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Abstract

This study employs a test of the cointegration null hypothesis to detect the presence of speculative bubbles in six Asian emerging markets. The test has good power against the presence of stochastic explosive root bubbles and we find evidence of bubbles in the stock markets of Taiwan, Malaysia, the Philippines, Indonesia, and Thailand but find no existence of bubbles in South Korea over the sample periods.

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Keywords: stochastic explosive root bubbles, test of the cointegration null hypothesis, Asian stock markets

JEL codes: C13, C32, E3

1. Introduction

If a speculative bubble exists, the residual process from the regression of stock prices on dividends will not be stationary. Therefore, Diba and Grossman (1988) propose applying standard unit root tests to the regression residuals to obtain evidence of bubbles. However, standard unit root tests may erroneously reject the bubble existence when prices contain stochastic bubbles. In this paper, we examine, by means of Monte Carlo experimentation, the power performance of a new test of the cointegration null hypothesis in the presence of bubbles with a stochastic explosive root. Since the test has satisfactory powers, we apply it to data on the six Asian emerging stock markets of Taiwan, Malaysia, Indonesia, the Philippines, Thailand, and South Korea for bubble detection.

2. Present value model and stochastic explosive bubbles

The present-value stock prices model can be written as:

$$\boldsymbol{P}_t = \boldsymbol{e}^{-r} \boldsymbol{E}_t (\boldsymbol{D}_t + \boldsymbol{P}_{t+1}), \tag{1}$$

where $\boldsymbol{P}_t$ is the real price of a stock at the beginning of period *t*, $\boldsymbol{D}_t$ is the real dividends paid over period *t*, $\boldsymbol{r}$ is the instantaneous real discount rate, and $\boldsymbol{E}_t$ is the mathematical expectation conditional upon the information at the beginning of period *t*.

Recursively substituting forward for the expected next-period price using the law of iterated expectations and imposing the transversality condition, $\lim_{j\to\infty} e^{-r(j+1)} E_t(P_{t+1+j}) = 0$, would yield the following fundamental price solution to (1):

$$P_t^f = \sum_{j=0}^{\infty} e^{-r(j+1)} E_t(D_{t+j}). \tag{2}$$

If the transversality condition fails to hold, the general solution to (1) is

$$P_t = P_t^f + B_t, \tag{3}$$

where B_t is the bubble solution that satisfies

$$B_t = e^{-r} E_t(B_{t+1}). \tag{4}$$

By re-arranging the terms in Eq. (2) and substituting the resulting expression for P_t^f into Eq. (3), we obtain

$$P_t = (e^r - 1)^{-1} D_t + (e^r - 1)^{-1} \sum_{j=1}^{\infty} e^{-r(j)} E_t(\Delta D_{t+j}) + B_t. \tag{5}$$

Eq. (5) implies that if P_t and D_t are first-difference stationary, then P_t and D_t are cointegrated with cointegrating parameter $(e^r - 1)^{-1}$ so long as $B_t = 0$. However, P_t and D_t cannot be cointegrated if $B_t \neq 0$. Hence, the rejection of cointegration between stock prices and dividends implies the existence of explosive bubbles.

Standard cointegration methods, however, may overly reject the noncointegration null hypothesis when the class of periodically collapsing bubbles proposed by Evans (1991) is present in the price data. Charemza and Deadman (1995) further examine whether the weakness of standard tests extends to a class of stochastic explosive root (STER) bubble processes, which is defined as:

$$\boldsymbol{B}_{t+1} = \theta_{t+1}\boldsymbol{B}_t . \boldsymbol{u}_{t+1}, \qquad (6)$$

where θ_{t+1} is a random variable that satisfies $\boldsymbol{E}_t(\theta_{t+1}) = \boldsymbol{e}^r > 1$, and is exogenous from $\boldsymbol{B}_t$ and independent from $\boldsymbol{u}_{t+1}$, where $\boldsymbol{u}_{t+1}$ is a stationary, and identically distributed series with $\boldsymbol{E}_t(\boldsymbol{u}_{t+1}) = 1$. The nonnegative property of the STER bubble can be ensured by the multiplicative specification and the lognormal formulation for both θ_t and $\boldsymbol{u}_t$, i.e. $\theta_t = \exp(\Theta_t)$ and $\boldsymbol{u}_t = \exp(\boldsymbol{U}_t)$, where $\Theta_t \sim \boldsymbol{IIN}(\boldsymbol{e}^r - \sigma_\Theta^2/2, \sigma_\Theta^2)$ and $\boldsymbol{U}_t \sim \boldsymbol{IIN}(-\sigma_U^2/2, \sigma_U^2)$. Also, due to the stochastic nature of θ_t, the STER bubble process is highly explosive if $\theta_t > \boldsymbol{e}^r$, mildly explosive if $1 < \theta_t < \boldsymbol{e}^r$, and collapsing if $\theta_t < 1$. Thus, the bursting behavior can be solely controlled by the value of θ_t for any given values of $\boldsymbol{r}$ and $\sigma_{\boldsymbol{u}}$.

