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

Explosive and periodically collapsing bubbles in emerging stockmarkets

Mauricio Nunes
Department of Economics, Federal University of Rio Grande Do Sul

Sergio Da Silva
Department of Economics, Federal University of Santa Catarina

Abstract

We detected bubbles in 22 emerging stockmarkets using both standard and threshold cointegration. Eighteen stockmarkets experienced explosive bubbles (and some of them periodically collapsing bubbles as well). The remaining four markets experienced periodically collapsing bubbles only.

We are grateful to an anonymous referee and to Juan Carlos Escanciano (associate editor) for their helpful comments. We also acknowledge financial support from the Brazilian agencies CNPq and CAPES (Procad).
Citation: Nunes, Mauricio and Sergio Da Silva, (2008) "Explosive and periodically collapsing bubbles in emerging stockmarkets." *Economics Bulletin*, Vol. 3, No. 46 pp. 1-18
Submitted: June 12, 2008. **Accepted:** August 21, 2008.
URL: http://economicsbulletin.vanderbilt.edu/2008/volume3/EB-08C50144A.pdf

1. Introduction

Standard (Johansen and Engle-Granger) cointegration tests can be employed to detect stock price bubbles. Absence of cointegration between the stock prices and dividends may indicate the presence of a rational bubble (Blanchard 1979, Blanchard and Watson 1982). The tests usually assume one unit root (as the null hypothesis) and one linear process as the alternative. That approach is quite common, though there are still skeptics (for instance, Evans 1991). As it happens, those tests also assume a symmetric adjustment process toward long run equilibrium. Because financial variables usually adjust asymmetrically (Enders and Granger 1998, Neftei 1984, Potter 1995, Balke and Fomby 1997, Enders and Siklos 2001), threshold cointegration can also be employed. Threshold nonlinear cointegration (Balke and Fomby 1997) generalizes standard linear cointegration to allow the adjustment to be nonlinear. Lo and Zivot (2001) provide a review of the growing applications of threshold cointegration.

Here we will consider four models of threshold cointegration, namely (1) a threshold autoregressive (TAR) model (Tong 1983), (2) a momentum threshold autoregressive (M-TAR) model (Enders and Granger 1998, Enders and Siklos 2001), (3) a consistent TAR model (Chan 1993), and (4) a consistent M-TAR model. In the TAR model the autoregressive decay of a variable depends on its state. The M-TAR model further allows for positive and negative changes in the variable autoregressive decay, thus capturing its possible asymmetric short run adjustment. Enders and Granger (1998) and Enders and Siklos (2001) carried out tests using random series to evaluate the relative testing power of the TAR and M-TAR models if compared with the standard Engle-Granger model; they found the M-TAR model to perform much better than the TAR model. In both the TAR and M-TAR models, the threshold coincides with the attractor zero. However, the threshold can also be estimated. Chan (1993) suggests an estimate based on the ordering of the series of estimated residuals. A TAR (M-TAR) model with an estimated threshold (that is not necessarily zero) is called a consistent TAR (consistent M-TAR) model. In what follows we will describe these four models in more detail.

Conventional cointegration detects explosive bubbles, whereas threshold cointegration tracks periodically collapsing bubbles, which are those that begin, burst, and then return. The TAR model for testing periodically collapsing bubbles follows the same two step approach of the standard Engle-Granger test. First a long run equilibrium equation is estimated through OLS, i.e.

$$P_t = \hat{\beta}_0 + \hat{\beta}_1 D_t + \hat{\mu}_t \tag{1}$$

where P_t is the stock price, D_t is the dividend, and $\hat{\mu}_t$ is the residual of the estimated cointegration equation (1). Secondly, an alternative specification allowing asymmetric adjustment in the error correction model is tested using

$$\Delta\hat{\mu}_t = I_t \rho_1 \hat{\mu}_{t-1} + (1 - I_t)\rho_2 \hat{\mu}_{t-1} + \sum_{i=1}^{l} \gamma_i \Delta\hat{\mu}_{t-1} + \varepsilon_t \tag{2}$$

where I_t is an indicator function defined as

$$I_t = \begin{cases} 1 \text{ if } \hat{\mu}_{t-1} \geq \tau \\ 0 \text{ if } \hat{\mu}_{t-1} < \tau \end{cases} \quad (3)$$

and τ is the threshold value. In the presence of periodically collapsing bubbles the estimated residual of equation (1) ($\hat{\mu}_t$) should be interpreted as reflecting the sequence of price increases that are followed by sudden drops. The no cointegration null hypothesis in the TAR model (equations (1)–(3)) is $H_0 : \rho_1 = 0$, $H_0 : \rho_2 = 0$, and $H_0 : \rho_1 = \rho_2 = 0$. Enders and Siklos (2001, Tables 1 and 2) provide the critical values for the appropriate t and F tests. If the no cointegration null is rejected, the hypothesis of symmetric adjustment $H_0 : \rho_1 = \rho_2 = 0$ can be tested using the F statistic. If $H_0 : \rho_1 = \rho_2 = 0$ cannot be rejected, P and D cointegrate through a linear and symmetric adjustment.

Necessary and sufficient conditions for the stationarity of sequence $\{\hat{\mu}_t\}$ are $\rho_1, \rho_2 < 0$ and $(1+\rho_1)(1+\rho_2) < 1$, $\forall \tau$ (Petruccelli and Woolford 1984). Convergence means $\hat{\mu} = 0$ in long run equilibrium. If $\hat{\mu}_{t-1}$ falls below this long run equilibrium value, the adjustment implies $\rho_2 \hat{\mu}_{t-1}$. Since the adjustment is symmetric if $\rho_1 = \rho_2$, Engle-Granger cointegration becomes a particular case of TAR cointegration. The TAR model can track sudden changes in the sequence because if $-1 < \rho_1 < \rho_2 < 0$ the negative phase of $\{\hat{\mu}_t\}$ gets more persistent than the positive one (Enders and Granger 1998). Thus periodically collapsing bubbles can be detected by the cumulative changes of $\hat{\mu}_{t-1}$ that fall above the threshold followed by sudden drop toward the threshold. (The same is not true of the cumulative changes of $\hat{\mu}_{t-1}$ that fall below the threshold.) If one finds no cointegration between stock prices and dividends, the hypothesis of periodically collapsing bubbles makes no sense. Andrews and Ploberger (1994) and Hansen (1996) show that inference is more difficult in that case because the threshold parameter is not identified under the null hypothesis. This is related to the Davies problem in literature (Davies 1977).

