Financial Integration and Variance Decomposition of Asian Stock Market: Evidence from India

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ABSTRACT

Manuscript type: Research paper

Research aims: International investments made in non-integrated economies provide benefits of portfolio diversification, but investment made in integrated economies may lead to oscillations due to volatility spillover. Therefore, the knowledge of market linkage of an economy is imperative for investors, as well as regulators. In this context, the present paper investigates the financial integration of the Indian stock market with China, Hong Kong, Japan, UK and USA.

Design/Methodology/Approach: To examine the financial integration in the long run, closing daily indices of leading stock markets of respective countries have been analysed through the Johansen cointegration method over a period of 20 years from 2002 to 2022. The vector error correction model has been applied to examine whether market equilibrium can be restored after an infusion of shock. The short run linkage has been investigated through a causality test. Further the possibility of volatility spillover has been examined through variance decomposition and impulse response function.

Research findings: The results show cointegration among the selected markets, which indicates the possibility of convergence towards market equilibrium in the long run. The stock markets of India and USA were observed to have a bidirectional causal relationship indicating lesser chances of benefits from international portfolio diversification. The results

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reveal the sensitivity of the Indian stock market to innovations in the UK and USA. However, no significant influence of the Hong Kong, Japanese, and Chinese stock markets has been observed on the Indian stock market. Further, the Indian stock market has a significant contribution to the volatility of other stock markets, except the Chinese stock market.
Theoretical contribution/Originality: The present study is crucial owing to two prominent reasons. Firstly, the linkage between various financial markets is very dynamic and needs to be studied in the present context. Secondly, the linkage of Indian economy with other countries has increased manifolds in recent few years so it will be fruitful to analyse the linkage of Indian economy with other economies.
Practitioner/Policy implications: The findings are useful to investors while designing international portfolios to reap diversification benefits. The results are fruitful for market regulatory bodies to mitigate the adverse impact of volatility spillover.
Research limitation/Implications: The study can be extended to other markets, monthly data and different sub-periods.

Keywords: Causality, Financial Integration, Impulse Response, Portfolio Diversification, Stock Market, and Volatility Spillover
JEL Classification: G15

1. Introduction

The stock market has always been the most crucial component of financial system of a country because it enables businesses to raise required capital for its operations. It accelerates economic growth through mobilizing savings and channelising it into productive avenues. The technical advancement, liberal government policies made the entire world as a global village where all products including financial securities can be traded by anyone across the territorial boundaries. Now all investors have access to international stock markets and they are allowed to make international investment to enjoy the benefits of portfolio diversification. Here it is important to note that as per modern portfolio theory the benefits of diversification can only be gained when markets have low correlation among them (Markowitz 1952). In other words, one can reap the benefits of portfolio diversification only when stock prices do not move in the same direction. By investing in unrelated economies, an investor can minimize his risk and possible losses. When markets are integrated the speed of information adjustments, information spillover, risk transfers restrict the investors to earn any excess returns. Therefore, the knowledge about short-term and long-term linkages of a stock market with other markets is very crucial. The financial integrated stock market is prone to contagious risk of

possible transmission of oscillations from one country to another i.e., volatility spillovers. Global crises (2008) and Euro-zone crises (2009) are few examples to demonstrate how crises emanating in one market led to global recession (Raj and Dhal, 2009; Subbarao, 2009).

The policy of globalisation and liberalisation in India was launched in the year 1991 and opened the doors for international investment and provided immense opportunities for trading in international stock markets. The policy led to an increase in the nexus of the Indian market with global stock markets both in short and long run (Bose and Mukherjee, 2005; Tripathi and Sethi, 2010; Kaundal and Sharma, 2010). This policy has resulted in the ever-increasing size of the Indian stock market and various innovative investment opportunities are coming to allure investors. To regulate these investments, various stock and commodity exchanges have been established which are working tirelessly. The growth of the Indian stock market is well appreciated all over the world. It is a well appreciable fact that in spite of the turmoil all around the world caused due to the outbreak of coronavirus, the Indian economy demonstrated its strength as compared to many developed countries. Modak (2022), pointed out that during 2022, despite a fall by 7.4%, the country's total market capitalisation stands at $3.21 trillion that is higher to the market capitalisation of the UK ($3.19 trillion), Saudi Arabia ($3.18 trillion), and Canada ($3.18 trillion). The Indian stock market is one of the fastest growing, emerging and oldest markets in Asia due to which it emerged out to be the preferred investment destination of investors. This resulted into increased mobility of funds, cross border exchange and capital inflows from different global markets (Raj and Marcus, 2019, Menon, Subha and Sagaran, 2009). The net capital flows as a ratio of GDP increased from 2% in 2018-19 to 2.9% in 2019-20 (Statista Research Department, 2021). In other words, deregulation and market liberalisation of the Indian economy accelerated economic growth and facilitated rich cash inflows into the stock market. But then arose the need to answer some intriguing questions, like, at present, how extensive are the Indian stock market's linkages with the other global stock markets? Whether co-movement in stock markets is a short-term phenomenon or if markets are integrated in the long run?

In this context, researchers have different set of opinions like Wong, Agarwal and Du (2005) observed existence of long run linkage of Indian market with that of US, UK and Japan. Similarly, Lehkonen (2015), Gupta and Shrivastav (2018) and Bhullar (2019), found that the financial integration of Indian stock market with other

markets has been happening over time. However, Chattopadhyay and Behera (2006) found that the Indian stock market is not co-integrated with developed stock markets in long run. Thangamuthu and Parthasarathy (2015) reported the absence of co-integration among the stock markets of India, South Africa and USA. The Indian stock market was reported not to have long run integration with Brazil (Sharma, Kumar and Saini, 2018). Nevertheless, in the study of BRICS nations conducted by Iltas (2020), the results indicate co-integration of Indian stock market with Brazil, Russia and China. However no significant co-integration was observed between India and South Africa. Bhattacharjee and Das (2020) concluded that there was no long run integration between Indian and USA stock market. Thus, the available literature represents the disagreement among the researchers in context of possible relationship of Indian stock market with other prominent markets of the world. For an instance, with reference to the Chinese stock market, a few researchers like Sachdeva, Bhullar and Gupta (2021) observed unidirectional relationship whereby Chinese stock market has an influence over Indian stock market while few others like Singh and Goyal (2021) proclaimed impact of Indian stock market over the Chinese stock market. A few subsequent studies (e.g., Syed and Kamal, 2022; Yadav, Sharma and Bhardwaj, 2023) pronounced the absence of any linkage whereas a few researchers like Gawade, Parab and Reddy (2019) discerned bidirectional relationships between the two markets. In order to resolve the disagreement pertaining to linkage of Indian stock market with other countries, it is essential to conduct an independent and comprehensive study that aims to answer the following questions:

- Does the Indian stock market have any short-term linkage with prominent global markets?
- Does the Indian stock market have any long-term linkage with prominent global markets?
- How sensitive is the Indian stock market towards the shocks infused in global stock markets?
- How far are other markets going to be affected from the volatility spillover from India?

The study is crucial owing to the two prominent reasons firstly linkage among various financial markets is very dynamic and needs to be studied in present context as several economies have faced lot of oscillation in the recent past like BREXIT for UK, the Covid-19

pandemic for China., the 2008 global financial crisis for the US, and the demonetisation of 2016 for India. Secondly, the linkage of Indian economy with other countries has increased manifolds in recent few years. That is the reason why, the economy is now more prone to get affected through volatility in other markets, possible changes in the behaviour and sentiments of international investors, cash flow position in other economies, domestic perturbations owing to the country specific issues etc. In recent times when the entire world thunderstruck with ineffable shocks, there is a need to explore the market linkage (short-run as well long-run) and also to analyse the possibility of volatility spillover and impulse response of market due to the shocks taking place in other countries. The outcomes will be helpful for the market regulators and participants to initiate actions for avoiding spillover effects and ensuring stability in the economy.

