*	0.006***	0.362
t-statistic	2.762	1.117	2.045	0.234
Panel C: 30% of Sample As Initial Window Size				
P-value	0.001***	0.056*	0.005***	0.295
t-statistic	2.762	1.117	2.045	0.234
Panel D: 40% of Sample As Initial Window Size				
P-value	0.001***	0.042**	0.004***	0.236
t-statistic	2.762	1.117	2.045	0.234
Critical Values of SADF				
	Panel A	Panel B	Panel C	Panel D
99% level	1.903	1.848	1.773	1.706
95% level	1.432	1.325	1.182	1.062
90% level	1.163	1.011	0.881	0.776

Data Sources: CEIC Data

Note:

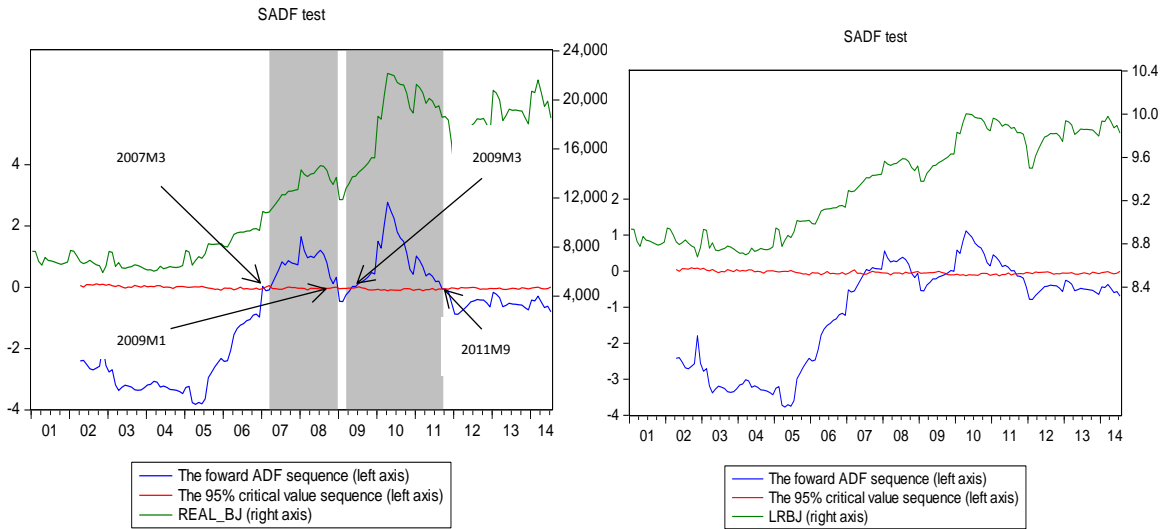
1. $Sup_{r \in [r_0, 1]} ADF_r$ (SADF) tests on both real house prices in levels and in logarithm terms. The null hypothesis is having a unit root against the alternative of explosive behaviours, where set $r_0 = 0.1$ in Panel A, i.e 10% of sample as the initial sample window of the recursive right-tailed ADF tests; $r_0 = 0.2$ for Panel B; $r_0 = 0.3$ for Panel C and $r_0 = 0.4$ for Panel D.
2. The critical values of $Sup_{r \in [r_0, 1]} ADF_r$ for Panel A to D are obtained by Monte Carlo simulation with 2,000 replications.
3. * notates for 10% level of significance; ** notates for 5% level of significance; *** notates for 1% level of significance in hypothesis test;

