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ABSTRACT

This paper investigates empirically the existence of periodically collapsing bubbles in the Asian emerging stock markets using the Enders-Siklos (2001) momentum threshold autoregressive model. As explained in Bohl (2003), this non-linear time series technique can be used to analyze bubble driven run-ups in stock prices followed by a crash in a non- cointegration framework with asymmetric adjustment. This technique offers a more potent insight in the stock prices behavior than can possibly be obtained using conventional non-cointegration tests. The empirical findings for ten Asian emerging stock markets from 1993 to 2005 refute the bubble hypothesis.

1. INTRODUCTION

The standard present value rule of asset pricing may fail in financial markets when infinitely many assets can be traded. It can be shown that asset prices can be meaningfully decomposed into a fundamental value and a pricing bubble. The fundamental value obeys the present value rule. Most of the deviations of stock prices from the present value model can be captured by the bubble. Since the early 1980s, new developments in the stock markets and renewed investors' interest in those markets have motivated academic researchers to show continuous interest in the phenomenon of speculative bubbles. The emergence of bubbles is explained in the finance literature as a self-organizing process of infection among traders leading to equilibrium prices which deviate from fundamental values. This economic explanation makes bubbles transient phenomena and leads to repeated fluctuations around fundamentals.

Rational bubbles can follow either explosive AR(1) processes with deterministic time trends or more complex stochastic processes. These classes of bubbles assume that stock prices and dividends are not cointegrated, that is, there does not exist a stationary linear combination of the stock price and dividend. Standard tests for non-cointegration are often subject to substantial size distortion in the presence of periodically collapsing bubbles. Advances in econometrics allow a deeper study of bubbles and can lead to a better understanding of the characteristics of stock markets.

Earlier studies of the consistency of dividend and stock price data with the market fundamental hypothesis found it difficult to distinguish the contribution of hypothetical rational bubbles to stock prices from that of unobservable market fundamentals. Diba and Grossman (1988a) proposed an alternative testing strategy using the standard unit root test and a test for non-cointegration between real stock prices and dividends as a test for bubbles. The intuition behind this approach is as follows: If stock prices are not more explosive than dividends, then rational bubbles do not exist because if they do, the stock price time series will have an explosive conditional expectation. But the standard unit root and non-cointegration tests assume a unit root as the null hypothesis and a linear autoregressive process. A special class of rational bubbles called periodically collapsing bubbles follow a non-linear process and therefore cannot be detected using the Diba and Grossman test methodologies. Using simulated data in the presence of periodically collapsing bubbles, Evans (1991) showed that the standard unit root and non-cointegration tests led to the incorrect conclusion of the absence of bubbles most of the cases. But, Evans' result is based only on Monte Carlo simulations, not on empirical evidence. Using the annual and monthly US real stock price and dividend time series for the period 1871-1995, Bohl (2003) investigates empirically the existence of periodically collapsing bubbles in stock prices using the Enders and Siklos (2001) momentum threshold autoregressive (MTAR) model. This model can handle non-linear processes in a non-cointegration framework and take into account asymmetries in departures from the long-term equilibrium relationship. Hence, the MTAR model, by design, can capture empirically the characteristics of periodically collapsing bubbles. Bohl's findings refute Evans' hypothesis of periodically collapsing bubbles in the US stock market.

This paper also uses the Enders-Siklos (2001) momentum threshold autoregressive model to investigate the existence of periodically collapsing bubbles in the Asian Emerging stock markets. The empirical findings, using the annual and monthly real stock and dividend time series for the period 1993-2005 for ten Asian emerging markets, refute the bubbles hypothesis.

The paper proceeds as follows. Section 2 explains the theoretical underpinnings of periodically collapsing bubbles. Section 3 describes the econometric concepts and methodologies underlying the MTAR technique and how this technique is appropriate to capture the behavior of this class of rational bubbles in stock prices. Section 4 provides the application and estimation results for the Asian emerging stock markets as well as the data description. Finally section 5 concludes the paper.

