Received 9 March 2022
Revised 2 June 2022
20 July 2022
15 September 2022
6 October 2022
Accepted 11 October 2022

A study on the nonlinear dynamics of ASEAN financial integration

Thai-Ha Le
VinFuture Foundation, Hanoi, Vietnam and
IPAG Business School, Paris, France
Long Hai Vo
The University of Western Australia, Perth, Australia, and
Farhad Taghizadeh-Hesary
Tokai University, Kumamoto, Japan

Abstract

Purpose – This study examines the co-integration relationships between Association of Southeast Nations (ASEAN) stock indices as a way to assess the feasibility of policy initiatives to strengthen market integration in ASEAN and identify implications for portfolio investors.

Design/methodology/approach – The authors employ threshold co-integration tests and a non-linear autoregressive distributed lag (NARDL) model to study the asymmetric dynamics of ASEAN equity markets. The study's data cover the 2009–2022 period for seven member states: Cambodia, Indonesia, Malaysia, the Philippines, Singapore, Thailand and Vietnam.

Findings – The authors find evidence supporting co-integration relationships; adjustment toward equilibrium is asymmetric in the short run and symmetric in the long run for these countries. While co-movement in ASEAN equity markets seems encouraging for initiatives seeking to foster financial integration in regional economies, the benefits for international portfolio diversification appear to be neutralized.

Originality/value – The issue of stock market integration is important among policymakers, investors and academics. This study examines the level of stock market integration in ASEAN during the 2009–2022 period. For this purpose, advanced co-integration techniques are applied to different frequencies of data (daily, weekly and monthly) for comparison and completeness. The empirical analysis of this study is conducted using the Enders and Siklos (2001) co-integration and threshold adjustment procedure. This advanced co-integration technique is superior compared to other co-integration techniques by permitting asymmetry in the adjustment toward equilibrium.

Keywords Stock market integration, Nonlinear ARDL model, Threshold co-integration, ASEAN

Paper type Research paper

1. Introduction

Stock market integration is important to policymakers, investors and academics. For policymakers, an integrated regional stock market implies a broader investor base that leads to more efficient capital allocation within a region. The range of financial products is also expanded, fostering the ability of domestic capital markets to compete on a global scale (Umutlu *et al.*, 2010) [1]. Stock market integration gives investors the opportunity to efficiently allocate capital to the most productive places in a region (Narayan *et al.*, 2011). For investors outside a region, the higher the level of stock market integration is, the lower the benefit of portfolio diversification across countries, since separate markets appear to move together

JEL Classification — F34, F36, G15

Journal of Asian Business and Economic Studies
Vol. 31 No. 1, 2024
pp. 2-14
Emerald Publishing Limited
2515-964X
DOI 10.1108/JABES-03-2022-0040

(Click and Plummer, 2005). The level of stock market integration across countries has received considerable attention from international finance scholars. Recent advances in time series analysis have led to the development of various co-integration techniques that enable the investigation of long-run co-movement and equilibrium among stock markets.

This study examines the level of stock market integration in Association of Southeast Asian Nation (ASEAN) (Cambodia, Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam) during the 2009–2022 period. Some studies have found regional Asian stock market integration to be stronger after the turmoil of the 2008 financial crisis (Yoshida, 2010; Chien *et al.*, 2015). However, others show that the regional integration of Asian stock markets was actually held back by the sub-prime financial crisis (Caporale *et al.*, 2019). The focus of this study is on the postcrisis period and concentrates on the profound, long-lasting impacts of the 2008 global financial crisis on economies and equity markets at both the global and regional levels. We use different frequencies of data for comparison. For this purpose, advanced co-integration techniques are applied to different frequencies of data (daily, weekly and monthly) for comparison and completeness. Based on financial theories, an integrated regional stock market is more efficient than segmented national markets (Narayan *et al.*, 2018).

The integration of ASEAN stock markets is interesting for several reasons. First, ASEAN is the seventh largest and one of the fastest-growing economic blocs in the world [2]. Established on August 8, 1967 with five founding members, ASEAN now has ten members: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam. The region's 661.8 million inhabitants were approximately 8.5% of the world's population in 2020 and offer tremendous economic potential. In 2020, ASEAN's total gross domestic product (GDP) reached US$3.0 tn, 3.5% of the world's GDP; the bloc has achieved an annual growth rate of 5.0% for the last two decades [3] and is expected to sustain that growth level for the next five years

Second, the bloc's stock markets have experienced significant growth in recent decades. Singapore enjoys a solid position among regional stock markets and has long been the first choice of ASEAN companies when going public because it creates the best opportunity for reaching international investors. However, this situation is changing rapidly as economies like Indonesia, Thailand and the Philippines seek to compete with Singapore. With a market capitalization of listed domestic companies of US$652.6 bn last year, Singapore is among the largest Asia–Pacific stock markets. However, its growth is not as robust as markets in other ASEAN countries [4].

Third, capital account liberalization and financial market deregulation are consistent policies of the bloc's governments in order to promote cross-border financial transactions. In April 2011, the ASEAN exchange network, a collaboration of seven exchanges from Malaysia, Vietnam (two exchanges), Indonesia, the Philippines, Thailand and Singapore, was formed to increase regional cross-border trading and facilitate easier funding and investment in the region.

For the purpose of the present study, an empirical analysis is conducted using Enders and Siklos's (2001) co-integration and threshold adjustment procedure. This advanced co-integration technique is superior to other co-integration techniques because it permits asymmetry in the adjustment toward equilibrium. Prior to conducting co-integration tests, we examine the stationarity of the data. For robustness and completeness, we undertake empirical analyses using different data frequencies, subject to data availability, that is, daily, weekly and monthly. Overall, the study finds evidence of strong co-integration that in turn indicates strong co-movement among the seven ASEAN stock markets between 2009 and 2022, regardless of data frequency. This accords with Yoshida's (2010) finding that regional stock integration in Asia appeared to be reinforced in the wake of the sub-prime financial crisis.

