6th International Scientific Conference ITEMA 2022 – Proceedings
DOI: https://doi.org/10.31410/ITEMA.2022.217

Risk Diversification in Asian Stock Markets: An Empirical Analysis in the Context of the 2020 and 2022 Events

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Received: October 11, 2022
Accepted: December 20, 2022
Published: June 12, 2023

Keywords:
Asian Markets;
Financial integration;
Long memories;
Portfolio diversification

Abstract: *The World Health Organization (WHO) designated coronavirus infection a worldwide pandemic in 2020, based on the risk of contagion and the number of confirmed cases in more than 195 countries. Covid-19 had a severe impact on the global economy as a result of uncertainty and pessimism, causing adverse effects on financial markets. On February 24th, 2022, Russia launched a full-scale military invasion against Ukraine, signifying a dramatic escalation of a conflict that began in 2014. Several analysts named the invasion the largest military invasion in Europe since World War II. In the context of these events, this paper aims to estimate whether portfolio diversification is practicable in the stock markets of Indonesia (JKSE), Malaysia (KLSE), South Korea (KOSPI), Japan (NIKKEI 400), Philippines (PSI), Thailand (SET) and China (SSEC), for the period from September 18th, 2017 to September 15th, 2022. In the purpose of reaching such analysis it is intended to provide answers to two questions: (i) if the global pandemic of 2020 and the Russian invasion in 2022 have accentuated financial integration in these Asian markets? (ii) If yes, the existence of persistence in returns, could put portfolio diversification into question? The results indicate that those markets have low levels of integration, both in periods of normality and in periods of global uncertainty. Complementarily, the 2020 and 2022 events have significantly increased persistence in these regional markets. These results demonstrate that prices do not fully reflect available information and that changes in prices are not i.i.d. This situation has implications for investors, as some returns may be expected, creating some opportunities for arbitrage and windfalls profits. The authors consider that these results provide an opportunity for regulators in these regional markets to take efforts to ensure better information between these markets and the international markets.*

1. INTRODUCTION

Over the last 40 years, China has experienced a high rate of economic growth. The connection of capital markets between China and other countries has gradually become an important subject. The Association of Southeast Asian Nations (ASEAN) founded on August 8th, 1967, in Bangkok, includes ten member states, namely Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam. ASEAN and China are geographically adjacent and have a long history of economic and cultural interactions. On September 5th, 2013, President Xi introduced the One Belt One Road initiative to strengthen cooperation with those nations. Under this initiative, China and ASEAN countries would continue to

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promote connectivity and strengthen economic ties. Additionally, with the ongoing regionalism of ASEAN countries and the implementation of the China-ASEAN Free Trade Area, the economical connection between China and ASEAN countries has been further reinforced (Li & Bai, 2022). The financial integration of Southeast Asian markets has been an important research topic. The performance of these developing markets has received considerable attention as a result of recent global financial market changes (Jacob et al., 2021).

China and the countries of Southeast Asia are geographically close and have had strong economic connections over a long period. In recent years, China and the Association of Southeast Asian Nations (ASEAN) countries have gradually opened their markets and strengthened their economic and trade ties, which have been reflected in their capital markets.

Considering the 2020 and 2022 events, this research paper will test whether portfolio diversification is achievable in the capital markets of Indonesia (JKSE), Malaysia (KLSE), South Korea (KOSPI), Japan (NIKKEI 400), Philippines (PSI), Thailand (SET) and China (SSEC) over the period from September 18th, 2017 to September 15th, 2022. The outcomes strongly suggest that the markets are partially integrated; however, we observe that during the global uncertainty of 2020 and 2022, the persistence in these regional markets has increased significantly. These outcomes may put into question the implementation of efficient portfolio diversification strategies in these regional markets.

This study contributes to the literature, particularly the study on portfolio diversification in those Asian regional markets during the pandemic breakout in 2020 and the Russian invasion in 2022. According to what we know, this is the first study to examine these Asian markets in the context of global economic instability.

The preference for these Asian financial markets is justified by the fact that they have unstable and dynamically developing economies and are connected by cultural heritage and by some similar economic conditions. In addition, following the recent financial crisis of 2008, international emerging markets, and those in Asia, have become important investment destinations. In this context, with large capital inflows, it is of high importance to understand the interdependencies and connections between these regional financial markets.

In terms of structure, this paper is organized into 5 sections. Section 1 is represented by the current introduction. Section 2 presents a literature review of articles concerning the integration of financial markets. Section 3 describes the data and methodology. Section 4 contains the results. Finally, Section 5 presents the main conclusions.

2. LITERATURE REVIEW

The comprehension of international connections between stock markets and the investigation of the occurrence of financial integration phenomena, in the context of stock market crashes, is important for investors, investment fund managers and academics, in several aspects, namely in portfolio diversification in an international context (Dias et al., 2019).

Karim and Karim (2012) examined the integration among the five emerging stock markets in ASEAN (Malaysia, Thailand, Indonesia, Philippines and Singapore), based on the Autoregressive Distributed Lag (ARDL) and the authors show that stock markets in the ASEAN region are integrated during the pre, post-1997 and post-US financial crisis. These results are in alignment

with many research studies on international stock market interdependencies, suggesting that ASEAN stock markets are drifting towards greater integration with each other, especially after the global financial crisis. This implies that the long-term diversification benefits that can be obtained by investors in ASEAN markets tend to decrease.

The authors Nittayagasetwat and Buranasiri (2018), on the other hand, examined portfolio diversification in the emerging markets of the 5 Association of Southeast Asian Nations (ASEAN) countries, namely Indonesia, Malaysia, Philippines, Singapore and Thailand. The authors evidence low correlations between the analyzed markets, but the level of integration indicates the existence of long-term relationships between the returns of the analyzed markets. Considering these findings, investors cannot fully obtain the benefit of diversification in the long term. In a complementary approach, the author Wu (2019) examined the financial integration between the stock markets of the ASEAN-5 economies, China (mainland China and Hong Kong), Japan and South Korea, through Vector Autoregressive (VAR) models along with a sliding window approach. The author suggests that the integration between markets in East and Southeast Asia is not as strong as it may appear. Although governments in this region have promoted collaboration and integration between these regional markets, however, barriers remain significant.