2. THEORY OF PERIODICALLY COLLAPSING BUBBLES

A stock nonarbitrage or fundamental value is typically defined as the present value of its expected future dividends based on all currently available information. Mathematically,

$$P_t = \eta E_t(P_{t+1} + D_{t+1}), \tag{1}$$

where P_t is a real stock price at time t (nonarbitrage or intrinsic value), η is a constant discount rate ($\eta = \frac{1}{1+r}$), r is the constant real expected return, D_{t+1} is the real dividend to the holder of the stock between t and t +1, and E_t denotes the expectations conditional on information at time t.

The market-fundamentals solution to equation (1) is

$$P_t = F_t = \sum_{k=1}^{\infty} \eta^k E_t D_{t+k} \tag{2}$$

provided the transversality condition $\lim_{n->\infty} \eta^n E_t P_{t+n} = 0$ holds. This occurs when the conditional expectations are defined and the sum converges. When the transversality condition fails to hold, equation (1) has not one unique solution given by equation (2), but an entire class of solutions called homogeneous solutions given by

$$P_t = F_t + B_t , \tag{3}$$

where B_t , the bubble term, is any random variable that satisfies

$$B_t = \eta E_t B_{t+1} , \tag{4}$$

or equivalently $$B_{t+1} = \frac{B_t}{\eta} + b_{t+1} = B_t(1+ r) + b_{t+1}, \tag{5}$$

where $$b_{t+1} = B_{t+1} - E_t(B_{t+1}) \tag{6}$$

The bubble in the equity price is B_t, and the innovation in the bubble at time t +1 is b_{t+1} which has zero mean ($E_t\ b_{t+1} = 0$). A stochastic bubble is created when the innovation in the bubble b_t has a constant, nonzero variance. Hence, if bubbles exist, they must be expected to grow at the real rate of interest. B_t embodies the notion of a rational speculative bubble and, if present, it will cause P_t to deviate from the market fundamental path defined by $F_{t.}$

In the absence of bubbles ($B_t = 0,\ \forall$ k.), then equations (2) and (3) lead to

$$P_t - r^{-1}D_t = (r\eta)^{-1} \sum_{k=1}^{\infty} (\eta)^k E_t \Delta D_{t+k} \tag{7}$$

Clearly, equation (7) shows that if P_t and D_t are generated by I(1) processes, then $P_t - r^{-1}D_t$ is generated by a stationary process (there is a stationary linear combination of P_t and D_t , P_t and D_t must be cointegrated with cointegrating parameter r^{-1}).

In the presence of bubbles, the bubble term B_t must be added to the right-hand-side of equation (7) above. Because the bubble term B_t given in equation (4) follows a non-stationary process, P_t and D_t cannot be cointegrated in the presence of bubbles because $P_t - r^{-1}D_t$ will have an explosive conditional expectation. Therefore, Diba and Grossman (1988a) suggest testing for non-cointegration between real stock prices and dividends as a test for bubbles. But, Evans (1991) pointed out the limitation of this procedure which leads to the incorrect conclusion of non-existence of rational bubbles when periodically collapsing bubbles are present.

Evans (1991) periodically collapsing bubbles are a class of bubbles which are extremely attractive in that they collapse almost surely in finite time and are strictly positive (Diba and Grossman, 1988b):

$$B_{t+1} = \eta^{-1} B_t \in_{t+1} \ \text{if}\ B_t \leq \alpha. \tag{8a}$$

$$B_{t+1} = [\delta + (\pi\eta)^{-1}\ \theta_{t+1}(B_t - \eta\delta)] \in_{t+1} \quad \text{if}\ B_t > \alpha.\ , \tag{8b}$$

where $\eta = (1+r)^{-1}$, α and δ are positive parameters with $0 < \delta < \alpha\eta^{-1}$, $\in_{t+1}$ is an exogenous independently and identically distributed positive random variable with $E_t \in_{t+1} = 1$, and θ_{t+1} is an exogenous independently and identically distributed Bernoulli process (independent of $\in_{t+1}$) which takes the value 1 with probability π and the value 0 with probability $1-\pi$, where $0 < \pi < 1$. Hence, π is the probability of continuation of the bubble.