Table 1: Percentage of Market Cap of Selected Six Countries to World's Market Cap

Year	India	China	Japan	Hong Kong	United Kingdom*	United States	Total
2010	3.25	7.42	7.05	5.00	4.95	31.85	56.27
2011	2.62	7.18	7.00	4.75	6.17	32.91	60.63
2012	2.55	6.78	6.38	5.20	6.04	34.25	61.20
2013	1.97	6.14	7.06	4.82	6.13	37.34	63.46
2014	2.51	8.94	6.52	4.81	5.32	39.20	67.30
2015	2.80	13.15	7.86	5.11	6.10	40.26	75.28
2016	2.68	11.24	7.61	4.90	5.69	42.00	74.12
2017	3.22	10.96	7.83	5.47	6.82	40.40	74.70
2018	3.31	9.18	7.69	5.54	6.23	44.18	76.13
2019	2.90	10.80	7.85	6.22	5.66	42.99	76.42
2020	2.77	13.04	7.17	6.54	5.71	43.46	78.69

Source: Author's calculation from World Bank Report on World Development Indicators (*Data for UK from 2015-20 has been taken from www.statista.com)

In this context, the present study aims to unveil the financial integration of Indian stock market with some well-established stock markets of world including that of USA, UK, China, Japan and Hong Kong. The reason for selecting these markets is that these stock markets are amongst world's top ten stock exchanges (Statista Research Department, 2022). It is pertinent to note that amid all oscillations, the percentage of market capitalisation of the

selected countries to world's market capitalisation (market cap) is continuously increasing and since 2015 the total market capitalisation of the selected nations accounts for around 70% of world's market capitalisation (Table 1). Further, US, China and Hong Kong are among India's top four largest bi-lateral trading partners (WITS World Bank, 2019). Japan is also one of the largest trading partners of India. The outcomes will be helpful for Indian investors looking for potential opportunities to park their money in international securities. In the future, India is coming up as an attractive destination for investment (Bhunia 2017), it will provide an insight to international investors planning to assess India as their possible investment destination. The investigation of stock market integration will provide useful insight to regulatory bodies so that essential steps may be taken to protect interest of foreign investors, promote foreign institutional investment inflow and ensuring stability in the economy. The forthcoming section summarises the related literature. The same is followed by research methodology, results and conclusion.

2. Literature Review

The linkages among different economies and their stock markets have always been a matter of interest to researchers. Since the topic has far reaching impact on individual's profit margin as well as economic prosperity the nation, many studies have been undertaken. However, it is interesting to note that market linkage is a very dynamic concept and is very time-sensitive i.e., the linkage among different market varies with variation in time. For an instance, Tripathi and Sethi (2010) reported that the Indian stock market is not integrated with China, Japan and UK. The study found a positive integration of the Indian stock market with only the US market. Kaundal and Sharma (2010) found no long run integration of Indian stock market with selected Asian stock markets viz., Japan, Hong Kong, Taiwan and Singapore. The study applied the Johansen co-integration test to explore the integration among stock markets. The study of stock markets of India, Bhutan, Nepal, Pakistan and Bangladesh reported absence of long run co-integration among markets (Kharka and Kaushik 2012). Rajwani and Mukherjee (2013) conducted a study on global stock indices during a period from January 1991 to December 2011. The test for co-integration concluded the non-existence of co-integration between Indian stock market and other selected global markets, both individually and collectively. Singh and Shrivastav (2017) analysed the interdependence of the Indian stock market with the Colombo stock exchange in Sri Lanka. The results of Johansen

co-integration test found no short or long-term linkage between the selected stock market. Kumar (2021) also concluded the absence of cointegration among stock markets of India, China and Japan in long run. The study used Trace and Eigen value statistics to check possible linkages among selected markets. The absence of integration indicates the possibility of portfolio diversification because the oscillations taking in one country will not affect the other countries.

However, in contrary to above studies, some researchers observed significant long run co-integration of Indian stock market with other markets like Menon, Subha and Sagaran (2009) conducted a study to investigate the possible co-integration of Indian stock market with China, Hong Kong, Singapore and US. The study applied the Engle-Granger approach and results indicate the relationship of Indian stock market with selected markets. Singh (2010) found that Indian stock market is inter-linked with the stock markets of US, UK, China, Japan and Hong Kong in long run. The study applied co-integration approach and error correction model to explore the relationship. To scrutinise the diversification opportunities for investors, Khan (2011) applied the Johansen co-integration test to a comprehensive data set of 22 developed and developing markets. The results surmise that stock markets are co-integrated in long run but in the short run China, Malaysia and Austria were not responsive to US stock markets so investors may reap the benefit of diversification through international investment.

Deo and Prakash (2017) empirically investigated the co-integration of Indian stock market with major global stock markets including Japan, Hong Kong, China, UK and USA by using Johansen trace statistics. The study reported that there is a presence of long run integration among the selected markets. Gupta and Shrivastav (2018) found significant integration between stock markets of India and Japan. Similarly, equilibrium relation was observed between India and selected developed stock markets viz., Australia, Canada, France, Germany, India, UK and USA (Samadder and Bhunia 2018). Gupta and Shrivastav (2018) also reported significant integration between stock markets of India and Japan. Raj and Marcus (2019) discern impact of Indian stock market do have an impact on selected markets (Japan, China, US, Europe and Hong Kong) in short run. The study interposes linkage of Indian stock market with other stock markets in long run. Sharma (2019) applied block exogeneity causality test to examine the causality of five Asian countries. Secondary data was taken for a period of 19 years from January 2000 - December 2018 for top five Asian countries listed by IMF in terms of their GDP viz.,

China, Indonesia, Japan and South Africa. The results revealed that there is a unidirectional causality flowing from Indian stock market to other stock markets.

Lee (2019) analysed the Asian stock markets through applying panel co-integration test. The findings indicated that Asian financial market (except Chinese market) move together. The study reported that the Chinese financial market was not in sync with any other financial market. Another study by Caporale, You and Chen (2019) also divulged integration in Asian stock market at both global and regional level. However, the study observed that the speed of convergence was higher prior to global financial crisis however, it declined afterwards. The results confirmed the notion of high integration among countries before 2008. The higher degree of integration does not offer a good opportunity for international investors seeking to benefit from portfolio diversification in their investments. Narayan and Rehman (2020) also examined the long and short-term gains from portfolio diversification. The study anatomised the stock markets of US, Japan and Asia. The findings reveal differences in both short and long run gains from diversification. Mohamad et., al. (2020) examined the impact of formation of BRICS on benefits expected from portfolio diversification. The study divided the entire time period into pre and post period of BRICS formation. The results concluded that the financial integration has increased after the formation of BRICS. In case of integration, the chances of volatility spillover are comparatively higher and thus international investment may not provide the benefits of portfolio diversification.

Prakash and Nauriyal (2020) applied the Autoregressive Distribution Lag (ARDL) model to examine the interdependence among equity markets in South Asia (including India) for a period of 8 years (2010-2018). The results exhibit integration at global level in the long run. A positive correlation and long run co-integration was pronounced between Indian stock market and Asian stock markets by Agrawal, Nandan and Singh (2021). Jana (2021) conducted a study by taking 15 countries divided into along with US in order to examine stock integration of Indian market with its major trading partners. The results of co-integration approach and generalised autoregressive conditional heteroskedasticity (GARCH) models to Indian stock market with selected Asia Pacific and European nations, showed that the interlinkages among countries caused investors to be unable to diversify their portfolio. Similarly, Joshi, Mehta, Patel and Patel (2021) found bi-directional and uni-directional relation among the indices Indian stock market with developed stock markets of American and

European regions in short run. The markets were found to be co-integrated and interdependent in long run.

