



DO MULTIPLE HOUSING BUBBLES EXIST IN CHINA? FURTHER EVIDENCE FROM GENERALIZED SUP ADF TESTS¹

Wen-Chi LIU²

Abstract

This study examines whether the explosive behavior of housing prices or multiple housing bubbles exist in the 35 cities of China from 1998 Q1 to 2012 Q4, total of sixty quarters. The generalized sup ADF unit root test (GSADF) of Phillips, Shi, and Yu (2011a, 2013) and the ratios of housing price-to-income and housing price-to-rent are used to measure the explosive behavior of housing prices in China. The results reveal that two housing bubbles exist in 4 and 1 of 35 cities from the aspects of housing price-to-income ratios and housing price-to-rent ratios, respectively. Wholly, the problems of the explosive behavior of housing prices are almost well-controlled in China from 1998 Q1 to 2012 Q4.

Keywords: housing price-to-income ratio, housing price-to-rent ratio, multiple housing bubbles, explosive behavior of housing prices, generalized sup ADF test

JEL Classification: C1; G1

1. Introduction

The Quantitative Easing (QE) policies, involving large-scale purchases of government bonds, corporate bonds, and so forth, were undertaken by the Federal Reserve after the Financial Crisis of 2008 (QE1: March 2009 to March 2010). Accordingly, the U.S. base rate was cut towards zero and U.S. long-term bond prices rose. The Quantitative Easing policies of USA, attributable to the impact of financial globalization, resulted in large and sudden flows of capital for considerable economic benefits. Nonetheless, through lowering mortgage rates in the U.S., the Federal Reserve attempted to prevent a housing market collapse. Moreover, the European sovereign debt crisis beginning at the end of 2009 caused the international capital flows to keep away from Europe. The international hot money poured into emerging markets, including China, India, Southeast Asia, Brazil, Argentina, Japan, Taiwan, etc., along with high economic growth and good credit of government bonds, and would motivate financial market fluctuations.

¹ Supplementary materials (Appendices) are available online on journal's site (<http://www.rjef.ro>)

² Department of Finance, Da-Yeh University, Changhua, Taiwan.
Email: vincent8@mail.dyu.edu.tw

The implementation of QE3 begun by the Federal Reserve on September 15, 2012 further achieved the economic recovery and encouraged jobs growth. The implementation of the Quantitative Easing and the U.S. dollar depreciation would instigate the global energy and commodity prices to have been rising and ultimately passed to the China's CPI, especially for housing prices. QE3 has somehow extended a global environment of low interest rates and plentiful liquidity and has raised equity prices and real estate prices, while emerging markets would suffer the largest threat during the later stage of QE3. The increased interest rates and withdrawal of money would damage emerging market economies. The ratio of real estate investment in total investment in fixed assets is 20%. The total output value of real estate, cement, steel, furniture and other related industries is about 25% of GDP. Therefore, if the price of real estate declines, it would be destructive to China's economics. Thus, whether housing bubbles exist in China, measured by housing price-to-rent and housing price-to-income ratios, should be determined.

In 1998, from the perspective of the real-estate system in China, the Chinese government established private residential mechanism. By the effect of the vigorous promotion, the residential rate has accomplished 80%. After 1978, reforms and the Opening Up policy were commenced by the Chinese government. Substantial credit expansion and government fiscal stimulus packages have driven real estate investments and increased year by year, thus greatly affecting China's economic growth. Housing prices in China have increased promptly for many years, especially a large amount of monetary liquidity in 2009. After the Financial Crisis of 2008, a monetary policy lowering the benchmark lending rate and reducing lending restrictions to relieve the world economic recession was implemented by the Chinese government, though this monetary policy caused excessive money supply flows in the real-estate market. The astonishing rise in the price of housing showed that there was a housing bubble threatening China's economic stability. Since late 2009, the Chinese government had strived to restrain housing prices by a series of measures. However, the average growth rate in real-estate investments had still increased to 23.9% from 1998 to 2012, indicating that a housing bubble is destructively about to occurring. According to the global housing prices released by the International Monetary Fund (IMF) in the first half of 2016, the housing price-to-income ratios of Shenzhen (38.36), Beijing (33.32), Shanghai (30.91), and Guangzhou (25.85) are the first, fifth, sixth and tenth highest among major cities in the world, respectively. Real-estate prices which are rising could demonstrate the illusion of prosperity but can also prevent people from affording properties. However, the gap between the rich and the poor keeps widening. Banks might lose liquidity and might on the verge of collapse, once a housing bubble bursts.