Hung (2019) highlights that the volatility in the Chinese market had a significant impact on other markets, suggesting that equity markets are more integrated, as a result of the financial crisis. However, Sanusi et al. (2019) demonstrate the presence of long memories in ASEAN markets, which could be beneficial for investors, as these markets show some previsibility.

In 2020, the authors Stevanius and Sukamulja (2020) analyzed the integration and co-movements between Asian stock markets and Indonesia. The authors show that in the short run, there is a relationship between Kuala Lumpur Composite Index, Thailand Stock Exchange Index and Hang Seng Index against Jakarta Composite Index. Furthermore, the authors also provide evidence of integration and co-movement between the stock markets of Malaysia, Thailand, South Korea, Japan, Singapore, and Hong Kong with the Indonesian stock market.

Additionally, the authors' Silva et al. (2020) investigated portfolio diversification in the stock markets of Indonesia, Malaysia, the Philippines, Singapore, and Thailand (ASEAN-5). The authors discovered significant levels of integration among these regional markets, which may call the portfolio diversification hypothesis into question. Furthermore, except for the Singapore (SGX) market, the authors show that ASEAN-5 markets display persistence in returns, which means, the presence of pronounced long memories.

Jacob et al. (2021) analyzed the integration of Southeast Asian capital markets, namely Indonesia, Malaysia, Philippines, Singapore, and Thailand, and suggest that the Malaysian Stock Exchange, the Thai Stock Exchange, the Singapore Stock Exchange, and the Philippine Stock Exchange were fully integrated, while the Indonesian Stock Exchange was not. These results may call into question the hypothesis of efficient portfolio diversification.

Saji (2021) analyzed financial integration in Asian capital markets to gauge whether portfolio diversification was feasible in these regional markets. The author's evidence that the cointegration results could not produce any conclusive evidence of long-run relationships between stock markets. Furthermore, there is weak price convergence between markets and financial integration is partial and incomplete.

In more recent research, Li and Bai (2022) investigated the long-run and short-run synchronizations between China's markets and ASEAN-5 markets. The authors' evidence that the co-movement between China and ASEAN-5 countries is not statistically significant in the long-run, while the average spillover effect and the volatility spillover effect are both statistically significant in the short-run, which reflects the close financial ties between China and ASEAN-5 countries. In a complementary approach, the author Prasetya (2022) studied four cases. First, to find the long-run cointegration between East and Southeast Asia. Secondly, analyze the short-run causal relationship between East and South East Asian stock market. Third, to find the most dominant East Asian stock market towards Southeast Asia and the most dominant Southeast Asian stock market towards East Asia. Finally, to search the structural analysis of forecasting for the five-day horizon period of the price of each country in both East and Southeast Asia. The author highlights that Japan is the market with the most connections in Southeast Asia, while Singapore and Philippines are the markets with the most connections in East Asia. Another point to underline in this study is that Japan is the most influential stock market in East Asia, while Singapore is the most influential stock market in Southeast Asia. This study shows that policymakers in East and Southeast Asian countries should synchronize capital market standards and regulations and reduce barriers to capital flow to stimulate the integration of regional stock markets.

In conclusion, this paper is a contribution to provide information to investors and regulators in Asian markets, where individual and institutional investors seek to efficiently diversify their portfolios, in a period of uncertainty and lack of confidence arising from the global pandemic of 2020 and the Russian invasion in 2022.

3. METHODOLOGY AND DATA

3.1. Data

The data for this study were gathered from the Thomson Reuters Eikon platform and included the daily price index of the capital markets of Indonesia (JKSE), Malaysia (KLSE), South Korea (KOSPI), Japan (NIKKEI 400), the Philippines (PSI), Thailand (SET), and China (SSEC).

The quotes are daily and cover the period from September 18th, 2017, to September 15th, 2022, which is marked by the global pandemic of 2020 and Russia's invasion of Ukraine in 2022. To keep the time series as reliable as possible, we have kept the prices in local currency to minimize exchange rate distortions.

Table 1. The name of countries and their indexes under analysis in this paper

Country name	Index
Indonesia	JKSE
Malaysia	KLSE
South of Korea	KOSPI
Japan	NIKKEI 400
Philippines	PSI
Thailand	SET
China	SSEC

Source: Own elaboration

3.2. Methodology

The research will be carried out in stages. To describe the sample, descriptive statistics (mean, standard deviation, asymmetry, and kurtosis) will be employed, as well as Jarque and Bera's (1980) adherence test, residual stability charts, and Q-Q Plots. To evaluate the robustness of the results, we will estimate the time series stationarity using the Hadri (2000) and Levin et al. (2002) tests.

