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Interdependence of stock markets: evidence from Vietnam

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Abstract

The study investigates the effect of spillovers regionally and worldwide on Vietnam's stock market. The vector error correction model is used to analyze the collected data from Bloomberg. Data include eight comparable stock market indices, namely DJI, NKY, SHCOMP, SET, MXSG, PCOMP, FBMKLCI, and JCI. The empirical results show that the Vietnamese stock market is significantly linked to that of other countries. During the periods of dramatic market fluctuation, the cross-border linkage between the VN-Index and comparable indices is the largest. The impact of the stock markets of small nearby countries such as Singapore and Malaysia on the Vietnamese stock market is greater than the other large ones including the United States, Japan and China. The findings of this study contribute to the literature on the interdependence and interaction of stock markets. The common economic integration, especially in showing that effect found in other studies, is meaningful in explaining the observed phenomenon.

Keywords: Interdependence, Spillover effect, Price co-movement, Cross-border relationship ASEAN exchanges, Stock market indices

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1. Introduction

It can be clearly seen that for more than 20 years, the Vietnamese stock market has developed significantly and it has played an important role in the development of national economy in Vietnam. According to the State Securities Commission, the first session of the Vietnamese stock market in 2000 only involved two listed companies. By 2006, the number of companies listed on the stock exchange was about 200 and more than 1,600 by the end of 2019.

As of June 30, 2020, the total capitalization of the Vietnam stock market reached 5.5 million billion VND, the market capitalization to GDP ratio increased from 0.3% in 2000 to 104% GDP in June 2020. The stock market capitalization reached over 4 million billion VND, equivalent to about 64.5% of GDP in 2019. The stock market capitalization is estimated to have grown at an average rate of more than 50% per year over the past 20 years (Ta, 2020). Moreover, the number of investor accounts increased from 3,000 accounts in 2000 to 2.5 million accounts as of 30 June 2020. Which, there are about 33,000 accounts of foreign organizations and individuals with a total value of securities holding equivalent to nearly 35 billion USD. Foreign investors' portfolio value accounts for about 20% of Vietnam stock market capitalization (Ta, 2020).

As economic integration through participation in new-generation free trade agreements (FTAs) is a popular trend in recent years, the role of the stock market becomes even more important. The new-generation FTAs such as the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), FTA Vietnam - European Union (EVFTA) or the ASEAN Economic Community agreement (AEC) have been promoting the financial integration of Vietnam in general and the Vietnam stock market integration. In fact, stock market integration has attracted a lot of investors, academic researchers, and policymakers because it can generate a more competitive market and foster international portfolio diversification and risk sharing (Ahmed and Rui, 2018). However, there are not many quantitative studies that provide specific evidence on the interdependence of the Vietnam stock market and other ones.

To our best knowledge, there was only one research by Nguyen (2011) that focuses on the spillover effect of the United States macroeconomic news on the Vietnamese stock market returns. This sold study did not take into account the indices of these markets. Our research aims to investigate the interdependence between the Vietnamese stock market and other stock markets such as the US, Japan, and China. Several other neighboring countries' stock markets, including Thailand, Singapore, Philippines, Malaysia and Indonesia, are also taken into account. These stock markets are chosen since the US and Japan are considered the benchmark markets for many other countries. The US, Japan, and China are also the three most important trade partners of Vietnam (World Bank, 2021) and one would expect the economic integration effect on stock price co-movement. Moreover, due to the assumption that there is a stricter price co-movement among stock markets of countries that are close to each other than those further apart (Zhang *et al.*, 2016; Chong *et al.*, 2011; Eckel *et al.*, 2011; Chuang *et al.*, 2007), the stock markets of ASEAN countries are examined in this study. Furthermore, since it is convenient to compare interdependence between two markets In a stability of both

shock and post-shock periods (Yang *et al.*, 2003; Yiu *et al.*, 2010), the research span is divided into different sub-periods. It serves the purpose of evaluating the correlation between the VN-Index and the stock market index of other countries in terms of uptrends, downtrends and sideways trends. The vector error correction model (VECM) is employed to analyze the data.

Our article has made three major contributions. Firstly, the study adds evidence to the literature on the interdependence of stock markets, which is a matter of discussion in the context of growing economic and financial integration across countries. Secondly, the findings provide evidence on the interaction between the Vietnamese stock market and that of some leading trade partners and neighboring ASEAN countries. This study hopes to provide some quantitative evidence on these correlations. The results can be a useful reference for investors when building an investment strategy, as well as for policymakers when devising strategies to adjust the functioning and operation of the Vietnamese stock market. Third, it is shown that the economic integration effect does not explain the co-movement between the Vietnamese stock market and other markets.