Figure 8. The SADF Tests on Real House Prices for Beijing

Real House Prices in Level

Log of Real House Prices

10% of Sample As Initial Window



20% of Sample As Initial Window

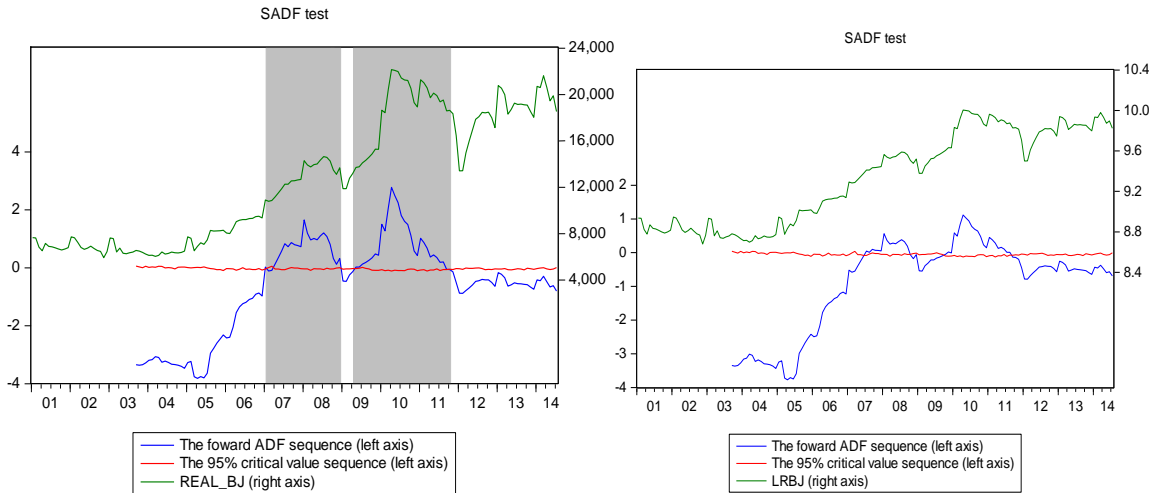
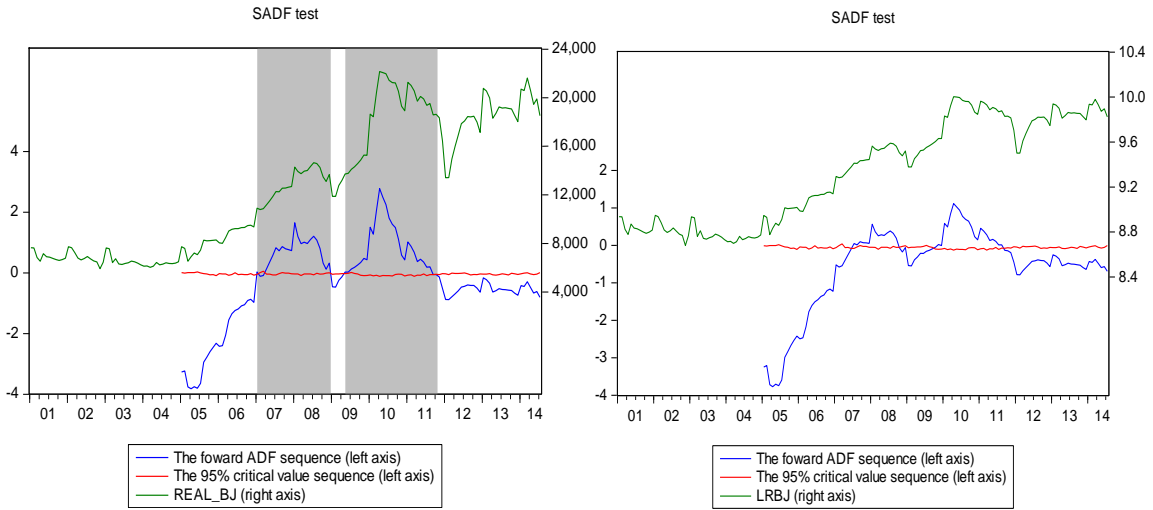
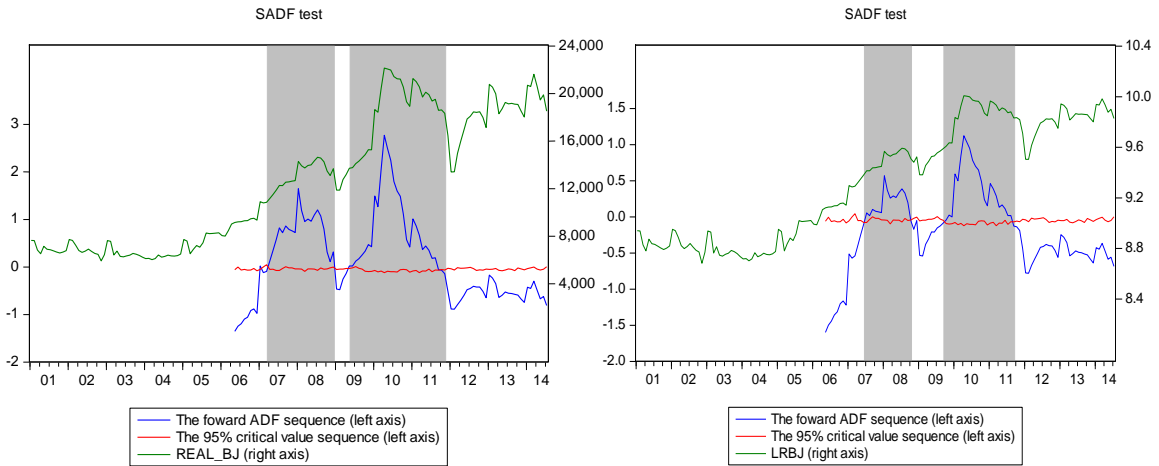