It is easy to verify that the process in equation (8) satisfies equation (4) and that $B_t > 0$ implies $B_m > 0$, $\forall\, m > t$. As long as $B_t \leq \alpha$, the bubble grows at mean rate $1 + r = \eta^{-1}$. When $B_t > \alpha$, the bubble moves into a phase in which it grows at the faster mean rate $(\pi\eta)^{-1}$ as long as the eruption continues, but in which the bubble collapses with probability $1-\pi$ per period. When the bubble collapses, it falls to a mean value of δ, and the process begins again. Varying δ, α, and π leads to an alteration of the frequency with which bubbles erupt, the average length of time before collapse, and the scale of the bubble.

Equations (8a) and (8b) show that Evans' bubbles model satisfies two theoretically well-grounded properties of stochastic bubbles. First, this class of bubbles cannot completely burst because after a complete collapse they cannot emerge again. Second, a negative stock price bubble cannot exist because it would imply a negative expected stock price which is not economically sound.

Periodically collapsing bubbles clearly satisfy equation (4). Using Monte Carlo simulations, Evans (1991) shows that this class of bubbles may appear to be stationary on the basis of standard tests even though they are explosive by construction. This may be due to the sudden collapse of the bubble which standard tests may interpret as a mean reversion, biasing the test towards rejection of non-cointegration. This paper explores the consequences of using the

Enders-Siklos momentum threshold autoregressive model to investigate empirically the existence of periodically collapsing bubbles in the Asian emerging markets stock prices. A brief description of this model follows.

3. THE MOMENTUM THRESHOLD AUTOREGRESSIVE MODEL

The momentum threshold autoregressive (MTAR) model in Enders and Siklos (2001) can capture the characteristics of periodically collapsing bubbles. When periodically collapsing bubbles are present in stock prices, the estimated residuals ω_t^* from the cointegration regression

$$P_t = \lambda_0^* + \lambda_1^* D_t + \omega_t^* \tag{9}$$

shows patterns of increases in stock prices followed by a sudden drop. This kind of behavior of the stock price can be captured in the following regression

$$\Delta\omega_t^* = K_t \phi_1 \omega_{t-1}^* + (1 - K_t)\phi_2 \omega_{t-1}^* + \sum_{j=1}^{\tau} \xi_j \Delta\omega_{t-j}^* + \mu_t \tag{10}$$

where K_t, the indicator variable, is defined as follows: $K_t = 1$ if $\Delta\omega_{t-1}^* \geq \Omega$ and $K_t = 0$ if $\Delta\omega_{t-1}^* < \Omega$, with Ω being the value of the threshold.

In the MTAR model, the null hypothesis of no cointegration is $H_0 : \phi_1 = 0,\quad H_0 : \phi_2 = 0$ and $H_0 : \phi_1 = \phi_2 = 0$. The critical values for the corresponding t- and F-statistics are provided in Enders and Siklos (2001), Tables 1 and 2. The null hypothesis of symmetric adjustment $H_0 : \phi_1 = \phi_2$ can be tested using the F-statistic if the null hypothesis of no cointegration is rejected. When the null hypothesis of symmetric adjustment is not rejected, we can conclude that the stock price series P_t and dividend series D_t are cointegrated. That is, there is a stationary linear combination of P_t and D_t with symmetric adjustment. A special case of the MTAR test is the Engle and Granger (1987) test. However, for a wide range of adjustment parameters, the MTAR test is more powerful when asymmetric departures from equilibrium occur.

