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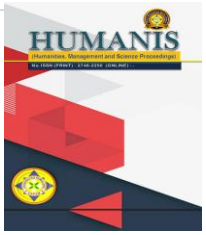

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Volatility Spillover Between Asean-5, Greece, And Japan Stock Market Indices

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Abstract: With its rapid economic development over the last few decades, ASEAN has played an essential role in the global markets. ASEAN has formed ASEAN Economic Community (AEC) to strengthen the long-term synergy among countries. Its export and import activities significantly influence its trading partners, such as EU28 and Japan. Using a Diagonal BEKK-GARCH model, this study aims to analyze the stock market linkages between ASEAN-5 countries and Greece, one of the EU28 members, and Japan in terms of volatility spillovers, considering Greece's sovereign debt crisis. The results indicate evidence of volatility spillovers for all seven countries examined. Using daily returns of ASEAN-5, Greece, and Japan stock market indices from 2005 to 2015, the findings show a larger magnitude of GARCH effects (volatility spillovers) than the ARCH effect (information spillover). Moreover, there is evidence of a high level of financial integration and correlation in the ASEAN-5, Greece, and Japan stock markets. Therefore, one of the crucial implications of this study is that investors cannot reduce their portfolio risk through diversification by adding stocks from these markets.
Keywords: Volatility spillover effect, Diagonal BEKK, multivariate GARCH, stock markets.

INTRODUCTION

Global financial conditions have changed in recent decades. The movement of capital and investment flows is becoming freer in this era of globalization due to rapid technological advances, erasing the dividing lines between the capital markets of countries in the world. After the Asian crisis in 1997, ASEAN sought incentives (CMIM and ABMI) to maintain regional financial stability by establishing a single market with a unified production base (capital and labor) and an ASEAN Economic Community. Financial integration has powerful implications for maintaining financial stability, which benefits a region in allocating capital efficiently, reducing the possibility of asymmetric shocks, and creating a more robust market framework (Umutlu et al., 2010). However, on the other hand, the existence of financial linkages in the world triggers the transmission of shocks (information) from one country, which can quickly affect the volatility of the financial market of another country. Therefore, a crisis that occurs in one country can increase the volatility of the stock market of other countries or stock markets worldwide due to the contagion effect.

This paper examines the stock market relations of Indonesia, Malaysia, the Philippines, Singapore, and Thailand by considering the impact of the Greek debt crisis. The linkages

between ASEAN stock markets and the Japanese stock market, a member of ASEAN+3, will also be investigated further.Countries in the ASEAN+3 region include ASEAN (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam), China, Japan, and South Korea.This study analyzes the stock market relationship between the ASEAN-5 stock market index and the Greek and Japanese stock market indices with a focus on volatility spillover. ASEAN is in the spotlight in this study because, over the last two decades, the economic growth of countries in the ASEAN region has been accompanied by an increasing share market size. This is due to several changes in the ASEAN capital market, especially in the ASEAN-5 capital market. Based on a report issued by ADB and the Korea Capital Market Institute on developing and integrating Asian capital markets (2014), the Singapore Stock Exchange opened in December 1999. It became the first stock exchange in the Asia-Pacific region in 2000. Then, The Philippine Stock Exchange, initially a corporate stock in 2001, became a publicly traded stock exchange in 2003.

In Indonesia, the Surabaya and Jakarta stock exchanges merged in 2007. Capital controls in Malaysia are gradually being reduced, mainly controlling foreign ownership in Malaysian securities. In Thailand, two capital market development plans were implemented in 2002 and 2006 to develop the corporate bond market and attract more investors and issuers. The capital market reforms further increased the ASEAN market capitalization, which was initially low after the Asian crisis in 1997 to reached its highest point in 2007. The increase in stock market capitalization of countries in the ASEAN region was marked by price appreciation from companies listed on the stock exchange and the number of companies listed on the stock exchange from year to year. The increase in the growth of stock market capitalization in ASEAN is a phenomenon of emerging markets.

In addition to increasing market capitalization growth, this research highlights ASEAN because, in 2014, ASEAN's GDP was recorded at $2.4 trillion, ASEAN's total trade increased by almost $1 trillion between 2007-2014, and total FDI inflows into ASEAN increased from $85 billion to $136 billion (ASEAN, 2015). This makes ASEAN the second fastest-growing economy after China–growing by 300% since 2001 and exceeding the average world growth in the last ten years. This paper further narrows the research focus to ASEAN-5 because the five member countries were early members of ASEAN, which was formed in 1967. In the following years, Brunei Darussalam (1984), Cambodia (1999), Laos (1997), Myanmar (1997), and Vietnam (1995) joined ASEAN. Over the past few years, ASEAN member states have significantly strengthened the region's capital market integration and financial cooperation. Examples of such efforts are establishing a free trade area (ASEAN Free Trade Area) in 1992 and an investment zone (ASEAN Investment Zone) in 1995. ASEAN-5 countries are the most likely candidate countries to undertake the first integrative steps, so these five countries become the focus of this research. The significant role of ASEAN-5 that has been described previously, starting from the establishment of ASEAN to the current effort to establish financial integration, makes ASEAN-5 essential to study.

