# Integration of Bond Markets and Portfolio Diversification : Evidence from the 2008 Global Financial Crisis

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## Abstract

**Purpose : This study aimed to examine the integration between the bond markets of the MSCI Emerging Markets and the USA concerning the 2008 financial crisis.**

**Methodology : Granger causality and correlation tests were used to assess the short-term integration of the bond markets. The long-term integration was examined using the Johansen co-integration test and VAR analysis.**

**Findings : Post-crisis, bond markets became more correlated with each other. Due to a lack of market integration in both periods, different portfolio combinations offered the chance for portfolio diversity. The MSCI Emerging Asian markets and US market integration increased with the global financial crisis of 2008. The results of the VAR analysis and impulse response analysis found that innovations in the markets of the USA and China affected the Indian market the most; whereas, the rest of the market had a nominal impact.**

**Practical Implications : The study has practical implications in the sense that based on the integration, investors might diversify their holdings to achieve a better risk-return balance. The investors can design their investment portfolio accordingly to have an optimal portfolio.**

**Originality : This study focused on building portfolio diversification with fixed-income securities.**

***Keywords :*** **bond markets, VAR analysis, MSCI Emerging Asian markets, financial crisis, portfolio diversification opportunity**

**JEL Classification Codes : F15, F21, G11, G15**

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In today's time, the bond market is one of the important financial markets. The bond markets at the regional and national levels need to be developed to improve the capital market (Patel & Patel, 2011; Patel, R., & Patel, D., 2012; Plummer & Click, 2005). The integration among the bond markets is significant for investors,

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researchers, and academicians because of portfolio diversification benefits. The lower correlation and integration among the bond markets allow the investors to reduce risk with portfolio diversification (Patel et al., 2022; Patel, 2022). Investors can lower their portfolio risk by diversifying their holdings when markets are weakly integrated or not at all integrated (Patel, R., & Patel, M., 2012; Patel, 2016).

In the past, many researchers have investigated the bond markets' time-varying integration using different approaches such as wavelet analysis (Bhuiyan et al., 2019), factor analysis (Agur et al., 2019; Patel 2021b; Patel, 2021c), GARCH Model (Šimović et al., 2016; Tsukuda et al., 2017), capital asset pricing model (Abad et al., 2010), Johansen co-integration test (Patel, 2019a; Patel, 2019b), and Granger causality test (Patel, 2017; Patel 2019c). Patel (2021a) applied the portfolio diversification benefit analysis in his study. This research focuses on the bond markets' time-varying integration, taking either short- or long-term integration into account. Earlier investigations have also been carried out on the bond markets of developed nations. In the present study, we address two research questions:

**Q.1.** Do the bond markets of the USA and MSCI Emerging Asian Markets hold the integration with respect to the 2008 global financial crisis?

**Q.2.** Is there any portfolio diversification opportunity with the bond market?

As a result, the current analysis focuses on the MSCI Emerging Asian markets and the USA about the global financial crisis of 2008. Both the short-term and long-term integration are covered in the current study. The Granger causality test and correlation are used to assess short-term integration. Johansen's co-integration test and VAR analysis are used to examine the long-term integration. The paper makes the following two contributions to the literature :

- It shows the integration relationship among the bond markets of the USA and MSCI Emerging Asian Markets with respect to the global financial crisis of 2008;
- It shows the possibility of the portfolio diversification opportunity with the bond market.

## Literature Review

In the early 1970s, empirical studies on financial market integration reported a lower correlation between the markets. Grubel (1968) demonstrated the advantages of portfolio diversification in the global marketplace. Many past studies have found the existence of integration between the bond markets. Rughoo and You (2016) discovered that following the 2008 financial crisis, the Asian bond markets became more integrated. Taningco (2018) found an increase in the integration of East Asian bond markets from 2001 – 2014 due to increases in investment and market size.

Few past studies found the opportunity for portfolio diversification due to weak integration among the bond markets. Using the GARCH model, Šimović et al. (2016) studied the integration of bond markets in the post-transition phase among Croatia, the Czech Republic, Hungary, Latvia, Lithuania, Poland, Romania, and Ukraine, covering a period from 2004 – 2014. According to the study, there was a decline in market integration following the financial crisis. Using Wavelet coherence and GARCH, Bhuiyan et al. (2019) investigated the bond markets' integration in developed economies. The study found that the lower co-movement among the markets revealed a significant opportunity for portfolio diversification.

Only a few studies discovered a minimal level of bond market integration. Using CAPM, Abad et al. (2010) found partial integration among the bond markets of European countries. Using Markov switching and smooth transition autoregression techniques, Georgoutsos and Migiakis (2013) found integration among the European

sovereign bonds. Using the dynamic conditional correlations approach, Tsukuda et al. (2017) found that Indonesia, Malaysia, the Philippines, and Thailand markets had low levels of integration. However, the Hong Kong and Singapore markets had a high level of integration. Agur et al. (2019) found that the partial integration among the European sovereign debt markets somewhat integrated with the local bond markets. Nautiyal and Kavidayal (2018) found that the short-run causality mostly extended from the Hong Kong market to India, Malaysia, Germany, and South Korea. It also extended from France to China. Aggarwal and Khurana (2018) revealed a single long-term cointegrating relationship between the investigated stock markets in Brazil, Russia, India, and China. Perumandla and Kurisetti (2018) found a short-term integration of BSE Sensex and Nifty 50 Indices returns. Some other recent studies (Agrawal et al., 2021; Mishra, 2019; Singh & Shrivastav, 2018) have also explored the comovement.

Most of the earlier research has focused on how the bond markets in Western and European nations are integrated. Further, very few past studies have examined market integration concerning financial crises. The current analysis is therefore conducted on the bond markets of the USA and MSCI Emerging Asian markets (according to the MSCI market classification framework) about the global financial crisis of 2008.

The present study examines the bond markets' integration during the 2008 financial crisis. The study explores the causal relationship between the MSCI Emerging Markets and the USA. The past studies did not explore bond integration; so, we have addressed it with this study. Thus, this study fills the literature gap by exploring the bond market linkage. Moreover, the bond is a fixed-income security, where the investors are inclined towards it due to the surety of return. Hence, this study is carried out to examine the fixed-income market.

## Empirical Framework

The present study is conducted with two objectives: (a) to investigate the bond markets' integration during the 2008 financial crisis, and (b) to find the causal relationship between the MSCI Emerging Markets and the USA. Granger causality and correlation tests are used to assess the short-term integration of the bond markets. The long-term integration is examined using Johansen's co-integration test and VAR analysis.