As clearly stated in Bohl (2003), the MTAR model is designed to empirically detect periodically collapsing bubbles because theoretically, there is a potential for these bubbles to take positive but not negative values. Moreover, the run-ups or increases in stock prices before a crash occurs are an indication of an asymmetry in the evolution of the residuals of the cointegration regression (9). The path of changes in ω_{t-1}^{*} above the threshold followed by a sharp drop to the threshold captures periodically collapsing bubbles. But, the path changes in ω_{t-1}^{*} below the threshold does not show bubble eruptions followed by a collapse.

If the threshold is constrained to zero (Ω = 0), a positive change in the estimated residuals ($\Delta\omega_t^{*} > 0$) indicates a rise in stock prices relative to dividends followed by a crash, where the departure from present value rules can be persistent and substantial according to Evans (1991). In contrast, when $\Delta\omega_t^{*} < 0$, decreases in stock prices relative to dividends followed by a sharp rebound back to the equilibrium position is less likely. These asymmetric deviations from the equilibrium position are indicative of the existence of periodically collapsing bubbles in stock prices. In this case, the estimated coefficient ϕ_1^{*} is statistically significant and negative and greater than ϕ_2^{*} in absolute value, and the null hypothesis of symmetric adjustment $H_0 : \phi_1 = \phi_2$ is rejected.

As opposed to a test of the null hypothesis of no cointegration, a test of cointegration with MTAR adjustment, even though an indirect test of the presence of periodically collapsing bubbles, overcomes the problems inherent in standard unit root and cointegration tests identified in Evans (1991).

The key objective and contribution of this paper is the investigation of the null hypothesis of symmetry, not the rejection of the null hypothesis of no cointegration. Therefore, using equations (8a) and (8b), Evan's (1991) Monte Carlo simulations are replicated by setting the parameter values as follows: $r = 0.05$; $\eta = \frac{1}{1+r} = 0.9524$; $\alpha = 1$; $\delta = 0.50$; B_t value at time zero $= \delta$; and $T = 100$. In this paper, 10,000 runs of the simulations are conducted and the corresponding regressions are assessed. Because the true value of the threshold parameter Ω is not known *ex ante,* Chan's (1993) approach is used to estimate this parameter. The estimated residuals are sorted in ascending order, with the 15% largest and smallest values deleted. From the remaining 70% residuals, the threshold parameter which yields the lowest residual sum of squares is selected (e.g., Enders and Siklos, 2001]. The degree of rejection of the null $H_0 : \Phi_1 = \Phi_2 = 0$ and $H_0 : \Phi_1 = \Phi_2$ is compiled in Table A at the 10%, 5% and 1% significance level and for different probabilities π varying from 0.99 to 0.10. The null hypothesis $\Phi_1 = \Phi_2 = 0$ is highly rejected for almost all significance levels and for almost all levels of the probability of continuation of the bubble per period π. The degree of rejection increases slightly as the probability π decreases. The degree of rejection of the null hypothesis $\Phi_1 = \Phi_2$ is more than acceptable and increases with the significance level. Overall, the explanatory power of both tests is very high. Hence, the F-test for the symmetry hypothesis is robust enough to identify any asymmetry when the actual data generating process is dictated by Evans' bubble model.

[TABLE A ABOUT HERE]

4. DATA AND EMPIRICAL RESULTS

Data were collected from ten emerging Asian stock markets: Hong Kong, Singapore, Taiwan, Thailand, Malaysia, India, Pakistan, Indonesia, Philippines, and South Korea. The data were obtained from the International Finance Corporation (IFC) Emerging Markets Data Base (EMDB). Tests are performed on the IFC Emerging Market Investable Indexes. The IFC investable indexes were introduced in March 1993. The IFC investable indexes are adjusted to reflect the accessibility of markets and individual stocks to foreign investors. These indexes offer a performance benchmark for international investors who might view the illiquid or restricted securities in a market to be irrelevant. Unit root tests and cointegration approaches are applied to the real annual and monthly stock price and dividend data for Asian investable emerging markets for the period 1993-2005. The index price series are the market capitalization weighted series of individual stock price series in the index. The index dividend series are also the market capitalization weighted series of the individual stock dividend series in the index. The index price series are regressed over the index dividend series. The empirical results are summarized in Tables B and C.