The rest of this paper is organized as follows. Section 2 reviews the literature on stock market integration, with a focus on the ASEAN context, and section 3 describes the data and methodologies used in the study. Section 4 presents the empirical results, while section 5 concludes and discusses policy implications.

2. Related literature

A significant body of research has investigated stock market integration, particularly with the use of co-integration techniques (e.g. Johnson and Soenen, 2002; Click and Plummer, 2005; Kim *et al.*, 2005; Horvath and Petrovski, 2013; Graham *et al.*, 2012; Tiwari *et al.*, 2013; Chien *et al.*, 2015; Mollah and Mobarek, 2016; Batten *et al.*, 2019). The majority of these studies have focused on examining the degree of correlation among individual stock markets.

However, less research has examined stock market integration in Asia, including ASEAN countries, than in other regions; taken together, conclusions regarding the integration of Asian stock markets are mixed (Click and Plummer, 2005). This might be partially attributable to different methodologies, even when using co-integration techniques, different investigation periods and/or different country samples. Focusing on the post-Asian financial crisis period, Click and Plummer (2005) found stock markets in five ASEAN countries to be co-integrated. However, only one co-integrating vector was found among those five markets, leaving four common trends among the five variables.

Graham *et al.* (2012) found co-movements of stock market returns between the USA and 22 emerging markets at low frequencies (i.e. long-term fluctuations). The degree of co-movement varied by country. Their findings suggest the time-varying degree of stock market integration; one important implication of their findings is that investing selectively in emerging markets may provide significant diversification benefits that depend on the specific investment horizon.

Chien *et al.* (2015) found at most one co-integrating vector among the stock markets of China and the ASEAN-5 (Indonesia, Malaysia, the Philippines, Singapore and Thailand) between 1994 and 2002. This finding suggests that regional financial integration among China and the ASEAN-5 countries gradually increased but remained limited. In the same vein, Wu (2020) shows that the high level of stock market integration in East and Southeast Asia is driven by common global factors but is not as strong as it appears.

Although there are some empirical studies on stock market integration in Asian countries and subregions, such as the ASEAN-5 (e.g. Click and Plummer, 2005), the ASEAN-5 with China (e.g. Chien *et al.*, 2015; Wu, 2020) and other external markets (e.g. Mensah and Premaratne, 2018; Caporale *et al.*, 2022), none has examined the relationships of ASEAN stock markets while including ASEAN countries outside the ASEAN-5 block, such as Cambodia and Vietnam, partly due to the unavailability of the stock market data for these countries. Furthermore, none of the above studies considered nonlinear adjustment mechanisms, which constitute a critical development in recent empirical time series literature (Enders and Siklos, 2001). This is because a large number of studies have documented an asymmetric adjustment over the course of the business cycle for key macroeconomic variables like GDP, unemployment, industrial production, stock price, exchange rates and commodity prices (e.g. Enders and Siklos, 2001; Chen *et al.*, 2005; Yau and Nieh, 2009; Ghosh and Kanjilal, 2016). Considering the properties of a theoretical model, the specific spill-overs of real economic activities in ASEAN countries should display similar dynamics in their stock prices (Chien *et al.*, 2015). The authors explore this possibility by examining stock market integration among ASEAN-5 member states in the aftermath of the global sub-prime financial crisis.

It is expected that increasing economic integration through trade linkages and investment flows will be reflected in the interdependence of stock markets (Narayan and Smyth, 2004; Caporale *et al.*, 2019). Based on the existing literature, we argue that the economic integration of ASEAN countries is determined by multiple direct and indirect channels that can become manifest in a stronger co-movement pattern among the members' equity exchanges. For example, regional economic integration via trade or financial development can shape a common sentiment regarding investment opportunities in the integrated markets. Additionally, when expanding their operations to regional markets through direct investments or mergers and acquisitions, the performance of firms listed on multiple exchanges could steer the evolution of

regional stock indices in the same direction. Therefore, a simple and intuitive test for market integration is to check for long-run equilibrium relationships among stock exchanges.

However, there is little reason to believe that the impact of positive and negative changes in sentiments or the investment environment more broadly among member states would affect every member to the same degree. One possible reason is the well-established leverage effect in financial markets, whereby negative changes in stock prices induce higher subsequent volatility than positive changes, due to a reduction in equity value and investors' confidence and increasing uncertainty about future economic prospects (Ait-Sahalia *et al.*, 2013; Black, 1976). Additionally, while there is a perception that world capital markets have become more integrated over time, country-specific investigations suggest that this is not always the case and that there exists a large degree of heterogeneity among countries regarding financial integration (Bekaert and Harvey, 1995; Bekaert *et al.*, 2009), especially during crises.

Overall, although co-integration analyses have been widely employed to investigate market integration, the existing literature does not adequately consider asymmetric adjustment dynamics. To fill this gap, we employ Enders and Siklos's (2001) tests for threshold co-integration and Shin *et al.*'s (2014) non-linear autoregressive distributed lag (NARDL) model for seven ASEAN nations' stock markets and investigate two related hypotheses: (1) co-integration exists among ASEAN markets and (2) adjustments toward long-run co-integrating relationship are asymmetric.

3. Data and methodologies

The stock index data of the seven ASEAN countries considered in this study were obtained from Thomson Reuters's financial data vendor at daily, weekly and monthly frequencies. All variables are log-transformed. The sample period runs from January 1, 2009 to May 4, 2022, excluding holidays, and contains 3,480 observations for each market. The choice of countries and sample period were subject to the availability of stock market data suitable for empirical analyses in the aftermath of the global financial crisis. Table A1 in Appendix describes the stock market indexes used in the sample and their data sources, while Table A2 provides statistical descriptions of the variables by level, log level and first difference of log. In terms of stock market returns, we note that all markets posted positive average performances and that markets in less developed countries (Cambodia, Indonesia, Philippines, Thailand, and Vietnam) appeared to outperform even the most developed countries (Singapore and Malaysia) during the sample period.

