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# Do Bubbles exist in Chinese Share Markets?

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## A B S T R A C T

In this paper, we apply a recursive unit root test to investigate whether there are multiple bubbles in two Chinese share markets – Shanghai and Shenzhen. The method is best suited for a practical implementation with a time series and delivers a consistent date-stamping strategy for the origination and termination of multiple bubbles. Empirical results indicate that there existed six bubbles during 1990s – 2016s, when the stock price deviated from its intrinsic value based on market fundamentals. Specifically, the stock price contains the fundamentals and bubble components. The dates of the bubbles corresponded to specific events in the politics and financial markets. These findings have important economic and policy implications to recognize the cause of bubbles and take corresponding measures to reduce the impact on the real economy cause of the fluctuation of stock price.

*Keywords:* Stock Price Bubbles; Generalized sup ADF; Speculation; Anticipation
*JEL classification:* G10 G12 Q40

## 1. Introduction

This paper examines whether multiple bubbles exist in two Chinese share markets – Shanghai and ShenZhen using the generalized sup Augmented Dickey-Fuller (GSADF) method proposed by Phillips *et al.* (2013). This paper makes a contribution to the existing literature by employing two methods of sup ADF and generalized sup ADF (GSADF) (Phillips *et al*. 2011, 2012, 2013) to locate possible presence multiple bubbles in two Chinese Share markets – Shanghai and ShenZhen.

Detecting asset bubbles has been extensively studied by worldwide scholars. Shiller (1981) firstly initiated a variance bounds test to detect rational bubbles though some reasonable factors cannot be revealed by this method. Then West (1987) proposed a two-step detection method, which, however, pays too much attention on detailed specification of an equilibrium asset price model. Then some improvements continue to spring up. Campbell and Shiller (1987) filled in the gap by employing a unit root test, at first, to demonstrate the presence of a bubble, and then a co-integration test when the series of asset price and fundamental value are both instable. Then the combination of the left-tailed unit root and co-integration tests is widely used in field of detecting asset bubbles. However Evans (1991) noted some drawbacks about using the unit root and co-integration tests when there are collapsing bubbles, which may reduce the efficiency of the tests existing in the series. After then, Phillips and Yu (2009) point out that the DF statistics diverge to negative infinity which may result to lower test efficiency of the method proposed by Campbell and Shiller (1987). Afterwards, Phillips et al. (2011) improve the detection method by using forward recursive right-tailed DF test. Along with the advancement of theoretical studies, large amount of empirical studies are also shining in the field of detecting asset bubbles. Arora et al. (2011) empirically test the explosive behavior in the headline price index of personal consumption expenditures (PCE) in comparison with core PCE (without considering less food and energy prices). The empirical results indicate headline price index should be taken into account when authorities implement monetary policy. Homm and Breitung (2012) make use of a Chow-type break test to investigate the rational bubbles with considering other detecting methods including Sup BT test proposed by Busetti and Taylor (2004) and also the test initiated by Phillips et al. (2011). The comparative results indicate the test of Phillips et al. (2011) performs more efficient and find explosive behavior in US, UK and Spanish housing price. Bettendorf and Chen (2013) investigate the rational bubbles in the foreign exchange markets and, for a further step, find non-traded goods play negligible role in the move trend of exchange rates. Chen and Funke (2013) detect the bubbles in housing market over the period from 1987Q3-2012Q4 and do not discover the deviation between asset price and underlying economic fundamentals.

After combing the existing literatures, we could come out that the test proposed by Phillips et al. (2011) has stronger efficiency in testing asset bubbles. So we utilize the GSADF test to investigate the existence of multiple bubbles in the two Chinese Share markets – Shanghai and ShenZhen in the period of 1990s to 2016. The data sets not only contain a series of geopolitical and speculative events, but they also describe the crisis, therefore we can explore the relationship between the bubbles and crisis. It is often marked by frequent and erratic structural changes, which are usually driven by various policy events and global importance. Results show that there are 3 bubbles in the sample period for both two Chinese share markets. Our results are consistent with the expectation that speculation plays an important role in the bubbles evolving process. The collapse in share prices contributes to the burst of bubbles and causes the most severe crisis and recession.