The stochastic properties of real Asian emerging markets stock price series and real dividend series are examined separately by applying the Dickey and Fuller (1981) or DF method and the Kwiatkowski, Phillips, Schmidt and Shin (1992) or KPSS approach. For these tests, the approximate critical values are taken from MacKinnon (1991) and Sephton (1995) respectively. Table B shows the results of the real Asian emerging markets stock price series P_t and real dividend series D_t as well as the series associated with the changes in these variables, namely

ΔP_t and ΔD_t. Hall (1994) procedure is used to determine the time lag τ of the DF tests while the Schwert (1989) approximation, $\tau = \text{int}\left[4(T/100)\right]^{\frac{1}{4}}$, is used for the KPSS tests. The KPSS tests investigate the null hypothesis of level stationarity and the DF tests are undertaken with a constant term. All test statistics are reported at the 10%, 5% and 1% significance level.

[TABLE B ABOUT HERE]

In Table B, the DF tests cannot reject the null hypothesis of a unit root in the real stock price and dividend time series but they reject the null hypothesis of a unit root in both time series of the changes in value ΔP_t and ΔD_t. The KPSS tests reject the null hypothesis of level stationarity but cannot reject the same null hypothesis for the ΔP_t and ΔD_t time series. A careful observation of the statistics in Table B leads to the conclusion of the existence of one unit root in the level of both types of time series. Another set of tests such as DF tests with a constant term and a linear time trend in the alternative hypothesis and KPSS tests that investigate the null hypothesis of trend stationarity are also examined. The findings of these alternative tests, not reported here, support the results presented in Table B. The data frequency does not affect the results in Table B, consistent with Bohl (2003) and other recent research in the literature of bubbles studies. The results of the unit root tests in Table B refute the existence of speculative bubbles in the Asian Emerging Stock Markets.

The test for cointegration between the real stock prices and dividends is then conducted using the Engle-Granger (1987) methodology based on equation (9) and the support regression $\Delta\omega_t^* = \Phi\omega_{t-1}^* + \sum_{j=1}^{\tau}\xi_j\Delta\omega_{t-j}^* + \mu_t$. The lag lengths τ are picked based on the statistically significant coefficients of the lagged values $\Delta\omega_{t-j}^*$. The results of the cointegrating regression

Durbin-Watson (DW) tests and the cointegrating regression augmented Dickey-Fuller (DF) tests are reported in Table C, Panel 1. Both tests reject the null hypothesis of no cointegration at the 5% significance level. In addition, the Johansen's (1991) maximum likelihood approach is applied with the lag lengths picked based on the criteria of serially uncorrelated residuals. To this end, the LM-type tests for first and fourth order autocorrelation ($LM1$ and $LM4$) are carried out. The finding based on the trace test statistics is that the real stock price series and real dividend series are cointegrated. Moreover, the estimated values of the cointegrating coefficients λ_1^* are stable for all the cointegration techniques implemented. Based on the conventional Engle-Granger and Johansen cointegration tests (Table C), which both assume *linear* and *symmetric* adjustment, the real stock price and dividend time series are cointegrated. Hence, these two conventional cointegration analyses refute the existence of *speculative* bubbles in the Asian emerging stock markets. The results achieved here are not affected by the alternative specifications and test methodologies.

[TABLE C ABOUT HERE]

But the conventional tests indicated above cannot rule out the existence of *periodically collapsing* bubbles. To be able to test for asymmetric adjustment patterns in favor of the existence of periodically collapsing bubbles, the momentum threshold autoregressive (MTAR) univariate model in Enders and Granger (1998) is applied separately to the time series ΔP_t and ΔD_t. The results, not displayed here, are as follows: (1) the annual time series do not show asymmetries; (2) the monthly time series show statistically significant adjustment patterns at the 10% level supporting the existence of periodically collapsing bubbles.