Rather than taking levels, Enders and Granger (1998) and Caner and Hansen (2001) consider changes in the previous period residuals $\{\Delta\hat{\mu}_{t-1}\}$ in the indicator function, i.e.

$$I_t = \begin{cases} 1 \text{ if } \Delta\hat{\mu}_{t-1} \geq \tau \\ 0 \text{ if } \Delta\hat{\mu}_{t-1} < \tau \end{cases} \quad (4)$$

Equations (1), (2), and (4) make up the M-TAR model, which tracks a series momentum in one direction rather than the other (Enders and Siklos 2001). Positive deviations from long run equilibrium are reverted faster in the M-TAR model if compared with the TAR model. Using Monte Carlo and bootstrap experiments, Enders and Granger (1998) and Enders and Siklos (2001) provide critical values for the appropriate t and F statistics. The most significant of the t-statistics for the null of $\rho_1 = 0$ and $\rho_2 = 0$ is called $t_{\max}$, and the less significant one is the $t_{\min}$. The F-statistic for the null of $\rho_1 = \rho_2 = 0$ is dubbed ϕ, which has more power than $t_{\max}$ and $t_{\min}$ but can only be used in case of both stationarity (because the ρ s must be negative) and convergence.

As the assumption that the threshold coincides with the attractor zero is relaxed, τ has to be estimated along with ρ_1 and ρ_2. One way of doing that is as follows (Chan 1993). Assuming there are no ties, the series of residuals can be ranked as $\hat{\mu}_1^c < \hat{\mu}_2^c < ... < \hat{\mu}_T^c$ in the TAR model (or as $\Delta\hat{\mu}_1^c < \Delta\hat{\mu}_2^c < ... < \Delta\hat{\mu}_T^c$ in the M-TAR), where T is the number of observations. Then the 15 percent biggest and smallest values of $\{\hat{\mu}_i^c\}$ are discarded. The possible attractor is thus supposed to lie in the set of the 70 percent remaining values. For those values, equations (1) and (2) are estimated. The estimated threshold with the smallest sum of squared residuals is taken as the appropriate threshold. These are known as consistent TAR and M-TAR models, for which the appropriate statistics are now $t_{\max}^c$, $t_{\min}^c$, and ϕ^c. The consistency of such models lies in the fact that the threshold is estimated endogenously. This allows one to track the idiosyncratic components of a particular series.

Finding ρ_1 and ρ_2 along with constraint $\rho_1 = \rho_2$ is problematic if τ is unknown, because the property of asymptotically multivariate normality does not hold for sure in that case. Yet Chan and Tong (1989) think it may hold. Also, Enders and Falk (1999) find the use of bootstrap experiments for the maximum likelihood statistic appropriate, at least for small samples. Another caveat is the following. Testing for the presence of cointegration (i.e. the presence of long run equilibrium) is one thing; the other is testing for linearity in short run dynamics. The literature commonly adopts a two step approach (Balke and Fomby 1997), in which the linear no cointegration null hypothesis is first examined against the linear cointegration alternative, and then the linear cointegration null hypothesis is tested against the threshold cointegration alternative. Yet four hypotheses are possible in threshold cointegration models: (1) linear no cointegration, (2) threshold no cointegration, (3) linear cointegration, and (4) threshold cointegration. The two step approach above excludes the threshold no cointegration hypothesis. Despite that, here we will follow the literature and adopt the two step approach. As a result, rejection of the linear no cointegration null hypothesis will be interpreted as either linear or threshold cointegration. Actually, an extra test is required to examine the linear no cointegration null. Although such a test is proposed in Enders and Granger (1998) and Enders and Siklos (2001) in a TAR model, they do not provide a formal distribution theory. More recently, Seo (2006) developed a cointegration test in a two regime threshold vector error correction model with a prespecified cointegrating vector, in which the linear no cointegration null hypothesis was examined along with an explicit distribution theory.

The aim of this paper is thus to investigate the presence of both explosive and periodically collapsing bubbles in 22 emerging stockmarkets using standard cointegration and the models of threshold cointegration discussed above. The rest of the paper is organized as follows. Section 2 presents data. Section 3 performs analysis. And Section 4 concludes.

2. Data

We collected monthly data (from Datastream) of stock prices and dividends for the 22 countries in the Standard & Poors' Emerging Markets Data Base. For most of the countries the data range was from January 1990 to December 2006 (204 observations). Table 1 shows more details. Consumer price indices were taken from the IMF's International Financial Statistics. The countries were as follows. Argentina (ARG), Brazil (BRA), Chile (CHI), China (CHN), Colombia (COL), Czech Republic (CZE), Indonesia (IDN), India (IND), Israel (ISR), Korea (KOR), Malaysia (MAS), Mexico (MEX), Peru (PER), the Philippines (PHI), Poland (POL), South Africa (RSA), Russia (RUS), Sri Lanka (SRI), Thailand (THA), Taiwan (TPE), Turkey (TUR), and Venezuela (VEN). Analysis was carried out with the natural logs of the variables.

3. Analysis

We first performed augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests for the variables in real terms (Tables 2 and 3). Though nonstationary in levels, the two series got stationary in first differences and thus cointegration between them could be evaluated.

We estimated six cointegration models for each of the 22 countries, namely Johansen's, Engle-Granger's, TAR, M-TAR, consistent TAR, and consistent M-TAR (Tables 4–25). All the emerging stockmarkets exhibited bubbles. Eighteen stockmarkets experienced explosive bubbles. The remained four experienced only periodically collapsing bubbles (Table 26).

For the markets that experienced explosive bubbles we could not reject the no cointegration null using standard cointegration. Thus stock prices behaved at odds with dividends. The four cases that showed no evidence of explosive bubbles were Chile (Table 6), Indonesia (Table 10), Korea (Table 13), and the Philippines (Table 17). Yet at least one of the threshold cointegration models could not reject the hypothesis of periodically collapsing bubbles (and of asymmetry) for those four markets. For Chile and Indonesia, the null of $\rho_1 = 0$ was rejected at the one percent significance level, thus suggesting the stock prices to be in line with fundamentals. Yet the TAR and consistent TAR models detected periodically collapsing bubbles. Also, the residuals changes adjusted faster from below the cointegration equation if compared with the adjustment from above the long run equilibrium equation, i.e. $|\rho_2| > |\rho_1|$. The findings for Korea gave support to Enders and Granger (1998) and Enders and Siklos (2001), who pointed out that the deviations from long run equilibrium revert faster in the M-TAR if compared with the TAR model. The stockmarket in the Philippines also showed nonlinearity and asymmetry (10 percent significant).

As for South Africa (Table 19), the positive coefficients ρ_1 also indicated explosive behavior (0.164 and 0.176 in the M-TAR and consistent M-TAR models respectively). At least one positive coefficient also emerged for Czech Republic, Malaysia, Sri Lanka (in all the models), Chile, Israel, Mexico, Poland, Russia, Taiwan, Turkey (in the M-TAR and consistent M-TAR models), Colombia (in the TAR model), and Venezuela (in the M-TAR model). Yet the null of $\rho_1 = \rho_2 = 0$ could not be rejected for those countries, and thus the rejection bias could not be assessed. For South Africa we relied on the $t^c_{\max}$ (and did not reject the no cointegration null) rather than on the values of ϕ and ϕ^c (6.22 and 5.37 respectively), which pointed to rejection of the null (10 percent significant). Considering ϕ and ϕ^c made no sense here because this would had lead to rejection of the null of $\rho_1 = \rho_2$ in the presence of lack of convergence (positive coefficient). Table 19 shows that the maximum *t*-statistics were the positive values 1.53 and 1.78 (in the M-TAR and consistent M-TAR model respectively), while the tabulated values are –1.76 and –1.66 respectively (Enders and Siklos 2001, Tables 2 and 6).