The US, China, and Japan are the three most important trade partners of Vietnam, accounting for 46.59% of Vietnam's trade volume in 2019 (World Bank, 2021). However, the linkage between the Vietnamese market and these large markets is weaker than that of Vietnam and other minor trade partners in the ASEAN. A possible explanation is the economic structure of Vietnam., where trade is dominated by foreign trade investment (FDI) companies. These enterprises are rarely listed in the Vietnamese stock market.

This paper consists of six sections. Following the introduction, the literature review and the methodology are presented in the second and third sections, continued by research results in the fourth section and discussion in the fifth section. Some conclusions are found in the last section.

2. Literature review

There exist different interpretations of the stock market interdependence (Forbes and Rigobon, 2002; Corsettia *et al.*, 2005; Jung and Maderitsch, 2014).

Forbes and Rigobon (2002) define the stock market interdependence as a structural stability of the correlation coefficient in all states of the world. It means that if there is no significant increase in the price co-movement between two stock indices following a shock, it suggests that there is a strong and stable interdependence between the two stock markets. This approach is considered relatively simple, and is fitted to be used as a measure in comparing interdependence between two markets during a stable period (Champagne *et al.*, 2017).

There has been an increase in international stock market interdependence over the past three decades (Baele and Inghelbrecht, 2010; Aityan *et al.*, 2010). This interdependence relationship is subject to change over time Invalid source specified. and this often occurs during a period of market volatility (Jinjarak and Zheng, 2014; Aityan *et al.*, 2010). The stock

markets within a short geographic distance tend to display greater price co-movement than those further apart (Chong *et al.*, 2011; Eckel *et al.*, 2011).

Pretorius (2001) attempts to provide a theory explaining stock market interdependence. The interdependence of stock markets primarily originates from three main sources. The first is the "contagious effect", which is the capability of spreading a country' economic crisis to other countries or a significant increase in cross-border relationships after a shock to one or a group of countries (Forbes and Rigobon, 2002). The second reason is the "characteristics" of the stock market, namely industrial similarity, market volatility and market size. The third is the "economic integration" between the two countries. This means that deeper integration of the two countries' economies makes their stock markets more interdependent. This interdependence becomes greater as countries intensify economic integration (Abbas *et al.*, 2013; Walti, 2011; Tavares, 2009) and liberalization of their capital markets (Bekaert and Harvey, 1997).

As economic growth is closely related to the development of the stock market, especially in the case of emerging countries (Mian *et al.*, 2010; Touny, 2012; Mohammad *et al.*, 2018) so that the stock markets can be classified in accordance with the division of countries suggested by Wallerstein's World Systems Theory. This theory divides countries in the world into three groups namely core, semi-periphery and periphery based on the economic growth of these countries if using this theory, the stock markets around the world can also be divided into similar groups. Specifically, the core can be defined as those countries with fully developed stock markets that are likely to impact the stock markets of other countries. The peripheral countries have weaker equity markets with little or no influence on the stock markets of other countries. The semi-periphery has a stock market with growth and influence lying at the level between the two above groups. Similar to the classification of countries, the stock markets can also change from the periphery to the semi-periphery and to the core group and vice versa. Regarding to studies on the interdependence of stock markets, we can also categorize such studies using this classification.

There are many studies on the interdependence between the stock markets of core countries. Assessing the interdependence between the European and US stock markets, Sanvi and Neto (2004) noted a strong linkage between market volatility and the stock returns correlation. Kim (2003) found that the impact of the US stock market on the Australian stock market gradually decreased after the Asian crisis while the Japanese stock market maintained a modest effect on the other two markets. Analyzing the interdependence between nine major stock markets Bessler and Yang (2003) showed that the Japanese stock market was the most exogenous market, and the Canadian and French stock markets were the least exogenous. However, the US stock market was the only market that had a large influence on price co-movements for the other stock markets in the long term.

In terms of studies on the interdependence between the stock markets of the core countries and the semi-periphery countries, Zhang *et al.* (2016) investigated the interdependence of twenty-seven markets in Asia, America, and Europe to find that stock markets from

different continents not only have a strong linkage with each other on the same day, but also at a delay of one day. In addition, we point out that this relationship often fluctuated very unpredictably during periods of financial downturn. Yang *et al.* (2003) and Yiu *et al.* (2010) also emphasized that spillover effects[2] were reinforced during periods of crisis.

There are also several studies on the interdependence between stock markets of the semi-periphery countries, such as Chuang *et al.* (2007), who found that the interdependence of six East Asian equity markets was high. We showed that while the Japanese stock market was the most exogenous and least sensitive to fluctuations from others, it had the greatest impact on the transmission of volatility to other stock markets under consideration. Liu (2013) explored the interdependence between forty stock markets from 1996 to 2010 based on analyzing four types of market linkages including information capacity, financial integration, economic integration, and similarity in industrial structure. We noted a clear difference between the interdependence of developed markets and that of developing markets.