To explain the integration of stock markets in seven ASEAN countries, the first step is to test for a unit root type of non-stationarity; we begin by testing for the presence of a unit root in stock prices. We employ two groups of unit root tests for comparison and completeness. One is based on Fourier approximations (augmented Dickey–Fuller ["ADF"] and Kwiatkowski–Phillips–Schmidt–Shin ["KPSS"] tests) and considers the no-linearity issue, while the other group—ADF, Phillips–Perron ("PP"), KPSS and Zivot and Andrews (1992)—does not.

In analyzing stock market integration in ASEAN countries, we account for nonlinear adjustment mechanisms, an important recent development in the time series econometric paradigm. Specifically, we employ Enders and Siklos's (2001) tests for threshold co-integration [5].

Let $Y_{i,t}$ be the logarithmic transformation of the stock market index of the ith ASEAN country $(j = 1, \ldots, 7)$ and $\boldsymbol{X}_t = \{X_{j,t}\}(j = 1, \ldots, 6; j \neq i)$ be the vector of the other six logarithmic ASEAN stock market indices, all of which are scalar I(1) variables. The co-integrating relationship in the first stage can be expressed as follows:

$$Y_{i,t} = \zeta_0 + \zeta_1 \boldsymbol{X}_t + \varepsilon_t, \tag{1}$$

where ε_t measures the deviation from the equilibrium relationship between X_t and $Y_{i,t}$. Here, ζ_0 and ζ_1 are estimated parameters, and ε_t is the disturbance term that may be serially correlated. The simple least squares method is then employed to obtain consistent estimates of the disturbance term ε_t. For the two variables to be co-integrated, ε_t should be stationary. In the second stage, to allow for asymmetric adjustment dynamics, the deviations from equilibrium in (1) are modeled to follow a threshold autoregressive (TAR) process:

$$\Delta\varepsilon_t = I_t\rho_1\varepsilon_{t-1} + (1 - I_t)\rho_2\varepsilon_{t-1} + \sum_{k=1}^{p}\phi_k\Delta\varepsilon_{t-k} + u_t, \tag{2}$$

where u_t is a white-noise disturbance, Δ denotes the difference operator and $I_t = 1$ if $\varepsilon_{t-1} \geq 0$ and $I_t = 0$ otherwise. By allowing ρ_1 and ρ_2 to take different values, the model recognizes that positive and negative deviations from equilibrium can be corrected for at different speeds. If there is co-integration, $\rho_1 < 0$ and $\rho_2 < 0$. Testing for the null hypothesis of no convergence (i.e. no co-integration) can be performed based on the t_{Max} and Φ tests proposed by Enders and Siklos (2001). The t_{Max} statistic is given by the larger of the t-statistics corresponding to ρ_1 and ρ_2. A significantly negative t_{Max} statistic implies that ρ_1 and ρ_2 are both negative, while a significantly positive t_{Max} statistic implies that ρ_1 and ρ_2 are both positive. The Φ statistic is for an F-test for the joint null hypothesis of $\rho_1 = \rho_2 = 0$.

Although Enders and Siklos's tests allow us to investigate whether adjustment of the error-correction term ε_t is asymmetric (subject to shocks to the error correction term itself), these tests do not allow us to pinpoint the source of the shocks. To complement them, we seek to decompose the shocks into positive and negative changes in stock indices—rather than in ε_t—and thus gauge the degree to which each member country reacts to common shocks from the other ASEAN markets. As such, we augment the above analysis by adopting Shin *et al.*'s (2014) nonlinear autoregressive NARDL (p, q), which is specified as

$$Y_{i,t} = \sum\nolimits_{j=1}^{p}\Phi_j Y_{i,t-j} + \sum\nolimits_{j=0}^{q}\left(\psi_j^{+}\widetilde{X}_{t-j}^{+} + \psi_j^{-}\widetilde{X}_{t-j}^{-}\right) + v_t\ (i = 1, \ldots, 7), \tag{3}$$

where $Y_{i,t}$ is defined as in (1), and $\widetilde{X}_t = (1/7)\sum_{i=1}^{7}Y_{i,t}$ denotes the logarithm of an equal weighted average of the ASEAN stock indices, which is also an I(1) variable. In (3), $\widetilde{X}_t$ is decomposed as $\widetilde{X}_t = \widetilde{X}_0 + \widetilde{X}_t^{+} + \widetilde{X}_t^{-}$ where $\widetilde{X}_0$ is the initial value in the sample, and $\widetilde{X}_t^{+} = \sum_{j=1}^{t}\Delta X_j^{+} = \sum_{j=1}^{t}\max\ (\Delta X_j, 0)$ and $\widetilde{X}_t^{-} = \sum_{j=1}^{t}\Delta X_j^{-} = \sum_{j=1}^{t}\min\ (\Delta X_j, 0)$ denote the partial sum processes of positive and negative changes in $\widetilde{X}_t$. Given that $Y_{i,t}$ and $\widetilde{X}_{t-j}^{+}$ and $\widetilde{X}_{t-j}^{-}$ are co-integrated, the corresponding error-correction form of (3) is

$$\Delta Y_{i,t} = \alpha Y_{i,t-1} + \beta^{+}\widetilde{X}_{t-1}^{+} + \beta^{-}\widetilde{X}_{t-1}^{-} + \sum\nolimits_{j=1}^{p-1}\gamma_j\Delta Y_{i,t-j} + \sum\nolimits_{j=0}^{q-1}\left(\lambda_j^{+}\widetilde{X}_{t-j}^{+} + \lambda_j^{-}\widetilde{X}_{t-j}^{-}\right) + \varsigma_t, \tag{4}$$