Table 15 shows that the values of ϕ and ϕ^c (6.51 and 8.60 respectively) for Mexico felt above the critical values, and the consistent TAR model was best (AIC and BIC tests). Since the series cointegrated, the null of symmetric adjustment $\rho_1 = \rho_2$ could be evaluated by the standard *F*-statistic. The calculated *F*s of 12.96 and 17.15 felt above the critical values (one percent significant), and then the null of symmetric adjustment was rejected for the TAR and consistent TAR models. Moreover, since $|\rho_2| > |\rho_1|$ the residuals adjustment from below the cointegration equation was the fastest. This suggests short run stock price increases above the fundamentals followed by a crash. The latter result could be extended to Peru (Table 16).

Both the M-TAR and consistent M-TAR models detected periodically collapsing bubbles for Colombia (Table 8), i.e. the values of ϕ and ϕ^c (7.21 and 7.49 respectively) pointed to rejection of the null. Also, the hypothesis of symmetric adjustment ($\rho_1 = \rho_2$) was rejected at both five and one percent significance levels. Moreover, negative parameters along with $|\rho_2| < |\rho_1|$ suggested that positive deviations from long run equilibrium were reverted faster than the negative ones.

Periodically collapsing bubbles were also detected for Brazil (Table 5) and Venezuela (Table 25) by the TAR and consistent M-TAR models (threshold values of 0.663 and –0.437 for Brazil). There was absence of mean reversion and also persistence for the values ranging from τ to the attractor zero. While there was no symmetric adjustment for Brazil, symmetry could not be dismissed for Venezuela. For Brazil, the deviations from above were more persistent than the deviations from below. This finding is consistent with stock price bubbles followed by crashes. And also with stock prices in line with dividends in long run equilibrium.

The consistent M-TAR model rejected the no cointegration null and favored the hypothesis of periodically collapsing bubbles in the Chinese data ($\phi^c = 6.51$, Table 7). For India (Table 11) the best model was the M-TAR, and the null of symmetric adjustment ($\rho_1 = \rho_2$) could not be rejected. There was evidence of cointegration of stock prices and dividends in Poland (Table 18). Periodically collapsing bubbles were present, short run adjustment was asymmetric, and the deviations from above the long run equilibrium equation converged faster toward the attractor.

4. Conclusion

We investigated the presence of bubbles in 22 emerging stockmarkets using standard linear cointegration along with threshold nonlinear cointegration. The six models considered were Johansen's, Engle-Granger's, TAR, M-TAR, consistent TAR, and consistent M-TAR. All the emerging stockmarkets exhibited bubbles. Eighteen stockmarkets experienced explosive bubbles (and some of them periodically collapsing bubbles as well). The four cases that showed no evidence of explosive bubbles were Chile, Indonesia, Korea, and the Philippines. Yet at least one of the threshold cointegration models still detected periodically collapsing bubbles in those markets.

Table 1. Sample

Country	Time Period	Number of Observations
ARG	Jul 1993 – Dec 2006	161
BRA	Jul 1994 – Dec 2006	149
CHI	Jan 1990 – Dec 2006	204
CHN	May 1994 – Dec 2006	151
COL	Apr 1992 – Dec 2006	176
CZE	Feb 1990 – Dec 2006	203
IDN	Apr 1990 – Dec 2006	201
IND	Jan 1990 – Dec 2006	204
ISR	Jan 1993 – Dec 2006	168
KOR	Jan 1990 – Dec 2006	204
MAS	Jan 1990 – Dec 2006	204
MEX	Jan 1990 – Dec 2006	204
PER	Jan 1994 – Dec 2006	155
PHI	Jan 1990 – Dec 2006	204
POL	Mar 1994 – Dec 2006	153
RSA	Jan 1990 – Dec 2006	204
RUS	Feb 1995 – Dec 2006	143
SRI	Jan 1990 – Dec 2006	204
THA	Jan 1990 – Dec 2006	204
TPE	Jan 1990 – Dec 2006	204
TUR	Jan 1990 – Dec 2006	204
VEN	Jan 1990 – Dec 2006	204

Table 2. Unit Root Tests for Stock Prices

Country	Levels				First Differences			
	ADF(l)	τ_{crit}	PP	τ_{crit}	ADF(l)	τ_{crit}	PP	τ_{crit}
ARG	–2.43*	–2.88	–2.53*	–2.87	–12.54	–1.94	–12.79	–1.94
BRA	–1.98**	–3.44	–2.14	–3.44	–11.00	–1.94	–11.00	–1.94
CHI	–2.89**	–3.43	–2.90	–3.43	–12.08	–1.94	–12.09	–1.94
CHN	–2.28*	–2.88	–2.17	–2.88	–12.17	–1.94	–12.33	–1.94
COL	–0.62(1)*	–2.88	–0.59*	–2.88	–10.06	–1.94	–10.06*	–2.88
CZE	–2.77**	–3.44	–2.77**	–3.44	–9.73**	–3.44	–9.63**	–3.44
IDN	–1.98*	–2.88	–2.03*	–2.88	–12.07	–2.88	–12.02	–1.94
IND	–2.16(1)*	–2.88	–1.72*	–2.88	–11.77	–1.94	–11.66	–1.94
ISR	–2.59**	–3.44	–2.68**	–3.44	–11.52	–1.94	–11.50*	–2.88
KOR	–2.96(1)**	–3.43	–2.33(1)*	–2.88	–12.06	–1.94	–12.03*	–2.88
MAS	–2.29(1)*	–2.88	–2.22*	–2.88	–11.92	–1.94	–11.90	–1.94
MEX	–1.59(1)*	–2.88	–1.79**	–3.44	–12.44*	–2.88	–12.40*	–2.88
PER	–0.69(2)**	–3.43	–0.79*	–2.88	–10.18(1)	–1.94	–11.29	–1.94
PHI	–1.65(3)*	–2.88	–1.66*	–2.88	–12.68	–1.94	–12.66*	–2.88
POL	–0.54	–1.94	–0.53	–1.94	–12.66	–1.94	–12.70	–1.94
RSA	–2.51(1)**	–3.43	–0.109(1)*	–2.87	–13.55**	–3.43	–13.48*	–2.88
RUS	–1.05*	–2.88	–1.61	–2.88	–9.93	–1.94	–10.14	–1.94
SRI	–2.15(1)*	–2.88	–2.11*	–2.88	–11.57	–1.94	–11.60	–1.94
THA	–1.60*	–2.88	–1.51*	–2.88	–14.11	–1.94	–14.19	–1.94
TPE	–2.64**	–3.43	–2.89**	–3.43	–11.96	–1.94	–11.95	–1.94
TUR	–2.42*	–2.88	–2.51*	–2.88	–14.04	–1.94	–14.06	–1.94
VEN	–3.28**	–3.44	–3.12**	–3.44	–12.60	–1.94	–12.40	–1.94

