Study on the Bubble Identification and Bursting Time of the Stock Market in America, Germany and Japan

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Abstract

As far as the financial market is concerned, every burst of the bubble has had a major impact on the national economy, leading to an increase in the unemployment rate. Identifying the financial bubble and predicting its bursting time has been a hot topic in finance academic research. This paper adopts the stochastic index (K value), the relative strength index (RSI value) and the positive deviation as the major indicators of stock market bubbles. When the K value and the RSI value reach 85, the deviation deviates from the standard of the past five years moving average, it is considered that there is a bubble in the stock market. On this basis, observe whether the bubble will burst and the time required for bursting. From the empirical results, it can be seen that the bubbles identified by the three countries using the technical indicators have a bursting probability greater than 87%. Comparing the three countries of America, Germany and Japan, we find that the United States is the most matured stock market in the world. Its bubble burst time is short and its impact on the market is small when it breaks. The Germany bubble burst time is also short, but it possibly shocks the stock market. While Japan's bubble burst time is generally longer, which makes the bubble expand and lead to a greater chance of shocking the market when bubbles burst.

Keywords: Bubbles, Technical Indicators, Bias, Moving Average, Bursting Time
JEL Classification: G15

1. Introduction

Ecclesiastes 1:9 "The thing that hath been, it is that which shall be; and that which is done is that which shall be done: and there is no new thing under the sun." Looking back at the history of the financial bubble, as King James said, human beings cannot remember the pain of the past bubbles. The bubbles have been repeated again and again, and caused financial turmoils and severe economic recessions. Since the first tulip financial bubble in the Netherlands in 1637, it has been 382 years. In 1720, France and the United Kingdom successively developed the Mississippi bubble and the South Sea bubble, claiming to be the world's three major bubble events. In 1837, a railway bubble occurred in the United
States and in 1930 the United States experienced the famous global economic depression bubble. In 1974, the global oil crisis occurred, in 1987, the US Black Monday bubble, the Southeast Asian financial crisis occurred in 1997, and the US Internet bubble occurred in 2000. Meanwhile, in 2008 the US subprime mortgage financial crises occurred, in 2012 and 2015 there were two European debt crises. During the past 382 years, financial crises continued to occur. The researchers of the academic as well as practical industry were all working hard to identify and predict the bursting time before the bubble burst. The research in this paper uses the technical indicators to show the overbought situation and the excessive deviation can be used as signals of bubbles, to estimate the bubble burst probability, and to explore whether there is a connection between the bubble burst time and its impact on the market.

2. Literature Review

For the study of financial bubbles, from the rational bubble model to the irrational bubble model based on nonlinear dynamics and behavioral finance, the research involves almost all the fields of finance. Scholars have tried to use these models to reasonably explain the bubble generation, expansion, persistence and bursting, and hope to accurately study the bubble identification, measurement, prediction and prevention.