Le, Vo and Hesary (2022) studied the dynamics of ASEAN markets integration. The study applied a co-integration test and a non-linear autoregressive distributed lag model. The study concluded that co-integration relationship is asymmetric in the short run and symmetric in the long run for selected economies. On the other hand, Saji (2022) reported weak and asymmetrical price convergence among Asian Markets. The study applied vector error correction model and Johansen co-integration test. The study of Asian Pacific countries by Rahman et al. (2023) through network structure and risk-adjusted return approach noted integration among the selected 15 countries. The examination of impact of G-8 countries on Chinese stock market through Johansen co-integration test, vector error correction model and variance decomposition test reported opportunities for portfolio diversification. The study reported no significant impact of Germany and Russia over Chinese stock market (Hull, Habib and Khan, 2023).

On the basis of literature review, it may be concluded that there is a huge disagreement among researchers about the co-integration of Indian stock market with other stock markets. Further, most of the researchers have examined the linkages only but further investigation can still be done about the contribution of different economies towards the variance caused in a specific economy. To fill the research gap, the present study makes an attempt to explore the interlinkage of the Indian stock market with some selected major stock markets. Variance decomposition analysis was also included in order to identify the market causing more fluctuations in Indian economy. The results of this study are expected to be fruitful for the regulators as through variance decomposition, it will be revealed that whether any fluctuations taking place in an economy are going to influence Indian economy or not.

3. Research Methodology

The present paper tries to examine the interlinkages of Indian stock market (SENSEX) with selected global stock markets. The study is entirely based on secondary data collected on daily frequency intervals so as to capture potential interactions among the time series. The study covers a time period spanning over 20 years starting from 1st November 2002 to 31st October 2022. The selected global developed nations are USA (S&P 500), UK (FTSE_100), China (SSE), Japan (NIKKIE) and Hong Kong (HangSang). All the data used in the study was acquired from Yahoo Finance and the Wall

Street Journal. Since the data was collected during daily intervals, the common data points have been considered i.e., data has been considered for those dates which were common for all countries. The data screening resulted into 4145 observations for each country i.e., total 24,870 observations have been analysed. To explore the linkage, following statistical / econometric techniques have been applied and the statistical software E-views was used for the same.

1. Descriptive Statistics

The descriptive statistics is used to analyse the statistical properties of selected stock markets across the period of 20 years. For this purpose, returns have been computed by dividing the current day's index value with previous day's index value and thereafter natural log has been taken for all stock returns. These logarithmic returns have been used for computing average return, standard deviation from mean value, skewness and kurtosis. The Skewness measures the asymmetry of the probability distribution of selected variable. Kurtosis expresses the extent to which the data of a probability distribution is centred around the mean. It represents the tails of a distribution. To check the distribution pattern of the data, the Jarque-Bera test was applied. The distribution pattern is helpful for selecting the appropriate test to be used for examining the unit root in the series. The test is named after Carlos Jarque and Anil Bera. The test is crucial to examine the normality of the data, which is essential to be pre-diagnosed before applying any econometric technique.

2. Unit Root Test

The present study is concerned with time series data which is subject to the presence of unit root i.e., the non-stationarity of data. To select the most appropriate test for exploring interlinkages among markets, it is essential to know, whether the data is stationary or not. The stationarity of data here implies that the mean and variance of the data does not change over time. In other words, the financial returns of different countries must have a fixed mean and variance for all time. There are two popular tests for checking the unit root in the data – Augmented Dickey-Fuller test (primarily used for normal distributed series) and the Phillips Perron unit root test (applicable for non-normal distribution). In the present study, the results of Jarque-Berra evidence the non-normal distribution of stock indices, therefore, Phillips Perron unit root test has been applied. The test is used to check the null hypothesis that the individual time series of selected countries (China, India, Japan, Hong Kong, UK and USA) does not have a unit root.

3. Correlation analysis

The series are expected to have integration, if they exhibit any correlation. Therefore, correlation analysis has been used to identify and quantify any possible relation between the stock indices. The most

popularly used test for measuring the degree of correlation is Karl Pearson's coefficient of correlation, also used in this study.

4. Lag length criterion

The correlation test provides an indication of possible contemporaneous linkage (integration) of the two variables. But the unique feature of clustering of financial series persuades to extend the scope of investigation to unveil any possible lead-lagged relationship among series that may cause contagious impact of oscillations in one stock market over other stock markets. To define the same, at the outset, an optimal lag length has been determined.

5. Co-integration test

There are two methods that may be used to examine inter-linkage among selected stock markets in long run. The first is the Engle-Granger two-step method which examines unit root in the residuals. If the residuals are stationary, the time series will be co-integrated in long run. Another method is the Johansen method which is most frequently used for larger samples. This method overcomes the limitation of the previous method by non-permitting more than one co-integrating relations. Previous studies like Prakash and Nauriyal (2020); Narayan and Rehman (2020); Joshi, Mehta, Patel and Patel (2021); Agrawal, Nandan and Singh (2021) and Jana (2021) also suggested the use of the Johansen cointegration test for checking co-integration.

The pre-condition to use test of co-integration is to have a data set which is non-stationary at original level and is stationary at same level of integration. The method assumes that if time series is non-stationary there is a chance that different time series data will be associated in long run and will share a co-integrating relation. It captures the responsiveness among two or more non-stationary time series as if they are co-integrated, they cannot deviate from equilibrium in long run. The test is based on the notion that if two or more than two variables are integrated of the same order where and there exists a stationary linear combination of these variables, the variables are said to be co-integrated.

Let x and y are I (1)

$$y_t = \alpha + \beta x_t + u_t$$

If u(t) is stationary, x and y are co-integrated, and the regression is a cointegration equation.
If u(t) is non-stationary, x and y are not cointegrated and the regression is spurious.

The Johansen cointegration test is based in two main forms trace test and Maximum Eigen Value test where number of linear combinations in a time series is examined. The computed test statistics for trace and maximum Eigen is compared with the critical value at 5% level of significance to test the null hypothesis which is as follows:

Null hypothesis: There is no significant cointegrating equation among the selected markets in long run.

If the test probability is more than 5%, the null hypothesis is being accepted otherwise the same cannot be accepted. The present study also applied Johansen cointegration method to examine the integration among the selected stock markets. If the result of co-integration test indicates the absence of co-integration, vector auto regression (VAR) model will be applied for further analysis. However, there are sufficient evidence of co-integration, vector error correction model (VECM) will be applied. In the current study, stock markets are detected to be cointegrated in the long run. Therefore, the VECM has been applied for further investigation.

6. Vector Error Correction Model (VECM) and Wald Test

The VECM is a technique which is used to analyse the behaviour of time series data in both the short run and the long run. VECM establishes the relationship between stock prices in short run and corrects the deviation in the long run. Its applicability depends upon the data series having one or more co-integrating vectors and it should be a non-stationary time series integrated of same order. Since the results suggest that selected time series are cointegrated, VECM has been applied to examine whether equilibrium can be restored after the infusion of shock.

If the cointegrating equation is:

$$y_t = \beta x_t$$

The corresponding VEC model is:

$$\Delta y_t = \alpha_y (y_{t-1} - \beta x_{t-1}) + \varepsilon_{y,t}$$

$$\Delta x_t = \alpha_x (x_{t-1} - \beta y_{t-1}) + \varepsilon_{x,t}$$

Here, the term α measures the speed of adjustment of the respective endogenous variable towards the equilibrium. The error correction coefficient measures the speed with which equilibrium will be restored in a model and how the dependent variable returns to an equilibrium after the independent variable has undergone a change. The negative sign of the coefficient indicates the ability to return back to equilibrium, whereas a positive sign is concerned with moving away from the equilibrium and instabilities in a model. Therefore, the coefficient of error term should be negative and less than one. Here error correction term is a variable that measures long run convergence. It further explains that previous period deviations from equilibrium influences short run dynamics of dependent variable. In the present study, since the objective is to investigate the relationship between the Indian stock market and other stock considered coefficients of lagged indices of

selected global markets. The null hypothesis is that different lagged markets, the Indian stock market was taken as a target variable. The Wald test has been applied to examine the significance of individual stock markets in affecting the Indian stock market. The test coefficients of individual stock market are at the same time equal to zero.