The test results for the MTAR model appear in Table C, Panel 3. These results include the estimated parameters ϕ_1^* and ϕ_2^* in equation (10) and the related $t-$statistics for the null hypotheses $H_0 : \phi_1 = 0$ and $H_0 : \phi_2 = 0$; the $F-$statistics, F_{NC}^*, which tests the null hypothesis of no cointegration $H_0 : \phi_1 = \phi_2 = 0$; the $F-$statistics, F_{SA}^*, which tests the null hypothesis of symmetric adjustment $H_0 : \phi_1 = \phi_2$; and the consistently estimated attractor parameter Ω^* using Chan's (1993) approach. The estimated parameters related to the deviations below and above the threshold are negative and statistically significant at the 5% and 1% level. The F_{NC}^* statistics are statistically significant at the 5% and 1% levels for the annual and monthly time series respectively and therefore reject the null hypothesis of no cointegration. In absolute terms, the estimated values for ϕ_1^* are higher than those for ϕ_2^*. The F_{SA}^* statistics cannot reject the null hypothesis of symmetric adjustment. This is most likely due to a synchronized asymmetric behavior across the two time series. The results of the MTAR cointegration tests in Panel 3 of Table C provide the evidence that refutes the existence of periodically collapsing bubbles in the Asian emerging stock markets: the null hypothesis of no cointegration is rejected and the residuals generated by the run-ups in the stock prices followed by a crash do not exhibit an asymmetric development.

5. CONCLUSIONS

This paper investigates empirically the existence of periodically collapsing bubbles in monthly and annual Asian emerging markets stock prices, using the Enders and Siklos (2001) momentum threshold autoregressive (MTAR) cointegration model. Although these bubbles clearly satisfy equation (4), Evans (1991) shows, using Monte Carlo simulations, that they may often appear to be stationary on the basis of standard tests, even though they are by construction explosive. Intuitively, this may be due to the sudden collapse of the bubble, which standard tests may in some sense 'mistake' for mean reversion, biasing the test towards rejection of non-cointegration. The proposed model is a generalization of Engle and Granger (1987) two-step procedure and can be used to formally test for rational speculative bubbles which may burst after they have reached certain levels. The bubbles component can be seen as a non-linear process in the alternative hypothesis. Even in the case the actual data generating process is given by Evans (1991) bubble model, the MTAR technique remains a very robust test to detect periodically collapsing bubbles. The results of the Monte Carlo simulations conducted here support this assertion.

Based on the MTAR approach, the empirical results in this paper refute the existence of periodically collapsing bubbles in the Asian emerging stock markets for the period 1993-2005. Moreover, deviations from the long-term equilibrium relationship do not appear to show an asymmetric adjustment of the residuals from the long-run relationship. These results do not support Evans' (1991) claim of periodically collapsing bubbles, but are consistent with Bohl (2003). These results are also consistent with Taylor and Peel (1998) who propose a test based on a modification to the least squares estimator designed to be robust in the presence of error terms which may exhibit strong skewness and kurtosis.

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<u>Table A</u>: Monte Carlo Simulation Results Based on the MTAR Methodology

Significance Level		10%		5%		1%	
Null Hypothesis		$\phi_1 = \phi_2 = 0$	$\phi_1 = \phi_2$	$\phi_1 = \phi_2 = 0$	$\phi_1 = \phi_2$	$\phi_1 = \phi_2 = 0$	$\phi_1 = \phi_2$
Exact rejection of the null hypothesis for different values of the probability π	0.99	0.991	0.718	0.982	0.601	0.968	0.513
	0.95	0.991	0.715	0.982	0.598	0.967	0.511
	0.85	0.991	0.708	0.983	0.589	0.967	0.499
	0.75	0.991	0.694	0.984	0.579	0.969	0.482
	0.65	0.992	0.648	0.986	0.553	0.978	0.464
	0.50	0.993	0.561	0.990	0.541	0.982	0.447
	0.25	0.994	0.476	0.994	0.463	0.986	0.396
	0.10	0.996	0.402	0.998	0.417	0.989	0.365

Each entry in Table A represents the percentage of cases in which the null hypothesis is correctly rejected. The details of the Monte Carlo simulation are provided in the text.