Reviewing the development of the financial bubble theory, it can be divided into three stages in terms of time. The first stage began in the early 1980s, various mathematical models of rational bubbles were established based on the rational expectation theory. Blanchard et al. (1982) firstly proposed a rational expectation bubble model, which argues that rational investors will require excess returns in order to compensate for the bubble's future bursting, and under rational expectations the bubble will expand with speed of this excess return. In other words, rational expectations cause the actual price of assets to deviate from the underlying value, forming a rational bubble. Shiller (1981) and LeRoy et al. (1981) proposed a variance bounds test to measure the relationship between variance of asset prices and dividends, and then to detect the existence of bubbles. West (1987) improved the limitations of this test method by proposing a two-step test, and then the cointegration test was used to detect the existence of a bubble. However, Evans (1991) argues that the method based on unit root test and cointegration test will fail when the bubble is repeatedly accumulated and broken during the observation period because they cannot cope with the nonlinear characteristics of such bubble processes. Assuming that investors have rational expectations are not reasonable, the nonlinear relationship is more common in the real economic life. From the late 1980s, the financial bubble theory gradually entered the second stage, based on behavioral finance, using the theory of noise traders to study financial bubbles. The DSSW model (noise trader model) established by DeLong et al. (1990) explains the continuous deviation of stock market prices from the underlying value, forming a rational bubble. Shiller (1990) proposed a fashion model that believes that stock prices are highly susceptible to pure fashion trends and social dynamics, and that high levels of investor attention may lead to bubbles. Toplol (1991) proposed an mimetic contagion model that portrayed the herd behavior of market investors, and the phenomenon of infection can explain the formation and breakdown of bubbles. In the early 1990s, bubble research entered the third stage, based on behavioral finance and nonlinear dynamics theory, to conduct more in-depth and general research on financial bubbles. Johansen and Sornette (1996) analogized the stock market crash and physical material fracture, and proposed the LPPL model (Log Periodic Power Law), using the oscillation of the first-order logarithmic periodic power law model to study the process of bubble collapse. Sornette et al. (2002) firstly proposed a super-exponential bubble model, which introduced positive and negative feedback of bubble accumulation on price, and identified the bubble by checking whether the indicator (m) of positive and negative feedback is significantly greater than 1. The critical time in the model obeys the inverse Gaussian distribution. Lin (2012) attempted to introduce a new super-exponential growth bubble model, which is called Stochastic Mean-Reverting Critical Times model. According this model,
detection and diagnostic of bubble were translated into testing existence of a stationary mean-reverting critical times series embedded into nonlinear non-stationary stock price series.

From the bubble research process, behavioral finance plays an important role, which provides theoretical support for the formation, expansion and rupture of bubbles. Shiller (2015), the representative of behavioral finance, considers two psychological orientations in his book, namely quantitative anchors and moral anchors. Quantitative anchors mean that investors will measure whether the stock market price is too high or too low than the average of stock prices in the past, which explains from a psychological perspective that the stock price will repeat the history and also explains the effectiveness of the BIAS indicator. This corresponds to the Envelope deviation indicator in the technical analysis, that is, firstly find out the average price of the stock, and then determine the difference between the stock price and the average price. If the bias comes to the upper line of the envelope line, it is the signal to sell; on the other hand, if the bias comes to the lower line of the envelope line, it is the signal to buy.

It can be seen that technical analysis has a certain foundation of behavioral finance. Because behavioral finance theory is widely used in irrational bubble research, so this paper tries to use technical analysis to identify stock market bubbles, and to further explore the bubbles bursting and the bursting time.

3. Research Method
The weekly data we will investigate are three stock indices including the US Dow Jones Index (DJI), the German DAX Index (DAX), and the Japanese Nikkei 225 Index (N225), and the dates are from January 1, 1996 to December 31, 2018.

Three technical indicators are used to determine whether the current market is in an overbought state to determine whether there is a bubble in the stock market. The eight rules of Granville were created based on the "stock price cycle rule" of Elliott Wave Theory and the observation of the US stock price structure based on the 200-day moving average (200MA) to predict the future trend of the stock price. In Figure 3-1, 1B represents the first buying point, 1S represents the first selling point, and we think that the bubble bursting is a point like 4S (the fourth selling point). At this time, 4S indicates that the stock price considerably deviates from the 200MA, which will lead to a large drop in stock prices.

![Figure 3-1: J.Granville Rules](image)
This paper uses weekly data instead of daily data to set the moving average parameters to capture the medium-term trend of the stock market. We set the parameter to 13 weeks MA (the season line) to calculate the bias of weekly data:

$$BIAS(t) = \frac{P_t - 13MA_t}{13MA_t}$$

Where $P_t = close$ price, $13MA_t = 13$ weeks moving average of stock price.