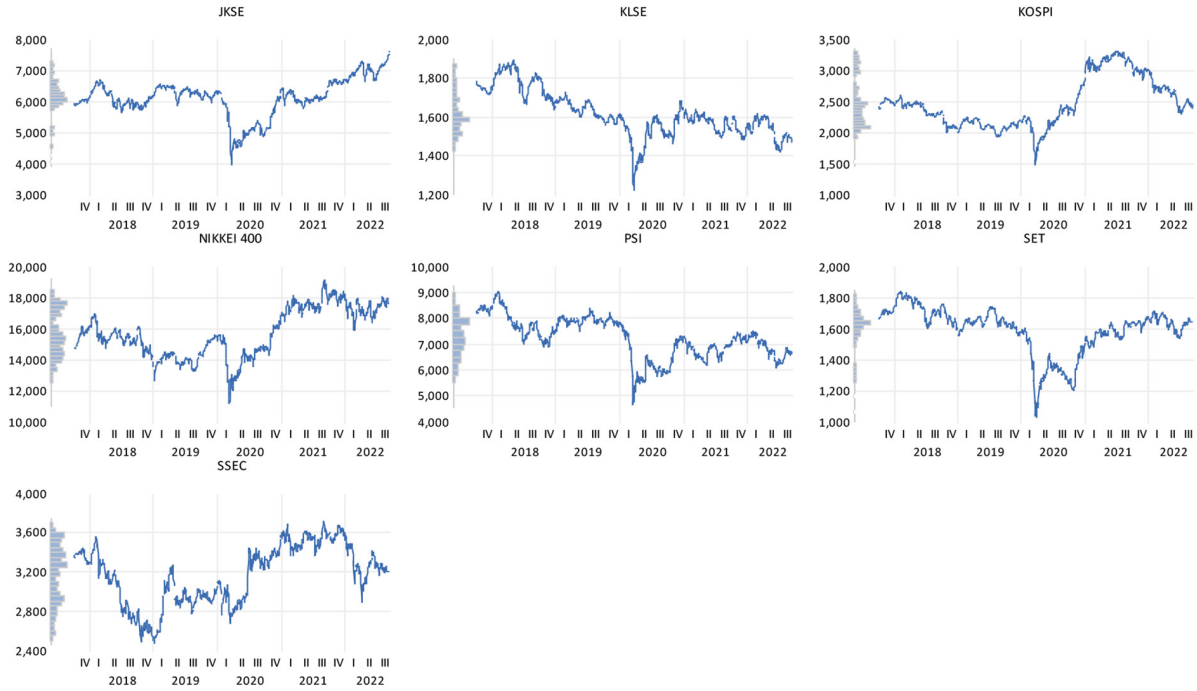
To answer the research questions, we will estimate the integration among Asian capital markets, using the Gregory and Hansen (1996) methodology that identifies structure breakdowns. In order to validate the results, we will use the Detrended Fluctuation Analysis (DFA) methodology. DFA is an analysis method that examines time dependence in non-stationary data series. This technique by assuming that time series are nonstationary avoids spurious results when the analysis focuses on the relationships of data series in the long run. DFA has the following interpretation: $0 < \alpha < 0.5$: anti persistent series; $\alpha = 0.5$ series exhibits random walk; $0.5 < \alpha < 1$ persistent series. The function of this technique is to examine the relationship between x_k and x_{k+t} values at different moments.

4. RESULTS

Figure 1 presents the evolution, in levels, of the 7 Asian stock exchanges, namely, the capital markets of Indonesia (JKSE), Malaysia (KLSE), South Korea (KOSPI), Japan (NIKKEI 400), Philippines (PSI), Thailand (SET) and China (SSEC), over the period from September 18th, 2017 to September 15th, 2022, a period of high complexity and economic pressure at global level triggered by the uncertainty caused by the global pandemic (Covid-19) and due to Russia's invasion of Ukraine in 2022. The markets under analysis have evidenced the existence of quite significant structural breaks during the first two quarters of 2020 triggered by the uncertainty caused by the outbreak of the Covid-19 pandemic, as well as during the year 2022, with the Russian invasion of Ukraine, although it is noted that the impact of the latter event causes less pronounced breaks in the time series.

In **Figure 2**, we can observe the evolution, in returns, of the seven capital markets under analysis. In general, the time series demonstrate a relative dispersion around the average, as well as a relative synchronization between the movements of the time series. We highlight a significant structural fall in the Japanese stock market index during the 1st and 2nd quarters of 2020, explained by the impact of the Covid-19 pandemic crisis.

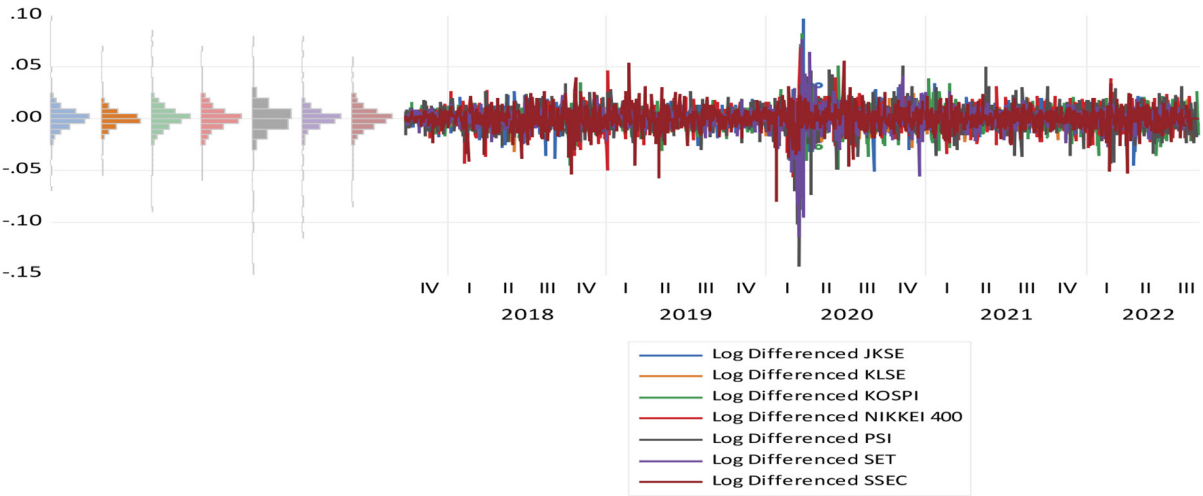
In order to understand the average returns and standard deviations of the data series of the price indexes referring to the capital markets of Indonesia (JKSE), Malaysia (KLSE), South of Korea (KOSPI), Japan (NIKKEI 400), Philippines (PSI), Thailand (SET) and China (SSEC), for the period from September 18th, 2017 to September 15th, 2022, we made graphs that can be seen in **Figures 3 and 4**. Through the analysis, we found negative average returns, namely in the KLSE (-0.000159), KOSPI (-5.54E-06), PSI (-0.000189), SET (-1.37E-05), SSEC (-4.05E-05) stock indexes, while the JKSE (0.000210) and NIKKEI 400 (0.000210) stock markets show positive average returns. As for the standard deviations of the capital markets analyzed, we found that the Philippine Stock Index (PSI) has the highest level (0.013677), while the markets of South Korea (0.011664), China (0.011291), Indonesia (0.010662), Japan (0.010985), Thailand (0.010536), Malaysia (0.007896).