The simulation study of Charemza and Deadman (1995) shows that the standard unit root tests fail to detect the STER bubbles. This arises because the STER bubbles, as in the case of periodically collapsing bubbles, can burst and re-start to grow periodically, which therefore do not behave like a fixed-coefficient autoregressive process as assumed by the standard tests. Although the class of STER processes represents a general way of modeling bubble processes and encompasses a wide range of nonnegative financial processes, it has received little research attention in the literature. To fill this gap, we propose using Xiao's (1999) recursive-estimates test for conducting bubble detection.

3. Methodology

The testing methodology of the empirical bubble analysis is taken from the two-step approach of Wu and Xiao (2002). The first step is to estimate the residuals, denoted $\hat{\boldsymbol{v}}_t^+$, from the regression of $\boldsymbol{P}_t$ on $\boldsymbol{D}_t$ using the fully-modified (FM) method of Phillips and Hansen (1990). The second step is to apply Xiao's (1999) recursive-estimates test statistic $\boldsymbol{R}_T$ to $\hat{\boldsymbol{v}}_t^+$ for examining the null hypothesis of cointegration:

$$\boldsymbol{R}_T = \max_{t=1\ldots T} \frac{\boldsymbol{i}}{\hat{\varpi}_{\nu.\boldsymbol{D}}\sqrt{\boldsymbol{T}}} \left| \frac{1}{\boldsymbol{i}}\sum_{t=1}^{\boldsymbol{i}} \hat{\boldsymbol{v}}_t^+ - \frac{1}{\boldsymbol{T}}\sum_{t=1}^{\boldsymbol{T}} \hat{\boldsymbol{v}}_t^+ \right|, \qquad (7)$$

where $\hat{\varpi}_{\nu.\boldsymbol{D}}^2$ is the long-run variance parameter of the FM regression, and $\boldsymbol{T}$ is the sample size. Since the limit distribution of $\boldsymbol{R}_T$ is non-standard, its critical values have to be obtained from Monte Carlo simulations.

Under the cointegration null hypothesis, the residuals, $\hat{\boldsymbol{v}}_t^+$, replicate the stationary behavior of disequilibrium errors and display a limited amount of fluctuations. If $\hat{\boldsymbol{v}}_t^+$ contains an explosive bubble component, the residual process will exhibit excessive fluctuations even if the explosive root of the process is nonlinear. Consequently, the partial sum of $\hat{\boldsymbol{v}}_t^+$ has a much larger order of magnitude than the non-bubble case, leading the $\boldsymbol{R_T}$ statistic to diverge with $\boldsymbol{T}$. The divergence rate of $\boldsymbol{R_T}$ under the alternative of noncointegration, however, depends on the choice of the bandwidth. For a given sample size, the power of the test will increase when the bandwidth parameter decreases. But as the bandwidth decreases it may cause a rise in the size distortion in the presence of persistent residual process (Xiao and Phillips, 2002). In view of this, the test should be calculated and evaluated using a range of appropriate bandwidth parameters.

4. Monte Carlo Simulations

In conducting the Monte Carlo experiments, we simulated data series for real stock price, dividend and bubbles. The simulated bubble processes, $\boldsymbol{B_t}$, were generated according to Eq. (6), where $\boldsymbol{r}$ was set at 0.25% with σ_Θ varying among $\{0, 0.1, 0.15, 0.2, 0.25, 0.3, 0.4, 0.5\}$ and σ_U fixed at the value of 0.02.[1] The assumed process for the real dividends $\boldsymbol{D_t}$ follows a random walk specification:

$$\boldsymbol{D_t} = \boldsymbol{c_D} + \boldsymbol{D_{t-1}} + \varepsilon_{\boldsymbol{Dt}}, \qquad \varepsilon_{\boldsymbol{Dt}} \sim \boldsymbol{N}(\mu_{\boldsymbol{D}}, \sigma_{\boldsymbol{D}}^2). \tag{8}$$