Figure 8 (Continued)

30% of Sample As Initial Window



40% of Sample As Initial Window



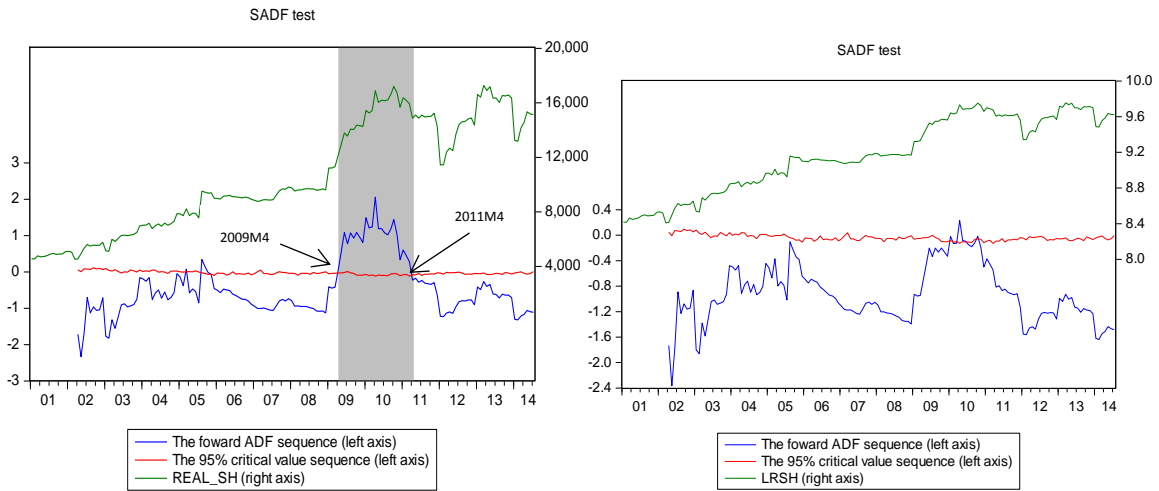
Data Sources: CEIC Data

Figure 9. The SADF Tests on Real House Prices for Shanghai

Real House Prices in Level

Log of Real House Prices

10% of Sample As Initial Window



20% of Sample As Initial Window

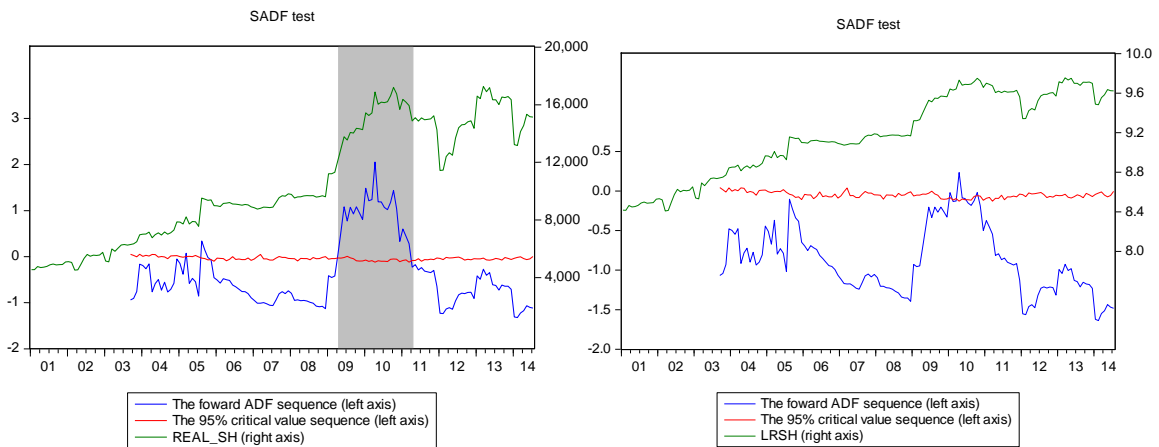
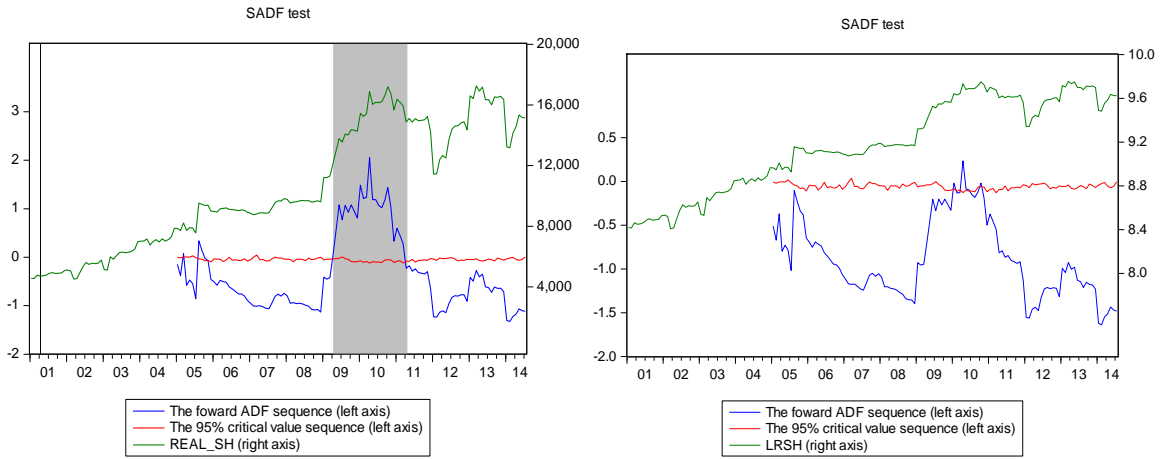
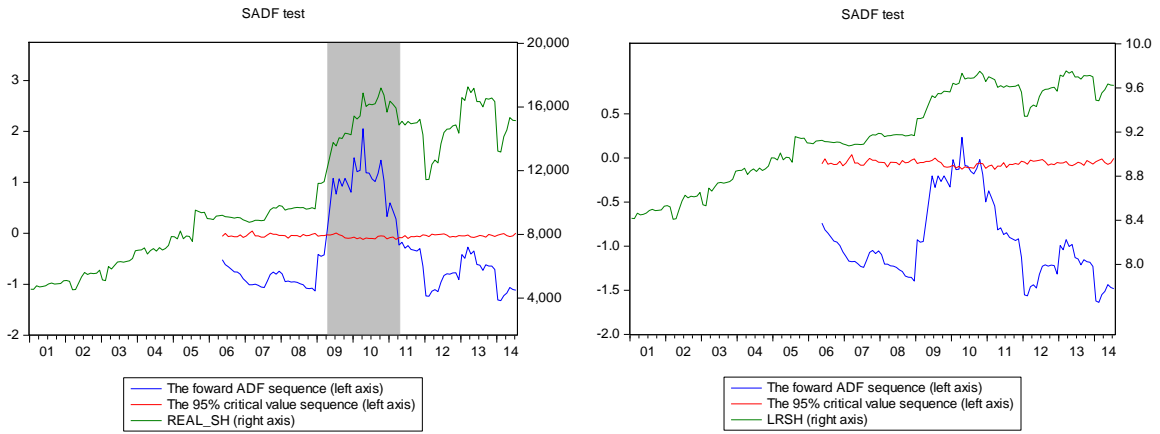


Figure 9 (Continued)

30% of Sample As Initial Window



40% of Sample As Initial Window



Data Sources: CEIC Data

Table 6. Summary of the Housing Bubbles for Beijing and Shanghai via the SADF

Test

	Wind Info Data			CEIC Data		
	Beijing 1	Beijing 2	Shanghai	Beijing 1	Beijing 2	Shanghai
Origination Date	2007M1	2010M1	2009M4	2007M3	2009M3	2009M4
Collapse Date	2008M9	2010M10	2011M1	2009M1	2011M9	2011M4
Duration (Month)	20	10	21	22	30	24

Note: The SADF tests on real house prices of Beijing and Shanghai. There are two bubbles are detected in Beijing, Beijing 1 denotes the first bubble and Beijing 2 denotes the second bubble in Beijing. All the tests are setting 10% of the whole sample as the initial window size and simulate 2,000 times to obtain the critical values.