Rational bubble diagnosis of Chinese stock market

Master Thesis

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Abstract

In this paper I investigate the existence of rational speculative bubbles in the Chinese stock market in recent years (during the period 2005 to mid-2012) using the duration dependence test developed by McQueen and Thorley (1994). There are four indexes that represent the whole Chinese stock market: the Shanghai A Share index, the Shanghai B Share index, the Shenzhen A Share index and the Shenzhen B Share index. All four indexes are tested in this paper. The test results show that rational speculative bubbles exist in three of the indexes except for the Shanghai A Share index. Therefore, the presence of rational speculative bubbles in the Chinese stock market during the period 2005 to mid-2012 is generally confirmed. This finding indicates that in recent years the investors in Chinese stock market are generally rational; in contrast to the common believe that many investors in emerging markets are irrational.

Key words: Chinese stock market; rational bubbles; the duration dependence test.

Contents

1. Introduction

Economists paid little attention to the bubbles in stock market until the 1980's. In traditional financial theories, stock market bubbles are seldom mentioned. Financial models such as the CAPM model and the Fama-French Four Factor model are both subjected to the efficient market hypothesis[1] and the economic man hypothesis[2], which are implying that any fluctuations in the price can be attributed to some changes in the fundamental value.

But after numbers of "bubble" events happened, for instance, the Tulip Bubble[3] (during 1636 to 1637), the South Sea Bubble[4] (during 1719 to 1720), and more recently, the Dot-com Bubble[5] (during 1995 to 2000) and the US Housing Bubble[6] (during 1998 to 2005), economists gradually noticed there could be a bubble factor in the stock prices. Financial bubbles are defined as follows: trades in high volumes at prices that are considerably at variance with intrinsic values (King, et al., 1993).

Generally, a bubble is often considered to be irrational (Garber, 1990). In the field of Behavioral Finance, some social psychological factors are introduced as irrational factors to explain price bubble: greater fool theory, extrapolation and herding[7]. Other

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1 An efficient market is one in which securities prices reflect all available information, which implies every security traded in the market is correctly valued by given the available information, Graeme Pietersz (2011)

2 An economic man refers to a hypothetical individual who acts rationally and with complete knowledge, but entirely out of the quest to maximize personal utility.

3 Tulip bubble refers to an event in Netherlands in its golden age that the prices of newly introduced tulip bulbs reach incredibly high levels and then suddenly collapsed.

4 South sea bubble refers to the event that the stock price of South Sea Company rose greatly in value while the company never realized any significant profit. The price reached its peak in 1720 and then quickly collapsed to just a little above its flotation value.

5 Dot-com bubble is a speculative bubble which was driven by the rise of internet-related stocks in industrialized countries during 1995 to 2000.

6 The US housing bubble is an economic bubble that affects the housing market in US. The housing price peaked at 2006 and started to decline to the current low in 2012.

7 For definitions of these irrational social psychological factors, see Appendix C.

than irrational factors, some rational factors can also explain the forming of bubbles, for instance, moral hazard and excessive monetary liquidity[8].

Theoretically, the rise of the stock price can be driven by the self-fulfilling prophecy[9] of the investors. To be exact, although there are no fundamental changes, stock prices can still go up only because the majority of investors believe in the continued rise of the price. Blanchard and Watson (1982) argued that this kind of behavior can be a rational choice. They developed the concept of rational bubble theory to justify it (See Appendix A).

The rational bubble theory assumes that there are no irrational investors. Although investors know that the price of an asset has already deviated from the fundamentals, they still believe there is a high enough probability that the price will keep going up, thereby yield a return high enough to compensate for the risk of bubble explosion.

Usually, investors in emerging stock markets are considered immature and less rational (Chen, Kim, Nofsinger, Rui, 2004). In the field of bubble diagnosis, more attention has been paid to the industrialized markets while actually emerging markets become increasingly important. Thus it is interesting and meaningful to investigate if these volatile stock markets contain rational speculative bubbles. In this paper I examine the existence and robustness of rational speculative bubbles in Chinese stock market. The statistical method I use in this paper is the duration dependence test developed by McQueen and Thorley (1994). My findings indicate that rational speculative bubbles do exist in the Shanghai B share index, the Shenzhen A share index and the Shenzhen B share index. However the empirical results of the Shanghai A share index are not significant, so the presence of rational speculative bubble in this index is ambiguous. In contrast to the common believe that many investors are irrational, the findings in this paper indicate that investors in Chinese stock market are

8 For explanations of rational causes of price bubbles, see Appendix C.

9 The self-fulfilling prophecy is, in the beginning, a false definition of the situation evoking a new behavior which makes the original false conception come 'true'. Merton, Robert K (1968).

generally rational. Investor behaviors are more predictable because they are generally subjected to some criteria[10]. This implies that Chinese stock market may be less risky, more predictable and more attractive to investors than previously believed.

The reminder of this thesis is organized as follows: Section 2 covers representative and influential articles and publications on bubble diagnosis methods. Then Section 3 will introduce the hypotheses and methodology of this article. In Section 4, the process of data gathering and analysis is described. In Section 5, the empirical test results of the full sample and subsample will be discussed in order. Finally in Section 6, the conclusions of this thesis and recommendations for future research will be discussed.

2. Literature Review

2.1. The Concept of Bubble and Rational Speculative Bubble

Economists began to study financial bubbles about 4 decades ago. In the 1970s, Zeeman (1974) and Thom (1976) classified the participants of stock market into two categories: the speculators and conservatives. They separated the speculative risk factors from the many factors that affect the stock market. This theory allows the existence of bubbles.

Stiglitz (1990) presented an intuitive and specific definition of what a bubble is: "If the reason that the price is high today is only because the investors believe that the selling price will be higher tomorrow, when fundamental factors do not seem to justify such a price, then a bubble exists." Stiglitz insists that when an infinite deadline for investment is impossible, the sole market power cannot guarantee the economy to grow in a path without boom and burst, because investors can end their investments before the asset prices fall back to their intrinsic value and it is still possible to earn a high return. From a rational perspective, some speculative bubbles can always survive when a limit of investment horizon is given because of the

10 See rational speculative bubble theory in Appendix A.

continued entry of speculators. Therefore investing in bubble assets is not necessarily an irrational behavior. Stiglitz (1990) stated that under certain circumstances, there are rational components of the bubbles. He thinks that due to capital market inefficiency, it is no surprise that there exists a mismatch of the price and fundamentals.