where $\alpha = \sum_{j=1}^{p}\Phi_j - 1$; $\gamma_j = -\sum_{i=j+1}^{p}\Phi_i$ for $j = 1, \ldots, p-1$; $\beta^{+} = \sum_{j=0}^{q}\psi_j^{+}$; $\beta^{-} = \sum_{j=0}^{q}\psi_j^{-}$; $\lambda_j^{+} = -\sum_{i=j+1}^{q}\psi_j^{+}$ and $\lambda_j^{-} = -\sum_{i=j+1}^{q}\psi_j^{-}$ for $j = 1, \ldots, q-1$. The country-specific nonlinear error-correction term in this context is $\xi_{i,t} = Y_{i,t} - \left(\frac{\beta^{+}}{\alpha}\right)\widetilde{X}_{t-1}^{+} - \left(\frac{\beta^{-}}{\alpha}\right)\widetilde{X}_{t-1}^{-}$, with $-\left(\frac{\beta^{+}}{\alpha}\right)$ and $-\left(\frac{\beta^{-}}{\alpha}\right)$ being the asymmetric long-run parameters. From the estimated results of (4), we can derive the cumulative dynamic multipliers [6] of a 1% change in $\widetilde{X}_{t-j}^{+}$ and $\widetilde{X}_{t-j}^{-}$ as $dm_h^{+} = \sum_{k=0}^{h}\frac{\partial Y_{i,t+k}}{\partial X_{t-1}^{+}}$; $dm_l^{+} = \sum_{k=0}^{h}\frac{\partial Y_{i,t+k}}{\partial X_{t-1}^{-}}$; $h = 0, 1, 2, \ldots$ Note that as $h \to \infty$, $dm_h^{+} \to -\left(\frac{\beta^{+}}{\alpha}\right)$

and $dm_h^- \to -\left(\frac{\beta^-}{\alpha}\right)$. These dynamic multipliers provide us with the ideal tool to visualize the asymmetric adjustment paths of ASEAN stock markets following positive and negative shocks to other markets, as proxied by the average index.

4. Empirical results

4.1 Nonlinear co-integration tests

Table A3 in Appendix presents the pairwise correlations for stock market indexes (log level) and stock market returns (difference of first log) for all pairs of seven ASEAN countries. In log levels of stock market indexes, generally, we identify more than 80% of the correlation coefficients between ASEAN-7 stock market indexes to be above 0.5. Furthermore, six pairs of stock market indexes have very strong correlation coefficients (above 90%): Indonesia and Philippines, Thailand and Indonesia, Malaysia and Indonesia, the Philippines and Malaysia, Thailand and the Philippines, and Malaysia and Thailand. The five founding members of ASEAN comprise 72.8% of ASEAN's population and 95.1% of its GDP (Chien *et al.*, 2015). The ASEAN-5 also have the most developed stock markets among ASEAN countries.

Meanwhile, among all pairs of stock market indexes, the lowest two correlation coefficients are Cambodia with Malaysia and Cambodia with Singapore. From the perspective of a regional investor in Singapore and Malaysia, low correlation coefficients raise potential portfolio diversification gains that can be obtained by investing in emerging markets. The correlation coefficients are still positively significant for all pairs of stock market returns but are much lower than the stock market indexes discussed above. Portfolio construction based on simple correlation analysis, however, might be misleading due to the temporal instability of such correlation coefficients (Graham *et al.*, 2012). As such, more advanced methodologies are needed.

To account for nonlinearity and following Enders and Lee (2012), we implement the unit root tests based on Fourier approximations (ADF and KPSS tests) and present the results in Table A4 in Appendix. As is clear, most tests imply that all the variables considered in this study are nonstationary at levels. On the other hand, the majority of the unit root test results suggest that all variables are stationary in the first log of difference. Furthermore, as a robustness check, we perform conventional (linear) unit root tests without structural breaks, namely, ADF, PP and KPSS tests (with no structural break considered), along with the Zivot-Andrews unit root tests to account for one endogenous structural break. The main results of these tests are qualitatively the same as those reported above.

Table 1 shows the results of the t_{Max} and Φ tests for co-integration. To gain additional insights into possible channels of stock market transmission in ASEAN countries, we explore all the possibilities of co-integrating relationships among the selected stock markets. Specifically, we test seven co-integrating relationships with each country's stock market serving as a dependent variable and the other markets combined being the driving force and thus independent variables. The t_{Max} and Φ test results strongly support the existence of long-run equilibrium relationships between all seven possible co-integration relationships at the 1% significance level.

In many areas of financial economics research, the sensitivity of econometric tests to data frequency may lead to misleading empirical results (Chien *et al.*, 2015; Narayan and Sharma, 2015; Phan *et al.*, 2015; Urom *et al.*, 2021). One possible reason is due to temporal aggregation bias (Taylor, 2001). To check whether this concern is valid, we perform threshold co-integration analyses for the seven ASEAN stock markets using data with lower frequencies, that is, weekly and monthly data. The results are presented in Tables 2 and 3, respectively, and confirm strong evidence for the co-integration reported in the previous paragraph. Our finding is in line with Click and Plummer (2005), Caporale *et al.* (2019) and Wu (2020), who documented co-movement among ASEAN-5 stock markets in the aftermath of the 1997 Asian financial crisis and/or the 2008 global financial crisis. However, the evidence for

Variables in the co-integrating relationship		Co-integration test statistics	
Dependent variable	Independent variables	t_{max}	Φ
Lcam	lindo lmalay lphi lsing lthai lviet	−4.130***	19.225***
Lindo	lcam lmalay lphi lsing lthai lviet	−3.375***	15.388***
Lmalay	lcam lindo lphi lsing lthai lviet	−3.007***	10.675***
Lphi	lcam lindo lmalay lsing lthai lviet	−4.1852***	18.176***
Lsing	lcam lindo lmalay lphi lthai lviet	−3.334***	13.093***
Lthai	lcam lindo lmalay lphi lsing lviet	−4.219***	19.668***
Lviet	lcam lindo lmalay lphi lsing lthai	−3.223***	15.628***