7. Granger causality / Block exogeneity test

The VECM and Wald test provided a fair idea about the possible influence of specific stock markets over the Indian stock market. However, it is silent about the possible two-way direction of causality where the lagged value of one variable is influencing (causing change to) the other variable and at the same time is being affected by the lagged value of another variable. Since it is quite possible that changes in the Indian stock market are causing changes in another stock market, The Granger causality / Block exogeneity test has been applied to scrutinise all possible directions of causality between the variables.

The test is based upon the fact that if during the short term, one variable gets affected by the lagging of another variable, there is a relation of causality between them and the causality tends to flow from the lagged variable to another variable. In order to examine the short-term association between the two variables – the Indian financial market and other developed global stock markets (China, Japan, Hong Kong, UK and USA) Granger causality test is used. When the lagged value of Y(t) provides information to predict X(t+1) at time t, it is said that Y(t) Granger causes X(t). Thus, if the prediction of future values of variable Y is based on not only its own past values but also on the past values of another value i.e., X, it is said the X Granger cause Y. The test can be conducted only on the time series which are integrated at same order. The strength of causality differs on the basis of time period and accordingly there can be bi-directional or unidirectional causality. The test examines the following null hypothesis:

Null Hypothesis: Variable X does not Granger causes Variable Y.

In simple words, the changes in variable X will not Granger cause any change in variable Y. To examine the null hypothesis, at the outset, the test is conducted by running auto regression model on the Y(t) firstly without inclusion of lagged value of another variable i.e., X(t-1) and thereafter the model is conducted with inclusion of lagged X variable. It can be represented as follows:

If $y_{(t)}$ is correlated to $x_{(t\text{-}i)}$, y is Granger caused by x.

$$y_t = \alpha + \sum_{i=1}^{l} \alpha_i y_{t-i} + \sum_{j=1}^{l} \beta_j x_{t-j} + \varepsilon_t$$

If $x_{(t)}$ is correlated to $y_{(t\text{-}i)}$, x is Granger caused by y.

$$x_t = \omega + \sum_{i=1}^{l} \gamma_i x_{t-i} + \sum_{j=1}^{l} \theta_j y_{t-j} + \varepsilon_t$$

The difference between the dependent variables computed through the two equations above is tested through comparison of test statistics with the critical value for the same. If the test statistics is less than the critical value (or probability is more than 5%) the null hypothesis is accepted, and it is concluded that there is a causal relationship between the two variables during short run. However, if the test statistics is more than the critical value (or probability is less than 5%) the null hypothesis is rejected, and it is concluded that there is no causal relationship between the two variables during short run.

8. Impulse response function and variance decomposition analysis

In order to capture the volatility spillover from one country to another, the impulse response function and variance decomposition analysis have been used. Volatility spillover refers to the transmission of instability from one market to another market. It occurs when a volatile price change in one market causes a lagged impact on the volatility of price in another market. Impulse response function and variance decomposition analysis are the most common tools used to capture the effect of stochastic disturbances on selected variables. The impulse response function examines the impact of shocks infused in one market over the other stock market at a lagged interval. The present study applies an impulse response function to investigate the sensitivity of the Indian stock market towards the shocks occurring in other stock markets. Further the responsiveness of other stock markets towards the shocks taking place in Indian stock market has also been scrutinised.

Variance decomposition analysis estimates the contribution of other markets towards the error variance in the domestic market. The analysis is based upon the assumption that the variance in a country's market may be contributed by the country's own innovations and can also be on account of other stock markets. The present study also applies the same methodology to specify whether global stock markets have any contemporaneous impact over Indian stock market or not. It has been used to capture the proportion of variations in Indian stock market due to other countries and due to internal factors. Further the contribution of Indian stock market towards the variance in other markets has also been examined.

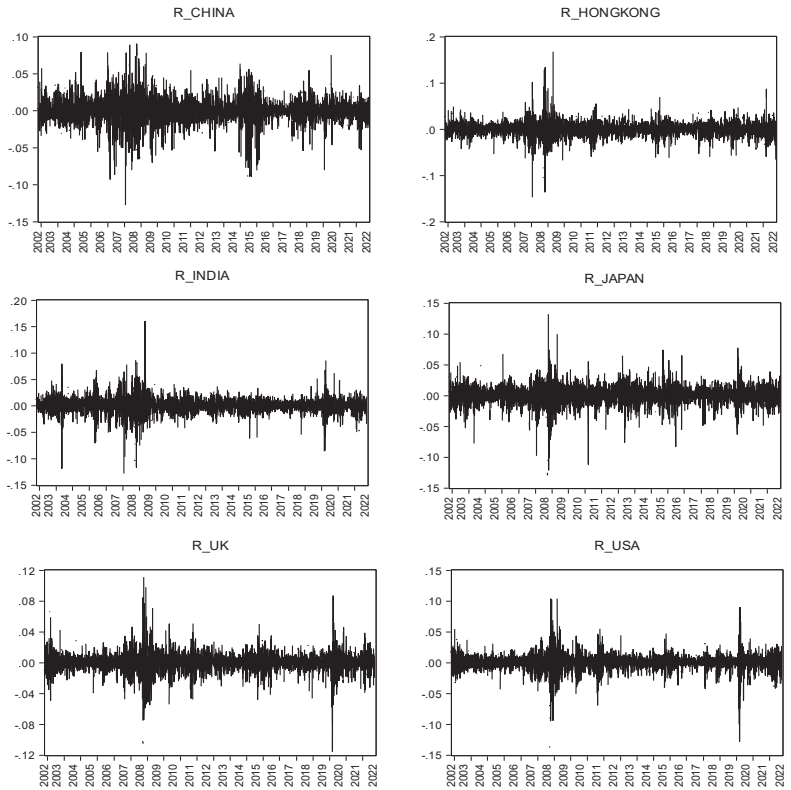
These two techniques have been commonly adopted by researchers to examine the dynamic relationship among different economies at different time intervals. Mustafa (2023) applied impulse response function and variance decomposition analysis to study dynamic relations among South Asian countries. Hull, Habib and Khan (2023) also applied these techniques to investigate the dynamic relations between the Chinese stock market and G8 nations. The impulse

response and variance decomposition were used to capture the impact of volatility in G-8 Countries over Chinese market and vice-versa.

4. Results and Discussion

The stock market returns of different countries have been depicted through Figure 1. During the span of 20 years from November 2002, Indian stock market experienced first turbulence during 2004. On 17th May 2004, Sensex experienced a massive fall of 12.77% and crashed by 824 points during intraday trade. This was owing to the election as well as FII trade in the country. The total FII purchases and sales on 17th May 2004 reported to be 1,236.77 crore INR and 1,310 crore INR respectively. Later the market experienced fluctuation during 2008-09 and 2020-21. The fluctuations may be attributed to the occurrence of global financial crisis and outbreak of Covid-19 respectively.

Figure 1: Returns from Stock Markets (November 2002-October 2022)



Source: Author's Calculations

Minor oscillation was observed during 2015 as a result of Chinese stock crash. USA stock market faced situations of financial stress and crises during 2008 owing to the global financial crisis emanating from hosing bubble and bankruptcy of Lehman Brothers on September 15, 2008. Further during 2018, the USA economy faced turmoil due to the trade war with China in 2018. The outbreak of corona virus in late 2019 also led to the fall in trade, production and growth rates hence having an impact on financial market. During the fag-end of the study period, again an oscillation was observed on account of Russia's ongoing war with Ukraine. Hong-kong, Japanese and UK stock market experienced volatile environment during 2008-09 on account of global financial crisis. The Chinese stock crash during 2015-16 also affected the economies. The year 2020 brought a sharp decline in returns in UK and other markets due to the pandemic.