It was observed that few past studies had used weekly data, but to get strong results, the present study uses the daily closing date of the bond indices of USA and MSCI Emerging Asian markets (capitalization-weighted methods are used to calculate each index.). All the indices were taken from investing.com. The two series don't have to be in the same currency for the cointegration method to work (Ding et al., 1999). Considering this, the current analysis overlooks currency concerns and denominates the index data in local currency units. The lack of data resulting from holidays makes it difficult to measure market integration. The missing data can be filled in with the previous day's price (Jeon & Von Furstenberg, 1990). Considering this suggestion of Jeon and Von, in the context of Occam's razor, in this study, the deficient value is filled in using the previous day's pricing.

A descriptive research design has been used for the study. The present study uses the returns of government bonds of China, India, Indonesia, Malaysia, Pakistan, Philippines, South Korea, Taiwan, Thailand, and the USA. The study period is from January 1, 2001 to December 31, 2021. However, the period of the study witnessed the financial crisis. Thus, to get a disturbance-free outcome, the data in this study have been divided into two phases, excluding the period of the financial crisis: pre-crisis and post-crisis. The era before the financial crisis runs from January 1, 2001 to June 30, 2008. The post-crisis period spans the dates of January 1, 2009 to December 31, 2021. Each series is converted into a natural logarithm. The study was conducted in April 2022.

## Data Analysis and Results

Table 1 shows the descriptive statistics of the bond returns. In the duration of the pre-crisis period, India, Thailand,

**Table 1.** ***Descriptive Statistics***

| Particulars | Mean | Maximum | Minimum | *SD* | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| | | | **Pre-Crisis Period** | | | |
| China | 2.01 | 12.67 | –16.35 | 1.84 | –0.384 | 15.11 |
| India | –1.02 | 22.28 | –21.96 | 1.98 | 3.50 | 159.32 |
| Indonesia | 1.30 | 13.99 | –15.98 | 1.38 | 0.00 | 36.15 |
| Malaysia | 2.00 | 15.82 | –11.61 | 1.52 | 0.81 | 19.57 |
| Pakistan | 7.30 | 38.30 | –31.2 | 2.78 | 2.86 | 77.69 |
| Philippines | –4.40 | 20.39 | –13.07 | 1.46 | 1.28 | 35.72 |
| Korea | –1.70 | 18.70 | –9.83 | 1.56 | 1.80 | 28.42 |
| Taiwan | 2.51 | 26.51 | –34.58 | 4.06 | 7.06 | 173.86 |
| Thailand | –1.72 | 14.44 | –11.11 | 1.73 | 1.02 | 14.31 |
| USA | –0.30 | 7.98 | –15.44 | 1.81 | –0.1 | 7.97 |
| | | | **Post-Crisis Period** | | | |
| China | 0.90 | 9.37 | –8.94 | 1.38 | 0.17 | 11.03 |
| India | 0.91 | 9.74 | –3.9 | 0.62 | 3.05 | 44.71 |
| Indonesia | –1.61 | 7.27 | –6.79 | 1.15 | 0.30 | 8.74 |
| Malaysia | –0.61 | 6.81 | –4.05 | 0.64 | 1.10 | 19.28 |
| Pakistan | 2.14 | 19.79 | –19.13 | 1.40 | 5.47 | 167.17 |
| Philippines | 3.91 | 18.22 | –21.96 | 2.88 | 0.89 | 21.14 |
| Korea | –8.02 | 8.26 | –100 | 2.27 | –31.54 | 1384.06 |
| Taiwan | 16.1 | 4.34 | –9.77 | 8.39 | 37.65 | 1668.95 |
| Thailand | –10.8 | 13.08 | –10 | 3.72 | –21.5 | 578.84 |
| USA | –0.60 | 11.36 | –10.44 | 2.07 | 0.20 | 5.45 |

the Philippines, Korea, and the USA witnessed average negative returns. Pakistan experienced the highest average return of any market, at 7.3%. In the duration of the post-crisis period, Indonesia, Malaysia, Korea, Thailand, and the US witnessed a negative average return. Among all the markets, Taiwan witnessed the highest average return. In the pre-crisis period, Taiwan witnessed the highest standard deviation. Among all the markets, Indonesia has the lowest standard deviation. The Pakistani bond's high return and high risk demonstrate the financial theory that greater risk results in greater returns. In the duration of the post-crisis period, the Taiwan market has a maximum standard deviation. The Taiwan market has the highest return, proving that the higher the risk, the higher the return. Among all the markets, India has the lowest standard deviation. After the financial crisis, the bond returns of China, India, Indonesia, Malaysia, and Pakistan have fallen. However, the bond returns of the Philippines, Korea, Taiwan, Thailand, and the USA witnessed an upward trend.

### *Correlation Analysis*

Table 2 shows the results of the correlation between the bond returns for the pre-and post-crisis periods. In the pre-crisis period, the Indian bond is positively correlated with the Chinese bond, Malaysian bond, and US bond. The Indian bond does not have a significant correlation with the bonds of Indonesia, Pakistan, the Philippines,

**Table 2.** ***Correlation Analysis***

| | | Pre-Crisis Period | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Market** | **China** | **India** | **Indonesia** | **Malaysia** | **Pakistan** | **Philippines** | **Korea** | **Taiwan** | **Thailand** | **USA** |
| **P** | **China** | 1 | 0.34 | 0.021 | –0.008 | 0.31 | –0.005 | –0.003 | 0.25 | 0.006 | 0.023 |
| **o** | **India** | 0.41 | 1 | 0.004 | 0.29 | 0.017 | 0.019 | 0.004 | 0.005 | 0.022 | 0.244 |
| **s** | **Indonesia** | 0.35 | 0.21 | 1 | –0.001 | 0.018 | 0.165 | –0.005 | 0.009 | 0.142 | –0.003 |
| **t** | **Malaysia** | –0.013 | 0.314 | –0.012 | 1 | 0.056 | –0.027 | –0.021 | –0.019 | 0.013 | 0.005 |
| **–** | **Pakistan** | 0.001 | 0.015 | 0.003 | 0.010 | 1 | 0.010 | 0.002 | –0.009 | –0.005 | 0.027 |
| **c** | **Philippines** | 0.014 | 0.036 | 0.013 | –0.034 | –0.015 | 1 | –0.018 | 0.010 | 0.012 | 0.022 |
| **r** | **Korea** | –0.003 | 0.12 | –0.003 | 0.031 | –0.010 | –0.014 | 1 | 0.001 | 0.021 | –0.003 |
| **i** | **Taiwan** | –0.003 | –0.013 | –0.029 | 0.002 | –0.002 | 0.005 | 0.047 | 1 | 0.003 | 0.001 |
| **s** | **Thailand** | 0.019 | 0.008 | 0.035 | 0.004 | 0.000 | 0.030 | –0.009 | 0.003 | 1 | –0.034 |
| **i** | **USA** | 0.005 | 0.422 | –0.006 | 0.004 | –0.022 | –0.001 | –0.010 | –0.001 | –0.035 | 1 |
| **s** | | | | | | | | | | | |

Korea, Taiwan, and Thailand. In the post-crisis period, the Indian bond has a positive correlation with the US, China, Malaysia, Indonesia, and Korea bonds only. In the pre-crisis period, China's bond has a positive correlation with the bonds of India, Pakistan, and Taiwan. China's bond does not have a significant correlation with any other bond. In the post-crisis period, China's bond has a positive correlation with Indian and Indonesian bonds only.