The remainder of this paper is organized as follows. Section 2 briefly analyzes theoretic modeling that allows stock price exuberance. We introduce the methodology that allows us to test for possible bubbles. In section 3, we describe the data and empirical results. Section 4 presents our conclusions.

## 2. Theoretical Model and Methodology

The literature on the identification of the rational bubble from market fundamentals stems from the Lucas (1978) asset pricing model. Then lots of econometric methods are applied to test the explosive bubble. A best-known model of testing the intrinsic bubble begin with the following equation (Gurkaynak, 2008)

$$SP_t = (1+r_f)^{-1} E_t(\delta_{t+1} + U_{t+1}) \tag{1}$$

where $SP_t$ is the share price in the period $t$, $r_f$ is the free-risk rate, $E_t$ is the expectation, $\delta_{t+1}$ represents the dividend returns in the period of $t+1$ and $U_{t+1}$ is the invisible component in market.

$$SP_t^f = \sum_{i=0}^{\infty} (\frac{1}{1+r_f})^i E_t(\delta_{t+i} + U_{t+i}) \quad \text{for } i = 0,1,2,... \tag{2}$$

where $SP_t^f$ is the fundamental price of share price, $\delta_{t+i}$ is the dividend of share price in the period $t+i$. It describes the determinants in the fundamental price without bubble.

$$B_t = (1+r_f)^{-1} E_t(B_{t+1}) \tag{3}$$

which is any sequence of random variables that satisfies the homogeneous expectational equation:

$$P_t = P_t^f + B_t \tag{4}$$

and Equation (4) denotes the general solution to Equation (1) as a sum of a market fundamentals component and a bubble component.

$B_t = 0$, denotes there is no bubble. Therefore the spot crude oil price is the fundamental price determined by supply-and-demand. If we find $B_t \neq 0$ , it is concluded that the bubble will not end until explores because of the expectation.

Based on the explosive property of bubbles, Diba and Grossman (1988) recommend the strategy of using a stationarity test for the logarithmic asset price and observable market fundamentals. The conventional stationarity test is based on the standard ADF test or Phillips-Perron test (Phillips and Perron, 1998), which has an explosive alternative hypothesis. Considering the model

$$\Delta sp_t = \alpha + \beta sp_{t-1} + \sum_{i=1}^{k} \psi_i \Delta sp_{t-i} + \mu_t \tag{5}$$

where $sp_{t-1}$ is the logarithmic asset price $\mu_t \sim N(0,\sigma^2)$, and $k$ is the number of the lags which is determined by significance tests in our empirical application. The null hypothesis of $\beta = 1$, which implies that $sp_{t-1}$ is a unit root process (and $\Delta sp_t$ is stationary). The alternative hypothesis of $\beta > 1$ which means that $sp_{t-1}$ is an explosive process. However, Phillips and Yu (2011) argue that their tests have discriminatory power because they are sensitive to the changes that occur when a process undergoes changes from a unit root to a mildly explosive root or vice versus. This sensitivity is much greater than in left-tailed unit root tests against stationary alternatives. In addition, this is not all as we know that bubbles usually collapse periodically. Therefore, conventional unit root tests have limited power in detecting periodically collapsing bubbles (Evans, 1991). In order to overcome this shortcoming Phillips and Yu (2011) suggest using the supreme of recursively determined ADF *T*-statistics.