Note: Data processed by the authors (software: Eviews12)

Figure 1. Evolution, in levels, of the financial market under analysis, for the period from September 18th, 2017, to September 15th, 2022.

Source: Own Elaboration



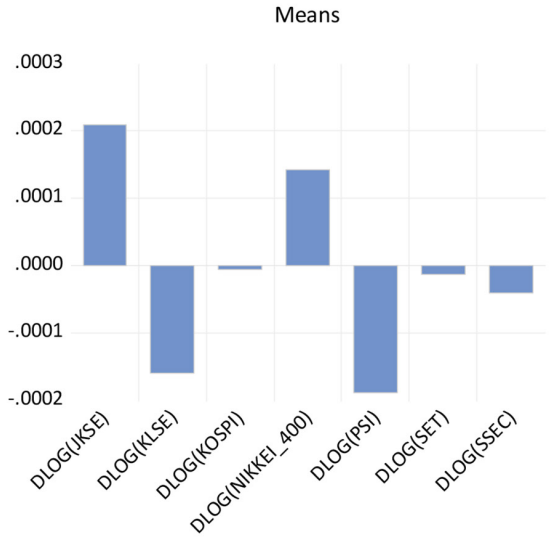
Note: Data processed by the authors (software: Eviews12)

Figure 2. Evolution of the returns, of the financial market under analysis, in the period from September 18th, 2017 to September 15th, 2022.

Source: Own Elaboration

To validate whether the time series present normal distributions, we calculated the skewness and kurtosis of the capital markets of Indonesia (JKSE), Malaysia (KLSE), South Korea (KOSPI), Japan (NIKKEI 400), Philippines (PSI), Thailand (SET) and China (SSEC), in the period from September 18th, 2017, to September 15th, 2022. In **Figures 5 and 6** we can check these statistics, and we can ascertain that the coefficients of asymmetry and kurtosis, most prominently are centered on the capital markets of Thailand (Skewness = -2.009865; Kurtosis = 29.11360) and the Philippines (Skewness = -1.393738; Kurtosis = 17.94907). Regarding the stock indexes,

they show asymmetries and kurtosis different from a normal distribution (Skewness = 0; Kurtosis = 3), JKSE (-0.167870;12.69804), KLSE (-0.221266; 11.16387), KOSPI (-0.242733; 10.48160), SSEC (-0.669519; 8.077473), NIKKEI 400 (-0.157310; 6.352479). In summary, we can see that the time series are leptokurtic and asymmetric.



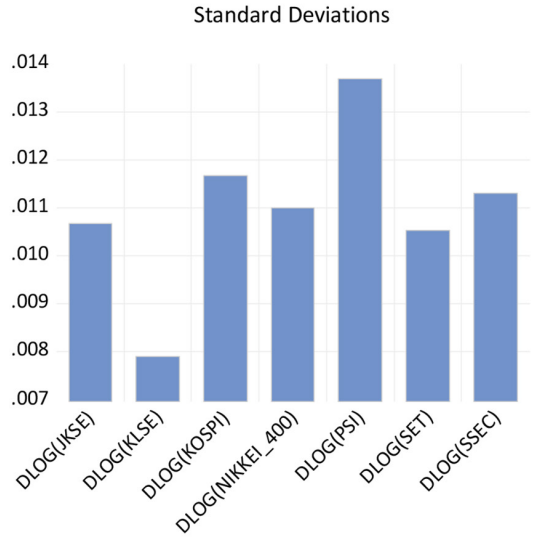


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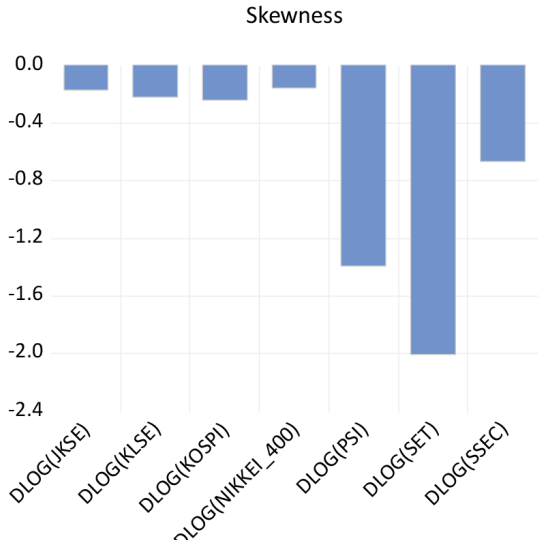
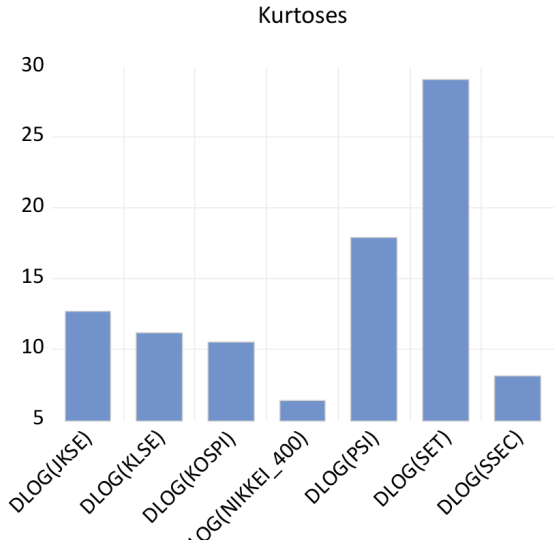
Figure 3. Average of the 7 financial markets during the period under analysis