Notes

ADF(·) is the augmented Dickey-Fuller test with the optimal lag length in brackets (Akaike-Schwarz criterion)

PP is Philips-Perron test

τ_{crit} stands for critical values at the five percent significance level

* test with a constant

** test with both constant and trend

Table 3. Unit Root Tests for Dividends

Country	Levels				First Differences			
	ADF(·)	τ_{crit}	PP	τ_{crit}	ADF(·)	τ_{crit}	PP	τ_{crit}
ARG	−1.92(1)**	−3.44	−1.33*	−2.88	−10.33	−1.94	−10.49	−1.94
BRA	−1.62*	−2.88	−1.67*	−2.88	−9.39	−1.94	−9.54	−1.94
CHI	−2.58(1)**	−3.43	−2.83**	−3.43	−13.30*	−2.88	−13.31*	−1.94
CHN	−2.22*	−2.88	−2.20*	−2.88	−7.47(2)	−1.94	−12.07	−1.94
COL	−1.59(1)	−1.94	−1.54	−1.94	−10.10	−1.94	−10.11	−1.94
CZE	−3.13**	−3.44	−2.55*	−2.88	−12.04	−1.94	−12.10	−1.94
IDN	−3.15**	−3.44	−3.10**	−3.44	−16.70	−2.88	−16.51	−1.94
IND	−2.35*	−2.88	−2.40*	−2.88	−14.14	−1.94	−14.13	−1.94
ISR	−1.76*	−2.88	−1.75*	−2.88	−13.09	−1.94	−13.10	−1.94
KOR	−2.88(5)**	−3.43	−2.71**	−3.44	−5.56(4)	−1.94	−11.99	−1.94
MAS	−2.48*	−2.88	−2.53*	−2.88	−11.79	−1.94	−11.95	−1.94
MEX	−2.44**	−3.44	−2.22**	−3.44	−13.43*	−2.88	−14.32*	−2.88
PER	−1.82*	−2.88	−1.77*	−2.88	−13.59	−1.94	−13.58	−1.94
PHI	−2.57*	−2.88	−2.53*	−2.88	−11.62	−1.94	−11.69	−1.94
POL	−2.52(2)*	−2.88	−2.14*	−2.88	−6.60(2)	−1.94	−11.78	−1.94
RSA	−2.63**	−3.44	−2.55**	−3.44	−14.39*	−2.88	−14.90*	−2.88
RUS	−2.56*	−2.88	−2.48*	−2.88	−12.25	−1.94	−12.62	−1.94
SRI	−1.31**	−3.44	−1.58**	−3.44	−13.88	−1.94	−14.00	−1.94
THA	−1.93*	−2.88	−2.12*	−2.88	−14.08	−1.94	−14.12	−1.94
TPE	−2.36(1)*	−2.88	−1.70*	−2.88	−11.71	−1.94	−11.69	−1.94
TUR	−1.02**	−3.44	−1.13**	−3.44	−13.24*	−1.94	−13.23*	−2.88
VEN	−2.03*	−2.88	−2.15*	−2.88	−12.47	−1.94	−12.48	−1.94

Notes

ADF(·) is the augmented Dickey-Fuller test with the optimal lag length in brackets (Akaike-Schwarz criterion)

PP is Philips-Perron test

τ_{crit} stands for critical values at the five percent significance level

* test with a constant

** test with both constant and trend

Table 4. Argentina

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	16.39(C,4)	–	–	–	–	–
ρ_1	–	–0.088	–0.095(1)	0.084(2)	–0.042(C,1)	0.178(C,1)
t-statistic		(–2.66)	(–1.78)	(0.72)	(–0.81)	(1.52)
ρ_2	–	–	–0.083	–0.048	–0.128	–0.183
t-statistic			(–2.02)	(–0.42)	(–2.61)	(–1.39)
AIC	–	43.40	45.40	49.91	46.17	48.88
BIC	–	49.51	54.51	59.00	58.31	61.00
τ	–	–	–	–	–0.277	–0.083
ϕ, ϕ^c	–	–	3.55	0.35	4.16	1.84
$\rho_1 = \rho_2$	–	–	0.03	0.66	0.42	2.38
p-value			(0.857)	(0.415)	(0.513)	(0.124)

Notes

λ_{trace} is trace statistic

ρ_1 and ρ_2 are the lagged residuals coefficients ($\hat{\mu}_{t-1}$)

AIC is Akaike information criterion

BIC is Schwarz information criterion

τ is the consistent threshold value

ϕ and ϕ^c are the F-statistic values for rejecting the no cointegration null in the TAR (M-TAR) and consistent TAR (M-TAR) models respectively

$\rho_1 = \rho_2$ is the F-statistic for rejecting the null of symmetric adjustment

Values in brackets are for first differences of the lagged residuals for both $\Delta\hat{\mu}_{t-i}$ and the deterministic component

Critical values: $\lambda_{\text{trace (1\%)}} = 19.96$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (5\%)}} = 4.99$, $\phi_{\text{M-TAR (10\%)}} = 5.47$, $\phi^c_{\text{TAR (10\%)}} = 6.02$, $\phi^c_{\text{M-TAR (10\%)}} = 5.76$

Table 5. Brazil

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	6.89(C,2)	–	–	–	–	–
ρ_1	–	–0.022(1)	–0.018	–0.068	–0.026(2)	–0.016(1)
t-statistic		(–1.51)	(–1.15)	(–0.05)	(–1.65)	(–0.88)
ρ_2	–	–	–0.142	–0.359	–0.166	–0.450
t-statistic			(–2.11)	(–3.48)	(–3.42)	(–0.00)
AIC	–	546.84	532.51	545.87	520.43	540.33
BIC	–	552.83	550.37	551.87	544.23	549.30
τ	–	–	–	–	0.663	–0.437
ϕ, ϕ^c	–	–	4.64	5.22	6.88	7.96
$\rho_1 = \rho_2$	–	–	5.97	3.27	7.98	7.12
p-value			(0.016)	(0.072)	(0.005)	(0.008)

Critical values: $\lambda_{\text{trace (1\%)}} = 19.96$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (10\%)}} = 4.92$, $\phi_{\text{M-TAR (10\%)}} = 5.45$, $\phi^c_{\text{TAR (10\%)}} = 6.02$, $\phi^c_{\text{M-TAR (5\%)}} = 6.86$

Table 6. Chile

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	22.62(4)	–	–	–	–	–
ρ_1	–	–0.043(C,4)	–0.004(4)	0.272(2)	–0.028(C,4)	0.282(4)
t-statistic		(–4.14)	(–0.36)	(2.96)	(–2.29)	(3.12)
ρ_2	–	–	–0.054	0.032	–0.034	0.015
t-statistic			(–3.76)	(0.34)	(–2.08)	(0.162)
AIC	–	675.45	681.64	692.80	667.00	692.02
BIC	–	695.24	701.43	712.59	700.09	711.81
τ	–	–	–	–	0.634	–0.174
ϕ, ϕ^c	–	–	7.19	4.52	8.79	4.92
$\rho_1 = \rho_2$	–	–	6.60	3.10	6.14	3.87
p-value			(0.010)	(0.08)	(0.014)	(0.06)

