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Understanding Market Inefficiency in the East Asian Region during Times of Crisis

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The study of financial market efficiency has important implications in terms of global macroeconomic stability. The case of six selected East Asian stock markets (China, Japan, Hong Kong, Malaysia, Singapore and South Korea) during the Asian Financial Crisis (AFC) and Global Financial Crisis (GFC) is analysed here using a battery of well-known econometric techniques that starts with traditional unit root testing for random walk behaviour. The six countries were selected on the basis of market capitalization to offer insights into the behaviour of the most relevant markets in the region. The results show that during both crises, these markets exhibited significant inefficiencies. This is shown by the fact that positive correlations characterized markets returns behaviour in general, except for South Korea and Hong Kong, during the GFC. Of particular note is the case of China; its stock markets suffered losses and high volatility during the GFC and exhibited increasing correlations with other stock markets in the region, showing progressive levels of integration within the region and more exposure to global events.

Keywords: East Asian region, market inefficiency, Asian Financial Crisis, Global Financial Crisis.

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1. Introduction

Since the 1990s, the East Asian region has been exposed to two major episodes of financial turmoil that stirred uncertainty, namely the 1997–98 Asian Financial Crisis (AFC), and the 2007–09 Global Financial Crisis (GFC). High levels of volatility in financial markets are a source of major concern among market participants (investors, regulators, governments and market analysts) due to the magnitude of the

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damage and the socio-economic hardship that they can cause. Increasing levels of market uncertainty have a negative impact on investors' levels of confidence; they undermine the efficient allocation of resources and ultimately cause significant delays in terms of investment decisions. At the time of crisis, the circulation of liquidity deteriorates in a significant manner, placing major restrictions on economic activities and disrupting regional and international financial systems. Noteworthy delays are caused by the need of introducing changes on already designed investment portfolios with the aim of incorporating appropriate assessments on market uncertainty and increasing levels of risk to counteract negative effects on the overall investment portfolio. When volatility levels are identified to be highly persistent and exhibit clustering behaviour, past volatility can be used to construct forecasts on future volatility, a behaviour in clear contradiction with the basic principles of efficient markets, in which forecasting abilities are not considered to be plausible. In addition, periods of relative tranquillity, when stock markets are considered to be stable, can be followed by intervals of high instability due to regional or global events, leading to a change of dynamics of market interlinkages.

Even after decades of empirical investigation, little is known about differences in the degree of efficiency across markets. Equally little is known about the underlying factors that contribute to greater stock market efficiency in the context of significant market uncertainty associated with severe periods of market disruption. This is an issue explored in this study by looking at the inefficiencies of individual markets during two major crisis events in the Asian region and by analysing whether the dynamics of individual markets have been significantly affected.

The literature indicates that the highest levels of inefficiency are registered during times of crisis, a state of affairs that might be justified by heavy government intervention seeking to control the behaviour of markets. These actions could end up introducing predictable patterns in market dynamics, and as a result they could undermine their efficiency in the context of the Efficient Market Hypothesis. In the finance literature, an efficient market is one in which stock prices fully reflect all available information, thereby leading to the efficient allocation of scarce capital resources (Samuelson 1965; Fama 1965, 1970, 1991). Hence, market inefficiency could seriously limit the ability of the stock market to allocate funds to the most productive sectors of the economy, potentially hampering long-term growth. Consequently, a financial system that is efficient lays the economic foundations for public policy intervention in the economy and its stock markets, but at the same time it raises concerns regarding the limits of this intervention and on how resource allocation can turn up being affected by governments' own interests in terms of capital provisions. Market interventions could lead to the enhancement of market inefficiencies, an argument that is supported by studies finding significant inefficiency levels during periods of crisis (Cajueiro and Tabak 2004, 2005*a*, 2005*b*; Lim 2008). Therefore, a study examining market efficiency during periods of crisis is needed in the Asian context, as it will help gain further understanding of market dynamics and how they are affected by financial uncertainty. Moreover, the study seeks to identify if Asian markets are exhibiting different dynamics as their economies mature and become more integrated.

Cognizant of the relevance of understanding how global and regional events affect financial markets, the study proposes a comparative analysis of stock market performance and efficiency during times of extraordinary uncertainty such as those associated with crises periods. The goal is to examine the volatility behaviour of major stock markets in the East Asian region (namely Japan, Hong Kong, Malaysia, Singapore, South Korea, and China), and their behaviour during the Asian and Global Financial Crises. The chosen markets were selected on the basis of market capitalization (value of all shares traded on the selected stock exchange); consequently, this study can be seen as representative for the entire East Asian region. The main objective of the study is to understand how market efficiency levels might have varied during the occurrence of the two major crises, and also to confirm if market inefficiencies are a common finding in the case of the two shocks.

A Unit Root framework combined with Variance Ratio tests (VR), cointegration modelling (Johansen and Engle & Granger tests) and volatility analysis (GARCH) is used to identify volatility persistence patterns in the region. This study focuses on the detection of significant changes in both market returns variance and market long-run relationships and provides some initial results and insights on market interlinkages and volatility behaviour in the region during times of sustained uncertainty. Overall, the paper contributes to the current discussion on the issue of how market inefficiency can be explained by existing theories that do not take into account imperfect (or manipulated) information and its pernicious effects on both the financial markets and the macro-economy.

The paper is structured as follows. The second section discusses whether the behaviour of markets can be understood in line with the theoretical frameworks popularized by Samuelson (1965) and Fama (1965, 1970). Arguments in line with the psychological and sociological factors influencing investors' behaviour (Shiller 1982) are also alluded to in this section. The subsequent section explains the methodology used and connections made with research studies that have been supported by the chosen tests. The fourth section proposes a comparative analysis of the two crisis periods to gain a better understanding of market dynamics, and the fifth section deals with policy implications. The final section concludes.

2. A General Review of the Efficient Market Hypothesis

In the economy described by the classical economists of the late eighteenth and early nineteenth centuries (Smith 1776), markets behave spontaneously under the impulse of price changes (the famous "invisible hand") that lead to adjustments between supply and demand and to equilibrium. Perfect information is an implicit important assumption in this idealized economy. It is upon these premises that Fama (1965, 1970) developed the efficient market hypothesis applicable to the case of financial markets. According to this hypothesis, a market is said to be efficient if, for any assets in that market, the price of that asset can be written as $Pt = EtPt$, where Pt is the present value of future prices, and where Et corresponds to the mathematical expectation conditional on all information available at time (t), with n well informed and profit maximizing market participants that are risk neutral. The above definition suggests that in an efficient market, all available information at time (t) is fully reflected in an asset price; no algebraic interpretation of one asset price as a function of another can therefore be performed, and no unexploited opportunities for (abnormal) profits exist.