Figure 4. Standard Deviations of the 7 financial markets during the period under analysis

Source: Own Elaboration





Note: Data processed by the authors (software: Eviews12)

Figure 5. Skewness of the 7 financial markets during the period under analysis

Figure 6. Kurtosis of the 7 financial markets during the period under analysis

Source: Own Elaboration

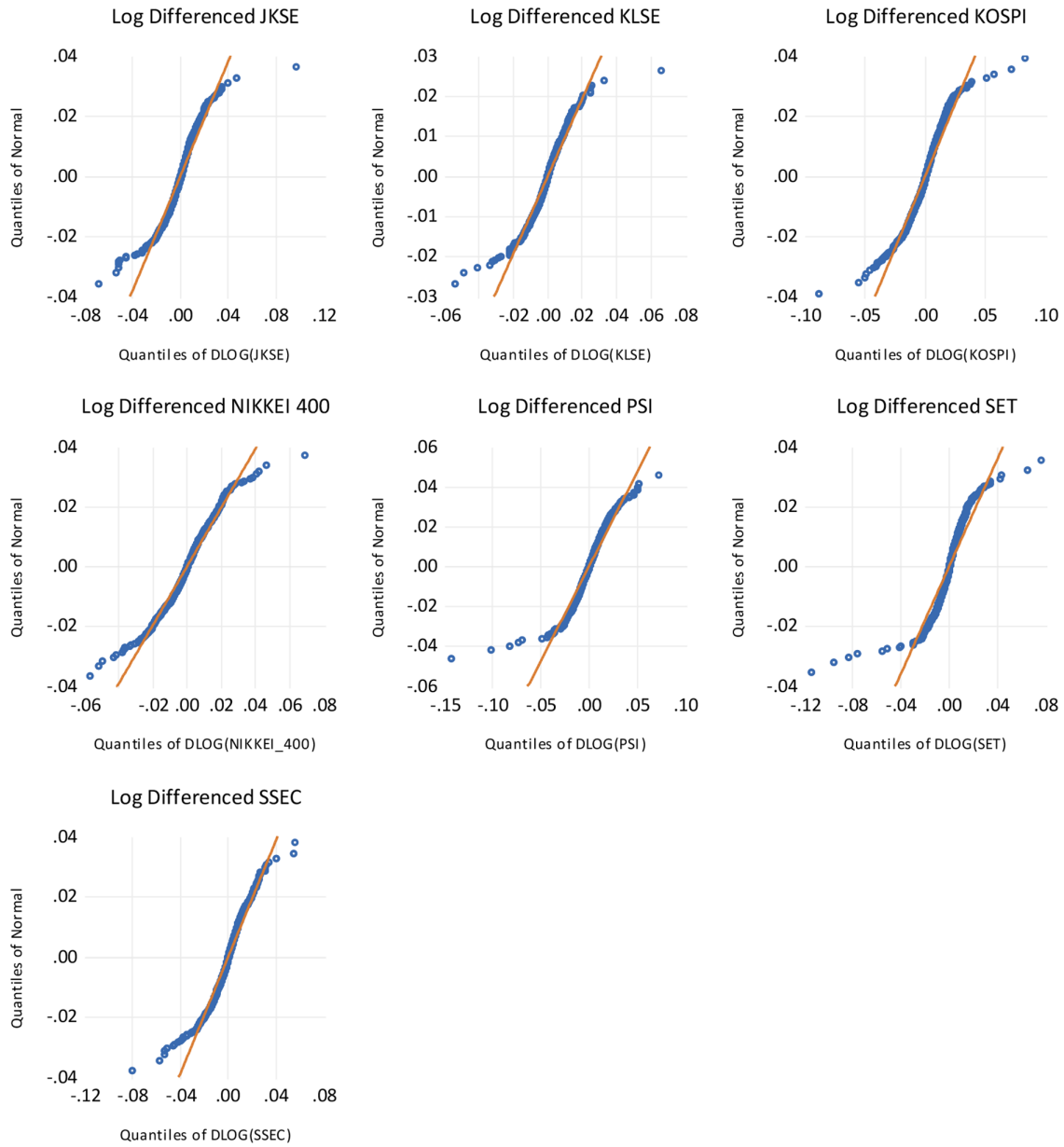
Table 2 contains the results of the test of Jarque and Bera (1980) and we verify the validation of the results of asymmetries and kurtosis that were previously estimated for the capital markets under analysis. The test of Jarque and Bera (1980) validated our results, that is, the null hypothesis of normality (H0) in favor of the alternative (H1 - non-normality), was rejected for a significance level of 1%.

Table 2. Test of Jarque and Bera (1980), in returns, of the 7 financial markets for the period from September 18th, 2017 to September 15th, 2022

	JKSE	KLSE	KOSPI	NIKKEI 400	PSI	SET	SSEC
Jarque-Bera	4810.250	3414.648	2871.395	579.1879	11812.76	35660.17	1408.559
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	1226	1226	1226	1226	1226	1226	1226

Source: Own Elaboration

Note: Data processed by the authors (software: Eviews12)



Note: Data processed by the authors (software: Eviews12)

Figure 7. Q-Q Plots, in returns, of the 7 financial markets, for the period from September 18th, 2017 to September 15th, 2022

Source: Own Elaboration

Through the graphical observation of quantiles illustrated in **Figure 7**, we can also infer on the normality of time series data under analysis. The normal distribution line is graphically represented

in orange and the data distribution for each time series is represented in blue. When the time series data dispersion is compared to the normal distribution line, it is clear that none of the series overlap.