The statement that a housing bubble possibly occurred has been claimed as Chang et al. (2016), Zaemah et al. (2012), Hwang et al. (2012), Clark and Coggin (2010), Xiao and Tan (2007), and Hui and Yue (2006) revealed that price bubbles did exist in the housing markets of Beijing, Shanghai. Shih et al. (2014) found that the catching regions around Beijing and Shanghai had the spillover effects. Bubbles covered most of the regions and were cointegrated together. Zhang (2013) indicated that the bubble was particularly enormous in the south-east coastal cities. Tsai et al. (2015) found that housing bubbles in China were either short-term or extremely short-term bubbles, while other researchers (e.g., Zeren and Erguzel (2015), Zhao (2015), Wang et al. (2011),

Han (2010), Mikhed and Zemčík (2009), Baker (2007), and Himmelberg et al. (2005) opposed the existence of a housing bubble. Feng and Wu (2015) suggested that the house price existed in the national level. Zhou¹ and Guo (2015) showed that the housing price bubble in Shenzhen, China, was much smaller. Given these diverse findings, whether the housing market has experienced a price bubble should be determined by robust methods.

The global attention has been fascinated by the raising and high prices in China's housing markets. When housing prices increase too rapid to reflect fundamental value, a housing price bubble happens. Case and Shiller (2003) indicated that investors would suffer huge losses generated by the collapse in asset prices if housing prices were not corresponded to the basic elements of fundamental pricing. The approach used to explore housing bubbles is the housing price-to-rent and housing price-to-income ratios. Through discounted rental incomes, on the basis of rational expectations theory, the basic value of a real-estate property price can be calculated. According to Alessandri (2006), the discounting model of rental income can be applied to identify if the housing market is in a bubble. Since 2007 Q1, the price-to-rent ratio in Beijing has increased by 30% to 70%. Calculating the fundamental value of housing prices by discounting the rental income is the method of estimating housing price. The present value of housing price is calculated as follows:

$$P_t = \frac{E(D_{t+1} + P_{t+1})}{1 + R_{t+1}} \quad (1)$$

The model could be referred to the dividend discount model. P is the housing price (similar to the stock price), D is rent (similar to the cash dividend per share), and R is the real interest rate (similar to the dividend discount rate).

The present value model of housing prices developed by Black et al. (2006) is to apply the discounted future disposable income:

$$P_t = E_t \sum_{i=1}^{\infty} \left(\frac{1}{\prod_{j=1}^i (1 + \rho_{t+j}^*)} \right) Q_{t+i} \quad (2)$$

where P_t is the housing price in t , Q_{t+i} is the family real disposable income in $t + 1$, ρ is the real discount rate, and E_t is the conditional expected value.

This study measures the degree of the housing market bubble through the housing price-to-rent and housing price-to-income ratios. The housing prices, incomes, and rents of four municipalities in China, namely, Beijing, Shanghai, Tianjin, and Chongqing, are identified. Considering multiple bubbles, the GSADF is used in this study. We hope that the empirical results of this study can be more robust than that of previous studies.

2. The Data

This empirical study employs data from 1998 Q1 to 2012 Q4 were obtained from the CEIC China economic database, covering the quarterly data of the housing price index, rental index, and per capita disposable income of 35 cities in China,

Figs. 1 and 2 plot the housing price-to-income and housing price-to-rent ratios for 35 cities in China. The housing price-to-income ratios in Fig. 1 exhibit the downward trend and seasonal effect. The Census Bureau's X-13 seasonal adjustment tools will be used to deseasonalize the time series data before applying GSADF tests with trend. The housing prices in China are basically sustained by per capita disposable income from the aspect of downward trend. The housing bubbles are probably an insignificant problem in China. From Fig. 2, the mean-reverting process of housing price-to-rent ratios exists in 35 cities. Thus, housing prices in China is still probably under control.