After the Asian financial crisis in 1997-1998 that rocked Asian financial markets and economies, several regional financial cooperation efforts in the ASEAN+3 region were established, such as the Chiang Mai Initiative (CMI) and Asian Bond Markets Initiatives (ABMI) agreements—strengthening financial cooperation and integration in the region. The Chiang Mai Initiative (CMI) is a form of regional liquidity assistance mechanism that was formed based on the agreement of the finance ministers of ASEAN+3 countries in May 2000 to prevent a re-emergence of the crisis. CMI strengthens regional finance by establishing a network of Bilateral Swap Arrangements (BSA) which aims to prevent countries in the region from facing balance of payments problems and short-term liquidity difficulties.

Furthermore, to better cope with the financial crisis, ASEAN+3 finance ministers are committed to multilateralizing CMI (Chiang Mai Initiative Multiralisation) by creating a reserve pooling arrangement governed by a contractual agreement that allows ASEAN+3 members to utilize the foreign exchange reserves. In addition to CMI, there is a capital market initiative that is no less important in helping to develop the bond market and increase financial

resilience in the ASEAN+3 region, namely ABMI. The Asian Bond Market Initiative (ABMI) was launched in August 2003 to develop an efficient and liquid bond market in Asia with a focus on two things: (i) facilitating market access by expanding the diversity of bond issuers and types of bonds and (ii)) improve market infrastructure to help develop bond markets in Asia.

From the explanation above, it can be seen that Japan, which is a member of ASEAN+3, has close economic relations with ASEAN countries to strengthen regional financial cooperation. Moreover, Japan is ASEAN's third largest trading partner after China and the EU28 in 2014 (see Table 1) and the second largest contributor to FDI inflows for ASEAN after the EU28 in 2013 (see Table 2). Furthermore, this study uses daily yield data from the Greek stock market indices selected for the Eurozone. The crisis itself began with the debt crisis experienced by Greece in 2009. The crisis that shook Greece directly affected the economic stability of countries in the EU region and made the value of the Euro against the Dollar increasingly depreciate, creating a domino effect for EU member countries. This is the basis for choosing to include the Greek stock market index in this study. Supported by the fact that EU28 is ASEAN's second-largest trading partner after China in 2014 and was ranked one of the most significant contributors to FDI inflows for ASEAN in 2013. It can be said that the Greek debt crisis that rocked the EU had an impact on trade and investment relations between the EU28 and ASEAN.

Table 1. Top 5 ASEAN trading partners data (ASEAN, 2015)

Total Extra-ASEAN Trade (Imports and Exports) in 2014

Partner	*Value (Mio €)*	*% World*
China	279,234	19.8
EU28	182,939	13
Japan	168,161	11.9
US	156,676	11.1
South Korea	97,061	6.9

Data Source : search data 2022

Table 2. Data on the top 5 countries contributing to the most significant FDI Inflows for ASEAN (ASEAN, 2014)

Contributors of FDI Inflows to ASEAN in 2013

Country	*% Total Share*
EU28	22%
Japan	18.7%
Intra-ASEAN	17.4%
China	7.1%
Hong Kong	3.7%

Data Source : search data 2022

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Volatility spillover has become an interesting research topic in recent decades because it has a vital role in risk management and market stability assessment. Volatility spillover is a condition where the volatility of a market tends to follow the movement of volatility in other markets (Brooks, 2019). Karolyi (1995) found that there were innovation shocks from the US stock market to the Canadian stock market and vice versa. Kim, In, and Viney (2001) found a volatility spillover in the Australian stock, bond, and money markets. Saleem (2009) found that the Russian stock market was only partially integrated with the world market, and during the Russian crisis period, there was a contagion effect.Kim, Moshirian, and Wu (2018) found a one-way volatility spillover from the bond markets of European countries to their stock markets.

