Identifying the Stock Bubble Period: Evidence from Long Term S&P 500 Index

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Abstract

This study performs intrinsic bubble tests over 1871-2004 sample periods using annual data on U.S. S&P 500 stock prices and dividends. The estimated results reject the null hypothesis of no bubble over the full sample period. It means that S&P 500 stock bubble exists over 1871-2004. However, results of sub-periods tests provide evidence that intrinsic bubble is only present over pre-1950 sub-periods but absent from the sub-periods containing post-1951 data.

Keywords: Stock Market Bubble, Intrinsic Bubble, Predict
1. Introduction

A speculative stock bubble occurs when the stock price deviates from its fundamentals, usually measured by dividends or earnings. In the U.S. history, during the 1920s, the 1980s, the 1990s and the late 2000s, stock prices rose considerably above the values that could be reasonably justified by dividends or earnings. Shiller (2005) argued that there are ambiguous relations between stock prices changes and dividends changes and between stock price changes and earnings changes during different periods. For examples, real S&P stock prices increased almost sevenfold from 1920 to 1929, and real earnings tripled over the same time period. However, low real earnings increase of only 16 percent, compared with high stock prices jump of threefold from 1950 to 1960, suggests that correspondence between price growth and earning growth is less than clear.

The bubbles literature includes research on rational bubbles and intrinsic bubbles. Rational bubbles are generated by extraneous events or rumors and driven by self-fulfilling expectations which are not relevant to the fundamentals. Examples include Blanchard and Watson (1982), Blanchard (1979), and Flood and Garber (1980). However, the empirical results on this type of bubble are inconclusive. Diba and Grossman (1988) and Barsky and DeLong (1993) fail to reject the null hypothesis of no bubbles, while West (1987) and Wu (1997) reach the opposite conclusion. Unlike rational bubbles, intrinsic bubbles are driven by fundamentals alone. This type of bubbles was first introduced in Froot and Obstfeld (1991). They show that several puzzling behavior of United States stock prices may be explained by the presence of a specific type of rational bubble. They call bubbles of this type “intrinsic” bubbles, because they derive all of their volatility from exogenous economic fundamentals, dividends, and none from extraneous factors. Ma and Kanas (2004) point out that a finding of a long-run nonlinear stock price-dividend relationship is interpreted as evidence that intrinsic bubble is relevant in the long run and, hence, is important in explaining the long-run excessive volatility of stock prices. Empirically, they find significant evidence to support their model based on estimations for the U.S. market from 1871 to 1996.

Froot and Obstfeld (1991) argue there exists intrinsic bubble during sample period between 1900-1988. However, it was not pointed out whether stock prices deviate from their fundamental during the whole period or intermittently in some subsamples of their full sample period. Hence, we could not indentify stock bubble period from their studies. In light of intrinsic bubbles literature, our goal is to identify stock bubble
periods, which are critical for investors to allocate their portfolios.

The paper is structured as follows. Section 1 is an Introduction. In section 2, we review the intrinsic bubble model. In section 3, we describe data, perform the tests, and present the empirical results. Section 4 provides a summary and a conclusion.

2. Research Method

Froot and Obstfeld (1991) propose that relationship between the real stock price and dividends presented by (1), it means that the real stock price should be equal to the present discounted value of real dividend payment plus the real stock price of next period. Let \( P_t \) is the real stock price at the beginning of period \( t \), \( D_t \) is the real stock dividend paid at the end of period \( t \), \( r \) is the constant real rate of discount.

\[
P_t = e^{-r} E_t (D_t + P_{t+1}) \tag{1}
\]

Where \( E_t (\cdot) \) is the market’s expectation conditional on information known at the beginning of period \( t \).

The present value solution \( P^{PV}_t \) is a particular solution for real stock price \( P_t \) solved from equation (1). We call \( P^{PV}_t \) is the fundamental value of stock price, which equates a stock’s price the sum of the present discounted value of expected future dividends payments.

\[
P^{PV}_t = \sum_{s=1}^{m} e^{-r(s-t)} E_s (D_s) \tag{2}
\]

Under transversality condition (3), the present value solution can be derived by successive forward substitutions into (1) converges to (2). If the present value (2) always exists, continuously compounded growth rate of the expected dividends is less than \( r \). There are other solutions other than (2) but they can’t satisfy (3).

\[
\lim_{s \to 0} e^{-r} E_s (P_s) = 0 \tag{3}
\]

The process of log dividends \( d_t = \ln(D_t) \) is assumed to be a random walk with a drift \( \mu \):

\[
d_{t+1} = \mu + d_t + \xi_{t+1} \tag{4}
\]

where residual of regression \( \xi_{t+1} \sim N(0, \sigma^2) \) is a normal random variable with
conditional zero mean and standard deviation $\sigma$. (4) is used to get the present value of stock price that is directly proportional to dividends:

$$P_i^{pv} = \kappa D_i$$

(5)

where $\kappa = (e^r - e^{\mu + \sigma^2/2})^{-1}$. The assumption that the sum in (2) converges implies $\mu + \sigma^2/2$ is smaller than $r$.