Table 2 depicts the descriptive statistics, results of Jarque-Bera test and Unit root test. As evident from the table, during the study period, the average daily returns are highest for India. The returns are mainly accorded to optimistic attitude of investors as India is seen as an emerging and growing market in past decades. Developed nation like USA is second largest contributor in India's FDI inflow. India has seen some bullish trends in past years. The Indian stock returns are followed by USA, Japan, Hong Kong and China. Daily average returns have been observed to be lowest for UK. The reason for low average returns in UK may be attributed to its exit from European Union, and its sluggish growth rate due to covid-19 pandemic resulting in increased business uncertainty, supply chain problems and rising inflation.

Table 2: Descriptive Statistics and Results of JB Test, Unit Root Test and Correlation

Particulars	India	China	Hong Kong	Japan	UK	USA
Daily Log. Average Return	0.073	0.016	0.011	0.028	0.014	0.036
Maximum Return	15.99	9.03	16.80	13.23	11.11	10.42
Minimum Return	-12.80	-12.76	-14.70	-12.92	-11.51	-13.78
Standard Deviation	1.53	1.67	1.56	1.57	1.25	1.32
Skewness	-0.27	-0.42	0.11	-0.59	-0.26	-0.68
Kurtosis	13.44	8.07	15.48	11.24	14.01	17.28
Jarque-Bera Test Statistics*	18865.2 (0.00)	4555.4 (0.00)	26914.9 (0.00)	11961.5 (0.00)	20985.9 (0.00)	35535.8 (0.00)

Particulars	India	China	Hong Kong	Japan	UK	USA
Unit root statistics at original level*	0.74 (0.99)	-2.13 (0.23)	-2.35 (0.16)	-0.74 (0.84)	-2.37 (0.15)	-0.02 (0.96)
Unit root statistics at First Difference*	-63.50 (0.00)	-64.33 (0.00)	-65.07 (0.00)	-65.61 (0.00)	-65.71 (0.00)	-70.11 (0.00)
Correlation among indices						
India	1.00					
China	0.57	1.00				
Hong Kong	0.71	0.74	1.00			
Japan	0.89	0.52	0.64	1.00		
UK	0.79	0.57	0.85	0.79	1.00	
USA	0.97	0.47	0.62	0.94	0.75	1.00

*Probability is in parentheses
Source: Author's Calculation

Further the standard deviation has been observed to be least for the stock market of UK and the same is followed by USA, India, Japan and Hong Kong. The highest standard deviation has been observed in Chinese stock market (1.67%). This may be attributed to the fact that in addition to all global oscillations, the Chinese stock market was exposed to major stock crash during 2015. The turbulence in the Chinese stock market began with the popping of the stock market bubble on 12th June 2015 due to number of reasons like margin financing and the shadow banking sector (Hsu 2016). Investments have been fuelled in the economy due to the reducing borrowing costs. Nevertheless, since the dramatic rise in the market was driven by momentum and not due to the fundamental characteristics, the market took a U-turn and economy lost steam.

All stock indices (except Hang Sang) reported negative skewness and high indicating the presence of outliers i.e., during short-run investors may get abnormal (positive/negative) returns. To check the distribution pattern, Jarque Bera test has been conducted which examines the null hypothesis of normality of distribution. The test statistics reveal the rejection of null hypothesis as the probability is less than 5% for all indices. Thus, it can be concluded that none of the stock market follows normal distribution. Since the data is not normally distributed, a non-parametric unit root test i.e., Phillips Perron (PP) Unit root test has been applied. The significance of results is checked on the basis of p value. The test examines the null hypothesis of presence of unit root in the series i.e., the series is non-

stationary in nature. The null hypothesis will be accepted only when probability is observed to be more than 0.05. The comparison of test statistics with critical values indicates that at original level of indices, the probability is more than 5%. Therefore, the null hypothesis is acceptable for all indices at original level i.e., it can be concluded that all indices have unit root. Since there is a unit root i.e., data is non-stationary at original level, the first difference has been computed and the unit root test has been applied again. The comparison of test statistics at first difference with critical values reveal that probability is less than 5% i.e., the null hypothesis cannot be accepted. Therefore, it can be concluded that at first difference there is no unit root in indices. In other words, all indices are integrated at first order.

To examine the possible integration among the selected economies, initially Karl Pearson coefficient of correlation has been computed (Table 2). The high correlation of Indian stock market with Hong-Kong, USA, China and UK witnesses the capital inflow to Indian economy. Further very high correlation has been observed of USA with India and Japan. The correlation of stock market of UK stock market is very high for Hong Kong, India and Japan. Chinese stock market has highest correlation with Hong-Kong and lowest with Japanese stock market. One of the main reasons for increasing association among selected countries is their trade relations, increased investment and capital flows. Correlation between USA and India is very high and highest with a value of 0.97. India recorded highest ever FDI in fiscal year 2022 with USA being second largest investor with 21% of inflows. The bi-lateral trade between both the nations is also on an increase USA has remained India's one of the major trading partners in past years. In FY2021-2022 USA surpassed China and became India's top trading partner where trade stood at $119.42 billion.

China being top trading partner of India for many years shared very high correlation with India till 2009. But afterwards, China started to re-balance its economy by increasing domestic consumption and production of value-added products. This resulted in lower growth rate in China and weakens the relationship between two countries. The Chinese stock market turbulence in 2015 also led to enfeeble the relation between two economies. As it can be seen from above table correlation between China and India is moderate and stands at 0.57. Japan also shares a very strong positive correlation with India (0.89). The relationship between the two nations is not just quantitative but also qualitative one. Both the nations are partner in peace and shares common responsibility for promoting security and

prosperity in Asia. Apart from this around 6% of India's FDI comes from Japan. Further UK shares a high positive correlation with Hong Kong (0.85) and India (0.79). UK is third largest investor in India and India is second largest foreign investor in UK making their relation strong and positive. The correlation analysis of the selected countries reveals that the selected countries are having moderate to high correlation with each other which indicates the possibility of market integration (linkage) and also the risk of volatility spillovers.

To start the investigation of market integration, it is essential to determine appropriate lag length. The determination of optimal lag length of autoregressive process is very crucial because the results of further econometric investigation largely depend upon the selected length. There are popular methods viz., Final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SIC) and Hannan-Quinn information criterion (HQIC). All these methods have been applied to get an idea about he optimal lag length (Table 3). These methods suggest the optimal length on the basis of lowest error / information values. As revealed from the table, SIC recommends two lags, HQIC suggests three lags and remaining two criterions i.e., AIC and FPE favours the use of four lags. The present study applies four lags owing to the three reasons viz., firstly it has been recommended by two criterions. Secondly, AIC and FPE minimize the chance of under estimation while maximizing the chance of recovering true lag length (Liew, 2004) and lastly, AIC is the most frequently used criterion.

Table 3: Selection of Optimal Lag Length

Lag	AIC	FPE	HQIC	SIC
0	102.7764	1.74 E +37	102.7796	102.7855
1	72.2761	9.87 E + 23	72.2986	72.3399
2	71.9614	7.21 E + 23	72.0034	72.0801*
3	71.9411	7.06 E + 23	72.0024*	72.1144
4	71.9349*	7.02 E + 23*	72.0155	72.1629
5	71.9381	7.04 E + 23	72.0381	72.2208
6	71.9383	7.04 E + 23	72.0577	72.2758
7	71.9362	7.03 E + 23	72.0749	72.3283
8	71.9381	7.04 E + 23	72.0962	72.3850

Source: Author's Calculation

Since the results of unit root test indicates all indices are integrated at first difference, Johansen co-integration test has been applied to explore long-run integration among selected stock markets (Table 4). The null hypothesis proclaims absence of any co-integrated equation among selected economies. The acceptance (rejection) of null hypothesis depends upon the critical values.