Critical values: $\lambda_{\text{trace (1\%)}} = 16.31$, $\tau_{(1\%)} = -4.07$, $\phi_{\text{TAR (5\%)}} = 6.35$, $\phi_{\text{M-TAR (10\%)}} = 5.36$, $\phi^c_{\text{TAR (5\%)}} = 7.56$, $\phi^c_{\text{M-TAR (10\%)}} = 5.32$

Table 7. China

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	4.59(4)	–	–	–	–	–
ρ_1	–	–0.042	–0.016(2)	–0.091(2)	–0.007(2)	–0.105(2)
t-statistic		(–2.17)	(–0.53)	(–0.88)	(–0.24)	(–0.24)
ρ_2	–	–	–0.070	–0.373	–0.083	–0.406
t-statistic			(–2.75)	(–2.95)	(–3.14)	(–3.19)
AIC	–	–46.75	–52.32	–52.30	–54.32	–55.88
BIC	–	–40.73	–40.31	–40.28	–42.30	–43.86
τ	–	–	–	–	–0.229	–0.026
ϕ, ϕ^c	–	–	3.92	4.68	4.98	6.51
$\rho_1 = \rho_2$	–	–	1.85	7.87	3.83	9.52
p-value			(0.175)	(0.005)	(0.052)	(0.002)

Critical values: $\lambda_{\text{trace (5\%)}} = 12.53$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (10\%)}} = 4.99$, $\phi_{\text{M-TAR (10\%)}} = 5.47$, $\phi^c_{\text{TAR (10\%)}} = 6.02$, $\phi^c_{\text{M-TAR (10\%)}} = 5.76$

Table 8. Colombia

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	7.36(C,4)	–	–	–	–	–
ρ_1	–	–0.010(4)	–0.006(1)	–0.289(C)	–0.006(1)	–0.337(C)
t-statistic		(–0.90)	(–0.38)	(–2.41)	(0.35)	(–3.05)
ρ_2	–	–	–0.015	–0.263	–0.028	–0.218
t-statistic			(–0.90)	(–1.79)	(–1.64)	(–1.97)
AIC	–	18.40	18.26	18.77	18.25	18.26
BIC	–	27.58	27.76	28.26	25.74	25.75
τ	–	–	–	–	–0.345	0.080
ϕ, ϕ^c	–	–	0.48	7.21	1.48	7.49
$\rho_1 = \rho_2$	–	–	0.12	5.18	3.83	8.75
p-value			(0.723)	(0.023)	(0.147)	(0.003)

Critical values: $\lambda_{\text{trace (5\%)}} = 19.96$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (5\%)}} = 4.99$, $\phi_{\text{M-TAR (5\%)}} = 5.98$, $\phi^c_{\text{TAR (10\%)}} = 6.02$, $\phi^c_{\text{M-TAR (5\%)}} = 6.78$

Table 9. Czech Republic

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	17.84(C,4)	–	–	–	–	–
ρ_1	–	0.006(4)	0.070(C,2)	0.076(C)	0.003	0.054(C)
t-statistic		(0.40)	(–2.68)	(0.52)	(0.20)	(0.40)
ρ_2	–	–	0.164	0.301	–0.087	0.301
t-statistic			(–3.27)	(2.34)	(–2.24)	(2.74)
AIC	–	–67.67	–73.10	–36.46	–30.81	–37.23
BIC	–	–52.62	–57.98	–27.37	–21.70	–28.14
τ	–	–	–	–	–0.263	–0.045
ϕ, ϕ^c	–	–	4.62	3.70	2.53	4.10
$\rho_1 = \rho_2$	–	–	11.17	0.21	0.30	1.78
p-value			(0.001)	(0.645)	(0.587)	(0.184)

Critical values: $\lambda_{\text{trace (5\%)}} = 19.96$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (10\%)}} = 4.99$, $\phi_{\text{M-TAR (10\%)}} = 5.47$, $\phi^c_{\text{TAR (10\%)}} = 5.95$, $\phi^c_{\text{M-TAR (10\%)}} = 5.73$

Table 10. Indonesia

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	19.69(2)	–	–	–	–	–
ρ_1	–	–0.095(C,4)	–0.116(C,4)	–0.117(C)	–0.095(C,4)	–0.006(C,1)
t-statistic		(–3.71)	(–3.43)	(–0.87)	(–3.11)	(–0.05)
ρ_2	–	–	–0.034	–0.156	–0.098	–0.214
t-statistic			(–0.49)	(–1.53)	(–1.79)	(–2.19)
AIC	–	861.62	862.70	885.55	853.62	878.93
BIC	–	881.29	885.65	895.43	876.56	892.08
τ	–	–	–	–	1.042	–0.456
ϕ, ϕ^c	–	–	7.33	2.01	6.86	2.43
$\rho_1 = \rho_2$	–	–	4.88	0.26	3.59	0.08
p-value			(0.028)	(0.612)	(0.059)	(0.772)

Critical values: $\lambda_{\text{trace (5\%)}} = 12.53$, $\tau_{(5\%)} = -3.37$, $\phi_{\text{TAR (5\%)}} = 6.35$, $\phi_{\text{M-TAR (10\%)}} = 5.36$, $\phi^c_{\text{TAR (10\%)}} = 6.44$, $\phi^c_{\text{M-TAR (10\%)}} = 5.57$

Table 11. India

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	8.74(4)	–	–	–	–	–
ρ_1	–	–0.032(2)	–0.003	0.057(C,4)	–0.005(C,6)	–0.070(C,6)
t-statistic		(–1.66)	(–0.12)	(0.49)	(–0.17)	(0.50)
ρ_2	–	–	–0.380	–0.219	–0.076	–0.377
t-statistic			(–3.15)	(–1.58)	(–2.23)	(–3.26)
AIC	–	–21.71	–22.03	–35.32	–27.97	–33.31
BIC	–	11.80	15.40	10.20	30.18	9.09
τ	–	–	–	–	0.135	–0.034
ϕ, ϕ^c	–	–	4.98	5.96	2.58	5.36
$\rho_1 = \rho_2$	–	–	0.28	1.83	3.26	0.48
p-value			(0.591)	(0.176)	(0.007)	(0.490)

Critical values: $\lambda_{\text{trace (5\%)}} = 12.53$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (5\%)}} = 6.35$, $\phi_{\text{M-TAR (10\%)}} = 5.36$, $\phi^c_{\text{TAR (10\%)}} = 6.44$, $\phi^c_{\text{M-TAR (10\%)}} = 5.32$

