E C O N O M I C S B U L L E T I N

Rational Bubbles in the Korea Stock Market? Further Evidence based on Nonlinear and Nonparametric Cointegration Tests

Wen-Chi Liu
Department of Business Administration, Da-Yeh University, Chang-Hua, Taiwan

Tsangyao Chang
Department of Finance, Feng Chia University, Taichung, Taiwan

Abstract

In this study, we revisit the issue as to the presence of Rational Bubbles in the Korea stock market during the May 1996 to November 2007 period using three cointegration tests, namely JJ (Johansen and Juselius, 1990), KSS (Kapetanois et al., 2006) and BN (Bierens, 1997, 2004) approaches. The results from the conventional JJ test support the existence of rational bubbles, whereas those from both nonlinear test of KSS and nonparametric test of BN attest to the absence of rational bubbles in the Korea stock market.

We wish to thank the Associate editor, Dr. Conley and an anonymous referee for their time and effort in reviewing our paper
Citation: Liu, Wen-Chi and Tsangyao Chang, (2008) "Rational Bubbles in the Korea Stock Market? Further Evidence based on Nonlinear and Nonparametric Cointegration Tests." *Economics Bulletin*, Vol. 3, No. 34 pp. 1-12
Submitted: January 5, 2008. **Accepted:** June 6, 2008.
URL: http://economicsbulletin.vanderbilt.edu/2008/volume3/EB-08C30021A.pdf

1. INTRODUCTION

Over the past two decades, a vast amount of research has been devoted to investigating the presence of rational bubbles in stock markets (e.g., Campbell and Shiller, 1987; Diba and Grossman, 1988; Froot and Obstgeld, 1991; Timmermann, 1995; Crowder and Wohar, 1998; Bohl, 2003; Nasseh and Strauss, 2004; Cunado et al, 2005; Mokhtar et al., 2006; Chang et al., 2007, among others). The occurrence of rational bubbles signifies that no long-run relationships exist between stock prices and dividends. In pursuit of determining whether or not stock prices and dividends are cointegrated, empirical studies have, for the most part, employed cointegration techniques. Among the most notable of these is the widely employed Johansen cointegration test (Johansen, 1988; Johansen and Juselius, 1990) which is based on the linear autoregressive model and, as such, assumes that the underlying dynamics are in a linear form. From a theoretical perspective, there is no sound reason to assume that economic systems are intrinsically linear (see, Barnett and Serletis, 2000). In fact, numerous studies have empirically demonstrated that financial time series, such as stock prices, exhibit nonlinear dependencies (see, Hsieh, 1991; Abhyankar et al., 1997). Besides this, substantive evidence from the Monte Carlo simulations in Bierens (1997, 2004), in fact, has indicated that inherent to the conventional Johansen cointegration framework is a misspecification problem when the true nature of the adjustment process is nonlinear and that the speed of adjustment varies with the magnitude of the disequilibrium. The work of Balke and Fomby (1997) also pointed out a potential loss of power in conventional cointegration tests under the threshold autoregressive data generating process (DGP).

Motivated by the aforementioned considerations, the purpose of this study is to revisit the issue as to the presence of Rational Bubbles in the Korea stock market during the May 1996 to November 2007 period using three cointegration tests, namely JJ (Johansen and Juselius, 1990), KSS (Kapetanois et al., 2006) and BN (Bierens, 1997, 2004) approaches. The results from the conventional JJ test fully support the existence of rational bubbles, whereas those from both nonlinear test of KSS and nonparametric test of BN attest to the absence of rational bubbles in the Korea stock market.

2. DATA

The empirical study employs both the monthly KOSPI200 and KOSPI stock price indexes and dividends data over the May 1996 to November 2007 period which we take from Korea Stock Exchange Corporation publications (Website: http://www.kse.or.kr/index.html). The data begin from May 1996 since dividend data are available from this period. Table 1 provides summary statistics for the stock price index return and dividend data for both KOSPI200 and KOSPI. As shown in Table 1, the average monthly stock index returns for both KOSPI200 and KOSPI in the Korea stock market were about 1.44% and 1.80%, respectively, over the entire sample period. The Jarque-Bera tests show that the distribution of both the stock price index returns and dividends data are non-normal. The Ljung-Box statistics with time lags of 5 and 10 periods show that significant linear and nonlinear dependencies exist in the dividends of KOSPI200 and KOSPI, and the stock index returns of KOSPI200.