Consequently, from a technical viewpoint and following the argument outlined by Granger (1986) if, in a given market, two or more asset prices show a stable common relationship in the long run (i.e., if two or more asset prices are cointegrated), the market will not be "efficient" (Richards 1995). The establishment of a cointegration relationship is equivalent to the existence of an error correction term (ECM). In this case, the price of one asset does not only depend on its own past prices but also on the history of the prices of different assets. The ECM implies that, in the case of a deviation of one asset price from the induced long-run relationship, unused profit opportunities would automatically arise. If market participants were aware of the existence of a stable long-run relationship between prices, they would be able to exploit them and be in a position to make excess profits (Copeland 1991), therefore contradicting the efficient market hypothesis (EMH). In short, the existence of cointegration between assets contradicts the weak form of the market efficiency argument because of its forecastability. A market is not efficient if cointegration between pairs is found, since cointegration means the predictability of at least one of the variables and this contradicts the notion of the market behaving in a random fashion. Existing research in the field (Alam, Hasan and Kadapakkam 1999; Phylaktis and Ravazzolo 2005; Chen, Firth and Meng 2002; Narayan, Smyth and Nandha 2004) has been supported by the use of Vector Autoregression, Cointegration and Error Correction Methodology (ECM) to examine markets' behaviour with the aim of understanding if they follow a random walk. These studies have been laying the ground for the selected

research methodology to support the present study. If markets are found to follow an autoregressive process (i.e., there is no random walk), the weak form of the market efficiency argument is then rejected.

Many tests on the EMH have been performed leading to a plethora of diverse results with mild support for the hypothesis particularly up to the 1990s (see Lim and Brooks 2011). In the case of Asian countries, the 1997 AFC had stirred a renewed interest in the EMH as applied to the case of primarily Southeast Asian and East Asian countries. Since currency markets were at the epicentre of the financial turmoil at the time, several studies applied the EMH test to Asian currency markets. For example, the study by Jeon and Seo (2003) on the exchange rate markets of Indonesia, Malaysia, Thailand and South Korea over the 1996–2001 period concludes with the existence of market inefficiency over the entire period. Covering a broader range of Asia-Pacific exchange markets (including Thailand, Indonesia, Malaysia, Japan, Singapore, Taiwan, South Korea and the Philippines) over a longer time-period (December 1996 to May 2003), Kan and Andreosso-O'Callaghan (2007) find support in favour of the EMH in the case of most countries. An explanation for this overall support of the EMH might be the increased momentum in terms of financial and monetary integration in the region towards the end of the chosen period, in particular with the 1999 Chiang Mai Initiative (CMI). In the case of stock markets after the AFC, weak form of market efficiency is reported for South Korea, Taiwan and Thailand by Kim and Abdul (2008), and only for a few countries such as Singapore and Thailand by Kim and Abdul (2008). In addition, Cooray and Wickramasighe (2007) find that post-deregulation, South Asian stock markets are generally efficient over the 1996–2005 period, except for Bangladesh which shows mixed results.

Of specific interest are the factors that may have rendered the Asian markets more efficient over time. Asian economies have been engaging in financial cooperation with the aim of developing their financial markets and of strengthening their economies so as to become more competitive and efficient. The Chiang Mai Initiative (CMI) is a prominent example of how East Asian economies sought to enhance financial cooperation since the 1997 AFC (Chey 2009). The crisis resulted in severe economic contraction in the region, which was felt more acutely because of the lack of concerted effective crisis management mechanisms. With an agreement reached between the finance ministers of Japan, China, Korea and ASEAN+3 countries to develop a currency swap and repurchase mechanisms that provided emergency foreign currency liquidity to support the region in the event of a future financial crisis, the CMI sought to enhance regional financial stability through financial cooperation in the region; as such, the initiative has helped to deepen regional integration (Park and Wang 2005). The CMI embraces three pillars: liquidity assistance; monitoring and surveillance; and exchange rate and financial policy cooperation. Since cooperation started with the enhancement of financial liquidity, it has laid the foundation for systemic, legal and institutional convergence, paving the way to further integration and the improvement of the financial system mechanisms — two pillars that are tightly connected to the desired aim of market efficiency (Zukrowska 2015). As Asian economies mature, the development of deeper and more complex regional economic interdependencies is leading towards intergovernmental cooperation that contributes to the creation of market efficiency (Eichengreen 2003; Hamilton-Hart 2006).

In particular, at the level of ASEAN, many post-Asian Crisis efforts have been deployed to enhance the development of capital markets with the ultimate goal of achieving higher levels of cross-border integration and efficiency that generate incentives and make the region more attractive to regional and international investors. Foreign owned/invested firms are attractive for developing economies that are seeking rapid economic growth and development, as these firms exhibit superior performance, higher levels of productivity, robust stock values and efficiency (Mohd Ghazali 2010; Khawar 2003; Haniffa and Cooke 2002; Huang and Shiu 2009). Moreover, foreign firms are able to benefit from the access to new markets, from the opportunities to exploit resources and to extract gains from lower labour costs, and from liberalization policies and tax incentives (Luo 2002). On the other hand, government interventions to encourage the presence of international investors by allowing the acquisition of equity, reducing corporate

tax rates and offering other types of incentives also lead to distorted investment behaviour that can harm market efficiency (Chen et al. 2011). These points provide an economic foundation for public policy interventions in stock markets, but at the same time raise concerns regarding the limits of intervention (Mookerjee and Yu 1999; Kavussanos and Dockery 2001). Therefore, it is important to consider that market efficiency requires both good institutions and good norms, and that government intervention should not seek to influence institutions or rules in order to safeguard the government's own interests (Ahsan 2012).