Let rational bubble $\{B_i\}_{i=0}^{\infty}$ be any sequence of random variable such that

$$B_i = e^{-r}E(B_{i+1})$$

(6)

Some rational bubbles are driven from variables other than the fundamental, but the bubbles here depend only on the fundamental of asset price. Such bubbles are called “Intrinsic bubbles”, because they depend on dividends alone. The intrinsic bubble $B_i$ is postulated to be a nonlinear function of fundamentals that satisfies (6). Let

$$B(D_i) = cD_i^\lambda$$

(7)

where $\lambda$ is the positive root of quadratic equation

$$\frac{\sigma^2}{2}\lambda^2 + \mu\lambda - r = 0$$

(8)

and $c$ is an arbitrary constant.

If bubble exists and $P_i = P_i^{pv} + B_i$ is a solution to (1), then real stock price $P_i$ can be thought of the sum of present value $P_i^{pv}$ and a rational bubble $B_i$.

$$P(D_i) = P_i^{pv} + B(D_i) = \kappa D_i + cD_i^\lambda$$

(9)

The inequality $r > \mu + \sigma^2/2$ implies $\lambda$ needs to exceed 1. There is an explosive nonlinear relation between bubbles and dividends, so stock prices may overreact to information about dividends.

Froot and Obstfeld(1991) divide (9) by $D_i$, because of the collinearity among the explanatory variables, before an equation for price-dividend ratio is estimated. The null hypothesis of no bubble implies that $c_i = 0$.
\[
\frac{P_t}{D_t} = c_0 + c_1 D_{t-1}^{\delta-1} + \zeta_t
\]

(10)

3. Data and Empirical Results

3.1 Data

This study uses annual data on U.S. S&P 500 stock prices and dividends from an update of the data described in Shiller (1989).\(^1\) The stock prices are January values for Standard and Poor Composite Stock Price Index. The dividends and earnings are annual average of the year. Nominal stock prices and dividends are deflated by the consumer price index to get real stock prices, dividends and earnings. The sample period is from 1871 to 2004. The total sample consists of 134 annual observations (N = 134).

Different sample periods are used in the empirical analyses. Analyses are conducted using the full sample period from 1871-2004 and for 9 different overlapping sub-periods with length of 50 years. The first sub-period spans from 1871 to 1920. The second sub-period spans 1881 to 1930, and etc. The last sub-period is 1951 to 2000.

\[\text{Fig. 1 Real stock price, fundamental plus bubble, and fundamental from 1871 to 2004}\]

3.2 Intrinsic Bubble Tests

We use the method in Froot and Obstfeld (1991) to test whether there are intrinsic bubbles over the whole sample period 1871-2004. The parameter $\mu$ in equation (4), the growth trend in dividends, is estimated as 0.012, and the parameter $\sigma$, the standard deviation of residual of log-dividend regression, is estimated as 0.118. The sample-average gross real return on stocks is $e^r = 1.086$ per annum. From equation (5), we can conclude that one dollar increase in dividends should result in a raise of stock prices by $\kappa$ dollars.

$$\kappa = \left( e^r - e^{\mu + \sigma^2/2} \right)^{-1} = \left( 1.086 - e^{0.012 + 0.118^2/2} \right)^{-1} = 14.9$$

and we can find the positive root of $\lambda = 2.71$ from solving equation (8).

Panel A of Table 1 reports the estimated result for intrinsic bubble tested by equation (10). We achieve $c_0 = 11.991$ (t-statistic is 4.73) and $c_1 = 0.242$ (t-statistic is 3.70). Two coefficients are all statistically significant with 1% level of significance. The null hypothesis of no bubble implies $c_1 = 0$, therefore, the null hypothesis of no intrinsic bubble is rejected.

![Fig. 2 Real Dividend, fundamental and Bubble from 1871 to 2004](image)
Fig. 1 compares real stock prices, $P_t$, with fundamental plus bubble, $\hat{P}_t$, and fundamental, $\hat{P}_t^{fv}$, in natural log value. Fig. 2 presents real dividends, $D_t$, bubble, $\hat{B}_t$, and fundamental, $\hat{P}_t^{fv}$, in natural log value. Bubble has grown over time and has been particularly large during the post-World War II period. Further, bubble component is smaller than fundamental component before 1950 because dividend is not big enough to explode bubble. Fig. 1 indicates that $\hat{P}_t$ explains real stock price movement during 1900-1975 in a better matter. $\hat{P}_t$ overestimates real stock price during 1975-1995. $\hat{P}_t$ underestimates real stock price during 1996-2004. However, the S&P stock price was raised to an unprecedented level with sharp increase during this period.