The Greek debt crisis (2009-2001) was the second source of the global financial crisis after the subprime mortgage crisis that occurred in the United States in 2007-2009. As explained earlier, the crisis period amplifies volatility in world financial markets. The subprime mortgage crisis in the United States has increased volatility in almost all financial markets. Johansson (2011) found that the EU and ASEAN+3 experienced an increase in regional comovement during the global financial crisis. Using the multivariate GARCH model in the form of BEKK Diagonal, this study discusses the main issue: analyzing the stock market relationship between ASEAN-5 and the Greek and Japanese stock markets. This study found that the GARCH effect (volatility spillover) has a greater magnitude than the ARCH effect (information spillover), and there is a high level of integration and financial correlation between the ASEAN-5 stock market and the Greek and Japanese markets. Although the approach using the BEKK diagonal has often been used in researching international market relations and market volatility spillovers during crisis periods, so far, no one has used this approach during the Greek debt crisis period by paying attention to the volatility spillover between the ASEAN-5 stock market and Greece and Japan stock markets. One of the critical implications of research on the transmission of international stock market volatility is for international investors and portfolio managers who seek to minimize their portfolio risk exposure by diversifying. Based on the findings in this study, investors cannot reduce their portfolio risk through diversification by adding stocks from the seven markets studied.

METHODS

The Autoregressive Conditional Heteroscedasticity (ARCH) process initiated by Engle in 1982 and the Generalized ARCH initiated by Bolerslev in 1986 is a univariate approach used in stock returns modeling. The univariate approach alone is insufficient in examining the volatility relationship between countries, so a multivariate GARCH approach is needed. However, the initial model of MGARCH, namely VECH, proposed by Bollerslev, Engle, and Wooldridge in 1988, failed to maintain the positive definiteness of the conditional variance matrix and had many parameters so that the parameter estimates did not always converge. This problem is solved in the BEKK diagonal model (Engel & Kroner, 1995), which provides dynamic restriction or parameterization on the conditional variance-covariance matrix so that the number of estimated parameters is reduced compared to the VECH model. Therefore, the MGARCH model is used in this study to analyze the relationship between the ASEAN-5 stock market and the Greek and Japanese stock markets. In BEKK diagonal, the parameter matrix is delimited diagonally so that the conditional covariance matrix can be positively maintained. BEKK Diagonal Equation is as follows:

$$H_t = C'C + A'(\varepsilon_{t-1}\varepsilon'_{t-1})A + B'(H_{t-1})B$$

Where H_t is the nxn conditional variance-covariance matrices, C is the upper triangular matrix parameter, ε_{t-1} is the nx1 disturbance vector, and A and B are nxn diagonal parameter matrices. Thus, the second moment of the above equation can be described as follows:

$$H_t = C'C + \begin{bmatrix} a_{11} & 0 \\ 0 & a_{22} \end{bmatrix}' \begin{bmatrix} \varepsilon^2_{1,t-1} & \varepsilon_{1,t-1},\varepsilon_{2,t-1} \\ \varepsilon_{1,t-1},\varepsilon_{2,t-1} & \varepsilon^2_{2,t-1} \end{bmatrix} \begin{bmatrix} a_{11} & 0 \\ 0 & a_{22} \end{bmatrix} + \begin{bmatrix} b_{11} & 0 \\ 0 & b_{22} \end{bmatrix}' H_{t-1} \begin{bmatrix} b_{11} & 0 \\ 0 & b_{22} \end{bmatrix}$$

If $C'C$ is the same 2x2 matrix as Ω, then

$$\begin{aligned} \Omega &= C'C \\ &= \begin{bmatrix} c_{11} & 0 \\ c_{12} & c_{22} \end{bmatrix} \begin{bmatrix} c_{11} & c_{12} \\ 0 & c_{22} \end{bmatrix} \\ &= \begin{bmatrix} c^2_{11} & c_{11}c_{12} \\ c_{11}c_{12} & c^2_{12}c^2_{22} \end{bmatrix} \end{aligned}$$

The equation for $H_t$above can be more clearly developed into a conditional variance-covariance equation as follows:

$$h_{11,t} = \Omega_{11} + a_{11}^2 \varepsilon_{1,t-1}^2 + b_{11}^2 h_{11,t-1}$$
$$h_{12,t} = \Omega_{12} + a_{11} a_{12} \varepsilon_{1,t-1} \varepsilon_{2,t-1} + b_{11} b_{22} h_{12,t-1}$$
$$h_{22,t} = \Omega_{22} + a_{22}^2 \varepsilon_{2,t-1}^2 + b_{22}^2 h_{22,t-1}$$