These efforts have been reiterated at the ASEAN Finance Ministers Meetings which aim to boost financial integration in the region with the objective of achieving greater economic integration (Guidi and Gupta 2011). Countries in the region have introduced a series of reforms to create a financial sector that is more open and attractive to regional and international investors. Singapore is a case in point. Since 1998, the Singaporean government has introduced major reforms that are aligned with new regulatory and supervisory market practices in compliance with best international practice (IMF 2004). Another example is Malaysia. In the 1990s, the Malaysian government allowed international investors to acquire equity in domestic firms combined with a reduction in the taxation rate applied to their profits. Furthermore, the government has been liberalizing the services sector since 2009 by offering a broad range of incentives to companies that seek to invest and expand on new projects. Special investment capital allowances and a variety of tax deductions have been offered to enhance market efficiency, encourage innovation and broaden the market, while emphasizing good governance practices (Deloitte 2016; PwC 2017). The last decades of economic development in Southeast Asia are marked by vibrant dynamics as the region has witnessed extraordinary growth, which were also accompanied by rising inequality and periodic crises. South Korea and Singapore are two examples of adequate policy responses to the crises (Bayoumi and Eichengreen 1999; Zhang, Sato and McAleer 2004; and Bacha 2008). These economies were severely affected by the Asian Crisis, with a subsequent upswing that was interrupted by the world economic recession (Weber 2012). Singapore and South Korea have become each other's top trading partner and the two economies seek to deepen cooperation in sectors such as communication technology, real estate and transport. Since the establishment of diplomatic ties in August 1975, the two countries have cooperated closely on the political, economic and cultural fronts, with unprecedented growth in bilateral trade and investment, and in terms of people-to-people exchange. A recent development includes the Singapore–South Korea cooperation agreement in FinTech signed in October 2016. The agreement seeks to explore potential joint innovation projects in technologies such as big data and mobile payments, and it enhances the financial relationship that exists between Korea and Singapore (Monetary Authority of Singapore 2016).

The case of China needs to be singled out since: (1) the country has gone through the AFC relatively unscathed; and (2) the level of government intervention in the financial sector is at the maximum. Interestingly, the variance ratio (VR)-based studies by Liu, Song and Romilly (1997), Long, Payne and Feng (1999), and Lima and Tabak (2004) all conclude that the Chinese stock markets confirm the weak form of the EMH. On the other hand, some VR-based studies such as those by Ma (2004) and Mookerjee and Yin (1999) find no support for the efficiency hypothesis. Mindful of the need to allow China to embark on a new economic growth path, financial reforms have been a major element of the Chinese 12th Five-Year Plan (2011–15) reiterated by the November 2013 Third Plenum Committee meeting. These new "reforms" are also aimed at tackling the issue of "financial repression" due to the heavy control of China's Communist Party on the banking system leading to skewed capital allocation and manipulated interest rates (Andreosso-O'Callaghan and Gottwald 2013).

In summary, the study of market efficiency in the case of Asian financial systems — in particular stock markets — has led to conflicting findings. The results depend on the techniques selected to perform the market analysis, on the chosen time periods as well as on the existence of structural breaks.

In this regard, the application of conventional VR tests seems to support the main argument of the existence of market efficiency with markets in the region following a random walk. The implementation of multivariate variance ratio tests provides more robust results, as they take into account the presence of heteroscedasticity. However, the results are also conflicting when the sample is subject to splitting, as testing multiple subperiods leads to contradictory results. It is quite common to find that markets behave in line with the random walk hypothesis during recent periods and depart from such behaviour when the samples under analysis deal with older data sets. The existence of mixed results can ultimately be justified by the dynamic nature of stock markets that are subject to the relaxation of regulatory policies that aim for example to control capital flows, and also by the level of uncertainty exhibited by the markets over time.

Given the IMF-inspired reforms (except in the case of China) following the AFC and in favour of deregulation, comparing market efficiency during the two crises becomes pertinent. Government intervention through reforms has been aimed at attaining greater efficiency. Conversely, it can also lead to market adjustments that might be translated into the development of undesirable patterns such as for example the creation of market opportunities to "specific players". It is thus possible to argue that government intervention might ultimately result in market inefficiency instead of efficiency with the markets departing from the desirable uncorrelated behaviour. Also, the invisible hand can easily be manipulated and guided by powerful market players that are looking to drive certain reactions, so as to materialize their own profits and/or protect their particular interests — leaving ordinary investors reacting to information that is biased. This ends up exacerbating irrational behaviour due to confusion and to the distortion of the information available. In today's increasingly financialized economies, high-profile cases such as Enron, Worldcom and Anglo-Irish Bank show that information can indeed be skewed to conceal a real situation and to protect certain individuals' interests. Government intervention through bailout programmes, and through real interests behind such actions during the GFC, have also tended to distort the behaviour of financial markets. These are all elements that seem to question the relevance of the EMH and leave some space to behavioural finance (Shiller 2003; Lim and Brooks 2011).

Bearing these issues in mind, the main motivation of this study is to analyse market dynamics during times of significant mayhem and understand if market integration (conversely independence) increases (decreases) when systemic shocks occur. It examines how a region that has dealt with a major financial crisis in the late 1990s might have learned some valuable lessons to minimize the levels of uncertainty and the sequential negative spillover effects, all leading towards more efficient markets.

3. Data and Methodological Framework

3.1 Data Description

The selected data set consists of daily stock market prices in local and common currencies for the main identified indices in the East Asian region. The U.S. dollar was used to conduct a sensitivity analysis that confirms the robustness of the research outcomes (see Appendix). The main markets under analysis are: China (Shanghai Composite Index); South Korea (KOSPI Index); Singapore (Straight Times Index); Hong Kong (Hang Seng Index); Japan (Nikkei 225); and Malaysia (KLCI Index). Two distinct time periods are subject to examination: (1) the Asian Crisis (July 1997 to December 1998); and (2) the Global Financial Crisis (July 2007 to December 2009). Data was obtained from Thomson Reuters DataStream and all the prices were transformed into continuously compounded returns. Before implementing any of the selected tests, the existence of correlations between market returns was studied, as they offer early insights into the markets that do not follow a random walk. When a market is identified as being weak-form efficient, stock prices follow a random walk, indicating that price changes are independent and

not related to each other, and that historical information is fully and instantaneously reflected in current prices. Such market behaviour eliminates the potential of opportunities of any abnormal gains on the basis of historical information, in line with the discussion above, following Fama's (1965 and 1970) market efficiency hypothesis. The research methodology helps to detect the existence of a weak form efficiency in the sample. But before any tests assessing the EMH were conducted, structural break tests were considered in order to confirm the existence of breakpoints in the selected time periods. Pitarakis (2014), Meligkotsidou, Tzavalis and Vrontos (2017) and Pan and Mishra (2018) highlight the importance of testing for structural breaks in time series, as they lead towards different dynamics that can impact on the model estimations. As this study is focused on the analysis of two well-known crisis periods, structural break testing was conducted with the help of the well-known Chow test (1960). The main objective of the test is to identify if there are significant differences in the estimated equations. Test findings showing evidence of significant difference would indicate the existence of structural change in the relationship.

$$F = \frac{(SSR_n - (SSR_{n_1} + SSR_{n_2}))/k_1}{(SSR_{n_1} + SSR_{n_2})/(n_1 + n_2 + 2k)}$$

The assumptions behind the Chow test are that there are no structural breaks; consequently, SSR_n and SSR_{n_1} and SSR_{n_2} should not be statistically different. The null hypothesis will be rejected (i.e., no structural break) if the computed F-value does exceed the critical F-value (Gujarati 2004; Khanam et al. 2017).