The SADF test estimates the ADF model repeatedly on a forward expanding sample sequence and tests the hypothesis based on the sup value of the corresponding ADF statistic sequence. The window size $r_w$ ranges from $r_0$ to 1, where $r_0$ is the smallest sample window, on the other hand 1 is the largest sample window, which is the total sample size. The starting point $r_1$ of the sample sequence is fixed at 0, thereby the ending point of each sample $r_2$ is equal to $r_i$, changing from $r_0$ to $r_1$. The ADF statistic for a sample that runs from 0 to $r_2$ is denoted by $ADF_0^{r_2}$. The SADF statistic is defined as:

$$SADF(r_0) = \sup_{r_2 \in [r_0,1]} \{ADF_{r_2}\} . \tag{6}$$

SADF is particularly effective when there is a single bubble episode in the sample. However, there could be multiple asset price bubbles when the sample period is long. Phillips *et al.* (2012, 2013) demonstrate that when the sample period includes multiple bubble episodes of origin and collapse, the SADF test may suffer from existence of bubbles. This weakness is particularly evident in long time series or rapidly changing markets for which more than one episode of exuberance is suspected. To overcome this weakness and deal with multiple breaks of exuberance and collapse, the generalized sup ADF (GSADF) test uses flexible window widths in the implementation (Phillips *et al.*, 2012, 2013). Instead of fixing the starting point of the recursion on the first observation, the GSADF test extends the sample coverage by changing the starting and the ending point of the recursion over a feasible range of flexible windows. Since the GSADF test covers more sub-samples of the data and has greater window flexibility, it is more efficient than the SADF test in detecting explosive behavior when multiple bubbles occur in the data.

The GSADF test continues repeatedly running a series sample sequence based on the ADF test. However, comparing to the SADF test, this sample sequence is broader. In addition to varying the end point of the regression $r_2$ from $r_0$ to 1, the GSADF test allows the starting points $r_1$ to change within a feasible range, which is from 0 to $r_2 - r_0$. Because the GSADF test covers more sub-samples and it has greater window flexibility, the accuracy in detecting explosive behavior in multiple episodes has improved. The superior performance of the GSADF test is demonstrated in simulations comparing the two tests in terms of their size and power in boom detection. Phillips *et al.* (2012, 2013) define the GSADF statistic to be the largest ADF statistic over the feasible ranges of $r_1$ and $r_2$, and they denote this statistic by GSADF( $r_0$ ). That is,

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

When the regression model includes an intercept and the null hypothesis is a random walk, the limit distribution of the GSADF test statistic is:

$$\sup_{r_2 \in [r_0, 1], r_1 \in [0, r_2 - r_0]} \{ \frac{(1/2) r_w [w(r_2)^2 - w(r_1)^2 - r_w] - \int_{r_1}^{r_2} w(r) dr [w(r_2) - w(r_1)]}{r_w^{1/2} \{ r_w \int_{r_1}^{r_2} w(r)^2 dr - [\int_{r_1}^{r_2} w(r) dr]^2 \}^{1/2}} \} \tag{8}$$

where $r_w = r_2 - r_1$ is a standard Wiener process. Phillips *et al*. (2012, 2013) infer that the GSADF test nests the SADF test. If that the true process is a random walk then both the SADF and GSADF statistics converge to the standard normal distribution. Phillips *et al.* (2012, 2013) apply to simulation to obtain the asymptotic critical values of the ADF statistic distributions under the null hypothesis that the true process is a random walk. The first step is to simulate the standard Wiener process. Because the Wiener process is continuous and stochastic, only a path sampled with a finite number of points can be generated. Suppose that $n_1 \ n_2 \ ... \ n_N$ are equally spaced within a finite interval. At each point, a Gaussian random variable with mean zero and variance 1/N is generated. The right-tail critical values of the GSADF test are larger than those of the SADF test. We obtain the asymptotic critical values by numerical simulations, and resort a bootstrap methodology to compute the finite sample distributions of the recently proposed tests. Pavlidis *et al.* (2012) suggest that the method does not require the specification of the process followed by the fundamentals. Also, the method is not affected by a possible explosive root of the determinants of the asset price, and it provides a date-stamping strategy.