Table B: Unit Root Tests

Annual Data	P_t	D_t	ΔP_t	ΔD_t
DF	-0.058	-0.093	-12.472*	-11.033*
τ	0	0	0	0
KPSS	1.975*	3.022*	0.384	0.269

Monthly Data	P_t	D_t	ΔP_t	ΔD_t
DF	0.082	-1..323	-16.398*	-12.104*
τ	5	5	4	4
KPSS	14.109*	16.481*	0.43	0.13

P_t is the real stock price at time t, D_t is the real dividend at time t, ΔP_t is the change in the stock price at time t, ΔD_t is the change in dividend at time t, *DF* is the augmented Dickey-Fuller (1981) statistic and *KPSS* is the Kwiatkowski, Phillips, Schmidt and Shin (1992) statistic. Hall (1994) procedure is used to determine the time lag τ of the *DF* tests. The Schwert (1989) approximation, $\tau = \text{int}[4(T/100)]^{\frac{1}{4}}$, is used to compute the time lag of the KPSS tests. For the KPSS tests, the time lag is $\tau = 4$ for annual data and $\tau = 7$ for monthly data. Annual and monthly stock and dividend time series for ten Asian emerging stock markets are used. These markets include Hong Kong, Singapore, Taiwan, Thailand, Malaysia, India, Pakistan, Indonesia, Philippines, and South Korea. These data are obtained from the International Finance Corporation (IFC) Emerging Markets Data Base (EMDB). Tests are performed on the IFC Emerging Market Investable Indexes.
* means statistically significant at the 1%.

<u>Table C</u>: Cointegration Tests

Panel 1: Engle-Granger Results	Monthly Data	Annual Data
Estimated Cointegrating Parameter λ_1^*	37.781	33.146
Cointegrating Regression Durbin-Watson Statistic DW	0.085	0.611**
Cointegrating Regression Augmented Dickey-Fuller Statistic DF	- 6.174*	- 4.295**
Coefficient of Determination $\overline{R}^2$	0.848	0.912
Lag Length τ	1, 5	0

Panel 2: Johansen Procedure (Trace Test)	Monthly Data	Annual Data
Estimated Cointegrating Parameter λ_1^*	39.011	35.951
Number of Cointegrating Vectors $\vartheta = 0$	33.264*	14.625***
Number of Cointegrating Vectors $\vartheta \leq 1$	0.214	0.087
$LM1$ - Type Test of First Order Autocorrelated Residuals	3.726	3.382
$LM4$ - Type Test of Fourth Order Autocorrelated Residuals	6.083	4.513
Lag Length τ	1, 2, 3	1

Panel 3: MTAR Methodology	Monthly Data	Annual Data
Estimated Threshold Parameter Ω^* Using Chan (1993)	0.782	11.228
Estimated Parameter of the MTAR Model ϕ_1^*	- 0.053 (5.221)*	- 0.625 (4.241)*
Estimated Parameter of the MTAR Model ϕ_2^*	- 0.027 (2.13)**	- 0.313 (2.371)**
$F-$statistic for the Null Hypothesis of no Cointegration F_{NC}^*	11.491*	8.053**
$F-$statistic for the Null Hypothesis of Symmetric Adjustment F_{SA}^*	3.978	2.492
Lag Length τ	1, 5	0

*, **, *** mean statistically significant at the 1%, 5% and 10% level, respectively.
$t-$statistics are in parentheses.