The fact that Asia is considered a vibrant economic development area in the last three decades has also made these countries' stock markets thrive. Many Asian countries have reformed their domestic financial markets in the direction of opening up their economy and integrating with the world market. This makes the stock markets of these countries more linked with each other and more associated with the stock markets of other countries in the world. This indicates that stock market interdependence in the emerging markets (or semi-periphery) countries in Asia seems to be a widely accepted fact (Pretorius, 2001), there is a growing body of research examining the Asian stock market interdependence, such as Xiao *et al.* (2017), Ginanjar *et al.* (2016), Chuang *et al.* (2007) and Samarakoon (2011).

There are only a few studies on stock market interdependence in emerging Latin American countries, which are also considered as semi-periphery countries, however, they indicate that stock markets in those countries are also interdependent (Christofi and Pericli, 1999), Choudhry (1997).

Few studies have focused on the interdependence of African stock markets with the rest of the world. Ahmed and Rui (2018) analyze the dynamic linkages between Chinese and African stock markets in recent years to find strong evidence of spillover effects in price co-movement implying that Chinese and African stock markets are showing signs of interdependence. Collins and Abrahamson (2004) indicate that the oldest and largest stock markets in the African continent such as those in South Africa, Egypt and Morocco are the most integrated globally.

Narayan and Rehman (2017) found a stable long-term interdependence between the stock markets of Asian semi-periphery and periphery countries and the US and Japanese stock markets for the period 2000-2013 (Narayan and Rehman, 2017) as well as for two stages

[2] Spillover effects are the impacts that seemingly unrelated events in one country could have on the economies of other countries. Diebold and Yilmaz introduce a volatility spillover measure based on forecast variance decompositions from vector autoregression (Diebold and Yilmaz, 2009; Diebold and Yilmaz, 2012).

2000-2013 and 2000-2018 (Narayan and Rehman, 2020). They also found similar results when comparing the stock markets of semi-periphery countries with those of peripheral countries in Asia (Narayan and Rehman, 2018),

Regarding periphery countries, the interdependence between the stock markets of those countries and the stock markets of other countries in the world is not strong. For example, Elyas *et al.* (1998) did not find a significant interdependence between the capital market of Sri Lanka and the markets of its major trading partners.

In terms of methodology, researchers use different methodologies and models to analyze the stock market interdependence which is summarized in Appendix A.

2. Research methodology

2.1 Research design and data collection

The study aims to investigate whether there is an interdependence between the stock market in Vietnam and eight other stock markets, including the United States, Japan, China, Thailand, Singapore, Philippines, Malaysia and Indonesia. To be precise, the research is expected to determine which stock market is mostly correlated with the Vietnamese stock market and in which context (among uptrends, downtrends and sideways trends) the stock market in Vietnam is mostly affected by international stock markets. There are three hypotheses to be verified, including:

H1: The Vietnamese stock market comoves with eight other stock markets, including the United States, Japan, China, Thailand, Singapore, Philippines, Malaysia, and Indonesia.

H2: There are differences in linkages between the Vietnamese stock market and eight other stock markets, including the United States, Japan, China, Thailand, Singapore, Philippines, Malaysia, and Indonesia in different stock market trends (including uptrends, downtrends and sideways trends).

H3: The Vietnamese stock market has greater co-movement with neighboring stock markets than those of the United States, Japan, and China.

Data consist of daily closing stock market indices from Vietnam (VN-Index), the United States (DJI Index), Japan (NKY Index), China (SHCOMP Index), Thailand (SET Index), Singapore (MXSG Index), Philippines (PCOMP Index), Malaysia (FBMKLCI Index) and Indonesia (JCI Index), which are sourced from Bloomberg from November 2012 to March 2021. Based on the technical analysis, this research period is divided into five distinct sub-periods mentioned in the Figure 1. The first sub-period from November 2012 to August 2014, the third sub-period from March 2016 to April 2018 and the last sub-period from April 2020 to March 2021 experienced an upward trend in the VN-Index while this index stayed stable during the second sub-period from September 2014 to February 2016 and a slight decrease from May 2018 to March 2021.