For time series estimation, the stationary nature of data series from 7 capital markets should be analyzed, namely Indonesia (JKSE), Malaysia (KLSE), South of Korea (KOSPI), Japan (NIKKEI 400), Portugal (PSI), Thailand (SET) and China (SSEC). The Levin et al. (2002) test postulates as null hypothesis the existence of a unit root in the observable components of the time series, that is, the non-stationarity of the time series. Based on the results presented in **Table 3**, the t-statistic of Levin et al. (2002) leads us to reject the null hypothesis at a significance level of 1%, indicating the stationarity of the time series under study. In addition, to validate these findings, Hadri's (2000) test was applied, and in table 4 we can see that the statistical result leads to the non-rejection of the null hypothesis at a significance level of 1%, validating the stationarity of the time series, suggesting that we are dealing with white noise (mean = 0; constant variance). This way, with stationary series, we can apply models and tests, without running the risk of getting spurious regressions.

Table 3. Levin et al. stationarity test (2002), applied to the 7 financial markets, in the period from September 18th, 2017 to September 15th, 2022

Method				Statistic		Prob.**	
Levin, Lin & Chu t*				-98.9458		0.0000	
** Probabilities are computed assuming asymptotic normality							
Intermediate results on UNTITLED							
	2nd Stage	Variance	HAC of		Max	Band-	
Series	Coefficient	of Reg	Dep.	Lag	Lag	width	Obs
JKSE	-0.91331	0.0001	2.E-06	2	22	123.0	1223
KLSE	-1.01883	6.E-05	2.E-07	0	22	779.0	1225
KOSPI	-0.88846	0.0001	3.E-06	1	22	90.0	1224
NIKKEI 400	-0.96909	0.0001	2.E-06	0	22	95.0	1225
PSI	-1.05112	0.0002	4.E-06	0	22	88.0	1225
SET	-0.77714	0.0001	3.E-06	4	22	77.0	1221
SSEC	-1.00212	0.0001	3.E-06	0	22	89.0	1225
	Coefficient	t-Stat	SE Reg	mu*	sig*		Obs
Pooled	-0.98191	-77.157	1.002	-0.500	0.707		8568

Note: Data processed by the authors (software: Eviews12)

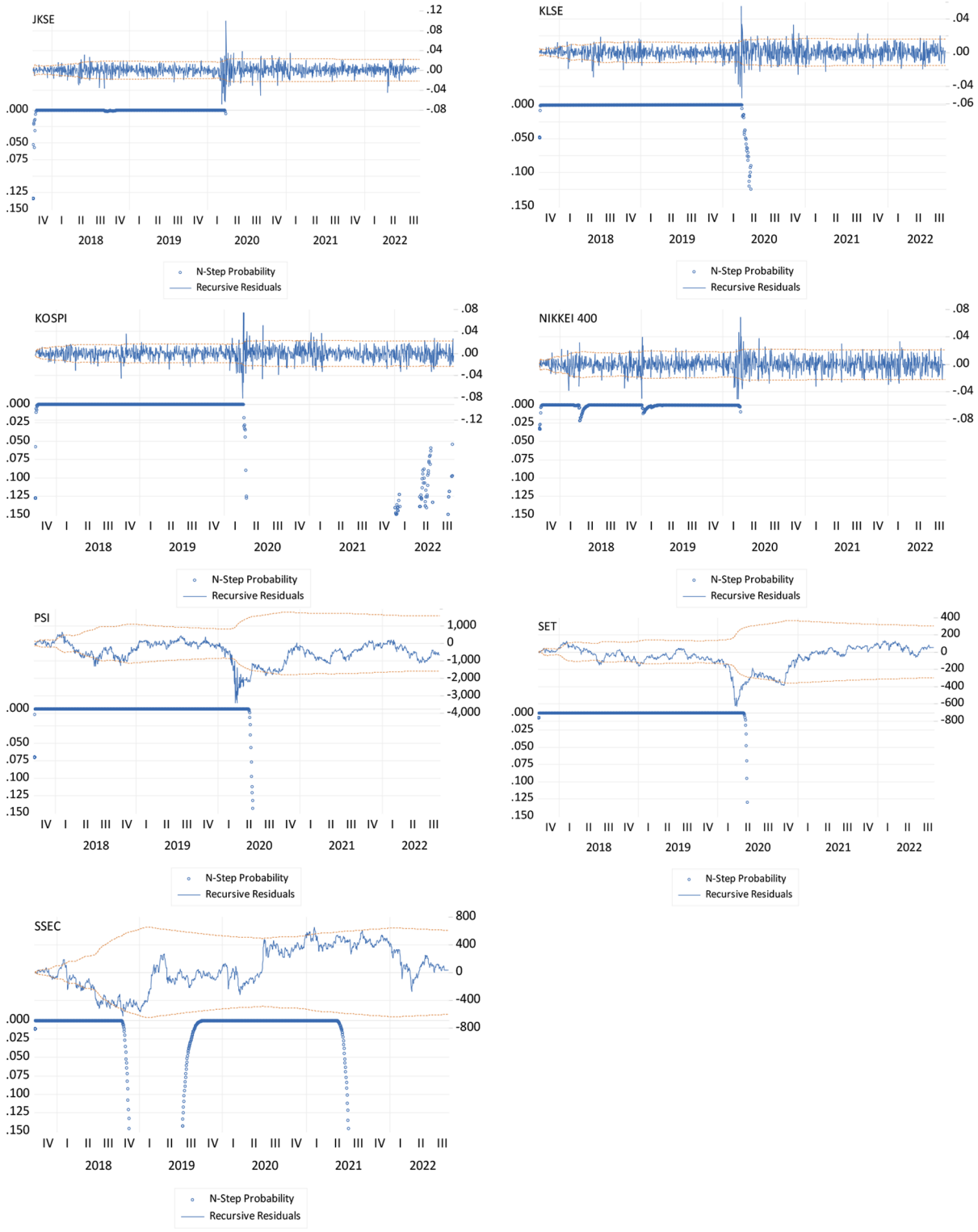
Source: Own Elaboration

Table 4. Hadri Stationarity test (2002), applied to the 7 financial markets, in the period from September 18th, 2017 to September 15th, 2022.