Table 4: Cointegration Results

Hypothesised number of cointegrated equation(s)	Trace Value Test				Max-Eigen Value Test			
	Test Statistic	Critical Value	Probability	Null Hypothesis	Test Statistic	Critical Value	Probability	Null Hypothesis
None	83.47	107.35	0.61	Accepted	24.26	43.42	0.93	Accepted
At Most 1	59.21	79.34	0.60	Accepted	19.29	37.16	0.93	Accepted
At Most 2	39.93	55.25	0.52	Accepted	13.75	30.82	0.95	Accepted
At Most 3	26.17	35.01	0.32	Accepted	12.56	24.25	0.72	Accepted
At Most 4	13.61	18.40	0.21	Accepted	9.24	17.15	0.47	Accepted
At Most 5*	4.36	3.84	0.04	Rejected	4.36	3.84	0.04	Rejected

Source: Author's Calculation

Table 4 reveals that the probability value of only 'At most 5 cointegrating equations' is less than 5%. Thus, it can be inferred that there is a possibility of maximum 4 cointegrating equations among the variables. The results are inconsistent with the results of the correlation test, and it can be concluded that there exist long run cointegration among the selected markets. Cointegration explains a long-term trend and a common force among the selected economies making them converge in long run. Convergence simply indicates that the benefit of diversification will be lesser. With the co-integration among the markets, the risk of volatility spillover increases. In case of co-integrated economies, the spillovers may be contagious resulting into mass spread of turbulence from one nation to another leading to a situation of global crises. As the results of co-integration test suggests that selected time series are co-integrated, Vector Error Correction Model (VECM) has been applied to examine whether after infusion of shock, equilibrium can be restored or not. Since the present study aims at exploring the relationship of Indian stock market with global stock markets therefore, Indian stock market

has been taken as dependent variable and other markets have been taken as independent variables. The calculation has been made at the lag length of 4 (as recommended by Akaike information criterion), which provides three lagged coefficients of each variable ranging from C(2) to C(19). All the coefficients have been shown in Table 5.

Table 5: Results of VECM and Wald Test

VECM					Wald Test		
Variable	**Coefficient**	**Value**	**Test Statistic**	**Prob.**	**Null Hypothesis**	**F-Statistic**	**Prob.**
ECT	C (1)	-0.001	-0.72	0.47	C (2) = C (3) = C (4) = 0 i.e., Indian Stock Market does not have significant impact of own market in short run.	**6.81**	**0.00**
India	At lag one C (2)	-0.084	**-4.46**	**0.00**			
	At lag two C (3)	-0.013	-0.67	0.50			
	At lag three C (4)	-0.012	-0.66	0.51			
China	At lag one C (5)	-0.236	**-2.03**	**0.04**	C (5) = C (6) = C (7) = 0 i.e., Chinese Stock Market does not affect Indian Stock market in short run.	1.74	0.16
	At lag two C (6)	-0.040	-0.34	0.73			
	At lag three C (7)	-0.114	-0.98	0.33			
Hong Kong	At lag one C (8)	-0.008	-0.32	0.75	C (8) =C (9) = C (10) =0 i.e., Hong Kong Stock Market does not affect Indian Stock market in short run	1.17	0.32
	At lag two C (9)	-0.044	-1.86	0.06			
	At lag three C (10)	0.000	0.01	0.99			
Japan	At lag one C (11)	-0.059	**-2.05**	**0.04**	C (11) = C (12) = C (13) = 0 i.e., Japanese Stock Market does not affect Indian Stock market in short run	2.50	0.06
	At lag two C (12)	0.011	0.37	0.71			
	At lag three C (13)	-0.041	-1.53	0.13			

VECM					Wald Test		
Variable	**Coefficient**	**Value**	**Test Statistic**	**Prob.**	**Null Hypothesis**	**F-Statistic**	**Prob.**
UK	At lag one C (14)	0.061	0.61	0.54	C (14) = C (15) = C (16) = 0 i.e., UK Stock Market does not affect Indian Stock market in short run.	**3.04**	**0.03**
	At lag two C (15)	0.237	**2.32**	**0.02**			
	At lag three C (16)	0.234	**2.33**	**0.02**			
USA	At lag one C (17)	3.162	**13.22**	**0.00**	C (17) = C (18) = C (19) = 0 i.e., USA Stock Market does not affect Indian Stock market in short run.	**60.50**	**0.00**
	At lag two C (18)	1.449	**5.52**	**0.00**			
	At lag three C (19)	0.033	0.13	0.90			
Constant	C (20)	12.306	**2.39**	**0.02**			

Source: Author's Calculation

These coefficients of lagged value of global indices pronounce whether any change in independent variables (selected stock markets) during short run granger causes the Indian stock market or not. The coefficient will be treated as significant if its probability is less than 5%. The significant coefficients have been shown in bold font. The coefficient C(1) depicts the error correction coefficients that measure the speed with which dependent variable returns to equilibrium after independent variable has undergone a change. The coefficient of error term should be negative and less than one. Here error correction term (ECT) is a variable that measures long run convergence. It is known as the speed of adjustment also because it explains how previous period deviations from long-term equilibrium affect the short-term dynamics of the dependent variable. It is the lagged residual value from the long run co-integrating regression. As depicted in table 6, the error correction term (C1) is -0.001 and with a probability value of 0.47. Since the probability is more than 5% i.e., 0.05, the ECT is found to be insignificant. The statistical insignificance of ECT confirms that the selected stock markets (China, Japan, Hong Kong, UK and USA) do not have any causal impact over Indian stock market in long run. Though no long run causality has been observed but it does not reject the possibility of presence of short-run causality among markets

and the same can be tested through Wald test and Granger / Block exogeneity tests.

With respect to other stock markets, the individual coefficients of lagged values of different markets like C(5) for Chinese stock market at lag one, C(11) for Japanese stock market at lag one, C(15) and C(16) for UK stock market at lag two as well as lag three, C(17) and C(18) for USA stock market at lag two as well as lag three are observed to be significant. To draw out the concrete conclusions, Wald test has been applied. The test considers coefficients of lagged indices of selected global markets. The null hypothesis is that different lagged coefficients of individual stock market are at the same time equal to zero. In other words, that market does not affect another market in short-run.

The probability of Wald test conducted to examine the null hypotheses for Chinese, Hong Kong and Japanese stock markets have been accepted as the probabilities of the test statistics for these markets are more than 0.05 (i.e., 5% level of significance) and tends to be 0.16, 0.32 and 0.06 respectively. Thus, it can be concluded that different lagged coefficients of these stock markets are at the same time equal to zero. In other words, these stock markets do not have any significant impact over Indian stock market. However, the same for India, UK and USA could not be accepted as the probabilities for these two markets are less than 5%. Therefore, from the results of Wald test, it is evident that both UK and USA stock markets can significantly affect Indian stock market in short run whereas for China, Hong Kong and Japan no significant impact has been observed. However, it is possible that Indian stock market Granger causes another stock market. To have the detailed analysis of short run causality Granger causality/Block Exogeneity test has been applied (Table 6).

The Granger causality test determines unidirectional and bidirectional relation among the nations. It provides an idea about the potential predictions and forecasting power of one variable with respect to another. In the table above, the value for chi-square statistics have been mentioned and the hypothesis accepted or rejected on the basis of probability values (more than or less than 0.05) respectively. In the case where the hypothesis was rejected for both the nations, they can be said to possess a bidirectional relationship, in case where one hypothesis is rejected, and one accepted. It can be concluded to have a unidirectional relation flowing only from one nation to another. In case where the hypothesis was accepted for both the nations, they were said to have no causal relation.