Note(s): The lag used for each test is determined using the general-to-specific method (Ng and Perron, 1995) with a maximum lag order of 8 allowed. The null hypothesis under test is no co-integration. Approximate critical values for the t_{max} and Φ tests are taken from Tables 1 and 2 in Enders and Siklos (2001). For the t_{max} test statistic, critical values are −1.69 for the 10% significance level, −1.89 for the 5% significance level and −2.29 for the 1% significance level. For the Φ test statistic, critical values are approximately 5.21 for the 10% significance level, 6.33 for the 5% significance level and 9.09 for the 1% significance level. Statistical significance is indicated by triple asterisks (***) for the 1% level

Table 1.
Results from the Enders–Siklos test for threshold co-integration

Variables in the co-integrating relationship		Co-integration test statistics	
Dependent variable	Independent variables	t_{max}	Φ
lcam	lindo lmalay lphi lsing lthai lviet	−3.705***	14.773***
lindo	lcam lmalay lphi lsing lthai lviet	−2.627***	10.229***
lmalay	lcam lindo lphi lsing lthai lviet	−2.623***	8.048***
lphi	lcam lindo lmalay lsing lthai lviet	−3.499***	13.619***
lsing	lcam lindo lmalay lphi lthai lviet	−3.493***	12.596***
lthai	lcam lindo lmalay lphi lsing lviet	−3.729***	13.799***
lviet	lcam lindo lmalay lphi lsing lthai	−3.104***	12.125***

Note(s): The lag used for each test is determined using the general-to-specific method (Ng and Perron, 1995) with a maximum lag order of 8 allowed. The null hypothesis under test is no co-integration. Approximate critical values for the t_{max} and Φ tests are taken from Tables 1 and 2 in Enders and Siklos (2001). For the t_{max} test statistic, critical values are −1.69 for the 10% significance level, −1.89 for the 5% significance level and −2.29 for the 1% significance level. For the Φ test statistic, critical values are approximately 5.21 for the 10% significance level, 6.33 for the 5% significance level and 9.09 for the 1% significance level. Statistical significance is indicated by triple asterisks (***) for the 1% level

Table 2.
Robustness check: results from the Enders–Siklos test for threshold co-integration (Weekly data)

Variables in the co-integrating relationship		Co-integration test statistics	
Dependent variable	Independent variables	t_{max}	Φ
lcam	lindo lmalay lphi lsing lthai lviet	−3.886***	14.729***
lindo	lcam lmalay lphi lsing lthai lviet	−2.679***	9.908***
lmalay	lcam lindo lphi lsing lthai lviet	−2.647***	7.501***
lphi	lcam lindo lmalay lsing lthai lviet	−3.504***	11.532***
lsing	lcam lindo lmalay lphi lthai lviet	−3.338***	11.303***
lthai	lcam lindo lmalay lphi lsing lviet	−3.766***	13.867***
lviet	lcam lindo lmalay lphi lsing lthai	−3.347***	10.337***

Note(s): The lag used for each test is determined using the general-to-specific method (Ng and Perron, 1995) with a maximum lag order of 8 allowed. The null hypothesis under test is no co-integration. Approximate critical values for the t_{max} and Φ tests are taken from Tables 1 and 2 in Enders and Siklos (2001). For the t_{max} test statistic, critical values are −1.71 for the 10% significance level, −1.91 for the 5% significance level and −2.34 for the 1% significance level. For the Φ test statistic, critical values are approximately 5.23 for the 10% significance level, 6.35 for the 5% significance level and 8.94 for the 1% significance level. Statistical significance is indicated by triple asterisks (***) for the 1% level

Table 3.
Robustness check: results from the Enders–Siklos test for threshold co-integration (Monthly data)

co-integration among the ASEAN markets in our sample after the global financial crisis is quite strong. As a robustness check, for daily data, we redo the Enders and Siklos (2001) co-integration tests with critical values derived from distributions under the (asymmetric) TAR and momentum-threshold autoregressive adjustment (M-TAR) processes when the threshold is unknown; the results are presented in Table 4. All test statistics and significance levels are comparable to those presented in Tables 2 and 3 [7].

4.2 Nonlinear dynamic multipliers

Figure 1 presents the plots for the dynamic multipliers discussed in Section 3. To conserve space, only the daily data results are presented; weekly and monthly results are qualitatively similar and available on request. The lag orders (p, q) are selected using Akaike information criteria. Interestingly, the figure shows that five of seven countries (Indonesia, the Philippines, Malaysia, Singapore and Thailand) exhibit insignificant impacts from changes in the average stock market index. This is because the effects of positive and negative changes (indicated by the dashed red and blue lines, respectively) offset each other and yield a composite effect (solid blue line) close to zero. For these countries, the asymmetric effect is small and concentrated in the first few days, while in the long run (up to 100 days), the impact of the changes is quite symmetric. In contrast, the least developed markets—Cambodia and Vietnam—exhibit much stronger asymmetric effects toward positive changes in the short run. Though the effect is insignificant for Vietnam, the Cambodian stock market index increases significantly (almost 1%) when there is a 1% increase in the average index. The estimates for both exhibit much higher uncertainty (i.e. larger confidence intervals) than the other five markets, which results from their more volatile nature.

In summary, our empirical results are strong evidence of co-integration among seven ASEAN stock markets, implying that these markets have moved together in the aftermath of the 2007–2008 global financial crisis. Indeed, representatives of ASEAN stock markets have been

Variables in the co-integrating relationship		Co-integration test statistics	
Dependent variable	Independent variables	t_{max}	Φ
A. TAR adjustment			
lcam	lindo lmalay lphi lsing lthai lviet	−2.27***	7.94***
lindo	lcam lmalay lphi lsing lthai lviet	−3.38***	14.85***
lmalay	lcam lindo lphi lsing lthai lviet	−3.46***	11.90***
lphi	lcam lindo lmalay lsing lthai lviet	−3.83***	14.85***
lsing	lcam lindo lmalay lphi lthai lviet	−3.46***	11.90***
lthai	lcam lindo lmalay lphi lsing lviet	−3.83***	14.45***
lviet	lcam lindo lmalay lphi lsing lthai	−3.84***	14.20***
B. M-TAR adjustment			
lcam	lindo lmalay lphi lsing lthai lviet	−1.75***	8.76***
lindo	lcam lmalay lphi lsing lthai lviet	−3.70***	14.78***
lmalay	lcam lindo lphi lsing lthai lviet	−3.35***	11.87***
lphi	lcam lindo lmalay lsing lthai lviet	−3.70***	13.78***
lsing	lcam lindo lmalay lphi lthai lviet	−3.35***	11.87***
lthai	lcam lindo lmalay lphi lsing lviet	−3.63 ***	14.41***
lviet	lcam lindo lmalay lphi lsing lthai	−3.35***	12.87***