Figure 1

Housing price-to-income ratios for 35 cities in China from 1998 Q1 to 2012 Q4

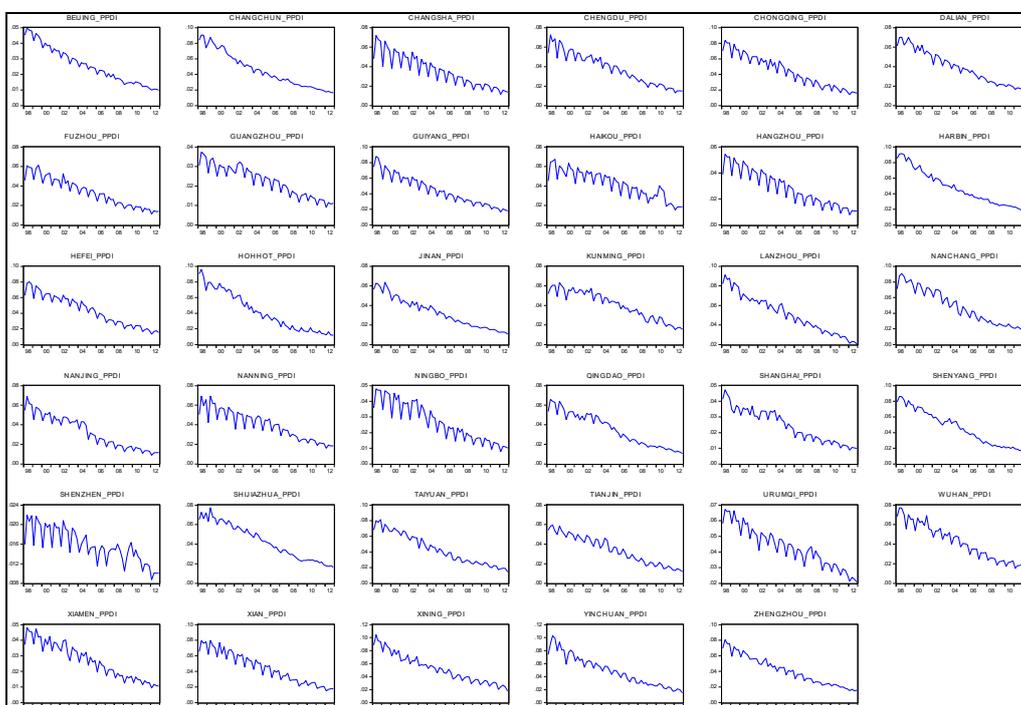
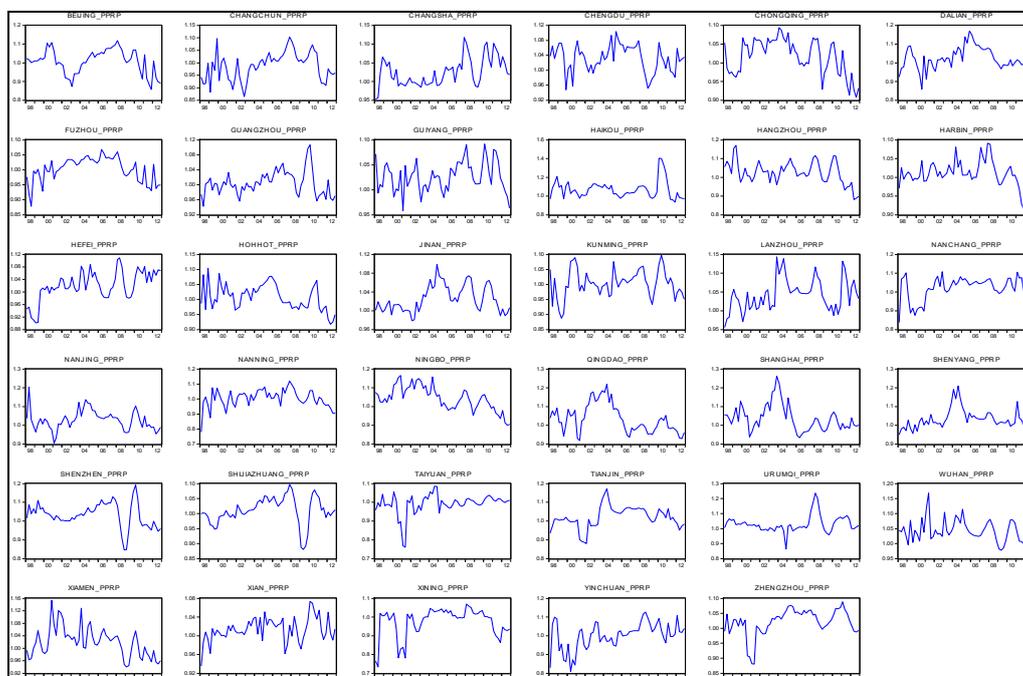