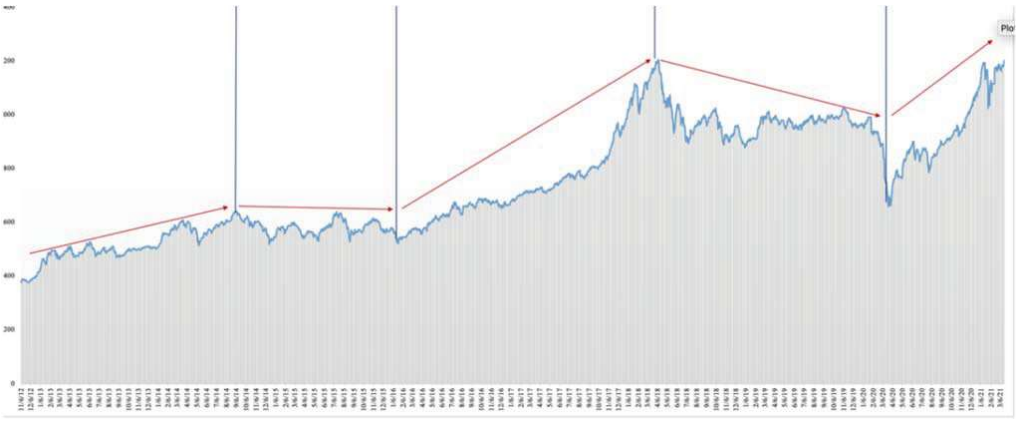

Figure 1. Movement of the VN-Index from November 2012 to March 2021

Source: Bloomberg

2.2 Methods of data analysis

The correlation between market return in Vietnam and market returns of eight distinct stock markets (including the United States, Japan, China, Thailand, Singapore, Philippines, Malaysia, and Indonesia) is determined by the vector error correction model (VECM) since this research method allows evaluation of the relationship between stock market in both short and long run. This means that the VECM can give results about the number of cointegrations between two variables and number of lags between them. This means how long the dependent variables can influence independent variables, which can clearly answer the research questions. The VECM includes four main steps, starting with the stationarity of market return data by the Augmented Dickey-Fuller test. Stock market returns are calculated by the following equation:

$$R_t = \frac{(P_t - P_{t-1})}{P_{t-1}}$$

where R_t denotes market return at time t ; P_t represents stock index at time t; P_{t-1} denotes the stock index at time t - 1.

A basic regression models between ΔR_t and R_{t-1} results ina β as a coefficient. If β is equal to 0, the time series is non-stationary (H_0). This hypothesis is rejected if t-Statistic is bigger than τ on Kendall's tau table. Moreover, the higher R^2 in the regression between R_t and R_{t-1}, the better the intercept c and @trend and slope coefficients are.

Consequently, the process of data analysis continues with determination of optimal lag length by some criteria, such as Akaike information criterion (AIC), Schwarz information criterion (SC), FPE criterion (final prediction error) and Hannan Quinn information criterion (HQ), which is followed by Johansen cointegration test. The market return in Vietnam has a cointegration with the market return in the compared country when the Trace and Max Eigenvalue statistic value of smaller than 5% critical value.

If there is no cointegration, the research tests a Granger causality to consider the short-term causal relationship between the market return in Vietnam and the market return in the

compared country. By contrast, in the case of a cointegration, the final step of VECM is executed to verify both short and long-run between variables by an estimated VECM as below:

$$\Delta R_{j,t} = \beta_0 + \sum^{n}_{i=1}\beta_i \Delta R_{j,t-1} + \sum^{n}_{i=1}\delta_i \Delta R_{i,t-1} + \omega\mu_{t-1} + v_t \quad (1)$$

where $R_{i,t}$ denotes market return in compared country at time t, $R_{j,t}$ is market return in Vietnam at time t, Δ is the difference in return, μ_{t-1} denotes the lagged value of the error correction term, v_t is a white noise error term.

The long-run relationship between the market return in Vietnam and the compared market return is explained through the cointegrate equation (long-run model):

$$\mu_{t-1} = ETC_{t-1} = R_{j,t-1} - \beta_0 - \beta_1 R_{i,t-1} . \quad (2)$$

Variables experience a long-run relationship when the coefficient of the cointegrate equation which indicates how quickly the dependent variable ($R_{j,t}$) returns to equilibrium after a change in the independent variable ($R_{j,t}$), is between -1 and 0 statistical significance.

3. Empirical results

3.1 Data description

In terms of returns on stock market indices, table 1 indicates that in the first three sub-periods, the NKY Index experienced the biggest maximum values as well as the smallest minimum values, when compared to the VN-Index and other indices, which lead to the highest standard deviation of the NKY. However, there was a shift in positions between the DJI Index and the NKY Index, in terms of maximum and minimum values as well as standard deviation since the fourth sub-period in May 2018. In fact, there were no regulations about price fluctuation limits in the American and Japanese stock markets while the VN-Index and other indices like the SHCOMP Index went up and down around the price range of +-7% of the reference price. As regards to ASEAN countries, the FBMKLCI Index in Malaysia always had the smallest standard deviation while the highest one belonged to the PCOMP Index in the Philippines. Moreover, indices in most countries had the biggest standard deviation in sub-period 4, when the stock market went down compared to its upward and stable periods.