Blanchard and Watson (1982) proposed the concept of a rational speculative bubble. They think economists overstated the case that price deviation from fundamental value is only due to irrationality of investors. They are of the opinion that it is not necessary to always view the asset price equals to the intrinsic value of the asset just in order to emphasize “rationality”. Blanchard and Watson (1982) discussed and characterized the rational bubble, why it forms and how does it deviate from the fundamentals. They try various methods to investigate how we can detect such deviation empirically. They mainly use "run test" (a test for autocorrelation) and "tail test" (a test for kurtosis) to test the existence of bubbles. They gave the following reasons: "If bubbles grow for a while and then crash, the innovations in the bubble will tend to be of the same sign (exhibiting autocorrelation) while the bubble continues, then reverse sign when a crash occurs. The runs[11] for the bubble innovation will then tend to be longer than for a purely random sequence, making the total number of runs over the sample smaller. Crashes will produce large outliers so that the distribution of innovations will have fat tails (exhibiting leptokurtosis)."

After discussion and mathematical derivations, Blanchard and Watson come to the conclusion that speculative activities stimulate the virtual asset bubble. As time goes by it finally becomes the main factor responsible for the burst of the asset bubbles. Because of the herding effect (See Appendix C, Herding), more and more people become speculators and thus are pushing up the price to unreasonably high level. The mismatch between stock prices and the real productivity finally lead to the crash of the market.

[11] A run contains a series of consecutive innovations of the same sign.

2.2. The Justifiability of the Existence of Bubbles

Shleifer and Lawrence (1990) introduced noise traders approach based on two assumptions: limited arbitrage and investor sentiment. Limited arbitrage means that due to imperfect reality[12], there does not always exist a perfect (riskless) replicated portfolio for an asset and risk free arbitrage is not always possible. Investor sentiment refers to the fact that the majority of investors sometimes make wrong judgments (too optimistic or too pessimistic) about the market because of the common psychological traits of the human mind. These two assumptions imply that arbitrageurs cannot fully counter the deviations of the prices and therefore the deviations affect security returns. They show that the overall impact of noise trading has a negative effect on both the traders themselves and the rest of the society.

Shiller (1981) examined the differences between detrended[13] price index and the present price value of the actual subsequent detrended real dividends of Standard and Poor's Composite Stock Price Index and Dow Jones Industrial Average. He found that in both indexes the movements of detrended price are too turbulent, so that the movements of discounted value of actual subsequent detrended dividends do not seem to justify this. If the efficient market hypothesis is true, this should not be the case, because in the stock market the dividend stream is the main determinant of the stock price and efficient market assumes that all the known factors that can affect the price are already reflected in the price. This finding suggests that the existence of stock market bubbles is possible.

In addition, Shiller (2001) argued that human (investor) behaviors are less-than-rational. According the 1999 NACUBO Endowment Study (a study about university endowment management), just before the stock market peak at March 2000, most of the universities' portfolio managers allocated their portfolio mostly in US

[12] For example, there is no perfect replicated portfolio for shares of a particular stock. Additionally, due to a finite horizon, arbitrageurs will face another risk that the price deviates even more from the intrinsic value when they sell the stock.

[13] To detrend means to remove long-term trends in order to emphasize short-term changes.

stock market. The study's data shows the median endowment in 1999 had 54.7% in US equity market while only 10.5% in non-US equity market. At this point in time, professional or academic investors, who are presuming intelligent, were involved in the market just before the peak and not withdrawing from it. So Shiller thinks we are all subjected to human weaknesses, even professional scholars. To be exact, these weaknesses are psychological terms such as the representativeness's heuristic[14], overconfidence[15], attention anomalies[16], self-esteem[17], conformity pressures[18], salience[19] and self-justification[20]. These recognition errors are contagious among investors. Therefore he concluded that "Human patterns of less-than-perfectly rational behavior are central to financial market behavior, even among investment professionals, while at the same time there is little outright foolishness among investors." He also pointed out that due to the impossibility for them to review all the relevant academic literatures, the media people refer to pop psychology too often and misinterpret the nature of irrationality. This is part of the reason why we are not aware of the existence of speculative bubble in time.

2.3. Empirical Test for the Existence of Asset Pricing Bubble

In recent decades, a variety of quantitative methods are developed to examine the existence of bubbles.

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[14] Representativeness's heuristic is the degree to which [an event] (i) is similar in essential characteristics to its parent population, and (ii) reflects the salient features of the process by which it is generated. Kahneman & Tversky (1982)

[15] Overconfidence is a well-established bias in which someone's subjective confidence in their judgments is reliably greater than their objective accuracy, especially when confidence is relatively high. Pallier, Gerry, et al. (2002)

[16] Attention anomaly is the tendency of emotionally dominant stimuli in one's environment to preferentially draw and hold attention and to neglect relevant data when making judgments of a correlation or association.

[17] Self-esteem is a term in psychology to reflect a person's overall evaluation of his or her own worth. People sometimes perform irrationally to keep the sense of self-esteem.

[18] Conformity pressure is the act of matching attitudes, beliefs, and behaviors to group norms (Norms are implicit rules shared by a group of individuals that guide their interactions with others and among society or social group.). Hogg, M. A.; Vaughan, G. M. (2005). Social psychology.

[19] Salience is the state or condition of being prominent. It is used as a measure of how prominent or relevant perceptions coincide with reality. Richard E Vatz (1968)

[20] Self-justification describes how, when a person encounters a situation in which a person's behavior is inconsistent with their beliefs, that person tends to justify the behavior and deny any negative feedback associated with the behavior. Festinger, L. (1957).

West (1987) argued that the existing tests for bubble existence were not powerful enough. He developed a formal test for rational speculative bubbles when estimating equilibrium model of fundamentals. The test compared two sets of estimates of parameters that determined the present discounted value of the dividends of an asset, conditional on the past and present knowledge of the asset's dividends. One set contains a bubble factor; the other set contains no bubble factor. Apart from sampling error, if the asset price series does not contain a bubble the two sets of estimates of parameters should be the same. But if the asset price series contains a bubble, the two sets of parameters will not be the same because the coefficient of the bubble factor will not be zero. Therefore the coefficient of the bubble factor can affect the coefficients of other factors because it is correlated with them. West checked bubbles on long-term annual data on the Standard and Poor's 500 index (1871-1980) and the Dow Jones index (1928-1978), and he found bubbles in both indexes.