Note(s): The lag used for each test is determined using the general-to-specific method (Ng and Perron, 1995) with a maximum lag order of 8 allowed. The null hypothesis under test is no co-integration. Panels A and B present results based on distributions of critical values with adjustments for the TAR and M-TAR categories, respectively. Approximate critical values for the t_{max} and Φ tests are taken from Tables 5 and 6 in Enders and Siklos (2001). Statistical significance is indicated by triple asterisks (***) for the 1% level

Table 4.
Enders–Siklos tests with TAR and M-TAR adjustments (Daily data)

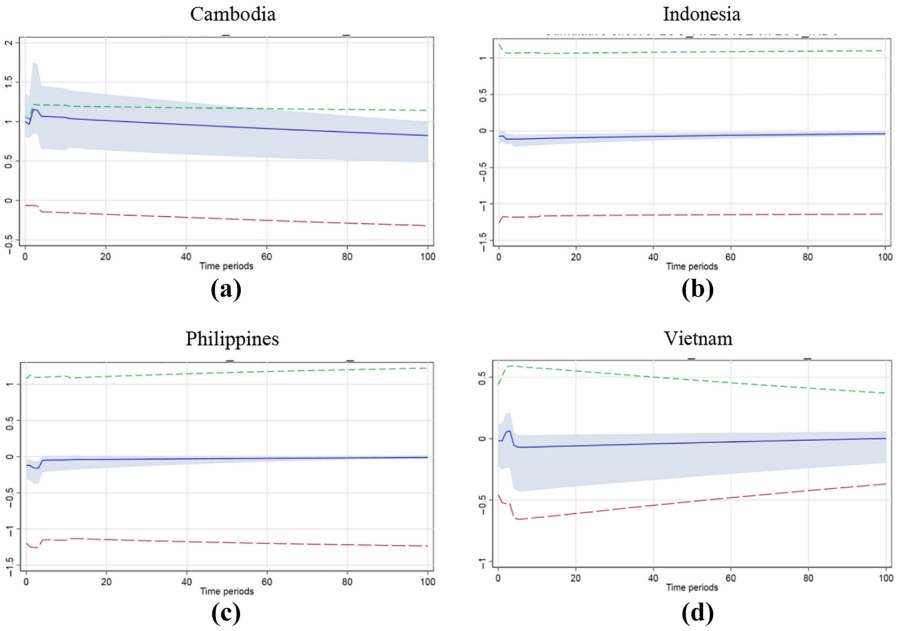


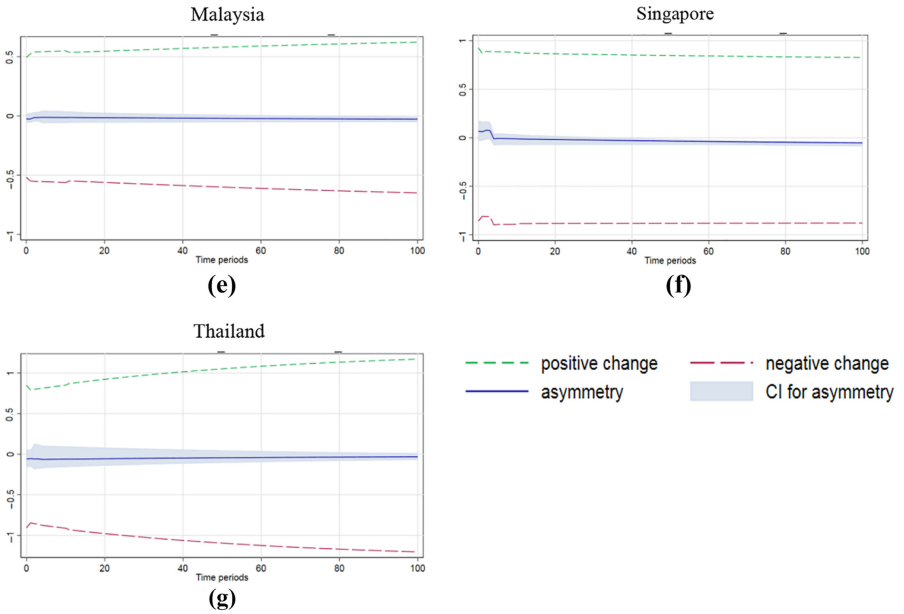
Figure 1.
The cumulative effect of daily changes in ASEAN stock indexes on member countries' indexes

discussing becoming a common stock market at a large overall scale in order to attract international investors and issuers. The initial goal of connecting ASEAN securities markets is to develop homogeneous investment products on those markets. This is an important step to take advantage of the effects of the ASEAN Economic Community (AEC), which has already profoundly impacted the regional economy in recent years. Furthermore, the co-movement of stock markets in ASEAN countries could be attributable to the ongoing capital account liberalization and financial market deregulation undertaken by the bloc's governments to promote cross-border financial transactions. For example, the ASEAN Exchanges network—a pilot effort combining seven exchanges from Malaysia, Vietnam (two exchanges), Indonesia, the Philippines, Thailand and Singapore—was formed in April 2011 to increase regional cross-border trading and enhance the feasibility of funding and investment in the region.