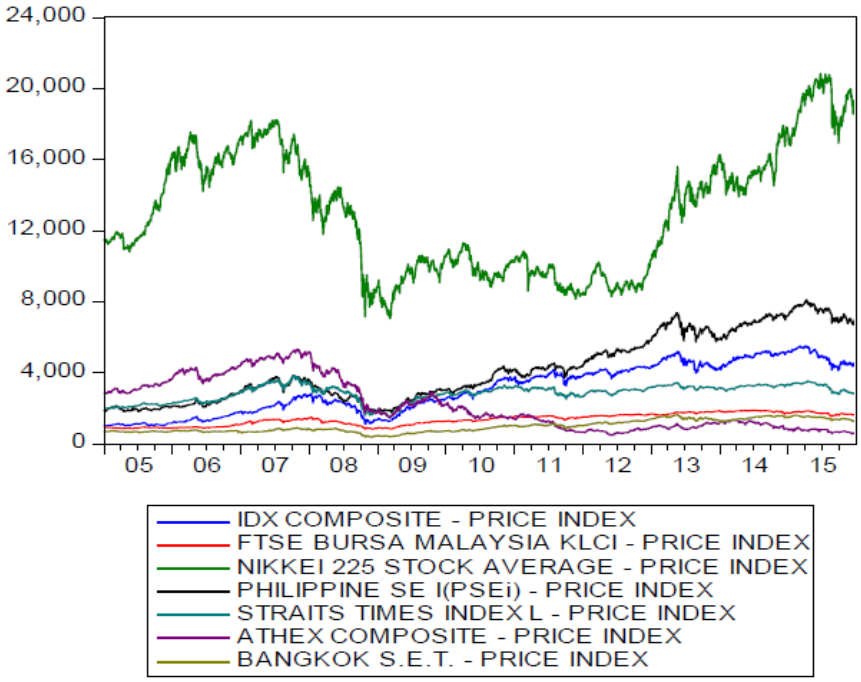
The MGARCH parameter from the above specification can be estimated by maximizing the log-likelihood function L(θ):

$$\mathrm{L}(\theta) = -\frac{TN}{2} - \frac{1}{2}\sum_{t=1}^{T}(\log|H_t| + \varepsilon_t H_t^{-1} \varepsilon_t$$

Thus, the hypothesis that the stock markets in the seven observed countries showed an increase in correlation (volatility spillover) during the Greek debt crisis can be tested using the MGARCH specification above.

RESULT AND DISCUSSION

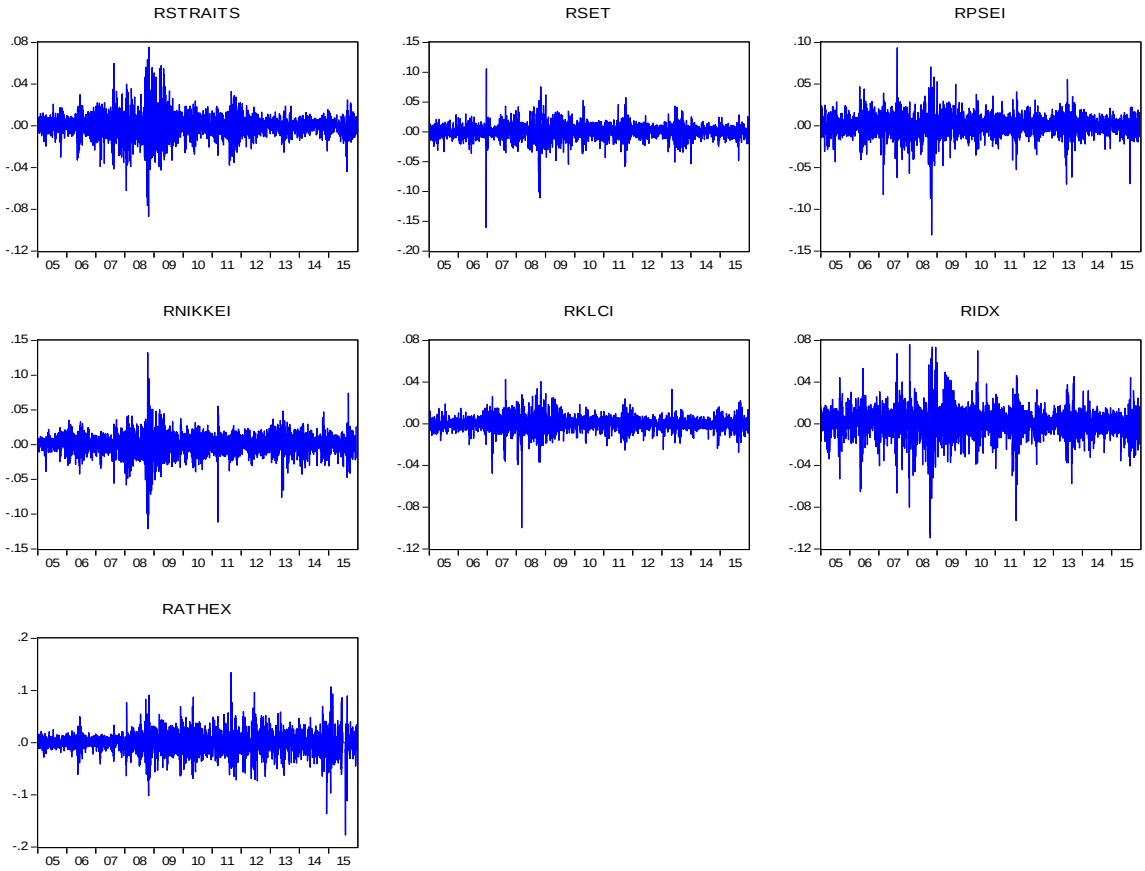
The data used in this study is data on closing prices for the stock market indexes of ASEAN-5, Greece, and Japan in local currencies obtained from Datastream. The evaluation period from January 3, 2005, to December 31, 2015, resulted in 2868 observations for each stock market index. The data is divided into pre-crisis, crisis, and post-crisis. Figure 1, which illustrates the closing prices of the stock market indexes of ASEAN-5, Greece, and Japan starting from January 3, 2005, to December 31, 2015, can be seen that from 2005-2007 there was an upward trend from index prices in the seven stock markets but decreased. Starting in 2007, the seven stock market indices have decreased simultaneously. This was because, during this period, the global subprime mortgage financial crisis occurred in the United States. The year 2009 was a period of recovery from the crisis in which the stock market index prices of the observed countries began slowly rising again. However, the Greek stock market index experienced a persistent decline in the same year until the end of 2015.