We chose $\boldsymbol{c_D} = 0$, $\sigma_{\boldsymbol{D}} = 0.0005$ and $\mu_{\boldsymbol{D}} = 0$, which are the average values of the estimated parameters obtained by applying the OLS regression to Eq.(8) using the

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[1] We set $\boldsymbol{r}$ to be 0.25%, which corresponds to 3% on an annual basis. The other parameters of the STER bubbles are same as those used in Charemaz and Deadman (1995).

actual real dividends data from the six stock markets under study.[2] With $\boldsymbol{D}_t$ generated using Eq.(8), $\boldsymbol{P}_t^f$ is simply equal to $(\boldsymbol{e}^r - 1)^{-1}\boldsymbol{D}_t$, and $\boldsymbol{P}_t$ is obtained by adding $\boldsymbol{B}_t$ to $\boldsymbol{P}_t^f$. The sample length of the simulated series was set at 180 so that it matches the sample size of the actual data series used in the subsequent empirical analysis.

The power of the test was found by applying the $\boldsymbol{R}_T$ statistic to the residuals, $\hat{\boldsymbol{v}}_t^+$, and then by calculating the number of Monte Carlo replications that have correctly rejected the cointegration null at the 5% significance level. As mentioned above, the power of the $\boldsymbol{R}_T$ test is sensitive to the selection of bandwidth. For comparison, we have chosen a range of representative bandwidth parameters: $\boldsymbol{l}_1 = 0.5\boldsymbol{T}^{1/3}$, $\boldsymbol{l}_2 = \boldsymbol{T}^{1/3}$, $\boldsymbol{l}_3 = 4(\boldsymbol{T}/100)^{1/4}$, $\boldsymbol{l}_4 = 6(\boldsymbol{T}/100)^{1/4}$ and $\boldsymbol{l}_5 = 8(\boldsymbol{T}/100)^{1/4}$. $\boldsymbol{l}_1$ and $\boldsymbol{l}_2$ are of order $\boldsymbol{T}^{1/3}$, while $\boldsymbol{l}_3$, $\boldsymbol{l}_4$ and $\boldsymbol{l}_5$ are of order $\boldsymbol{T}^{1/4}$. These bandwidths have been widely adopted in such previous studies as Xiao and Phillips (2002), and Wu and Xiao (2002).[3]

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[2] The details of the data will be described in Section 5.

[3] We exclude from our simulation study the choices of bandwidth equal to $2\boldsymbol{T}^{1/3}$ and Andrews' (1991) data-dependent bandwidth because, as shown by Xiao and Phillips (2002), the former suffers from considerable power loss when the sample size is small (the power is below 50% for $\boldsymbol{T} < 300$), and the latter has almost no power for any sample sizes.

Table 1 presents the calculated rejection frequencies of the $\boldsymbol{R_T}$ test in the presence of the simulated STER bubble process. The results depend upon the values of σ_Θ and the choices of bandwidth. In particular, the rejection rate tends to increase as the value of σ_Θ falls, which occurs because the bubble process is subject to less frequent collapses as σ_Θ becomes smaller. The power of the test strengthens as the value of the bandwidth decreases. To sum up, the rejection frequency of $\boldsymbol{R_T}$ exceeds 70% in most cases, which shows that the power is quite high in detecting the class of STER bubbles.

Table 1 Empirical power for detecting the STER bubbles

σ_Θ	l_1	l_2	l_3	l_4	l_5
0.0	97.50	87.36	91.58	87.76	77.00
0.1	94.92	78.76	84.72	73.82	64.98
0.15	94.70	79.76	85.18	75.36	66.96
0.20	94.76	80.48	85.24	76.08	66.94
0.25	95.00	80.88	85.80	76.42	68.34
0.30	94.70	80.80	86.14	75.84	67.18
0.40	94.92	78.34	84.92	72.38	62.52
0.50	93.34	71.98	83.76	64.92	53.40

Notes:

(1) The rejection frequencies are based on 5000 replications for a sample size of 180.

(2) A constant is included in the FM regression of P_t on D_t.

(3) The 5% critical value for R_T is 1.122, which is obtained from 20,000 Monte Carlo replications.

(4) For the case where $T = 180$, the bandwidth parameters are equal to 2, 5, 4, 7, and 9 when $l = l_1, l_2, l_3, l_4$, and l_5, respectively.