Figure 2

Housing price-to-rent ratios for 35 cities in China from 1998 Q1 to 2012 Q4



3. Methodology

A. Generalized sup ADF Unit Root Test

Econometric methods can not solve the limited sample bias, therefore, detecting a bubble in real time, for econometric researchers, has proven to be challenging. For example, conventional unit root and cointegrated tests are unlikely to detect periodically collapsing bubbles though the tests are able to detect starting and ending bursting speculative bubbles. Thus, the considerable warning signs of future stock-price bubbles on which attempts are made have been obstructed by the requirement to catch the multiple one-off points. Changes from $I(0)$ to $I(1)$ and back to $I(0)$ cannot be completely handled by conventional unit root tests. Owing to bias and kurtosis, the detection made by cointegrated techniques is difficult (Evans, 1991).

Defined as the static model and afterwards views, conventional unit root tests have limited power in identifying periodically collapsing bubbles. Phillips and Yu (2011) and Phillips et al. (2013) declare an innovative and convincing approach for the real-time identification and dating of multiple bubbles. Phillips and Yu (2011) and Phillips et al. (2013) persist that the explosive property of bubbles is not the same as random walk behavior. When bubbles emerge, not after the collapse, speculative bubbles should be spotted. Thus, a recursive econometric methodology that infers gently explosive unit roots as hints for bubbles is developed. Phillips and Yu (2011) propose a modified right-

sided recursive unit root test and the parameters can be changed in the recursive estimation. This dynamic model can detect the dynamic structure breaks of the time series and find the starting and ending point of an asset bubble. Phillips and Yu (2011) suggest the use of the supremum (sup) of recursively determined Augmented Dickey–Fuller (ADF) t-statistics would distinguish the time period when the bubble component containing the explosive property becomes dominant in the housing price process. When the ADF t-statistic is bigger than its corresponding critical value in the right-sided unit root test, the beginning of the bubble is estimated as the first date. When the ADF t-statistic is below the said critical value, the end of the speculative bubble is the first period. The SADF test depends on the repeated estimation of the ADF model on a forward extending sample sequence and the test is gotten as the sup value of the corresponding ADF statistic sequence.

Moreover, the window size r_w expands from r_0 to 1. In the recursion, r_0 is the initializing computation and 1 is the total sample size. r_1 , the beginning point of the sample sequence, is fixed at 0, the end point of each sample (r_2) is equal to r_w , and changes from r_0 to 1. $ADF_0^{r_2}$ denotes the ADF statistic for a sample from 0 to r_2 and the SADF statistic is defined as:

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

In the current study, the ADF statistic is obtained for the asymmetric interval $[r_0, 1]$. A rolling function of the SADF test employed by Phillips et al. (2011b) can have the starting window move over the sample, though the size of the starting window remains fixed, limiting the power of the test.

Phillips et al. (2013) exhibit that the moving sample GSADF examination is superior to the SADF test and rarely, even in relatively modest sample sizes, provides false alarms. Compared with the SADF test, the GSADF test covers more data subsamples and can discern potential multiple bubbles in the data. The GSADF test that Phillips et al. develop maintains the idea of repeatedly running the ADF test regression on subsamples of the data in a recursive mode. The subsamples employed in the recursion are much more extended than those of the SADF test. Phillips et al. (2013) suggest the use of the GSADF test as a dating mechanism. The GSADF examination based on the idea of the sequential right-tailed ADF tests extends the sample sequence to a flexible range and the GSADF test modifies the starting and ending points of the sample over a reasonable range of windows, replacing fixing the beginning point of the sample. In addition, varying the end point r_2 from r_0 to 1, the GSADF test allows the starting point r_1 to change within a reasonable range, i.e. from 0 to $r_1 - r_0$. The GSADF statistic is defined to be the largest ADF statistic over all reasonable ranges of r_1 and r_2 , and this statistic is denoted by GSADF (r_0): $GSADF(r_0) = \sup$

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

Details on both the SADF and GSADF tests are provided by Philips and Yu (2011) and Philips *et al.* (2011a, 2011b, 2013).