Table 1. Summary Statistics of the Data

A. KOSPI200	$\Delta \ln P$		ln D	
Mean	0.0144		14.9663	
Std. Dev.	0.1397		0.8442	
Max.	0.7346		16.2439	
Min.	-0.8339		13.3442	
Skewness	-0.2833		0.0030	
Kurtosis	15.6473		1.6875	
Jarque-Bera	1001.7190 ***	(0.0000)	10.8390***	(0.0044)
Ljung-Box Q(5)	15.7240***	(0.0080)	676.5600 ***	(0.0000)
Ljung-Box Q(10)	17.7140*	(0.0600)	1239.9000 ***	(0.0000)
Ljung-Box $Q^2(5)$	30.5480 ***	(0.0000)	679.3400 ***	(0.0000)
Ljung-Box $Q^2(10)$	31.7140 ***	(0.0000)	1246.5000 ***	(0.0000)
B. KOSPI	$\Delta \ln P$		ln D	
Mean	0.0180		15.1747	
Std. Dev.	0.1166		0.7825	
Max.	0.7361		17.0223	
Min.	-0.3175		13.8702	
Skewness	1.8552		0.1153	
Kurtosis	12.4829		1.8759	
Jarque-Bera	648.0743***	(0.0000)	8.2854 **	(0.0159)
Ljung-Box Q(5)	3.5762	(0.6120)	662.7400 ***	(0.0000)
Ljung-Box Q(10)	5.1273	(0.8830)	1208.6000 ***	(0.0000)
Ljung-Box $Q^2(5)$	1.2000	(0.9450)	658.1300 ***	(0.0000)
Ljung-Box $Q^2(10)$	1.7308	(0.9980)	1201.1000 ***	(0.0000)

Notes: 1. Numbers in parentheses indicate the p-value for J-B normality.

2. The ***, **, and * indicate significance at the 0.01, 0.05 and 0.1 level, respectively.

3. $\Delta \ln P = \ln P_t - \ln P_{t-1}$, $\ln D = \ln D_t$.

3. METHODOLOGY AND EMPIRICAL RESULTS

3.1 Unit Root Tests.

Recently, there is a growing consensus that stock price data might exhibit nonlinearities, and that conventional tests for stationarity, such as the ADF unit root test, have low power in detecting the mean-reverting tendency of the series. For this reason, stationarity tests in a nonlinear framework must be applied. We use the nonlinear stationary test advanced by Kapetanios, Shin, and Snell (2003) (henceforth, KSS test). Following Kapetanios et al. (2003), the KSS test is based on detecting the presence of nonstationarity against a nonlinear but globally stationary exponential smooth transition autoregressive (ESTAR) process. The model is given by

$$\Delta Y_t = \gamma Y_{t-1}\left\{1-\exp\left(-\theta Y_{t-1}^2\right)\right\}+v_t, \qquad (1)$$

Where Y_t is the data series of interest, v_t is an i.i.d. error with zero mean and constant variance, and $\theta \geq 0$ is the transition parameter of the ESTAR model and governs the speed of transition. We are interested in testing the null hypothesis of $\theta=0$ against the alternative $\theta>0$. Under the null hypothesis, Y_t follows a linear unit root process, but Y_t follows a nonlinear stationary ESTAR process under the alternative. One problem with this framework is that the parameter, γ, is not identified under the null hypothesis.

Following Luukkonen, Saikkonen, and Terasvirta (1998) and Kapetanios et al., (2003), we use a first-order Taylor series approximation for $\left\{1-\exp(-\theta Y_{t-1}^2)\right\}$ under the null hypothesis $\theta=0$ and then approximate Eq. (1) by the following auxiliary regression:

$$\Delta Y_t = \xi + \delta Y_{t-1}^3 + \sum_{i=1}^{k} b_i \Delta Y_{t-i} + v_t, \quad t=1,2,\ldots,T \qquad (2)$$

In this framework, the null hypothesis and alternative hypotheses are expressed as $\delta=0$ (nonstationarity) against $\delta<0$ (nonlinear ESTAR stationarity). The simulated critical values for this test are given in Table 1 of Kapetanios et al.¡s (2003). Table 2 reports the KSS nonlinear stationary test results. The results indicate that the four series are integrated of order one.