5. Data and empirical results

The data series, collected from the *Datastream*, include the monthly aggregate stock price indices, dividend yields, and price indices for the stock markets of Taiwan, Malaysia, Indonesia, the Philippines, Thailand, and South Korea. The sample periods span from January 1991 to December 2005 for all markets except the Philippines, where the data start from May 1992. The dividend series are estimated by multiplying the price indices by the dividend yields. The stock price indices and dividends are deflated by the producer price index for Malaysia, and by the consumer price indices for the other markets.

The empirical results of the $\boldsymbol{R_T}$ statistics are reported in Table 2. Although the values of the test statistics depend somewhat on the choices of bandwidth, they generally produce consistent results on the empirical analysis.[4] For the data on Taiwan, Malaysia, the Philippines, and Indonesia, the null hypotheses of cointegration are rejected for all the bandwidth choices. Further, the test rejects the cointegration null using the data on Thailand for all but one bandwidth, indicating the possibility that a bubble exists. However, the test cannot reject the cointegration null hypothesis in the case of South Korea across all the chosen bandwidths except $\boldsymbol{l}_1$. This exception may be due to the large size distortion in the presence of the autocorrelation in the residuals. Therefore, the results are consistent with the nonexistence of bubbles for South Korea.[5]

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[4] The $\boldsymbol{R_T}$ statistic can be used as a stationarity test. We reject the null hypothesis of stationarity in favour of nonstationary alternative using $\boldsymbol{R_T}$ for all real stock prices and dividends at the simulated 5% critical value of 0.8531.

[5] Following the argument of Wu and Xiao (2002), we tried to add the interest rate yields into the fundamental regressions to allow for the risk premium effects. However, the results of the cointegration tests are qualitatively the same.

6. Conclusion

We adopted a recursive-estimates test, based on the work of Xiao (1999), to detect price bubbles in six Asian emerging stock markets. The test, evaluated by means of Monte Carlo experiments, performs well in the presence of the STER bubble processes. The empirical evidence supports the existence of bubbles in the stock markets of Taiwan, Malaysia, the Philippines, Indonesia, and Thailand from the early 1990s to 2005.

Table 2 Testing for stock price bubbles using the R_T test

Markets	l_1	l_2	l_3	l_4	l_5
Taiwan	1.8526*	1.3795**	1.4922*	1.3292**	1.1983**
Malaysia	2.1982*	1.6254*	1.7623*	1.5602*	1.3921*
Indonesia	2.3459*	1.7642*	1.9055*	1.6982*	1.5247*
Philippines	2.7551*	2.0252*	2.1980*	1.9750*	1.7367*
Thailand	1.4241*	1.0684***	1.1614**	1.0283***	0.8999
South Korea	1.2256**	0.8173	0.9337	0.7881	0.6900

Notes:

(1) A constant is included in the FM regression of P_t on D_t.

(2) Critical values for R_T equal 1.3505, 1.1220, and 1.0091 at the 1%, 5%, and 10% levels, respectively.

(3) Significance levels are denoted as follows: *(1%), **(5%), and ***(10%).

References:

Andrews, D., 1991. Heteroskedasticity and autocorrelation consistent covariance matrix estimation. Econometrica 59, 817-858.

Charemza, W.W. and Deadman, D.F., 1995. Speculative bubbles with stochastic explosive roots: The failure of unit root testing. Journal of Empirical Finance 2, 153-163.

Diba, B.T. and Grossman, H.I., 1988. Explosive rational bubbles in stock prices? American Economic Review 78, 520-530.

Evans, G.W., 1991. Pitfalls in testing for explosive bubbles in asset prices. American Economic Review 81, 922-930.

Phillips, P.C.B. and Hansen, B.E., 1990. Statistical inference in instrumental variables regression with I(1) processes. Review of Economic Studies 57, 99-125.

Wu, Z. and Xiao, Z., 2002. Are there speculative bubbles in stock markets? Evidence from an alternative approach. Working paper, University of Michigan Business School (www.nes.ru/~agoriaev/Papers/Wu Bubbles US Honkong.pdf)

Xiao, Z., 1999. A residual based test for the null hypothesis of cointegration. Economic Letters 64, 133-141.

Xiao, Z. and Phillips, P.C.B., 2002. A CUSUM test for cointegration using regression residuals. Journal of Econometrics 108, 43-61.

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Important Note

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