In the pre-crisis period, Indonesian bonds do not have a significant correlation with any bond. The Indonesian bond has the highest positive correlation with the China bond only in the post-crisis period. The Malaysian bond has the highest positive correlation with the Indian bond only in both periods. Pakistan bond has the highest positive correlation with the China bond only during the pre-crisis period. Even during the post-crisis period, the Pakistan bond does not have a significant correlation with any bond. The Philippines bond has the highest positive correlation with the Indonesian bond only in the pre-crisis period. However, in the post-crisis period, the Philippines bond does not have a significant correlation with any bond. The Korean bond has a somewhat positive correlation with the Indian bond only. The Taiwan bond has a positive correlation with the China bond only in the pre-crisis period. The Taiwan bond is not correlated with any other bond during the post-crisis period. Thailand's bond has a positive correlation with the Indonesian bond only in the pre-crisis period. The Thailand bond is not correlated in the post-crisis period. The US bond has a positive correlation with the Indian bond only in the pre-crisis and post-crisis periods. Overall, after the financial crisis, a correlation between the bond returns has increased.

### *Unit Root Test*

The results of the unit root test (ADF and PP test) are displayed in Table 3. To perform the bivariate causalities, the data needs to be stationary (Gujarati, 2009; Harvey, 1990). Here, the augmented Dickey–Fuller test (ADF) test (Dickey & Fuller, 1979; Dickey et al., 1986), and Phillips–Perron test (Phillips & Perron, 1988) are performed to check the stationarity of the data. The ADF and PP test is performed in EViews 9 Econometric Software. Here, the H0 for the unit root test gets failed to reject at a 1% significance level. The H0 can, however, be rejected at the first difference level. As a result, all the series are integrated into the same sequence and are stationary, that is, I (1). So, the data is found to be suitable for performing further tests.

**Table 3.** ***Unit Root Test***

| | Pre-Crisis Period | | | | Post-Crisis Period | | | |
|---|---|---|---|---|---|---|---|---|
| **Market** | **Level** | | **First Difference** | | **Level** | | **First Difference** | |
| | **ADF** | **PP** | **ADF** | **PP** | **ADF** | **PP** | **ADF** | **PP** |
| China | –2.54 | –2.45 | –81.45* | –78.89* | –2.45 | –2.39 | –84.46* | –80.02* |
| India | –1.67 | –1.71 | –53.34* | –55.45* | –1.78 | –1.83 | –55.57* | –57.67* |
| Indonesia | –1.87 | –1.91 | –77.35* | –79.45* | –1.87 | –1.89 | –78.56* | –75.45* |
| Malaysia | –1.98 | –1.93 | –60.34* | –62.45* | –1.98 | –1.99 | –64.56* | –68.57* |
| Pakistan | –2.02 | –2.00 | –65.45* | –68.96* | –2.23 | –2.21 | –66.68* | –71.21* |
| Philippines | –2.08 | –2.01 | –75.45* | –76.98* | –2.87 | –2.01 | –78.45* | –79.45* |
| Korea | –2.21 | –2.12 | –89.12* | –92.11* | –2.11 | –2.34 | –88.56* | –91.35* |
| Taiwan | –2.12 | –2.14 | –99.34* | –99.87* | –2.10 | –2.23 | –99.56* | –95.45* |
| Thailand | –2.34 | –2.15 | –82.46* | –86.56* | –2.21 | –2.35 | –87.34* | –83.46* |
| USA | –2.45 | –2.44 | –92.85* | –94.56* | –2.34 | –2.48 | –91.46* | –90.45* |

***Note.*** * significant at the 1% level. The AIC is the basis for the lag lengths. The ADF and PP are trending and consistent.

**Table 4.** ***Granger Causality Test – Pre-Crisis Period***

| | | Caused to | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Market** | **China** | **India** | **Indonesia** | **Malaysia** | **Pakistan** | **Philippines** | **Korea** | **Taiwan** | **Thailand** | **USA** |
| **C** | **China** | – | → | ≠ | ≠ | → | ≠ | ≠ | → | ≠ | ≠ |
| **a** | **India** | ≠ | – | ≠ | → | ≠ | ≠ | ≠ | ≠ | ≠ | → |
| **u** | **Indonesia** | ≠ | ≠ | – | ≠ | ≠ | → | ≠ | ≠ | → | ≠ |
| **s** | **Malaysia** | ≠ | ≠ | → | – | ≠ | ≠ | → | ≠ | ≠ | ≠ |
| **e** | **Pakistan** | ≠ | ≠ | ≠ | ≠ | – | ≠ | ≠ | ≠ | ≠ | ≠ |
| **d** | **Philippines** | → | ≠ | ≠ | → | ≠ | – | ≠ | ≠ | ≠ | ≠ |
| | **Korea** | ≠ | ≠ | ≠ | ≠ | ≠ | ≠ | – | ≠ | ≠ | ≠ |
| **b** | **Taiwan** | → | → | ≠ | ≠ | ≠ | ≠ | ≠ | – | ≠ | ≠ |
| **y** | **Thailand** | ≠ | ≠ | → | ≠ | ≠ | → | ≠ | ≠ | – | ≠ |
| | **USA** | → | → | ≠ | ≠ | ≠ | ≠ | ≠ | ≠ | ≠ | – |

### *Granger Causality Test*

Tables 4 and 5 show the results of the Granger causality test for the pre-and post-crisis periods, respectively. China does Granger cause to India in both periods, with a unidirectional relationship. China has a one-way relationship with Indonesia in the post-crisis period only. China doesn't have any Granger causality with Malaysia and Thailand during both periods. Before the financial crisis, China had one-way relations with Pakistan and the Philippines. However, China does not have Granger causality with Pakistan and the Philippines in the post-crisis period. China and Korea do not have causality during the pre-crisis period. However, during the post-crisis period, both markets have a bi-directional relationship. Taiwan and China have a bi-directional and unidirectional relationship in the pre-crisis and post-crisis periods, respectively. China has a uni-directional association with the