For the sake of comparison, we also incorporate the Augmented Dickey and Fuller (1981, ADF), the Phillips and Perron (1988, PP) and the Kwiatkowski *et al.* (1992, KPSS) tests into our study. Table 3 shows the results from the non-stationary tests for the stock prices and dividends using the ADF, PP and the KPSS tests. Again, the test results further indicate that the four series are non-stationary in levels and are stationary in first differences.

Table 2. Nonlinear unit root tests based on Kapetanios et al.¡s (2003) approach

Variable	t statistic on $\hat{\delta}$
KOSPI200D	-0.36073(2)
KOSPI200P	-0.15252(2)
KOSPID	0.602791(2)
KOSPIP	0.925619(2)

Notes: 1. The critical values for t statistic on $\hat{\delta}$ are tabulated at Kapetanios et al.¡s (2003) Table 1 of their paper.

2. The ***, **, and * indicate significance at the 0.01, 0.05 and 0.1 level, respectively.

3. The number in the parenthesis indicates the selected lag order of the testing model. Lag-length were chosen based on Campbell and Perron (1991)

Table 3. Conventional Unit Root Test Results

A. Level	ADF	PP	KPSS
KOSPI200D	-0.58916(0)	-0.27514[10]	1.395244[10]***
KOSPI200P	-0.5921(0)	-0.37961[12]	1.357579[10]***
KOSPID	0.571889(0)	0.657886 [2]	1.377864[10]***
KOSPIP	0.85392(0)	0.762842[2]	1.315836 [10]***
B. First difference	ADF	PP	KPSS
KOSPI200D	-11.80847(0)***	-12.35176 [12] ***	0.116288[11]
KOSPI200P	-10.76659 (0) ***	-10.98060 [17] ***	0.095426[14]
KOSPID	-12.5707(0)***	-12.567[3]***	0.277554[3]
KOSPIP	-10.9836(0)***	-10.9711[3]***	0.259555[1]

Notes: 1. The number in parentheses indicates the selected lag order of the ADF model. Lags are chosen based on Campbell and Perron(1991)

2. The number in brackets indicates the selected lag truncation for the Bartlett kernel, as suggested by the New-West(1987) test..

3. The ***, **, and * indicate significance at the 0.01, 0.05 and 0.1 levels, respectively.

In light of these results, we proceed to test whether there were rational bubbles in the Korea stock market during the sample period, and to this end, we employ conventional JJ cointegration test, the KSS nonlinear cointegraion test and Bierens (1997, 2004) nonparametric cointegration approaches.

3.2. Testing For Cointegration

3.2.1. JJ Cointegration Tests based on Johansen and Juselius (1990) Approach

Following Johansen and Juselius (1990), we construct a p-dimensional (2 x 1) vector autoregressive model with Gaussian errors, expressed by its first-differenced error correction form as

$$\Delta Y_t = \Gamma_1 \Delta Y_{t-1} + \Gamma_2 \Delta Y_{t-2} + ... + \Gamma_{k-1} \Delta Y_{t-k+1} - \Pi Y_{t-1} + \mu + \varepsilon_t \quad (3)$$

where Y_t are share price indexes and dividends data studied, ε_t is i.i.d. N(0,Σ), $\Gamma_i = -I + A_1 + A_2 + ... + A_i$, for i=1,2,...,k-1, and $\Pi = I - A_1 - A_2 - ... - A_k$. The Π matrix conveys information about the long-run relationship between Y_t variables, and the rank of Π is the number of linearly independent and stationary linear combinations of variables studied. Thus, testing for cointegration involves testing for the rank of Π matrix r by examining whether the eigenvalues of Π are significantly different from zero.

Johansen and Juselius (1990) propose two test statistics for testing the number of cointegrating vectors (or the rank of Π), namely, the trace (T_r) and the maximum eigenvalue (L-max) statistics. The Johansen method applies the maximum likelihood procedure to determine the presence of cointegrating vectors in nonstationary time series. It is well known the cointegration tests are very sensitive to the choice of lag length. Schwartz Criterion (SC) was used to select the number of lags required in the cointegration test. A VAR model is first fit to the data to find an appropriate lag structure. Table 4 presents the results from the Johansen and Jueslius (1990) cointegration test. As shown in this table, both T_r statistic and L-max statistic suggest that the null hypothesis of no cointegration cannot be rejected. What this means is that the rational bubbles might exist in the Korea stock market during the May 1996 to November 2007 period.