Table 12. Israel

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	6.36(C,4)	–	–	–	–	–
ρ_1	–	–0.020	–0.002	0.083	–0.006	0.021
t-statistic		(–1.10)	(–0.09)	(0.75)	(0.25)	(0.17)
ρ_2	–	–	–0.042	0.089	–0.045	0.131
t-statistic			(–1.57)	(0.89)	(–1.65)	(1.33)
AIC	–	–15.17	–14.46	–13.94	–15.55	–15.22
BIC	–	–8.95	–5.12	–7.72	–9.31	–5.90
τ	–	–	–	–	0.120	0.068
ϕ, ϕ^c	–	–	1.24	0.62	1.39	0.90
$\rho_1 = \rho_2$	–	–	1.26	0.01	1.96	0.47
p-value			(0.262)	(0.974)	(0.162)	(0.492)

Critical values: $\lambda_{\text{trace (5\%)}} = 19.96$, $\tau_{(5\%)} = -3.37$, $\phi_{\text{TAR (10\%)}} = 4.94$, $\phi_{\text{M-TAR (10\%)}} = 5.86$, $\phi^c_{\text{TAR (10\%)}} = 5.95$, $\phi^c_{\text{M-TAR (10\%)}} = 5.73$

Table 13. Korea

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	47.13(4)	–	–	–	–	–
ρ_1	–	–0.007(C,6)	–0.003(C,6)	–0.299(C,4)	–0.003(C,9)	–0.343(C)
t-statistic		(–3.07)	(–0.70)	(–3.09)	(–0.61)	(–3.65)
ρ_2	–	–	–0.009	–0.164	–0.012	–0.127
t-statistic			(–1.89)	(–0.33)	(–1.47)	(–0.74)
AIC	–	–986.03	–995.92	–998.93	–978.85	–1003.69
BIC	–	–953.25	–996.13	–979.14	–939.57	–973.76
τ	–	–	–	–	–0.006	5.15 e^{-4}
ϕ, ϕ^c	–	–	3.93	6.84	5.94	9.05
$\rho_1 = \rho_2$	–	–	1.84	9.22	1.98	13.07
p-value			(0.175)	(0.002)	(0.161)	(0.000)

Critical values: $\lambda_{\text{trace (1\%)}} = 16.31$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (5\%)}} = 5.23$, $\phi_{\text{M-TAR (5\%)}} = 6.12$, $\phi^c_{\text{TAR (10\%)}} = 6.44$, $\phi^c_{\text{M-TAR (1\%)}} = 8.47$

Table 14. Malaysia

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	7.69(C,4)	–	–	–	–	–
ρ_1	–	–0.011(4)	0.004(C,4)	0.115(C,4)	0.005(C,6)	0.018(C,8)
t-statistic		(–0.78)	(–0.20)	(1.18)	(0.24)	(0.87)
ρ_2	–	–	–0.024	0.142	–0.114	0.250
t-statistic			(–1.25)	(1.36)	(–3.51)	(2.33)
AIC	–	–308.83	–309.50	–308.24	–298.83	–305.36
BIC	–	–292.34	–302.86	–291.75	–231.09	–259.75
τ	–	–	–	–	–0.206	0.023
ϕ, ϕ^c	–	–	1.81	1.62	6.25	2.83
$\rho_1 = \rho_2$	–	–	0.99	0.04	0.20	0.016
p-value			(0.320)	(0.849)	(0.657)	(0.900)

Critical values: $\lambda_{\text{trace (5\%)}} = 19.96$, $\tau_{(5\%)} = -3.37$, $\phi_{\text{TAR (10\%)}} = 5.23$, $\phi_{\text{M-TAR (10\%)}} = 5.13$, $\phi^c_{\text{TAR (10\%)}} = 6.44$, $\phi^c_{\text{M-TAR (10\%)}} = 5.73$

Table 15. Mexico

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	14.66(C,4)	–	–	–	–	–
ρ_1	–	–0.020(C,2)	–0.008(4)	0.237(4)	–0.009(5)	0.244(5)
t-statistic		(–2.17)	(–1.04)	(2.35)	(–1,16)	(2.15)
ρ_2	–	–	–0.085	–0.075	–0.098	–0.026
t-statistic			(–3.49)	(–0.76)	(–4.01)	(–0.29)
AIC	–	842.56	825.47	821.80	821.45	823.05
BIC	–	855.79	848.53	844.81	844.50	846.07
τ	–	–	–	–	–1.722	0.498
ϕ, ϕ^c	–	–	6.51	2.97	8.60	2.39
$\rho_1 = \rho_2$	–	–	12.96	4.69	17.15	3.46
p-value			(0.000)	(0.031)	(0.000)	(0.064)

Critical values: $\lambda_{\text{trace (5\%)}} = 19.96$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (10\%)}} = 5.23$, $\phi_{\text{M-TAR (10\%)}} = 5.13$, $\phi^c_{\text{TAR (10\%)}} = 6.44$, $\phi^c_{\text{M-TAR (10\%)}} = 5.73$

Table 16. Peru

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	6.88(C,4)	–	–	–	–	–
ρ_1	–	–0.007(2)	–0.035(4)	–0.116(C,8)	–0.040(6)	–0.080(C,6)
t-statistic		(–0.36)	(–1.29)	(–0.70)	(–1.51)	(–0.60)
ρ_2	–	–	–0.086	0.447	–0.101	0.284
t-statistic			(–2.51)	(2.69)	(–2.91)	(2.54)
AIC	–	–119.05	–120.78	–118.16	–123.75	–121.22
BIC	–	–109.96	–96.75	–85.34	–99.72	–99.24
τ	–	–	–	–	–0.097	0.052
ϕ, ϕ^c	–	–	5.26	3.72	6.77	3.33
$\rho_1 = \rho_2$	–	–	8.30	0.60	11.30	0.45
p-value			(0.004)	(0.440)	(0.000)	(0.502)

Critical values: $\lambda_{\text{trace (5\%)}} = 19.96$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (10\%)}} = 5.20$, $\phi_{\text{M-TAR (10\%)}} = 5.20$, $\phi^c_{\text{TAR (10\%)}} = 6.35$, $\phi^c_{\text{M-TAR (10\%)}} = 5.52$

Table 17. The Philippines

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	27.13(C,4)	–	–	–	–	–
ρ_1	–	–0.058(C,4)	–0.054(C,6)	–0.271(C,4)	–0.050(C,3)	–0.316(C,3)
t-statistic		(–3.25)	(–2.16)	(–2.27)	(–2.15)	(–2.90)
ρ_2	–	–	–0.128	–0.219	–0.109	–0.137
t-statistic			(–2.78)	(–1.58)	(–2.88)	(–1.54)
AIC	–	994.09	957.14	986.92	982.11	1,003.27
BIC	–	1,013.88	996.41	1,016.42	1,011.71	1,023.06
τ	–	–	–	–	1.376	0.607
ϕ, ϕ^c	–	–	7.84	5.96	7.25	6.17
$\rho_1 = \rho_2$	–	–	3.20	1.83	3.39	3.55
p-value			(0.075)	(0.176)	(0.067)	(0.064)