Table 1 Intrinsic Bubble Tests for Full Sample Period and Different Sub-periods
This table contains the slope coefficients and $t$-statistics (in brackets) of Equation (10)
$P_t / D_t = c_0 + c_1 D_t \lambda + \zeta_t$ for different sub-periods. Panel A shows the results for full sample period, 1871-2004. Panel B shows the results for overlapping sub-periods with 50 years in length. The standard errors are Newey-West, allowing for serial correlation and conditional heteroscedasticity.

<table>
<thead>
<tr>
<th>Period</th>
<th>Bubble</th>
<th>$c_0$</th>
<th>$c_1$</th>
<th>$\lambda$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A. Full sample period 1871-2004</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1871-2004</td>
<td>Yes</td>
<td>11.9910**</td>
<td>0.2418**</td>
<td>2.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[4.7334]</td>
<td>[3.6961]</td>
<td></td>
</tr>
<tr>
<td><strong>Panel B. Overlapping subperiods with 50 years in length</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1871-1920</td>
<td>No</td>
<td>19.3760**</td>
<td>0.0714</td>
<td>2.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[7.4629]</td>
<td>[0.4138]</td>
<td></td>
</tr>
<tr>
<td>1881-1930</td>
<td>No</td>
<td>21.0256**</td>
<td>-0.0037</td>
<td>2.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[7.2958]</td>
<td>[-0.2008]</td>
<td></td>
</tr>
<tr>
<td>1891-1940</td>
<td>No</td>
<td>20.7865**</td>
<td>-0.0463</td>
<td>2.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[5.4039]</td>
<td>[-0.1232]</td>
<td></td>
</tr>
<tr>
<td>1901-1950</td>
<td>No</td>
<td>17.7927**</td>
<td>0.1443</td>
<td>2.16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[6.0274]</td>
<td>[0.5772]</td>
<td></td>
</tr>
<tr>
<td>1911-1960</td>
<td>Yes</td>
<td>14.6650**</td>
<td>0.1538*</td>
<td>2.60</td>
</tr>
</tbody>
</table>
1921-1970  Yes  
2.42  
1931-1980  Yes  
2.70  
1941-1990  Yes  
3.54  
1951-2000  Yes  
6.01  

** Significant at the 0.01 level.

Panel B of Table 1 reports the estimated results for intrinsic bubble tested over different sub-periods. The bubble was not found in the first four overlapping sub-periods, namely, 1871-1920, 1881-1930, 1891-1940, 1901-1950. However, the null hypothesis of no bubble was rejected in the latter five overlapping sub-periods of 1911-1960, 1921-1970, 1931-1980, 1941-1990, and 1951-2000. It seems that the real dividend is not enough to intrigue bubble explosion over all the sub-periods before 1950. The exponent of dividend $\lambda$ in the bubble equation (7) falls between 2 and 3 for all sub-periods before 1980. However, $\lambda$ jumps to 3.54 over 1941-1990 sub-period and bounces sharply to 6.01 over 1951-2000 period. The sharp rising in exponent $\lambda$ conforms to the record high stock prices during 1980-2000 sample period.

4. Conclusion

During the 1920s, the 1980s, the 1990s, and the late 2000s, stock prices rose considerably above the values that could reasonably be justified by dividends or earnings. Shiller (2005) presents that there are ambiguous relations between stock price changes and dividends changes, as well as between stock price changes and earnings changes during different periods. Froot and Obstfeld (1991) show there exists intrinsic bubble during 1900-1988 sample period. However, it was not pointed out whether stock prices deviate from their fundamental during the whole period or intermittently in some subsamples of their full sample period. Hence, we could not identify stock bubble period from their studies. In light of intrinsic bubbles literature, our goal is to identify stock bubble periods, which are critical for investors to allocate their portfolios.

To test the hypothesis, we split the whole sample containing annual data on 1871-2004
U.S. S&P 500 stock prices into several overlapping sub-periods to check whether intrinsic bubble exists on each of sub-periods. There are two main results. First, the existence of the bubble is confirmed, as stated in Froot and Obstfeld (1991), although the full sample period of 1871-2004 here extends longer than the counterparts period of 1900-1988. Second, from Fig. 2, it is observed that bubble line pass through fundamental line at about year 1950 and hence the bubble is bigger than the fundamental in magnitude after 1950. The estimated results from sub-periods confirm these findings. The test fails to reject the null hypothesis of no bubble over sub-periods before 1950, but rejects no bubble hypothesis over sub-periods containing data after 1951.

References