3.2 Research Methodology

This analysis is supported by a variety of econometric tests that seek to reconcile contradicting research outcomes by cross-checking the consistency of the main findings.

(a) The Augmented Dickey-Fuller (ADF) test was selected to test for the existence of weak-form efficiency in the selected East Asian region. If the ADF test confirms the existence of unit roots, the series are non-stationary and the results would align with a random walk behaviour and consequently with market efficiency postulations. This is shown as:

$$\Delta y_t = \alpha y_{t-1} + x_t'\delta + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \ldots + \beta_p \Delta y_{t-p} + \upsilon_t \quad (1)$$

where y_t is a series that follows an autoregressive process of order p; x_t are optional exogenous regressors that would consider the inclusion of a constant and/or a trend; α, β and δ are parameters to be estimated and υ is the error term that is assumed to be white noise. The null hypothesis is the presence of a unit root or non-stationarity. The non-rejection of the null hypothesis would imply that the series follows a random walk and confirms the existence of a weak form of market efficiency.

(b) The Kwiatkowsky, Phillips, Schmidt, and Shin test (KPSS) is an alternative unit root test, where the null hypothesis of stationarity is tested against the alternative of a unit root. The KPSS test acts as a complementary unit root test in this analysis, with the aim of strengthening the results from the ADF test outlined above. In this case, the rejection of the null hypothesis would indicate that the market follows a random walk hypothesis, and, consequently, that the market is weak-form efficient. The KPSS test statistic is based on the analysis of the residuals from the OLS regression of y_t on the exogenous variable x_t that is represented in the equation below:

$$y_t = x_t'\delta + \upsilon_t \quad (2)$$

An LM statistic defined as $LM = \frac{\sum_t S(t)^2}{T^2 f_0}$ is computed using the residuals of the OLS equation in order to test the null hypothesis for stationarity.

(c) The Ljung-Box Q-Statistic Test is integrated in this study to develop a comparison with the Variance Ratio (VR) analysis so as to make the results more robust. The Ljung-Box Q-Statistic is used to test the joint hypothesis that all the autocorrelation coefficients up to a defined lag (m) are simultaneously equal to zero. This test checks for the existence of high-order serial correlation in the residuals:

$$Q = n(n+2)\sum_{k=1}^{m}\left(\frac{\rho^2{}_k}{n-k}\right) \tag{3}$$

where n is the number of observations, m is the number of lags and ρ_k is the autocorrelation coefficient at lag k. Q follows a χ^2 distribution with m degrees of freedom. This test is used to check the strongest form of random walk. The test is used to verify if the outcomes of the variance ratio test support the existence of a random walk behaviour and consequently if it aligns with the concept of "weak-form efficiency".

(d) The Variance Ratio (VR) test is implemented to support the unit root tests above. The existence of a unit root is not sufficient to confirm that markets follow a random walk, as unit root processes can have predictable elements. However, for stock prices to be considered random, their returns must be found to be uncorrelated. Therefore, the random walk hypothesis is tested using the Lo and MacKinlay (1988) variance ratio (VR) test. The test is based on the assumption that the variance of a random walk term increases linearly with time. This test is selected because it is considered a standard tool in the testing for random walk processes.

$$VR(q) = \frac{\sigma^1(q)}{\sigma^2(1)} \tag{4}$$

where σ^2 is the unbiased estimator $(1/q)$ of the variance of the q-th difference and $\sigma^2(1)$ is the variance of the first difference. Under the assumption of homoscedastic increments, a standard normal statistic $z(q)$ is calculated as follows:

$$z(q) = \frac{VR(q)-1}{\sqrt{v(q)}} \sim N(0,1) \tag{5}$$

where $v(q) = [2(2q-1)(q-1)]/3q(nq)$. A second test statistic $z^*(q)$ is developed under the assumption of heteroskedastic increments as follows:

$$z^*(q) = \frac{VR(q)-1}{\sqrt{v^*(q)}} \sim N(0,1) \tag{6}$$

where

$$v^*(q) = \sum_{k=1}^{q-1}\left[\frac{2(q-k)}{q}\right]^2 \phi(k) \tag{7}$$

$$\phi(k) = \frac{\sum_{t=k+1}^{nq} (p_t - p_{t-1} - \hat{\mu})^2 \, (p_{t-k} - p_{t-k-1} - \hat{\mu})^2}{\left[\sum_{t=1}^{nq} (p_t - p_{t-1} - \hat{\mu})^2\right]^2} \tag{8}$$

Both the $Z(q)$ and $Z^*(q)$ statistics test the null hypothesis that $VR(q) = 1$ or that the chosen index follows a random walk. When the random walk hypothesis is rejected and $VR(q) > 1$, the returns would be positively serially correlated indicating that the markets are inefficient.

(e) Market Integration Analysis is used to identify if the markets display the same risk-adjusted expected returns. In the case where markets are found to be segmented, the risk-return relationship in each national market would be determined by domestic factors and there would be no evidence of international effects. Pure random walks cannot be cointegrated, unless they are perfectly correlated. Given that market efficiency is interpreted to mean that prices follow random walks, the arguments that prices in efficient markets cannot be cointegrated would be correct. If two-time series are found to have the same order of integration and if a linear combination of these series exists, these series would be referred to as being cointegrated. Engle and Granger (1987) proposed a two-step procedure to estimate cointegration. In this two-step procedure, the first series (y_t) is regressed on the second series (x_t) and the resulting error (e_t) is tested for stationarity. If the null hypothesis of non-stationarity of the residual is rejected, it can be said that the time series are cointegrated. Cointegration implies that both series would move together in the long run and they cannot drift apart very much from each other (Granger 1981).