**Table 5.** ***Granger Causality Test – Post-Crisis Period***

| | | Caused to | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Market** | **China** | **India** | **Indonesia** | **Malaysia** | **Pakistan** | **Philippines** | **Korea** | **Taiwan** | **Thailand** | **USA** |
| **C** | **China** | – | → | → | ≠ | ≠ | ≠ | → | → | ≠ | ≠ |
| **a** | **India** | ≠ | – | → | → | ≠ | ≠ | → | ≠ | ≠ | → |
| **u** | **Indonesia** | ≠ | → | – | ≠ | ≠ | → | → | ≠ | ≠ | ≠ |
| **s** | **Malaysia** | ≠ | ≠ | → | – | ≠ | ≠ | ≠ | ≠ | ≠ | ≠ |
| **e** | **Pakistan** | ≠ | ≠ | ≠ | → | – | ≠ | ≠ | ≠ | ≠ | ≠ |
| **d** | **Philippines** | ≠ | ≠ | → | → | ≠ | – | ≠ | ≠ | ≠ | → |
| | **Korea** | → | → | ≠ | ≠ | ≠ | ≠ | – | ≠ | ≠ | ≠ |
| **b** | **Taiwan** | ≠ | → | ≠ | ≠ | ≠ | → | ≠ | – | → | ≠ |
| **y** | **Thailand** | ≠ | ≠ | → | ≠ | ≠ | → | ≠ | ≠ | – | ≠ |
| | **USA** | ≠ | → | ≠ | → | ≠ | ≠ | ≠ | ≠ | ≠ | – |

USA in the pre-crisis period. However, both the markets do not Granger cause to each other in the post-crisis period. India and Indonesia do not have a relationship in the pre-crisis period, but both markets have a bi-directional relationship in the post-crisis period.

India has a one-way relationship with Malaysia in both periods. India does not have any Granger causality with Pakistan, the Philippines, and Thailand in both periods. India does not have a relationship with Korea in the pre-crisis period, but in the post-crisis period, both markets have a bi-directional relationship. India and Taiwan have a unidirectional relationship in both periods. India and USA have a bi-directional relationship in both periods. In the pre-crisis period, Indonesia does not have Granger causality with Pakistan, Korea, Taiwan, and USA. Indonesia has a uni-directional relationship with Malaysia and the Philippines only. Indonesia has a bi-directional relationship with Thailand only. In the post-crisis period, Indonesia only has uni-directional relationships with Malaysia, Korea, and Thailand. Indonesia has a bi-directional relationship with the Philippines only.

In the pre-crisis period, Malaysia has a uni-directional relationship with India, the Philippines, Indonesia, and Korea only. In the post-crisis period, Malaysia has a uni-directional relationship with India, Pakistan, Philippines, Indonesia, and the USA only. Pakistan has a unidirectional relationship with China and Malaysia only in pre- and post-crisis periods, respectively. In the pre-crisis period, the Philippines has uni-directional relationships with Indonesia, Thailand, China, and Malaysia only. However, in the post-crisis period, the Philippines has a uni-directional relationship with Taiwan and Thailand. The Philippines has a bi-directional relationship with Indonesia in the post-crisis period. Korea is Granger caused by Malaysia only in the pre-crisis period. However, Korea has a bidirectional relationship with China and India in the post-crisis period.

Taiwan has bi-directional and uni-directional relations with China and India, respectively, in the pre-crisis period. In the post-crisis period, Taiwan has a uni-directional relationship with India, the Philippines, Thailand, and China only. In the pre-crisis period, Thailand has uni-directional and bi-directional relationships with the Philippines and Indonesia, respectively. In the post-crisis period, Thailand has a uni-directional relationship with Taiwan, the Philippines, and Indonesia only. The USA has a bidirectional relationship with India in both periods. The USA has a unidirectional relationship with China and the Philippines, in pre-and post-crisis periods, respectively. Overall, after the financial crisis, the bond markets became more integrated.

**Table 6.** ***Johnsen Co-Integration Test – Pre-Crisis Period***

| Option No. | Portfolio Combinations | Null Hypothesis | Trace Statistics | Maximum Eigen Statistics | Probability |
|---|---|---|---|---|---|
| 1 | China, India, Pakistan, Taiwan | $r \leq 0$ | 2117.400** | 619.5205** | 0.0001 |
| | | $r \leq 1$ | 1497.879 | 549.1344 | 0.0001 |
| | | $r \leq 2$ | 948.7450 | 507.6064 | 0.0001 |
| | | $r \leq 3$ | 441.1385 | 441.1385 | 0.0000 |
| 2 | India, Malaysia, USA | $r \leq 0$ | 1257.459** | 471.4865** | 0.0001 |
| | | $r \leq 1$ | 785.9724 | 425.1150 | 0.0001 |
| | | $r \leq 2$ | 360.8574 | 360.8574 | 0.0000 |
| 3 | Indonesia, Philippines, Thailand | $r \leq 0$ | 1101.834 | 411.8761 | 0.0102 |
| | | $r \leq 1$ | 689.9582 | 382.6970 | 0.0981 |
| | | $r \leq 2$ | 307.2612 | 307.2612 | 0.0740 |
| 4 | Malaysia, Indonesia, Korea | $r \leq 0$ | 1128.008 | 422.5970 | 0.1050 |
| | | $r \leq 1$ | 705.4106 | 358.2165 | 0.9240 |
| | | $r \leq 2$ | 347.1940 | 347.1940 | 0.8645 |
| 5 | Philippines, China, Malaysia | $r \leq 0$ | 1252.052 | 501.5580 | 0.1241 |
| | | $r \leq 1$ | 750.4941 | 386.1089 | 0.1045 |
| | | $r \leq 2$ | 364.3851 | 364.3851 | 0.0987 |
| 6 | Taiwan, China, India | $r \leq 0$ | 1500.301** | 549.2641** | 0.0001 |
| | | $r \leq 1$ | 951.0369 | 509.6429 | 0.0001 |
| | | $r \leq 2$ | 441.3940 | 441.3940 | 0.0000 |
| 7 | Thailand, Indonesia, Philippines | $r \leq 0$ | 1101.834 | 411.8761 | 0.1201 |
| | | $r \leq 1$ | 689.9582 | 382.6970 | 0.1090 |
| | | $r \leq 2$ | 307.2612 | 307.2612 | 0.0983 |
| 8 | USA, China, and India | $r \leq 0$ | 1383.356** | 513.7507** | 0.0120 |
| | | $r \leq 1$ | 869.6049 | 450.6838 | 0.0110 |
| | | $r \leq 2$ | 418.9210 | 418.9210 | 0.0091 |