The shortcoming of his model is the use of one set of parameters to state the relations between all the observations and the value of prior observations. Therefore, the method requires detailed specifications of the fundamental equilibrium model. This implies that the null hypothesis of no bubbles can be rejected due to the wrong model but not the presence of the bubbles. This shortcoming has been solved by Diba and Crossman (1988). They built a method that does not need detailed specifications of the fundamental equilibrium to test bubbles. "In this model, the market-fundamentals component of the stock price is defined to be the particular solution to this expectational difference equation that equates the product of the stock price and the marginal utility of consumption to the expected present value of the products of future dividends and future marginal utilities of consumption". They suggest, by examining the co-integration of the prices and fundamentals, one can test the bubbles without knowing the detailed specifications of the fundamental equilibrium model.

McQueen and Thorley (1994) thought “run test “(autocorrelation), “tail test” (kurtosis) (Blanchard and Watson, 1982) and "median test" (skewness) (Evans, 1986) are not unique to bubbles. For example, autocorrelation can be induced by fads and time-varying risk premiums. Skewness could result from asymmetric fundamental news. Leptokurtosis could be a consequence of the batched arrival of information. Therefore, the features of autocorrelation, kurtosis and skewness can occur without having bubbles. They proposed the "Duration Dependence Test" to test the bubbles that do not need specifications of fundamental equilibrium model. It is a simple and clear test: If the price contains bubbles, the trend of its positive, but not negative abnormal returns will exhibit negative duration dependence. That is to say, the probability of the burst of a bubble declines with the length of the time that the bubble lasts, given that the duration time is not infinite. This is due to the assumption that if the investors are rational, they do not sell the assets which prices are even above theirs intrinsic value because the returns of keeping them can adequately compensate for the risk of the burst of the bubbles. Rational speculative bubbles normally exhibit a characteristic of a long run-up in price and then followed by a crash.

In their paper they use the duration dependence test to examine historical data of both equally and value weighted portfolios of all New York Stock Exchange (NYSE) stocks for monthly returns from 1927 to 1991. The test results are statistically significant in positive, but not negative runs. This result is consistent with the existence of the rational speculative bubble. The result is particularly robust in the equally-weighted portfolio.

2.4. Conclusion of Literature Review

The existence of price bubble is broadly confirmed. But due to complexity of the economy, economists cannot be very sure about the presence of price bubbles, needless to say, the scale or scope of them.

A bubble is not necessarily irrational; there is at least a rational component to it. When the benefits of holding a bubble asset exceed the drawbacks of it, this behavior is considered rational. Blanchard and Watson (1982) defined the rational speculative bubble very specifically with mathematical formulas (See Appendix A, equation 5). When the return of the rise of the bubble asset can compensate for the risk of its burst, rational bubble forms. Several economists (West, McQueen and Thorley, etc.) develop empirical methods to test the existence of rational speculative bubbles. In this paper I will use the duration dependence test to test for bubbles in the Chinese stock market.

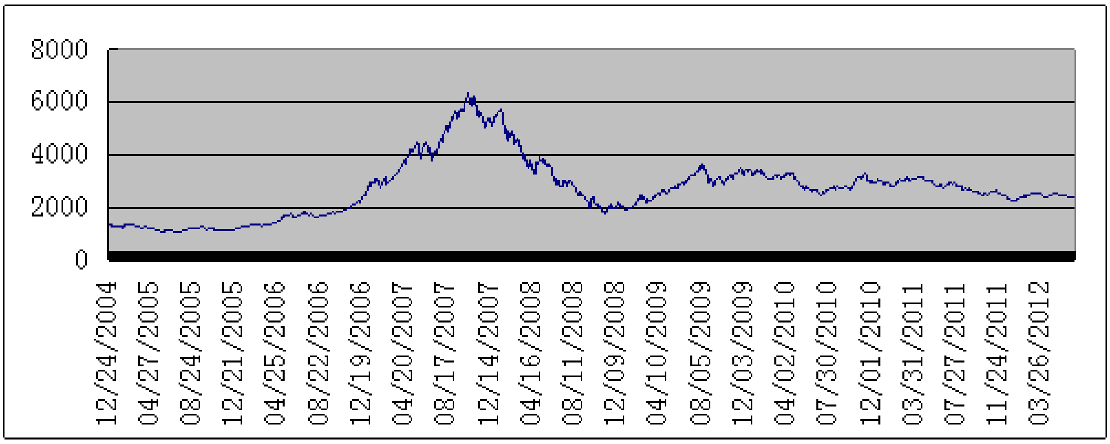
3. Research Hypotheses and Methodology

3.1. Research Hypotheses

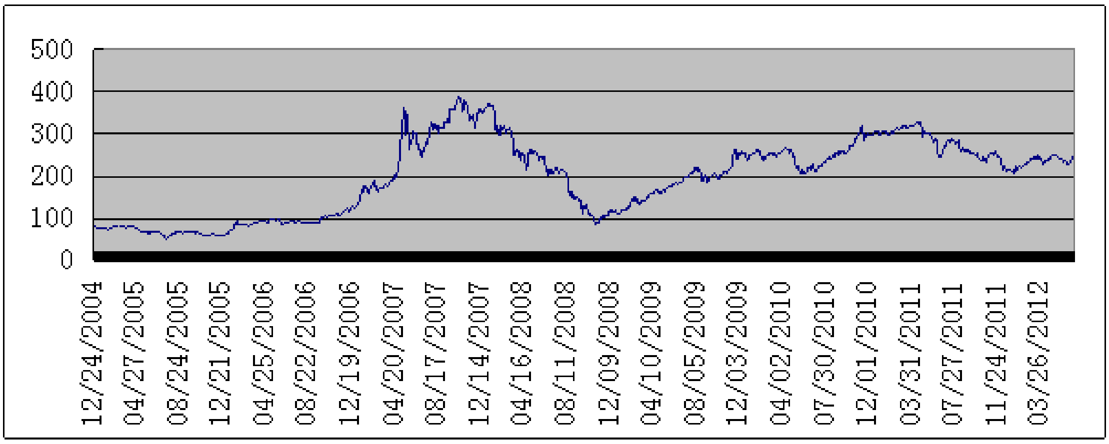
Stock market bubble investigations were mainly concentrated on developed stock markets. Little attention has been paid to emerging markets which are fast developing and increasingly important market forces. This article is aim to test if there is any rational speculative bubble in Chinese stock market in recent years (during the period 2005 to mid-2012).