Table 1. Descriptive statistics about returns on the stock market index of Vietnam and comparing countries

Return	VN-Index	DJI Index	NKY Index	SHCOMP Index	SET Index	MXSG Index	PCOMP Index	FBMKLCI Index	JCI Index
Sub-Period 1: November 2012 to August 2014									
Max	3.47	2.35	4.94	4.32	4.42	2.37	5.70	3.38	4.65
Min	-5.87	-2.36	-7.32	-5.30	-5.23	-2.65	-6.75	-2.43	-5.58
Mean	0.14	0.06	0.03	0.00	0.06	0.03	0.05	0.01	0.04
Standard deviation	1.04	0.64	1.45	1.03	1.07	0.59	1.15	0.48	1.10

Table 1. Descriptive statistics about returns on the stock market index of Vietnam and comparing countries *(continued)*

Return	VN-Index	DJI Index	NKY Index	SHCOMP Index	SET Index	MXSG Index	PCOMP Index	FBMKLCI Index	JCI Index
Sub-Period 2: September 2014 to February 2016									
Max	3.85	3.95	7.71	5.76	2.87	2.88	3.64	2.25	4.55
Min	-5.28	-3.57	-5.40	-8.49	-4.73	-4.22	-6.70	-2.70	-3.97
Mean	0.00	0.00	0.02	0.16	0.00	0.00	0.00	0.00	0.05
Standard deviation	1.05	0.96	1.47	2.24	0.84	0.88	0.97	0.69	0.99
Sub-Period 3: March 2016 to April 2018									
Max	3.77	2.84	6.72	4.26	4.59	2.76	3.09	1.34	2.79
Min	-5.10	-4.60	-7.92	-4.05	-3.15	-2.36	-2.88	-2.19	-4.01
Mean	0.15	0.05	0.01	0.06	0.03	0.01	0.00	0.00	0.01
Standard deviation	0.88	0.70	1.13	0.80	0.63	0.72	0.89	0.43	0.70
Sub-Period 4: May 2018 to March 2020									
Max	4.71	11.37	8.04	5.60	7.95	6.72	7.44	6.85	10.19
Min	-6.28	-12.93	-6.08	-7.72	-10.80	-7.14	-13.34	-5.26	-6.58
Mean	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Standard deviation	1.12	1.58	1.22	1.25	1.20	1.08	1.43	0.80	1.17
Sub-Period 5: April 2020 to March 2021									
Max	4.98	7.73	4.88	5.71	6.68	4.15	5.23	3.33	4.07
Min	-6.67	-6.90	-4.50	-4.50	-5.44	-3.38	-7.07	-3.05	-5.01
Mean	0.22	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Standard deviation	1.38	1.37	1.23	1.09	1.21	1.09	1.48	0.93	1.21

Source: Authors' calculation

3.2 The results of estimating VECM

Firstly, a regression with intercep c and @trend shows that the absolute value of t-statistics is bigger than the absolute value of criteria value τ on the Mackinnon table (Table 2). This means that all the series of index returns in Vietnam, the United States, Japan, China, Thailand, Singapore, Philippines, Malaysia, and Indonesia had no trend and intercept during all five research sub-periods from November 2012 to 19 March 2021.

Table 2. Augmented Dickey-Fuller test statistic

Augmented Dickey-Fuller test statistic	t-Statistic	Prob.*
VNIndex	-21.361	0.000
DJI Index	-22.953	0.000
NKY Index		-23.611
SHIMCOMP Index	-20.953	0.000
SET Index		-21.100
MXSG Index		-20.674
PCOMP Index	-19.917	
FBMKLCI Index	-19.425	
JCI Index	-19.541	
Test critical values:	1% level	-3.443
	5% level	-2.867
	10% level	-2.569

Source: Authors' calculation

Secondly, by showing the value of AIC, SC, HQ with the lowest statistic values, the second step indicates optimal lags between returns on the VN-Index and those on indices in the United States, Japan, China and five neighboring countries in Table 3. Overall, index pairs reach the highest optimal lags in the fourth period during the fourth sub-period when VN-Index decreased. Moreover, most of the return pairs between the VN-Index and compared indices have an optimal lag of 1 during the sideways period (in sub-period 2), apart from pairs of the VN-Index & the SHCOMP Index and the VN-Index and the PCOMP Index. Furthermore, there are differences in optimal lags when stock markets increase in the first, third and fifth sub-periods.

Table 3. Optimal lags between VN-Index Returns and Returns of compared indices

	Sub-period 1	Sub-period 2	Sub-period 3	Sub-period 4	Sub-period 5
VN-Index & DJI Index	1	1	4	8	1
VN-Index & NKY Index	3	1	-	7	2
VN-Index & SHCOMP Index	-	-	-	3	-
VN-Index & SET Index	-	1	-	6	-
VN-Index & MXSG Index	5	1	-	5	-
VN-Index & PCOMP Index	4	-	-	5	-
VN-Index & FBMKLCI Index	3	1	-	3	-
VN-Index & JCI Index	3	1	3	3	2

Source: Authors' calculation

Thirdly, the Johansen cointegration test results to the Eigenvalue statistic value is smaller than 5% critical value, leading to a cointegration (long-term relationship) at the 5% significance level between returns on the VN-Index and returns on compared indices over the research period from November 2012 to March 2021(Table 4).