Method			Statistic	Prob.**
Hadri Z-stat			-0.27353	0.6078
Heteroscedastic Consistent Z-stat			-0.30346	0.6192
* Note: High autocorrelation leads to severe size distortion in Hadri test, leading to over-rejection of the null.				
** Probabilities are computed assuming asymptotic normality				
Intermediate results on UNTITLED				
Variance				
Series	LM	HAC	Bandwidth	Obs
JKSE	0.0586	0.000131	11.0	1226
KLSE	0.0271	7.21E-05	8.0	1226
KOSPI	0.1550	0.000135	1.0	1226
NIKKEI 400	0.0366	0.000130	3.0	1226
PSI	0.0329	0.000188	5.0	1226
SET	0.0479	0.000138	11.0	1226
SSEC	0.0750	0.000113	15.0	1226

Note: Data processed by the authors (software: Eviews12)

Source: Own Elaboration



Note: Data processed by the authors (software: Eviews12)

Figure 8. Stability Tests conducted on results of the 7 financial markets, for the period from September 18th, 2017 to September 15th, 2022

Source: Own Elaboration

Figure 8 graphically represents the stability tests performed on the residuals of the seven capital markets, namely the stock indices of Indonesia (JKSE), Malaysia (KLSE), South of Korea (KOSPI), Japan (NIKKEI 400), Portugal (PSI), Thailand (SET) and China (SSEC), for the

period from September 18th, 2017 to September 15th, 2022. The performances of these stability tests are related to the existence of structure breaks, which means, sharp falls in prices that cause imbalances in financial markets. The detection of structural breakdowns is important because it has the same impact as the existence of unit roots in the visible components of time series. The presence of disturbances in the variance may be observed using graphical analysis, as well as the violation of the 95 percent probability boundaries, indicating an unstable behavior in the time series investigated.

The Gregory and Hansen (1996) test was used to examine the extent of financial integration across the seven stock markets during a period of tremendous complexity defined by the economic crisis and the Russian invasion of Ukraine, during which markets broke down severely. The methodology used postulates that in the null hypothesis there is an absence of cointegration and is tested against the alternative hypothesis, that is, long term relations between markets. Thus, the behavior and degree of integration between variables will be under evaluation.

Table 5 shows the results of the Gregory and Hansen (1996) test on stock markets in Indonesia (JKSE), Malaysia (KLSE), South Korea (KOSPI), Japan (NIKKEI 400), Portugal (PSI), Thailand (SET), and China (SSEC) during the Smooth subperiod. Overall, we can conclude that the markets are partially integrated since they present 11 integrations (in 42 possible ones). When analyzing in terms of individual markets it is possible to validate that the markets that present more integrations are the KOSPI, JKSE, PSI and SSEC stock indices (2 in 7 possible), while the KLSE, NIKKEI 400 and SET stock markets present only one integration.

These results demonstrate that in this Smooth subperiod the markets are partially integrated, that is, they do not present marked synchronizations, showing that these regional markets present relevant characteristics for a successful portfolio diversification strategy. These conclusions are validated by the authors Dias et al. (2019) for Latin American markets.

Table 5. Gregory and Hansen (1996) test, relating to the 7 Asian capital markets in the Smooth period, September 18th, 2019 to December 31st, 2020

Market	Test	Test Statistic	Method	Lags	Breakpoint	Date	Results
KOSPI - NIKKEI 400	-5,31**	Zt	Trend	0	314	04/01/2019	Integration
KOSPI - SSEC	-4,7*	ADF	Regime	3	352	05/03/2019	Integration
JKSE - PSI	-5,84***	Zt	Regime	2	95	08/02/2018	Integration
JKSE - SET	-5,15**	Zt	Regime	1	289	27/11/2018	Integration
KLSE - SET	-5,15**	Zt	Regime	0	375	05/04/2019	Integration
NIKKEI400 - KOSPI	-5,58***	Zt	Trend	0	314	04/01/2019	Integration
PSI - JKSE	-5,85***	Zt	Regime	0	95	08/02/2018	Integration
PSI - SSEC	-5,11**	Zt	Regime	0	309	26/12/2018	Integration
SET - KLSE	-5,23**	ADF	Regime	0	374	04/04/2019	Integration
SSEC - KOSPI	-4,94*	ADF	Regime	3	355	08/03/2019	Integration
SSEC - NIKKEI400	-4,88*	Zt	Trend	0	344	20/02/2019	Integration

Note: Data processed by the authors (software: Stata). The critical values are found in Gregory and Hansen (1996). The critical values for the ADF and Zt parameters are: −5,45 (1%); −4,99 (5%); −4,72 (10%). For the Za parameter, the critical values are: −57,28 (1%); −47,96 (5%); −43,22 (10%). The asterisks ***, **, * indicate statistical significance at 1%, 5% and 10%, respectively

Source: Own Elaboration

Table 6 displays the results of the Gregory and Hansen (1996) test on capital markets, namely Indonesia (JKSE), Malaysia (KLSE), South Korea (KOSPI), Japan (NIKKEI 400), Portugal (PSI), Thailand (SET) and China (SSEC), in the Stress subperiod, that is, in a period of uncertainty in the global economy and financial markets. In general, the integration of markets decreased from 11 in the Smooth period to 10 in the Stress subperiod. When we look at the integration of the markets individually, we can see that the KOSPI stock index only integrates once with Japan, while the Indonesia market (JKSE) integrates with the Philippines market (PSI) and Thailand (SET), and the Malaysia stock index (KLSE) integrates with Thailand (SET) and Japan (NIKKEI 400) with South Korea (KOSPI). Regarding the capital markets, the Philippines (PSI) integrates with Indonesia (JKSE) and China (SSEC), Thailand (SET) integrates only once with the Malaysian market (KLSE), while China (SSEC) integrates with the Korean market and Japan. When we compare the two sub-periods we find that the uncertainty in the current global economy of the 2020 global pandemic and the Russian invasion in 2022, did not accentuate the integration in these regional markets; these findings allow us to evidence that the implementation of portfolio diversification strategies in these regional markets may be viable.