On this basis, this paper adds common technical indicators: the Relative Strength Index (RSI) and the Stochastic Oscillator (KD) to help the Bias more accurately capture the bubble. In technical analysis, these two technical indicators are the most commonly used by investors. The RSI value and the K value are used in the following ways: 0 to 20 are oversold areas and 80 to 100 are overbought areas. When the stock price rises to the historical high point, the value of the RSI and KD indicators will enter the overbought area of 80-100, like boiling water to 80-100 centigrade, the stock market is overheated and the stock price will be pulled back to the normal range. Therefore, the research uses both RSI and KD greater than 85 as the bubble recognition condition.

In addition, because the volatilities of different stock markets are different, the technical indicator BIAS is closely related to stock market volatility. Therefore, it is not accurate to predict the stock market bubble by using the volatility conditions of the unified standard value. This paper introduces the M value as the limit of the BIAS, and the M value indicates that the BIAS has shifted by one standard deviation over the past 5 years (260 weeks). The specific definition is as follows:

$$BIAS_{Moving\ average}(t) = \mu_t = \frac{1}{260} \sum_{i=1}^{260} BIAS_{t-i}$$

$$BIAS_{standard\ deviation}(t) = \sigma_t = \sqrt{\frac{1}{260} \sum_{i=1}^{260} (BIAS_{t-i} - \mu_t)^2}$$

$$M_t = \mu_t + \sigma_t$$

In summary, when the situations satisfy three conditions: both RSI and K are greater than 85, and the BIAS is greater than the M value, it is determined that there is a bubble in the current stock price. On this basis, this paper studies the drop and time of the bubble burst. When the stock price has a bubble at time $t_0$, that is, the three technical indicators of the stock price touch the three conditions above. If the stock price falls by more than 5% within one month after the time point $t$ in observation period (6 months), indicating that the bubble is broken, and the number of weeks from the $t_0$ is the burst time of the bubble.

$$Drop_t = \min_{0<s-t<4} \left(\frac{Stock\ index_s - stock\ index_t}{Stock\ index_t}\right) \times 100\% \quad (t \leq t_0 + 24)$$

$$Burst\ Time = t - t_0$$
4. Empirical Results

4.1. The United States

**Figure 4-1:** the Bubble Points of DJI

The red dot in Figure 4-1 represents a bubble in the stock price index at this time, that is, the three technical indicators of the current stock price index trigger the conditions. As can be seen from the figure, there are 31 bubble points in the US stock market, and most of them are distributed near the top of the peak. The 31 bubble points were further studied to see if they would burst within 6 months.

The first figure in Figure 4-2 shows the maximum monthly drop distribution of the bubbles in the observation interval. The first bar indicates the number of bubbles with a monthly drop less than 5% within the 6-month observation period. The second bar indicates the number of bubbles with a drop between 5% and 6%, and the other bars are the analogous. It can be seen from the figure that 31 bubble points, the maximum monthly drop of 6 bubbles are not greater 5%, indicating that there are 6 bubbles not bursting and 27 bubbles bursting in the US market. Thus, the bubble burst probability is 87.1%. The 27 bursting bubbles fall with the range of 5% to 8%, indicating that the impact of the bubble burst on the US market is small.

The second figure in Figure 4-2 is used to observe the bubble bursting time distribution, which is the time from bubble appearing to bubble bursting (drop more than 5%). As can be seen from the
figure, the 27 bubbles all burst within 20 weeks, and the bursting time was concentrated on the range of 0 to 4 weeks, indicating that the bubbles burst fast in the US market.

In summary, the United States, as the most matured stock market in the world, will burst in a short period of time after the bubble appearing, so the impact of the bubble burst on the market is relatively small. It can be seen that the stock price changes in the US market are relatively stable and the ability to resist risks is good.