Table 4. Results of the co-integration test

	Eigenvalue	0.05 Critical Value
VNIndex & DJI Index	0.344	15.494
VNIndex & NKY Index	0.240	
VNIndex & SHCOMP Index	0.499	
VNIndex & SET Index	0.503	
VNIndex & MXSG Index	0.157	
VNIndex & PCOMP Index	0.234	
VNIndex & FBMKLCI Index	0.221	
VNIndex & JCI Index	0.263	

Source: Authors' calculation

In addition, values of the coefficient of ETC among eight index pairs which are presented in table 5 confirm a total long-run relationship between returns on the VN-Index and returns on compared indices. In other words, hypothesis H1 is accepted.

Table 5. Coefficients of ETC

Pairs	Sub-period 1	Sub-period 2	Sub-period 3	Sub-period 4	Sub-period 5
VN-Index & DJI Index	(0.12132)	(0.20718)	(0.05245)	(0.78140)	(0.51759)
VN-Index & NKY Index	0.000721	(0.05049)	(0.47744)	(0.15900)	(0.12407)
VN-Index & SHCOMP Index	(0.71056)	(0.30179)	(0.99896)	0.052024	(0.71108)
VN-Index & SET Index	(0.61229)	(0.18354)	(1.02629)	(0.31311)	(0.38979)
VN-Index & MXSG Index	(0.94936)	(0.12841)	(0.99670)	(0.85066)	(0.55286)
VN-Index & PCOMP Index	(0.02504)	(0.16391)	(0.97892)	(0.31692)	(0.40641)
VN-Index & FBMKLCI Index	(0.10506)	(0.74806)	(0.84008)	(0.48909)	(0.15213)
VN-Index & JCI Index	(0.05392)	0.008453	(0.04440)	(0.70600)	(0.02286)

Source: Authors' calculation

Finally, the long-run relationship between returns on the VN-Index and returns on compared indices become stronger in case of an increase or reduction in indices while correlations between returns on the VN-Index and returns on compared indices have the smallest values in the case of sideways trends, meaning that the hypothesis H2 is accepted. To be precise, in the significantly upward period from March 2016 to April 2018, all three coefficients of the cointegrating equation reached the highest level, followed by a slight decrease period

from May 2018 to March 2020 while the lowest values appear in the sideways period (or the second sub-period). Furthermore, concerning the speed at which the dependent variable (i.e. returns on the VN-Index) reaches equilibrium after a change in an independent variable (i.e. returns on compared indices), returns on VN-Index and these compared indices experience the highest level in the third sub-period when the market dramatically falls, followed by the fourth sub-period when there is a decrease in stock market indices.

As regards compared indices, there are close correlations between returns on the VN-Index and those on stock market indices of neighboring countries, such as Singapore, Thailand, Philippines, Malaysia and Indonesia, meaning that the hypothesis H3 is accepted. To be precise, in sub-period 3 from March 2016 to April 2018 when there is significant growth in the VN-Index, coefficients of ETC between returns on the VN-Index and those on the SET, MXSG, PCOMPand FBMKLCI Indices are -1.02629, -0.996704, -0.978917 and -0.840079, respectively, compared to -0.052448 of the DJI Index and -0.477744 of the NKY Index. Similarly, when markets go down, these coefficients of ETC also have high values (-0.850661 for return pairs between the VN-Index and the MXSG Index or -0.706002 for return pair between the VN-Index and the JCI Index). In addition, returns on the VN-Index are mostly affected by the MXSG Index in Singapore in case of upward or downward trends in stock market indices. Coefficients of ETC between returns on the VN-Index and returns on the MXSG Index reach the highest value of -0.850661 when stock markets decrease and always remain at a high level when there is a downward trend in stock market indices. In case of fluctuations of stock market indices, the coefficient of ETC between returns on the VN-Index and returns on the FBMKLCI Index reaches the highest level of -0.748057. In other words, the role of Malaysia's stock market is evident when stock markets rise and fall.

In terms of big stock markets, and also major trade partners, like those of the United States, Japan and China, coefficients of ETC between returns on the VN-Index and returns on the DJI Index in the periods of downtrends and sideways trends are respectively -0.7814 in the period of downtrends (which are ranked at second place in terms of value, after the highest coefficient of ETC between returns on the VN-Index and the MXSG index of -0.850661) and -0.207181 in sideways periods. This is smaller than the coefficients between returns on the VN-Index and the FBMKLCI Index (-0.748057) and the SHCOMP Index (-0.301787). In addition, the values of the coefficient of ETC also show that returns on the VN-Index are mostly impacted by the SHCOMP Index and the NKY Index in case of a significant increase in the stock market index (-0.99896 and -0.47744 respectively, compared to very small values in another movement of indices). Moreover, the SHCOMP Index also has an impact on the VN-Index when the stock market slightly increases or fluctuates.