## 3. Data and Empirical Results

**T**o test whether bubbles that exist in two Chinese Share markets –Shanghai and ShenZhen and we use weekly Composite share price index from both Shanghai and ShenZhen Stock Exchanges. Both share price indexes are obtained from Wind Database, and both share price indexes end at November 4 2016. Due to data availability, share price index starts at January 3, 1990 for Shanghai share market and January 3 1992 for ShenZhen share market. A total of sample 1312 weeks for Shanghai and 1256 weeks for ShenZhen. We use weekly data instead of daily data due to too much noise in daily data sets and monthly data might lose some information during the estimation process. In this sample period, we can explore the relationship between the bubbles and crisis because the data set contains geopolitical, speculative events and crisis. The sampling period includes the Asian financial crisis (1997) and sub-prime crisis (2008), which may lead to furious price fluctuation and bubbles. Each of these exponential growth periods ends with a sudden crash in prices (Balcilar, 2014). All these features point towards possible existence of bubbles. Table 1 reports summary statistics of share price returns from both share markets. Based on Table 1 that we find Shanghai stock exchange has higher mean weekly return of 2.55% than that of ShenZhen stock exchange of 2.33%. Shanghai also has higher volatility than that of Shenzhen in terms of standard deviation measures.

We first apply the SADF test to locate the bubble periods in two Chinese Share markets. These values were obtained by 10000 replications. Several conclusions could be drawn from the results presented in Table 2. Based on the tests, we conclude that there is evidence of bubbles in the price of both two Share markets. The SADF statistics for both the share markets are 5.245 and 5.5011. We reject the null hypothesis of $H_0 : r = 1$ at the 1% significance critical values (i.e. 5.245>1.9082, 5.5011>2.2686). The results provide evidence that the price of both stock exchanges has explosive sub-periods. Therefore, we conclude that there is significant evidence of exuberance in the price of two share markets based on SADF tests, and it allows us to highlight the possible presence of bubbles. We then go the GSADF statistics and we find for the full data series the GSADF statistic are 7.7927 (> 2.7231) and 9.3381 (> 3.1447) for both two share markets indicating that there exist multiple bubbles in two Chinese Share markets.

**Table 1. Summary Statistics of Share Price Returns**

| | Shanghai | ShenZhen |
|---|---|---|
| Mean | 0.00255 | 0.00233 |
| Median | 0.00189 | 0.00274 |
| Maximum | 0.9008 | 0.51900 |
| Minimum | -0.22629 | -0.33567 |
| Std. Dev. | 0.05592 | 0.04983 |
| Skewness | 5.36927 | 0.79709 |
| Kurtosis | 78.6795 | 16.4097 |
| Jarque-Bera | 319158.4 | 9536.05 |
| Probability | 0.00000 | 0.00000 |
| Observations | 1312 | 1256 |

**Table 2: The SADF and GSADF tests results for Shanghai Composite Stock Price**

| Stock price | SADF | GSADF |
|---|---|---|
| | 5.245*** | 7.7927*** |
| Critical value | | |
| 90% | 1.2461 | 2.0258 |
| 95% | 1.3731 | 2.1755 |
| 99% | 1.9082 | 2.7231 |

Note: * * * indicates significance at the 1% level. These tests are used by Eview 9.0 software.

**Table 3: The SADF and GSADF tests results for Shenzhen Stock Price**

| Stock price | SADF | GSADF |
|---|---|---|
| | 5.5011*** | 9.3381*** |
| Critical value | | |
| 90% | 1.4244 | 2.0353 |
| 95% | 1.6316 | 2.2261 |
| 99% | 2.2686 | 3.1447 |

Note: * * * indicates significance at the 1% level. These tests are used by Eview 9.0 software.