Data Source : search data 2022

Figure 1. The closing price data for the stock market indexes of ASEAN-5, Greece, and Japan at the level (3 January 2005-31 December 2015).

From Figure 2, there is a volatility clustering phenomenon where the volatility tends to be high during the crisis and, during the post-crisis period, the volatility is low to medium. Furthermore, volatility was seen to be higher in 2007-2008 due to the subprime mortgage crisis experienced by the United States. There was also volatility clustering in 2009-2011, although the magnitude was not as great as during the global financial crisis in 2007-2008. Then, one of the implications of volatility clustering, as seen from the stock yield chart, is that volatility in a certain period has an autocorrelation with volatility in the previous period so that it can be modeled using Autoregressive Conditional Heteroskedasticity (ARCH).



Data Source : search data 2022

Figure 2. Daily stock yield data from ASEAN-5, Greece, and Japan stock market indexes at the level (January 3, 2005, to December 31, 2015).

As a first step, stationarity was tested using the Augmented Dickey-Fuller test at the level. The results in Table 3 show that the data is not stationary with H0, which states that the data have unit roots that cannot be rejected. In Table 4, after the ADF test on the first difference, it was found that the yield data was stationary, indicated by a p-value smaller than the critical value of 5%. Therefore, the H0 of the ADF test, which states that there is a unit root in the yield data of the seven stock market indices observed, can be rejected.

Table 3. The ADF unit root test results of the closing price data for the ASEAN-5, Greece, and Japan stock market indices at the level (January 3, 2005, to December 31, 2015).

Country	Thailand	Philippines	Singapore	Malaysia	Indonesia	Greece	Japan
t-statistic	-0.927418	-0.605384	-2.199856	-1.243598	-1.106846	-0.443449	-0.942430
Prob.	0.7800	0.8670	0.2065	0.6575	0.7153	0.8993	0.7751

Data Source : search data 2022

Table 4. The ADF unit root test results for the ASEAN-5, Greece, and Japan stock market indices yield data (January 3, 2005, to December 31, 2015).

Country	Thailand	Philippines	Singapore	Malaysia	Indonesia	Greece	Japan
t-statistic	-53.64857	-47.61586	-52.39278	-47.41998	-48.37272	-50.25502	-54.78980
Prob.	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Data Source : search data 2022

Furthermore, as previously mentioned, one of the implications of volatility clustering, as seen from the stock yield chart, is that volatility in a certain period has an autocorrelation with volatility in the previous period, so it needs to be modeled using Autoregressive Conditional Heteroskedasticity (ARCH). First, the yield data were tested using the ARCH LM test. It was found that there is an ARCH effect in the residuals where H0, which states that there is no ARCH effect, is rejected because the F-statistic and Obs*R-squared statistical values are significant. The value of 2 is greater than the critical p-value of 0 (see attachments). Thus, the data can be further modeled using Generalized Autoregressive Conditional Heteroskedasticity (GARCH).