Table 6. Gregory and Hansen (1996) test, relating to the 7 Asian capital markets in the Stress period, January 1st, 2020 to September 15th, 2022

Market	Test	Test Statistic	Method	Lags	Breakpoint	Date	Results
KOSPI – NIKKEI 400	-5,31**	Zt	Trend	0	311	28/12/2018	Integration
JKSE - PSI	-5,84***	Zt	Regime	2	95	08/02/2018	Integration
JKSE - SET	-5,15**	Zt	Regime	1	289	27/11/2018	Integration
KLSE - SET	-5,15**	Zt	Regime	0	375	05/04/2019	Integration
NIKKEI400 - KOSPI	-5,58***	Zt	Trend	0	314	04/01/2019	Integration
PSI - JKSE	-6,06***	Zt	Trend	0	394	03/05/2019	Integration
PSI - SSEC	-5,11**	Zt	Regime	0	309	26/12/2018	Integration
SET - KLSE	-5,38**	Zt	Trend	0	372	02/04/2019	Integration
SSEC - KOSPI	-5,55**	ADF	Trend	0	343	19/02/2019	Integration
SSEC – NIKKEI 400	-4,88*	Zt	Trend	0	344	20/02/2019	Integration

Note: Data processed by the authors (software: Stata). The critical values are found in Gregory and Hansen (1996). The critical values for the ADF and Zt parameters are: −5,45 (1%); −4,99 (5%); −4,72 (10%). For the Za parameter, the critical values are: −57,28 (1%); −47,96 (5%); −43,22 (10%). The asterisks ***, **, * indicate statistical significance at 1%, 5% and 10%, respectively

Source: Own Elaboration

Table 7 illustrates the results of the α DFA exponents for the stock markets of Indonesia (JKSE), Malaysia (KLSE), South Korea (KOSPI), Japan (NIKKEI 400), Philippines (PSI), Thailand (SET) and China (SSEC), for two sub-periods: The first is from September 18th, 2019 to December 31st, 2020, which we refer to as Smooth Period, and the second is from January 1st, 2020 to September 15th, 2022, which we refer to as Stress Period.

During the Smooth period, there were long memories in select stock indexes, including the KOSPI (0.57), KLSE (0.60), NIKKEI 400 (0.53), SET (0.57), and SSEC (0.54) markets, while there was considerable persistence, that is, the existence of short-term memories, in the JKSE (0.46) and PSI (0.49) markets. In relation to the subperiod which we call Stress in stock markets, all DFA exponents increased significantly, with the exception of China's market, which went from long term memory (0.54) to anti persistence (0.48). In the individual market analysis, we find that the DFA exponents of KOSPI (0.60), JKSE (0.60), KLSE (0.61), NIKKEI 400 (0.56), PSI

(0.59), SET (0.64) stock indexes exhibit significant long memories. These results demonstrate that prices do not fully reflect available information and that changes in prices are not i.i.d. This carries implications for investors as some returns may be expected, creating opportunities for arbitrage and above average returns without incurring additional risk. These conclusions are consistent with the evidence suggested by Santos et al. (2020), Dias et al. (2020), Dias et al. (2021), Zebende et al. (2022), Dias et al. (2022), Guedes et al. (2022), that suggests the existence of long term memory in international financial markets.

Table 7. DFA exponent for return. The values of the linear adjustments for αDFA always had $R^2 > 0.99$

Index	DFA exponent (Tranquilo)	DFA exponent (Stress)
JKSE	0.46 ≅ 0.0113	0.60 ≅ 0.0029
KLSE	0.60 ≅ 0.0020	0.61 ≅ 0.0168
KOSPI	0.57 ≅ 0.0051	0.60 ≅ 0.0013
NIKKEI 400	0.53 ≅ 0.0069	0.56 ≅ 0.0149
PSI	0.49 ≅ 0.0213	0.59 ≅ 0.0250
SET	0.57 ≅ 0.0056	0.64 ≅ 0.0326
SSEC	0.54 ≅ 0.0012	0.48 ≅ 0.0243

Note: The hypotheses are H_0: $\alpha = 0.5$ and H_1: $\alpha \neq 0.5$

Source: Own elaboration

5. CONCLUSION

The general conclusion to be retained and supported by the results obtained through the tests carried out with econometric and mathematical models suggests that these Asian regional markets are partially integrated. In corroboration, through the DFA model, these regional markets reveal signs of market inefficiency, in its weak form, namely during the global uncertainty resulting from the 2020 global pandemic and the Russian invasion in 2022.

This situation has implications for investors, as some returns may be expected, creating opportunities for arbitrage and abnormal profits, contrary to the assumptions of *random walk* and informational efficiency.

In conclusion, the authors suggest that the implementation of efficient portfolio diversification strategies in these regional markets may be questionable. This study demonstrates that policymakers in East and Southeast Asian countries should synchronize stock market standards and regulations and reduce barriers to capital flows to stimulate regional stock market integration. These conclusions also provide an opportunity for the regulators of these regional markets to introduce policies to ensure better information between these regional markets and the international markets.

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