4. Discussion

First, this research supports theories about stock market interdependence by showing interdependence between the VN-Index and other market indices, such as the DJI Index, the NKY Index, the SHCOMP Index and stock market indices in ASEAN countries through the VECM. The Vietnamese stock market is significantly affected by spillovers from

neighboring countries' stock markets including Singapore, Malaysia, and bigger worldwide stock markets such as the United States, Japan and China. The results of this research are consistent with similar studies on Latin American countries (Christofi and Pericli, 1999; Choudhry, 1997), African countries (Collins and Abrahamson, 2004; Sugimoto *et al.,* 2014; Ahmed and Rui, 2018).

Second, the Vietnamese stock market is mostly linked with the compared countries (including the United States, Japan, China, Singapore, Thailand, Philippines, Malaysia, and Indonesia) during the significant uptrends and downward trends in indices, which is clearly presented through the highest level of coefficients of ETC and optimal lags. During the fourth sub-period from May 2018 to March 2021, where there were dramatic drops in stock markets, optimal lags between VN-Index Returns and compared indices' returns were from three to eight. This means that the VN-Index was considerably impacted, for three days at least, by stock market indices of compared countries in general and by bigger stock markets like the United States, Japan, Singapore, and Thailand in particular. Moreover, the empirical results show a strong relationship between returns on the VN-Index and returns on compared countries' stock markets when stock markets dramatically increase (such as in the third sub-period) or decrease (as in the fourth sub-period). In fact, stock markets tend to be more linked and associated with each other during periods of shock rather than stable periods or periods of post-shock. The Vietnamese stock market also follows this tendency. In particular, the Vietnamese stock market is considered to be a market of individual investors (more than 90%) who follow the psychology of the crowd or herd behavior (Dang, 2010). Most domestic individuals do not deeply imbibe and understand market information or consult news published by domestic and foreign experts. They accordingly participate in the market with high risks and short-term vision. For instance, during the crisis, information spreading through the media made Vietnamese investors believe that prices would continue to fall further. At this time, behavioral finance theory and feedback trading model show that many Vietnamese investors' psychology may have been significantly affected.

Third, the Vietnamese stock market is mostly influenced by neighboring countries' stock market indices like the MXSG Index in Singapore rather than Indices of the United States, Japan and China. This finding is at first puzzling, since not only are these three countries the largest economies in the world, but also they are the largest trade partners of Vietnam, accounting for nearly half of the trade volume of Vietnam in 2019. ASEAN nations are not important to trade partners for Vietnam. The economic integration effect is not dominant in explaining stock market co-movement in Vietnam. Our hypothesis is that Vietnamese trade, especially export, is largely dominated by FDI companies. In the first quarter of 2021, FDI firms accounted for 76% of total export. FDI companies are also weakly linked to the domestic economy and domestic companies have a hard time joining the global value chain led by FDI firms (Dao, 2021). We leave this question of trade-global value chain implication for financial linkage for future research.

Last not but least, the correlations between the Vietnamese stock market and the Asian markets are not necessarily due to the economic integration effect between these countries, but rather due to similarity in economic structures. Therefore, they tend to behave similarly when a global shock hits. If tourism is an important sector in these economies, then COVID-19 would have a negative effect on these economies. With the exception of Singapore, most countries in the region depend on FDI-led exports in manufacturing. The US – China trade war, which diverts trade and investment away from China and into ASEAN countries, would have a positive effect on these economies. As a result, the stock markets of Asean countries are strongly correlated. What is driving ASEAN stock market correlation despite low regional economic integration is also a worthwhile question to be investigated in the future.

5. Conclusion

By using the VECM, the research demonstrates the high coefficient of the cointegrating equation and high coefficient of ETC (ω) between returns on the VN-Index and those of the three big stock exchanges, including the United States, Japan, and China, as well as five neighboring markets, including Singapore, Thailand, Philippines, Indonesia, and Malaysia, during five distinct periods from November 2012 to March 2021. The research results indicate that the Vietnamese stock market is closely correlated with the stock markets of neighboring countries rather than the stock market indices of the United States, Japan, and China. These correlations become stricter when stock markets significantly rise or slump. In other words, the study provides the first empirical quantitative evidence about the interdependence between the VN-Index and international stock markets, making a contribution to providing empirical evidence on the spillover effect among stock markets in general and stock markets in emerging countries in particular. The study results are also significant for both investors and policymakers. Investors as well as policymakers can refer to these findings to choose an efficient investment strategy and adjust operations in the Vietnam stock market, respectively. Finally, the study finds weak explanatory power of the economic integration effect in explaining stock market co-movement in Vietnam, which could be due to the dominant role of FDI firms in Vietnamese exports as well as their weak linkage to the domestic economy. We leave this hypothesis for future research.