***Note.*** **MacKinnon-Haug-Michelis (1999) *p*-values. ; ** significance at the 1% level.

### *Johansen Co-Integration Test*

Table 6 shows the outcomes of the Johansen co-integration test for the pre-crisis period. Based on short-term integration between the markets, a total of eight different portfolio combinations were developed. The H0 is that there is no cointegration. The null hypothesis is rejected at a significance level of 1% for four different portfolio combinations, that is, Portfolio Combination 1 (China, India, Pakistan, and Taiwan), Portfolio Combination 2 (India, Malaysia, and USA), Portfolio Combination 6 (Taiwan, China, and India), and Portfolio Combination 8 (USA, China, and India). The value of trace statistics and maximum Eigen statistics are significant in all these portfolios. Further, the trace value is more than the critical value in all four portfolio options. The H0 fails to reject a significance level of 1% for four different portfolio combinations, that is, Portfolio Combination 3 (Indonesia, Philippines, and Thailand), Portfolio Combination 4 (Malaysia, Indonesia, and Korea), Portfolio Combination 5 (Philippines, China, and Malaysia), and Portfolio Combination 7 (Thailand, Indonesia, Philippines). Hence,

**Table 7. *Johnsen Co-Integration Test – Post-Crisis Period***

| Option No. | Portfolio Combinations | Null Hypothesis | Trace Statistics | Maximum Eigen Statistics | Probability |
|---|---|---|---|---|---|
| 1 | China, India, Indonesia, Korea, Taiwan | $r \leq 0$ | 2545.490** | 631.1220** | 0.0001 |
| | | $r \leq 1$ | 1914.368 | 559.4693 | 0.0001 |
| | | $r \leq 2$ | 1354.899 | 470.2339 | 0.0001 |
| | | $r \leq 3$ | 884.6648 | 448.1213 | 0.0001 |
| | | $r \leq 4$ | 436.5435 | 436.5435 | 0.0000 |
| 2 | India, Indonesia, Malaysia, Korea, USA | $r \leq 0$ | 2438.291** | 561.1334** | 0.0001 |
| | | $r \leq 1$ | 1877.158 | 548.3285 | 0.0001 |
| | | $r \leq 2$ | 1328.829 | 456.9414 | 0.0001 |
| | | $r \leq 3$ | 871.8879 | 451.2474 | 0.0001 |
| | | $r \leq 4$ | 420.6405 | 420.6405 | 0.0000 |
| 3 | Indonesia, India, Philippines, Korea | $r \leq 0$ | 2046.496** | 631.0212** | 0.0001 |
| | | $r \leq 1$ | 1415.475 | 514.2765 | 0.0001 |
| | | $r \leq 2$ | 901.1984 | 456.0125 | 0.0001 |
| | | $r \leq 3$ | 445.1858 | 445.1858 | 0.0000 |
| 4 | Malaysia, Indonesia | $r \leq 0$ | 898.5874 | 454.3394 | 0.1121 |
| | | $r \leq 1$ | 444.2480 | 444.2480 | 0.1034 |
| 5 | Pakistan, Malaysia | $r \leq 0$ | 994.3872 | 548.5914 | 0.1143 |
| | | $r \leq 1$ | 445.7958 | 445.7958 | 0.1073 |
| 6 | Philippines, Indonesia, Malaysia, USA | $r \leq 0$ | 2027.253 | 613.9176 | 0.1250 |
| | | $r \leq 1$ | 1413.335 | 538.0873 | 0.1010 |
| | | $r \leq 2$ | 875.2475 | 449.0451 | 0.0914 |
| | | $r \leq 3$ | 426.2025 | 426.2025 | 0.0853 |
| 7 | Korea, China, India | $r \leq 0$ | 1631.164** | 630.2326** | 0.0001 |
| | | $r \leq 1$ | 1000.931 | 546.1031 | 0.0001 |
| | | $r \leq 2$ | 454.8282 | 454.8282 | 0.0000 |
| 8 | Taiwan, India, Philippines, Thailand | $r \leq 0$ | 2136.170** | 625.2243** | 0.0001 |
| | | $r \leq 1$ | 1510.946 | 579.8553 | 0.0001 |
| | | $r \leq 2$ | 931.0902 | 489.3270 | 0.0001 |
| | | $r \leq 3$ | 441.7632 | 441.7632 | 0.0000 |
| 9 | Thailand, Indonesia, Philippines | $r \leq 0$ | 1596.029 | 617.0892 | 0.1242 |
| | | $r \leq 1$ | 978.9402 | 537.6063 | 0.1041 |
| | | $r \leq 2$ | 441.3339 | 441.3339 | 0.0900 |
| 10 | USA, India, Malaysia | $r \leq 0$ | 1496.600** | 560.1268** | 0.0001 |
| | | $r \leq 1$ | 936.4736 | 508.1951 | 0.0001 |
| | | $r \leq 2$ | 428.2786 | 428.2786 | 0.0000 |

Portfolio Combination 3, 4, 5, and 7 provide the opportunity for portfolio diversification, as there is no cointegration in these portfolio combinations.

Table 7 shows the outcomes of the Johansen co-integration test during the post-crisis period. Based on short-term integration between the markets, a total of 10 different portfolio combinations were developed. The null hypothesis is rejected at a significance level of 1% for six different portfolio combinations, that is, Portfolio Combination 1 (China, India, Indonesia, Korea, Taiwan), Portfolio Combination 2 (India, Indonesia, Malaysia, Korea, USA), Portfolio Combination 3 (Indonesia, India, Philippines, Korea), Portfolio Combination 7 (Korea, China, India), Portfolio Combination 8 (Taiwan, India, Philippines, Thailand), and Portfolio Combination 10 (USA, India, Malaysia). The value of trace statistics and maximum Eigen statistics are significant in all these portfolios. Further, the trace value is more than the critical value in all six portfolio options. The H0 fails to reject a significance level of 1% for four different portfolio combinations, that is, Portfolio Combination 4 (Malaysia, Indonesia), Portfolio Combination 5 (Pakistan, Malaysia), Portfolio Combination 6 (Philippines, Indonesia, Malaysia, USA), and Portfolio Combination 9 (Thailand, Indonesia, Philippines). Portfolio Combination 4, 5, 6, and 9 provide the opportunity for portfolio diversification as there is no cointegration in these portfolio combinations. Moreover, it is found that the MSCI Emerging Asian markets and the US market turn out to be more integrated after the 2008 global financial crisis.