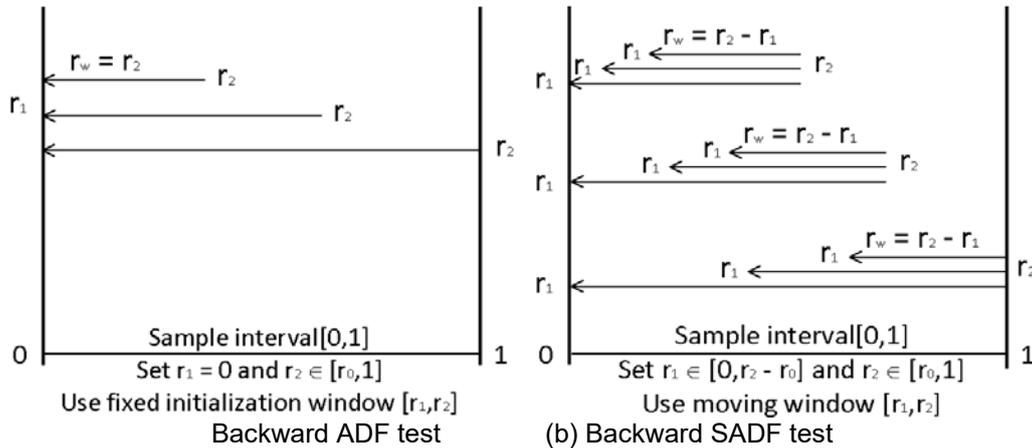
B. Date-Stamping for Bubbles

The recursive use of a right-tailed ADF test that Philips *et al.* (2011a) suggest is to use information up to this observation (i.e., $I_{[r_2]} = \{y_1, y_2, \dots, y_{[r_2]}\}$). $I_{[r_2]}$ may include one or more occurrences of bubble collapses. The ADF test, similar to the conventional cointegration-based test for bubbles, may bring about finding pseudo stationary behavior and a backward SADF test performed on $I_{[r_2]}$ is recommended to improve identification accuracy.

Following the recommendation of Philips *et al.* (2011a), we perform a backward SADF test, that is, an SADF test on a backward expanding sample sequence in what in which the ending points of the samples are fixed at r_2 and the starting point varies from 0 to r_2 . We can compose the ADF statistic for each regression with r_1 , starting point, and r_2 , ending point, to get $BADF_{r_1}^{r_2}$. The equivalent ADF statistic sequence is $\{BADF_{r_1}^{r_2}\}_{r_1 \in [0, r_2 - 0]}$. The backward SADF statistic is defined as the sup value of the ADF statistic sequence denoted by $BSADF_{r_2}(r_0)$. In the present study, we can write the $BSADF_{r_2}(r_0)$ as $Sup_{r_1 \in [0, r_2 - 0]} = \{BSADF_{r_1}^{r_2}\}$. The backward ADF test is a particular case of the backward SADF test with $r_1 = 0$. We denote the backward ADF statistic by $BADF_{r_2}$. Figure 3 illustrates the difference between the backward ADF test and backward SADF test.

Figure 3

Sample sequences of the backward ADF test and backward SADF test



We can then compare $BADF_{r_2}$ with the right-tail critical values of the standard ADF statistic to disclose the explosiveness of observation $[Tr_2]$ and the reasonable range of r_2 from r_0 to one. The date which a bubble starts $[Tr_2]$ is calculated as the first observation by time order and its backward ADF statistic is above the critical value. The calculated origination date is denoted as $[T\hat{r}_e]$. The date which a bubble terminates $[T\hat{r}_e]$ is the first observation by the order after $[T\hat{r}_e] + \log(T)$ and its backward ADF statistic falls below the critical value. Philips et al. (2011b) imposed the condition that the period of a bubble is longer than $\log(T)$:

$$\hat{r}_e = \inf_{r_2 \in [r_0, 1]} \{r_2 : BADF_{r_2} > cv_{r_2}^{\beta_T}\} \text{ and } \hat{r}_f = \inf_{r_2 \in [\hat{r}_e + \log(T)/T, 1]} \{r_2 : BADF_{r_2} < cv_{r_2}^{\beta_T}\} \quad (5)$$

The new strategy, instead of using the backward ADF statistic, implies making inferences on the explosiveness of observation $[Tr_2]$ on the basis of the backward SADF statistic $BSADF_{r_2}(r_0)$.