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Appendix A. Summary of models and variables used in papers on stock market interdependence

No.	Authors	Models	Variables
1	Boako *et al*. (2020)	Continuous Morlet Wavelet and its coherency model	African stock market indices, commodity prices, and commodity indices. All data is monthly and in US dollars (US$) from 1996 to 2017. The equity market data is taken from Bloomberg; commodities prices are obtained from the IMF.
2	Fernandez-Diaz and Morley (2019)	(MGARCH) model, consistent dynamic conditional correlation model.	Monthly data from 1982 to 2012 for the real exchange rate, short-term interest rate (the three-month Treasury bill secondary market rate).
3	Abdullahi and Rui (2018)	Bayesian VAR, BEKK GARCH	Daily closing price of stock indices from fifteen African stock exchanges and Shanghai Stock Exchange (DataStream).
4	Xiao *et al.* (2017)	Wavelet coherence analysis	Daily West Texas Intermediate (WTI) spot oil prices, 10 East Asian countries stock markets indexes from 1992 to 2015 (DataStream).
5	Champagne *et al.* (2017)	Structural models, GARCH-DCC model	Equity market return, equity market volatility, the risk-free rate. Daily option-adjusted spread (OAS) for 7 corporate bond indices from January 2001 through January 2013. Market variables are the daily return for the S&P500 (US) or S&P-TSX (Canada) index, the implied volatility for the VIX (US) or the VIXC (Canada), the 3-month US or Canadian T-bill rate.
6	Syed *et al.* (2017)	Fluctuation analysis	Daily closing prices of 11 US CDS and equity sectoral indices from December 17, 2007 to December 31, 2014 (DataStream).
7	Ginanjar *et al.* (2016)	Disccrete wavelet transform, continuous wavelet transform	Daily data from 30 January 1970 to 31 August 2011 for Japan (NIKKEI) and Hong Kong (Hang Seng); from 29 May 1992 to 31 August 2011 for Australia (AS200) due to its inception date of the index (DataStream)
8	Zhang *et al.* (2016)	Complex network analysis	Daily price returns of 27 indices from 2006 to 2015 (Yahoo Finance API).
9	He *et al.* (2014)	PCA, multi-factor R-squared measure	Daily closing price of 39 sector indices, Shanghai Composite Index, Standard & Poor's 500 Index from January 3, 2000 to May 31, 2011 (DataStream).

Appendix A. Summary of models and variables used in papers on stock market interdependence *(continued)*

No.	Authors	Models	Variables
10	Liu (2013)	Gravity model with dynamic panel specification	Main stock market indices denominated in US of 40 economies from the beginning of 1995 to the end of 2010 (MSCI).
11	Samarakoon (2011)	VAR model	Daily index returns for 62 stock markets for period from 2000 to 2009. All market indices are obtained from Bloomberg, except for Ecuador (from DataStream) and Indonesia and Vietnam (MSCI).
12	Chuang *et al*. (2007)	VAR-BEKK model, VEC model	Weekly closing prices of the Nikkei 225 Index, the Hang Seng Index, the Strait Times Index of Singapore, the Seoul Composite of South Korea, the TAIEX of Taiwan and the SET Index of Thailand from January 3, 1992 to June 10, 2006. The S&P 500 of the US and the FTSE 100 of the U.K. are considered as the exogenous control variables.
13	Egert and Kocenda (2007)	Cointegration tests	Daily stock indices in Budapest (BUX), Prague (PX-50), Warsaw (WIG-20), London (FTSE-10, UKX), Frankfurt (DAX-30), Paris (CAC-40) from June 2003 to February 2005 (Bloomberg).
14	Sanvi and Neto (2004)	Constant conditional correlations ARCH model	Daily closing price of French CAC40, German DAX, US Dow Jones from 31 December 1993 to 30 July 2002.
15	Bessler and Yang (2003)	VEC model, directed acyclic graphs (DAG)	Daily closing prices of stock index of Australia, Japan, Hong Kong, United Kingdom, Germany, France, Switzerland, United States, and Canada.
16	Elyas *et al*. (1998)	VAR model	Daily closing price of All Share Price Index (Sri Lanka), CRSP index (US), Nikkei 500 (Japan), BSE National Price Index (India), Hang Seng Price Index (Hong Kong), SE Composite Price Index (South Korea), DS Total Market Index (Taiwan), and Straits T. Industrial Price Index (Singapore) from 1 January 1989 to 10 June 1994.

Source: Authors' compilation