4.2. Germany

Figure 4-3: the Bubble Points of DAX

![Image](image-url)

Figure 4-4: the Bubble Drop Distribution and Bursting Time Distribution of DAX

![Image](image-url)

It can be seen from Figure 4-3 that there are a total of 43 bubbles in Germany, and more concentrated before the year of 2000. As we all know, 1997 was the climax of the world economy and at the beginning of 1998, the Germany economy continued to develop at a high speed. However, since August, due to the impact of the Russian financial crisis and the US stock market plunging, the Germany stock market has also declined. The bubble in the vicinity of 2000 was due to the advent of the Internet era, the Internet-related industry or company name was linked to the Internet, and its share price rose rapidly, which caused the Internet bubble in 2000.

From the first diagram in Figure 4-4, it can be seen that 5 of the 43 bubble points have not broken, and the Germany stock market bubble burst probability is 88.4%. When the bubble bursts, the
maximum drop in the month is concentrated in the range of 5% to 7%. Additionally, there are 3 bubbles drop 10% to 12%. It shows that the bubble burst in the Germany stock market has less impact on the market generally, but there is still a certain chance that there will be a sharp decline.

The second figure in Figure 4-4 shows the bursting time distribution of 38 burst bubbles. It can be seen from the figure that half of the bubbles burst in 0~4 weeks, indicating that the Germany stock market bubble bursts rapidly.

In summary, the Germany stock market is more sensitive to the bubbles. When the bubble appears, the market reacts before it expands too far. Therefore, in most cases, the bubble burst will not seriously impact the market.

4.3. Japan

**Figure 4-5:** the Bubble Points of N225

It can be seen from Figure 4-5 that the Japan stock market has a total of 44 bubbles, and the bubble point was concentrated in 2013, mainly because the Japanese government conducted restructuring policies such as expansionary monetary policy and a series of measures to promote economic growth, e.g., consumption tax reduction. These policies effectively stimulated the strong performance of the stock market in 2013, causing the stock price to rise sharply.

The first diagram in Figure 4-6 shows the distribution of the maximum monthly drop of 44 bubbles in the observation interval. It can be seen from the figure that the maximum monthly drop of 5
bubbles are not greater than 5%, indicating that there are 5 bubbles not bursting and 39 bubbles bursting in the Japan market. The bubble bursting probability is 88.6%. The maximum drop in the month was concentrated in the range of 5%~6% and 11%~12%, indicating that there is a greater chance that the Japanese stock bubble will hit the market sharply, causing the stock price to fall by 11%~12% within the month.

The second figure in Figure 4-6 shows the bursting time distribution of 39 burst bubbles. It can be seen from the figure that most of the bubble have a burst time of more than 8 weeks, indicating that the Japan stock market bubbles take more time to burst.

In summary, the Japan stock market is not sensitive enough to the bubble. When the bubble is formed, it will break down after a long period of expansion. Therefore, the bursting of the expanded bubble will hit the stock market more seriously.

5. Conclusion
In observation period, the number of bubbles in the stock indices of the US, Germany and Japan was 31, 43 and 44, respectively. And the probabilities of bubble bursting were all greater than 87%. This shows that the bubbles identified by the technical indicators burst with high probability.

Comparing the bubble drop distribution of three countries, the overall drop in the US market is small, followed by Germany, while Japan has a greater chance of a sharp drop. It shows that the US market has stronger anti-risk ability in the three stock markets. Even if the stock price has a bubble, its impact on the stock market is relatively small.

Comparing the bubble bursting time distribution of the three countries, most of Germany's bubble points have a shorter bursting time, showing that Germany is more sensitive to stock price bubbles and its bursting response is rapid. The bursting time of the US market bubble is also short, and it bursts before it expanded further. While the Japanese bubbles burst after it expanded, so they take longer time to burst.

In summary, if the bubbles take long time to burst, they have the greater chance to expand and lead to a more serious impact on the market when they burst. Therefore, discovering the stock price bubble as soon as possible and taking measures to prevent the bubble from further expanding can eliminate potential threats of stock bubbles and promote the orderly operation of financial markets.

References