Critical values: $\lambda_{\text{trace (1\%)}} = 24.60$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (5\%)}} = 6.35$, $\phi_{\text{M-TAR (10\%)}} = 5.13$, $\phi^c_{\text{TAR (10\%)}} = 6.44$, $\phi^c_{\text{M-TAR (10\%)}} = 5.32$

Table 18. Poland

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	11.96(4)	–	–	–	–	–
ρ_1	–	–0.067	–0.155(C)	–0.116(1)	–0.141	–0.219(C)
t-statistic		(–2.26)	(–2.96)	(–0.70)	(–3.46)	(–1.57)
ρ_2	–	–	–0.032	0.447	–0.006	0.177
t-statistic			(–0.53)	(2.69)	(–1.40)	(1.81)
AIC	–	21.53	25.80	21.62	23.45	23.80
BIC	–	27.58	34.89	30.67	29.51	32.88
τ	–	–	–	–	0.175	0.072
ϕ, ϕ^c	–	–	6.69	0.11	6.97	2.55
$\rho_1 = \rho_2$	–	–	7.27	0.086	4.15	2.51
p-value			(0.007)	(0.769)	(0.044)	(0.141)

Critical values: $\lambda_{\text{trace (5\%)}} = 12.53$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (5\%)}} = 5.98$, $\phi_{\text{M-TAR (10\%)}} = 5.47$, $\phi^c_{\text{TAR (5\%)}} = 6.95$, $\phi^c_{\text{M-TAR (10\%)}} = 5.73$

Table 19. South Africa

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	22.64(C,4)	–	–	–	–	–
ρ_1	–	–0.040(4)	–0.070(1)	0.164(6)	–0.058(6)	0.173
t-statistic		(–2.40)	(–2.18)	(1.53)	(–1.74)	(1.78)
ρ_2	–	–	–0.008	–0.124	–0.020	–0.171
t-statistic			(–0.27)	(–1.22)	(–0.57)	(–1.71)
AIC	–	708.28	711.75	545.87	709.85	756.93
BIC	–	753.81	754.03	551.87	758.63	763.55
τ	–	–	–	–	1.392	–0.449
ϕ, ϕ^c	–	–	1.90	6.22	3.06	5.37
$\rho_1 = \rho_2$	–	–	5.20	3.79	3.97	6.13
p-value			(0.023)	(0.0053)	(0.047)	(0.014)

Critical values: $\lambda_{\text{trace (1\%)}} = 24.60$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (5\%)}} = 4.92$, $\phi_{\text{M-TAR (10\%)}} = 5.13$, $\phi^c_{\text{TAR (10\%)}} = 6.44$, $\phi^c_{\text{M-TAR (10\%)}} = 5.32$

Table 20. Russia

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	8.89(C,2)	–	–	–	–	–
ρ_1	–	–0.045(4)	–0.027	–0.037	–0.041(6)	–0.207(C)
t-statistic		(–1.68)	(–0.76)	(–0.295)	(–1.24)	(–1.39)
ρ_2	–	–	–0.045	0.195	–0.118	0.261
t-statistic			(–1.27)	(1.79)	(–2.41)	(2.46)
AIC	–	221.67	233.04	225.95	199.82	223.79
BIC	–	236.30	238.96	231.85	234.41	232.64
τ	–	–	–	–	–0.662	0.138
ϕ, ϕ^c	–	–	1.09	1.66	3.14	3.66
$\rho_1 = \rho_2$	–	–	0.12	1.93	2.13	2.22
p-value			(0.722)	(0.166)	(0.146)	(0.138)

Critical values: $\lambda_{\text{trace (5\%)}} = 19.96$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (10\%)}} = 5.01$, $\phi_{\text{M-TAR (10\%)}} = 5.47$, $\phi^c_{\text{TAR (10\%)}} = 6.35$, $\phi^c_{\text{M-TAR (10\%)}} = 5.73$

Table 21. Sri Lanka

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	5.29(2)	–	–	–	–	–
ρ_1	–	–0.020(4)	0.009	0.154	0.004(C,6)	0.010(4)
t-statistic		(–1.55)	(0.38)	(1.60)	(0.19)	(0.11)
ρ_2	–	–	–0.067	0.241	–0.062	0.269
t-statistic			(–2.04)	(2.43)	(–2.36)	(2.99)
AIC	–	–62.60	–70.33	–42.55	–65.46	–63.97
BIC	–	–46.11	–57.22	–35.92	–35.86	–47.47
τ	–	–	–	–	0.273	0.044
ϕ, ϕ^c	–	–	2.47	4.25	3.06	4.66
$\rho_1 = \rho_2$	–	–	0.59	0.39	0.31	3.73
p-value			(0.445)	(0.532)	(0.581)	(0.054)

Critical values: $\lambda_{\text{trace (5\%)}} = 12.53$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (10\%)}} = 4.94$, $\phi_{\text{M-TAR (10\%)}} = 5.38$, $\phi^c_{\text{TAR (10\%)}} = 6.44$, $\phi^c_{\text{M-TAR (10\%)}} = 5.32$

Table 22. Thailand

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	8.37(C,2)	–	–	–	–	–
ρ_1	–	–0.032(2)	0.011(C,1)	–0.132(C)	–0.002(C,6)	–0.148(C)
t-statistic		(–1.83)	(0.38)	(–1.17)	(–0.09)	(–1.43)
ρ_2	–	–	–0.092	0.186	–0.089	0.161
t-statistic			(–2.44)	(1.32)	(–2.65)	(1.49)
AIC	–	205.94	208.20	210.41	188.65	208.94
BIC	–	215.87	221.45	220.35	250.15	218.88
τ	–	–	–	–	0.463	0.104
ϕ, ϕ^c	–	–	3.25	1.15	3.65	1.88
$\rho_1 = \rho_2$	–	–	0.59	1.49	0.01	2.13
p-value			(0.442)	(0.224)	(0.753)	(0.145)

Critical values: $\lambda_{\text{trace (5\%)}} = 19.96$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (10\%)}} = 4.92$, $\phi_{\text{M-TAR (10\%)}} = 5.38$, $\phi^c_{\text{TAR (10\%)}} = 6.44$, $\phi^c_{\text{M-TAR (10\%)}} = 5.58$

Table 23. Taiwan

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	13.94(C,2)	–	–	–	–	–
ρ_1	–	–0.028(2)	–0.059(C,2)	0.163(C,2)	–0.012(C,8)	0.254(9)
t-statistic		(–1.71)	(–0.15)	(1.40)	(–0.50)	(2.95)
ρ_2	–	–	–0.044	0.142	–0.040	0.032
t-statistic			(–1.48)	(1.11)	(–1.60)	(0.30)
AIC	–	44.35	47.93	51.27	3.24	3.14
BIC	–	54.28	64.47	67.82	45.72	39.14
τ	–	–	–	–	0.417	–0.053
ϕ, ϕ^c	–	–	1.65	2.41	1.53	4.38
$\rho_1 = \rho_2$	–	–	0.00	1.81	0.33	2.53
p-value			(0.997)	(0.179)	(0.564)	(0.113)