$$y_t = \alpha + \beta x_t + e_t \tag{9}$$

An alternative method to test for cointegration is based on a vector autoregressive (VAR) model. The vector X_t contains the endogenously seen variables and has the dimension $n \; x \; 1$, where n is the number of endogenous variables. Each variable follows a process that is influenced by its own lagged variables and the lagged variables of the other endogenous variables, that is:

$$X_t = \prod_1 X_{t-1} + \ldots + \prod_k X_{t-1} + \varepsilon_t \qquad \text{with } t = 1, \ldots, T \tag{10}$$

The matrix of coefficients $\prod_k$ has the dimension $n \; x \; n$. Based on the equation above, the VAR can be transferred to a VAR of first differences. For this purpose, the lagged variable of the endogenous variables is subtracted from both sides leading to the system below:

$$\Delta X_t = \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \prod_k X_{t-k} + \mu + \varepsilon_t \tag{11}$$

where $\Gamma_i = -I + \prod_1 + \ldots + \prod_i$ with $I = 1, \ldots, k - 1$ and $\prod = -(I - \prod_1 - \ldots - \prod_k)$ Johansen and Juselius (1990) propose two tests to determine the cointegration rank, namely the trace statistic and the maximum eigenvalue test. Both tests should be used simultaneously. In this case the researcher should be aware that different conclusions can be drawn from the tests, and that the Johansen test does not allow the identification of the specific variables that are found to be cointegrated. The estimation of the parameters for the cointegration vector, adjustment coefficients or eigenvalues is done through the maximum likelihood procedure.

(f) The analysis of volatility persistence in the region is conducted with the support of the traditional GARCH (1,1) econometric framework to be performed on each market. A commonly used random walk model used in finance can be defined through the equation below:

$$Y_t = \mu + Y_{t-1} + \varepsilon_t \qquad \text{with} \qquad \varepsilon_t = (0, \sigma^2_t) \tag{12}$$

where ε_t, t=1,…,n are serially independent. If α=1 then $\{Y_t\}$ follows a random walk model and an AR(1) model otherwise. The fundamental idea of the GARCH (1,1) model (Bollerslev 1986) is to describe the evolution of the variance σ^2_t as:

$$\sigma^2_t = \omega + \alpha\varepsilon^2_{t-1} + \beta\sigma^2_{t-1} \tag{13}$$

The parameters satisfy $0 \le \alpha \le 1$, $0 \le \beta \le 1$, and $\alpha + \beta \le 1$. The variance process is stationary if $\alpha + \beta < 1$, and the stationarity variance is given by $\frac{\omega}{1 - \alpha - \beta}$. The parameter $\eta = \alpha + \beta$ is known as persistence and it defines how slowly a shock in the market is forgotten. In the case where the $\alpha + \beta$ coefficients are close to one, the results would indicate a process that is long-lived and that would characterize markets that are not in line with an efficiency behaviour, as they would be exhibiting clustering and long-lasting patterns of market uncertainty. In these markets, forecasting possibilities would rise, which is inconsistent with the notion of a random walk behaviour.

The entire methodological framework was designed with the aim of combining a variety of econometric techniques that provide an in-depth discussion with regard to the existence of market efficiency in the East Asian region during the crisis periods under study. Furthermore, the selected methods were carefully chosen after a thorough review of research studies looking at the EMH that have been supported by the outlined tests.

4. Critical Assessment of Markets Inefficiency and Volatility in the East Asian Region

In a weakly efficient market, price formation does not follow a trend behaviour, implying random behaviour (Guidi and Gupta 2011). The analysis that follows aims to identify whether the East Asian region can be considered to be exposing a weak form of efficiency during the Asian and Global Financial Crises, a field of study that is characterized by conflicting findings. Some authors like Liu, Song and Romilly (1997), Long, Payne and Feng (1999), Lima and Tabak (2004), Kan and Andreosso-O'Callaghan (2007) tend to find support for market efficiency in the region, while others such as Ma (2004) and Mookerjee and Yin (1999) find no such evidence. For this study, the discussion begins with the basic descriptive statistics, followed by the interpretation of the main research findings, and finally some implications for investors in the region.

Table 1 shows that the average returns during the AFC were negative with significant volatility revealed in the stock markets of Hong Kong, South Korea and Malaysia. The lowest volatility in the region was registered in China (the most insulated market of all at the time) and Japan. The series also exhibited negative skewness only for the case of China, and all the series were found to be leptokurtic and non-normal.

During the GFC, Table 2 shows that the losses in the Chinese stock market were slightly higher, followed by an increase in market volatility. In the case of Hong Kong, South Korea, and Malaysia there was a drop in volatility levels with negative returns more or less in the same bands, as during the AFC — with the exception of Hong Kong that registered a flat trend. During this period, the trend in Singapore was in line with the patterns followed by the rest of the markets in the region, i.e., negative returns and series that are slightly skewed to the left (the latter indicates a higher probability of materializing losses during the period). The series are also leptokurtic, a phenomenon translated by the minimization

TABLE 1
Descriptive Statistics: Asian Crisis

Statistics	*China*	*Hong Kong*	*Japan*	*South Korea*	*Malaysia*
Mean	–0.022%	–0.106%	–0.096%	–0.076%	–0.156%
Std. Dev.	1.50%	2.90%	1.75%	3.16%	3.53%
Skewness	–0.880898	0.436372	0.198203	0.272231	0.55998
Kurtosis	8.683354	9.099658	4.909498	4.190189	15.393
Jarque-Bera	578.2725	620.136	62.12089	27.97882	2529.065

NOTES: Market returns were calculated as follows: Rt = Ln (PIt / PIt – 1), being Rt = returns, Ln = natural log, PI = price index.
Singapore was not included in the analysis of the Asian Crisis due to non-availability of daily data for the period.
SOURCE: Authors' calculations.

TABLE 2
Descriptive Statistics: Global Financial Crisis

Statistics	*China*	*Hong Kong*	*Japan*	*South Korea*	*Malaysia*	*Singapore*
Mean	–0.024%	0.000%	–0.083%	–0.008%	–0.011%	–0.028%
Std. Dev.	2.31%	2.52%	2.17%	1.97%	1.09%	1.84%
Skewness	–0.149387	0.132004	–0.323219	–0.493444	–1.218347	–0.030284
Kurtosis	4.475999	7.100891	9.062982	8.314394	14.58084	5.475853
Jarque-Bera	61.70414	459.4674	1011.541	794.9384	3810.616	166.8827

SOURCE: Authors' calculations.

of the potential for extreme outcomes when compared with normally distributed series. The Jarque-Bera statistics indicates that the series under analysis are non-normal for the crisis periods.