China has long become the representative of emerging markets. Because of a stable and high GDP growth rate (10.3% on average, all years' rates between 8 to 13%) between 2000 and 2010, China has become a desirable emerging market for investors. However, the stock market in China has become one of the most volatile markets in the world, but the return of the stocks is not high accordingly. Until recently, the compound growth rate of the stock market index, for instance, the Shanghai (securities) composite index from 01-04-2002 to 01-04-2012 is only 40.68% (nominal rate), annual compound growth rate is only averagely 3.47% with a standard deviation of 32.60%. The standard deviation is impressively large when the return is relatively low. An explanation of the mismatch of the economic growth and stock market growth can be the explosion of the stock bubble, which is something I am going to test in this paper.

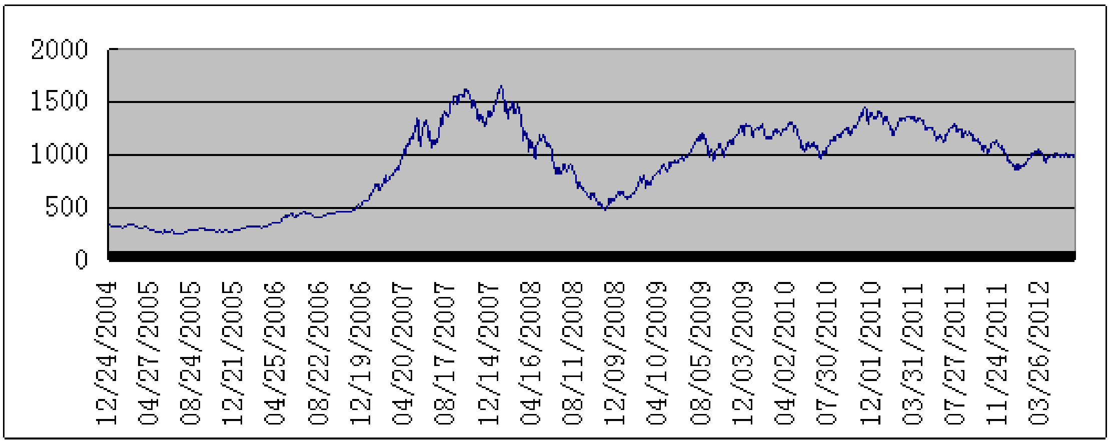
Graph 1: Shanghai A Share



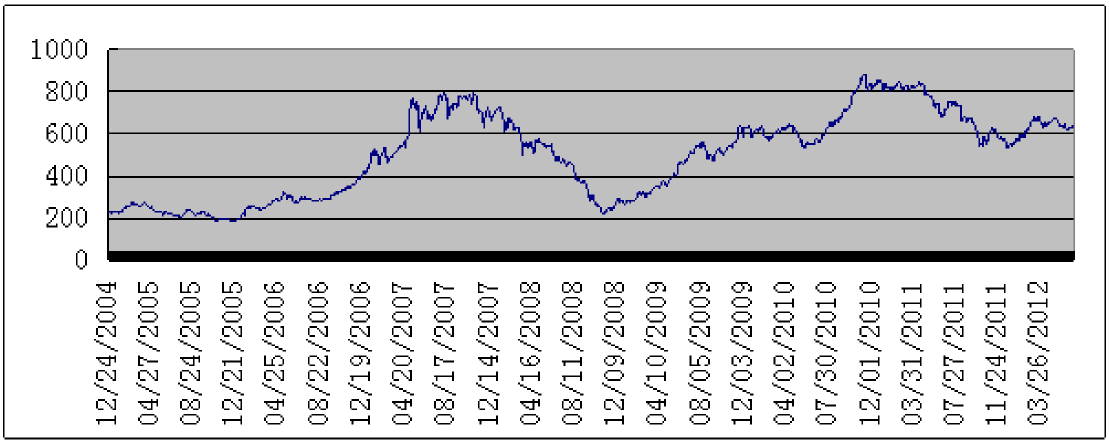
Graph 2: Shanghai B Share



Graph 3: Shenzhen A Share



Graph 4: Shenzhen B Share



Looking at Graph 1 to Graph 4, you can see approximately in the same period, there is an obvious "hill" (uphill followed by downhill) in all four indexes. The question is whether these price movements are rational speculative bubbles or not.

As described above, I use the duration dependence test of McQueen and Thorley (1994) to empirically examine if there are rational speculative bubbles in Chinese stock market from 2005 to mid-2012. So the research hypotheses of this paper are as follows:

Hypothesis 1: The probability of seeing a bubble burst decline with the increase of bubble duration.

Hypothesis 2: Only the positive runs, not negative, exhibit negative duration dependence. There is no negative bubble in reality.

Hypothesis 3: The "hills" (uphill and downhill) seen from Graph 1 to Graph 4 are rational speculative bubbles.

3.2. Research Methodology

In McQueen and Thorley (1994), the rational bubble model developed by Blanchard and Watson (1982) is also introduced to describe the characteristics of rational speculative bubble (I put this model in the Appendix A). The most important point is a more detectable condition: As equation 10 in the Appendix A shows, when a bubble grows, the probability of seeing a negative abnormal return declines, so long runs of positive abnormal returns may suggest the presence of a bubble.

Just as McQueen and Thorley (1994), a run is defined as a sequence of abnormal returns of the same sign (positive runs or negative runs). For example, the abnormal return of the stock price has continuously been positive for 5 days (weeks, months, depended on the unit), then followed by a negative abnormal return at the sixth day, then I define the run length of positive abnormal returns as 5. The definition of a run for negative abnormal returns is analogous.