The research period is divided into three sub-periods: pre-crisis, crisis, and post-crisis Greek debt. The reason why this study chose to highlight the crisis was explained earlier, namely because Greece, apart from its developed stock market, is a member of the EU28, which is the second largest trading partner for ASEAN after China. Below are tables of descriptive statistics from the stock market index return data of ASEAN-5, Greece, and Japan based on the division of three subperiods. In the pre-crisis subperiod, in table 5, the Indonesian stock market index gave the highest yield (0.00029), and Malaysia gave the lowest yield (-2.92E-05). The highest standard deviation was found in the Japanese stock market (0.017005), followed by Indonesia (0.016409), and the lowest was found in the Malaysian stock market (0.009172). From these findings, it can be concluded that a slight standard deviation (risk) value produces a small mean (return) and vice versa.

Meanwhile, during the crisis (Table 6), the Indonesian stock market index also gave the highest yield among the seven observed stock markets, namely 0.001327, and the stock market index that gave the lowest yield was Japan (-5.98E-05). The highest standard deviation is owned by the Greek stock market index (0.021639), followed by Japan (0.01486), and the lowest standard deviation is owned by Malaysia (0.006836). It can be concluded that the high standard deviation in the Greek stock market index was because a debt crisis hit Greece during that period. In the post-crisis subperiod (see Table 7), Japan recovered by providing the highest yield of the seven stock market indexes observed, namely 0.000778, and Malaysia again provided the lowest yield (-9.3E-05). The highest standard deviation was found again in the Greek stock market index (0.023745), and the lowest standard deviation was again in the Malaysian stock market index (0.005463). These findings indicate that Greece can still not fully recover from the crisis that hit it in 2009-2011. Overall yield data from the seven stock markets in the three subperiods have positive kurtosis (leptokurtic data distribution), mostly negative skewness (asymmetry in the negative direction), and significant Jarque-Bera p-value (rejecting H0, which states that data are normally distributed).

Table 5. Descriptive statistics of stock returns on ASEAN-5, Greece, and Japan stock market indexes in the pre-crisis period (3 January 2005-31 December 2008).

	Thailand	Phillipines	Singapore	Malaysia	Indonesia	Greece	Japan
Mean	-0.00038	1.34E-05	-0.00012	-2.92E-05	0.000291	-0.00044	-0.00025
Median	0	0	0.000121	0.00013	0.000841	0.000492	0
Maximum	0.10577	0.093653	0.075305	0.042587	0.076231	0.091144	0.132346
Minimum	-0.16063	-0.13089	-0.08696	-0.09979	-0.10954	-0.10214	-0.12111
Std. Dev.	0.014887	0.01552	0.013785	0.009172	0.016409	0.01498	0.017005
Skewness	-1.567.869	-0.85084	-0.4746	-1.602.795	-0.8403	-0.59953	-0.55945
Kurtosis	2.466.931	1.168.355	9.093.359	1.930.031	1.029.069	1.078.049	1.458.203
Jarque-Bera	20813.6	3.399.515	1.651.136	11981.96	2.430.404	2.690.694	5.878.421

Probability	0	0	0	0	0	0	0
ADF	0	0	0	0	0	0	0
P-value	0	0	0	0	0	0	0
ARCH Test							

Data Source : search data 2022

Table 6. Descriptive statistics of stock returns on ASEAN-5, Greece, and Japan stock market indices during the crisis period (1 January 2009-30 December 2011).

	Thailand	Philippines	Singapore	Malaysia	Indonesia	Greece	Japan
Mean	0.001055	0.001085	0.000521	0.000714	0.001327	-0.00124	-5.98E-05
Median	0.000705	0.000208	0.00016	0.000379	0.000919	-0.00087	0
Maximum	0.061895	0.05295	0.057684	0.028982	0.070136	0.134311	0.055223
Minimum	-0.05812	-0.05267	-0.04243	-0.02531	-0.093	-0.07168	-0.11153
Std. Dev.	0.013441	0.011624	0.012371	0.006836	0.013956	0.021639	0.01486
Skewness	-0.18947	-0.09037	0.35297	0.063026	-0.32111	0.364669	-0.58817
Kurtosis	5.565.771	5.285.025	5.738.534	4.757.054	7.733.372	5.641.837	7.868.817
Jarque-Bera	2.189.007	1.709.741	2.602.656	1.009.809	7.425.114	2.444.282	8.164.431
Probability	0	0	0	0	0	0	0
ADF	0	0	0	0	0	0	0
P-value	0	0	0	0	0	0	0
ARCH Test							

Data Source : search data 2022

Table 7. Descriptive statistics of stock returns on ASEAN-5, Greece, and Japan stock market indices in the post-crisis period (2 January 2012-31 December 2015).