The correlation coefficients during the AFC were close to zero in the case of China (a relatively sheltered economy) and positive and below 0.5 for the rest of the markets (Table 3); Hong Kong and Malaysia displayed the highest level of correlation with the markets in the region.

During the GFC, the correlation matrix displayed significant changes in the region when compared to the case of the AFC (Table 4). China's correlations with the rest of the markets were positive and significantly higher than before, with the highest correlations with Hong Kong and a positive correlation with the South Korean stock market that was registered as negative during the AFC. These results indicate greater connection of the Chinese stock market with other markets in the region with the passage of time. China's correlations are still below 0.5, suggesting that during the AFC, the Chinese stock market still exhibited relatively independent behaviour, while the rest of the markets were positively correlated. Such outcomes suggest the existence of market inefficiency. The results for the GFC indicate high levels of positive correlation in the region, which corroborates the initial preliminary results of market inefficiency during the AFC.

If a market is characterized by weak form efficiency, the returns on that market should follow a random walk process and consequently, should be non-stationary. During both crisis periods, the ADF and the KPSS offer evidence that the markets were, in fact, stationary — the only exception being the case of

TABLE 3
Correlation Matrix for Stock Returns: Asian Crisis

Correlation Matrix	*China*	*Hong Kong*	*Japan*	*South Korea*	*Malaysia*
China	1	0.053067	0.009768	–0.001029	0.060581
Hong Kong	0.053067	1	0.394334	0.193724	0.36432
Japan	0.009768	0.394334	1	0.169279	0.218062
Korea	–0.001029	0.193724	0.169279	1	0.239546
Malaysia	0.060581	0.36432	0.218062	0.239546	1

SOURCE: Authors' calculations.

TABLE 4
Correlation Matrix for Stock Returns: Global Financial Crisis

Correlation Matrix	*China*	*Hong Kong*	*Japan*	*South Korea*	*Malaysia*	*Singapore*
China	1	0.501944	0.311237	0.367937	0.323749	0.34402
Hong Kong	0.501944	1	0.660495	0.690049	0.517822	0.781086
Japan	0.311237	0.660495	1	0.704374	0.481896	0.602627
Korea	0.367937	0.690049	0.704374	1	0.540108	0.682364
Malaysia	0.323749	0.517822	0.481896	0.540108	1	0.597557
Singapore	0.34402	0.781086	0.602627	0.682364	0.597557	1

SOURCE: Authors' calculations.

South Korea during the AFC as shown by the KPSS results at 10 per cent level of significance (Table 5). The analysis from the autocorrelation coefficients (Q-test) for thirty-six lags indicate significant results in the case of Hong Kong, South Korea and Malaysia where the markets are correlated and do not follow a random walk. On the other hand, China and Japan appear to be following a random walk process during the Asian Crisis, as the returns were found to be uncorrelated (and in line with the EMH proposition). However, the outcomes are quite different when looking at the GFC, where a change on market behaviour is visible (Table 6). During this period, the markets that seem to be in line with a weak form of efficient behaviour are Hong Kong and South Korea, with the rest of the markets exhibiting evidence of correlated returns. The results from the autocorrelation functions indicate that the markets are quite dynamic and that adjustment processes are taking place in the region.

The outcomes from the individual and joint variance ratio tests indicate that the markets are not following a random walk and that daily returns across markets were positively correlated (and therefore, inefficient) during both crisis periods. This is in line with the results from Ma (2004) and Mookerjee and Yin (1999) who do not support the existence of market efficiency. These findings indicate that abnormal profit opportunities were available to investors during the crisis periods, but also that high levels of risk were associated with market operations in the region due to the markets' inability to price their stocks efficiently. The cointegration analysis showed a lack of long-run relationships among regional markets during both crisis periods with the exception of Singapore and South Korea during the GFC as their market linkages improved due to greater economic and political cooperation (Bayoumi and Eichengreen 1994; Zhang, Sato and McAleer 2004; and Bacha 2008).

TABLE 5
Econometric Modelling Results: Asian Crisis

Test/Countries	*China*	*Hong Kong*	*Japan*	*South Korea*	*Malaysia*
Chow test	Break*	Break*	Break*	Break*	Break*
ADF	–19.34(0.00)*	–19.97(0.00)*	–21.47(0.00)*	–17.54(0.00)*	–20.10(0.00)*
KPSS	0.073(0.46)*	0.16(0.46)*	0.066(0.46)*	0.47(0.46)	0.27(0.46)*
Q-test	36(insig)	36(sig)*	36(insig)	36(sig)*	36(sig)*
VR joint tests	8.94(0.00)*	3.57(0.00)*	6.32(0.00)*	6.38(0.00)*	2.96(0.012)**
VR (2,4,8,16)	0.00*	0.00*	0.00*	0.00*	0.05**
Johansen	No	No	No	No	No
Engle & Granger	No	No	No	No	No
GARCH (α)	0.26577*	0.157342*	0.075402*	0.069566*	0.140491*
GARCH (β)	0.468925*	0.823371*	0.89068*	0.934154*	0.863731*
GARCH ($\alpha+\beta$)	0.734695*	0.980713*	0.966082*	1.003	1.004
Half-life volatility	3 days	36 days	21 days	Non-stationary	Non-stationary

NOTES: ** 5% level of significance and * 1% level of significance. A VAR test was conducted to identify the number of lags to be applied in the selected econometric tests. The values presented in brackets are the p-values, for the ADF, KPSS and VR joint test. The results are considered at the 5% level of significance. Singapore was not included in the analysis of the Asian crisis due to non-availability of daily data for the index. For the KPSS test the critical value at 5% level of significance is presented in brackets.
Key: ADF (Augmented Dickey-Fuller Test), KPSS (Kwiatkowsky, Phillips, Schmidt, and Shin), Q-test (Ljung-Box Q-statistic test), VR (Variance Ratio test), Johansen (Johansen Cointegration test), Engle &Granger (Cointegration test), GARCH (Generalized Autoregressive Conditional Heteroscedastic model). The GARCH model framework was conditioned to the small number of observations that could explain explosive behaviour in the case of South Korea and Malaysia. The results for the GARCH model were tested for autocorrelation and heteroscedasticity to ensure that they were robust estimations; the results are not presented for the sake of brevity, but they are available upon request.
SOURCE: Authors' calculations.