Table 4. JJ Cointegration Test based on Maximum Likelihood Ratio

	Trace test	5% critical value	L-max test	5% critical value
KOSPI200				**(VAR lag = 5)**
$H_0 : r \leq 0$	11.7421	15.49471	11.74085	14.2646
$H_0 : r \leq 1$	0.001246	3.841466	0.001246	3.841466
KOSPI				**(VAR lag = 1)**
$H_0 : r \leq 0$	12.39111	15.49471	11.94735	14.2646
$H_0 : r \leq 1$	0.443754	3.841466	0.443754	3.841466

Notes： 1. Critical values are taken from Osterwald-Lenum (1992).
2. r denote the number of cointegrating vectors.
3. Schwarzt Criterion (SC) was used to select the number of lags required in the cointegrating test.

As we know that the evidence from the Monte Carlo simulations in Bierens (1997, 2004) indicates that the conventional Johansen cointegration framework has a misspecification problem when the true nature of the adjustment process is nonlinear and the speed of adjustment varies with the magnitude of the disequilibrium.

Therefore, in the following section, we proceed to test the existence of rational bubbles in the Korea stock market using both nonlinear and nonparametric cointegratiton tests

3.2.2. KSS Cointegraion Tests based on Nonlinear Unit Root

Using a general nonlinear exponential STR (ESTR) ECM framework and following a pragmatic residual-based two-step procedure in the style of Engle and Granger (1987), Kapetanios et al.¡s (2006) propose that a null hypothesis of no cointegration against an alternative of a globally stationary ESTR cointegration be tested directly by examining the significance of the parameter controlling the degree of nonlinearity in the speed of adjustment. Kapetanios et al.¡s (2006) develop two operational test statistics, denoted t_{NEC} and t_{NEG}, respectively, and derive their asymptotic distributions. The t_{NEC} test refers to the *t*-type statistic obtained directly from the nonlinear ESTR error correction regression, whereas the t_{NEG} test is the nonlinear analogue to the Engle and Granger (EG) statistic for linear cointegration. In our study, only t_{NEG} is used. The results from t_{NEC} are available upon request. According to Kapetanois et al. (2006), the test is specified as

$$Y_t = X_t'\beta_0 + \delta_t + \varepsilon_t, \varepsilon_t \sim IN(0,\sigma^2) \quad (4)$$

$$\Delta\varepsilon_t = \gamma\varepsilon_{t-1}\{1-\exp(-\theta\varepsilon_{t-1}^2)\} + \nu_t \quad (5)$$

where Y_t is the dependent variable (stock prices or dividends in our case), X_t is a vector of nonstationary explanatory variables (dividends or stock prices in our case) and $-2 < \gamma < 0$. We are now interested in testing the null hypothesis of $\theta = 0$ against the alternative $\theta > 0$. Under the null ε_t follows a linear unit root process (no cointegration), whereas it is nonlinear stationary ESTAR process under the alternative (non-linear cointegration). However, the parameter γ is not identified under the null hypothesis. Following Luukkonen et al. (1988) and Kapetanios et al. (2006), we use a first-order Taylor series approximation to $\{1-\exp(-\theta\varepsilon_{t-1}^2)\}$ under the null $\theta = 0$ and approximate Equation (5) by the following auxiliary regression:

$$\Delta\varepsilon_t = \xi + \delta\varepsilon_{t-1}^3 + \sum_{i=1}^{k} b_i\Delta\varepsilon_{t-i} + \nu_t, \quad \text{t = 1, 2,¡ ., T} \quad (6)$$

Here we test the null hypothesis of $\delta = 0$ (no cointegraiton) against the alternative hypotheses of. $\delta < 0$ (non-linear cointegration) using a *t*-type statistic of $t_{\hat{\delta}}$. The simulated critical values for different k in Equation (6) are tabulated at KSS¡s (2003) Table 1 of their paper. Table 5 reports the results from the KSS test and further demonstrate the null hypothesis of no cointegration can be rejected for both

KOSPI200 and KOSPI two cases. These results indicate the absence of rational bubbles in the Korea stock market.