Then we can identify the date which a bubble starts as the first observation and its backward SADF statistic is above the critical value of the backward SADF statistic. The date which a bubble terminates is defined as the first observation after $[T\hat{r}_e] + \delta \log(T)$ and its backward SADF statistic is under the critical value of the backward SADF statistic. We assume that $\delta \log(T)$ is shorter than the period of the bubble and δ is frequency dependent. Following the suggestion of Philips et al. (2011a, 2013), we can set the following: $\delta = 0.7$ for the yearly data, $\delta = 2$ for the quarterly data, and $\delta = 5$ for the monthly data.

The (fractional) points that a bubble starts and terminates (i.e., r_e and r_f , respectively) are calculated in relation to the following first crossing time equations:

$$\hat{r}_e = \inf_{r_2 \in [r_0, 1]} \{ r_2 : BADF_{r_2}(r_0) > scv_{r_2}^{\beta_1} \} \quad (6)$$

4. Empirical Results

Phillips et al. (2013) proved that the moving sample GSADF examination is superior to the SADF test on the basis of an expanding sample size in distinguishing explosive behavior in multiple bubble occurrences. Furthermore, the moving sample GSADF examination, even in comparatively modest sample sizes, rarely provides false alarms analysis. The reason for these features is that, related to the SADF test, the GSADF test attaches more data subsamples.

The null hypothesis of GSADF whole tests is stationary (no bubble). Based on Table 1, the housing price-to-income ratios are stationary in 32 of the 35 cities in China. Simply Fuzhou, Haikou, and Ningbo can reject the null hypothesis of stationarity (no bubble). However, from Table 2, the housing price-to-rent ratios are stationary in 31 of the 35 cities in China. Four cities, Hefei, Lanzhou, Shenyang, and Zhengzhou, are non-stationary (with bubble). In general, the housing bubble is not a severe problem in China. To trace exact bubble periods, the backward SADF statistic sequence are compared with the 95% SADF critical value sequence, taken from Monte Carlo simulations with 5,000 replications. The third column of Table 1 and Figs. 4 to 9 display the outcomes for the date-stamping approach over the period for the housing price-to-income ratios of 35 cities. We find that Nanjing, Ningbo, Tianjin, and Urumqi have two bubbles, whereas there is one bubble and none bubble in 14 (40%) and 17 (49%) cities, respectively. Similarly, the third column of Table 2 and Figs. 10 to 15 display the outcomes for the date-stamping approach over the period for the housing price-to-rent ratios. The result also shows that only Shijiazhuang has two bubbles; however, one bubble and none bubble exist in 13 (37%) and 21 (60%) cities, respectively. Wholly, the problems of the explosive behavior of housing prices or multiple housing bubbles from the aspect of housing price-to-income ratios or housing price-to-rent ratios are under well control in China from 1998 Q1 to 2012 Q4.

5. Conclusions

This study investigates whether the explosive behavior of housing prices or multiple housing bubbles exists in the 35 cities of China by using the generalized sup ADF test (GSADF) unit root tests proposed by Phillips et al. (2013). Our results indicate that only Nanjing, Ningbo, Tianjin, and Urumqi have two bubbles from the aspect of housing price-to-income ratios. One bubble exists in 40% cities and none bubble exists in 49% cities, respectively. However, from the aspect of housing price-to-rent ratios, only Shijiazhuang has two bubbles. One bubble exists in 37% cities and none bubble and exists in 60% cities, respectively. To sum up, from 1998 Q1 to 2012 Q4, the explosive behavior of housing prices or multiple housing bubbles are not a severe problem in China.