Using the GSADF tests results, we graph the estimate of the two share prices, with 95% critical value, in Fig.1 and 2. The upper curve represents the price of share price. The middle curve is the 95% critical value. The bottom curve represents the GSADF statistic. Focusing on the origin and collapse of bubbles, we find that there are 3 bubbles during the analyzed period. Phillips *et al.* (2013) demonstrate that the moving sample GSADF diagnostic outperforms the

SADF test based on an expanding sample size in detecting explosive behaviour in multiple bubble episodes and seldom gives false alarms, even in relatively modest sample sizes. The reason is that the GSADF test covers more subsamples of the data. Based on this argument, we can conclude that there is evidence of multiple bubbles in two Chinese Share markets.

The first bubble originated in December 1996 and quickly burst at April 1997. The impact of extreme events on share markets is of great importance in share price analysis (Zhang et al, 2009). The occurrence of the Asian financial crisis in 1997 incurs the first crisis in Chinese Share markets, leading to a huge decrease in share prices for both Chinese Share markets. As we can see in Figures 1 and 2, the period of first price bubble last for 4 months. According to Zhang *et al*. (2009), small fluctuation will not have a long-term effect on share prices. The next two bubbles are found between 2007-2008 and 2014-2015. Chinese Share prices both reached their lowest levels during 2007-2008 after the outbreak of the Global financial crisis and then rebound slowly. In October 2007, we find the second bubble, which collapsed in the September 2008. This bubble last longer than ever, nearly one year. The subprime crisis erupts followed by the burst of bubble. When the sup-prime crisis erupts comprehensively, investors have a negative expectation for the future economy, staple commodities including share price fall sharply. Thereby bubble bursts up with the slump in capital markets and the world economy accordingly.