As the rational speculative model in Appendix A illustrates, some signals can be observed: If the price contains bubbles, runs of positive abnormal returns will exhibit negative duration dependence; but as bubbles cannot be negative, for negative abnormal returns they will not exhibit positive or negative duration dependence.

For cumulative variable y, h_y represents the conditional probability that a run ends at y, given that it lasts until i:

$$(1) \quad h_y = \lim_{\Delta y \to 0} \frac{P(y \le Y < y + \Delta y | Y \ge y)}{\Delta y}, 0 < y < \infty$$

Similarly, for discrete variable, say i, we have h_i:

$$(2) \quad h_i = P(I = i | I \ge i), i = 1, 2, \cdots, \infty$$

Actually, the lengths of runs of returns (unit can be a day, a week, a month, etc.) are only natural numbers, which are not necessarily consecutive. So the lengths of runs are discrete variables.

According to McQueen and Thorley (1994), the logistic regression method can be used to reveal the relationship between h_i and the run length i.

$$(3)\quad h_i = \frac{1}{1+e^{-(\alpha+\beta \ln i)}}$$

The dependent variable h_i is 1(0) if the run ends (does not end) in the next period. The independent variable is the log of the run length i. Here logistic function of the log of i shrinks the unbounded range of $\alpha+\beta\ln i$ into the (0, 1) space of h_i. If a rational speculative bubble presents, we expect the hazard rate h_i declines with the run length i (lni), which means β should be negative and significantly different from zero. Also, the Likelihood Ratio Test (LRT) of β=0 is performed to check if lni is an important variable to the logit model of the hazard rate.

4. Data Gathering and Analysis

There are only two stock exchange markets in China. I will use Shanghai to refer to the Shanghai Stock Exchange, where Shenzhen is used to refer to the Shenzhen Stock Exchange. In addition, there are two kinds of shares in Chinese stock market, the A share and the B share. The official name of the A share is *Renminbi* (RMB) *Common Share*, while the B share is called *Renminbi* (RMB) *Special Share*. An A share can only be bought by Chinese citizens and there is a daily rise or fall restriction (10%) for this kind of share (if the price reach the deadline, the trading will be closed at that day until the following trading day). Alternatively, a B share is only selling to foreign investors, and no restrictions on daily price changes. All four indexes are value-weighted indexes for all the shares in its range.

This paper uses the data of the Shanghai A share index, the Shanghai B share index, the Shenzhen A share index and the Shenzhen B share index, which are almost representing the whole Chinese stock market. In this article, the daily data is downloaded from the trade system of Ping An Security, one of the biggest stock trader in China. In order to obtain more meaningful and fresh results, this article uses relatively recent data from 2005 to mid-2012.

In contrast to McQueen and Thorley (1994), this article uses daily data called "weekly return of the day", which is constructed as follows (In China, a week contains normally 5 trading days.):

$$(4)\quad \mathrm{R}_t = \frac{P_t - P_{t-5}}{P_{t-5}}$$

Where t indicates the date. The benefits of transforming the data in this way are threefold: (1) using daily data provides large amount of observations to increase the statistic power; (2) using weekly returns per day can smooth out short-term fluctuations; (3) in the volatile emerging markets, daily changes in stock price are large compared to mature markets, so the distinctions between daily observations (returns) are large enough to get meaningful results.

Initially, one would want to include daily inflation rates, dividend yield, and term spread to establish a model that allows me to measure the abnormal returns more precisely (See also McQueen and Thorley, 1994). However, due to lack of data availability, I can only follow Chan et al. (1998) and use a fourth-order autoregressive model of weekly return per day to determine normal returns. Abnormal returns are accordingly defined as the residuals of the AR(4) model:

$$(5)\quad R_t = \alpha_0 + \alpha_1 R_{t-1} + \alpha_2 R_{t-2} + \alpha_3 R_{t-3} + \alpha_4 R_{t-4} + \varepsilon_t$$

Where t-x is the xth lag of return R, α_0 is the constant and ε_t is the residual. Chan argued that an AR(4) model is a preferable model to access common mean of stock returns, because it can control the short term sources of autocorrelation, such as nonsynchronous trading. The remaining correlation is attributed to stock price bubbles.

Two sample periods will be examined in this article: the full sample period (2005.01.04 to 2012.06.25) and the subsample bubble period containing an obvious uphill and downhill (2006.08.01 to 2008.11.28, see Graph 1 to Graph 4). The full sample contains 1810 observations while the subsample contains 565. Only the subsample period contains fewer observations compared to McQueen and Thorley (1994), which contains 780 monthly observations. The larger the amount of observations the better, because the statistic test result will be more accurate with large amount of observations. But here in the subsample, due to the period constraint, number of observations can be no more than 565 (This period contains only 565 trading days.).

5. Empirical Results

5.1. Full Sample Period (2005.01.04 to 2012.06.25)

TABLE 1
The Logit Regression & The Likelihood Ratio Test Results
Full Sample Period Positive Runs

Positive Runs	SHA	SHB	SZA	SZB
Observations	1000	1015	1038	1028
Lni(β)	-0.05 (-0.50)	-0.20** (-2.21)	-0.20** (-2.25)	-0.19** (-2.11)
Constant(α)	-1.51*** (-9.70)	-1.19*** (-8.56)	-1.28*** (-8.84)	-1.23*** (-8.75)
LR chi2(1)	0.25	4.92	5.11	4.49
P value of LRT	0.62	0.03	0.02	0.03

Notes: * * * Significant at 1% level, * * Significant at 5% level, * Significant at 10% level. Lni(β) is the coefficient of Lni, which is the logarithm of the count of the length of the run. Constant(α) is the constant term of the logit regression (See equation 3.). LR chi2(1) is the chi-square value of the Likelihood Ratio Test with one degree of freedom. Z values of logit regressions are in parentheses.

At first, I calculate the weekly return of the day as equation 4 has defined out of the price data for all observations. Then I apply the auto-regressive model to the full sample period. These regressions are aimed to get the abnormal returns out of the stock prices, which are residuals of the AR(4) model as defined above(equation 5), and I put the auto-regression results at Appendix B. In this thesis, I use abbreviations

SHA, SHB, SZA and SZB to represent the Shanghai A Share index, the Shanghai B Share index, the Shenzhen A Share index and the Shenzhen B Share index respectively.