References

- Alessandri, P., 2006. Bubbles and Fads in The Stock Market: Another Look at the Experience of The US. *International Journal of Finance & Economics*, 11(3), pp.195.
- Baker, D., 2007. 2007 Housing bubble update: 10 economic indicators to watch. Issue Brief, Center for Economic and Policy Research.
- Black, A. Fraser, P. and Hoesli, M., 2006. House prices, fundamentals and bubbles. *Journal of Business Finance & Accounting*, 33(9), pp.1535-1555.
- Case, K. E. and R. J. Shiller 2003. Is there a bubble in the housing market? *Brookings Papers on Economic Activity*, 2, 299-362.
- Chang, H.-L. Su, C.-W. and Jiang, X.-Z., 2016. China's housing bubble burst? *Economics of Transition*, 24(2), pp.361-390.
- Clark, S.P. and Coggin, T.D., 2010. Was there a U.S. house price bubble? An econometric analysis using National and Regional panel data. *Quarterly Review of Economics and Finance*.
- Evans, G.W., 1991. Pitfalls in testing for explosive bubbles in asset prices. *The American Economic Review*, 81, 922–930.
- Feng, Q. and Wu, G.L., 2015. Bubble or riddle? An asset-pricing approach evaluation on China's housing market. *Economic Modelling*, 46, 376-383.
- Han, X., 2010. Housing demand in Shanghai: A discrete choice approach. *China Economic Review*, 21, 355-376.
- Himmelberg, C. Mayer, C. and Sinai, T., 2005. Assessing high house prices: Bubbles, fundamentals and misperceptions. *Journal of Economic Perspective*, 19(4), pp.67-92.
- Hui, E.C.M. and Yue, S., 2006. Housing price bubbles in Hong Kong, Beijing and Shanghai: A comparative study. *Journal of Real Estate Finance and Economics*, 33(4), pp.299-327.
- Hwang, J.-T. Wang, C.-H. and Chung, C.-P., 2012. The Estimation of Housing Price Bubbles in China. *International Economics and Finance Journal*, 7(1), pp.127-154.
- Mikhed, V. and Zemčík, P., 2009. Testing for bubbles in housing markets: A panel data approach. *The Journal of Real Estate Finance and Economics*, 38(4), pp.366-386.
- Phillips, P.C.B. and Yu, J., 2011. Dating the timeline of financial bubbles during the subprime crisis. *Quantitative Economics*, 2(3), pp.455-491.
- Phillips, P. C. B., S. Shi, and J. Yu 2011a. Testing for multiple bubbles. *Singapore Management University Working Paper No. 09-2011*.
- Phillips, P. C. B., S. Shi, and J. Yu 2013. Testing for Multiple Bubbles 1: Historical Episodes of Exuberance and Collapse in the S&P 500. *Singapore Management University Working Paper No. 04-2013*.
- Phillips, P.C.B. Wu, Y. and Yu, J., 2011b. Explosive behaviour in the 1990s NASDAQ: when did exuberance escalate asset values? *International Economics Review*, 52(1), pp.
- Shih, Y.N. Li, H.C. Qin, B., 2014. Housing price bubbles and inter-provincial spillover: Evidence from China. *Habitat International*, 43, pp.142-151.

- Tsai, S.-L. Kung, H.-H. Haga, K.-Y. A., 2015. Testing for Multiple Bubbles in the 35 Large and Medium Cities of Real Estate Price in China. *Theoretical & Applied Economics*, 22(4), pp.275-290.
- Wang, S. Yang, Z. and Liu, H., 2011. Impact of urban economic openness on real estate prices: Evidence from thirty-five cities in China. *China Economic Review*, 22, 42-54.
- Xiao, Q. and Tan, G.K.R., 2007. Signal extraction with kalman filter: A study of the Hong Kong property price bubbles. *Urban Studies*, 44(4), pp.865-888.
- Zaemah, Z. Jali, N.M. Gan, C. and Ward, B., 2012. Revitalizing the issues, theories and concept of house price bubbles. 3rd International Conference On Business And Economic Rearch (3rd ICBER 2012) Proceeding.
- Zeren, F. and Erguzel, O.S., 2015. Testing for bubbles in the housing market: Further evidence from turkey. *Financial Studies*, 19(1), pp.40-52.
- Zhang, Y. 2013. Is there a Bubble in the Chinese Housing Market? *Urban Policy & Research*, 31(1), pp.27-39.
- Zhao, B. 2015. Rational Housing Bubble. *Economic Theory*, 60(1), pp.141-201.
- Zhou1, Y. and Guo, H., 2015. Is Shenzhen Housing Price Bubble that High? A Perspective of Shenzhen Hong Kong Cross- Border Integration. *International Real Estate Review*, 18(3), pp.365-382.