Table 6: Results of Granger Causality/ Block Exogeneity Test

Group of countries	Null Hypothesis: No Causality from country X to Country Y i.e., X ↛ Y	Chi-square Statistics	Probability	Result	Causality
India and China	China ↛ India	5.22	0.16	Accepted	Unidirectional
	India ↛ China	7.93	0.048	Rejected	
India and Hong Kong	Hong Kong ↛ India	3.52	0.32	Accepted	Unidirectional
	India ↛ Hong Kong	31.08	0.00	Rejected	
India and Japan	Japan ↛ India	7.51	0.06	Accepted	Unidirectional
	India ↛ Japan	15.34	0.00	Rejected	
India and UK	UK ↛ India	9.11	0.02	Rejected	Bidirectional
	India ↛ UK	20.16	0.00	Rejected	
India and USA	USA ↛ India	181.50	0.00	Rejected	Bidirectional
	India ↛ USA	9.84	0.02	Rejected	

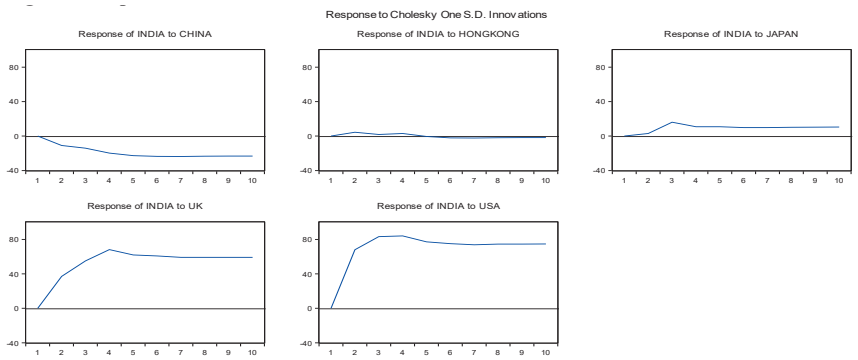
Source: Author's Calculation

During short-run, bi-directional relation of India can be observed with USA. The bi-directional relation exists mainly because USA is major trading partner of India and India remains an attractive destination for USA to invest. Apart from common bi-lateral policies and treaties both countries have multiple trade and investment transactions. The results indicate that the magnitude of short-term causality stands high (181.50) from USA to India whereas weak short-term causality (9.84) exists from India to USA. It indicates the possibility of volatility transmission between the two countries. The results are expected to be fruitful for regulators to formulate policy for stabilization of economy and ensuring steady growth. The results are in consensus with the findings of Sachdeva, Bhullar and Gupta, (2021). The study analysed the stock markets of India, Brazil, China, Indonesia, Germany, Japan and USA. The results reported bidirectional causality between US and Indian stock market. The similar result of bidirectional causality was observed for UK and India. The magnitude of short-term causality flowing from UK to India (9.11) is comparatively lesser to the same flowing from India to UK (20.16). Mishra, Agarwal and Patwa (2022) also reported a direct

causation of UK stock market to Indian stock market. The study analysed daily data for a period of 12 years from January 2008 to December 2019. The relationship explains that causality flows from one nation to another in other words there will be spillovers from one nation to another making it a bit risky for investors to diversify their portfolio internationally. The simultaneous investment in these nations may prove to be risky for investors there is a threat of volatility arising from one nation and getting transferred to another nation.

Unidirectional relations have been observed from India to China, Hong Kong and Japan. The results are in line with the fact that China is among India's top 3 trading partner in past few years. Similarly, Japan is considered as a major partner in transformation of Indian economy as the bilateral trade between India and Japan has increased in the past years due to India's growing market and its human resources also the flow of investment has increased in previous years as Japan ranks among third largest investor in India. Since 2000 to 2019 total investments made in India by Japan stands at 32.058 billion US$. Sachdeva, Bhullar and Gupta (2021) also reported the presence of unidirectional causality of Indian with China and Japan. The results of present study are in accordance with previous studies conducted by Menon, Subha and Sagaran (2009) and Singh (2010).

Figure 2: Impact of Shocks in Selected Stock Markets over Indian Stock Market



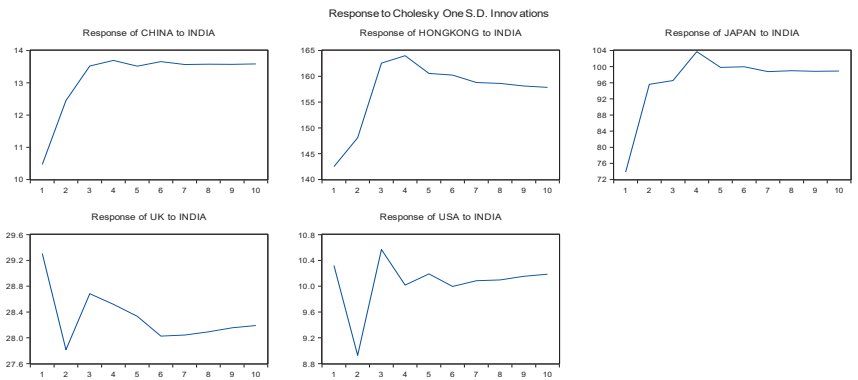
Source: Author's calculation

The analysis tells us that in the short run, there is a limited chance for diversification in the market, therefore creating a small window for investors to gain profits and reduce risk arising from volatility

spillovers. To understand the contribution of different countries to the volatility of the Indian stock market, impulse response and variance decomposition analysis have been done. Figure 2 depicts the responsiveness of the Indian stock market to the shocks occurred in selected stock markets. As a response to shocks in the Chinese stock market, Indian stock markets has shown a reversal of trends. However, for other markets, a positive response has been observed. The sensitivity of the Indian stock market is highest towards the innovations (shocks) occurring in the USA stock market and the same is followed by UK stock market. The impact of shocks in Hong Kong and Japanese stock markets has not been found to be so significant.

During the initial period, the Chinese, Hong Kong and Japanese stock markets depicted a positive response to the shocks infused in Indian stock market whereas the stock markets of UK and USA witness a negative response as shown in Figure 3. The response to shocks experienced in the Indian stock market, was observed to be least in USA stock market and the same is followed by Chinese and UK stock markets. Highest impact was observed on Hong Kong stock market and the same is followed by the Japanese stock market. The result endorses the unidirectional causality flowing from India to China, Hong and Japan as concluded by Granger causality/ Block Exogeneity Wald test.

Figure 3: Impact of Shocks in Indian Stock Market over Selected Global Stock Markets



Source: Author's calculation

To estimate how much of the variability in the dependent variable (one stock market) is explained by its own shock vis-a-vis the shocks in the other selected stock markets, variance decomposition

analysis has been done. It is known as forecast error decomposition also as it depicts the percentage of errors in forecasting one variable (India stock market) at t period ahead due to a specific shock in different markets. In the present study forecasting has been done till 10 days period ahead and the percentage of errors have been reported in Table 7. With reference to the Indian stock market, the results of the variance decomposition analysis reported that global stock markets do not have any contemporaneous impact over Indian stock market and the entire (100%) variations the in Indian stock market is explained by its own self. After an interval of 5 days, the own influence reduced to 93.36% and after 10 days it declined to 92.62%. Amongst all the selected markets in this study, the USA has a maximum impact of 4.39% at the 10th interval. Gulzar, Kayani, Xiaofeng, Ayub and Rafique (2019) also observed that a shock in USA market does have a short-term impact on the Indian stock market. The UK stock market also has an impact over Indian stock market. The result tallies with the previous results which denote correlation, and the Granger causality test. The influence of Hong Kong stock market on Indian stock market has been discerned to be least and the same is followed by Japanese and Chinese stock markets. The results indicate the possibility of reducing portfolio risk through diversification of investments to Indian stock market during the turbulent time period in Hong Kong, Japan and China.