After withdrawing the abnormal returns of the four indexes in the full period, the Logit regression and the Likelihood ratio test are applied. Table 1 and Table 2 show the results of the Logit Regression and the Likelihood Ratio Test.

TABLE 2
The Logit Regression & The Likelihood Ratio Test Results
Full Sample Period Negative Runs

Negative Runs	SHA	SHB	SZA	SZB
Observations	810	795	772	782
Lni(β)	0.04	-0.08	0.00	-0.1
	(0.39)	(-0.80)	(0.03)	(-0.95)
Constant(α)	-1.35***	-1.05***	-1.18***	-1.03***
	(-8.81)	(-7.56)	(-8.03)	(-7.31)
LR chi2(1)	0.16	0.65	0.00	0.90
P value of LRT	0.69	0.42	0.98	0.34

Notes: * * * Significant at 1% level, * * Significant at 5% level, * Significant at 10% level. Lni(β) is the coefficient of Lni, which is the logarithm of the count of the length of the run. Constant(α) is the constant term of the logit regression (See equation 3.). LR chi2(1) is the chi-square value of the Likelihood Ratio Test with one degree of freedom. Z values of logit regressions are in parentheses.

In positive runs (See Table 1), except for the Shanghai A Share, the estimated Betas of all other three indexes are negative and significant at 5% level, which tells the probability of ending a positive run declines as the run length increases. The p values of the likelihood ratio test are statistically significant at 5% level, which indicates model with the independent variable lni is a better model than if it is without the variable. But in the Shanghai A share index the situation is quite different. The p value is 0.62, which implies that I cannot reject the null hypothesis. To conclude, there is empirical evidence that rational speculative bubbles exist in the Shanghai B share, the Shenzhen A share and the Shenzhen B share during the full sample period (2005.01.04 to 2012.06.25), but in the Shanghai A share, there is no empirical evidence that suggest the present of rational speculative bubble.

In terms of negative runs (Table 2), the results are quite different. In all regressions the beta coefficients are not statistically significant, which indicate there is no obvious relationship between hazard rates and length of negative runs. Additionally, the p values of the Likelihood Ratio Test in all four shares are obviously not statistically significant. Both facts are consistence with the rational bubble theory (See Appendix A), which states that negative runs do not demonstrate duration dependence.

According to the results above, it seems that rational bubbles exist in at least three indexes of Chinese stock market in the full sample period.

When looking at the Graphs I draw above in part 3 (Graph 1 to Graph 4), we can see from the graphs that, there is an obvious uphill and downhill between about August 2006 to November 2008 for all the four indexes. We know a bubble contains a boom and a burst, which will demonstrate as uphill and downhill in a graph. So I cut a subsample period between 2006.08.01 to 2008.11.28 (For comparison purpose, I choose the same subsample period for all four indexes, because the suspect bubble periods are almost overlapping.) to test if this "hills" are rational bubbles.

5.2. Subsample Period (2006.08.01 to 2008.11.28)

After we obtain residuals (abnormal returns) from the autoregressive model (See Appendix B), I apply the Logit regression and subsequently the Likelihood Ratio Test to see if there is any rational speculative bubble in the subsample period (2006.08.01 to 2008.11.28). Table 3 and Table 4 demonstrate the results of the Logit regression and the Likelihood Ratio Test for the subsample period. Compared to the full sample period, the results of subsample period exhibit diversity among indexes.

In terms of positive runs (Table 3), the Shanghai A Share is not significant in the Likelihood Ratio test, though this time the coefficient of the logarithm of the run length i is slightly negative (but not significant). But in terms of the Shanghai B Share and the Shenzhen A Share, the p values of the Likelihood Ratio Test have impressively improved to almost equal zero compared to the full sample. This result indicates that we can be very sure about the presence of rational speculative bubbles in the two indexes. The coefficients of lni of the two indexes are negative and at 1% and 5% significant level respectively, indicating that it is quite sure that the probability of ending a positive run declines with the length of the run. The significant level of the Shenzhen B Share index has declined to insignificant level compared to the full sample period. But it is still negative and the p value of the Likelihood Ratio Test 0.16 is still relatively small, though not statically significant.

TABLE 3
The Logit Regression & The Likelihood Ratio Test Results
Subsample Period Positive Runs

Positive Runs	SHA	SHB	SZA	SZB
Observations	323	303	317	311
Lni(β)	-0.03 (-0.15)	-0.47*** (-2.99)	-0.40** (-2.62)	-0.23 (-1.41)
Constant(α)	-1.71*** (-5.59)	-0.71*** (-3.18)	-1.00*** (-4.04)	-1.19*** (-4.69)
LR chi2(1)	0.02	9.40	7.17	2.02
P value of LRT	0.88	0.00	0.00	0.16

Notes: * * * Significant at 1% level, * * Significant at 5% level, * Significant at 10% level. Lni(β) is the coefficient of Lni, which is the logarithm of the count of the length of the run. Constant(α) is the constant term of the logit regression (See equation 3.). LR chi2(1) is the chi-square value of the Likelihood Ratio Test with one degree of freedom. Z values of logit regressions are in parentheses.

In terms of negative runs (Table 4), except for the Shanghai A Share, for other three indexes all p values of the Likelihood Ratio Test are statistically insignificant, which is a similar result compared to the negative runs of the full sample in Table 2. But for the Shanghai A Share, the p value (0.08) is significant at 10% level, together with the coefficient (-0.31, also significant at 10% level) of lni suggest that in negative runs the probability of ending a run declines with the length of the run, which is conflicted with the rational bubble theory (according to the theory, only positive runs demonstrate negative duration dependence).

TABLE 4
The Logit Regression & The Likelihood Ratio Test Results
Subsample Period Negative Runs

Negative Runs	**SHA**	**SHB**	**SZA**	**SZB**
Observations	242	262	248	254
Lni(β)	-0.31*	-0.21	-0.12	-0.13
	(-1.73)	(-1.17)	(-0.61)	(-0.67)
Constant(α)	-0.98***	-0.87***	-1.10***	-1.10***
	(-3.67)	(-3.73)	(-4.22)	(-4.22)
LR chi2(1)	3.03	1.39	0.37	0.45
P value of LRT	0.08	0.24	0.54	0.50

Notes: * * * Significant at 1% level, * * Significant at 5% level, * Significant at 10% level. Lni(β) is the coefficient of Lni, which is the logarithm of the count of the length of the run. Constant(α) is the constant term of the logit regression (See equation 3.). LR chi2(1) is the chi-square value of the Likelihood Ratio Test with one degree of freedom. Z values of logit regressions are in parentheses.