TABLE 6
Econometric Modelling Results for the Global Financial Crisis

Test/Countries	*China*	*Hong Kong*	*Japan*	*South Korea*	*Malaysia*	*Singapore*
Chow test	Break*	Break*	Break*	Break*	Break*	Break*
ADF	–25.72(0.00)*	–27.08(0.00)*	–25.72(0.00)*	–9.74(0.00)*	–12.96(0.00)*	–14.96(0.00)*
KPSS	0.30(0.46)*	0.19(0.46)*	0.23(0.46)*	0.17(0.46)*	0.43(0.46)*	0.39(0.46)*
Q-test	36(sig)*	36(insig)	36(sig)*	36(insig)	36(sig)*	36(sig)*
VR joint tests	8.94(0.00)*	6.97(0.00)*	6.23(0.00)*	6.81(0.00)*	4.44(0.00)*	7.04(0.00)*
VR (2,4,8,16)	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*
Johansen	No	No	No	Yes	No	Yes
Engle & Granger	No	No	No	Yes	No	Yes
GARCH (α)	0.082122*	0.128026*	0.111546*	0.082354*	0.192758*	0.116913*
GARCH (β)	0.888557*	0.842712*	0.858508*	0.897346*	0.794388*	0.877942*
GARCH ($\alpha+\beta$)	0.970679*	0.970738*	0.970054*	0.9797*	0.987146*	0.994855*
Half-life volatility	24 days	24 days	23 days	34 days	54 days	135 days

NOTES: ** 5% level of significance and * 1% level of significance. A VAR test was conducted to identify the number of lags to be applied in the selected econometric tests. The values presented in brackets are the p-values, for the ADF, KPSS And VR joint test. The results are considered at the 5 % level of significance.
SOURCE: Authors' calculations.

The main implications of the findings of this study are that investors, in general, cannot infer market behaviour simply by looking at regional patterns. The GARCH framework signals that volatility is highly persistent and exhibited a clustering behaviour for almost all markets in both crises periods, again denoting market inefficiencies. The Chinese stock exchange market, however, was able to absorb market shocks quite fast during the AFC, characterizing market efficiency behaviour. In fact, it took around just three days for the Chinese stock market to return half-way back to its unconditional volatility level in the absence of any further shocks, while, for the other markets, this adjustment process took roughly a month. The situation changed during the GFC with all markets exhibiting volatility persistence that lasted roughly a month in the case of China, Hong Kong, Japan and South Korea; heavy persistence was visible in Malaysia and Singapore, two markets characterized by significant long-lasting effects. Based on the results, China seems to be increasingly aligning its behaviour with the rest of the markets in the region, and Singapore and Malaysia appear to be heavily exposed to shocks that spillover because of positive correlations. However, the effects might not be long-lasting and more in line with short-lived shocks due to the lack of cointegration that offers initial evidence of market segmentation in the region. Furthermore, there is a need of considering that market interventions during periods of sustained volatility can result in inefficiencies (Mookerjee and Yu 1999; Kavussanos and Dockery 2001; Chen et al. 2011).

5. Critical Insights and Policy Implications

The research outcomes have interesting implications in terms of investment diversification and the development of public policy aimed at minimizing the level of disruption. From the investors' viewpoint, Asian stock markets have gained significant importance in international portfolios, requiring close monitoring of their performance. The two major crises have changed the nature of regional integration among Asian stock markets; these are becoming generally more mature, more competitive and more efficient, while their linkages are becoming stronger (Eichengreen 2003; Hamilton-Hart 2006). As a result, portfolio managers need to be aware of the gains derived from portfolio diversification, but at the same time need to reconsider Asian market dynamics and how increasing levels of integration (Guidi and Gupta 2011) can lead to greater exposure during times of turmoil.

Another aspect that needs to be closely monitored is the loss of efficiency during times of crisis (Cajueiro and Tabak 2004, 2005*a*, 2005*b*; Lim 2008) that are characterized by significant market interventions ultimately leading to disturbances. For policymakers, the existence of correlations among equity markets are important, given their impact on financial stability.

It is also vital to consider that monetary policy strategy is influenced by international and regional stock market developments and that shocks can propagate to the real economy through stock markets. Consequently, policymakers need to be able to understand the magnitude of generated spillover effects when coordinating their efforts to pursue economic recovery after crises periods (Kumar and Persaud 2002). From a policy perspective, it is paramount to distinguish between crises that arise from bad fundamentals and those arising mainly from abrupt shifts in investors' preferences, as they lead to different market dynamics. Finally, while designing economic and financial policies for the Asian region, policymakers must also consider the increasing level of integration of the Chinese stock market with other Asian markets.

6. Conclusion

This study of six East Asian economies (Japan, Hong Kong, Malaysia, Singapore, South Korea and China) during two major crisis periods (July 1997 – December 1998 and July 2007 – December 2009) was primarily conducted to check for any learning effect that the AFC and GFC might have had on

subsequent macroeconomic policies in the region. The results indicate that during both crises, the East Asian region exhibited significant inefficiencies. This is shown by the fact that most markets in the region did not follow a random walk process during the two periods under analysis, and that positive correlations characterized the behaviour of market returns. In addition, according to the cointegration results, only South Korea and Singapore appeared to be moving together in the long run, while the rest of the markets seemed to diverge from each other. The main implication of this analysis is that well-informed investors were able to earn excess profits using historical information, at the expense of less informed and active investors. Moreover, deviations from efficient market behaviour and lack of integration in the region — with markets reacting differently to successive market shocks — indicate that policymakers would have to consider each market individually and that common policies would not suffice. The results for the region also highlight the need for further reforms and advances to increase transparency and expedite the development of legal and information systems that aid the process of price discoveries. Further research is required to determine the precise level of integration in these markets and its evolution before, during, and after financial crises so as to gain a better understanding of the regional and global dynamics prevalent in Asian stock markets.

APPENDIX

Results with data in U.S. dollars (stock prices for all studied markets were converted into U.S. dollars). Overall, the research findings are in line with the outcomes for the tests run using local prices. Additionally, different outcomes were registered only in a very few cases; it is important to consider that the significance level was 10 per cent.

TABLE 7
Descriptive Statistics: Asian Crisis

Statistics	*China*	*Hong Kong*	*Japan*	*Korea*	*Malaysia*
Mean	–0.022%	–0.106%	–0.092%	–0.155%	–0.260%
Std. Dev.	1.50%	2.91%	2.18%	4.34%	4.37%
Skewness	–0.878965	0.432052	0.749299	0.009951	1.18647
Kurtosis	8.675846	9.073889	6.470673	7.312056	14.00492
Jarque-Bera	576.6572	614.7672	233.4257	303.7057	2070.074

NOTES: Market returns were calculated as follows: Rt = Ln (PIt/PIt – 1), being Rt = returns, Ln = natural log, PI = price index. Singapore was not included in the analysis of the Asian Crisis due to non-availability of daily data for the period.
SOURCE: Authors' calculations.