Table 5. KSS Cointegration Tests based on Nonlinear Unit Root (t_{NEG})

Regression	T Statistic on $\hat{\delta}$
KOSPI200_PD	-2.68104(1)**
KOSPI_PD	-2.828182(1)**

Notes:1. The critical values for t statistic on $\hat{\delta}$ are tabulated at Kapetanios et al.¡s (2003) Table 1 of their paper. .

2. The ***, **, and * indicate significance at the 0.01, 0.05 and 0.1 level, respectively.

3. The number in the parenthesis indicates the selected lag order of the testing model. Lag-length were chosen based on Campbell and Perron (1991)

3.2.3. Nonparametric Cointegration Test of Bierens (1997, 2004)

Bierens (1997, 2004) pointed out that one of the major advantages of his nonparametric method lies in its superiority to detect cointegration when the error correction mechanism is nonlinear. We have followed Granger and Terasvorta (1993) by employing a nonlinear test on our error-correction term. The results indicate that the true nature of the adjustment process is nonlinear and that the speed of adjustment varies with the magnitude of the disequilibrium for both KOSPI200 and KOSPI two cases (results are not presented here but are available upon request). Hence we have full confidence in using this test in our study.

The Bierens nonparametric cointegration test considers the general framework to be:

$$y_t = \pi_0 + \pi_1 t + z_t \tag{7}$$

where $\pi_0(qx1)$ and $\pi_1(qx1)$ are the terms for the optimal mean and trend vectors, respectively, and z_t is a zero-mean unobservable process such that Δz_t is stationary and ergodic. Apart from these conditions of regularity, the method does not require further specifications of the DGP for y_t, and in this sense, it is completely nonparametric.

The Bierens method is based on the generalized eigenvalues of the matrices A_m and $(B_m + cT^{-2}A_m^{-1})$, where A_m and B_m are defined in the following matrices:

$$A_m = \frac{8\pi^2}{T}\sum_{k=1}^{m} k^2 (\frac{1}{T}\sum_{t=1}^{T}\cos(2k\pi(t-0.5)/T)z_t)(\frac{1}{T}\sum_{t=1}^{T}\cos(2k\pi(t-0.5)/T)z_t)' \tag{8}$$

$$B_m = 2T\sum_{k=1}^{m}(\frac{1}{T}\sum_{t=1}^{T}\cos(2k\pi(t-0.5)/T)\Delta z_t)(\frac{1}{T}\sum_{t=1}^{T}\cos(2k\pi(t-0.5)/T)\Delta z_t)' \tag{9}$$

which are computed as the sums of the outer-products of the weighted means of y_t and Δy_t, and where T is the sample size. To ensure invariance in the test statistics to drift terms, we recommend using the weighted functions of $\cos(2k\pi(t-0.5)/T)$.

Very much like the properties in the Johansen likelihood ratio method are the ordered generalized eigenvalues that we obtain from this nonparametric approach. These serve as the solution to the problem $\det[P_T - \lambda Q_T] = 0$ when we define the pair of random matrices $P_T = A_m$ and $Q_T = (B_m + cT^{-2} A_m^{-1})$. Thus, we can use these to test the hypothesis for the cointegration rank r. To estimate r, Bierens (1997, 2004) proposed two statistics tests. One is the $\lambda \min$ test which corresponds to Johansen¡s maximum likelihood procedure, and it tests hypothesis $H_0(r)$ against hypothesis $H_1(r+1)$. The critical values are tabulated in his article (Bierens, 1997, 2004). The second set of statistic is determined by the $g_m(r_0)$ test, which is computed from the Bierens¡s generalized eigenvalues:

$$\hat{g}_m(r_0) = \begin{cases} (\prod_{k=1}^{n} \hat{\lambda}_{k,m})^{-1}, if ....r_0 = 0 \\ (\prod_{k=1}^{n-r} \hat{\lambda}_{k,m})^{-1} (T^{2r} \prod_{k=n-r+1}^{n} \hat{\lambda}_{k,m}), if ...r_0 = 1,....,n-1 \\ T^{2n} \prod_{k=1}^{n} \hat{\lambda}_{k,m}, if ....r_0 = n \end{cases} \quad (10)$$

This statistic employs the tabulated optimal values (see Bierens, 1997, Table 1) for m when $n > r_0$, provided that we select $m = n$ for $n = r_0$. This verifies that $\hat{g}_m(r_0) = O_p(1)$ for $r = r_0$, and in terms of probability, it converges to infinity if $r \neq r_0$.