5. Concluding remarks

This study finds strong evidence of co-integration relationships existing in all possible considerations of stock market indexes for seven ASEAN countries between 2009 and 2022. The co-integration exists regardless of data frequencies. Overall, our empirical evidence shows a strong regional financial integration among ASEAN countries. In the longer-term future, integration between the seven stock markets will result in a larger and more diversified market and pool of investors. Drawing on our empirical results, we provide some suggestions below.

The evidence of stock market integration implies that ASEAN policymakers can adopt a coordinated approach to boost sequential liberalization and integration processes and improve their regulatory standards to comply with international standards. In addition, integration in stock markets might help foster the development of less developed capital markets in the region, such as Vietnam and Cambodia. However, despite gains in market efficiency, integration also entails potential risks. To address this issue, financial integration should be executed in a systematic and complementary manner.



Note(s): These cumulative effects are derived from the dynamic multipliers of a NARDL model (Shin *et al.,* 2014) employed for seven ASEAN countries. In each panel, the gray area indicates the 95% confidence interval computed using a bootstrap procedure with 1,000 draws. The green and red dashed lines indicate the impacts of positive and negative changes in the average stock index, respectively. The blue line is the difference between these values, which represents the composite effect

Figure 1.

The ASEAN community still has much work to do. In addition to expanding its relations with external partners such as the six Indo-Pacific states with which ASEAN has existing free trade agreements (China, Japan, South Korea, India, Australia and New Zealand), the ASEAN bloc needs to consistently promote co-operation throughout the region. Each ASEAN country can offer leverage for other members. The less developed group of ASEAN states, such as Vietnam, Cambodia, Laos and Myanmar, also need to strengthen their macroeconomic policy reform efforts to improve the competitiveness of their economies and help preserve and enhance peace, stability and prosperity in the region.

In this study, we were particularly interested in examining the long-run relationships among ASEAN stock markets. Future studies could explore short-run causal linkages between ASEAN stock markets to see if there is a solid theoretical basis for that causality to exist. Furthermore, it would be helpful to have a thorough analysis of ASEAN stock market integration across different sectors of the economy. As the worst of the COVID-19 pandemic is expected to be over in the very near future, research could be conducted on ASEAN financial integration during the recovery period to address the pandemic's long-term impacts.

Notes

1. Furthermore, since stock markets are critical components of the overall economy, regional stock market integration might be regarded as a precondition for regional monetary or currency unification (Click and Plummer, 2005). Fry-McKibbin *et al.* (2018) documented an overall trend

toward improvements in financial integration over time, despite deviations occurring during periods of financial crisis in Asia, the Eurozone and the USA.

2. Important developments in ASEAN in the areas of trade and finance include the formal launch of the Regional Comprehensive Economic Partnership (RCEP) in November 2012; it involves six Indo-Pacific states with which ASEAN has existing free trade agreements (China, Japan, South Korea, India, Australia and New Zealand). According to World Bank data for 2021, prospective RCEP member states accounted for almost one-third of the world's population with 2.3 billion people and a total GDP of US$25.8 tn or about 30% of global GDP.
3. See https://www.aseanstats.org/wp-content/uploads/2021/12/ASEAN-KEY-FIGURES-2021-FINAL-1.pdf
4. World Federation of Exchanges data show that the total capitalization of the Singapore Exchange (SGX) has increased by 13.6% since 2016, far below Hong Kong (37.3%). In Southeast Asia, the market capitalization of Vietnam's Ho Chi Minh City Stock Exchange (HoSE) increased the most at 75.2%, followed by Indonesia (22.6%), the Philippines (22%), Thailand (15.7%) and Malaysia (14.5%). Regional exchanges have successfully attracted new listings, especially from domestic companies. ASEAN stock markets are much smaller than many neighboring countries' stock markets (e.g. Japan Exchange Group, Shanghai Stock Exchange, Hong Kong Stock Exchange and Bombay Stock Exchange). ASEAN may move toward the creation of a single supranational stock market if capital market integration does succeed (Click and Plummer, 2005).
5. This is a residual-based two-stage estimation that extends Engle and Granger's procedure to account for possible asymmetric adjustments to disequilibrium. The differences between the two procedures lie in the formulation of linearity and nonlinearity at the second stage of the unit root test (Yau and Nieh, 2009).
6. The multiplier is akin to the impulse response function in the multi-equation context; i.e. in the vector autoregression model.
7. Robustness checks for weekly and monthly data yield similar results and are available on request.

References

Ait-Sahalia, Y., Fan, J. and Li, Y. (2013), "The leverage effect puzzle: disentangling sources of bias at high frequency", *Journal of Financial Economics*, Vol. 109 No. 1, pp. 224-249.

Batten, J.A., Kinateder, H., Szilagyi, P.G. and Wagner, N.F. (2019), "Time-varying energy and stock market integration in Asia", *Energy Economics*, Vol. 80, pp. 777-792.

Bekaert, G. and Harvey, C.R. (1995), "Time-varying world market integration", *Journal of Finance*, Vol. 50 No. 2, pp. 403-444.

Bekaert, G., Hodrick, R.J. and Zhang, X. (2009), "International stock return co-movements", *The Journal of Finance*, Vol. 64 No. 6, pp. 2591-2626.

Black, F. (1976), "Studies of stock price volatility changes", in *Proceedings of the 1976 Meetings of the American Statistical Association*, American Statistical Association, Washington, pp. 171-181.

Caporale, G.M., You, K. and Chen, L. (2019), "Global and regional stock market integration in Asia: a panel convergence approach", *International Review of Financial Analysis*, Vol. 65, 101381, DOI: 10.1016/j.irfa.2019.101381.

Caporale, G.M., Gil-Alana, L.A. and You, K. (2022), "Stock market linkages between the ASEAN countries, China and the US: a fractional integration/cointegration approach", *Emerging Markets Finance and Trade*, Vol. 58 No. 5, pp. 1502-1514.

Chen, L.H., Finney, M. and Lai, K.S. (2005), "A threshold cointegration analysis of asymmetric price transmission from crude oil to gasoline prices", *Economics Letters*, Vol. 89 No. 2, pp. 233-239.