TABLE 8
Descriptive Statistics: Global Financial Crisis

Statistics	*China*	*Hong Kong*	*Japan*	*Korea*	*Malaysia*	*Singapore*
Mean	–0.0076%	0.0019%	–0.0413%	–0.0434%	–0.0097%	–0.0154%
Std. Dev.	2.31%	2.52%	2.05%	2.44%	1.3051%	2.01%
Skewness	–0.142983	0.142243	–0.19761	–0.191615	–0.888007	–0.07315
Kurtosis	4.436123	7.102435	7.631394	12.72992	11.02935	5.554535
Jarque-Bera	58.34081	460.1176	587.8634	2579.847	1839.957	178.1343

NOTE: Market returns were calculated as follows: Rt = Ln (PIt/PIt – 1), being Rt = returns, Ln = natural log, PI = price index.
SOURCE: Authors' calculations.

TABLE 9
Correlation Matrix: Asian Crisis

Correlation Matrix	*China*	*Hong Kong*	*Japan*	*Korea*	*Malaysia*
China	1	0.053435403	–0.034386271	–0.025045793	0.067337612
Hong Kong	0.053435403	1	0.374355459	0.253405285	0.366416518
Japan	–0.03438627	0.374355459	1	0.197295307	0.203348556
Korea	–0.02504579	0.253405285	0.197295307	1	0.257107285
Malaysia	0.067337612	0.366416518	0.203348556	0.257107285	1

SOURCE: Authors' calculations.

TABLE 10
Correlation Matrix: Global Financial Crisis

Correlation Matrix	*China*	*Hong Kong*	*Japan*	*Korea*	*Malaysia*	*Singapore*
China	1	0.503498	0.288019	0.310573	0.330641	0.349693
Hong Kong	0.503498	1	0.576983	0.608292	0.533154	0.78313
Japan	0.288019	0.576983	1	0.563889	0.416052	0.50123
Korea	0.310573	0.608292	0.563889	1	0.519197	0.620383
Malaysia	0.330641	0.533154	0.416052	0.519197	1	0.623217
Singapore	0.349693	0.78313	0.50123	0.620383	0.623217	1

SOURCE: Authors' calculations.

TABLE 11
Econometric Modelling Results for the Asian Crisis

Test/Countries	*China*	*Hong Kong*	*Japan*	*Korea*	*Malaysia*
Chow Test	Break*	Break*	Break*	Break*	Break*
ADF	–19.34*(0)	–19.96*(0.00)	–19.99*(0.00)	–11.58*(0)	–18.22*(0.00)
KPSS	0.073(0.46)*	0.16(0.46)*	0.24(0.46)*	0.37(0.46)*	0.32(0.46)*
Q-test	36(insig)	36(sig)*	36(insig)	36(sig)*	36(sig)*
VR joint tests	4.81(0.00)*	3.57(0.00)*	5.83(0.00)*	4.07(0.00)*	3.34(0.00)*
VR (2,4,8,16)	0.00*	0.00*	0.00*	0.00*	0.00*
Johansen	No	No	No	No	No
Engle & Granger	No	Cointegration***	Cointegration***	No	No
GARCH (α)	0.261199*	0.151176*	0.087583*	0.146714*	0.142476*
GARCH (β)	0.489637*	0.82562*	0.890734*	0.868742*	0.876617*
GARCH ($\alpha+\beta$)	0.750836*	0.976796*	0.978317*	1.015456	1.019093
Half-life volatility	2.41878757	29.52395363	31.61947008	Non-stationary	Non-stationary

NOTES: ** 5% level of significance and * 1% level of significance. A VAR test was conducted to identify the number of lags to be applied in the selected econometric tests. The values presented in brackets are the p-values, for the ADF, KPSS and VR joint test. The results are considered at the 5% level of significance. Singapore was not included in the analysis of the Asian Crisis due to non-availability of daily data for the index. For the KPSS test the critical value at 5% level of significance is presented in brackets. Key: ADF (Augmented Dickey-Fuller Test), KPSS (Kwiatkowsky, Phillips, Schmidt, and Shin), Q-test (Ljung-Box Q-statistic test), VR (Variance Ratio test), Johansen (Johansen Cointegration test), Engle & Granger (Cointegration test), GARCH (Generalized Autoregressive Conditional Heteroscedastic model). The GARCH model framework was conditioned to the small number of observations that could explain explosive behaviour in the case of South Korea and Malaysia. The results for the GARCH model were tested for autocorrelation and heteroscedasticity to ensure that they were robust estimations; the results are not presented for the sake of brevity, but they are available upon request.
SOURCE: Authors' calculations.

TABLE 12
Econometric Modelling Results for the Global Financial Crisis

Test/Countries	*China*	*Hong Kong*	*Japan*	*Korea*	*Malaysia*	*Singapore*
Chow Test	Break*	Break*	Break*	Break*	Break*	Break*
ADF	–25.8*(0.00)	–27.03*(0.00)	–21.51*(0.00)	–19.75*(0.00)	–23.19*(0.00)	–24.68*(0.00)
KPSS	0.27(0.46)*	0.18(0.46)*	0.16(0.46)*	0.22(0.00)	0.38(0.46)*	0.36934 (0.46)*
Q-test	36(sig)*	36(insig)	36(sig)*	36(insig)	36(sig)*	36(sig)*
VR joint tests	8.94(0.00)*	6.96(0.00)*	7.81(0.00)*	4.33(0.00)*	5.05(0.00)*	7.03(0.00)*
VR (2,4,8,16)	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*
Johansen	No	No	No	No	No	No
Engle & Granger	No	Yes***	No	No	No	Yes***
GARCH (α)	0.078*	0.12*	0.11*	0.11*	0.16*	0.11*
GARCH (β)	0.89*	0.84*	0.85*	0.85*	0.77*	0.87*
GARCH ($\alpha+\beta$)	0.97	0.97	0.97	0.97	0.93	0.99
Half-life volatility	25	23	23	23	10	92

NOTES: ** 5% level of significance and * 1% level of significance. A VAR test was conducted to identify the number of lags to be applied in the selected econometric tests. The values presented in brackets are the p-values, for the ADF, KPSS and VR joint test. The results are considered at the 5% level of significance.

SOURCE: Authors' calculations.

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