Critical values: $\lambda_{\text{trace (5\%)}} = 19.96$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (10\%)}} = 4.92$, $\phi_{\text{M-TAR (10\%)}} = 5.36$, $\phi^c_{\text{TAR (10\%)}} = 6.44$, $\phi^c_{\text{M-TAR (10\%)}} = 5.32$

Table 24. Turkey

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	17.02(C,T,4)	–	–	–	–	–
ρ_1	–	–0.084(6)	–0.117(8)	–0.001	–0.095(2)	–0.079(2)
t-statistic		(–3.06)	(–2.77)	(–0.01)	(–2.62)	(–0.91)
ρ_2	–	–	–0.084	0.072	–0.049	0.111
t-statistic			(–2.37)	(0.69)	(–1.57)	(1.00)
AIC	–	261.36	258.81	281.84	266.21	273.45
BIC	–	290.86	298.02	288.47	279.44	286.68
τ	–	–	–	–	0.309	–0.107
ϕ, ϕ^c	–	–	4.84	0.24	4.55	0.92
$\rho_1 = \rho_2$	–	–	0.40	0.28	0.92	1.82
p-value			(0.526)	(0.599)	(0.338)	(0.179)

Critical values: $\lambda_{\text{trace (5\%)}} = 25.32$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (10\%)}} = 5.23$, $\phi_{\text{M-TAR (10\%)}} = 5.38$, $\phi^c_{\text{TAR (10\%)}} = 5.92$, $\phi^c_{\text{M-TAR (10\%)}} = 5.57$

Table 25. Venezuela

	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
λ_{trace}	14.38(C,2)	–	–	–	–	–
ρ_1	–	–0.003(4)	–0.037(4)	0.155	–0.102(C,4)	–0.184(1)
t-statistic		(–1.98)	(–2.77)	(1.68)	(–3.83)	(–2.06)
ρ_2	–	–	–0.019	0.103	–0.011	–0.057
t-statistic			(–0.90)	(0.97)	(–0.61)	(0.498)
AIC	–	274.92	276.52	297.27	268.23	297.08
BIC	–	291.36	296.25	303.88	291.25	306.98
τ	–	–	–	–	0.706	–0.115
ϕ, ϕ^c	–	–	2.14	1.88	7.32	6.22
$\rho_1 = \rho_2$	–	–	0.38	0.14	10.57	0.74
p-value			(0.536)	(0.707)	(0.338)	(0.389)

Critical values: $\lambda_{\text{trace (5\%)}} = 19.96$, $\tau_{(10\%)} = -3.03$, $\phi_{\text{TAR (10\%)}} = 5.23$, $\phi_{\text{M-TAR (10\%)}} = 5.38$, $\phi^c_{\text{TAR (10\%)}} = 6.44$, $\phi^c_{\text{M-TAR (10\%)}} = 5.57$

Table 26. Summary of Results

Country	Explosive Bubbles		Periodically Collapsing Bubbles			
	Johansen	Engle-Granger	TAR	M-TAR	Consistent TAR	Consistent M-TAR
ARG	yes	yes	–	–	–	–
BRA	yes	yes	–	–	yes	yes
CHI	no	no	yes	–	yes	yes
CHN	yes	yes	–	–	–	yes
COL	yes	yes	yes	–	yes	–
CZE	yes	yes	–	–	–	–
IDN	no	no	yes	–	yes	–
IND	yes	yes	–	yes	–	yes
ISR	yes	yes	–	–	–	–
KOR	no	no	–	yes	–	yes
MAS	yes	yes	–	–	–	–
MEX	yes	yes	yes	–	yes	–
PER	yes	yes	yes	–	yes	–
PHI	no	no	yes	yes	yes	yes
POL	yes	yes	yes	–	yes	–
RSA	yes	yes	–	–	–	–
RUS	yes	yes	–	–	–	–
SRI	yes	yes	–	–	–	–
THA	yes	yes	–	–	–	–
TPE	yes	yes	–	–	–	–
TUR	yes	yes	–	–	–	–
VEN	yes	yes	–	–	yes	yes

References

Andrews D., and W. Ploberger (1994) "Optimal tests when a nuisance parameter is present only under the alternative" *Econometrica* **62**, 1383–1414.

Balke, N. S., and T. B. Fomby (1997) "Threshold cointegration" *International Economic Review* **38**, 627–643.

Blanchard, O. (1979) "Speculative bubbles, crashes, and rational expectations" *Economics Letters* **3**, 387–389.

Blanchard, O., and M. W. Watson (1982) "Bubbles, Rational Expectations, and Financial Markets" NBER working paper 945.

Caner, M., and B. E. Hansen (2001) "Threshold autoregression with a unit root" *Econometrica* **69**, 1555–1596.

Chan, K. S. (1993) "Consistency and limiting distribution of the least squares estimator of a threshold autoregressive model" *The Annals of Statistics* **21**, 520–533.

Chan, K. S., and H. Tong (1989) "A Survey of the Statistical Analysis of a Univariate Threshold Autoregressive Model" in *Advances in Statistical Analysis and Statistical Computing: Theory and Applications, Vol. 2* by R. Mariano, Ed., JAI Press Inc.: Greenwich, Conn., 1–42.

Davies, R. B. (1977) "Hypothesis testing when a nuisance parameter is present only under the alternative" *Biometrika* **64**, 247–254.

Enders, W., and C. W. J. Granger (1998) "Unit-root tests and asymmetric adjustment with an example using the term structure of interest rates" *Journal of Business & Economic Statistics* **16**, 304–311.

Enders, W., and B. Falk (1998) "Threshold-autoregressive, median-unbiased, and cointegration tests of purchasing power parity" *International Journal of Forecasting* **14**, 171–186.

Enders, W., and P. Siklos (2001) "Cointegration and threshold adjustment" *Journal of Business & Economic Statistics* **19**, 166–176.

Engle, R., and C. L. W. Granger (1987) "Cointegration and error-correction: representation, estimation, and testing" *Econometrica* **55**, 251–276.

Evans, G. (1991) "Pitfalls in testing for explosive bubbles in asset prices" *American Economic Review* **81**, 922–930.

Hansen, B. (1996) "Inference when a nuisance parameter is not identified under the null hypothesis" *Econometrica* **64**, 413–430.

Lo, M., and E. Zivot (2001) Threshold cointegration and nonlinear adjustment to the law of one price" *Macroeconomic Dynamics* **5**, 533–576.

Neftei, S. N. (1984) "Are economic time series asymmetric over the business cycle?" *Journal of Political Economy* **92**, 307–328.

Petruccelli, J. D., and S. W. Woolford (1984) "A threshold AR(1) model" *Journal of Applied Probability* **21**, 270–286.

Potter, S. (1995) "A nonlinear approach to U.S. GNP" *Journal of Applied Econometrics* **10**, 109–125.

Seo, M. (2006) "Bootstrap testing for the null of no cointegration in a threshold vector error correction model" *Journal of Econometrics* **134**, 129–150.

Tong, H. (1983) *Threshold Models in Non-Linear Time Series Analysis*, Springer-Verlag: New York.