Chien, M.S., Lee, C.C., Hu, T.C. and Hu, H.T. (2015), "Dynamic Asian stock market convergence: evidence from dynamic co-integration analysis among China and ASEAN-5", *Economic Modelling*, Vol. 51, pp. 84-98.

Click, R.W. and Plummer, M.G. (2005), "Stock market integration in ASEAN after the Asian financial crisis", *Journal of Asian Economics*, Vol. 16 No. 1, pp. 5-28.

Enders, W. and Lee, J. (2012), "A unit root test using a Fourier series to approximate smooth breaks", *Oxford Bulletin of Economics and Statistics*, Vol. 74 No. 4, pp. 574-599.

Enders, W. and Siklos, P.L. (2001), "Cointegration and threshold adjustment", *Journal of Business and Economic Statistics*, Vol. 19 No. 2, pp. 166-176.

Fry-McKibbin, R., Hsiao, C.Y.L. and Martin, V.L. (2018), "Global and regional financial integration in East Asia and the ASEAN", *North American Journal of Economics and Finance*, Vol. 46, pp. 202-221.

Ghosh, S. and Kanjilal, K. (2016), "Co-movement of international crude oil price and Indian stock market: evidences from nonlinear cointegration tests", *Energy Economics*, Vol. 53, pp. 111-117.

Graham, M., Kiviaho, J. and Nikkinen, J. (2012), "Integration of 22 emerging stock markets: a three-dimensional analysis", *Global Finance Journal*, Vol. 23 No. 1, pp. 34-47.

Horvath, R. and Petrovski, D. (2013), "International stock market integration: central and South Eastern Europe compared", *Economic Systems*, Vol. 37 No. 1, pp. 81-91.

Johnson, R. and Soenen, L. (2002), "Asian economic integration and stock market comovement", *Journal of Financial Research*, Vol. 25 No. 1, pp. 141-157.

Kim, S.J., Moshirian, F. and Wu, E. (2005), "Dynamic stock market integration driven by the European Monetary Union: an empirical analysis", *Journal of Banking and Finance*, Vol. 29 No. 10, pp. 2475-2502.

Mensah, J.O. and Premaratne, G. (2018), "Integration of ASEAN banking sector stocks", *Journal of Asian Economics*, Vol. 59, pp. 48-60.

Mollah, S. and Mobarek, A. (2016), *Global Stock Market Integration: Co-movement, Crises, and Efficiency in Developed and Emerging Markets*, Springer, Cham.

Narayan, P.K. and Sharma, S.S. (2015), "Does data frequency matter for the impact of forward premium on spot exchange rate?", *International Review of Financial Analysis*, Vol. 39, pp. 45-53.

Narayan, P.K. and Smyth, R. (2004), "Modelling the linkages between the Australian and G7 stock markets: common stochastic trends and regime shifts", *Applied Financial Economics*, Vol. 14 No. 14, pp. 991-1004.

Narayan, P.K., Mishra, S. and Narayan, S. (2011), "Do market capitalization and stocks traded converge? New global evidence", *Journal of Banking and Finance*, Vol. 35 No. 10, pp. 2771-2781.

Narayan, S., Le, T.H. and Srinanthakumar, S. (2018), "The influence of terrorism risk on stock market integration: evidence from eight OECD countries", *International Review of Financial Analysis*, Vol. 58 July, pp. 247-259.

Ng, S. and Perron, P. (1995), "Unit root tests in ARMA models with data-dependent methods for the selection of the truncation lag", *Journal of the American Statistical Association*, Vol. 90 No. 429, pp. 268-281.

Phan, D.H.B., Sharma, S.S. and Narayan, P.K. (2015), "Oil price and stock returns of consumers and producers of crude oil", *Journal of International Financial Markets, Institutions and Money*, Vol. 34, pp. 245-262.

Shin, Y., Yu, B. and Greenwood-Nimmo, M. (2014), "Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework", in Sickles, R.C. and Horrace, W.C. (Eds), *Festschrift in Honor of Peter Schmidt: Econometric Methods and Applications*, Springer, New York, NY, pp. 281-314.

Taylor, A.M. (2001), "Potential pitfalls for the purchasing-power-parity puzzle? Sampling and specification biases in mean-reversion tests of the law of one price", *Econometrica*, Vol. 69 No. 2, pp. 473-498.

Tiwari, A.K., Dar, A.B., Bhanja, N. and Shah, A. (2013), "Stock market integration in Asian countries: evidence from wavelet multiple correlations", *Journal of Economic Integration*, Vol. 28 No. 3, pp. 441-456.

Umutlu, M., Akdeniz, L. and Altay-Salih, A. (2010), "The degree of financial liberalization and aggregated stock-return volatility in emerging markets", *Journal of Banking and Finance*, Vol. 34 No. 3, pp. 509-521.

Urom, C., Mzoughi, H., Abid, I. and Brahim, M. (2021), "Green markets integration in different time scales: a regional analysis", *Energy Economics*, Vol. 98, doi: 10.1016/j.eneco.2021.105254.

Wu, F. (2020), "Stock market integration in East and Southeast Asia: the role of global factors", *International Review of Financial Analysis*, Vol. 67, doi: 10.1016/j.irfa.2019.101416.

Yau, H.Y. and Nieh, C.C. (2009), "Testing for cointegration with threshold effect between stock prices and exchange rates in Japan and Taiwan", *Japan and the World Economy*, Vol. 21 No. 3, pp. 292-300.

Yoshida, Y. (2010), "Is this time different for Asia? Evidence from stock markets", Discussion Paper 4. Kyushu Sangyo University, available at: https://www.kyusan-u.ac.jp/keizai-kiyo/dp40.pdf

Zivot, E. and Andrews, D.W.K. (1992), "Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis", *Journal of Business and Economic Statistics*, Vol. 10, pp. 251-270.

Appendix

The Appendix for this article can be found online.

Corresponding author

Thai-Ha Le can be contacted at: v.halt51@vinfutureprize.org