Hence, a consistent estimate of r is given by $\hat{r}_m = \arg\min_{r_0 < n} \{\hat{g}_m(r_0)\}$. This statistic is an invaluable tool when double-checking the determination of r.

Table 6 presents the results from both the $\lambda \min$ test and the $g_m(r_0)$ test. The $\lambda \min$ test results suggest that there are long-run relationships between stock price and dividends. These findings are further supported by the $g_m(r_0)$ statistics given in Table 6, with the smallest value only appearing in the cointegrating rank of $r = 1$. These results reveal that rational bubbles were nonexistent in the Korea stock market when both KOSPI200 and KOSPI data are used in our study during the May 1996 to November 2007 period**.**

Table 6. Bierens Nonparametric Cointegration Test Results

A. KOSPI200

1. $\lambda \min$ Test

Hypothesis	Test stat.	5% critical value	Test stat.	10% critical value
$H_0: r = 0$ $H_a: r = 1$	**0.00346****	(0,0.005)	**0.00346***	(0,0.017)

$H_0: r=1$ $H_a: r=2$	3.43136	(0,0.054)	3.43136	(0,0.111)

2. $g_m(r_0)$ Test

Cointegration rank (r)	$g_m(r_0)$	Eigenvalue
$r_0 = 0$	45.41811008E+001	
$r_0 = 1$	**37.61149065E+000**	**11.47668487E-001**
$r_0 = 2$	11.14643474E+005	19.18467669E-004

B. KOSPI

1. λ min Test

Hypothesis	Test stat.	5% critical value	Test stat.	10% critical value
$H_0: r=0$ $H_a: r=1$	0.33118	(0,0.017)	**0.00000***	(0,0.005)
$H_0: r=1$ $H_a: r=2$	4.32452	(0,0.054)	4.32452	(0,0.111)

2. $g_m(r_0)$ Test

Cointegration rank (r)	$g_m(r_0)$	Eigenvalue
$r_0 = 0$	99.63918080E+003	
$r_0 = 1$	**12.07467959E-003**	**43.24524654E-001**
$r_0 = 2$	50.80832620E+002	23.20766647E-007

Notes: 1. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

2. Both the results of the $\lambda \min$ test and the $g_m(r_0)$ test indicate one cointegration rank.

4. CONCLUSIONS

In this study, we revisit the issue as to the presence of Rational Bubbles in the Korea stock market during the May 1996 to November 2007 period using three cointegration tests, namely JJ, KSS, and BN approaches. The results from the conventional JJ test support the existence of rational bubbles, whereas those from both nonlinear test of KSS and nonparametric test of BN indicate that rational bubbles could not have been present in the Korea stock market.

ACKNOWLEDGEMENTS

The authors are grateful to Professor H. J. Bierens who kindly provided the EasyReg program.

REFERENCES

Abhyankar, A., L. S. Copeland, and W. Wong (1997), ¡Uncovering Nonlinear Structure in Real Time Stock Market Indexes: The S&P 500, the DAX, the Nikkei 225, and the FTSE-100,¡ *Journal of Business and Economic Statistics*, 15, 1-14.

Balke, N. S. and T. B. Fomby (1997), ¡Threshold Cointegration,¡ *International Economic Review*, 38, 627-645.

Barnett, W. A. and A. Serletis (2000), ¡Martingales, Nonlinearity, and Chaos,¡ *Journal of Economic Dynamics and Control*, 24, 703-724.

Bierens, H. J. (1997), ¡Nonparametric Cointegration Analysis,¡ *Journal of Econometrics*, 77, 379-404.

Bierens, H. J. (2004), ¡EasyReg International,¡ Department of Economics, Pennsylvania State University, University Park, P. A. USA.

Bohl, M. T. (2003), ¡Periodically Collapsing Bubbles in the US Stock Market?¡ *International Review of Economics and Finance*, 12, 385-397.

Campbell, J. Y. and P. Perron (1991), ¡Pitfalls and Opportunities: What Macroeconomists Should Know about Unit Roots,¡ NBER/Macroeconomics Annual, 1991, 6, 141-201.