	Thailand	Philippines	Singapore	Malaysia	Indonesia	Greece	Japan
Mean	0.000219	0.000439	8.20E-05	9.63E-05	0.000179	-6.23E-05	0.000778
Median	0.000146	0.000243	0	6.09E-06	0.00041	0	0.000278
Maximum	0.043234	0.055419	0.024898	0.033222	0.045438	0.106806	0.074262
Minimum	-0.05373	-0.06989	-0.04391	-0.02738	-0.05746	-0.17713	-0.07597
Std. Dev.	0.00947	0.010167	0.006657	0.005463	0.010213	0.023745	0.013154
Skewness	-0.44505	-0.99983	-0.41909	-0.21384	-0.41982	-0.49943	-0.35664
Kurtosis	6.808.688	1.035.637	5.750.912	6.664.481	6.413.226	8.618.747	6.255.896
Jarque-Bera	6.648.424	2.525.572	3.594.029	5.915.259	5.369.329	1.415.353	4.828.056
Probability	0	0	0	0	0	0	0
ADF	0	0	0	0	0	0	0
P-value	0	0	0	0	0	0	0
ARCH Test							

Data Source : search data 2022

The estimation results from the conditional variance-covariance equation below can capture the spillover cross volatility among the seven stock market indices. These equations are presented in table 8.

$h\ 11,t = 0.00000887 + 0.03436 \in 1,t-12 + 0.922287 h\ 1,1t-1$
$h\ 12,t = 0.00000186 + 0.035855329 \in 1,t-1 \in 2,t-1 + 0.9250562 h\ 12,t-1$
$h\ 13,t-1 = 0.00000163 + 0.039225432 \in 1,t-1 \in 3,t-1 + 0.935261925 h\ 13,t-1$, etc

Table 8. Implied variance-covariance using BEKK diagonal model.

	PRE-CRISIS			CRISIS			POST-CRISIS		
	C	A	B	C	A	B	C	A	B
h11	0.00000887	0.034359812	0.922287488	0.00001	0.042964998	0.895557503	0.00000266	0.051305	0.918596
h12	0.00000186	0.035855329	0.9250562	0.00000457	0.028464311	0.874085071	0.000000784	0.038622	0.932388
h13	0.00000163	0.039225432	0.935261925	0.00000359	0.046896478	0.907969685	0.000000719	0.040891	0.92636
h14	0.000000799	0.032224419	0.944863584	0.00000176	0.021822646	0.928538363	0.00000117	0.067915	0.846771
h15	0.00000258	0.04273326	0.924987055	0.00000526	0.050539424	0.887700997	0.000000952	0.041688	0.927287
h16	0.00000195	0.05846844	0.89589493	0.00000721	0.012088777	0.901381273	0.00000292	0.049689	0.868653
h17	0.00000148	0.045713172	0.925588239	0.00000539	0.063617341	0.850018724	0.000000821	0.034314	0.934797
h22	0.00000762	0.037415939	0.927833224	0.0000164	0.018857606	0.853127475	0.00000227	0.029075	0.946387
h23	0.000000913	0.040932726	0.938069586	0.00000358	0.031068917	0.886199651	0.000000572	0.030783	0.940268
h24	0.000000609	0.033626993	0.94770007	0.00000252	0.014457503	0.906275162	0.00000156	0.051126	0.859484
h25	0.00000174	0.044593233	0.927763871	0.00000601	0.033482369	0.866416937	0.000000895	0.031383	0.941209
h26	0.00000139	0.061013289	0.898584411	0.00000352	0.008008815	0.879769207	0.00000255	0.037406	0.881695
h27	0.00000144	0.047702846	0.92836686	0.00000781	0.042146489	0.829638157	0.000000956	0.034314	0.948832
h33	0.00000123	0.044780062	0.948418881	0.00000342	0.051187705	0.920553897	0.0000013	0.032591	0.93419
h34	0.00000026	0.03678765	0.958155614	0.00000126	0.02381951	0.941407651	0.00000115	0.05413	0.853928
h35	0.00000137	0.048784626	0.937999468	0.00000427	0.055163996	0.90000429	0.000000758	0.033226	0.935125
h36	0.00000126	0.066748031	0.908498084	0.00000601	0.013194951	0.913874171	0.00000232	0.039603	0.875995
h37	0.000000951	0.052186517	0.938609109	0.00000555	0.069438598	0.861799751	0.00000101	0.027349	0.942698
h44	0.0000003	0.030221736	0.967992306	0.000000992	0.011084089	0.962733816	0.00000365	0.089902	0.780562
h45	0.000000647	0.040077474	0.947629231	0.00000235	0.025669824	0.920392524	0.00000168	0.055184	0.854782
h46	0.000000501	0.054834744	0.917824979	0.0000022	0.006140093	0.934576607	0.00000128	0.065776	0.800733
h47	0.000000393	0.04287219	0.948245131	0.00000351	0.032312318	0.881322519	0.0000018	0.045423	0.861705
h55	0.0000051	0.053147308	0.927694523	0.0000111	0.059449168	0.879913413	0.00000269	0.033873	0.93606
h56	0.0000017	0.072717133	0.898517244	0.00000747	0.014219943	0.893473676	0.00000245	0.040375	0.876871
h57	0.00000142	0.056853421	0.928297466	0.00000751	0.074832629	0.842561718	0.000000938	0.027882	0.943641
h66	0.00000587	0.099492931	0.870257631	0.0000418	0.003401339	0.907242915	0.0000733	0.048125	0.821425
h67	0.00000109	0.077787906	0.899101224	0.0000074	0.01789959	0.855546357	0.00000334	0.033233	0.883973
h77	0.00000296	0.060817972	0.928900802	0.0000208	0.094196817	0.806795576	0.00000418	0.02295	0.951284