**Table 8.** ***Variance Decomposition of India***

| Pre-Crisis Period | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Period** | **India** | **Indonesia** | **Korea** | **Malaysia** | **Pakistan** | **Philippines** | **Taiwan** | **Thailand** | **USA** | **China** |
| 1 | 92.81 | 0.79 | 0.12 | 0.51 | 0.21 | 0.31 | 0.75 | 0.13 | 2.79 | 1.58 |
| 2 | 92.84 | 0.81 | 0.12 | 0.53 | 0.21 | 0.31 | 0.79 | 0.14 | 2.81 | 1.58 |
| 3 | 91.71 | 0.81 | 0.13 | 0.53 | 0.21 | 0.31 | 0.79 | 0.29 | 3.59 | 1.92 |
| 4 | 91.64 | 0.84 | 0.13 | 0.55 | 0.21 | 0.31 | 0.81 | 0.30 | 3.59 | 1.92 |
| 5 | 91.28 | 0.84 | 0.13 | 0.55 | 0.21 | 0.31 | 0.81 | 0.30 | 3.59 | 1.98 |
| 6 | 91.26 | 0.86 | 0.13 | 0.55 | 0.21 | 0.31 | 0.81 | 0.30 | 3.59 | 1.98 |
| 7 | 91.26 | 0.86 | 0.13 | 0.55 | 0.21 | 0.31 | 0.81 | 0.30 | 3.59 | 1.98 |
| 8 | 91.26 | 0.86 | 0.13 | 0.55 | 0.21 | 0.31 | 0.81 | 0.30 | 3.59 | 1.98 |
| 9 | 91.26 | 0.86 | 0.13 | 0.55 | 0.21 | 0.31 | 0.81 | 0.30 | 3.59 | 1.98 |
| 10 | 91.26 | 0.86 | 0.13 | 0.55 | 0.21 | 0.31 | 0.81 | 0.30 | 3.59 | 1.98 |
| **Post-Crisis Period** | | | | | | | | | | |
| 1 | 92.4 | 0.81 | 0.66 | 0.52 | 0.27 | 0.39 | 0.73 | 0.47 | 2.23 | 1.52 |
| 2 | 92.26 | 0.91 | 0.66 | 0.54 | 0.27 | 0.39 | 0.74 | 0.47 | 2.24 | 1.52 |
| 3 | 90.96 | 0.91 | 0.79 | 0.57 | 0.27 | 0.42 | 0.81 | 0.47 | 2.84 | 1.96 |
| 4 | 90.84 | 0.92 | 0.79 | 0.57 | 0.3 | 0.42 | 0.81 | 0.55 | 2.84 | 1.96 |
| 5 | 88.99 | 1.22 | 0.91 | 0.57 | 0.3 | 0.42 | 0.86 | 0.55 | 3.97 | 2.21 |
| 6 | 88.89 | 1.22 | 0.91 | 0.57 | 0.3 | 0.42 | 0.86 | 0.55 | 3.97 | 2.31 |
| 7 | 88.89 | 1.22 | 0.91 | 0.57 | 0.3 | 0.42 | 0.86 | 0.55 | 3.97 | 2.31 |
| 8 | 88.89 | 1.22 | 0.91 | 0.57 | 0.3 | 0.42 | 0.86 | 0.55 | 3.97 | 2.31 |
| 9 | 88.89 | 1.22 | 0.91 | 0.57 | 0.3 | 0.42 | 0.86 | 0.55 | 3.97 | 2.31 |
| 10 | 88.89 | 1.22 | 0.91 | 0.57 | 0.3 | 0.42 | 0.86 | 0.55 | 3.97 | 2.31 |