5.3. Conclusion of the Tests

Based on the empirical findings of the previous subsection, except for the Shanghai A Share index, the other three indexes (the Shanghai B Share index, the Shenzhen A Share index and the Shenzhen B Share index) are overall consistence with the rational bubble theory (positive runs, but not negative, exhibit negative duration dependence) in both the full sample and the subsample. These results are in line with **Hypothesis 1** and **Hypothesis 2**. In addition, except for the Shanghai A Share index and the Shenzhen B Share index, the results in subsample (bubble period) of the other two indexes are even more robust than the full sample, which means the bubble is a rational speculative bubble. This fact complies with **Hypothesis 3**.

For the Shanghai A Share index, the result shows no obvious trend. Therefore I cannot make definite statements about the present of rational speculative bubbles in its full sample period or subsample period. Judging from Graph 1, there was an uphill and downhill during subsample period (2006.08.01 to 2008.11.28), but the characteristics of this "hill" remain unknown.

For the Shenzhen B Share index in its subsample, the p value of Likelihood Ratio test is less significant than its full sample, and falling out of the statistically significant level. This result seems strange but can be the consequence of sampling errors[21].

In conclusion, all the hypotheses (1 to 3) are generally confirmed. But due to limited data and limited indexes (only 4 indexes, 1 is not significant), I cannot be very sure about the validity of the hypotheses.

5.4. Limitations

In this paper, the results of the Shanghai A Share index are not statistically significant. Although not all the results in all four indexes are statistically significant, I conclude that there are rational speculative bubbles in Chinese stock.

The duration dependence test is only used to examine the presence of a rational bubble, but not the scale and scope, as well as the causes of it. An empirical diagnosis to investigate irrational bubble is even harder, so economists and psychologists can only use sociological or psychological terms and concepts to generally explain the cause factors, just like Shiller (2001).

In the article of McQueen & Thorley (1994), both equally weighted and value weighted indexes of the market are examined. But here I cannot get equally weighted

[21] Sampling process error occurs because researchers draw different subjects from the same population but still, the subjects have individual differences. Normally, the study with a larger sample size will have less sampling process error compared to the study with smaller sample size.

indexes, because in China only value weighted indexes are calculated by the authority. Also I cannot calculate the equally weighted index because of the lack of individual data.

6. Conclusion

This article uses the duration dependence test to investigate whether rational speculative bubbles exist in Chinese stock market during 2005 to mid-2012. In this paper I find mixed evidence.

In the full sample period, after performing the Likelihood Ratio Test for all the four indexes, I find rational speculative bubbles in the Shanghai B Share index, the Shenzhen A Share index and the Shenzhen B Share index, while there is no significant evidence supporting the presence of rational speculative bubbles in the Shanghai A Share index.

In the subsample from Aug 2006 to Nov 2008, I find rational speculative bubble in the Shanghai B Share index and the Shenzhen A Share index. The test results in subsample period of the two indexes are even more robust than their full samples. The p value of the likelihood ratio test of the Shenzhen B Share index declines to statistically insignificant level, but the p value of 0.16 is still relatively small. This result could be a consequence of sampling errors (lacking observations because of the limited time period of the subsample). There is still no evidence to indicate there exists bubbles in the Shanghai A Share index in the subsample period.

Many academic scholars claim that investors in China are irrational (See for example, Chen, Kim, Nofsinger, Rui, 2004), making the stock market in China even more unpredictable and volatile. As a consequence, investors have to bear more risk than usual and thus making the investment in Chinese stock market relatively unattractive. Generally, as the results of this paper show, Chinese local stock investors are overall rational, at least in the market of the Shanghai B Share, the Shenzhen A Share and the Shenzhen B Share at recent years (2005 to mid-2012). Bubbles in the Chinese stock market are mostly rational bubbles. Because in a rational bubble the risk of the burst can be adequately compensated by high returns, the Chinese stock market is worth investing even though sometimes there exists a bubble. These results make the Chinese stock market more attractive.

For future research, it would be interesting to investigate what are the driving factors of a rational speculative bubble. The duration dependence test only tests the existence of rational speculative bubbles, not much to say about the essence of the bubbles. As Shiller (2001) suggested, studying the causes of investor behavior is not merely a subject of finance. It should be an integrated field combining finance and other social sciences, for instance, psychology and sociology.

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Appendix A

Rational Speculative Bubble Model

One simple condition of the efficient market hypothesis is the expected return of the stock equals the required return:

$$(1)\quad E_t(R_{t+1}) = r_{t+1}$$

E_t suggests that given the information at t, the expectation of the return at t+1; r is the required return. Based on (1), we have:

$$(2)\quad \mathrm{P}_t = \frac{E_t(P_{t+1} + d_{t+1})}{(1 + r_{t+1})}$$

Solve recursively for (2) yields the equation of fundamental value under equilibrium condition:

$$(3)\quad P_t * = \sum_{i=1}^{\infty} \frac{E_t d_{t+i}}{\prod_{j=1}^{t}(1 + r_{t+j})}$$

However, Shiller (1978), Blanchard and Waston (1982) and West (1987) think actual price can deviate from the fundamentals, note that:

$$(4)\, \mathrm{P}_t = P_t * + b_t \text{, where } \ \mathrm{E}_t b_{t+1} = (1 + r_{t+1}) b_t$$

is also a solution under equilibrium condition. So the stock price may deviate from the fundamental value because of a rational speculative bubble, b_t, conditional on the bubble factor grows as the investors required.

According to Blanchard and Watson (1982), the process that the bubbles grow and burst can be explained by the following equations:

$$(5)\quad b_{t+1} = \begin{cases} \frac{(1+r_{t+1})b_t}{\pi} - \frac{1-\pi}{\pi} a_0, \text{with probability } \pi \\ a_0, \text{with probability } 1-\pi \end{cases}$$

Under this process, the bubble grows at a fix amount that needed to compensate the investor for the probability (1-π) that the bubble may crash to the initial amount $a_0>0$. In order to be consistent with the traditional characteristic of bubbles (In the long run there will be a crash after a long run-up), the probability of the bubble continuing to next period, π, must be greater than 1/2.