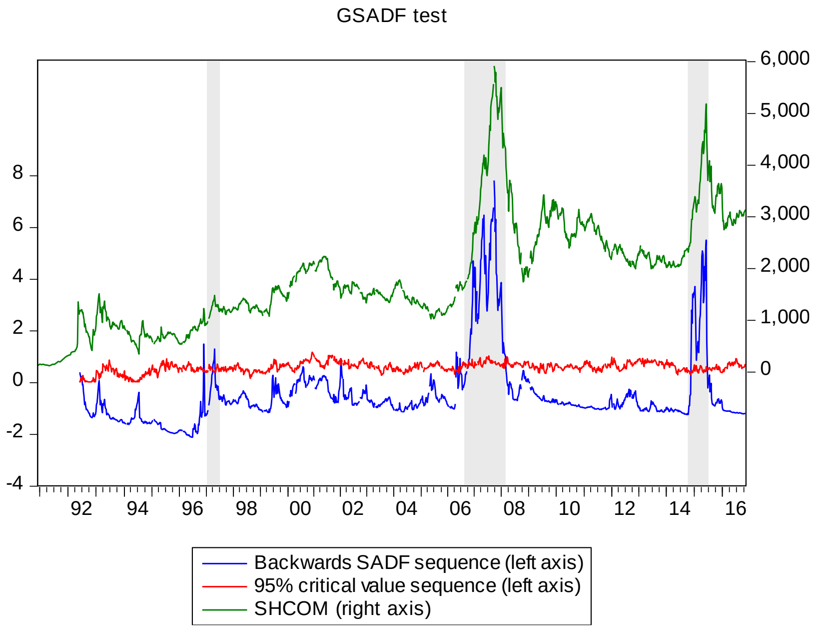

**Figure.1. GSADF test of the Shanghai Composite Stock Price. Note: the shadow are sub-periods with bubbles.**

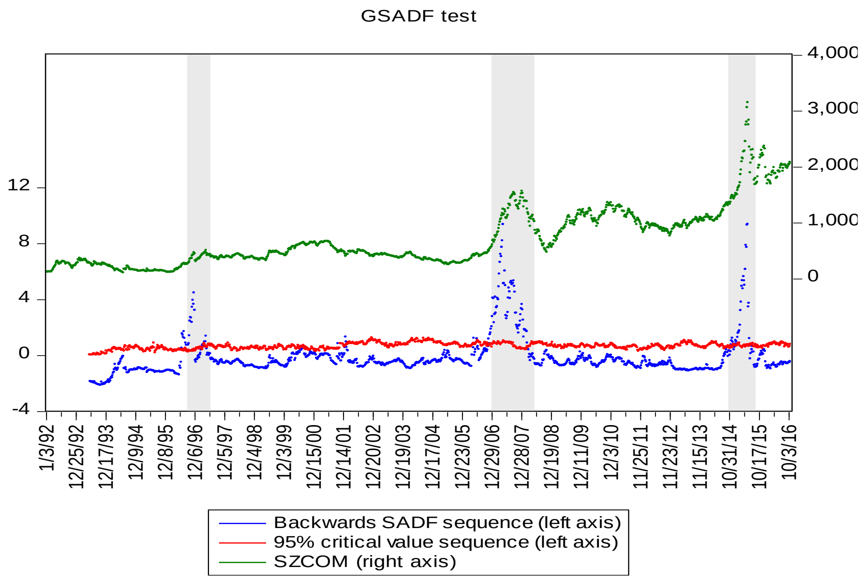

**Figure.2. GSADF test of the Shenzhen Stock Price. Note: the shadow are sub-periods with bubbles.**

Finally, the last bubble occurs in the 2014-2015 period, where started from November 2014 and burst in June 2015. The continuous increasing trend lasts only about 8 months. After the forceful increment, the soaring price quickly slumped and touched the ground in just several weeks. The momentum of the bully trend originated from the reform of Chinese state-owned enterprises which makes various investing companies long the Chinese stock market. In the meanwhile, the monetary policy, at this phase, is comparatively loose with more flowing cash in the market. However, the jump of the booming stock market did not last long and quickly broke in June 2015 due to huge profit foreign capital continuous flowing from homeland to overseas. Then sheep-flock effect occurs n Chinese stock market again with the performance of all of the investors overlooking the policy guidance implemented by authorities.

After analyzing the bullish trend in Chinese stock market, we could find policy-dependent feature. The policy implemented by authorities often point out the direction of stock market's next step. Besides, knowing the time of bubble formation could help the authorities making more efficient policy and avoid making incorrect policy implications resulting to the evaporations of investors' interests.

## 4. Conclusions

In this study, we apply the GSADF tests proposed by Phillips et al. (2013) to identify the beginning and end of potential speculative bubbles in two Chinese Share markets – Shanghai and ShenZhen from 1990s to 2016. The new method can be applied to data at any frequency to test for the presence of bubbles, whereas other approaches rely on the subjective judgment of deviations from the fundamentals or from moderate states. The result indicates that there are explosive multiple bubbles in the two Chinese Share markets in 1996-97, 2007-2008 and 2014-2015. Our theoretic model is derived from the intrinsic bubble model (Gurkaynak, 2008) that there exert some expectation and invisible components in the forming of asset price. Generally, share price bubbles mostly occur in the period of price volatility, while bubbles triggered by geopolitical components (economical or political events) last for a relative short period (Zhang et al., 2009). Additionally, a longer term bubbles in share markets widely recognized as the result of speculation. Especially a speculative bubble might have been an important driving force behind the increase in share prices when we analysis the data prior to the financial crisis in mid-2008 (Hamilton, 2008, 2009). We can identify the crucial variables driving the occurrence of share price bubbles by locating the starting and ending point that share price bubbles have occurred in the past. Furthermore, we believe that a bubble in the share markets may indicate fear of an economic slide among investors, which may be one of the early warning signs of a financial crisis. Thus, it is important for policy makers to know when share price bubbles are most likely to occur, because of the potential implications of share price bubbles for financial stability (Baur and Glover, 2012). Apart from that, we consider that whether authorities should actively fight speculative bubbles or just observe their evolutions and crashes. Given the potential influence of economy on share price bubbles, the Chinese government should stabilize the economy in order to avoid erroneous decisions on the course of monetary policy (Lammerding et al., 2012).

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