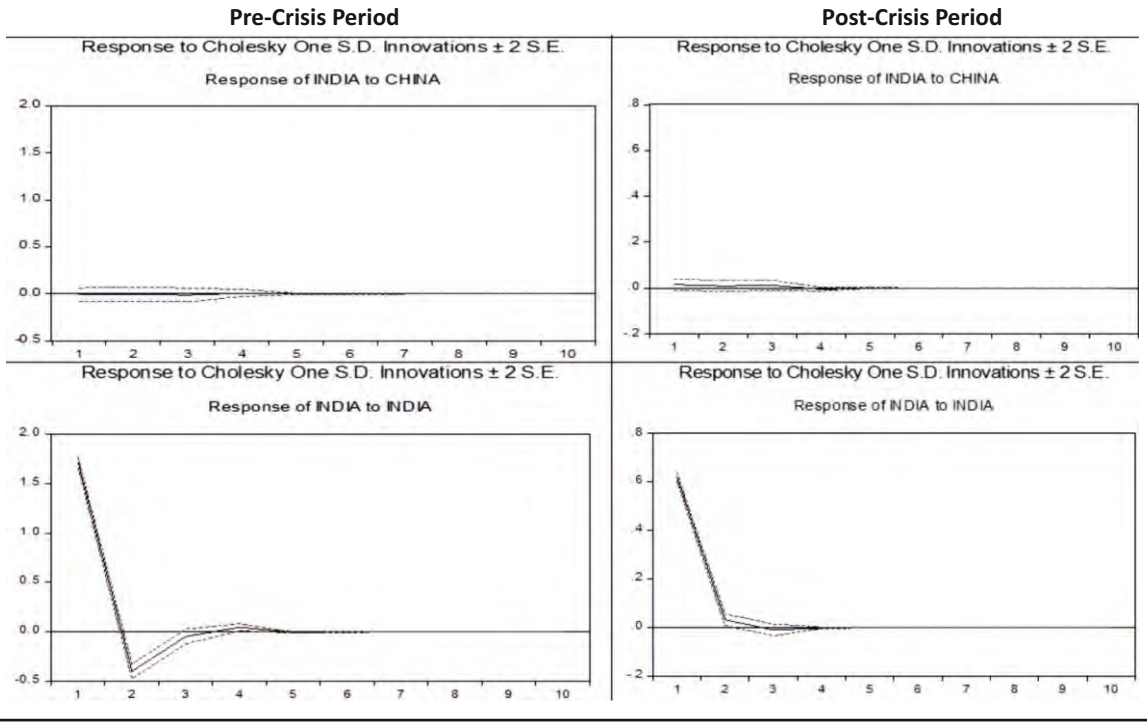
### *VAR Analysis*

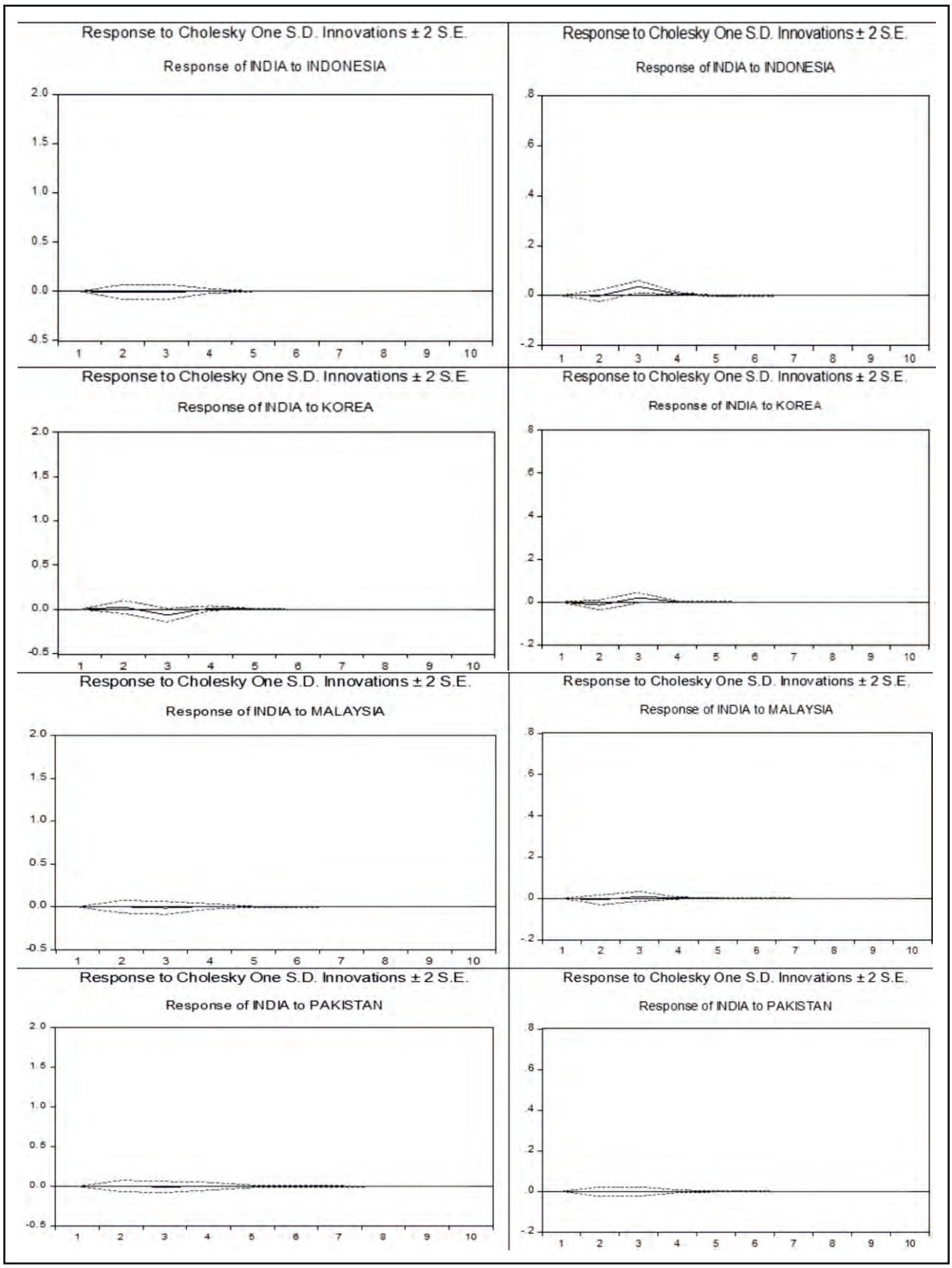
The VAR can be used concerning the existence of integration (Engle & Granger, 1987). Table 8 shows the results of VDCs of the pre-and post-crisis periods for the Indian bond. For its inventions, the Indian bond error variance is accounted. The Indian bond is affected by the innovations in the bond markets of the USA and China in both periods. The USA bond accounts for a significant value of 3.6% and 4% Indian forecast error variance during the pre and post-crisis periods, respectively. The China bond accounts for a significant value of 2% and 2.3% Indian forecast error variance during the pre and post-crisis periods, respectively. The China and USA markets are affected by the variations in the Indian bond in both periods. In the pre-crisis period, Indonesia, Taiwan, and Malaysia have a nominal effect on the Indian bond. The Indian bond is not affected by the innovations in Korea, Pakistan, Philippines, and Thailand bond markets in the pre-crisis period. In the pre-crisis period, Indonesia, Taiwan, Korea, Philippines, Thailand, and Malaysia have a nominal effect on the Indian bond. The Indian bond is not affected by the innovations in the Pakistan bond in the post-crisis period. The results of the VDC and IRF may be appropriate, given Cholesky's decomposition. As a result, Pesaran and Shin's (1998) impulse response analysis is also used in the research. Overall, the bond markets become more integrated after the financial crisis, but not significantly.

### *Impulse Response Analysis*

Figure 1 displays the findings of the impulse response study for the pre-and post-crisis eras. During the pre-crisis period, the innovations in the USA and China bond markets only affected the Indian bond market. The rest of the markets do not affect the Indian bond market. In the post-crisis period, the innovations in the China and USA