Data Source : search data 2022

From the empirical results of the variance-covariance equation above, it can be concluded that there is evidence of persistent volatility spillover (B) and weaker information spillover (A). All diagonal elements in matrices a and b are significant at the 1% level, indicating that the volatility of the seven observed stock markets is influenced by volatility and shocks in their past. The focus of this research is matrix B which is used to capture the volatility spillover between the stock market indexes of ASEAN-5, Greece, and Japan. Matrix B measures the volatility spillover from stock market i to stock market j. By using BEKK diagonal, the value of i = j, so that the diagonal coefficient in the b matrix (b11 Thailand, b22 Philippines, b33 Singapore, b44 Malaysia, b55 Indonesia, b66 Greece, and b77 Japan) is the effect of its own lagged volatility which is a form of autocorrelation in the conditional variance. If i≠j, then there are elements outside the diagonal matrix b that describe the spillover effect of volatility across the stock market.

All diagonal coefficients are statistically significant at the 1% level, indicating that the current conditional variance is highly correlated with the past conditional variance. Then, it can be seen from the table above that the diagonal coefficient in matrix b has a large magnitude in all subperiods with an average value of 90%. Therefore, it can be concluded

that the conditional variance in the seven observed stock markets represents a high level of persistence. Furthermore, the coefficients outside the diagonal matrix B indicate the persistent level of volatility spillover across the stock market, which is also high due to the magnitude of the volatility spillover, which averages 90% in all subperiods, so it can be said that the findings support the research hypothesis. Moreover, this paper provides an example of conditional covariance between the Greek and Bangkok stock markets to illustrate conditional covariance. The conditional covariance graph can be seen in the appendix, which shows that the movement of the conditional covariance of the Greek stock market with Bangkok was small in the pre-crisis period and began to increase sharply until the crisis occurred. Its persistence was still visible until the post-crisis period. There is evidence of volatility spillover between the two markets. All coefficients outside the diagonal matrix B are statistically significant at the 1% level and represent a one-way relationship regarding volatility spillover across the stock market. ASEAN-5, Greece, and Japan. (B12, b13, b14, b15, b16, b17, b23, b24, b25, b26, b27, b34, b35, b36, b37, b45, b46, b, 47, b56, b57, b67). The magnitude of the spillover between ASEAN-5, Greece, and Japan shows that the volatility of stock returns is.

CONCLUSIONS

This study concludes that by analyzing the relationship of the ASEAN-5 stock market with the Greek and Japanese markets and highlighting the Greek debt crisis, it is found that there is evidence of volatility spillover in the seven stock markets observed. It is also seen that the volatility spillover has a larger magnitude and a higher persistence level (matrix B) than shock/innovation (matrix A) in all subperiods: pre-crisis, crisis, and post-crisis. With this, it can be concluded that there is a high degree of integration and correlation between the ASEAN-5 stock market and the stock markets of its main trading partners, Greece and Japan.

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