Campbell, J. Y. and R. J. Shiller (1987), ¡Cointegration and Tests of Present Value Models,¡ *Journal of Political Economy*, 95, 1062-1088.

Chang, T., C. C. Chiu, and C. C. Nieh (2007), ¡Rational Bubbles in the US Stock Market? Further Evidence from a Nonparametric Cointegration Test,¡ *Applied Economics Letters*, 14, 517-521.

Crowder, W. J. and M. E. Wohar (1998), ¡Stock Price Effects of Permanent and Transitory Shocks,¡ *Economic Inquiry*, 36, 540-552.

Cunado, J., L. A. Gil-Alana, and F. Perez de gracia (2005) ¡A Test for Rational Bubbles in the NASDAQ Stock Index: A Fractionally Integrated Approach,¡ Journal of Banking and Finance, 29, 2633-2654.

Diba, B. T. and H. I.Grossman (1988), ¡The Theory of Rational Bubbles in Stock Prices,¡ *The Economic Journal*, 98, 746-754.

Dickey, D. A. and W. A. Fuller (1981), ¡Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root,¡ *Econometrica*,49(4),1057-1072.

Engle, R. F. and C. W. J. Granger (1987), ¡Co-integration and Error Correction: Representation, Estimation, and Testing,¡ *Econometrica*, 55(2), 251-276.

Froot, K. A. and M. Obstfeld (1991), ¡Intrinsic Bubbles: The Case of Stock Prices,¡ *The American Economic Review*, 81, 1189-1214.

Granger, C. W. J. and T. Terasvirta (1993), ¡Modeling Nonlinear Economic Relationships,¡ *Oxford University Press*, Oxford.

Hsieh, D. A. (1991), ¡Chaos and Nonlinear Dynamic: Application to Financial Markets,¡ *The Journal of Finance*, 46, 1839-1877.

Johansen, S. (1988), ¡Statistical Analysis of Cointegration Vectors,¡ *Journal of Economic Dynamics and Control*, 12, 231-254.

Johansen, S. and K. Juselius. (1990), ¡Maximum Likelihood Estimation and Inference on Cointegration--With Applications to the Demand for Money,¡ *Oxford Bulletin of Economics and Statistics*, 52, 169-210.

Kapetanios, G., Y. Shin, and A. Snell (2003), ¡Testing for a Unit Root in the Nonlinear STAR Framework,¡ *Journal of Econometrics*, 112, 359-379.

Kapetanios, G., Y. Shin, and A. Snell (2006), ¡Testing for Cointegration in Nonlinear Smooth Transition Error Correction Models,¡ *Econometric Theory*, 22(2), 279-303.

Kwiatkowski, D., P. C. B. Phillips, P. Schmidt, and Y. Shin (1992), ¡Testing the Null Hypothesis of Stationarity Against the Alternative of a Unit Root: How Sure Are We that Economic Time Series Have a Unit Root?¡ Journal of Econometrics, 54, 159-178.

Luukkonen, R., P. Saikkonen, and T. Terasvirta (1988), ¡Testing Linearity against Smooth Transition Autoregressive Models,¡ *Biometrika*, 75, 491-499.

Mokhtar, S. H., A. M. Nassir and T. Hassan (2006), ¡Detecting Rational Speculative Bubbles in the Malaysian Stock Market,¡ *International Research Journal of Finance and Economics*, 6, 102-115.

Nasseh, A. and J. Strauss (2004), ¡Stock Prices and the Dividend Discount Model: Did Their Relation Break Down in the 1990s¡ *The Quarterly Review of Economics and Finance*, 44, 191-207.

Newey, W. K. and K. D. West (1987), ¡A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix,¡ Econometrica, 55, 703-708.

Osterwald-Lenum, M. (1992), ¡A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics,¡ *Oxford Bulletin of Economics and Statistics*, 54, 461-472.

Phillips, P. C. B. and P. Perron (1988), ¡Testing for a Unit Root in Time Series Regression,¡ *Biometrika*, 75, 335-346.

Timmermann, A. (1995), ¡Cointegration Tests of Present Value Models with a Time-Varying Discount Factor,¡ *Journal of Applied Econometrics*, 10, 17-31.