Rational bubbles allow unexpected price changed $\varepsilon_{t+1} = (R_{t+1} - r_{t+1}) p_t$ comes from two unobservable changes:

Unexpected change in the fundamental,

$$(6)\quad \mu_{t+1} = P_{t+1}* + d_{t+1} - (1 + r_{t+1}) p_t *$$

And unexpected change in the bubble,

$$(7)\quad \eta_{t+1} = b_{t+1} - (1 + r_{t+1}) b_t *$$

The observable unexpected change of price $\varepsilon_{t+1} = \mu_{t+1} + \eta_{t+1}$, theoretically, exactly equals to the sum of the two components, unexpected price change of fundamental and also unexpected price change of the bubble,

$$(8)\quad \varepsilon_{t+1} = \begin{cases} \mu_{t+1} + \frac{(1-\pi)}{\pi}(1+r_{t+1})(b_t - a_0), \text{with probability } \pi \\ \mu_{t+1} - (1+r_{t+1}) b_t + a_0, \text{with probability } 1-\pi \end{cases}$$

Under efficient market hypothesis, the expected value of the total price change is zero. The probability of a positive innovation in the price can be greater than 1/2, even if the fundamental changes are symmetrically distributed around zero. The reason is the inherent characteristic of negative skewness of bubble innovation. The asymmetry of bubble innovation suggests when bubble continues, abnormal returns tend to be positive, and these results in autocorrelation and positive abnormal returns for longer runs.

To illustrative, assume μ_{t+1} are unimodal and symmetrically distributed around zero. From equation (8) we can obtain the probability of a negative innovation is,

$$(9)\quad \lambda_{t+1} = \pi F\left[-\frac{(1-\pi)}{\pi}((1+r_{t+1})b_t - a_0)\right] + (1-\pi)F\left[(1+r_{t-1})b_t - a_0\right]$$

From which F (.) is the cumulative density function of μ_{t+1}. For value of a_0 and $b_t > 0$, the observed distribution of excess return is negatively skew, which makes the value of λ_{t+1} less than zero. That is to say, the probability of a negative innovation declines with the bubble factor,

$$(10)\quad \frac{\partial\lambda_{t+1}}{\partial b_t} = -(1-\pi)(1+r_{t+1})[f(-\frac{1-\pi}{\pi}((1+r_{t+1})b_t - a_0)) - f((1+r_{t-1})b_t - a_0)] < 0$$

A basic assumption is that the innovation of fundamental value is symmetrically distributed with mean zero. For $\pi > 1/2$, the absolute value of the first density function of f(.) is greater than the second one, which makes the value of the term in square brackets positive. And the total value of the derivative is therefore negative, which exactly suggest negative relation between the probability of the bubble to crash and the scale of the bubble.

Appendix B

Results of Autoregressive Model

Table 5 shows the coefficients of all the four lags and the constant term for the full sample period (2005.01.04 to 2012.06.25). We can see all the coefficients of lags are at least significant at 10% level. And the R-squared numbers are about 0.70, which indicates the model is a good predictor of return.

TABLE 5
Autoregressive Model (4) Results--Full Sample Period

	SHA	**SHB**	**SZA**	**SZB**
L1	0.88***	0.97***	0.94***	0.93***
L2	-0.06*	-0.14***	-0.13***	-10***
L3	0.10***	0.13***	0.14***	0.09***
L4	-0.18***	-0.18***	-0.20***	-0.17***
Constant	0.00	0.00	0.00*	0.00*
R-squared	0.67	0.73	0.70	0.70

Notes: * * * Significant at 1% level.

* * Significant at 5% level.

* Significant at 10% level.

Similar to the full sample period, I apply autoregressive model to all the four price indexes to obtain the abnormal returns of bubble periods. Table 6 illustrates the results of the regressions. We can see all the coefficients of lags are at least significant at 10% level (Actually except for lag 2 of SHA, all other coefficients are at 1% level significant.). The R-square is about 0.7, which is relatively high. The results show that, at least in this sample period, AR(4) model is good to predict normal returns, so abnormal returns can be withdraw from the residuals(as equation 5 shows).

TABLE 6
Autoregressive Model (4) Results--Subsample Period

	SHA	**SHB**	**SZA**	**SZB**
L1	0.86***	0.95***	0.92***	0.93***
L2	-0.06*	-0.15***	-0.12***	-10***
L3	0.15***	0.21***	0.18***	0.09***
L4	-0.20***	-0.21***	-0.21***	-0.17***
Constant	0.00	0.00	0.00	0.00
R-squared	0.67	0.73	0.70	0.70

Notes: * * * Significant at 1% level.

* * Significant at 5% level.

* Significant at 10% level.

Appendix C

Irrational Explanations of Price Bubble

Greater fool theory says because investors believe though their acts to buy something at a price higher than its intrinsic value are "foolish", but there is still a good enough chance for other "more foolish" investors to take over the asset at a even higher price, who are called "the greater fools".

Extrapolation says that if the past performance of the asset was good, investors tend to assume the performance will continue to the future (disregarding the sustainability of the good performance), and therefore cause the pricing of the asset surpassing its real value.

Herding means investors tend to trade at the same direction of the market trend, buying the rising assets and selling the declining ones, causing the price of the rising asset to rise because the rise itself.

Rational Explanations of Price Bubble

Moral hazard is the prospect that investors will behave very differently from what they should (morally) do to maximize their own benefit when all or part of the risk is not bear by themselves but by another party. The typical example is the principle-agent problem, where agents usually take too much risk in order to seek more private benefits when the risk will be bore mostly by the principle.

Excessive monetary liquidity may also be a cause of price bubble. When the government is implementing expansionary monetary policy, too many currencies are floating on the market while relatively there are too little assets available. Even the price of junk assets will rise only because the money keep pumping in.

Self-fulfilling prophecy is a prediction that directly or indirectly causes itself to become true by the very terms of the prophecy itself due to positive feedback between belief and behavior.