Table 7: Variance Decomposition Analysis

Time Period	Forecast Standard Error	India	China	Hong Kong	Japan	UK	USA
Variance Decomposition of Indian stock market (in percentage)							
1	329.72	100.00	0.00	0.00	0.00	0.00	0.00
5	768.37	93.36	0.21	0.01	0.08	2.18	4.16
10	1091.25	92.62	0.33	0.00	0.09	2.57	4.39
Variance Decomposition of Chinese stock market (in percentage)							
1	50.80	4.24	95.76	0.00	0.00	0.00	0.00
5	116.22	6.05	91.13	0.30	0.10	1.45	0.97
10	165.76	6.34	90.25	0.40	0.15	1.79	1.07
Variance Decomposition of Hong Kong stock market (in percentage)							
1	306.31	21.65	16.75	61.60	0.00	0.00	0.00
5	703.59	24.51	10.08	56.25	0.08	5.12	3.97
10	985.31	25.47	8.86	55.44	0.14	5.94	4.15

Time Period	Forecast Standard Error	India	China	Hong Kong	Japan	UK	USA
Variance Decomposition of Japanese stock market (in percentage)							
1	213.62	11.96	3.01	11.16	73.87	0.00	0.00
5	519.32	16.55	1.47	9.19	56.48	7.70	8.62
10	732.06	17.49	1.13	8.25	55.58	8.73	8.82
Variance Decomposition of UK stock market (in percentage)							
1	68.32	18.40	0.89	7.46	2.55	70.70	0.00
5	149.62	18.19	0.44	7.14	2.88	69.20	2.15
10	207.48	18.63	0.29	6.70	2.87	69.61	1.91
Variance Decomposition of USA stock market (in percentage)							
1	26.50	15.17	0.16	1.29	2.47	15.55	65.35
5	56.94	15.49	0.08	1.00	3.00	17.41	63.03
10	78.87	16.28	0.06	0.87	3.10	17.46	62.23

Source: Author's Calculation

With reference to the influence of the Indian stock market over other stock markets, it has been discerned that the maximum variability in Hong Kong stock market is contributed by Indian stock market which is around 21.65% after one day interval which increases to 25.47% till an interval of 10 days. The reason of high contribution may be attributed to the bilateral trade relations between the two nations. The influence of Indian stock market has been observed to be lowest for Chinese market. During a span of 10 days, it increased from 4.24% to 6.34%. Such findings may be attributed to the political-geographical conflict between the two nations owing to which the linkage between China and India has reduced to great extent in the recent past. The same is quite apparent from comparatively lesser value of correlation (0.57) and unidirectional relation between the two nations. The Japanese stock market has been found to be influenced by India (11.96%) and Hong Kong (11.16%). The Indian stock market has a significant impression over Japanese market because both the nations share common bilateral policies. However, the influence of Hong Kong stock market faded away soon due to the growing impression of UK and USA markets. The contribution of Indian stock market towards the shocks infused in UK and USA stock markets are also quite significant as these countries are major trading partner as well as investment partners of India. The results are in consensus with the inferences drawn from correlation and block exogeneity test.

5. Conclusion

The present study is based on secondary data ranging from November 2002 to October 2022. The aim of the paper is to empirically investigate financial integration of Indian stock market with global markets and to assess volatility spillover effects. This paper investigates both the short and long-term dynamics of the Indian stock market and other selected developed markets using cointegration, the vector error correction model, Granger causality/ block exogeneity, impulse response function and variance decomposition method. The findings of the Unit Root test reveal that all the indices were stationary at first difference. The correlation matrix revealed the strength of linkage and association of the Indian stock market with US, UK, Hong Kong and Japan. The moderate correlation has been observed between India and China which indicates an opportunity for the investors to reap benefits through portfolio diversification. The results of trace statistics and Eigen statistics indicate long run relationship among selected markets. It can be concluded that markets will converge in the long run as dependency among the markets is seen to increase due to free flow of trade, regional blocks, ever increasing technical knowledge but investors cannot gain by performing arbitrage activities in the long run.

The results of Granger causality / Block exogeneity evidence bidirectional causality between India and USA. Impulse response function and variance decomposition analysis also reported the sensitivity of the Indian stock market towards the innovations in USA stock market. Amongst all selected markets, USA has maximum impact. The bi-directional relation exists between India and UK also. However, the magnitude of short-term causality flowing from UK to India found to be comparatively lesser to the same flowing from India to UK. This indicates the possibility of volatility spillovers from one nation to another making it a bit risky for investors to diversify their portfolio internationally. The sensitivity of the Indian stock market is highest towards the innovations (shocks) from the USA stock market and the same goes for the UK stock market. Unidirectional relations have been observed from India to China, Hong Kong and Japan. With reference to the influence of the Indian stock market over other stock markets, it has been discerned that the variability of Hong Kong, UK, Japanese and USA stock market at 10th interval period explained by Indian stock market in tune of around 25.47%, 18.63% and 17.49%, 16.28% respectively. The results are in line with the conclusions drawn in previous studies (Menon, Subha and Sagaran, 2009; Singh, 2010; Sachdeva, Bhullar and Gupta, 2021).

6. Implications, Limitations and Future Research Directions

In the present-day scenario, dependency, interlinkage, and integration of the financial markets are common in every economy. Almost every economy is going for financial integration with other countries for the sake of capital inflows in the form of foreign institutional investments. The cointegration of markets assists in maintaining stability as they will converge on the path to equilibrium in the long run, but at the same time, it exposes the country to the contagious risk of global financial oscillations, turbulence, volatility, and crises. Therefore, it becomes important for regulatory bodies to keep a close watch on the linkages of domestic markets with other countries.

The findings of this study is helpful for market regulators to identify the interlinkage of the Indian stock market with other prominent stock markets. The current study is expected to be helpful to policymakers and regulatory bodies to better understand the interdependence among economies and to closely monitor the functioning of other stock markets, particularly during times of turbulence in one economy. In a contemporary integrated global scenario, it is necessary to identify the economies that might have an immediate effect on the functioning of the domestic stock market. The findings of this study offer a line of thought with reference to possible integration among selected countries so that the respective regulatory bodies can design policies in order to safeguard the interests of foreign investors. The results are useful for devising an appropriate strategy to protect the interests of both investors and economic agents.

Furthermore, the study aims to assist market participants and investors as they can identify potential causes of volatility in the domestic market and be prepared so as to not get affected by the domestic crisis. The results of this study are expected to be crucial for determining the destination points for designing an international portfolio to reap the benefits of investment diversification.

In addition to this, the study contributes to the literature, which has wide disagreements about market linkages. The results are expected to provide a guide for researchers and academicians to analyse the impact of global shocks like the global financial crisis, Chinese stock market turbulence, the outbreak of coronavirus, and the Russia-Ukraine war on the domestic financial market. It will help to understand the dynamics of market integration and the possibility of volatility spillovers from one nation to another.

The present study has made every effort to tackle all the problems related to the topic, but some limitations remain. The first is that it only focuses on Asian markets; further studies can take other emerging economies into account. Secondly, the study included only those economies that were among the top 10 stock markets on the basis of market capitalisation, but other markets that are stable and have been performing well can also be examined. Another limitation is that the data was collected daily; therefore, by taking monthly stock prices, a short- and long-term analysis could be done. Lastly, the data for the present study was collected from 2002, but detailed analysis could be done by dividing the whole time period into pre-reform (before 1991) and post-reform periods, and re-investigation with new variables and different time periods. Further, different models, like the threshold autoregressive model and stochastic volatility models like GARCH, APARCH, and EGARCH can be used to understand the dynamics of market volatility.

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