**Figure 1.** ***Impulse Response Analysis***




Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of INDIA to INDONESIA
Response to Cholesky One S.D. Innovations ± 2 S.E.
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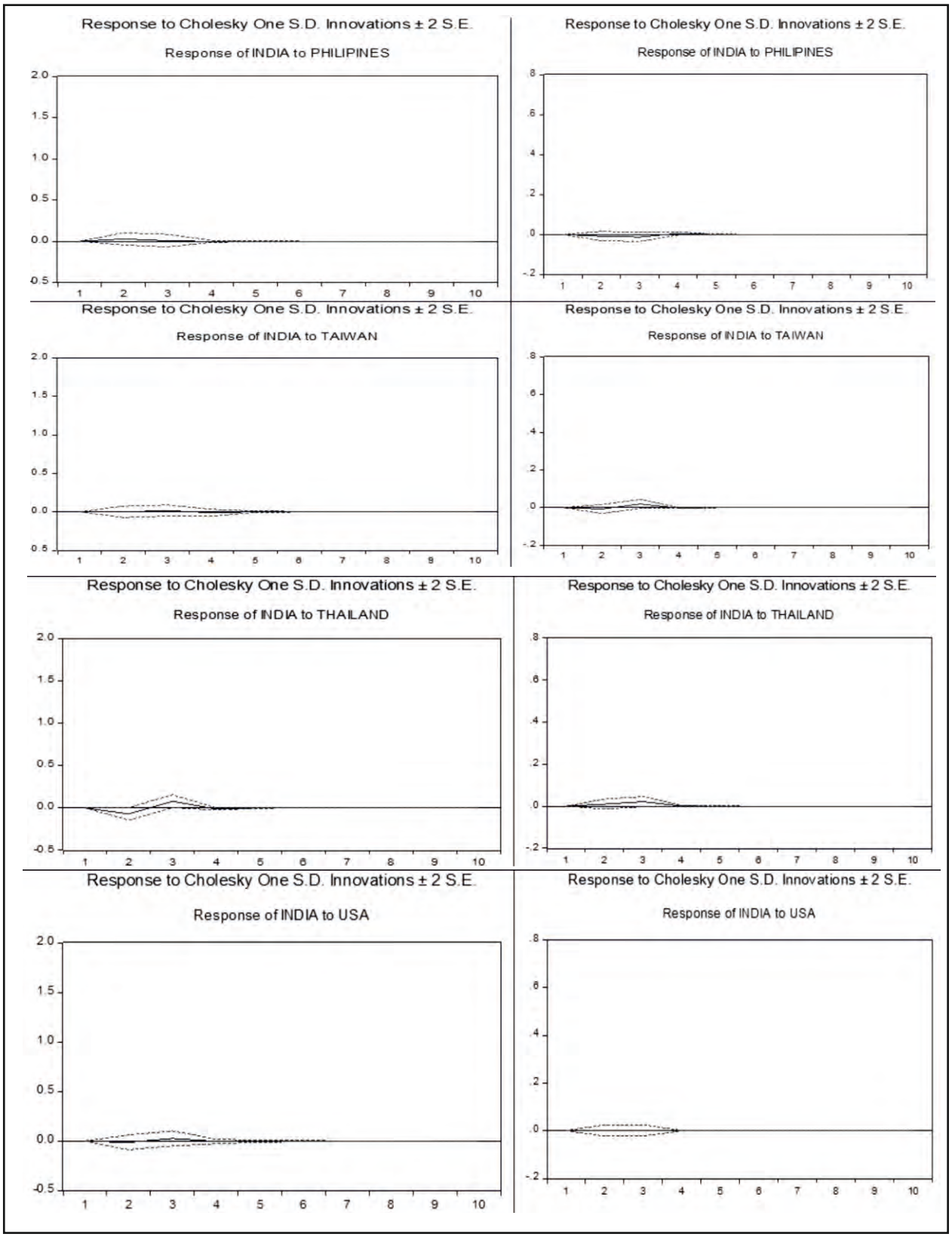
Response of INDIA to MALAYSIA
Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of INDIA to MALAYSIA
Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of INDIA to PAKISTAN
Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of INDIA to PAKISTAN


Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of INDIA to PHILIPINES
Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of INDIA to PHILIPINES
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Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of INDIA to USA

markets only affected the Indian bond market. Other markets do not affect the Indian bond market significantly. However, the market has a higher impact as compared to the pre-crisis period. Further, all the markets became highly integrated after the 2008 financial crisis.

## Conclusion

The results of the impulse response study for the pre-and post-crisis periods are shown in Figure 1. The study is performed on the bond returns of government bonds of China, India, Indonesia, Malaysia, Pakistan, Philippines, South Korea, Taiwan, Thailand, and the USA, covering a period from January 1, 2001 to August 31, 2020.

The correlation results show that post-financial crisis, the markets become highly correlated with each other. China has Granger causality with India, Pakistan, the Philippines, and the USA in the pre-crisis period. China has Granger causality with India, Indonesia, Korea, and Taiwan during the post-crisis period. India has Granger causality with Taiwan, Malaysia, China, and USA in the pre-crisis period. India has Granger causality with Indonesia, Malaysia, Korea, Taiwan, China, and USA in the post-crisis period. India does not have any Granger causality with Pakistan, the Philippines, and Thailand in both periods. In the pre-crisis period, Indonesia has a uni-directional relationship with Malaysia and the Philippines only. In the post-crisis period, Indonesia has a uni-directional correlation with Malaysia, Korea, and Thailand only. In the pre-crisis period, Malaysia has a uni-directional relationship with India, the Philippines, Indonesia, and Korea only. In the post-crisis period, Malaysia has a uni-directional relationship with India, Pakistan, Philippines, Indonesia, Korea, and USA only. Pakistan has a side relationship with China and Malaysia only in pre- and post-crisis periods, respectively. In the pre-crisis period, the Philippines has a uni-directional relationship with Indonesia, Thailand, China, and Malaysia only. The USA has a bidirectional relationship with India in both periods. The USA has a unidirectional relationship with China and the Philippines in the pre-and post-crisis periods. The results of the Granger test prove that those markets, which are economically and geographically close, are highly integrated (Janakiramanan & Lamba, 1998). Additionally, following the financial crisis, there was a rise in market integration during a short period. The bond markets did become slightly more integrated after the financial crisis, but not significantly.

The results of the Johansen co-integration test show that during the pre-crisis period, India has long-term integration with China and the USA. The Portfolio Combination 3 (Indonesia, Philippines, and Thailand), Portfolio Combination 4 (Malaysia, Indonesia, and Korea), Portfolio Combination 5 (Philippines, China, and Malaysia), and Portfolio Combination 7 (Thailand, Indonesia, Philippines) show no cointegration and hence provide the opportunity for portfolio diversification. In the post-crisis period, in 4 out of 10 portfolio options, Portfolio Combination 4, 5, 6, and 9 provide the opportunity for portfolio diversification, as there is no cointegration in these portfolio combinations. Moreover, it is found that MSCI Emerging Asian markets and the US market become highly integrated after the 2008 global financial crisis.

The results of the VAR analysis and impulse response analysis observe that innovations in the markets of the USA and China affect the Indian market in both pre-and post-crisis periods. However, the rest of the markets have a nominal impact on the Indian market in both pre-and post-crisis periods. It is found that after the financial crisis, the bond markets become more integrated, but not significantly. The findings are consistent with those of Rughoo and You (2016).

## Managerial and Theoretical Implications

The study has practical implications for investors. Based on the integration among various markets, investors can diversify their investments. Rather than investing in one particular market, investors diversify their investments,

which can result in a better risk-return trade-off. The integration between the markets offers a portfolio diversification prospect to investors. The outcomes of the study have implications for the monetary policies of the countries. The monetary and economic policies can be designed by considering the integration among the markets, which can help to decrease the economic-specific risk and crisis at the international level. Moreover, the integration among the markets can help design the policies to gain synergy. Hence, governments and policymakers can consider the level of market integration for drafting economic and monetary policies.

## Limitations of the Study and Scope for Future Research

The study is limited to one developed market (USA) and the emerging Asian markets. In the future, more studies can be conducted concerning Asian frontier markets and other emerging markets to evaluate the opportunities for portfolio diversification for the other developed markets of the world.

## Authors' Contribution

Dr. Ritesh J. Patel generated the idea of assessing the bond markets' integration and portfolio diversification and worked on the introduction, literature review, and research methodology. Dr. Divyesh J. Gandhi worked on the data collection, processing, and analysis. Dr. Mitesh K. Patel worked on the interpretation and conclusion. Prof. Tejas M. Modi worked on the conclusion, final review, and editing of the manuscript.

## Conflict of Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.


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